# Scilab Textbook Companion for
# Electric Machines - I
# by M. Verma And V. Ahuja[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.

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# Chapter 1

# Introduction To Electrical Machines

**Scilab code Exa 1.9** Find the emf induced in the coil

```scilab
1  //Chapter:1:Introduction to electrical Machines
2  //Caption:Find the emf induced in the coil
3  //Exa:1.9
4  clc;
5  clear;
6  close;
7  N=800;//No.of turns
8  Phy_1=2000*10^-6;//In Webers
9  Phy_2=1000*10^-6;//In Webers
10 t=0.1;//in seconds
11 e=N*(Phy_1-Phy_2)/t;
12 disp(e,'Emf induced in the coil (in volts)=')
```

**Scilab code Exa 1.10** Find the average value of emf induced in the coil

```
1 //Caption:Find the average value of emf induced in
      the coil
2 //Exa:1.10
3 clc;
4 clear;
5 close;
6 N=1000;//No.of turns
7 Phy_1=2000*10^-6;//In Webers
8 //On reversal of current
9 Phy_2=2000*10^-6;//In Webers
10 t=0.2;//in seconds
11 e=N*(Phy_1-(-Phy_2))/t;
12 disp(e,'Average value of emf induced in the coil (in
       volts)=')
```

**Scilab code Exa 1.11** Find the average emf induced in the coil and current through the coil

```
1 //Caption:Find the (1)average emf induced in the
      coil (2)current through the coil
2 //Exa:1.11
3 clc;
```

```
 4 clear;
 5 close;
 6 N=300;//No.of turns
 7 R=60;//resitance in ohms
 8 Phy_1=2*10^-3;//In Webers
 9 Phy_2=3*10^-3;//In Webers
10 t=0.2;//in seconds
11 e=N*(Phy_2-Phy_1)/t;
12 disp(e,'(1) Average emf induced in the coil (in
       volts)=');
13 i=e/R;
14 disp(i,'(2) Current through the coil (in Amperes)=')
```

**Scilab code Exa 1.12** Find the average value of emf induced across the feild terminals

```
 1 //Caption:Find the average value of emf induced
       across the feild terminals
 2 //Exa:1.12
 3 clc;
 4 clear;
 5 close;
 6 P=4;//no of poles
 7 N=4*250;//No.of turns
 8 Phy_1=40*P*10^-3;//In Webers
 9 Phy_2=5*P*10^-3;//In Webers
10 t=0.1;//in seconds
11 e=N*(Phy_1-Phy_2)/t;
12 disp(e,'average value of emf induced across the
       feild terminals (in volts)=')
```

# Chapter 2

# DC Machines

**Scilab code Exa 2.1** Find current delievered by each machine and terminal voltage

```
1  //Caption:Find (a)current delievered by each machine
        and (b)terminal voltage
2  //Exa:2.1
3  clc;
4  clear;
5  close;
6  //for 50kw generator
7  I_1=50*1000/500;//full load current in ampere
8  V_1=0.06*500;//full load voltage drop in volts
9  V_1pi=V_1/I_1;//voltage drop per ampere of current
        supply in volts/ampere
10 //for 100kw generator
11 I_2=100*1000/500;//full load current in ampere
12 V_2=0.04*500;//full load voltage drop in volts
13 V_2pi=V_2/I_2;//voltage drop per ampere of current
        supply in volts/ampere
14 i_1=250/(1+(V_1pi/V_2pi));//in amperes
15 i_2=250/(1+(V_2pi/V_1pi));//in amperes
16 disp(i_1,'(a) Current delievered in 50kw generator (
        in amperes)=');
```

```
17  disp(i_2,'      Current delievered in 100kw generator
       (in amperes)=');
18  V_t=500-V_1pi*i_1;//in volts
19  disp(V_t,'(b) Terminal voltage (in volts)=')
```

**Scilab code Exa 2.2** Find the load shared by two DC generators

```
1  //Caption:Find the load shared by two DC generators
2  //Exa:2.2
3  clc;
4  clear;
5  close;
6  E_g1=120;//in volts
7  E_g2=115;//in volts
8  R_a1=0.05;//armature winding resistance of first
       generator (in ohms)
9  R_a2=0.04;//armature winding resistance of second
       generator (in ohms)
10 R_f1=20;//feild winding resistance of first
       generator (in ohms)
11 R_f2=25;//feild winding resistance of seccond
       generator (in ohms)
12 P=25000;//in watts
13 V_t=(5275+sqrt((5275^2)-(4*45.09*25000)))/(2*45.09);
       //terminal voltage in volts
14 I_1=(E_g1-(V_t*(1+(R_a1/R_f1))))/R_a1;//in amperes
15 I_2=(E_g2-(V_t*(1+(R_a2/R_f2))))/R_a2;//in amperes
16 P_1=V_t*I_1/1000;//in kilo watts
17 P_2=V_t*I_2/1000;//in kilo watts
18 disp(P_1,'Power shared by generator -1(in Kilo Watts)
       = ');
```

```
19 disp (P_2 , 'Power  shared  by  generator −2( in  Kilo  Watts )
        = ') ;
```

**Scilab code Exa 2.3** Find the number of conductors

```
1 // Caption : Find  the  number  of  conductors
2 // Exa : 2 . 3
3 clc ;
4 clear ;
5 close ;
6 P =8; //no .  of  poles
7 A =8;
8 Phy =40*10^ -3; // flux  in  weber
9 N =500; // speed  in  rpm
10 E_g =250; //no−load  voltage  in  volts
11 Z =( E_g *60* A ) /( P * N * Phy ) ;
12 disp (Z , 'Number  of  conductors=')
```

**Scilab code Exa 2.4** Find the generated voltage and armature current

```
1 // Caption : Find  the  generated  voltage  and  armature
        current
2 // Exa : 2 . 4
3 clc ;
4 clear ;
```

```
5  close;
6  V_t=300;//in volts
7  V_b=1;//voltage drop per brush in volts
8  I=200;//in amperes
9  R_f=200;//shunt feild winding resistance in ohms
10 R_a=0.05;//armature winding resistance in ohms
11 R_se=0.04;//Series feild winding resistance in ohms
12 I_f=V_t/R_f;//in amperes
13 I_a=I+I_f;//in amperes
14 E_g=V_t+(R_a+R_se)*I_a+(2*V_b);
15 disp(E_g,'Value of generated voltage (in volts)=');
16 disp(I_a,'Value of armature current (in Ampers)=')
```

**Scilab code Exa 2.5** Find the shunt feild current and armature current and generated emf in armature and load resistance

```
1  //Caption:Find the (a)shunt feild current (b)
      armature current (c)generated emf in armature (d)
      load resistance
2  //Exa:2.5
3  clc;
4  clear;
5  close;
6  V_t=250;//in volts
7  I=195;//in amperes
8  R_f=50;//shunt feild winding resistance in ohms
9  R_a=0.05;//armature winding resistance in ohms
10 I_f=V_t/R_f;//in amperes
11 I_a=I+I_f;//in amperes
12 E_g=V_t+(R_a*I_a);
13 R_L=V_t/I;
```

```
14 disp(I_f,'(a) Value of shunt feild current (in
      Amperes)=')
15 disp(I_a,'(b) Value of armature current (in Amperes)
      =')
16 disp(E_g,'(c) Value of generated voltage (in volts)=
      ');
17 disp(R_L,'(d) Value of load resistance (in ohms)=')
```

**Scilab code Exa 2.6** Find the value of generated emf and armature current

```
1 //Caption:Find the value of generated emf and
      armature current
2 //Exa:2.6
3 clc;
4 clear;
5 close;
6 V_t=250;//in volts
7 V_AC=V_t;
8 V_b=1;//voltage drop per brush in volts
9 I=40;//in amperes
10 R_f=100;//shunt feild winding resistance in ohms
11 R_a=0.05;//armature winding resistance in ohms
12 R_se=0.04;//series feild winding resistance in ohms
13 V_BC=V_AC+I*R_se;//in volts
14 I_f=V_BC/R_f;//in amperes
15 I_a=I+I_f;//in amperes
16 E_g=V_BC+(R_a*I_a)*(2*V_b);
17 disp(I_a,' Value of armature current (in Amperes)=')
      ;
18 disp(E_g,' Value of generated voltage (in volts)=');
```

**Scilab code Exa 2.7** Find the value of generated emf

```
1  //Caption:Find the value of generated emf
2  //Exa:2.7
3  clc;
4  clear;
5  close;
6  P=8;//no. of poles
7  A=8;
8  Z=760;//no.of conductors
9  Phy=35*10^-3;//flux in weber
10 N=500;//speed in rpm
11 E_g=(P*N*Phy*Z)/(60*A);
12 disp(E_g,'Value of generated emf (in volts)=')
```

**Scilab code Exa 2.8** Find the speed of generator

```
1  //Caption:Find the speed of generator
2  //Exa:2.8
3  clc;
4  clear;
5  close;
6  P=8;//no. of poles
7  S=70;//no. of slots
```

```
8  C=22;//conductors per slot
9  A=8;
10 D=0.48;//in meter
11 Z=S*C;//no.of conductors
12 r=0.64;//ratio of pole arc to pole pitch
13 l=0.28;//length of pole shoe in meter
14 B=0.32;//air gap flux density in weber/meter^2
15 E_g=400;//in volts
16 Pole_arc=r*%pi*D/P;//in meter
17 Ao=Pole_arc*l;//Area of pole shoe in meter
18 Phy=Ao*B;//in weber
19 N=E_g*60*A/(Phy*Z*P);
20 disp(N,'Speed of generator (in rpm)=')
```

**Scilab code Exa 2.9** Find the armature current and generated emf and flux per pole

```
1  //Caption:Find the (a)armature current (b)generated
       emf (c)flux/pole
2  //Exa:2.9
3  clc;
4  clear;
5  close;
6  V_t=200;//in volts
7  P=4;//no. of poles
8  A=2;
9  Z=676;//no.of conductors
10 R_L=10;//load resistance in ohms
11 R_a=0.34;//armature winding resistance in ohms
12 R_f=100;//feild winding resistance in ohms
13 N=600;//speed in rpm
```

```
14  I_f=V_t/R_f;//in amperes
15  I=V_t/R_L;//in amperes
16  I_a=I+I_f;
17  E_g=V_t+I_a*R_a;
18  Phy=E_g*60*A/(P*N*Z);
19  disp(I_a,'(a) Armature current (in amperes)=');
20  disp(E_g,'(b) Generated emf (in volts)=');
21  disp(Phy*1000,'(c) flux/pole (in mili weber)=');
```

**Scilab code Exa 2.10** Find the load current and generated emf and flux per pole

```
1  //Caption:Find the (a)load current (b)generated emf
      (c)flux/pole
2  //Exa:2.10
3  clc;
4  clear;
5  close;
6  V_t=250;//in volts
7  P=6;//no. of poles
8  A=P;
9  Z=700;//no.of conductors
10  R_a=0.04;//armature winding resistance in ohms
11  R_f=100;//feild winding resistance in ohms
12  N=1000;//speed in rpm
13  I_f=V_t/R_f;//in amperes
14  I_a=7.2/R_a;//in amperes
15  I=I_a-I_f;//in amperes
16  E_g=V_t+I_a*R_a;
17  Phy=E_g*60*A/(P*N*Z);
18  disp(I,'(a) Load current (in amperes)=');
```

```
19 disp(E_g,'(b) Generated emf (in volts)=');
20 disp(Phy*1000,'(c) flux/pole (in mili weber)=');
```

**Scilab code Exa 2.11** Find the armature current and generated emf and number of conductors of armature

```
1 //Caption:Find the (a)armature current (b)generated
    emf (c) no. of conductors of armature
2 //Exa:2.11
3 clc;
4 clear;
5 close;
6 P_o=22000;//power in watts
7 V_t=220;//in volts
8 V_b=1;//per brush drop in volts
9 P=4;//no. of poles
10 A=2;
11 R_se=0.04;//series resistance in ohms
12 R_a=0.05;//armature winding resistance in ohms
13 R_f=110;//feild winding resistance in ohms
14 Phy=7.8*10^-3;//in weber
15 N=1000;//speed in rpm
16 I=P_o/V_t;//in amperes
17 I_f=V_t/R_f;//in amperes
18 I_a=I+I_f;
19 E_g=V_t+I_a*(R_a+R_se)+2*V_b;
20 Z=E_g*60*A/(Phy*N*P)
21 disp(I_a,'(a) Armature current (in amperes)=');
22 disp(E_g,'(b) Generated emf (in volts)=');
23 disp(Z,'(c) No. of conductors of armature=');
```

**Scilab code Exa 2.12** Find the power absorbed by the load

```scilab
1  //Caption:Find the power absorbed by the load
2  //Exa:2.12
3  clc;
4  clear;
5  close;
6  P=6;//no. of poles
7  A=2;
8  Z=350;//no. of conductors
9  R_a=0.8;//armature winding resistance in ohms
10 R_f=120;//feild winding resistance in ohms
11 Phy=0.02;//in weber
12 N=1000;//speed in rpm
13 R_L=12;//load resistance in ohms
14 E_g=Phy*N*Z*P/(60*A);//emf induced in volts
15 V_t=E_g/(1+((1/R_f)+(1/R_L))*R_a);
16 I_L=V_t/R_L;//in amperes
17 P_o=V_t*I_L;//in watts
18 disp(P_o,'Power absorbed by the load (in watts)=')
```

**Scilab code Exa 2.13** Find the percentage reduction in speed

```scilab
1  //Caption:Find the percentage reduction in speed
```

```scilab
2  //Exa:2.13
3  clc;
4  clear;
5  close;
6  P1=200*10^3;//initial load in watts
7  P2=125*10^3;//final load in watts
8  V_t=250;//in volts
9  V_b=2;//total brush drop in volts
10 P=6;//no. of poles
11 R_a=0.015;//armature winding resistance in ohms
12 I_g1=P1/V_t;//in amperes
13 I_a1=I_g1;//in amperes
14 E_g1=V_t+I_a1*R_a+V_b;//in volts
15 I_g2=P2/V_t;//in amperes
16 I_a2=I_g2;//in amperes
17 E_g2=V_t+I_a2*R_a+V_b;//in volts
18 //since E_g is directly proportional to N
19 //therefore,E_g1/E_g2=N_1/N_2
20 r=E_g2/E_g1;
21 reduction=(1-r)*100;
22 disp(reduction,'Percentage reduction in speed (%)=')
```

**Scilab code Exa 2.14** Find the speed

```scilab
1  //Caption:Find the speed
2  //Exa:2.14
3  clc;
4  clear;
5  close;
6  V_t=400;//in volts
7  V_b=2;//total brush drop in volts
```

```
8  R_a=0.12;//armature winding resistance in ohms
9  N1=1000;//speed in rpm
10 I_a1=150;//in amperes
11 I_a2=100;//in amperes
12 R_L=V_t/I_a1;//load resistance in ohms
13 E_g1=V_t+I_a1*R_a+V_b;//in volts
14 V_to=R_L*I_a2;//in volts
15 E_g2=ceil (V_to+I_a2*R_a+V_b);//in volts
16 //Since E_g is directly proportional to N
17 //therefore,E_g1/E_g2=N1/N2
18 N2= N1*E_g2/E_g1;//in rpm
19 disp(ceil(N2),'Speed (in rpm)=')
```

**Scilab code Exa 2.15** Find the Cu loss and iron and friction loss and torque

```
1  //Caption:Find the (a)Cu-loss (b)iron and friction
        loss (c) torque
2  //Exa:2.15
3  clc;
4  clear;
5  close;
6  P_o=25000;//output power in watts
7  V_t=250;//in volts
8  R_se=0.05;//series resistance in ohms
9  R_a=0.04;//armature winding resistance in ohms
10 R_f=50;//shunt feild winding resistance in ohms
11 Eff=0.89;//efficiency
12 N=1000;//speed in rpm
13 I=P_o/V_t;//in amperes
14 I_f=V_t/R_f;//in amperes
```

```
15  I_a=I+I_f;
16  P_cu=R_a*I_a^2+R_se*I_a^2+R_f*I_f^2;//copper loss in
        watts
17  disp(P_cu,'(a) Cu-loss (in watts)=');
18  P_i=P_o/Eff;//input power in watts
19  P_L=P_i-P_o;//total losses in watts
20  P_fric=P_L-P_cu;
21  disp(P_fric,'(b) Iron and friction loss (in watts)='
      );
22  T=P_i*60/(2*%pi*N);
23  disp(T,'(c) Torque (in N-m)=')
```

**Scilab code Exa 2.16** Find the Flux per pole and total number of conductors and torque

```
1  //Caption:Find the (a)Flux per pole (b)total number
      of conductors (c) torque
2  //Exa:2.16
3  clc;
4  clear;
5  close;
6  I_a=50;//in amperes
7  P=6;//no.of poles
8  E_g=200;//in volts
9  N=1500;//speed in rpm
10  A=6;
11  L=0.25;//in meter
12  d=0.2;//in meter
13  B=0.9;//in tesla
14  Theta=360/P;//angle subtended by pole shoe in
        degrees
```

```
15  l=%pi*L*Theta/360;//arc length of pole shoe in meter
16  area=l*d;//in meter^2
17  Phy=B*area;
18  disp(Phy,'(a) Flux per pole (in Weber)=');
19  Z=ceil(E_g*60/(Phy*N));
20  disp(Z,'(b) Total no. of conductors=');
21  T=9.55*E_g*I_a/N;
22  disp(T,'(c) Torque (in Newton-meter)=')
```

**Scilab code Exa 2.17** Find the Demagnetizing AT per pole and Cross magnetizing AT per pole and number of turns per pole

```
1  //Caption:Find the (a)Demagnetizing AT per pole (b)
       Cross magnetizing AT per pole (c) number of turns
        per pole
2  //Exa:2.17
3  clc;
4  clear;
5  close;
6  P=40000;//in watts
7  E_g=400;//in volts
8  A=4;
9  Pole=4;
10 Z=2*30*12;//no. of conductors
11 theta_m=10;//in degrees
12 I_a=P/E_g;//armature current in amperes
13 I=I_a/A;//current in each conductor in amperes
14 AT_d=Z*I*theta_m/360;
15 disp(AT_d,'(a) Demagnetizing Ampere Turns per pole='
       );
16 AT_cm=Z*I*((1/(2*Pole))-(theta_m/360));
```

```
17 disp(AT_cm,'(b) Cross magnetizing Ampere Turns per
      pole=');
18 n=Z*I*0.8/(2*Pole*100);
19 disp(n,'(c) Number of turns per pole=')
```

**Scilab code Exa 2.18** Find the current supplied by each generator and output voltage and output KW of each machine

```
1 //Caption:Find the (a)current supplied by each
      generator (b)output voltage (c) output KW of each
       machine
2 //Exa:2.18
3 clc;
4 clear;
5 close;
6 V_t1=280;//terminal voltage of generator-1 in volts
7 V_nl1=240;//no-load voltage of generator-1 in volts
8 V_t2=300;//terminal voltage of generator-2 in volts
9 V_nl2=240;//no-load voltage of generator-2 in volts
10 I_s1=40;//supply current to generator-1 in amperes
11 I_s2=50;//supply current to generator-2 in amperes
12 V_d1=V_t1-V_nl1;//voltage drop for generator-1 in
       volts
13 V_d2=V_t2-V_nl2;//voltage drop for generator-2 in
       volts
14 V_d1_pa=V_d1/I_s1;//voltage drop per ampere for
       generator-1 in volts/ampere
15 V_d2_pa=V_d2/I_s2;//voltage drop per ampere for
       generator-2 in volts/ampere
16 I_2=(20+60)/(V_d1_pa+V_d2_pa);//in amperes
17 I_1=60-I_2;//in amperes
```

```
18 disp(I_1,'(a) Current supplied by generator -1(in
      amperes)=');
19 disp(I_2,'     Current supplied by generator -2(in
      amperes)=');
20 V_1=V_t1-(V_d1_pa*I_1);//in volts
21 V_2=V_t2-(V_d2_pa*I_2);//in volts
22 disp(V_1,'(b) Output voltage of generator -1(in volts
      )=');
23 disp(V_2,'(b) Output voltage of generator -2(in volts
      )=');
24 P_1=V_1*I_1/1000;//in kilo watts
25 P_2=V_2*I_2/1000;//in kilo watts
26 disp(P_1,'(c) Output KW of generator -1(in Kilo watts
      )=');
27 disp(P_2,'(c) Output KW of generator -2(in Kilo watts
      )=');
```

**Scilab code Exa 2.19** Find the ratio of the speed as a generator to speed as a motor

```
1 //Caption:Find the ratio of the speed as a generator
      to speed as a motor
2 //Exa:2.19
3 clc;
4 clear;
5 close;
6 V=250;//in volts
7 I_L=80;//in amperes
8 R_a=0.12;//in ohms
9 R=100;//in ohms
10 I_f=V/R;//in amperes
```

```
11  I_a1 = I_L + I_f ; // in  amperes  ( generator )
12  E_1 = V + ( I_a1 * R_a ) ; // in  volts  ( generator )
13  I_a2 = I_L - I_f ; // in  amperes  ( motor )
14  E_2 = V - ( I_a2 * R_a ) ; // in  volts  ( motor )
15  Ratio = E_1 / E_2 ;
16  disp ( Ratio , 'Ratio  of  speed  as  a  generator  to  speed
        as  motor=')
```

**Scilab code Exa 2.20** Find the no load speed

```
1  // Caption : Find  the  no  load  speed
2  // Exa : 2.20
3  clc ;
4  clear ;
5  close ;
6  V =200; // in  volts
7  I_a0 =2; // in  amperes
8  R_a =0.4; // in  ohms
9  I_a1 =50; // in  amperes
10 N_1 =1200; // in  rpm
11 E_0 = V - ( I_a0 * R_a ) ; // in  volts
12 E_1 = V - ( I_a1 * R_a ) ; // in  volts
13 N_0 = N_1 * ( E_0 / E_1 ) ; // in  rpm
14 disp ( N_0 , 'No-load  speed  ( in  rpm )=')
```

**Scilab code Exa 2.21** Find the speed of motor

```
1  // Caption : Find the speed of motor
2  // Exa : 2.21
3  clc ;
4  clear ;
5  close ;
6  V =250; // in volts
7  I_L1 =5; // in amperes
8  R_a =0.2; // in ohms
9  R_f =250; // in ohms
10 I_f =V/ R_f ; // in amperes
11 I_a1 = I_L1 - I_f ; // in amperes
12 I_L2 =50; // in amperes
13 I_a2 = I_L2 - I_f ; // in amperes
14 N_1 =1000; // in rpm
15 E_2 =V -( I_a2 * R_a ); // in volts
16 E_1 =V -( I_a1 * R_a ); // in volts
17 N_2 = N_1 *( E_2 / E_1 ); // in rpm
18 disp ( N_2 , 'speed of motor ( in rpm )=')
```

**Scilab code Exa 2.22** Find the speed of machine

```
1  // Caption : Find the speed of machine
2  // Exa : 2.22
3  clc ;
4  clear ;
5  close ;
6  V =250; // in volts
7  P_i =50*10^3; // in watts
8  I_L1 = P_i /V; // in amperes
```

```
 9  R_a =0.02; //in  ohms
10  R_f =50; //in  ohms
11  I_f=V/R_f; //in  amperes
12  I_a1=I_L1+I_f; //in  amperes
13  I_L2=P_i/V; //in  amperes
14  I_a2=I_L2-I_f; //in  amperes
15  N_1 =400; //in  rpm
16  E_2=V-(I_a2*R_a)-(2*1); //in  volts
17  E_1=V+(I_a1*R_a)+(2*1); //in  volts
18  N_2=int(N_1*(E_2/E_1)); //in  rpm
19  disp(N_2,'speed  of  motor  (in  rpm)=')
```

**Scilab code Exa 2.23** Determine the total torque and useful torque and useful flux per pole and rotational losses and efficiency

```
 1  //Caption:Determine  the  (a)total  torque(b)useful
       torque(c)useful  flux  per  pole(d)rotational  losses
       (e)efficiency
 2  //Exa:2.23
 3  clc;
 4  clear;
 5  close;
 6  P=4; //no  of  poles
 7  Z=560; //no  of  conductors
 8  A=2;
 9  V=250; //in  volts
10  P_o=10*10^3; //in  watts
11  R_a =0.2; //in  ohms
12  I_f =1; //in  amperes
13  I_a =60; //in  amperes
14  N=1000; //in  rpm
```

```
15  V_b=1*2//in volts
16  E=V-(I_a*R_a)-V_b;//in volts
17  T=60*E*I_a/(2*%pi*N);//in Newton-meter
18  disp(T,'(a) Total torque (in Newton-meter)=');
19  T_useful=P_o*60/(2*%pi*N);
20  disp(T_useful,'(b) Useful torque (in Newton-meter)='
        );
21  Phy=60*E*A/(N*P*Z);
22  disp(Phy,'(c) Useful flux per pole (in Weber)=');
23  P_d=(V*I_a)-((I_a^2)*R_a)-(V_b*I_a);//in Watts
24  P_rot=P_d-P_o;
25  disp(P_rot,'(d) Rotational losses (in Watts)=');
26  P_i=V*(I_a+I_f);//in Watts
27  Eff=P_o*100/P_i;
28  disp(Eff,'(e) Efficiency (in %)=');
```

**Scilab code Exa 2.24** Determine the speed and percentage change in torque

```
1  //Caption:Determine the speed and percentage change
       in torque
2  //Exa:2.24
3  clc;
4  clear;
5  close;
6  V=460;//in volts
7  R_a=0.8;//in ohms
8  I_a1=40;//in amperes
9  I_a2=30;//in amperes
10 N_1=500;//in rpm
11 E_1=V-(I_a1*R_a);//in volts
12 E_2=V-(I_a2*R_a);//in volts
```

```
13  N_2=int(E_2*I_a1*N_1/(E_1*I_a2));
14  disp(N_2,'Speed (in rpm)=');
15  ratio=(I_a2/I_a1)^2;
16  T_c=(1-ratio)*100;
17  disp(T_c,'Percentage change in torque=')
```

**Scilab code Exa 2.25** Determine the speed

```
1  //Caption:Determine the speed
2  //Exa:2.25
3  clc;
4  clear;
5  close;
6  V=220;//in volts
7  R_a=0.1;//in ohms
8  I_a1=100;//in amperes
9  I_a2=sqrt(I_a1^2/2);//in amperes
10 N_1=800;//in rpm
11 E_1=V-(I_a1*R_a);//in volts
12 E_2=V-(I_a2*R_a);//in volts
13 N_2=int(E_2*I_a1*N_1/(E_1*I_a2));
14 disp(N_2,'Speed (in rpm)=');
```

**Scilab code Exa 2.26** Determine the speed

```
1 //Caption:Determine the speed
2 //Exa:2.26
3 clc;
4 clear;
5 close;
6 V=250;//in volts
7 R_a=0.25;//in ohms
8 I_a1=50;//in amperes
9 I_a2=I_a1/0.9;//in amperes
10 N_1=750;//in rpm
11 E_1=V-(I_a1*R_a);//in volts
12 E_2=V-(I_a2*R_a);//in volts
13 N_2=int(E_2*N_1/(E_1*0.9));
14 disp(N_2,'Speed (in rpm)=');
```

**Scilab code Exa 2.27** Determine the speed at half load and 125 percent full load

```
1 //Caption:Determine the speed (a)at half load (b)125
       % full load
2 //Exa:2.27
3 clc;
4 clear;
5 close;
6 V=120;//in volts
7 V_b=3;//in volts
8 R_a=0.2;//in ohms
9 R_f=60;//in ohms
10 I_L1=40;//in amperes
11 I_f=V/R_f;//inn amperes
12 I_a1=I_L1-I_f;//in amperes
```

```
13  N_1 =1800; //in rpm
14  E_1 =V -( I_a1 * R_a )-V_b ; //in volts
15  I_L2 = I_L1 /2;
16  I_a2 = I_L2 - I_f ;
17  E_2 =V -( I_a2 * R_a )-V_b ; //in volts
18  N_2 =int ( E_2 * N_1 / E_1 ) ;
19  disp ( N_2 , '( a ) Speed at half load ( in rpm )= ') ;
20  I_L3 = I_L1 *1.25;
21  I_a3 = I_L3 - I_f ;
22  E_3 =V -( I_a3 * R_a )-V_b ; //in volts
23  N_3 =int ( E_3 * N_1 / E_1 ) ;
24  disp ( N_3 , '( b ) Speed at 125% load ( in rpm )= ') ;
```

**Scilab code Exa 2.28** Determine the value of resistance

```
1  //Caption:Determine the value of resistance
2  //Exa:2.28
3  clc ;
4  clear ;
5  close ;
6  V =220; //in volts
7  R_a =0.1; //in ohms
8  N_1 =800; //in rpm
9  N_2 =520; //in rpm
10  I_a1 =20; //in ampers
11  E_1 =V -( I_a1 * R_a ) ; //in volts
12  E_2 = N_2 * E_1 / N_1 ; //in volts
13  R_A = -( E_2 -V + I_a1 * R_a ) /20;
14  disp ( R_A , 'Additional resistance ( in ohms )= ') ;
```

**Scilab code Exa 2.29** Determine the value of additional resistance at starting and at 1000rpm

```
 1 //Caption:Determine the value of additional
      resistance (a)at starting (b)at 1000rpm
 2 //Exa:2.29
 3 clc;
 4 clear;
 5 close;
 6 V=240;//in volts
 7 R_a=0.3;//in ohms
 8 N_1=1500;//in rpm
 9 I_a=40;//in ampers
10 E=V-(I_a*R_a);//in volts
11 R_1=(V-I_a*R_a)/I_a;
12 disp(R_1,'(a) Additional resistance at starting (in
      ohms)=');
13 N_2=1000;//in rpm
14 E_2=N_2*E/N_1;//in volts
15 R_2=-(E_2-V+I_a*R_a)/I_a;
16 disp(R_2,'(b) Additional resistance at 1000 rpm (in
      ohms)=');
```

**Scilab code Exa 2.30** Determine the speed at full load and speed at double full load and stalling torque in terms of full load torque

```
1  //Caption:Determine the (a)speed at full load (b)
      speed at double full load (c)stalling torque in
      terms of full load torque
2  //Exa:2.30
3  clc;
4  clear;
5  close;
6  V=250;//in volts
7  R_a=0.2;//in ohms
8  N_1=800;//in rpm
9  R_f=250;//in ohms
10 I_f=V/R_f;//in amperes
11 I=41;//in ampers
12 I_a1=I-I_f;//in amperes
13 E_1=V-(I_a1*R_a);//in volts
14 E_2=V-(I_a1*(R_a+2));//in volts
15 N_2=E_2*N_1/E_1;
16 disp(N_2,'(a) Speed at full load (in rpm)=');
17 I_a2=I_a1*2;//in amperes
18 E_3=V-I_a2*(R_a+2);//in volts
19 N_3=E_3*N_1/E_1;//in rpm
20 disp(N_3,'(b) Speed at double full load (in rpm)=');
21 I_ao=V/(R_a+2);
22 r=I_ao/I_a1;
23 disp(r,'(c) stalling torque is (times full load
      torque) =')
```

**Scilab code Exa 2.31** Determine the resistance to be inserted in series

```
1  //Caption:Determine the resistance to be inserted in
        series
2  //Exa:2.31
3  clc;
4  clear;
5  close;
6  V=200;//in volts
7  R_a=0.4;//in ohms
8  N_1=1000;//in rpm
9  N_2=800;//in rpm
10 I_a1=20;//in amperes
11 E_1=V-(I_a1*R_a);//in volts
12 I_a2=0.8*I_a1;//in amperes
13 E_2=N_2*I_a2*E_1/(N_1*I_a1);//in volts
14 R=-(E_2-193.6)/16;
15 disp(R,'the resistance to be inserted in series (in
        ohms)=')
```

**Scilab code Exa 2.32** Determine the resistance to be inserted in series

```
1  //Caption:Determine the resistance to be inserted in
        series
2  //Exa:2.32
3  clc;
4  clear;
5  close;
6  V=500;//in volts
7  R_a=0.5;//in ohms
8  I_a1=60;//in amperes
9  E_1=V-(I_a1*R_a);//in volts
10 I_a2=sqrt(((0.75)^3)*I_a1^2);//in amperes
```

```
11  E_2=0.75*E_1*I_a2/I_a1;//in volts
12  R=-(E_2-480.5)/38.97;
13  disp(R,'the resistance to be inserted in series (in
        ohms)=')
```

**Scilab code Exa 2.33** Determine the output and efficiency when input current is 20A and 100A

```
1  //Caption:Determine the output and efficiency when
       input current is (a)20A (b)100A
2  //Exa:2.33
3  clc;
4  clear;
5  close;
6  V=500;//in volts
7  R_a=0.2;//in ohms
8  I_o=4;//in amperes
9  I_f=1;//in amperes
10 P_c=V*I_o-(((I_o-I_f)^2)*R_a);//in watts
11 I_1=20;///in amperes
12 P_i1=V*I_1;//in watts
13 P_a1=((I_1-I_f)^2)*R_a;//in watts
14 P_L1=P_c+P_a1;//in watts
15 P_o1=P_i1-P_L1;//in watts
16 disp(P_o1,'(a) Output (in watts)=');
17 disp(P_o1/P_i1*100,'  Efficiency (in %)=');
18 I_2=100;///in amperes
19 P_i2=V*I_2;//in watts
20 P_a2=((I_2-I_f)^2)*R_a;//in watts
21 P_L2=P_c+P_a2;//in watts
22 P_o2=P_i2-P_L2;//in watts
```

```
23 disp(P_o2,'(b) Output (in watts)=');
24 disp(P_o2/P_i2*100,'  Efficiency (in %)=');
```

**Scilab code Exa 2.34** Determine the no load speed and Full load speed and Speed Regulation

```
1 //Caption:Determine the (a)no load speed  (b)Full
     load speed (c)Speed Regulation
2 //Exa:2.34
3 clc;
4 clear;
5 close;
6 V=240;//in volts
7 V_b=2;//in volts
8 R_a=0.15;//in ohms
9 P=4;
10 Z=700;
11 Phy=0.06;//in Webers
12 A=P;
13 I_o=7;//in amperes
14 I_f=2;//in amperes
15 I=90;//in amperes
16 I_ao=I_o-I_f;//in amperes
17 E_bo=V-I_ao*R_a-V_b;//in volts
18 N_o=E_bo*60*A/(P*Phy*Z);//in rpm
19 disp(N_o,'(a)no load speed (in rpm)=');
20 I_a=I-I_f;//in amperes
21 E_b1=V-I_a*R_a-V_b;//in volts
22 N=E_b1*N_o/(E_bo*0.98);
23 disp(N,'(b)Full load speed (in rpm)=');
24 SR=100*(N_o-N)/N;
```

```
25 disp(SR,'(c)Speed Regulation (in %)=');
```

**Scilab code Exa 2.35** Determine the no load speed and Percentage reduction in flux per pole

```
1 //Caption:Determine the (a)no load speed  (b)
      Percentage reduction in flux per pole
2 //Exa:2.35
3 clc;
4 clear;
5 close;
6 V=220;//in volts
7 V_b=1;//in volts
8 R_f=110;//in ohms
9 R_a=0.14;//in ohms
10 I_o=7;//in amperes
11 I_f=2;//in amperes
12 I=90;//in amperes
13 N_1=700;//in rpm
14 I_ao=I_o-I_f;//in amperes
15 E_bo=V-I_ao*R_a-V_b;//in volts
16 I=55;//in amperes
17 I_a1=I-I_f;//in amperes
18 E_b1=V-I_a1*R_a-V_b;//in volts
19 N_o=E_bo*N_1/E_b1;
20 disp(N_o,'(a)no load speed (in rpm) =');
21 I_a2=35;//in amperes
22 N_2=900;//in rpm
23 E_b2=V-I_a2*R_a-V_b;//in volts
24 Phy_r=E_b2*N_1/(E_b1*N_2);
25 R=(1-Phy_r)*100;
```

```
26  disp (R, '( b ) Percentage  reduction  in  flux  per  pole  ( in
        %)=');
```

---

**Scilab code Exa 2.36** Determine the full load speed and Speed regulation and HP rating and Full load efficiency

```
1  // Caption : Determine  the  ( a ) full  load  speed   ( b ) Speed
        regulation  ( c )HP  rating  ( d ) Full  load  efficiency
2  // Exa : 2.36
3  clc ;
4  clear ;
5  close ;
6  V =240; // in  volts
7  R_f =120; // in  ohms
8  R_a =0.25; // in  ohms
9  I_1 =60; // in  amperes
10 I_f = V / R_f ; // in  amperes
11 I_a1 = I_1 - I_f ; // in  amperes
12 E_b1 = V - I_a1 * R_a ; // in  volts
13 N_o =1000; // in  rpm
14 I =6; // in  amperes
15 I_ao = I - I_f ; // in  amperes
16 E_bo = V - I_ao * R_a ; // in  volts
17 N_1 = N_o * E_b1 / E_bo ;
18 disp ( N_1 , '( a ) Full  load  speed  ( in  rpm )  =') ;
19 SR =100*( N_o - N_1 ) / N_o ;
20 disp ( SR , '( b ) Speed  regulation  ( in  %)  =') ;
21 P_o = E_b1 * I_a1 - ( E_bo * I_ao ) ;
22 HP = P_o /746;
23 disp ( HP , '( c )HP  rating  ( in  HP)=') ;
24 P_i = V * I_1 ;
```

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```
25  Eff = P_o *100/ P_i ;
26  disp ( Eff , '(d) Efficiency  ( in  %)=')
```

**Scilab code Exa 2.37** Determine the speed Torque and Efficiency

```
1  // Caption : Determine  the  (a) speed    (b) Torque  (c)
      Efficiency
2  // Exa :2.37
3  clc ;
4  clear ;
5  close ;
6  V =240; // in  volts
7  P =4;
8  Phy =0.008; // in  webers
9  Z =1000;
10  A =2;
11  R_f =240; // in  ohms
12  R_a =0.4; // in  ohms
13  I_1 =25; // in  amperes
14  I_f = V / R_f ; // in  amperes
15  I_a1 = I_1 - I_f ; // in  amperes
16  E_b = V - I_a1 * R_a ; // in  volts
17  N = E_b *60* A /( P * Z * Phy ) ;
18  disp ( N , '(a) speed  ( in  rpm)  =') ;
19  P_m = E_b * I_a1 ;
20  T_g =(9.55* P_m )/ N ;
21  disp ( T_g , '(b) Torque  ( in  N–m)=') ;
22  P_f = P_m -800;
23  P_i = V * I_1 ;
24  Eff = P_f *100/ P_i ;
25  disp ( Eff , '(c) Efficiency  ( in  %)=')
```

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**Scilab code Exa 2.38** Determine the efficiency and power input

```
 1 //Caption:Determine the efficiency and power input
 2 //Exa:2.38
 3 clc;
 4 clear;
 5 close;
 6 P_out=20000;//in watts
 7 P_in=23000;//in watts
 8 V=250;//in volts
 9 R_f=125;//in ohms
10 R_a=0.2;//in ohms
11 I_L=P_in/V;//in amperes
12 I_f=V/R_f;//in amperes
13 I_a1=I_L-I_f;//in amperes
14 P_cu=(I_a1^2)*R_a;
15 P_fcu=V*I_f;
16 P_tcu=P_cu+P_fcu;
17 P_fric=P_in-P_out-P_tcu;
18 P_o=12000;//in watts
19 P_m=P_o+P_fric
20 I_a2=53.85;
21 P_tcu2=((I_a2^2)*R_a)+250;
22 P_in_2=P_m+P_tcu2;
23 disp(P_in_2,'Power input (in watts)=');
24 Eff=P_o*100/P_in_2;
25 disp(Eff,'Efficiency (in %)=')
```

**Scilab code Exa 2.39** Determine the efficiency armature current and max efficiency

```
1 //Caption:Determine the (a)efficiency (b)armature
        current (c)max efficiency
2 //Exa:2.39
3 clc;
4 clear;
5 close;
6 V=240;//in volts
7 R_f=240;//in ohms
8 R_a=0.6;//in ohms
9 I_o=5;//in amperes
10 I=18;//in amperes
11 I_f=V/R_f;//in amperes
12 I_ao=I_o-I_f;
13 I_a1=I-I_f;
14 E_bo=V-I_ao*R_a;//in volts
15 E_b1=V-I_a1*R_a;//in volts
16 P_dnL=E_bo*I_ao;//in watts
17 P_m=E_b1*I_a1;//in watts
18 P_o=P_m-P_dnL;
19 P_i=V*I;//in watts
20 Eff=P_o/P_i;
21 disp(Eff*100,'(a)Efficiency (in %)=')
22 I_a=sqrt((P_dnL+V*1)/R_a)
23 disp(I_a,'(b)Armature current (in Amperes)=')
24 E_b=V-I_a*R_a;
25 P_m2=E_b*I_a;//in watts
26 P_out=P_m2-P_dnL;//in watts
```

```
27  P_in=V*I_a;//in watts
28  Eff_m=P_out/P_in;
29  disp(Eff_m*100,'(c)Max Efficiency (in %)=')
```

**Scilab code Exa 2.40** Calculate the Speed at full load and developed torque and Shaft power and Efficiency

```
1  //Caption:Calculate the (a)Speed at full load and
      developed torque (b)Shaft power (c)Efficiency
2  //Exa:2.40
3  clc;
4  clear;
5  close;
6  V=230;//in volts
7  R_a=0.4;//in ohms
8  I_a1=3.4;//in amperes
9  R_f=170;//in ohms
10  E_b1=V-I_a1*R_a;
11  I_f=V/R_f;
12  I_L=41;//in amperes
13  I_a2=I_L-I_f;
14  E_b2=214.142;//in volts
15  N_1=1000;//in rpm
16  N_2=N_1*E_b2/(E_b1*0.96);//in rpm
17  disp(N_2,'(a)Speed at full load (in rpm)=')
18  T_a=9.55*E_b2*I_a2/N_2;
19  disp(T_a,'Torque Developed (in N–m)=')
20  P_r=E_b1*I_a1;
21  P_m=E_b2*I_a2;
22  P_f=P_m-P_r;
23  disp(P_f,'(b)Shaft Power (in watts)=')
```

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```
24  P_in=V*I_L;
25  Eff=P_f/P_in;
26  disp(Eff*100,'(c)Efficiency (in %)=')
```

**Scilab code Exa 2.41** Calculate the value of external resistance when the load torque is independent of speed and when the load torque is proportional to speed andthe load torque varies as square of the speed

```
1  //Caption:Calculate the value of external resistance
       when (a)the load torque is independent of speed
       (b)the load torque is proportional to speed (c)
       the load torque varies as square of the speed
2  //Exa:2.41
3  clc;
4  clear;
5  close;
6  V=240;//in volts
7  R_a=0.25;//in ohms
8  R_f=120;//in ohms
9  I_f=V/R_f;
10  I_L=26;//in amperes
11  I_a=I_L-I_f;
12  N_1=1000;//in rpm
13  N_2=900;//in rpm
14  E_b1=V-I_a*R_a;
15  r=N_1/N_2;
16  R=(E_b1-(E_b1/r))/I_a;
17  disp(R,'(a)Value of external resistance when the
       load torque is independent of speed (in ohms)= ')
       ;
18  I_a2=I_a/r;
```

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```
19  R1=(E_b1-(E_b1/r))/I_a2;
20  disp(R1,'(b)Value of external resistance when the
       load torque is proportional to speed (in ohms)= '
       );
21  I_a2_n=I_a/r^2;
22  R2=(E_b1-(E_b1/r))/I_a2_n;
23  disp(R2,'(a)Value of external resistance when the
       load torque is independent of speed (in ohms)= ')
       ;
```

**Scilab code Exa 2.43** Find the efficiency of the motor

```
1  //Caption:Find the efficiency of the motor
2  //Exa:2.43
3  clc;
4  clear;
5  close;
6  V=240;//in volts
7  P=10000;//in watts
8  R_a=0.25;//in ohms
9  R_f=160;//in ohms
10 I_f=V/R_f;
11 I_L=5.2;//in amperes
12 I_ao=I_L-I_f;
13 W=V*I_ao-I_ao^2*R_a;
14 I_a=(V-sqrt(V^2-4*R_a*(P+W)))/(2*R_a);
15 P_in=P+W+I_a^2*R_a+I_f^2*R_f;
16 Eff=P/P_in;
17 disp(Eff*100,'Efficiency of the motor (in %)=')
```

**Scilab code Exa 2.44** Find the armature voltage drop

```
1 //Caption:Find the armature voltage drop
2 //Exa:2.44
3 clc;
4 clear;
5 close;
6 V=440;//in volts
7 N_1=1000;//in rpm
8 N_2=1050;//in rpm
9 r=N_1/N_2;
10 V_drop=2*(V-V*r)
11 disp(V_drop,'Armature voltage drop (in volts)=')
```

**Scilab code Exa 2.45** Find the no load speed

```
1 //Caption:Find the no load speed
2 //Exa:2.45
3 clc;
4 clear;
5 close;
6 V=220;//in volts
7 R_a=2.5;//in ohms
8 N_1=859;//in rpm
```

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```
 9  I_ao =0;
10  I_a =8;//in  amperes
11  E_b1 = V - I_a * R_a;
12  E_bo = V - I_ao * R_a;
13  N_o = N_1 * E_bo / E_b1;
14  disp(N_o ,'No  Load  Speed  (in  RPM)=')
```

**Scilab code Exa 2.46** Find the percentage reduction in feild flux and value
of additional resistance

```
 1  //Caption:Find  the  percentage  reduction  in  feild
        flux  and  value  of  additional  resistance
 2  //Exa:2.46
 3  clc;
 4  clear;
 5  close;
 6  V =220;//in  volts
 7  R_a =0.2;//in  ohms
 8  R_f =110;//in  ohms
 9  N_1 =700;//in  rpm
10  N_2 =900;//in  rpm
11  T_a1 =90;//in  N-m
12  T_a2 =70;//in  N-m
13  I_1 =27;//in  amperes
14  I_f = V / R_f;
15  I_a1 = I_1 - I_f;
16  E_b1 = V - I_a1 * R_a;
17  x =( V + sqrt ( V ^2 -4*276.43*4.168))/(2*276.43);
18  disp((1 - x)*100 ,'percentage  reduction  in  feild  flux  (
        %)=');
19  I_f2 = x * I_f;
```

```
20  R=(V-I_f2*R_f)/I_f2;
21  disp(R,'Value of additional resistance (in ohms)=')
```

**Scilab code Exa 2.47** Find the new speed as a percentage of the original speed

```
1  //Caption:Find the new speed as a percentage of the
        original speed
2  //Exa:2.47
3  clc;
4  clear;
5  close;
6  V=400;//in volts
7  R_f=200;//in ohms
8  I_1=25;//in amperes
9  I_f=V/R_f;
10  I_a1=I_1-I_f;
11  x=(-V+sqrt(V^2+4*345*400))/(2*345);
12  disp(x*100,'New Speed is= ');
13  disp('percent of original speed')
```

# Chapter 3

# Single Phase Transformers

**Scilab code Exa 3.1** Determine the number of turns of primary and secondary windings and emf per turn

```
1  // Caption: Determine  the  (a)number  of  turns  of
       primary  and  secondary  windings  (b)emf  per  turn
2  // Exa:3.1
3  clc ;
4  clear ;
5  close ;
6  A =500*10^ -4;// in  m^2
7  B_max =1.5;// in  tesla
8  f =50;// in  Hz
9  E_1 =5000;// in  volts
10 E_2 =500;// in  volts
11 S_f =0.85;// Stacking  factor
12 N_1 =int ( E_1 /(4.44* f * B_max * A * S_f ) );
13 disp ( N_1 , '(a)Number  of  turns  in  primary  winding=');
14 N_2 =int ( E_2 * N_1 / E_1 );
15 disp ( N_2 , 'Number  of  turns  in  secondary  winding=');
16 disp ( E_1 / N_1 , '(b)Emf  per  turn  (in  Volts )=');
```

**Scilab code Exa 3.2** Determine the number of turns of primary and secondary windings and cross section area of the core

```
1  //Caption:Determine the (a)number of turns of
       primary and secondary windings (b)cross section
       area of the core
2  //Exa:3.2
3  clc;
4  clear;
5  close;
6  B_max=1.4;//in tesla
7  f=50;//in Hz
8  E_1=660;//in volts
9  E_2=440;//in volts
10 E_T1=1.1;//in volts
11 N_1=int(E_1/E_T1);
12 disp(N_1,'(a)Number of turns in primary winding=');
13 N_2=int(E_2*N_1/E_1);
14 disp(N_2,'Number of turns in secondary winding=');
15 A=E_1/(4.44*f*N_1*B_max);
16 disp(A,'(b)Cross section area of the core (in m^2)='
       );
```

**Scilab code Exa 3.3** Determine the number of turns of primary and secondary windings

```
1 //Caption:Determine the number of turns of primary
     and secondary windings
2 //Exa:3.3
3 clc;
4 clear;
5 close;
6 Phy_max=7.82*10^-3;//in webers
7 f=50;//in Hz
8 E_1=5000;//in volts
9 E_2=500;//in volts
10 N_1=int(E_1/(4.44*f*Phy_max));
11 disp(N_1,'Number of turns in primary winding=');
12 N_2=int(E_2*N_1/E_1);
13 disp(N_2,'Number of turns in secondary winding=');
```

**Scilab code Exa 3.4** Determine the Secondary voltage current flowing through windings and max value of flux

```
1 //Caption:Determine the (a)Secondary voltage (b)
     current flowing through windings (c)max value of
     flux
2 //Exa:3.4
3 clc;
4 clear;
5 close;
6 f=50;//in Hz
7 E_1=2500;//in volts
8 N_1=500;
```

```
 9  N_2=100;
10  P=50*1000;//in watts
11  E_2=E_1*N_2/N_1;
12  disp(E_2,'(a)Secondary Voltage (in volts)=');
13  I_1=P/E_1;
14  disp(I_1,'(b)Primary current (in amperes)=');
15  I_2=P/E_2;
16  disp(I_2,'   Secondary current (in amperes)=');
17  Phy_max=E_1/(4.44*f*N_1);
18  disp(Phy_max,'(c)Max value of flux (in Wb)=')
```

**Scilab code Exa 3.5** Determine the No load power factor iron loss component of current and magnetising component of current

```
 1  //Caption:Determine the (a)No load power factor(b)
       iron loss component of current (c)magnetising
       component of current
 2  //Exa:3.5
 3  clc;
 4  clear;
 5  close;
 6  f=50;//in Hz
 7  W=80;//in watts
 8  V=4400;//in volts
 9  I=0.04;//in amperes
10  pf=W/(V*I);
11  disp(pf,'(a)No load power factor=');
12  I_w=I*pf;
13  disp(I_w,'(b)Iron loss component of current (in
       amperes)=');
14  I_m=I*sqrt(1-pf^2);
```

```
15  disp(I_m,'(c)Magnetising  component  of  current  (in
        amperes)')
```

---

**Scilab code Exa 3.6** Determine the No load input power magnetising component of current and no load power factor

```
1  //Caption:Determine  the  (a)No  load  input  power  (b)
        magnetising  component  of  current  and  no  load
        power  factor
2  //Exa:3.6
3  clc;
4  clear;
5  close;
6  f=50;//in  Hz
7  P=20*1000;//in  watts
8  E_1=2200;//in  volts
9  E_2=220;//in  volts
10  I=1.3;//in  amperes
11  I_w=0.5;//in  amperes
12  W=E_2*I_w;
13  disp(W,'(a)No  load  input  power  (in  watts)=')
14  pf=I_w/I;
15  disp(pf,'(b)No  load  power  factor=');
16  I_m=I*sqrt(1-pf^2);
17  disp(I_m,'   Magnetising  component  of  current  (in
        amperes)')
```

---

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**Scilab code Exa 3.7** Determine the Equivalent resistance leakage reactances and impedance reffered to high voltage side and Equivalent resistance leakage reactances and impedance reffered to high voltage side and Total copper loss of transformer

```
1 //Caption:Determine the (a)Equivalent resistance,
      leakage reactances and impedance reffered to high
       voltage side (b)Equivalent resistance,leakage
      reactances and impedance reffered to high voltage
       side (c)Total copper loss of transformer
2 //Exa:3.7
3 clc;
4 clear;
5 close;
6 f=50;//in Hz
7 P=30*1000;//in watts
8 E_1=3000;//in volts
9 E_2=300;//in volts
10 R_1=2.5;//in ohms
11 R_2=0.018;//in ohms
12 X_1=3.8;//in ohms
13 X_2=0.052;//in ohms
14 a=E_1/E_2;
15 R1=R_1+a^2*R_2;
16 X1=X_1+a^2*X_2;
17 Z1=sqrt(R1^2+X1^2);
18 disp(R1,'(a)Equivalent resistance reffered to high
      voltage side (in ohms)=');
19 disp(X1,'   Equivalent reactance reffered to high
      voltage side (in ohms)=');
```

```
20  disp(Z1,'     Equivalent  impedance  reffered  to  high
       voltage  side  (in  ohms)=');
21  R2=R_1/a^2+R_2;
22  X2=X_1/a^2+X_2;
23  Z2=sqrt(R2^2+X2^2);
24  disp(R2,'(b)Equivalent  resistance  reffered  to  low
       voltage  side  (in  ohms)=');
25  disp(X2,'     Equivalent  reactance  reffered  to  low
       voltage  side  (in  ohms)=');
26  disp(Z2,'     Equivalent  impedance  reffered  to  low
       voltage  side  (in  ohms)=');
27  I_1=P/E_1;
28  I_2=P/E_2;
29  P_cu=I_1^2*R1;
30  disp(P_cu,'(c)Total  copper  loss  of  transformer  (in
       watts)=')
```

**Scilab code Exa 3.8** Find the equivalent circuit parameters reffered to primary side

```
1  //Caption:Find  the  equivalent  circuit  parameters
      reffered  to  primary  side
2  //Exa:3.8
3  clc;
4  clear;
5  close;
6  a=400/200;
7  I_o_Lv=2;//in  amperes
8  I_o_Hv=I_o_Lv/a;//in  amperes
9  V_o=400;//in  volts
10 P_occ=90;//in  watts
```

```
11  pf = P_occ /( V_o * I_o_Hv ) ;
12  I_w = I_o_Hv * pf ;
13  disp ( I_w , 'I_w ( in Amperes )=') ;
14  I_m = I_o_Hv * sqrt (1 - pf ^2) ;
15  disp ( I_m , 'Magnetising current I_m ( in Amperes )=') ;
16  R_o = V_o / I_w ;
17  disp ( R_o , 'R_o ( in ohms )=') ;
18  X_o = V_o / I_m ;
19  disp ( X_o , 'Magnetizing reactance X_o ( in ohms )=') ;
20  V_sc =20; // in volts
21  I_sc =10; // in amperes
22  P_sc =100; // in watts
23  Z_o1 = V_sc / I_sc ;
24  R_o1 = P_sc / I_sc ^2;
25  disp ( R_o1 , 'Effective resistance reffered to primary
        side ( in ohms )=') ;
26  X_o1 = sqrt ( Z_o1 ^2 - R_o1 ^2) ;
27  disp ( X_o1 , 'Effective reactance reffered to primary
        side ( in ohms )=')
```

**Scilab code Exa 3.9** Find the readings of transformers when it is connected for OC test and SC test

```
1 // Caption : Find the readings of transformers when it
      is connected for ( a ) OC test ( b ) SC test
2 // Exa :3.9
3 clc ;
4 clear ;
5 close ;
6 V1 =460; // in volts
7 V2 =230; // in volts
```

```
8  a=V1/V2;
9  R1=0.4;//in ohms
10 R2=0.1;//in ohms
11 X1=0.5;//in ohms
12 X2=0.12;//in ohms
13 R_o=650;//in ohms
14 X_o=250;//in ohms
15 I_w=V1/R_o;
16 I_m=V1/X_o;
17 P_occ=V1*I_w;
18 disp('Readings of transformer for OC test');
19 disp(V1,'Voltage Reading (in volts)=');
20 disp(sqrt(I_w^2+I_m^2),'Current Reading (in Amperes)
     =');
21 disp(P_occ,'Power output reading (in watts)=');
22 R_O1=R1+a^2*R2;
23 X_O1=X1+a^2*X2;
24 Z=sqrt(R_O1^2+X_O1^2);
25 I=4000/V1;
26 V_sc=I*Z;
27 P_sc=I^2*R_O1;
28 disp('Readings of transformer for SC test');
29 disp(V_sc,'Voltage Reading (in volts)=');
30 disp(I,'Current Reading (in Amperes)=');
31 disp(P_sc,'Power output reading (in watts)=');
```

**Scilab code Exa 3.10** Find the equivalent circuit parameters of the transformer reffered to LV side and also calculate the secondary voltage

```
1 //Caption:Find the equivalent circuit parameters of
     the transformer reffered to LV side and also
```

```scilab
     calculate the secondary voltage
2  //Exa:3.10
3  clc;
4  clear;
5  close;
6  V1=300;//in volts
7  I_o=0.8;//in amperes
8  W_o=70;//in watts
9  pf=W_o/(V1*I_o);
10 I_w=I_o*pf;
11 I_m=I_o*sqrt(1-pf^2);
12 R_O=V1/I_w;
13 X_O=V1/I_m;
14 a=300/600;
15 V_sc=20;//in volts
16 I_sc=12;//in amperes
17 P_sc=90;//in watts
18 Z_O2=V_sc/I_sc;
19 R_O2=P_sc/I_sc^2;
20 X_O2=sqrt(Z_O2^2-R_O2^2);
21 R_O1=a^2*R_O2;
22 X_O1=a^2*X_O2;
23 I_2=6000/(600*0.8);
24 V2=I_2*(R_O2*pf+X_O2*sqrt(1-pf^2));
25 disp(R_O,'R_O (in ohms)=');
26 disp(X_O,'X_O Magnetising reactance (in ohms)=');
27 disp(R_O1,'Equivalent Resistance reffered to LV Side
       (in ohms)=');
28 disp(X_O1,'Equivalent Reactance reffered to LV Side
      (in ohms)');
29 disp(600-V2,'Secondary Terminal Voltage (in volts)='
      )
```

**Scilab code Exa 3.11** Find the equivalent circuit parameters of the transformer reffered to LV side and also calculate the efficiency

```
1  //Caption:Find the equivalent circuit parameters of
       the transformer reffered to LV side and also
       calculate the efficiency
2  //Exa:3.11
3  clc;
4  clear;
5  close;
6  V1=200;//in volts
7  I_o=0.8;//in amperes
8  W_o=80;//in watts
9  pf=W_o/(V1*I_o);
10 I_w=I_o*pf;
11 I_m=I_o*sqrt(1-pf^2);
12 R_O=V1/I_w;
13 X_O=V1/I_m;
14 a=200/400;
15 V_sc=25;//in volts
16 I_sc=10;//in amperes
17 P_sc=90;//in watts
18 Z_O2=V_sc/I_sc;
19 R_O2=P_sc/I_sc^2;
20 X_O2=sqrt(Z_O2^2-R_O2^2);
21 R_O1=a^2*R_O2;
22 X_O1=a^2*X_O2;
23 I_2=12;
24 I_1=I_2/a;
25 V2=sqrt((V1*pf+I_1*R_O1)^2+(V1*sqrt(1-pf^2)+I_1*X_O1
```

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```
      )^2);
26  P_iron=80;//in watts
27  P_cu=(12/10)^2*90;
28  P_total=P_cu+P_iron;
29  Eff=6000*0.8/(6000*0.8+P_total);
30  disp(R_O,'R_O (in ohms)=');
31  disp(X_O,'X_O Magnetising reactance (in ohms)=');
32  disp(R_O1,'Equivalent Resistance reffered to LV Side
         (in ohms)=');
33  disp(X_O1,'Equivalent Reactance reffered to LV Side
         (in ohms)');
34  disp(Eff*100,'Efficiency (in %)=')
```

**Scilab code Exa 3.12** Calculate Efficiency of transformer Load KVA at which max efficiency occurs and max efficiency and voltage regulation

```
 1  //Caption:Calculate (a)Efficiency of transformer (b)
        Load KVA at which max efficiency occurs and max
        efficiency (c)voltage regulation
 2  //Exa:3.12
 3  clc;
 4  clear;
 5  close;
 6  V1=2000;//in volts
 7  pf=0.8;
 8  I1=10000/V1;//in amperes
 9  P_iron=60;//in watts
10  V_sc=40;//in volts
11  I_sc=4;//in amperes
12  a=2000/200;
13  P_sc=70;//in watts
```

```
14  Z_01=V_sc/I_sc;
15  R_01=P_sc/I_sc^2;
16  X_01=sqrt(Z_01^2-R_01^2);
17  R_02=R_01/a^2;
18  X_02=X_01/a^2;
19  I2=I1*a/2;//At half load
20  Del_V=I2*(R_02*pf+X_02*sqrt(1-pf^2));
21  V2=200-Del_V;
22  P_o=V2*I2*pf;//in watts
23  P_cu=(2.5/4)^2*P_sc;//At half load
24  Eff=0.5*P_o/(0.5*P_o+P_iron+P_cu);
25  disp(Eff*100,'(a)Efficiency (in %)=');
26  I_1=sqrt(P_iron/R_01);
27  KVA_Load=10*I_1/5;
28  disp(KVA_Load,'(b)Load KVA at which max efficiency
        occurs=');
29  Eff_max=P_o/(P_o+P_iron+P_iron);
30  disp(Eff_max*100,'   Max Efficiency (in %)=');
31  I_2=50;//at full load
32  VR=(I_2*(R_02*pf-X_02*sqrt(1-pf^2)))/200;
33  disp(VR*100,'(c)Voltage Regulation (in %)=')
```

**Scilab code Exa 3.13** Determine the KVA rating of auto transformer with additive and subtractive polarity also find the efficiency at full load and unity power factor

```
1  //Caption:Determine the KVA rating of auto
      transformer with additive and subtractive
      polarity also find the efficiency at full load
      and unity power factor
2  //Exa:3.13
```

```
 3  clc;
 4  clear;
 5  close;
 6  P=120*1000;//in watts
 7  V1=2400;//in volts
 8  V2=240;//in volts
 9  I1=P/V1;//in amperes
10  I2=P/V2;//in amperes
11  KVA_1=V1*(I1+I2)/1000;
12  P_trans=V2*I2/1000;
13  P_cond_1=KVA_1-P_trans;
14  P_loss_1=((1/0.98)-1)^2*P_trans;
15  Eff_a=1-(P_loss_1/KVA_1)
16  disp(KVA_1,'KVA Rating of transformer with additive
         polarity (in KVA)=');
17  disp(Eff_a*100,'Efficiency of auto transformer with
         additive polarity (in %)=');
18  KVA_2=V1*(I2-I1)/1000;
19  P_trans=V2*I2/1000;
20  P_cond_2=KVA_2-P_trans;
21  P_loss=((1/0.98)-1)^2*P_trans;
22  Eff_s=1-(P_loss/KVA_2)
23  disp(KVA_2,'KVA Rating of transformer with
         subtractive polarity (in KVA)=');
24  disp(Eff_s*100,'Efficiency of auto transformer with
         subtractive polarity (in %)=');
```

**Scilab code Exa 3.14** Calculate the parameters reffered to LV Side and also find the voltage regulation at full load and efficiency of transformer at full load and half load

```scilab
 1 //Caption:Calculate the parameters reffered to LV
       Side and also find the voltage regulation at full
        load and efficiency of transformer at full load
       and half load at 0.8pf lagging
 2 //Exa:3.14
 3 clc;
 4 clear;
 5 close;
 6 a=0.5;
 7 V1=200;//in volts
 8 I_o=0.8;//in amperes
 9 W_o=75;//in watts
10 pf=W_o/(V1*I_o);
11 pf2=0.8;
12 R_O=V1/(I_o*pf);
13 X_O=V1/(I_o*sqrt(1-pf^2));
14 V_sc=20;//in volts
15 I_sc=10;//in amperes
16 P_sc=90;//in watts
17 Z_O2=V_sc/I_sc;
18 R_O2=P_sc/I_sc^2;
19 X_O2=sqrt(Z_O2^2-R_O2^2);
20 R_O1=a^2*R_O2;
21 X_O1=a^2*X_O2;
22 I_2=4000/400;//in amperes
23 VR=I_2*(R_O2*pf2+X_O2*sqrt(1-pf2^2))/400;
24 disp(R_O,'R_O (in ohms)=');
25 disp(X_O,'X_O Magnetising reactance (in ohms)=');
26 disp(R_O1,'Equivalent Resistance reffered to LV Side
        (in ohms)=');
27 disp(X_O1,'Equivalent Reactance reffered to LV Side
       (in ohms)');
28 disp(VR*100,'Voltage Regulation at full load (in %)=
       ');
29 P_o=(400-I_2*(R_O2*pf2+X_O2*sqrt(1-pf2^2)))*I_2*pf2;
30 P_i=75;//in watts
31 P_cu=P_sc;
32 P_cu_h=0.5^2*P_cu;
```

```
33  Eff = P_o /( P_o + P_i + P_cu );
34  disp ( Eff *100 , ' Efficiency  at  full  load  ( in  %)=' );
35  P_o_h =(400 - I_2 *0.5*( R_O2 * pf2 + X_O2 * sqrt (1 - pf2 ^2)))*
        I_2 *0.5* pf2 ;
36  Eff_h = P_o_h /( P_o_h + P_i + P_cu_h );
37  disp ( Eff_h *100 , ' Efficiency  at  half  load  ( in  %)=' );
```

**Scilab code Exa 3.15** Calculate the circuit parameters reffered to LV Side and also calculate the regulation and efficiency of transformer at full load and half load

```
1  // Caption : Calculate  the  circuit  parameters  reffered
       to  LV  Side  and  also  calculate  the  regulation  and
       efficiency  of  transformer  at  full  load  and  half
       load  at  0.8  pf
2  // Exa :3.15
3  clc ;
4  clear ;
5  close ;
6  a =0.5;
7  V1 =250; // in  volts
8  I_o =1.2; // in  amperes
9  W_o =80; // in  watts
10  pf = W_o /( V1 * I_o );
11  pf2 =0.8;
12  R_O = V1 /( I_o * pf );
13  X_O = V1 /( I_o * sqrt (1 - pf ^2));
14  V_sc =25; // in  volts
15  I_sc =10; // in  amperes
16  P_sc =95; // in  watts
17  Z_O2 = V_sc / I_sc ;
```

```
18  R_O2=P_sc/I_sc^2;
19  X_O2=sqrt(Z_O2^2-R_O2^2);
20  R_O1=a^2*R_O2;
21  X_O1=a^2*X_O2;
22  I_2=6000/500;//in amperes
23  VR=I_2*(R_O2*pf2+X_O2*sqrt(1-pf2^2))/500;
24  VR_h=0.5*I_2*(R_O2*pf2+X_O2*sqrt(1-pf2^2))/500;
25  disp(R_O,'R_O (in ohms)=');
26  disp(X_O,'X_O Magnetising reactance (in ohms)=');
27  disp(R_O1,'Equivalent Resistance reffered to LV Side
         (in ohms)=');
28  disp(X_O1,'Equivalent Reactance reffered to LV Side
        (in ohms)');
29  disp(VR*100,'Voltage Regulation at full load (in %)=
        ');
30  disp(VR_h*100,'Voltage Regulation at half load (in %
        )=');
31  P_o=(500-I_2*(R_O2*pf2+X_O2*sqrt(1-pf2^2)))*I_2*pf2;
32  P_i=80;//in watts
33  P_cu=(12/10)^2*P_sc;
34  P_cu_h=0.5^2*P_cu;
35  Eff=P_o/(P_o+P_i+P_cu);
36  disp(Eff*100,'Efficiency at full load (in %)=');
37  P_o_h=(500-I_2*0.5*(R_O2*pf2+X_O2*sqrt(1-pf2^2)))*
        I_2*0.5*pf2;
38  Eff_h=P_o_h/(P_o_h+P_i+P_cu_h);
39  disp(Eff_h*100,'Efficiency at half load (in %)=');
```

**Scilab code Exa 3.16** Find the efficiency of transformer at full load and 75 percent of full load

```
1 //Caption:Find the efficiency of transformer at full
      load and 75 percent of full load (a)at unity
      power factor (b)0.8 power factor
2 //Exa:3.16
3 clc;
4 clear;
5 close;
6 I_2=200;//in amperes
7 R_O2=0.008;//in ohms
8 x=0.75;
9 P_cu=x^2*I_2^2*R_O2;//in watts
10 P_i=190;//in watts
11 KVA=40;
12 P_o=40*1000;//in watts
13 Eff=P_o/(P_o+P_i+I_2^2*R_O2);
14 Eff_2=KVA*1000*0.8/(KVA*1000*0.8+P_i+I_2^2*R_O2);
15 disp(Eff*100,'(a)Efficiency of transformer at full
      load and at unity power factor (in %)=');
16 disp(Eff_2*100,'(b)Efficiency of transformer at full
       load and at 0.8 power factor (in %)=');
17 Eff_3=x*P_o/(x*P_o+P_i+P_cu);
18 Eff_4=x*P_o*0.8/(x*0.8*P_o+P_i+P_cu);
19 disp(Eff_3*100,'(a)Efficiency of transformer at 75%
      of load and at unity power factor (in %)=');
20 disp(Eff_4*100,'(b)Efficiency of transformer at 75%
      of load and at 0.8 power factor (in %)=');
```

**Scilab code Exa 3.17** Determine the Load at which max efficiency occurs and value of max efficiency and New core loss and Cu loss

```
1 //Caption:Determine the (a)Load at which max
```

```
         efficiency  occurs  and  value  of  max  efficiency  (b)
         New  core  loss  and  Cu  loss
 2  //Exa:3.17
 3  clc;
 4  clear;
 5  close;
 6  KVA=20;
 7  P_i=250;//in  watts
 8  P_cu=500;//in  watts
 9  x=sqrt(P_i/P_cu);
10  disp(x*100,'(a)Max  efficiency  will  occur  at');
11  disp('Percent  of  full  load');
12  P_o=x*KVA*1000;
13  Eff=P_o/(P_o+P_i+P_i);
14  disp(Eff*100,'Maximum  Efficiency  (in  %)=');
15  P_cu_n=(P_i+P_cu)/(0.85^2+1);
16  P_i_n=P_i+P_cu-P_cu_n;
17  disp(P_i_n,'(b)Core  Loss  (in  watts)=');
18  disp(P_cu_n,'    Copper  Loss  (in  watts)=')
```

**Scilab code Exa 3.18** Calculate the secondary current at which max efficiency will occur and also calculate the max efficiency

```
 1  //Caption:Calculate  the  secondary  current  at  which
        max  efficiency  will  occur  and  also  calculate  the
        max  efficiency  at  0.8 pf  lagging
 2  //Exa:3.18
 3  clc;
 4  clear;
 5  close;
 6  a=1000/200;
```

```
 7  R_1=0.25;//in ohms
 8  R_2=0.018;//in ohms
 9  R_O2=R_2+R_1/a^2;
10  P_i=240;//in watts
11  I_2=sqrt(P_i/R_2);
12  disp(I_2,'The secondary current at which max
        efficiency will occur (in Amperes)=');
13  P_o=200*I_2*0.8;//in watts
14  P_t=2*P_i;//in watts
15  Eff=P_o/(P_o+P_t);
16  disp(Eff*100,'Max efficiency at 0.8pf lagging(in %)=
        ')
```

**Scilab code Exa 3.19** Find the iron loss copper loss at full load Load KVA at which maximum efficiency occurs and maximum efficiency of transformer

```
 1  //Caption:Find the (a)iron loss (b)copper loss at
        full load (c)Load KVA at which maximum efficiency
         occurs (d)maximum efficiency of transformer at
        0.8pf lagging
 2  //Exa:3.19
 3  clc;
 4  clear;
 5  close;
 6  KVA=150;
 7  pf=0.8;
 8  Eff=0.96;
 9  P_o=KVA*1000*pf;//in watts
10  P_cu=P_o*((1/Eff)-1)*(1-0.5)*4/3;
11  P_i=4999.9-P_cu;
12  disp(P_i,'(a)Iron Loss (in watts)=');
```

```
13  disp(P_cu,'(b)Copper Loss at full load (in watts)=')
       ;
14  x=sqrt(P_i/P_cu);
15  disp(x*KVA,'(c)Load KVA at which maximum efficiency
       occurs (in KVA)=');
16  Eff_max=x*KVA*1000*0.8/(x*KVA*1000*0.8+2*P_i);
17  disp(Eff_max*100,'(d)maximum efficiency of
       transformer at 0.8pf lagging(in %)=')
```

**Scilab code Exa 3.22** Calculate Efficiency at full load and half load

```
1  //Caption:Calculate (a)Efficiency at full load and
       at unity power factor (b)Efficiency at half load
       and 0.8 power factor (c)Efficiency at 75 percent
       of load and 0.7 power factor (d)load KVA at which
        maximum efficiency will occcur (e)maximum
       efficiency at 0.85 power factor
2  //Exa:3.22
3  clc;
4  clear;
5  close;
6  KVA=100;
7  P_cu=1200;//in watts
8  P_i=960;//in watts
9  x1=1;
10 pf1=1;
11 P_o_1=x1*KVA*pf1*1000;
12 Eff_1=P_o_1/(P_o_1+P_i+x1^2*P_cu);
13 disp(Eff_1*100,'(a)Efficiency at full load and at
       unity power factor (in %)=');
14 x2=0.5;
```

```
15  pf2=0.8;
16  P_o_2=x2*KVA*1000*pf2;
17  Eff_2=P_o_2/(P_o_2+P_i+x2^2*P_cu);
18  disp(Eff_2*100,'(b)Efficiency at half load and at
        0.8 power factor (in %)=');
19  x3=0.75;
20  pf3=0.7;
21  P_o_3=x3*KVA*1000*pf3;
22  Eff_3=P_o_3/(P_o_3+P_i+x3^2*P_cu);
23  disp(Eff_3*100,'(c) Efficiency at 75 percent of load
         and 0.7 power factor(in %)=');
24  KVA_max=KVA*sqrt(P_i/P_cu);
25  disp(KVA_max,'(d)load KVA at which maximum
        efficiency will occcur (in KVA)=');
26  Eff_max=KVA_max*1000*0.85/(KVA_max*1000*0.85+2*P_i);
27  disp(Eff_max*100,'(e)maximum efficiency at 0.85
        power factor(in %)=')
```

**Scilab code Exa 3.23** Calculate the core loss and copper loss and also find the value of load current at which max efficiency will be attained

```
1  //Caption:Calculate the core loss and copper loss
       and also find the value of load current at which
       max efficiency will be attained
2  //Exa:3.23
3  clc;
4  clear;
5  close;
6  KVA=100;
7  V2=11000;//in volts
8  x1=1;
```

```
 9  x2 =0.5;
10  pf1 =0.8;
11  pf2 =1;
12  Eff_1 =0.985;
13  Eff_2 =0.99;
14  P_cu =( KVA *1000* x1 * pf1 *((1/ Eff_1 ) -1) - x2 * KVA *1000*((1/
        Eff_2 ) -1)) *(4/3) ;// in watts
15  P_i =1218 - P_cu ;// in watts
16  I_fl = KVA *1000/ V2 ;
17  I_2 = I_fl * sqrt ( P_i / P_cu );
18  disp ( P_cu , 'Copper loss (in watts )=');
19  disp ( P_i , 'Core loss (in watts )=');
20  disp ( I_2 , 'Load current (in amperes )=')
```

**Scilab code Exa 3.24** Calculate the efficiency of the transformer at 75 percent of full load and maximum efficiency

```
 1  // Caption : Calculate the efficiency of the
        transformer at 75 percent of full load and
        maximum efficiency
 2  // Exa :3.24
 3  clc ;
 4  clear ;
 5  close ;
 6  P_o =500; // in watts
 7  Eff_fl =0.9;
 8  Eff_hl =0.9;
 9  P_cu =((( P_o -0.5* P_o )/ Eff_fl ) -0.5* P_o ) *4/3; // in
        watts
10  P_i =0.5* P_cu ;// in watts
11  Eff = P_o *0.75/( P_o *0.75+ P_i +0.75^2* P_cu );
```

```
12  disp(Eff*100,'Efficiency of transformer at 75
        percent of full load(in %)=');
13  P_o_max=P_o*sqrt(P_i/P_cu);
14  Eff_max=P_o_max/(P_o_max+P_i+P_i);
15  disp(Eff_max*100,'Maximum efficiency (in %)=')
```

**Scilab code Exa 3.25** Calculate the efficiency of the transformer on full load and half load at unity power factor

```
1  //Caption:Calculate the efficiency of the
        transformer on full load and half load at unity
        power factor
2  //Exa:3.25
3  clc;
4  clear;
5  close;
6  KVA=100;
7  P_i=1300;//in watts
8  P_cu=1200;//in watts
9  pf=1;
10 Eff_fl=KVA*1000*pf/(KVA*1000*pf+P_i+P_cu);
11 disp(Eff_fl*100,'Efficiency of transformer at full
        load (in %)=');
12 Eff_hl=KVA*1000*0.5*pf/(KVA*0.5*1000*pf+P_i+0.25*
        P_cu);
13 disp(Eff_hl*100,'Efficiency of transformer at half
        load (in %)=');
```

**Scilab code Exa 3.26** Find the voltage regulation

```
1  //Caption:Find the voltage regulation
2  //Exa:3.26
3  clc;
4  clear;
5  close;
6  KVA=100;
7  Eff_max=0.98;
8  x=0.8;
9  pf=0.8;
10 P_o=x*KVA*1000*pf;//in watts
11 P_i=(P_o-P_o*Eff_max)/(2*Eff_max);//in watts
12 P_cu=P_i/x^2;
13 R_equ=P_cu/(KVA*1000);
14 Z_equ=0.05;
15 X_equ=sqrt(Z_equ^2-R_equ^2);
16 VR=R_equ*pf+X_equ*sqrt(1-pf^2);
17 disp(VR*100,'Voltage Regulation (in %)=')
```

**Scilab code Exa 3.27** Calculate the percentage resistance and reactance drops and the percentage of full load at which max efficiency will occur

```scilab
1  //Caption:Calculate the percentage resistance and
       reactance drops and the percentage of full load
       at which max efficiency will occur
2  //Exa:3.27
3  clc;
4  clear;
5  close;
6  KVA=20;
7  V1=1100;//in volts
8  V2=220;//in volts
9  a=V1/V2;
10 P_i=175;//in watts
11 R1=0.25;//in ohms
12 R2=0.012;//in ohms
13 X1=1.1;//in ohms
14 X2=0.055;//in ohms
15 R_O2=R2+R1/a^2;
16 X_O2=X2+X1/a^2;
17 I2=KVA*1000/V2;
18 V_r=I2*R_O2*100/V2;
19 disp(V_r,'Percentage Resistance drop (in %)=');
20 V_re=I2*X_O2*100/V2;
21 disp(V_re,'Percentage Reactance drop (in %)=');
22 P_cu=I2^2*R_O2;
23 x=sqrt(P_i/P_cu);
24 disp(x*100,'Max Efficiency will occur at');
25 disp('percent of full load');
```

**Scilab code Exa 3.28** Find the voltage regulation

```scilab
1  //Caption:Find the voltage regulation
```

```
2 //Exa:3.28
3 clc;
4 clear;
5 close;
6 KVA=500;
7 V2=500;//in volts
8 x=0.75;
9 pf=1;
10 Eff_max=0.97;
11 P_i=(KVA*x*1000*pf-KVA*x*1000*pf*Eff_max)/(2*Eff_max
      );//in watts
12 P_cu=P_i/x^2;
13 R_equ=P_cu/(KVA*1000);
14 X_equ=sqrt(0.1^2-R_equ^2);//in ohms
15 VR=R_equ*0.8+X_equ*0.6;
16 disp(VR*100,'Voltage Regulation (in %)=')
```

**Scilab code Exa 3.29** Calculate the value of iron loss and copper loss which will give max efficiency and also the max efficiency

```
1 //Caption:Calculate the value of iron loss and
      copper loss which will give max efficiency and
      also the max efficiency
2 //Exa:3.29
3 clc;
4 clear;
5 close;
6 KVA=25;
7 P_iron=350;//in watts
8 //For max efficiency P_iron=P_cu
9 P_cu=P_iron;
```

```
10  disp(P_iron,'Iron loss (in watts)=');
11  disp(P_cu,'Copper Loss (in watts)=');
12  Eff=KVA*1000/(KVA*1000+P_iron+P_cu);
13  disp(Eff*100,'Maximum Efficiency (in %)=');
```

**Scilab code Exa 3.30** Find the Efficiency and voltage regulation of transformer

```
1  //Caption:Find the Efficiency and voltage regulation
       of transformer
2  //Exa:3.30
3  clc;
4  clear;
5  close;
6  P_i=100;//in watts
7  V2=400;//in volts
8  P_sc=200;//in watts
9  I_2=11.4;//in amperes
10  R_02=P_sc/I_2^2;//in ohms
11  KVA=5;
12  I_2fl=KVA*1000/V2;
13  P_cu=I_2fl^2*R_02;
14  pf=0.9;
15  Eff=KVA*1000*pf/(KVA*1000*pf+P_cu+P_i);
16  disp(Eff*100,'Efficiency (in %)=');
17  V_2sc=40;//in volts
18  Z_02=V_2sc/I_2;
19  X_02=sqrt(Z_02^2-R_02^2);
20  VR=I_2fl*(R_02*pf+X_02*sqrt(1-pf^2))/V2;
21  disp(VR*100,'Voltage Regulation (in %)=')
```

# Chapter 4

# Three Phase Transformers

**Scilab code Exa 4.1** Find the value of line current

```
1  //Caption:Find the value of line current
2  //Exa:4.1
3  clc;
4  clear;
5  close;
6  a=2200/200;//transformation ratio
7  P=450*1000;//in watts
8  pf=0.85;
9  V_s=200;//in volts
10 I_2=P/(pf*V_s);//in amperes
11 I_1=1.15*I_2/a;
12 disp(I_1,'Value of line currents (in Amperes)=')
```

**Scilab code Exa 4.2** Find the value of line current

```
1  //Caption:Find  the  value  of  line  current
2  //Exa:4.2
3  clc;
4  clear;
5  close;
6  a=2200/200;//transformation  ratio
7  P_1=400*1000;//in  watts
8  P_2=500*1000;//in  watts
9  pf=0.8;
10 V_s=200;//in  volts
11 I_2=P_1/(pf*V_s);//in  amperes
12 I_1=1.15*I_2/a;
13 I_1T=I_1/2;
14 I_2M=P_2/(pf*V_s*a);
15 I_p=sqrt((I_1T^2)+(I_2M^2));
16 disp(I_p,'Value  of  line  current  (in  Amperes)=')
```
─────────────────────────────────────────

**Scilab code Exa 4.3** Determine the efficiency of transformer

```
1  //Caption:Determine  the  efficiency  of  transformer  at
       (a)full  load  and  0.85 pf  (b)75  percent  of  full
     load  and  unity  pf  (c)max  efficieny  at  unity  pf
2  //Exa:4.3
3  clc;
4  clear;
5  close;
6  P=100*1000;//in  watts
7  P_iron=1500;//in  watts
8  x=0.8;
9  P_cu=1500/x^2;//in  watts
10 pf=0.8;
```

```
11  a=5000/400;//transformation ratio
12  P_t=P_iron+P_cu;
13  P_o=0.85*P;//in watts
14  Eff=P_o/(P_o+P_t);
15  disp(Eff*100,'(a)Efficiency at full load and 0.85pf
       (in %)=');
16  P_cu_1=0.75*P_cu;//in watts
17  P_t_1=P_cu_1+P_iron;//in watts
18  P_o_1=0.75*P;
19  Eff_1=P_o_1/(P_o_1+P_t_1);
20  disp(Eff_1*100,'(b)Efficiency at 75 percent of full
       load and unity pf(in %)=');
21  P_t_2=2*P_iron;
22  P_o_2=P;
23  Eff_2=P_o_2/(P_o_2+P_t_2);
24  disp(Eff_2*100,'(c)max efficieny at unity pf(in %)='
       );
```

**Scilab code Exa 4.4** Find the value of line voltage and line current and output

```
1  //Caption:Find the value of line voltage,line
       current,and output when the transformer winding
       is connected as (a) Star−delta (b)delta−star
2  //Exa:4.4
3  clc;
4  clear;
5  close;
6  a=10;//transformation ratio
7  V_s=3300;//in volts
8  I_1=10;//in amperes
```

```
 9  V_1=V_s/sqrt(3);
10  V_2=V_1/a;
11  I_2=sqrt(3)*a*I_1;
12  P_o=sqrt(3)*V_2*I_2;
13  disp("For Star-Delta Configruation")
14  disp(V_2,'Line voltage (in volts)=');
15  disp(I_2,'Line current (in amperes)=');
16  disp(P_o,'Output (in watts)=');
17  V_2p=V_s/a;
18  V_2L=sqrt(3)*V_2p;
19  I_2L=I_1*a/sqrt(3);
20  P_o2=sqrt(3)*V_2*I_2;
21  disp("For Delta-Star Configruation")
22  disp(V_2L,'Line voltage (in volts)=');
23  disp(I_2L,'Line current (in amperes)=');
24  disp(P_o2,'Output (in watts)=');
```

**Scilab code Exa 4.5** Find the Efficiency

```
 1  //Caption:Find the Efficiency
 2  //Exa:4.5
 3  clc;
 4  clear;
 5  close;
 6  P=1200*1000;//in watts
 7  R_1=2;//in ohms
 8  R_2=0.03;//in ohms
 9  P_iron=20000;//in watts
10  V_1p=6600;//in volts
11  V_2p=1100/sqrt(3);//in volts
12  a=V_1p/V_2p;
```

```
13 R_o2=R_2+(R_1/a^2);//in ohms
14 I_2p=P/(sqrt(3)*1100);//in amperes
15 P_cu=3*R_o2*I_2p^2;
16 P_t=P_iron+P_cu;
17 P_o=0.9*P;//in watts
18 Eff=P_o/(P_o+P_t);
19 disp(Eff*100,'Efficiency (in %)=')
```

**Scilab code Exa 4.6** Find the percentage resistance and reactance drop and efficiency and voltage regulation

```
1 //Caption:Find the percentage resistance,reactance
      drop,efficiency and voltage regulation
2 //Exa:4.6
3 clc;
4 clear;
5 close;
6 P=1500*1000;//in watts
7 phy=acosd(0.8);
8 V_1P=300;//in volts
9 V_1L=6600;//in volts
10 I_1P=131.21/sqrt(3);
11 Z_1=V_1P/I_1P;//in ohms
12 R_1=30*1000/(3*I_1P^2);
13 X_1=sqrt((Z_1^2)-(R_1^2));
14 R=I_1P*R_1*100/V_1L;
15 X=I_1P*X_1*100/V_1L;
16 disp(R,'% Resistance drop (in %)=');
17 disp(X,'% Reactance drop (in %)=');
18 VR=(R*cosd(phy))+(X*sind(phy));
19 disp(VR,'Voltage regulation (in %)=')
```

```
20  I_1_FL=P/(sqrt(3)*V_1L);
21  P_t=(30+25)*1000;//in watts
22  P_o=P*0.8;//in watts
23  Eff=P_o/(P_o+P_t);
24  disp(Eff*100,'Efficiency (in %)=')
```

**Scilab code Exa 4.7** Determine the KVA Load and Percentage rated load and Total KVA Rating and Ratio of star bank to delta bank transformer rating and percentage increase in load

```
1  //Caption:Determine the (a)KVA Load (b)Percentage
       rated load (c)Total KVA Rating (d)Ratio of star−
       star bank to delta−delta bank transformer rating
       (e)% increase in load
2  //Exa:4.7
3  clc;
4  clear;
5  close;
6  KVA=25;
7  KVA_s=50/sqrt(3);
8  disp(KVA_s,'(a)KVA Load supplied by each transformer
       (in KVA)=');
9  r=KVA_s/KVA;
10 disp(r,'(b)Percent of rated load (in %)=');
11 KVA_t=2*25*0.866;
12 disp(KVA_t,'(c)Total KVA rating (in KVA)=');
13 ratio=KVA_t/75;
14 disp(ratio,'(d)Ratio=');
15 KVA_s2=50/3;
16 Inc=KVA_s/KVA_s2;
17 disp(Inc*100,'(e)Increase in load (in %)=')
```

**Scilab code Exa 4.8** Determine the Current flowing in various sections and Power transformed and Power conducted directly

```scilab
1  //Caption:Determine the (a)Current flowing in
       various sections (b)Power transformed (c)Power
       conducted directly
2  //Exa:4.8
3  clc;
4  clear;
5  close;
6  P=400*1000;//in watts
7  pf=0.8;
8  V_1=550;//in volts
9  V_2=440;//in volts
10 I_2=P/(sqrt(3)*V_2*pf);// in amperes
11 I_1=I_2*V_2/V_1;//in amperes
12 I=I_2-I_1;
13 disp(I,'(a)Currents in sections Oa,Ob and Oc (in
       amperes)=');
14 disp(I_1,' Currents in sections Aa,Bb and Cc (in
       amperes)=');
15 P_trans=P*(1-(V_2/V_1));
16 disp(P_trans/1000,'(b)Power transformed by
       transformer action (in Kw)=');
17 P_cond=P-P_trans;
18 disp(P_cond/1000,'(c)Power Conducted directly(in Kw)
       =')
```