UNIVERSITY OF GAZIANTEP
ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

EEE 322/LAB

EXPERIMENT 8

THE COMPLETE TORQUE/SPEED CHARACTERISTIC OF AN INDUCTION MOTOR

Object of the Experiment:

The object of this experiment is to measure the torque/speed characteristic of a squirrel cage and wound rotor I/M over a wide range of speed, covering operation as motor, generator and brake and to observe the variation of input power, power-factor and stator current over this range.

Theory

From the equivalent circuit of an I/M, torque can be determined as:

$$\tau = \frac{3V_1^{\,2}}{(R1 + R'_2/S)^2 + (X_1 + X'_2)^2}\,\frac{R'^2}{sw_s}$$

The general shape of the torque/speed characteristic or torque slip curve is shown in Fig.1.

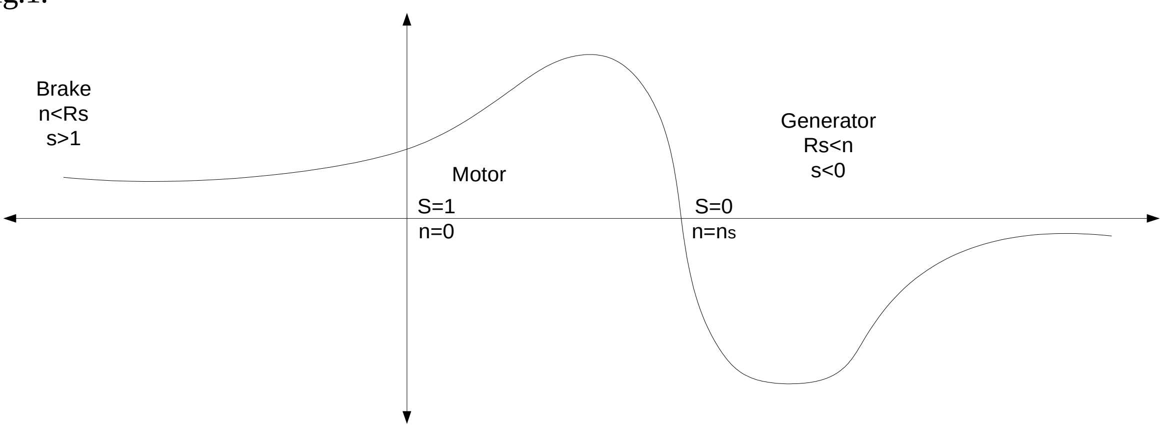


Fig.1 complete torque-slip curve of an induction machine

In the figure,

s<0 : Generator region of operation
0<s<l : Motor region of operation
0<s<1 : Brake region of operation

The slip which gives maximum torque is obtained by taking the derivative of T w.r.t. 's' and equating it to zero.
Hence s is found as:

$$S_{\max} = \frac{R'_2}{\sqrt{R_{TH}{}^2 + (X_{TH} + X_2{}^2)}}$$

and the corresponding torque for exact equivalent circuit is:

$$\tau \max = \frac{1.5 V_{TH}{}^2}{[R_{TH} + [R_{TH}{}^2 + (X_{TH} + X_2')^2]^{1/2}]} \frac{1}{w_{syn}}$$

where R_t and X_t Thevenin Equivalent parameters and V_{la} is the Thevenin Equivalent voltage of the stator circuit.

From Eqn.(1) it can be seen that torque is proportional to the square of input voltage. Investigations on Eqn's (2) and (3) reveal that rotor resistance (R_2) has no effect on T_{max} whereas, s_n is directly proportional to R'_2. Therefore, changing the rotor resistance, the slip at which T_{max} occurs can be varied, without affecting the magnitude of T_{max}.

The effect of voltage and added rotor resistance are shown in Fig.2. Since by varying the stator voltage and adding resistance to the rotor we can change torque/speed characteristics. We can use these two methods as methods of speed control of induction motors. This is also shown in Fig.2.

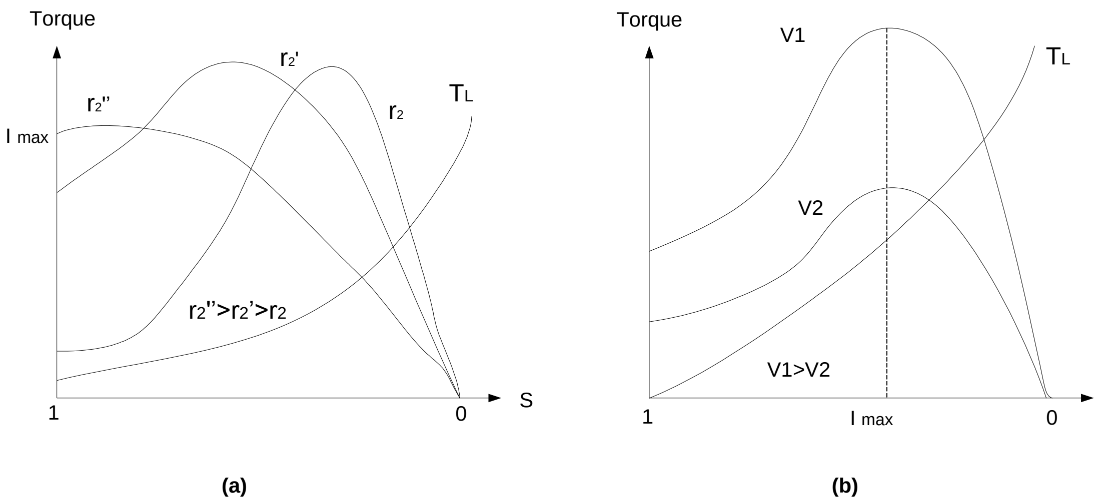


Fig.2. induction-motor torque-slip curves (T= load torque)

a) Effect of added rotor resistance
b) effect of stator voltage

C.Procedure

1. Connect the circuit as shown in Fig.3 with the positive terminal of eddy current brake assembly being open.

2. Close switch S1 and apply a stator voltage of around 100 Volts (line) using 3-phase variac. Observe the direction of rotation of the I/M. Then, switch off S1 and reduce the 3-phase variac to zero.

3. Close switch S2 and adjust the field current of the dc driving motor around 0.6 A using single phase variac. Switch on the dc power supply and adjust the terminal voltage of the dc driving motor to 220 Volts (line). Start the dc driving motor in such a direction that the dc driving motor will rotate in the same direction as the I/M in C.(2) above. If it rotates in the different direction, then interchange the two phases of the three-phase supply (R-S, S-T, T-R) connected to the I/M. Now adjust the field current of the dc driving motor to obtain a speed of 1500 rpm. Close switch S1 and increase the I/M stator voltage to 100 Volts (line) which should be held constant throughout the rest of the experiment.

4. Now decrease the field current of the dc driving motor until the speed of the I/M is 1800 rpm.

5. Increase the field current of the dc driving motor in steps so that the speed of the I/M is reduced from 1800 rpm to 1500 rpm. At each step, record the line current of the I/M and the readings of each wattmeter.

6. Connect the positive terminal of eddy current brake to the positive terminal of single phase variac. Stop the dc driving motor and disconnect its field winding from single phase rectifier.

Increase the load in steps so that the speed of I/M is reduced from 1500 rpm 1350 rpm. At each step record the line current of I/M, the readings of each wattmeter and the indication of the dynamometer,

7. Keep the eddy current brake at the level of last step of C.(6). Connect the field winding of the dc loading motor to single phase rectifier. Then start the dc motor.

Decrease the terminal voltage of dc loading motor in steps so that the speed of the I/M is reduced from 1350 rpm to 400 rpm. At each step, record the line current of I/M, the readings of each wattmeter and the indication of the dynamometer.

Important Note

It will be observed that in spite of the very reduced stator voltage used, the line current of the I/M exceeds the rated value for speeds other than those near synchronous speed. The test should therefore be performed as quickly as possible and a continuous check must be made for the temperature of the I/M stator winding. If it reaches a high temperature, then the m/c should be switched off.

8. With the I/M rotating at 400 rpm interchange the armature terminals of the dc motor (i.e A1-B2) using terminal board at the top of the dc motor. (Do not use the connection terminals in front of the experimental set) Disconnect positive terminal of eddy current brake from single phase rectifier.

Increase the terminal voltage of the dc driving motor to 220 Volts in steps so that the speed of the I/M changes from 400 rpm to 1800 rpm. If this speed is not attainable with the terminal voltage of the dc driving motor at the maximum possible value, then reduce the field current of the dc driving motor until a speed of 1800 rpm is obtained. At each step, record the line current of I/M and the readings of each wattmeter.

4. Adjust the speed of the dc driving motor to 1500 rpm. using single phase variac. Then, record the terminal voltage and current of the dc driving motor.

Stop dc driving motor using starter. Wait until the I/M comes to rest. Disconnect the I/M mechanically from the combined brake assembly.

Start the dc driving motor and adjust the speed to 1500 rpm. Record the terminal voltage and current of the dc driving motor.

This test gives information about the mechanical losses (friction and windage losses) of the I/M.

D. Results and Conclusions

In answering the following questions, assume that the friction and windage loss of the I/M is constant at all speeds.

1. Calculate the input power and power-factor at each experimental point of the tests described in C(5), C(6), C(7), C(8) and the net torque for the tests of C(5), C(6), C(7), C(8)

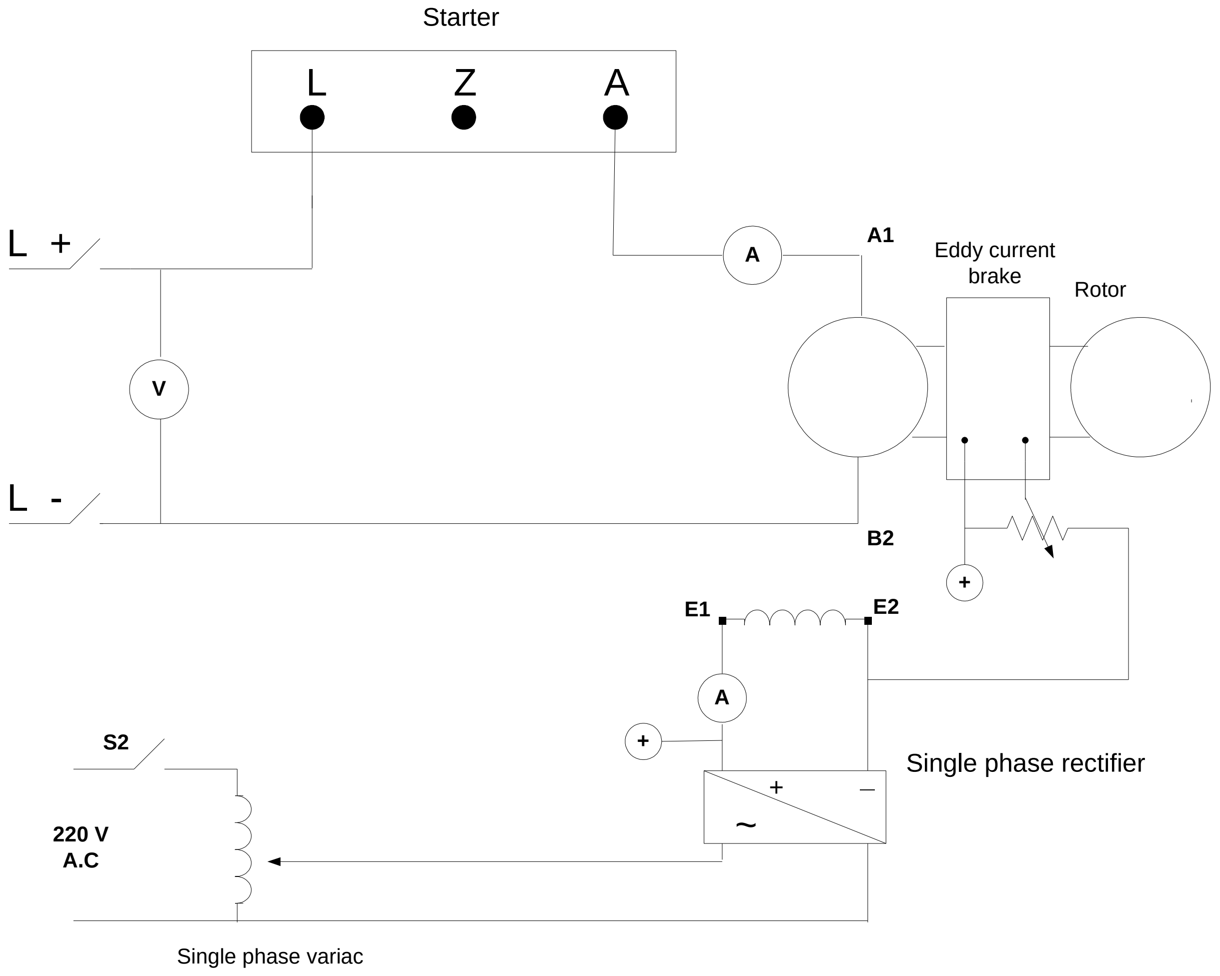
2. Plot on the same graph the calculated values of net-torque of the I/M for speeds from 1500 rpm to 400 rpm in forward direction and from 400 rpm to 1800 rpm in reverse direction. Hence draw the complete net torque/speed characteristics of the I/M.

3. Plot on another graph the values of stator power, power-factor and line current against speed from the tests of C(5), C(6), C(7), C(8) over the whole speed range.

4. Comment on the shapes of all curves and explain any discrepancies between the theoretical and actual results.

NOTE: All the results of this experiment should be retained since these will be used to plot Circle Diagram of the I/M for the next experiment.

D.C Loading/Driving Motor



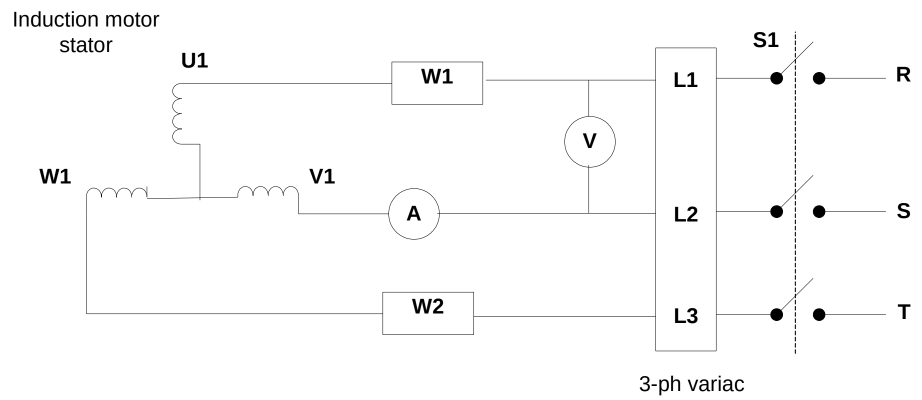


Fig.3

E.1 Table of results for C.5

n (r.p.m)	I1(A)	W1(W)	W2(W)
1800			
1750			
1700			
1650			
1600			
1550			
1500			

E.2 Table of results for C.6

n (r.p.m)	I1 (A)	W1 (W)	W2(W)	T(Nm)
1500				
1450				
1400				
1350				

E.3 Table of results for C.7

n (r.p.m.)	I1 (A)	W1 (W)	W2(W)	T(Nm)
1350				
1250				
1050				
850				
500				
250				

E.4 Table of results for C.8

n (r.p.m.)	I1 (A)	W1 (W)	W2(W)
400			
500			
800			
1400			
1600			
1800			

E.5 Table of results for C.9

n (r.p.m.)	Idc (A)	Wdc (W)	
1500			D.C M/C+ Brake+ I/M
1500			D.C M/C+ Brake

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