

Unit 21: Electrical Machines

Unit code	A/615/1495
Unit level	4
Credit value	15

Introduction

Electrical machines can be found in manufacturing, transport, consumer appliances and hospitals. People will come across them every day in their home and at work. They convert energy in three ways: transformers which change the voltage level of an alternating current; motors which convert electrical energy to mechanical energy; and generators which convert mechanical energy to electrical energy. Transducers and actuators are also energy converters, and can be found in a wide range of industrial and domestic applications.

This unit introduces students to the characteristics and operational parameters of a range of electromagnetic powered machines that are used in a variety of applications. Among the topics included in this unit are: principles underlying the operation and construction of transformers, induction motors, synchronous machines, electromagnetic transducers, actuators, and generators; and operating characteristics of electrical machines such as voltage, current, speed of operation, power rating, electromagnetic interference (EMI) and efficiency.

On successful completion of this unit students will be able to identify the constructional features and applications of transformers; investigate the starting methods and applications of three-phase induction motors and synchronous machines; investigate the types of generator available in the industry by assessing their practical application; and analyse the operating characteristics of electromagnetic transducers and actuators.

Learning Outcomes

By the end of this unit students will be able to:

1. Assess the constructional features and applications of transformers.
2. Analyse the starting methods and applications of three-phase induction motors and synchronous machines.
3. Investigate the types of generator available in industry by assessing their practical applications.
4. Analyse the operating characteristics of electromagnetic transducers and actuators.

Essential Content

LO1 **Assess the constructional features and applications of transformers**

Constructional features:

Construction, application, characteristics and testing of transformer types such as: step up, step down, and isolating

Shell and core, windings, connections, efficiency, short circuit and no-load testing, and equivalent circuit

LO2 **Analyse the starting methods and applications of the three-phase induction motors and synchronous machines**

Methods and applications:

Construction, application, characteristics and testing of induction and synchronous motors

Types of electric motors and their practical applications

Starting methods

Voltages, power, speed, torque, inertia, EMI, and efficiency

Cooling and protection devices

LO3 **Investigate the types of generators available in the industry by assessing their practical application**

Types of generators available:

Construction, application, characteristics and testing of generators

Types (direct current, alternating current and self-excitation)

Practical applications

Generation methods

Voltages, power, speed, torque, inertia, EMI, efficiency

Cooling and protection devices

LO4 **Analyse the operating characteristics of electromagnetic transducers and actuators**

Operating characteristics:

Construction, application, characteristics and testing of electromagnetic transducers and actuators

Transducer types (active, passive, sensor), actuator types (solenoids, linear, rotary)

Practical applications.

Voltage and current requirements, hysteresis and speed of operation

Torque

Insulation Protection (IP) rating

Contact types

Back Electromotive Force (EMF), EMI and efficiency

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
L01 Assess the constructional features and applications of transformers		D1 Assess the efficiency of a number of available transformers and make a recommendation for an actual operational requirement
P1 Examine the types of transformers available	M1 Illustrate the operation of the transformer, considering the equivalent circuit	
P2 Discuss suitable applications for available transformers		
P3 Discuss the different methods of connections available for three-phase transformers		
L02 Analyse the starting methods and applications of the three-phase induction motors and synchronous machines		D2 Critically evaluate the efficiency of a number of available motors and make a recommendation for a specified operational requirement
P4 Analyse the types of electrical motors available, discussing suitable applications	M2 Justify the selection of a motor for a specific industrial application	
P5 Analyse the different methods of starting induction motors and synchronous machines		
L03 Investigate the types of generators available in the industry by assessing their practical application		
P6 Explain the types and construction of generators	M3 Justify the application of a specific type of generator	D3 Assess the efficiency of a number of available generators and make a recommendation for a specified operational requirement
P7 Identify a generator for a specific application, considering their characteristics		

Pass	Merit	Distinction
LO4 Analyse the operating characteristics of electromagnetic transducers and actuators		D4 Analyse the practical application of transducers and actuators in an industrial situation and make recommendations to improve the operating efficiency of the units in use
P8 Analyse the operation, types and uses of electromotive transducers and actuators, examining features that support their suitability for specific applications	M4 Justify the selection of suitable transducers for specific industrial applications	

Recommended Resources

Textbooks

DE SILVA, C.W. (2015) *Sensors and Actuators: Engineering System Instrumentation*. 2nd Ed. CRC Press.

HUGHES, A. (2013) *Electric Motors and Drives: Fundamentals, Types and Applications*. 4th Ed. Newnes.

Websites

<https://ocw.mit.edu> MIT open courseware
Electric Machines
(Tutorials)

Links

This unit links to the following related units:

Unit 43: Machines and Drives