Unit 21: Electric 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
LO1 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. **P2** Discuss suitable applications for available transformers. **P3** Discuss the different methods of connections available for three-phase transformers.	**M1** Illustrate the operation of the transformer, considering the equivalent circuit.	
LO2 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. **P5** Analyse the different methods of starting induction motors and synchronous machines.	**M2** Justify the selection of a motor for a specific industrial application.	
LO3 Investigate the types of generators available in the industry by assessing their practical application		**D3** Assess the efficiency of a number of available generators and make a recommendation for a specified operational requirement.
P6 Explain the types and construction of generators. **P7** Identify a generator for a specific application, considering their characteristics.	**M3** Justify the application of a specific type of generator.	

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.

Electronic

MIT open courseware – Electric Machines

www.ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013

Links

This unit links to the following related units:

Unit 43: Machines and Drives