Unit 65: Utilisation of Electrical Energy

Unit code: A/601/1396

QCF level: 4

Credit value: 15

Aim

This unit aims to develop learners' understanding of the underlying technology involved in the utilisation of electrical energy in some of the more important areas of electrical engineering.

Unit abstract

Electrical energy needs to be used efficiently in order to reduce wastage, especially given the future limitation of fossil fuels and growing environmental concerns.

The selection of power transformers with their varied characteristics will assist distribution and provide electrical energy at usable voltage and current levels to meet client demands.

As an integrated component, the electrical system needs to be protected at its various stages of transmission and distribution against excessive demands and faults that may occur.

The uses of electrical energy are wide and varied but in many ways they can be categorised into three areas: lighting systems, general power consumption, and motors.

The first learning outcome considers the operation of power transformers, including construction and operating principles and star-star/delta-star/delta-zigzag connections.

Learning outcome 2 looks at circuit protection systems such as over-current and earth-fault protection.

Lighting systems are considered in learning outcome 3 with a look at the different types of lighting available followed by an explanation of how to design and plan a scheme for a small development.

The different types of tariff structures available are studied in learning outcome 4, together with calculations to evaluate the cost of running a system.

Finally, learning outcome 5 examines the operation of the different types of polyphase induction motor, operation principles, starting methods and speed control.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the operation of power transformers

2 Understand the applications of circuit protection for distribution and installation systems

3 Understand the design and construction of lighting systems

4 Be able to determine the cost of energy used in a system in order to be energy efficient

5 Understand the operation of a polyphase induction motor.

Unit content

1 **Understand the operation of power transformers**

Construction: shell and core types

Operating principles: derive the equivalent circuit for an ideal transformer on load; phasor diagram for an ideal transformer on load; identify the no-load losses; derive the equivalent circuit to represent no-load losses, leakage reactance, winding impedance; derive the complete equivalent circuit; components of the equivalent circuit referred to one winding; phasor diagram for the loaded transformer; voltage regulation; approximate formula for voltage regulation; calculation of voltage regulation, losses on load, efficiency of transformer; calculation of efficiency under load conditions, effects of load changes on losses, load conditions for maximum efficiency; calculation of maximum efficiency

Connections: star-star; delta-star; delta-zigzag

2 **Understand the applications of circuit protection for distribution and installation systems**

Over-current protection devices: construction of oil, vacuum and airblast circuit breakers, high rupture capacity fuse, overcurrent relay and miniature circuit breaker

Operating principles: characteristics and circuit positions of over-current relays, high rupture capacity fuse and miniature circuit breaker; calculation of 'time to clear' over-current faults; discriminations

Earth fault protection devices: construction of earth fault relay and residual current circuit breaker; performance requirements of earth fault protection; principle of operation and characteristics of earth fault relays and residual current circuit breaker; position in circuit; calculation of 'time to clear' earth faults; discrimination

3 **Understand the design and construction of lighting systems**

Common lamp types: low pressure mercury; high pressure mercury; low pressure sodium; high pressure sodium; fluorescent and halogen

Lighting design: quality of light; control of glare; luminance distribution; consistency of lighting levels; interior lighting design codes; lighting for visual tasks; emergency lighting

Light scheme: produce a scheme for one of the following developments or equivalent given the appropriate plans (eg small commercial development to involve roads, tunnel, pedestrian areas and car parks; small supermarket; administration office of a college, including computer stations)

4 **Be able to determine the cost of energy used in a system in order to be energy efficient**

Tariff structures: domestic; Domestic Economy 7; Domestic Smart 7; business (eg Economy 7 all-purpose, Economy 7 combined premises, evening and weekend); restricted hour; methods of controlling maximum demand; metering arrangements

Energy consumption: load scheduling; power factor correction techniques; calculation of apparent power rating of a capacitor to improve power factor of a load; location of power factor correction capacitors; efficient control of heating and lighting systems; recycling heat from heating and lighting systems

Cost of energy: cost of running a system using the different tariffs available; selection of appropriate tariff for a given installation and set of circumstances

5 **Understand the operation of a polyphase induction motor**

Types: single cage; double cage; wound rotor

Operating principles: production of a rotating magnetic field in the stator; synchronous speed; rotor resistance, reactance and induced voltage; standstill conditions; slip speed; the effect of rotor speed on rotor resistance and reactance; torque equations for a three-phase induction motor; torque/speed characteristic, stator and rotor losses; efficiency calculations

Starting methods: direct online; stator voltage reduction; rotor resistance method

Speed control: change of stator voltage and frequency

Learning outcomes and assessment criteria

Learning outcomes On successful completion of this unit a learner will:	Assessment criteria for pass The learner can:
LO1 Understand the operation of power transformers	1.1 explain the construction of different types of power transformer 1.2 identify the operating principles of a power transformer under no-load and load conditions 1.3 discuss the modes of connection for polyphase transformers
LO2 Understand the applications of circuit protection for distribution and installation systems	2.1 explain the construction of over-current protection devices 2.2 explain the operating principles of circuit over-current protection devices 2.3 explain the operating principles of earth fault protection devices
LO3 Understand the design and construction of lighting systems	3.1 explain the construction, operation and associated circuitry of common lamp types 3.2 explain the principles of good lighting design 3.3 plan a light scheme
LO4 Be able to determine the cost of energy used in a system in order to be energy efficient	4.1 discuss the factors governing tariff structures 4.2 analyse methods for reducing energy consumption 4.3 determine the cost of energy used in a system
LO5 Understand the operation of a polyphase induction motor	5.1 describe the types and explain the construction of induction motors 5.2 explain the operating principles and methods of starting induction motors 5.3 analyse the methods of speed control of induction motors.

Guidance

Links

This unit may be integrated with other units such as *Unit 1: Analytical Methods for Engineers*, *Unit 5: Electrical and Electronic Principles* and *Unit 63: Electrical Power*.

Essential requirements

Centres will need to provide access to appropriate laboratory test equipment (for example oscilloscopes, watt meters and test meters).

Single and three-phase supplies will also need be available, together with a variety of components including lamps (of various types), loads, transformers, induction motors, starters, etc.

Employer engagement and vocational contexts

Delivery of this unit will benefit from centres establishing strong links with employers willing to contribute to the delivery of teaching, work-based placements and/or detailed case study materials.