QMP 7.1 D/F

Channabasaveshwara Institute of Technology
(An ISO 9001:2015 Certified Institution)
NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

Department of Electrical & Electronics Engineering

SCILAB FOR ELECTRIC MOTORS
Lab Manual

21EEL482

B.E - IV Semester
Lab Manual 2022-23

Name :____

USN :____

Batch : ____________________Section : ________________

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Lab Manual

Version 1.0
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SCILAB FOR ELECTRIC MOTORS

Sub Code: 21EEL482	**CIE Marks: 50**
Hrs/week: 03	**Exam Hours: 02**
Credits – 1	**SEE Marks: 50**

1. Load test on dc shunt motor to draw speed – torque and horse power – efficiency characteristics
2. Field Test on dc series machines.
3. Speed control of dc shunt motor by armature and field control.
4. Swinburne’s Test on dc motor.
5. Regenerative test on dc shunt machines.
6. No load and Blocked rotor test on three phase induction motor to draw (i) equivalent circuit and (ii) circle diagram. Determination of performance parameters at different load conditions from (i) and (ii).
7. Load test on three phase induction motor.
8. Load test on single phase induction motor to draw output versus torque, current, power and efficiency characteristics.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION:

To be a department of excellence in electrical and electronics Engineering education and Research, thereby to provide technically competent and ethical professionals to serve the society.

MISSION:

- To provide high quality technical and professionally relevant education in the field of electrical engineering.
- To prepare the next generation of electrically skilled professionals to successfully compete in the diverse global market.
- To nurture their creative ideas through research activities.
- To promote research and development in electrical technology and management for the benefit of the society.
- To provide right ambience and opportunities for the students to develop into creative, talented and globally competent professionals in electrical sector.

Caution

1. *Do not play with electricity.*

2. *Carelessness not only destroys the valuable equipment in the lab but also costs your life.*

3. *Mere conductivity of the experiment without a clear knowledge of the theory is of no value.*

4. *Verify the program before execution.*

5. *Turn off all PC's before leaving lab.*

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Note:

Sl. No.	Name of the Experiment	Date			Manual Marks (Max . 20)	Record Marks (Max. 10)	Signature (Student)	Signature (Faculty)
		Conduction	Repetition	Submission of Record				
Average								

- **If the student fails to attend the regular lab, the experiment has to be completed in the same week. Then the manual/observation and record will be evaluated for 50% of maximum marks.**

Course objectives & outcomes

Course objectives:

1. Along with prescribed hours of teaching –learning process, provide opportunity to perform the experiments/programmes at their own time, at their own pace, at any place as per their convenience and repeat any number of times to understand the concept.

2. Provide unhindered access to perform whenever the students wish.

3. Vary different parameters to study the behavior of the circuit without the risk of damaging equipment/ device or injuring themselves.

Course outcomes:

At the end of the course, the student will be able to:

1. Analyse in a systematic way, think better, and perform better

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Experiment No: 01

Load test on dc shunt motor to draw speed – torque

Aim: To draw the torque speed characteristics of DC shunt motor.

Program Code:

```
clc;
clear;
close;
format('v',7);

//Given Data :
V=220;//V
f=50;//Hz
L=0.012;//H
Ra=0.72;//ohm
K=2;//V/rad/s
T=60;//N-m
alfa=90;//degree
Va=3*sqrt(3)*V*sqrt(2)/2/%pi*(1+cosd(alfa));//V
Ia=5;//A
disp(Ia,"Armature Current in A : ");
T1=Ia*K;//N-m
disp(T1,"Torque in N-m : ");
Eb=Va-Ia*Ra;//V
omega=Eb/K;//rad/s
N1=omega*60/2/%pi;//rpm
disp(N1,"Speed in rpm : ");
disp("");
Ia=10;//A
disp(Ia,"Armature Current in A : ");
T2=Ia*K;//N-m
disp(T2,"Torque in N-m : ");
Eb=Va-Ia*Ra;//V
omega=Eb/K;//rad/s
N2=omega*60/2/%pi;//rpm
disp(N2,"Speed in rpm : ");
Ia=20;//A
disp(Ia,"Armature Current in A : ");
T3=Ia*K;//N-m
disp(T3,"Torque in N-m : ");
Eb=Va-Ia*Ra;//V
omega=Eb/K;//rad/s
```

```
N3=omega*60/2/%pi;//rpm
disp(N3,"Speed in rpm : ");
Ia=30;//A
disp(Ia,"Armature Current in A : ");
T4=Ia*K;//N-m
disp(T4,"Torque in N-m : ");
Eb=Va-Ia*Ra;//V
omega=Eb/K;//rad/s
N4=omega*60/2/%pi;//rpm
disp(N4,"Speed in rpm : ");
plot([T1 T2 T3 T4],[N1 N2 N3 N4]);
title('Speed Torque Characteristics');
xlabel('Torque(N-m)');
ylabel('speed(RPM)');
```

Experiment No: 02

FIELD TEST ON DC SERIES MACHINES

Aim:

1) Determine the stray losses of DC series machines.
2) Calculate the Efficiency of Motor.
3) Calculate the Efficiency of Generator.

> **Example 2.9.1** *A Field's test on two mechanically coupled similar motors with their fields connected in series and with one machine running as motor and the other as a generator gave the following data :*
> *Motor : Armature current 40 A, armature voltage 200 V, the drop across its field winding 15 V.*
> *Generator : Armature current 32 A, armature voltage 160 V, the drop across its field winding 15 V.*
> *The resistance of each armature is 0.4 Ω. Calculate the efficiency of each machine at this load.*

Input Parameter: (Example 2.9.1 -UA Bhakshi & M V Bhakshi – Page No 2-41)
Volage across armature V=200V
Motor Input current I_1=40 A
Load current I_2=32 A
Voltage across generator V_2 =160V
Armature and Field Resistance Ra, Rse= 0.4Ω
Theroretical Calculation Results:
Efficiency of motor = 76.81%
Efficiency of Generator =75.9 %

Progam Code:

```
clc,clear
printf('Field Test')
printf('Motor Data')
I_1=input ('Eneter the value of Armature current in Amp')//motor input current
V=input('Eneter the value of Armature voltage in Volt') //voltage across armature
V_field = input ('Eneter the value of voltage drop across fiel winding in Volt')
//voltage drop across field winding of motor-generator
printf('Generator Data')
I_2=input ('Eneter the value of Armature current in Amp') // load current
```

```
V_2=input ('Eneter the value of Armature voltage in volts') // voltage across generator
R_a= input ('Eneter the value of Armature resistance for each machine in Ohm')
//armature resistance for each machine
R_se= (V_field/I_1) //series field resistance for each machine
total_input=(V+V_field)*I_1
output=V_2*I_2
total_loss_g_m= total_input - output //total losses of 2 machines
R_se=V_field/I_1 //series field resistance for both windings
total_cu_loss = (R_a+ 2*R_se)*I_1^2  + R_a*I_2^2  //total copper loss
stray_loss= total_loss_g_m -total_cu_loss
stray_loss_each = stray_loss/2 //stray loss for each machine

// for motor
motor_input = V*I_1
arm_cu_loss_m = (R_a+ R_se)*I_1^2   //armature coper losses of motor
total_loss_m=arm_cu_loss_m + stray_loss_each
motor_output=motor_input-total_loss_m
eta_m = 100*(motor_output/motor_input)//motor efficiency
printf('Efficiency of motor is %.4f percent\n',eta_m)

// for generator
arm_cu_loss_g = R_a*I_2^2 //armature coper losses of generator
series_field_cu_loss_g = V_field*I_1   //series field copper loss
total_loss_g=arm_cu_loss_g + series_field_cu_loss_g + stray_loss_each
generator_output=V_2*I_2
generator_input = generator_output + total_loss_g
eta_g = 100*(generator_output/generator_input)//generator efficiency
printf('Efficiency of generator is %.4f percent\n',eta_g)
```

Output :

Field TestMotor Data

Eneter the value of Armature current in Amp=40
Eneter the value of Armature voltage in Volt=200
Eneter the value of voltage drop across fiel winding in Volt=15

Generator Data

Eneter the value of Armature current in Amp =32
Eneter the value of Armature voltage in volts = 160
Eneter the value of Armature resistance for each machine in Ohm=0.4

Efficiency Values

Efficiency of motor is 76.8100 percent
Efficiency of generator is 75.9103 percent

Note : The above program is generalised ,it can be tested with any tested values of filed test.

Experiment No: 03

Speed Control of DC shunt Motor by armature and field control

Aim :

1) To Determine the speed at variable load.
2) Armature Voltage control method.

Program Code :1)To Determine the speed at variable load.

```
clc,clear,
V=230//voltage applied to motor
N1=1000//initial speed
Ia=35//armature current
Ra=.3//resistance of armature circuit
Eb1=V-Ia*Ra
N1=1000//speed in rpm
Ia=25//armature current in new situation
N2=750//changed speed in rpm
//back emf is directly proportional to speed
R=((V-Ia*Ra)*N1-N2*Eb1)/(Ia*N1)
mprintf("Additional resistance in armature circuit=%f ohm",R)
```

2)Armature Voltage Control Method.

```
//solving (i)
clc,clear;
Il=70//current drawn by the motor
V=200//applied voltage
Rsh=100//shunt field resistance
Ish=V/Rsh//shunt field current
Ia1=Il-Ish
N1=500//initial speed
Ra1=.2//armature resistance
Eb1=200-Ia1*Ra1
N2=350//reduced speed of motor
Ia2=Ia1//armature current remains same
//Eb2=200-68*(R+.2)
//back emf is proportional to speed
R=((V-Ia2*Ra1)*N1-Eb1*N2)/(Ia2*N1)
mprintf("Additional resistance in the armature circuit=%f ohm\n",R)
//solving (ii)
Ra2=R+Ra1//armature resistance
Ia3=35//armature current
Eb3=V-Ia3*Ra2
N3=N1*Eb3/Eb1
mprintf("Speed=%d rpm",N3);
```

Experiment No: 04

Swinburne's Test

Aim:

1) To determine Constant losses
2) To Calculate the Efficiency of Motor
3) To Calculate the Efficiency of Generator.

Input Parameter:

Example 2.5.1 *A 500 V, D.C. shunt motor when running on no load takes 5 A. Armature resistance is 0.5 Ω and shunt field resistance is 250 Ω. Find the output in kW and efficiency of the motor when running on full load and taking a current of 50 A.*

No load Voltage V = 500,
No Load Current I_o =5A
Rsh=250Ω, Ra=0.5Ω
Full load Current I_L=50A.

Theoretical Result :
Efficiency of Generator = 86.66 %
Motor Efficiency = 85.41 %

Program Code:

```
clc;
clear;
printf('Swinburne test or No load test';
V=input('Enter the supply voltage =');
Rsh=input('Enter the shunt resistance =');
Ra=input('Enter the armature resistance =');
ILo=input('Enter the nolad current =');
Ish=V/Rsh;
Iao=ILo-Ish;
Pc=(V*ILo)-(Iao)^2 *Ra;
printf('Constant losses in watts = %.2f\n',Pc);
disp(Pc);
printf('For Generator');
IL=input('Eneter the Full load current =')
Pout=IL*V;
Ia=IL+Ish;
Pcug=Ia^2*Ra;
Eff_gen=100*((Pout)/(Pout+Pcug+Pc)); // Efficiency of Generator
printf('Efficiency as a generator = %.2f percent\n',Eff_gen);
```

```
printf('For Motor');
Pin=Pout;
Ia=IL-Ish;
Pcum=Ia^2*Ra;
Eff_mot=100*((Pin-Pc-Pcum)/(Pin));
printf('Efficiency as a motor = %.2f percent',Eff_mot);
```

Output:

Swinburne test or No load test

Enter the supply voltage = 500
Enter the shunt resistance =250
Enter the armature resistance =0.5
Enter the No load current =5
Constant losses in watts = 2495.50

For Generator

Eneter the Full load current =50
Efficiency as a generator = 86.66 percent

For Motor

Efficiency as a motor = 85.41 percent

Experiment 05

Regenerative test on dc shunt machines

Aim:

1) To determine Constant losses
2) To Calculate the Efficiency of Motor
3) To Calculate the Efficiency of Generator.

Input Parameter:

Example 2.8.3 *Two identical d.c. shunt machine, when tested by Hopkinson's method, gave the following data :*

Line voltage = 230 V

Line current excluding the field current = 30 A

Motor armature current = 230 A

Field currents 5 A and 4 amp. The armature resistance of each machine is 0.025 Ω

Calculate the efficiency of both the machines. **VTU : Jan.-09, 14, March-02, 03, Marks 10**

Theoretical Calculation output:

Efficiency of Generator : 93.90%

Efficiency of Motor : 88.06%

Program Code:

```
clc,
clear
printf('Hopkinsons Test')
V=input('Enter the value of line voltage in Volt')
I=input ('Enter the value of line current excluding field current in Amp')
I_a_m =input('Enter the value of armature current of motoring machine in Amp')
//armature currents for generator and motor
I_a_g= (I_a_m - I)// Armature current of generator
I_sh_g= input ('Enter the value of field current of generator in Amp'),//current through shunt field for generator
I_sh_m = input ('Enter the value of field current of motor in Amp'), //current through shunt field for generator and motor
R_a= input ('Enter the value of armature resistance of each machine')//armature resistance
arm_cu_loss_g = R_a*I_a_g^2 //armature copper loss for generator
arm_cu_loss_m = R_a*I_a_m^2 //armature copper loss for motor
power_drawn=V*I
IFW_losses = power_drawn - (arm_cu_loss_g + arm_cu_loss_m) //Iron , friction and windage losses
```

```
IFW_losses_each=IFW_losses/2 //Iron,friction and windage losses for each machine
//for motor
field_cu_loss_m= V*I_sh_m //field copper loss for motor
total_loss_m= field_cu_loss_m + IFW_losses_each + arm_cu_loss_m //total losses in motor
motor_input=V * I_a_m
motor_output= motor_input - total_loss_m
eta_m = 100*(motor_output/motor_input)  //motor efficiency
printf('Efficiency of motor is %.4f percent\n',eta_m)

//for generator
field_cu_loss_g= V*I_sh_g //field copper loss for generator
total_loss_g = field_cu_loss_g + arm_cu_loss_g + IFW_losses_each //total losses in generator
generator_output=V*I_a_g
generator_input = generator_output + total_loss_g
eta_g = 100*(generator_output/generator_input)//generator efficiency
printf('Efficiency of generator is %.4f percent\n',eta_g)
```

Output

Hopkinson's Test

Enter the value of line voltage in Volt=230
Enter the value of line current excluding field current in Amp=30
Enter the value of armature current of motoring machine in Amp=230
Enter the value of field current of generator in Amp=5
Enter the value of field current of motor in Amp=4
Enter the value of armature resistance of each machine=0.25
Efficiency of motor is 88.6909 percent
Efficiency of generator is 93.9015 percent

Experiment 06

Load test on three phase induction motor.

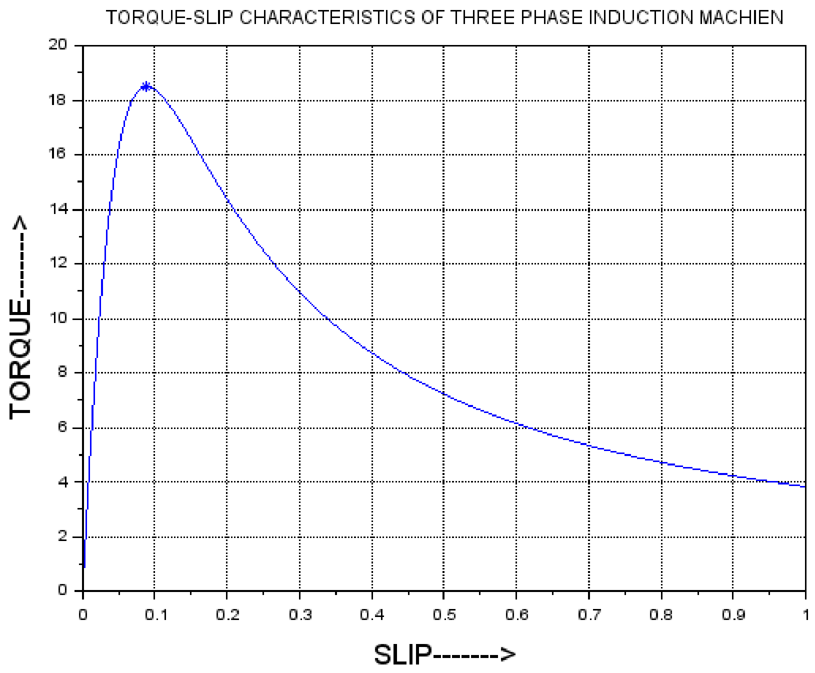
Aim :

1. To plot Torque slip characteristics of 3 Phase Induction motor
2. Torque-speed Characteristics of 3 Phase Induction Motor.

Program:

```
clear all;
clc;
V=input('eneter the value of voltage in volts:');
f=input('enter the value of frequency in hertz:');
P=input('enter the no of poles:');
N=input('Enter the rated speed in rpm:');
Rs=input('Enter the value of stator resistance:');
Rr=input('Enter the value of rotor resistance:');
Xs=input('Enter the vaue of stator reactance:');
Xr=input('Eneter the value of rotor reactance:');
Vph=V/sqrt(3);
//disp(Vph);
Ns=(120*f)/P;
s=(Ns-N)/Ns;
//disp(s);
Ws=Ns*(2*%pi/60);
s=[0.0001:0.001:1];
R1=Rr./s;
R=(Rs+R1);
X=(Xs+Xr);
T=(3*Vph^2.*R1)./(Ws*(R.^2+X.^2));
plot(s,T);
Smax=Rr/sqrt((Rs)^2+(Xs+Xr)^2)
title('TORQUE-SLIP CHARACTERISTICS OF THREE PHASE INDUCTION
MACHINE',"fontsize",2);
xlabel("SLIP------>","fontsize",4);
ylabel("TORQUE------>","fontsize",4);
plot(Smax,max(T),'*');
xgrid;
```

Output Graph

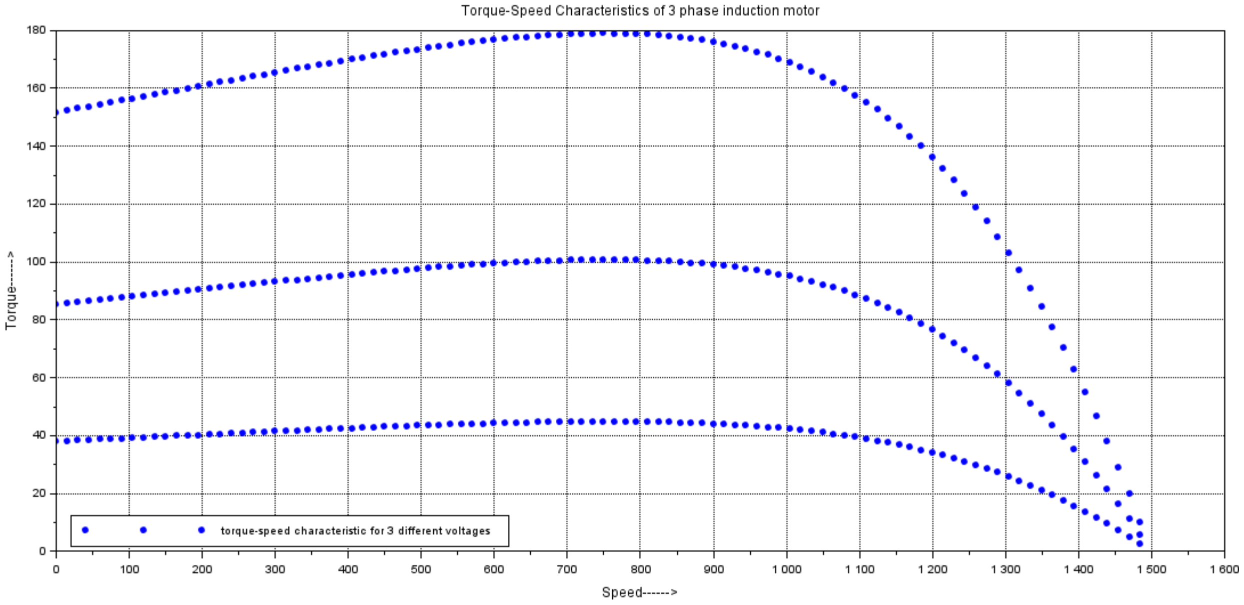


2. Torque-speed Characteristics of 3 Phase Induction Motor

Program:

```
clc;
clear all;
Pout=input('Enterthe value of Output Power:');
v=input('Enter the value of Voltage in volts;');
f=input('enter the vvalue of frequency in hertz:');
P=input('enter the no of poles:');
N=input('Enter the rated speed in rpm:');
Rs=input('Enter the value of stator resistance:');
Rr=input('Enter the value of rotor resistance:');
Xs=input('Enter the vaue of stator reactance:');
Xr=input('Eneter the value of rotor reactance:');
Xm=input('enter the value of Magnetising reactance:')
Ns=(120*f)/P; // Syncrhonous speed in rpm
s=(Ns-N)/Ns;
disp(s);
Ws=Ns*(2*%pi/60); // Angular speed in rad/sec
for s=0.01:0.01:1;
  for v=(v-200):100:v;
    Sm=(Rr/sqrt(Rs^2+(Xs+Xr)^2));
```

```
        N=(1-s)*Ns;
        a=(3/Ws);
        b=((v^2)/((Rs+(Rr/s))^2+(Xs+Xr)^2));
        c=(Rr/s);
        T=a*b*c;
        // Tm=(3/(2*Ws))*(v^2/Rs+sqrt(Rs^2+(Xs+Xr)^2)));
         plot(N,T,'.');
      end
    end
title('Torque-Speed Characteristics of 3 phase induction motor',"fontsize",2);
xlabel('Speed --- >');
ylabel('Torque ---->');
xgrid;
legend('torque-speed characteristic for 3 different voltages',3);
```



Experiment 07

No load and Blocked rotor test on three phase induction motor

Aim:
1) Calculation of Equivalent circuit parameter
2) Circle diagram. Determination of performance parameters at different load conditions.

1)Equivalent Circuit Parameter.

```
clc;
clear;
printf('No Load and Blocked rotor test \n \n');
R1=input('Enter the Stator winding  resistance=');
// Block rotor test
Vsc=input('Enter the Short circuit Voltage =');
Vscph=Vsc/sqrt(3); // Per phase voltage
Isc=input('Eneter the short circuit current=');
Wsc=input('Enter the short cirucuit power=');
Wscph=Wsc/3; //Per phase power
Z2=Vscph/Isc; // Per phase impedance
R2=Wscph/Isc^2; //Rotor resistance per phase
X2=sqrt((Z2^2)-(R2^2));
R2_dash=R2-R1;
X1=X2/2;
X2_dash=X1;
//No load test
Voc=input('Entertheopencircuitvoltage=');
Ioc=input('Entertheopencircuitcurrent=');
Woc=input('Eneter No load power =');
Wocph=Woc/3;
Vocph=Voc/sqrt(3);
pf=Wocph/(Vocph *Ioc);
//disp(pf)
phio=acos(pf);
Ic=Ioc*cos(pf);
Im=-Ioc*sin(phio);
Z1=sqrt(R1^2+X1^2);
Ro=(Vocph)/Ic;
Xm=(Vocph)/Im;
mprintf("Equivalent circuit parameters are\nR1=%f ohm;\nX1=%f
ohm;\nR2_dash=%fohm;\nX2_dash=%fohm;\nRo=%fohm;\nXm=%f
ohm",R1,X1,R2_dash,X2_dash,Ro,Xm);
```

(b) //Circle Diagram

```
clc
clear
k1=40//current scale
Vph=400/sqrt(3)//voltage per phase
P=k1*Vph//power per phase
k2=3*P//power scale
//calculating full load stator current
P=33.6D+3//output of motor
P1=P/k2//ouput of motor to scale
//P is the corresponding operating point
OP=1.55
I1=OP*k1
phi1=28.5
mprintf("Full load stator current=%f A with %f power factor lagging\n",I1,cos(phi1*%pi/180))
//calculating efficiency at full load
PL=2.35
PX=2.75
e=PL/PX*100
mprintf("Efficiency at full load=%f percent\n",e)
//calculating max power output
NPm=2.6
mprintf("Maximum output power=%f kW\n",NPm*k2*10^-3)
//calculting max torque developed
MTm=3.12
mprintf("Maximum torque developed by the motor=%f kW",MTm*k2*10^-3)
```

Experiment 08

Load test on single phase induction motor to draw output versus torque, current, power and efficiency characteristics.

Aim: Calculation of Equivalent circuit parameter

Program Code:

```
a)// To determine Equivalent circuit parameter
Clc;
clear all
f=50//frequency in Hz
P=4//no. ofpoles
Ns=120*f/P//synchronous speed
Nr=1420
//calculating forward slip
s=(Ns-Nr)/Ns
mprintf("Forward slip=%f p.u.\n",s)
//calculating backward slip
s1=2-s
mprintf("Backward slip s_b=%f p.u.\n",s1)
//calculating effective rotor resistance in forward branch
R2_dash=4.5
Rf=R2_dash/(2*s)
mprintf("Effective rotor resistance in forward branch=%f ohm\n", Rf)
//calculating effective rotor resistance in backward branch
Rb=R2_dash/(2*(2-s))
mprintf("Effective rotor resistance in backward branch=%f ohm", Rb)
//answers vary from the textbook due to round off error
```

(b) to determine the rotor losses

```
clc;
clear;
function [r, theta]=rect2pol(A)
  x=real(A)
  y=imag(A)
  r=sqrt(x^2+y^2)
  theta=atand(y/x)
endfunction
function [z]=pol2rect(r, theta)
  x=r*cos(theta*%pi/180)
  y=r*sin(theta*%pi/180)
  z=x+y*%i
endfunction
```

```
function [r]=mag(A)
  x=real(A)
  y=imag(A)
  r=sqrt(x^2+y^2)
endfunction
f=50//frequency
P=4//no. of poles
Ns=120*f/P//synchronous speed
Nr=1420//motor speed
s=(Ns-Nr)/Ns
R1=2.5
X1=3.365
Xm=60.945
R2_dash=3.28
X2_dash=3.365
Zf=(Xm*%i/2)*(R2_dash/(2*s)+%i*X2_dash/2)/(R2_dash/(2*s)+%i*(Xm+X2_da
sh)/2)//forward impedance
Zb=(%i*Xm/2)*(R2_dash/(2*(2-s))+%i*X2_dash/2)/(R2_dash/(2*(2-
s))+%i*(Xm+X2_dash)/2)//backward impedance
Z1=R1+%i*X1
Zin=Z1+Zf+Zb//input impedance
//calculating input current and power factor
V1=pol2rect(230,0)
I1=V1/Zin
[I1 theta]=rect2pol(I1)
mprintf("Input current drawn by the motor is %f A lagging the applied voltage by
an angle of %f degrees, that is at %f pf lagging\n", I1,-theta,cos(theta*%pi/180))
//calculating input power
Pin=mag(V1)*I1*cos(theta*%pi/180)
mprintf("Power input=%f W\n", Pin)
//calculating torque developed
Pgf=I1^2*real(Zf)
Pgb=I1^2*real(Zb)
omega_s=2*%pi*Ns/60
T=(Pgf-Pgb)/omega_s
mprintf("Resultant torque developed=%f N-m\n",T)
//calculating output power
Pm=(Pgf-Pgb)*(1-s)//mechanical power developed
W0=220//power consumed under no load
I0=6.4//no load current
Prot=W0-I0^2*(R1+R2_dash/4)//rotational losses
Pout=Pm-Prot
mprintf("Output power developed=%f W\n",Pout)
//calculating efficiency
```

```
e=Pout/Pin*100
mprintf("Efficiency=%f percent\n", e)
//calculating air gap power
Pg=Pgf+Pgb
mprintf("Air gap power=%f W\n",Pg)
//calculating rotor copper losses
Prc=s*Pgf+(2-s)*Pgb
mprintf("Rotor copper losses=%f W",Prc)
```