Scilab Textbook Companion for Electrical Machines by M. V. Despande[1]

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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

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

```
1  // 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
2  // Exa : 1.1
3  clc ;
4  clear ;
5  close ;
6  P_s =25000 // Supplied  power  ( in  VA)
7  V_1 =1910 // Voltage  on  primary  side  ( in  volt )
8  V_2 =240 // Voltage  on  secondary  side  ( in  volt )
9  f =50 // frequency  in  hertz
10 n= V_1 / V_2
11 disp ( n , ' ( a ) n−ratio = ' )
12 I_1 = P_s / V_1
13 disp ( I_1 , ' ( b ) load  current  referred  to  high  voltage
       side  ( in  A)= ' )
```

```
14  I_2=P_s/V_2
15  Z_2=V_2/I_2
16  disp(Z_2,'(c)load  impedance  on  low  voltage  side  for
        full  load  (in  ohm)=')
17  Z_1=Z_2*(n^2)
18  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

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

```
18  Culoss=(I_0^2)*R
19  disp(Culoss,'(d)copper loss in the primary winding
       is(in watt)=')
20  Coreloss=P-Culoss
21  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

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

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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

```
1  //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
2  //Exa:1.4
3  clc;
4  clear;
5  close;
6  V_1=2200//Primary side voltage(in volt)
7  V_2=220//secondary side voltage(in volt)
8  f=50//frequency(in hertz)
9  r_1=1.25//Primary side resistance(in ohm)
10 x_1=4//Primary side reactance(in ohm)
11 r_2=0.04//Secondary side resistance(in ohm)
12 x_2=0.15//Secondary side reactance(in ohm)
13 n=V_1/V_2
14 R_2=(n^2)*r_2
15 disp(R_2,'(a)equivalent resistance of low voltage
       side in terms of high voltage side=')
16 X_2=(n^2)*x_2
17 disp(X_2,'equivalent reactance of low voltage side
```

```
         in  terms  of  high  voltage  side =')
18  R_1=r_1/(n^2)
19  disp(R_1,'(b)equivalent  resistance  of  high  voltage
        side  in  terms  of  low  voltage  side =')
20  X_1=x_1/(n^2)
21  disp(X_1,'equivalent  reactance  of  high  voltage  side
        in  terms  of  low  voltage  side =')
22  R_t=r_1+R_2
23  disp(R_t,'(c)total  resistance  of  transformer  in
        terms  of  high  voltage  side=')
24  X_t=x_1+X_2
25  disp(X_t,'total  reactance  of  transformer  in  terms  of
         high  voltage  side=')
26  R_e=r_2+R_1
27  disp(R_e,'(d)total  resistance  of  transformer  in
        terms  of  low  voltage  side=')
28  X_e=x_2+X_1
29  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

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

```
7  V_1=200//Voltage on low voltage side(in volt)
8  x_m=231//Magnetising resistance(in ohms)
9  r_c=400//Core loss resistance(in ohms)
10 r_e=0.1//Equivalent resistance referred to low
      voltage side(in ohms)
11 x_e=0.5//Equivalent reactance referred to low
      voltage side(in ohms)
12 r_l=7.9//Load resistance(in ohms)
13 x_l=5.5//Load reactance(in ohms)
14 I_m=V_1/x_m
15 I_c=V_1/r_c
16 I_0=I_c+(%i*I_m)
17 R_l=r_l+r_e
18 X_l=x_l+x_e
19 I=V_1/(R_l+(%i*X_l))
20 I_1=I+I_0
21 V_2=V_1-I*(r_e+(%i*x_e))
22 v=sqrt(V_2*conj(V_2))
23 disp(v,'(a)terminal voltage on load(in volt)=')
24 V=v*n
25 disp(V,'(b)voltage on load at hgih voltage terminals
      (in volt)=')
26 P_o=v*real(I)
27 P_i=V_1*real(I_1)
28 eff=(P_o/P_i)*100
29 disp(eff,'(c)efficiency of transformer is(in %)=')
```

Scilab code Exa 1.6 Find impedance and percentage resistance and reactance

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

```scilab
        reactance
 2  //Exa:1.6
 3  clc;
 4  clear;
 5  close;
 6  P_s=500000//Power supplied(in VA)
 7  V_1=2200//Voltage on primary side(in volt)
 8  V_2=500//Voltage on secondary side(in volt)
 9  f=50//frequency(in hertz)
10  r=0.01//Resistance of transformer(in ohms)
11  z=0.1//impedance of transformer(in %)
12  I=P_s/V_2
13  Z=z*V_2/I
14  disp(Z,'(a)Impedance(in ohms)=')
15  R=(I*r/V_2)*100
16  disp(R,'(b) Resistance(in %)=')
17  x=sqrt(Z^2-r^2)
18  X=(x*I/V_2)*100
19  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

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

16

```
16  E=(Cu_1*t_1)+(Cu_2*t_2)+(Fe*24)//Energy  lost  on
        losses(in  watt−hours)
17  eff_1=(E_1+E_2)/(E_1+E_2+E)*100
18  disp(eff_1,'(a)All  day  efficiency(in%)=')
19  eff_2=(E_2)/(E_2+Cu_1+Fe)*100
20  disp(eff_2,'(b)commercial  efficiency  on  full  load(
        in%)=')
21  eff_3=(0.5*E_2)/(0.5*E_2+Cu_2+Fe)*100
22  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

```
 1  //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?
 2  //Exa:2.2
 3  clc;
 4  clear;
 5  close;
 6  P_s=25000//Power  supplied(in  VA)
 7  V_1=3300//Voltage  on  primary  side(in  volts)
 8  V_2=230//Voltage  on  secondary  side(in  volts)
 9  f=50//frequency(in  hertz)
10  P_i=300//Iron  loss(in  watt)
11  P_c=400//Copper  loss(in  watt)
12  pf=0.8//Power  factor
13  Cu=P_c*(0.5^2)//Copper  loss  on  half  load
14  P_o=P_s*0.5*pf//Output  of  transformer  on  half  load
15  eff=(P_o)/(P_o+Cu+P_i)*100
```

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

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

```
1  //Caption:Find (a)% resistance (b)Regulation for
       power factors— unity, 0.8 lagging and 0.8 leading
2  //Exa:2_3
3  clc;
4  clear;
5  close;
6  L_o=1//Ohmic  loss(%)
7  X=6//Reactance(in %)
8  pf_1=0.8//lagging  power  factor
9  pf_2=0.8//leading  power  factor
10  R=L_o
11  disp(R,'(a)% resistance(in %)=')
12  Re_1=L_o
13  disp(Re_1,'(b)Regulation  at  unity  power  factor(in%)=
       ')
14  theta=(acosd(pf_1))
15  a=sind(theta)
16  Re_2=L_o*pf_1+X*a
17  disp(Re_2,'Regulation  at  0.8  lagging  power  factor(
       in%)=')
18  Re_3=L_o*pf_2-X*a
```

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

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

```
 1  //Caption:Find  Regulation  on  full  load  at  0.8  power
       factor  lagging
 2  //Exa:2_4
 3  clc;
 4  clear;
 5  close;
 6  P_s=500000//Power  supplied(in  VA)
 7  V_1=2200//Voltage  on  primary  side(in  volt)
 8  V_2=500//Voltage  on  secondary  side(in  volt)
 9  f=50//frequency(in  hertz)
10  Eff=97//Efficiency  of  transformer(in  %)
11  Eff_m=75//Maximum  efficiency(in  %)  of  its  full  load
12  Z_1=10//Impedance(in  %)
13  pf_1=1//Power  factor  for  maximum  efficiency
14  pf_2=0.8//Power  factor  lagging
15  I_fl=P_s/V_2
16  I=(Eff_m*I_fl)/100
17  Losses=(100-Eff)/100
18  Cu=Losses/2
19  Fe=Losses/2
20  C=(Cu*P_s*Eff_m)/100
21  R=C/(I^2)
22  V=(Z_1*V_2)/100
23  Z=V/I_fl
24  X=sqrt(Z^2-R^2)
```

```
25  theta =( acosd ( pf_2 ))
26  Re =( I_fl * R * pf_2 )+( I_fl * X * sind ( theta ))
27  disp (Re , 'Regulation  on  full  load  at  0.8  power  factor
         lagging ( in  volt )=')
28  Reg =( Re / V_2 )*100
29  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

```
 1  // Caption :  Find :( a )  R_o  ( b ) X_o  ( c ) Resistance
        reffered  to  l.v  side  ( d ) Reactance  reffered  to  l.v
         side
 2  // Exa:2.5
 3  clc ;
 4  clear ;
 5  close ;
 6  P_s =5000 // Power  Supplied ( in  VA)
 7  V_1 =220 // Primary  side  voltage ( in  volt )
 8  V_2 =440 // Secondary  side  voltage ( in  volt )
 9  f =50 // frequency ( in  hertz )
10  I_o =0.75 // Open  circuit  test  current ( in  A)
11  P_o =75 // Open  circuit  test  power ( in  watt )
12  V_s =16 // Short  circuit  test  voltage ( in  volt )
13  P_c =80 // Short  circuit  test  power ( in  watt )
14  pf =( P_o )/( V_1 * I_o )
15  a = sind ( acosd ( pf ))
16  R_o =( V_1 )/( I_o * pf )
17  disp (R_o , '( a ) R_o ( in  ohms )=')
18  X_o =( V_1 )/( I_o * a )
19  disp (X_o , '( b ) X_o ( in  ohms )=')
```

```
20  I_l=P_s/V_2
21  Z=V_s/I_l
22  R=(P_c)/(I_l^2)
23  X=sqrt(Z^2-R^2)
24  n=V_2/V_1
25  r=(R)/(n^2)
26  disp(r',' (c) resistance reffered to low voltage side(
        in ohms)=')
27  x=(X)/(n^2)
28  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

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

```
15  R=P_sh/(I_sh^2)
16  X=sqrt(Z^2-R^2)
17  I_l=P_s/V_1
18  Re=(I_l*R*pf)+(I_l*X*sind(acosd(pf)))
19  V_r=Re+V_1
20  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

```
1  //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
2  //Exa:2.7
3  clc;
4  clear;
5  close;
6  P_s=220000//Supplied power (in VA)
7  V_1=11000//Primary side voltage(in volt)
8  V_2=440//Secondary side voltage(in volt)
9  P_i=2200//Iron losses(in watt)
10 V=500//voltage applied to high voltage side for open
        circuit test(in volt)
```

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

Scilab code Exa 2.8 Determine Efficiency and Regulation at loading conditions

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

23

```
5  close;
6  P_s=10000//Supplied power (in VA)
7  V_1=440//Primary voltage (in volts)
8  V_2=240//Secondary voltage(in volts)
9  f=50//frequency(in hertz)
10 I_l=35//Load current(in A)
11 V_l=234//Load voltage(in volts)
12 W=8500//Wattmeter reading(in watts) connected on 440
      V side
13 P_o=I_l*V_l
14 P_i=W
15 Eff=P_o/(P_i)*100
16 disp(Eff,'(a)Efficiency(in %)=')
17 V_d=V_2-V_l
18 Re=V_d/(V_2)*100
19 disp(Re,'(b)Regulation(in%)=')
```

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

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

24

```scilab
        transformer
10  r_2=0.015//Per unit resistance of second transformer
11  x_2=0.04//Per unit reactance of second transformer
12  P_l=750000//Load(in VA)
13  pf=0.8//Powerfactor lagging
14  V_2=400//Secondary voltage of each transformer(in
        volts)
15  Z_1=r_1+(%i*x_1)
16  Z_2=((2*r_2)+(2*%i*x_2))
17  Z=Z_1+Z_2
18  S=P_l*(pf-(%i*(sind(acosd(pf)))))
19  S_1=(S*Z_2)/(Z)
20  s_1=sqrt(((real(S_1))^2)+((imag(S_1)^2)))
21  disp(s_1,'Load on first transformer(in VA)=')
22  S_2=(S*Z_1)/(Z)
23  s_2=sqrt(((real(S_2))^2)+((imag(S_2)^2)))
24  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

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

```
17 disp(V_lc,I_lc,'(c)(in A),(in volts)=')
18 V_ld=V/(n*(3^0.5))
19 I_ld=(3^0.5)*I*n
20 disp(V_ld,I_ld,'(d)(in A),(in volts)=')
21 P=(3^0.5)*V*I/1000
22 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

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

```
        currents(inA)=')
18  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

```
 1  //Caption: Find possible voltage ratio and output
        for connections (a)BC=11500V,AC=2300V (b)BC=2300V
        ,AC=11500V
 2  //Exa:3.3
 3  clc;
 4  clear;
 5  close;
 6  V_1=11500//Voltage on primary side(in volts)
 7  V_2=2300//Voltage on secondary side(in volts)
 8  P_o=100000//Rated output(in VA)
 9  V=V_1+V_2
10  v=V/V_1
11  I_1=P_o/V_1
12  I_2=P_o/V_2
13  I=I_1+I_2
14  W_o=(V_1*I)/1000
15  Cu=1-(V_1/V)//(a)Ratio of weight of copper
16  disp(W_o,v,'(a)Voltage ratio and output(in KVA)=')
17  w_o=(V_2*I)/(1000)
18  cu=1-(V_2/v)//(b)Ratio of weight of copper
19  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

```
1  // 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
2  // Exa:4.1
3  clc;
4  clear;
5  close;
6  P=5000 // Power supplied to transformer (in VA)
7  f=50 // frequency (in Hertz)
8  V_1=415 // Primary side voltage (in volts)
9  V_2=240 // Secondary side voltage (in volts)
10 k=0.75
11 B=1.6 // Maximum flux density (in weber/m^2)
```

```
12  i_d=2//Current density(in A/mm^2)
13  k_w=0.3
14  E=k*sqrt(P/1000)
15  disp(E,'(a)Voltage per turn(in volts)=')
16  A_1=(E*(10^6))/(4.44*B*f)
17  disp(A_1,'(b)Cross sectional area of core(in mm^2)='
       )
18  i_2=P/V_2
19  A_2=i_2/i_d
20  disp(A_2,'(c)Cross sectional area of conductor for
       low voltage side(in mm^2)=')
21  i_1=P/V_1
22  A_1=i_1/i_d
23  disp(A_1,'(d)Cross sectional area of conductor for
       high voltage side(in mm^2)=')
24  n_2=V_2/E
25  disp(n_2,'(e)Number of turns in low voltage winding=
       ')
26  n_1=V_1/E
27  disp(n_1,'(f)Number of turns in high voltage winding
       =')
28  A_w=(P*(10^(9))/1000)/(2.22*A_1*k_w*i_d*B)
29  disp(A_w,'(g)Window area(in mm^2)=')
30  cu=(A_1*n_1)+(A_2*n_2)
31  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

```
1  //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
2  //Exa:4.2
3  clc;
4  clear;
5  close;
6  P=100000//Power supplied to transformer(in VA)
7  f=50//Frequency(in hertz)
8  V_1=11000//Primary side voltage(in volts)
9  V_2=433//Secondary side voltage(in volts)
10 k=0.45
11 B=1.65//Maximum flux density(in tesla)
12 k_w=0.28
13 i_d=2.5//Current density(in A/mm^2)
14 E=k*sqrt(P/1000)
15 disp(E,'(a)Voltage per turn(in volts)=')
16 A_1=E*(10^6)/(4.44*f*B)
17 disp(A_1,'(b)Cross sectional area of core(in mm^2)='
       )
18 I_1=P/(3*V_1)
19 a_1=I_1/i_d
20 disp(a_1,'(c)Cross sectional area of conductor in h.
       v winding(in mm^2)=')
21 n_1=V_1/E
22 disp(n_1,'(d)Number of turns per phase in h.v
       winding(in mm^2)=')
23 I_2=P/((3^0.5)*V_2)
24 a_2=I_2/i_d
25 disp(a_2,'(e)Cross sectional area of conductor in l.
       v winding(in mm^2)=')
26 v=V_2/(3^0.5)
27 n_2=v/E
28 disp(n_2,'(f)Number of turns in l.v winding=')
```

```
29  A_w =( P *(10^6))/(3.33* f * A_1 * k_w * i_d * B )
30  disp ( A_w , '( g ) Window Area ( in mm^2)=')
31  Cu =2*(( a_1 * n_1 )+( a_2 * n_2 ))
32  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

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

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```
18  disp(V_b1,I_1,'Current(in A) and voltage(in volts)
        for LAP winding=')
19  disp(V_b2,I_2,'Current(in A) and voltage(in volts)
        for WAVE winding=')
20  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

```
1  //Caption: Select a two circuit armature winding for
        a d.c machine
2  //Exa:7.6
3  clc;
4  clear;
5  close;
6  p=4//Number of poles
7  n=1000//Speed of d.c. machine(in r.p.m)
8  V=400//Voltage of d.cmachine(in volts)
9  B=0.04//Flux per pole(in weber)
10 s_1=41//Slot 1
11 s_2=45//Slot 2
12 s_3=51//Slot 3
13 a=2//Number of parallel paths
14 Z=(V*60*a)/(B*n*p)
15 Z_c=Z/a
16 Y=(s_3+1)/(p/2)
17 t=3//turns per coil
18 c=t*a
19 z=s_3*c
20 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

```
1  //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
2  //Exa:7.7
3  clc;
4  clear;
5  close;
6  p=4//Number of poles
7  B=0.04//Flux per pole(in weber)
8  c=740//Number of conductors for lap connection
9  n_1=750//Speed of machine(in r.p.m)
10 n_2=600//Speed of machine(in r.p.m)
11 V=400//Voltage of machine(in volts)
12 a=4//Number of parallel paths for lap winding
13 b=2//Number of parallel paths for wave winding
14 E=(B*c*n_1*p)/(60*a)
15 disp(E,'(a)E.M.F generated at 750r.p.m for lap wound
       (in volts)=')
16 E_1=(B*c*n_2*p)/(60*b)
17 disp(E_1,'(b)E.M.F generated at 600r.p.m for
       wavewound(in volts)=')
18 n=(V*60*b)/(B*c*p)
19 disp(n,'(c)Speed of machine(in r.p.m)=')
```

___

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

```
1  //Caption: Calculate (a)Total armature current (b)
       Current per armature path (c)Generated e.m.f
2  //Exa:7.8
3  clc;
4  clear;
5  close;
6  p=4//Number of poles
7  P=4000//Power of generator(in watts)
8  V=230//Voltage of generator(in volts)
9  r_f=115//Field resistance(in ohms)
10 r_a=0.1//Armature resistance(in ohms)
11 a=p//number of parallel paths
12 i_f=V/r_f
13 i_l=P/V
14 I_a=i_l+i_f
15 disp(I_a,'(a)Armature current(in A)=')
16 i=I_a/p
17 disp(i,'(b)Current per armature path(in A)=')
18 E=V+(I_a*r_a)
19 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

```
1  //Caption:Find the speed at which it will run as a
      motor
2  //Exa:7.9
3  clc;
4  clear;
5  close;
6  P_g=110000//Power of generator(in watts)
7  n=400//Speed of generator(in r.p.m)
8  V=220//Voltage of busbars(in volts)
9  P_m=10900//Power of motor(in watt)
10 r_a=0.025//Armature resistance(in ohms)
11 r_f=55//Field resistance(in ohms)
12 v_b=1//Voltage drop at each brush(in volt)
13 i_l=P_g/V
14 i_f=V/r_f
15 I_a=i_l+i_f
16 V_a=I_a*r_a
17 E=V+V_a+(2*v_b)
18 I_1=P_m/V
19 i_a=I_1-i_f
20 v_a=i_a*r_a
21 E_b=V-(i_a*r_a)-(2*v_b)
22 N_m=(n*E_b)/E
23 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

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```
1  //Caption: Calculate the speed of the motor when it
       is loaded and takes 60A from the mains
2  //Exa:7.10
3  clc;
4  clear;
5  close;
6  V=230//Voltage of motor(in volts)
7  n=800//Speedof motor(in r.p.m)
8  i=5//Current taken by motor(in A)
9  r_a=0.25//Armature resistance(in ohms)
10 r_f=230//field resistance(in ohms)
11 i_l=60//Load current(in A)
12 i_f=V/r_f
13 i_a=i-i_f
14 E_b1=V-(i_a*r_a)
15 i_al=i_l-i_f
16 E_b2=V-(i_al*r_a)
17 N=(n*E_b2)/E_b1
18 disp(N,'Required speed of motor(in r.p.m) is=')
```

Scilab code Exa 7.11 Calculate Power and torque developed

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

```
10  i_a=50//Armature current(in A)
11  B=0.3//Average flux density(in weber/m^2)
12  n=1000//Speedofmotor(in r.p.m)
13  T=(B*(l/100)*(i_a/p)*c*(d/100)*(1/2))
14  s=(2*%pi*n)/(60)
15  P=(T*s)/1000
16  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

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

Scilab code Exa 7.13 Find the time of Commutation

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

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

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

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

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

```
11  g=0.01//Interpolar airgap(in m)
12  a=p//LAP connection
13  I_a=P/V
14  F_a=(z*I_a)/(2*a*p)
15  A=(B*g)/(4*%pi*(10^(-7)))
16  A_t=A+F_a
17  T=A_t/I_a
18  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

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

Scilab code Exa 8.3 Find the resistance required

```
1  //Caption: Find the resistance required
2  //Exa:8.3
3  clc;
4  clear;
5  close;
6  I_1=40//Current taken by series motor(in A)
7  V=500//Supplied voltage(in volts)
8  n_1=100//Initial speed(in%)
9  n_2=80//final speed(in%)
10 I_2=sqrt(((I_1^2)*(n_2^2))/(n_1^2))
11 a=(I_1*(n_1/100))/(I_2*(n_2/100))
12 R=((a*V)-V)/(a*I_2)
13 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

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

```
4 clear;
5 close;
6 V=250//Voltage of motor(in volts)
7 R_a=0.5//Armature resistance(in ohms)
8 n=400//Speed of motor at full load(in r.p.m)
9 i=30//Current taken by motor(in A)
10 R=1//Series resistance with armature(in ohms)
11 E_b1=V-(i*R_a)
12 E_b2=V-((R_a+R)*i)
13 N=n*(E_b2/E_b1)
14 disp(N,'(a)Speed at full load torque(in r.p.m)=')
15 I=2*i
16 E_b=V-(I*(R+R_a))
17 N_1=n*(E_b/E_b1)
18 disp(N_1,'(b)Speed at double full load torque(in r.p
      .m)=')
19 I_ft=V/(R+R_a)
20 T_stalling=I_ft/i
21 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

```
1 //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
2 //Exa:8.6
3 clc;
```

```
 4  clear ;
 5  close ;
 6  V=230// Voltage of generator (in volts )
 7  I=150// Full load current (in A)
 8  R_a=0.1// Armature resistance (in ohms )
 9  R_f=230// Field resistance (in ohms )
10  P_s=1500// Stray losses (in watt )
11  I_f=V/R_f
12  I_a=I_f+I
13  W_ac=(I_a^2)*R_a
14  W_fc=(I_f^2)*R_f
15  P_c=W_fc+P_s
16  L_t=W_ac+P_c
17  P_o=V*I
18  P_i=P_o+L_t
19  disp(P_i,'(a)Input to generator from prime mover on
        full load (in watt )=')
20  Eff=(P_o/P_i)*100
21  disp(Eff,'(b)Efficiency on full load (in %)=')
22  I_l=sqrt(P_c/R_a)
23  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

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

```
4 clear;
5 close;
6 V=230//Voltage of motor(in volts)
7 i_l=50//Full load current(in A)
8 r_a=0.25//Armature resistance(in ohms)
9 r_f=230//Field resistance(in ohms)
10 i_o=3//No load current(in A)
11 i_1=40//Input current(in A)
12 i_2=25//Input current(in A)
13 P_c=V*i_o
14 P_i1=V*i_l
15 i_f=V/r_f
16 i_a1=i_l-i_f
17 L_fl=((i_a1^2)*r_a)+P_c
18 Eff_1=((P_i1-L_fl)/P_i1)*100
19 disp(Eff_1,'(a)Efficiency on full load(in%)=')
20 P_i2=V*i_1
21 i_a2=i_1-i_f
22 L=((i_a2^2)*r_a)+P_c
23 Eff_2=((P_i2-L)/P_i2)*100
24 disp(Eff_2,'(b)Efficiency on 40A input(in%)=')
25 P_i3=V*i_2
26 i_a3=i_2-i_f
27 L_1=((i_a3^2*r_a)+P_c)
28 Eff_3=((P_i3-L_1)/P_i3)*100
29 disp(Eff_3,'(c)Efficiency on 25A input(in%)=')
30 I_ao=i_o-i_f
31 E_bo=V-(I_ao*r_a)
32 E_bl=V-(r_a*i_a1)
33 Re=((E_bo-E_bl)/E_bo)*100
34 disp(Re,'(d)Full load speed regulation(in%)=')
```

Scilab code Exa 8.10 Calculate efficiency of motor and generator

```
1 //Caption: Calculate efficiency of (a)motor and (b)
      generator
2 //Exa:8.10
3 clc;
4 clear;
5 close;
6 V=230//Line voltage for both shunt machines(in volts
      )
7 I=70//Line current excluding field currents of both
      machines(in A)
8 i_a=400//Armature current(in A)
9 i_f1=4//Field current of first machine(in A)
10 i_f2=3//Field current of second machine(in A)
11 r_a=0.03//Resistance of armature of each mchine(in
      ohms)
12 P_acm=(i_a^2)*r_a
13 P_i=V*I
14 I_g=i_a-I
15 P_acg=(I_g^2)*r_a
16 P_f=(P_i-P_acm-P_acg)/2
17 P_m=(V*i_a)+(V*i_f2)
18 P_fc=V*i_f2
19 L_t=P_fc+P_acm+P_f
20 P_o=P_m-L_t
21 n_m=(P_o/P_m)*100
22 disp(n_m,'(a)Efficiency of motor(in%)=')
23 P_og=V*I_g
24 P_fcu=V*i_f1
25 L_t1=P_f+P_fcu+P_acg
26 P_ig=P_og+L_t1
27 n_g=(P_og/P_ig)*100
28 disp(n_g,'(b)Efficiency of generator(in%)=')
```

Scilab code Exa 8.11 Calculate efficiency of motor

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

Scilab code Exa 8.12 Find efficiency of motor

```
1  //Caption:Find efficiency of motor
2  //Exa:8.12
3  clc;
4  clear;
5  close;
```

```
 6  V =500// Voltage  of  shunt  motor ( in  volts )
 7  I =10// Current  taken  by  motor  on  no  load ( inA )
 8  I_f =3// Field  Current ( inA )
 9  r_a =0.1// Armature  resistance ( in  ohms )
10  P_i =100000// Input  power  to  motor ( in  watt )
11  P_nl = V * I
12  I_ao = I - I_f
13  P_acn =( I_ao ^2) * r_a
14  P_fcn = I_f * V
15  P_c =( P_nl ) - P_acn - P_fcn
16  I_l = P_i / V
17  I_al = I_l - I_f
18  P_acl =( I_al ^2) * r_a
19  P_fcl = V * I_f
20  L_t = P_acl + P_fcl + P_c
21  Eff =(( P_i - L_t ) / P_i ) *100
22  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

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

```
      *(10^(-3)))
19  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

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

```
22  R_4=R_3/g
23  r3=R_3-R_4
24  R_5=R_4/g
25  r4=R_4-R_5
26  R_6=R_5/g
27  r5=R_5-R_6
28  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

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

Scilab code Exa 11.2 Find Speed of motor And Percentage Slip

```
1  //Caption: Find (a)Speed of motor (b)%Slip
2  //Exa:11.2
3  clc;
4  clear;
5  close;
6  p=6//Number of poles
7  f_s=50//Stator frequency(in c/s)
8  f_r=2//Rotor frequency(in c/s)
9  n_s=(120*f_s)/p
10 n=(f_r*120)/p
11 s=n_s-n
12 disp(s,'(a)Speed of motor(in r.p.m)=')
13 S=(n/n_s)*100
14 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

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

```
 3 clc;
 4 clear;
 5 close;
 6 n=970//Speed of induction motor(in r.p.m)
 7 f=50//Frequency(in hertz)
 8 n_s=1000//Synchronous speed(in r.p.m)
 9 p=(f*120)/n_s
10 disp(p,'(a)Number of poles=')
11 s=((n_s-n)/n_s)*100
12 disp(s,'(b)Slip(in%)=')
13 S=((s/100)*2)*100
14 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

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

```
13  R_r=0.1//Resistance of rotor per phase(in ohms)
14  X_r=0.8//Reactance of rotor per phase at standstill(
        in ohms)
15  r_r=R_r*(t^2)//Rotor resistance referred to stator(
        in ohms)
16  x_r=X_r*(t^2)//Reactance of rotor at stanstill
        referred to stator(in ohms)
17  E=V/(sqrt(3))
18  P=((s/100)*(E^2)*r_r)/((r_r^2)+((s/100)^2)*(x_r^2))
19  T=(3*P)/(2*(%pi)*(n_s/60))
20  P_M=(3*P*sp)/n_s
21  disp(P_M,'(a)Mechanical power output(in watt)=')
22  disp(T,'(b)Torque(in N-m)=')
23  s_m=R_r/X_r
24  N=n_s*(1-s_m)
25  P_1=((s_m)*(E^2)*(r_r))/((r_r^2)+((s_m^2)*(x_r^2)))
26  T_m=(3*P_1)/(2*(%pi)*(n_s/60))
27  disp(T_m,'(c)Maximum torque(in N-m)=')
28  disp(N,'(d)Speed at maximum torque(in r.p.m)=')
29  P_o=(3*P_1*N)/n_s
30  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

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

```
 4 clear;
 5 close;
 6 V=3300//Voltage supplied to induction motor(in volts
     )
 7 p=10//Number of poles
 8 f=50//frequency(in hertz)
 9 R_r=0.015//Rotor resistance per phase(in ohms)
10 X_r=0.25//Standstill reactance per phase(in ohms)
11 s=2.5//Slip(in %)
12 n_s=(f*120)/p
13 n=n_s*(1-(s/100))
14 disp(n,'(a)Speed of the motor(in r.p.m)=')
15 S=R_r/X_r
16 N=n_s*(1-S)
17 disp(N,'(b)Speed at which torque will be maximum(in
     r.p.m)=')
18 T_f=(s/100)*R_r/((R_r^2)+(((s/100)^2)*(X_r^2)))
19 T_m=S*R_r/((R_r^2)+((S^2)*(X_r^2)))
20 R=T_m/T_f
21 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

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

```
7   f=50//Frequency(in hertz)
8   V=440//Supplied voltage to induction motor(in volts)
9   R_r=0.1//Rotor resistance per phase(in ohm)
10  X_r=0.8//Rotor reactance at standstill per phase(in
         ohm)
11  t=1.3//Ratio of stator turns per phase to rotor
         turns per phase
12  a=R_r/X_r
13  s=(-(a^2))+sqrt(1+(a^2))
14  n_s=120*f/p
15  N=n_s*(1-s)
16  disp(N,'(a)Required speed(in r.p.m)=')
17  r=R_r*t
18  x=X_r*t
19  E=V/sqrt(3)
20  P_m=(3*s*(E^2)*r*(1-s))/((r^2)+((s^2)+(x^2)))
21  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

```
1  //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
2  //Exa:11.7
3  clc;
4  clear;
```

```
5 close;
6 V=69.28//Induced e.m.f(in volts)
7 r=0.9//Resistance of rotor per phase(in ohm)
8 x=6//Standstill rectance of rotor per phase(in ohm)
9 z=4.1+(%i*2)
10 s=3//Slip(in%)
11 V_r=V/sqrt(3)
12 R_r=r+real(z)
13 X_r=(%i*2)+(%i*x)
14 Z=R_r+X_r
15 I_r=V_r/Z
16 disp(I_r,'(a)Current when rotor is at standstill=')
17 E=(s/100)*V_r
18 Imp=r+(%i*(s/100)*x)
19 i_r=E/Imp
20 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

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

```
11  S_r =1 -(.5*(S/100))
12  T=(S_r*R_r)/((R_r^2)+((S_r^2)*(X_r^2)))
13  Re =(1-sqrt(T_f/T))*100
14  disp(Re,'(a)% reduction in stator voltage(in %)=')
15  pf=R_r/(sqrt((R_r^2)+((S_r^2)*(X_r^2))))
16  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

```
1  //Caption:Find (a)the rotor copper loss per phase if
       motor is running at slip of 4% (b)Mechanical
     power developed
2  //Exa:11.9
3  clc;
4  clear;
5  close;
6  P_i =100000//Input power(in watt)
7  P_sc =2000//Stator copper loss(in watt)
8  s=4//slip(in %)
9  P_r=P_i-P_sc
10 P_rc =((s/100)*P_r)/3
11 disp(P_rc,'(a)Rotor copper lossper phase(in watt)=')
12 P_m=P_r-(P_rc*3)
13 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

```scilab
1  //Caption: Calculate (a)% slip (b)Rotor copper loss
       (c)Output from the rotor (d)Efficiency
2  //Exa:11.10
3  clc;
4  clear;
5  close;
6  V=440//Supplied voltage(in volts)
7  f=50//frequency(in hertz)
8  p=6//Number of poles
9  n=960//Speed of motor(in r.p.m)
10 P_i=50000//Input power(in watt)
11 P_wf=1800//Winding and friction losses(in watt)
12 P_s=1200//Stator losses(in watt)
13 n_s=(120*f)/p
14 S=((n_s-n)/n_s)*100
15 disp(S,'(a)% slip=')
16 P_r=P_i-P_s
17 P_rc=(S/100)*P_r
18 disp(P_rc,'(b)Rotor copper loss(in watt)=')
19 P_o=P_r-P_rc-P_wf
20 disp(P_o,'(c)Output of rotor(in watt)=')
21 eff=(P_o/P_i)*100
22 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

```
1  // 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
2  // Exa : 11.11
3  clc ;
4  clear ;
5  close ;
6  V =440 // Voltage supplied ( in volts )
7  p =8 // Number of poles
8  f =50 // Frequency ( in hertz )
9  r1 =0.2 // Stator resistance ( in ohm )
10 x1 =1.2 // Stator reactance ( in ohm )
11 r2 =0.3 // Equivalent resistance of rotor referred to
      stator ( in ohm )
12 x2 =1.2 // Equivalent reactance of rotor referred to
      stator ( in ohm )
13 r_m =150 // Magnetising resistance ( in ohms )
14 x_m =18 // Magnetising reactance ( in ohms )
15 P_wf =750 // Winding and friction losses ( in watt )
16 s =0.04 // Slip
17 n_s =( f *120) /( p *60)
18 y1 =1/ r_m
19 y2 =1/( %i * x_m )
```

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```
20  y3 =1/((r2/s)+(%i*x2))
21  Y=y1+y2+y3
22  Z=1/Y
23  Z_t=Z+(r1+(%i*x1))
24  E=V*Z/(Z_t)
25  z3=1/y3
26  i2=E/z3
27  disp(i2,'(a)Rotor current per phase(in A)=')
28  i1=V/Z_t
29  disp(i1,'(b)Stator current per phase(in A)=')
30  pf=cosd(atand(-(imag(Z_t))/real(Z_t)))
31  disp(pf,'(c)Power factor=')
32  P_r=(i2*(conj(i2)))*(r2/s)
33  disp(P_r,'(d)Rotor input(in watt)=')
34  P_rc=(i2*(conj(i2)))*r2
35  disp(P_rc,'(e)Rotor copper loss(in watt)=')
36  T=3*P_r/(2*%pi*n_s)
37  disp(T,'(f)Torque(in N-m)=')
38  P_me=P_r-P_rc-(P_wf/3)
39  disp(P_me,'(g)Mechanical output from rotor(in watts
        per phase)=')
40  P_st=V*(sqrt(i1*(conj(i1))))*pf
41  disp(P_st,'(h)Stator input(watts per phase)=')
42  eff=(P_me/P_st)*100
43  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

```scilab
1  //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
2  //Exa:11.12
3  clc;
4  clear;
5  close;
6  V=440//Voltage supplied(in volts)
7  p=8//Number of poles
8  f=50//Frequency(in hertz)
9  r1=0.2//Stator resistance(in ohm)
10 x1=1.2//Stator reactance(in ohm)
11 r2=0.3//Equivalent resistance of rotor referred to
       stator(in ohm)
12 x2=1.2//Equivalent reactance of rotor referred to
       stator(in ohm)
13 r_m=150//Magnetising resistance(in ohms)
14 x_m=18//Magnetising reactance(in ohms)
15 P_wf=750//Winding and friction losses(in watt)
16 s=0.04//Slip
17 I2=V/((r1+(r2/s))+(%i*x1)+(%i*x2))
18 disp(I2,'(a)Equivalent rotor current per phase(in A)
       =')
19 y1=1/r_m
20 y2=1/(%i*x_m)
21 I_o=V*(y1+y2)
22 I_1=I2+I_o
23 disp(I_1,'(b)Stator current per phase(in A)=')
24 pf=cosd(atand(imag(I_1)/real(I_1)))
25 disp(pf,'(c)Power factor=')
26 P_r=(I2*conj(I2))*(r2/s)
27 disp(P_r,'(d)Rotor input(in watt)=')
28 P_rc=(I2*conj(I2))*r2
29 disp(P_rc,'(e)Rotor copper losses(in watts)=')
30 T=P_r/(2*%pi*((f*120)/(p*60)))
```

```
31  disp(T,'(f)Torque(in N-m)=')
32  P_me=P_r-P_rc-(P_wf/3)
33  disp(P_me,'(g)Mechanical power output from rotor(in
        watts per phase)=')
34  P_si=V*pf*(sqrt(I_1*conj(I_1)))
35  disp(P_si,'(h)Stator input(in watts per phase)=')
36  e=(P_me/P_si)*100
37  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

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

```
17  E=(V/sqrt(3))-(I1*Z_s)
18  I2=E/Z
19  disp(I2,'(a)Equivalent Rotor current(in A)=')
20  disp(I1,'(b)Stator current(in A)=')
21  pf=cosd(atand(imag(Zt)/real(Zt)))
22  disp(pf,'(c)Power factor=')
23  P_s=sqrt(3)*V*sqrt(I1*conj(I1))*pf
24  disp(P_s,'(d)Stator input(in watt)=')
25  P_r=3*(I2*conj(I2))*(real(Z_r)/s)
26  disp(P_r,'(e)Rotor input(in watt)=')
27  P_ro=P_r*(1-s)
28  P_me=P_ro-P_wf
29  e=(P_me/P_s)*100
30  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

```
1  //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
2  //Exa:12.1
3  clc;
4  clear;
5  close;
6  P=3000//Power of motor(in watt)
7  V=415//Voltage supplied(in volts)
8  f=50//Frequency(in hertz)
9  p=6//Number of poles
10 pf=0.8//Power factor
11 I_n=3.5//No load current(in A)
```

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

Scilab code Exa 12.2 Find Starting current And Starting torque

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

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

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

```
1  //Caption:Find starting current in terms of full
       load current
2  //Exa:12.5
3  clc;
4  clear;
5  close;
6  s=0.04//Slip
7  a=1//Starting torque T_st/Full load torque(T_fl) are
       equal
8  I_s=sqrt(a/s)
9  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

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

Scilab code Exa 12.8 Find the Percentage tappings required

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

Scilab code Exa 12.9 Find the line current at start

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

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

Scilab code Exa 12.11 Calculate external resistance per phase

```
 1  // Caption : Calculate  external  resistance  per  phase
 2  // Exa :12.11
 3  clc ;
 4  clear ;
 5  close ;
 6  p=6// Number  of  poles
 7  f =50// Frequency (in  hertz )
 8  r =0.25// Resistance  per  phase (in  ohms)
 9  n_1 =965// Speed  on  full  load (in  r.p.m)
10  n_2 =800// Reduced  speed (in  r.p.m)
11  n_s =(120*f)/p
12  s_1 =(n_s -n_1)/n_s
13  s_2 =(n_s -n_2)/n_s
14  R=((s_2*r)/s_1)-r
15  disp (R, 'Required  external  resistance  per  phase (in
        ohms )=')
```

Scilab code Exa 12.12 Find the dimensions of D and L

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

Chapter 13

Synchronous Machines

Scilab code Exa 13.1 Find the frequency of voltage generated

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

Scilab code Exa 13.2 Find Speed And number of poles

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

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

Scilab code Exa 13.3 Find distribution factor of winding

```
1  //Caption:Find distribution factor of winding
2  //Exa:13.3
3  clc;
4  clear;
5  close;
6  ns=18//Number of slots
7  ph=3//Number of phases
8  p=2//Number of poles
9  m=ns/(ph*p)
10 P_p=ns/p
11 theta=180/P_p
12 k_b=sind(m*(theta/2))/(m*sind(theta/2))
13 disp(k_b,'Distribution factor=')
```

Scilab code Exa 13.4 Find coil span factor

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

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

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

```
10 B=0.04//Flux per pole(in wb)
11 n=375//Speed of alternator(in r.p.m)
12 C_s=160//Coil Span(in degrees)
13 f=(p*n)/120
14 disp(f,'(a)Frequency(in hertz)=')
15 ct=(sl*cs)/2
16 nt=ct/ph
17 m=sl/(p*ph)
18 P_p=sl/p
19 theta=180/P_p
20 k_b=sind(m*(theta/2))/(m*sind(theta/2))
21 k_p=cosd(theta/2)
22 E_ph=4.44*B*f*nt*k_b*k_p
23 disp(E_ph,'(b)Phase e.m.f(in volts)=')
24 E_l=sqrt(3)*E_ph
25 disp(E_l,'(c)Line e.m.f(in volts)=')
```

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

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

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

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

```
1 //Caption:Calculate synchronous reactance and
      synchronous impedance per phase
2 //Exa:13.12
3 clc;
4 clear;
5 close;
6 V=3300//Voltage of alternator(in volts)
7 f=50//Frequency(in hertz)
8 r=0.4//Effective resistance per phase(in ohm)
9 I_f=20//Field current(in ohms)
10 I_fl=300//Full load current(in A)
11 e=1905//Voltage induced on open circuit(in volts)
12 Zs=e/I_fl
13 Xs=sqrt((Zs^2)-(r^2))
14 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

```
1  //Caption:Estimate terminal voltage for (a)same
       excitation (b)Load current at 0.8 power factor
       lagging
2  //Exa:13.13
3  clc;
4  clear;
5  close;
6  P=1000//Power of alternator(in KVA)
7  V=3300//Voltage of alternator(in volts)
8  ph=3//Phase of alternator
9  pf=0.8//Power factor lagging
10 r=0.5//Resistance per phase(in ohms)
11 x=6.5//Reactance per phase(in ohms)
12 V_ph=V/sqrt(3)
13 I=(P*1000)/(sqrt(3)*V)
14 Eo=sqrt(((V_ph+(I*r*pf)+(I*x*sind(acosd(pf))))^2)
       +(((I*x*pf)-(I*r*sind(acosd(pf))))^2))
15 disp(Eo,'(a)Required terminal voltage(in volts)=')
16 v=sqrt((Eo^2)-(((I*r*sind(acosd(pf)))+(I*x*pf))^2))
       +((I*x*sind(acosd(pf)))-(I*r*pf))
17 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

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

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

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

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Scilab code Exa 14.3 Find Regulation and resultant excitation

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

Scilab code Exa 14.5 Find the regulation of the machine

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

```scilab
2 //Exa:14.5
3 clc;
4 clear;
5 close;
6 Vf=400//Full load voltage(in volts)
7 Vr=480//No load voltage(in volts)
8 Re=(Vr-Vf)*100/Vf
9 disp(Re,'Regulation of the machine(in %)=')
```

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

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

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

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

```
1   //Caption:Find (a)Armature current of second machine
        (b)Power factor of ecach machine
2   //Exa:14.9
3   clc;
4   clear;
5   close;
6   L=1000//Total load(in KW)
7   V=6600//Total voltage(in volts)
8   pf=0.8//Power factor
9   Ia=50//Armature current(in A)
10  L1=L/2
11  Ia1=(L1*1000)/(sqrt(3)*V)
12  pf1=Ia1/Ia
13  a1=acosd(pf1)
14  b=tand(a1)
15  P1=L1*b
16  Pl=L*tand(acosd(pf))
17  P2=P1-Pl
18  pf2=cosd(atand(P2/L1))
19  Ia2=Ia1/pf2
20  disp(Ia2,'(a)Armature current of second machine(in A
```

```
   )=')
21 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

```
 1 //Caption:Find (a)Load supplied by second machine
      and its power factor (b)Power factor of total
      load
 2 //Exa:14.10
 3 clc;
 4 clear;
 5 close;
 6 P1=300//Lighting load(in KW)
 7 P2=500//Industrial load(in KW)
 8 P3=200//Industrial load(in KW)
 9 P4=100//Load(in KW)
10 Pa=500//Power supplied by first machine(in KW)
11 pf1=0.8
12 pf2=0.707
13 pf3=0.9
14 pfa=0.8
15 La=P1+P2+P3+P4
16 Lr=(P2*tand(acosd(pf1)))+(P3*tand(acosd(pf2)))+(P4*
      tand(acosd(pf3)))
17 Pb=La-Pa
18 Prl=Pa*(tand(acosd(pfa)))
19 Pc=Lr-Prl
20 pfb=cosd(atand(Pc/Pb))
21 pfl=cosd(atand(Lr/La))
22 disp(pfb,Pb,'(a)Load supplied by second machine(in
```

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

Chapter 15

Synchronous Motors

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

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

```
21  disp ( pfm , ' ( b ) Power  f a c t o r = ' )
```

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

```
 1  // Caption : ( a ) How  much  KVA  should  be  supplied  by
        synchronous  motor  ( b ) Power  factor  of  synchronous
        motor
 2  // Exa : 1 5 . 7
 3  clc ;
 4  clear ;
 5  close ;
 6  Pm =40 // Power  absorb  by  motor ( in  Kw)
 7  Pl =300 // Load  connected  in  parallel  with  motor ( in  KW)
 8  pfm =0.85 // Power  factor  of  motor
 9  pfl =0.9 // Power  factor  on  load
10  Pt = Pl + Pm
11  Pr = Pt * tand ( acosd ( pfl ) )
12  Pri = Pl * tand ( acosd ( pfm ) )
13  Ps = Pri - Pr
14  pf = cosd ( atand ( Ps / Pm ) )
15  disp ( Ps , ' ( a ) Power  supplied  by  synchronous  motor ( in
        KVA)= ' )
16  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

```
1  //Caption: (a)Power alternator can supply (b)Power
       factor of synchronous motor (c)Load taken by
       motor
2  //Exa:15.8
3  clc;
4  clear;
5  close;
6  P=500//Load supplied by alternator(inKW)
7  pf=0.8//Power factor
8  e=0.9
9  L=P/pf
10 Ps=L-P
11 disp(Ps,'(a)Power alternator can supply(in KW)=')
12 Pr=P*tand(acosd(pf))
13 pfm=cosd(atand(Pr/Ps))
14 disp(pfm,'(b)Power factor of synchronous motor=')
15 l=Ps*e
16 disp(l,'(c)Load taken by motor(in Kw)=')
```

Scilab code Exa 15.9 Find efficiency of machine

```
1  //Caption:Find efficiency of machine
2  //Exa:15.9
3  clc;
4  clear;
5  close;
6  P=50000//Power of alternator(in KVA)
7  V=11//Voltage of alternator(in Kv)
```

```
8  pf=0.8//Power factor
9  r=0.01//Resistance of stator winding per phase(in
      ohms)
10 Wc=150//Copper loss(in KW)
11 Wf=100//Friction loss(in KW)
12 Ww=250//Winding loss(in KW)
13 Wco=200//Core loss(in KW)
14 We=15//Excitor loss(in KW)
15 Is=(P*1000)/(sqrt(3)*V*1000)
16 Ps=(Is^2)*3*(r/1000)
17 Ws=(0.5*Ps)
18 Lt=Ps+Ws+Wc+Wf+Ww+Wco+We
19 Po=P*pf
20 Pi=Po+Lt
21 e=Po*100/Pi
22 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

```
 1 //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
 2 //Exa:16.1
 3 clc;
 4 clear;
 5 close;
 6 Pi=750//Power of Single phase induction motor(in
     Watts)
 7 p=4//Number of poles
 8 f=50//Frequency(in hertz)
 9 V=230//Voltage supplied to motor(in volts)
10 R1=2//Resistance of stator(in ohm)
11 X1=2.6//Reactance of stator(in ohm)
12 Wf=25//Friction and winding loss(in Watts)
13 R2=3.8//Resistance of rotor(in ohm)
14 X2=2.6//Reactance of rotor(in ohm)
15 Xm=56//Magnetising Reactance(in ohms)
```

```scilab
16  r2=1.9//Imaginary resistance of rotor(in ohm)
17  x2=1.3//Imaginary reactance of rotor(in ohm)
18  xm=28//Imaginary magnetising reactance(in ohm)
19  s=0.05//Slip
20  Z1=R1+(%i*X1)
21  Z2=((%i*xm)*((r2/s)+(%i*x2)))/((r2/s)+(%i*(x2+xm)))
22  Z3=((%i*xm)*((r2/(2-s))+(%i*x2)))/((r2/(2-s))+(%i*(
        x2+xm)))
23  Z=Z1+Z2+Z3
24  I=V/Z
25  disp(I,'(a)Input Current(in A)=')
26  pf=cosd(atand(imag(Z)/real(Z)))
27  disp(pf,'(b)Power factor=')
28  Wp=V*pf*sqrt(I*conj(I))
29  disp(Wp,'(c)Input power(in watts)=')
30  z2=sqrt(((r2/s)^2)+((x2)^2))
31  v2=sqrt(I*conj(I))*sqrt(Z2*conj(Z2))
32  i2=v2/z2
33  z3=sqrt(((r2/(2-s))^2)+((x2)^2))
34  v3=sqrt(I*conj(I))*sqrt(Z3*conj(Z3))
35  i3=v3/z3
36  Tf=((i2)^2)*(r2/s)
37  disp(Tf,'(d)Torque due to forward field(in Nm)=')
38  Tb=(i3^2)*(r2)/(2-s)
39  disp(Tb,'(e)Torque due to backward field(in Nm)=')
40  T=Tf-Tb
41  disp(T,'(f)Torque(in Nm)=')
42  Wo=(T*(1-s))-Wf
43  disp(Wo,'(g)Output(in Watts)=')
44  e=(Wo/Wp)*100
45  disp(e,'(h)Efficiency(in %)=')
```

Scilab code Exa 16.2 Find equivalent circuit resistance

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

Chapter 17

AC Commutator Motors

Scilab code Exa 17.1 Find Speed And Power factor of motor

```scilab
1  //Caption:Find (a)Speed (b)Power factor of motor
2  //Exa:17.1
3  clc;
4  clear;
5  close;
6  r=25//Resistance of motor(in ohms)
7  P=2//Number of poles
8  l=0.4//Inductance of motor(in henry)
9  n=1800//Speed of motor(in r.p.m)
10 V=230//Voltage supplied(in volts)
11 Il=1//Load current(in A)
12 f=50//Frequency(in hertz)
13 fr=(P*n)/120
14 Eb=V-(r*Il)
15 Er=Eb/fr
16 fac=(sqrt((V^2)-((Il*2*(%pi)*f*l)^2))-(Il*r))/Er
17 n=fac*(120/P)
18 disp(n,'(a)Speed(in rpm)=')
19 pf=sqrt((V^2)-((Il*2*(%pi)*f*l)^2))/V
20 disp(pf,'(b)Power factor=')
```