# 1 Experiment No. 11

# 2 Experiment Title

Observation of Speed-Torque Characteristic Curve of a 3-Phase Induction Motor.

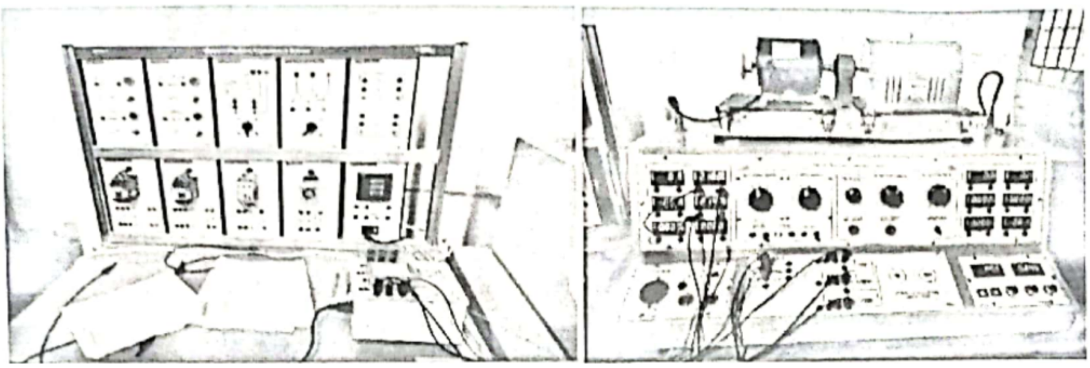
# 3 Objective

The objectives of this lab are as follows:

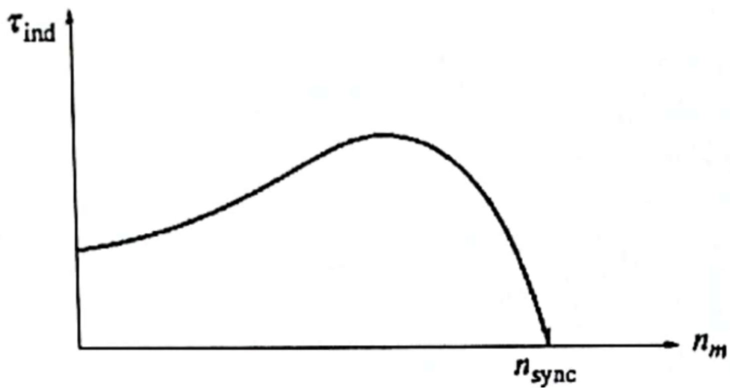
- To observe the speed-torque characteristics of a 3-phase induction motor under varying load conditions
- To examine how slip and power factor change with increasing mechanical load
- To understand the practical implications of motor performance curves

## Theory

Three-phase induction motors are widely used in industry due to their reliability and efficiency. When a 3-phase supply is given to the stator windings, a rotating magnetic field (RMF) is generated. This field induces current in the rotor, producing a secondary magnetic field that interacts with the RMF to generate torque.



(a) 3-phase induction motor test setup




(b) Speed-Torque Characteristic Curve of a 3-Phase Induction Motor

The synchronous speed ($N_s$) is given by:

$$N_s = \frac{120f}{P}$$

where $f$ is the supply frequency and $P$ is the number of poles.
Slip ($S$), the difference between synchronous and rotor speed ($N_r$), is defined as:

$$S = \frac{N_s - N_r}{N_s}$$

Torque depends on slip, rotor resistance, and reactance. The torque-speed characteristic shows regions of operation from no load to maximum torque (pull-out torque). At low load, power factor is low due to dominant reactive power. As load increases, active power and power factor improve.

## 4 Circuit Diagram

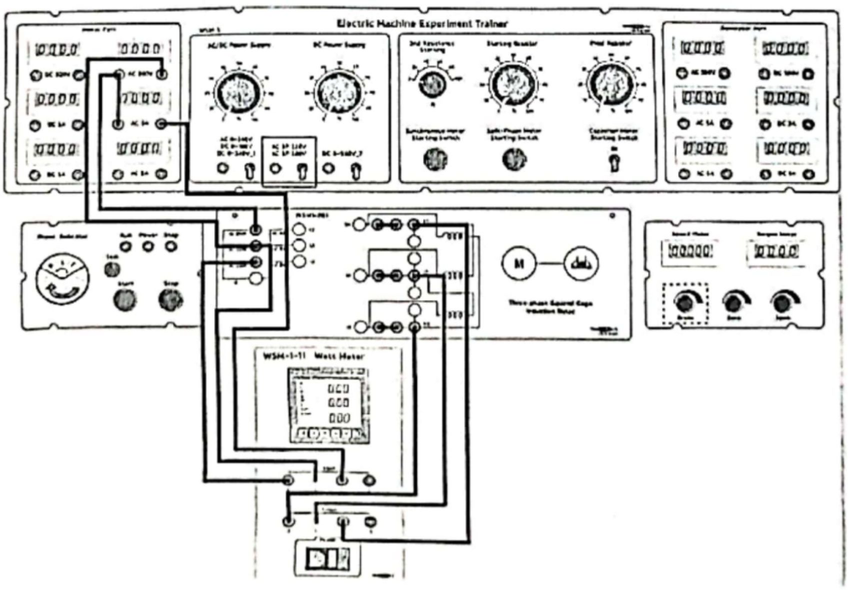



Figure 2: Circuit diagram for 3-phase induction motor test setup

## 5 Required Apparatus

Table 1: List of Required Equipment

| SN | Equipment | Specification |
|---|---|---|
| 1 | 3-Phase Induction Motor | Output: 360W, Voltage: 220V, Current: 2.2A, Speed: 1480 RPM |
| 2 | Electric Machine Trainer | – |
| 3 | Dynamometer | Imax = 3A, Speedmax = 4000 RPM |
| 4 | Star-Delta Switch | – |
| 5 | AC Multimeter | Vrmsmax = 500V, Imax = 5A |
| 6 | Connecting Wires | – |

## 6 Procedure

1. Connect the motor to the dynamometer and measuring instruments as per the circuit diagram
2. Start the motor with no load and record the initial speed, current, and power readings
3. Gradually increase the mechanical load using the dynamometer
4. At each load step, record:
   - Motor speed (RPM)
   - Torque (Nm)
   - Current (A)
   - Active power (W)
   - Reactive power (VAR)
   - Apparent power (VA)
   - Power factor
5. Continue until the motor reaches near full-load conditions
6. Plot the speed-torque characteristic curve

## 7 Result

Table 2: Experimental Data Table

| Speed (RPM) | Torque (Nm) | Current (A) | Active Power (W) | Reactive Power (VAR) | Apparent Power (VA) | Power Factor |
|---|---|---|---|---|---|---|
| 1497 | 0.001 | 1.972 | 181.1 | 754.2 | 774.1 | 0.23 |
| 1484 | 0.257 | 2.006 | 309.9 | 711.5 | 775.2 | 0.40 |
| 1479 | 0.315 | 2.021 | 360.0 | 708.0 | 792.5 | 0.45 |
| 1477 | 0.342 | 2.040 | 375.0 | 690.0 | 783.0 | 0.47 |
| 1474 | 0.379 | 2.062 | 390.0 | 692.0 | 792.0 | 0.49 |
| 1473 | 0.408 | 2.080 | 425.0 | 686.0 | 805.0 | 0.53 |
| 1469 | 0.443 | 2.120 | 475.0 | 687.0 | 833.0 | 0.57 |
| 1460 | 0.469 | 2.190 | 519.0 | 679.0 | 854.0 | 0.61 |

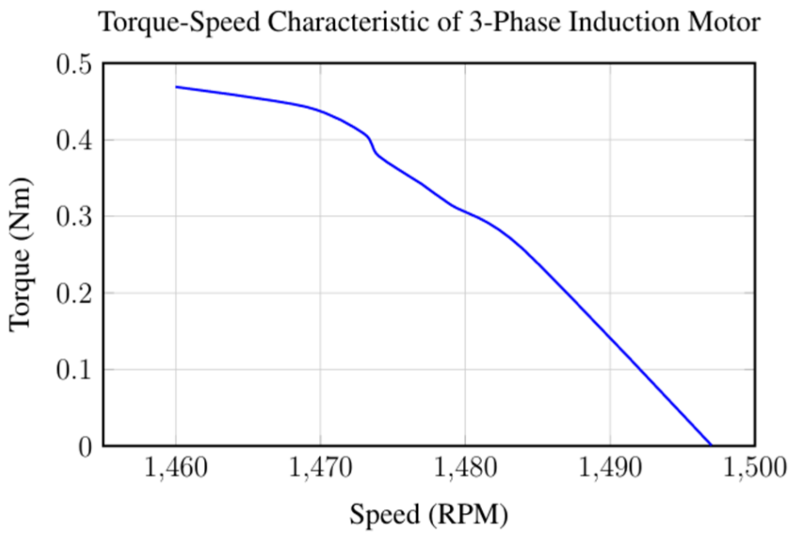



Figure 3: Speed-torque characteristic curve

## 8 Discussion

The experimental results demonstrate key characteristics of the 3-phase induction motor. As mechanical load increases from 0.001 Nm to 0.469 Nm, the motor speed decreases slightly from 1497 RPM to 1460 RPM, showing the expected speed-torque relationship. This corresponds to increasing slip from 0.002 to 0.027. The power factor improves significantly from 0.23 (no-load) to 0.607 (full-load), indicating better energy utilization under load, while current increases moderately from 1.972A to 2.190A. These observations confirm theoretical predictions, with the speed-torque curve showing the characteristic downward slope and stable operation across the entire load range.

## 9 Conclusion

The experiment successfully characterized the induction motor's performance, showing: (1) minimal 2.5% speed variation from no-load to full-load, (2) significant power factor improvement (0.23 to 0.607), and (3) stable operation matching theoretical predictions. These results validate the motor's design and suitability for industrial applications requiring consistent performance under varying loads.

## 10 Precautions

1. Ensure all connections are secure before applying power
2. Do not exceed the motor's rated current (2.2A) during testing
3. Gradually increase the load to avoid sudden torque shocks
4. Monitor temperature during prolonged operation

## 11 Reference

Stephen J. Chapman, *Electric Machinery Fundamentals*.