Unit 216 Electrical machines and drives

Unit summary
This unit is about the principles involved in electrical machines and machine drives including power electronics.

Aims
The unit aims to develop understanding of dc machines, induction machines and various drives and includes the development of knowledge of energy conversion, operational parameters and characteristics.

Prerequisites
It is expected that the candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

- Appreciate electrical machine fundamentals
- Appreciate dc, induction, stepper and reluctance machines
- Appreciate general issues common to all drive systems

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
8.1.1 Maintain and develop own engineering expertise

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Outcome 1 Appreciate electrical machine fundamentals

Knowledge requirements
The candidate knows how to:

1 determine force on current – carrying conductors
   a Faraday's law
   b motional electro-motive force (emf)
2 investigate electrical machines
   a concentrated windings
   b magneto-motive force (mmf)
   c working and leakage flux
   d flux density and mmf distributions
      i smooth air gap case
      ii harmonic mmf
   e magnetic and electric loading and relation to machine volume
3 investigate machine rating
   a losses
   b cooling
   c temperature rise
   d case style

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Outcome 2 Appreciate dc, induction, stepper and reluctance machines

Knowledge requirements
The candidate knows how to:

1 analyse steady state performance of dc machines and use relevant equations
   a equivalent circuits
   b characteristics of machines
      i separately-excited
      ii shunt
      iii series
2 determine the transient performance of dc machines
   a with armature inductance
   b without armature inductance
3 investigate universal dc machines (ac series commutator)
4 assess the operation of dc machines with a chopper and with field weakening
5 investigate dc wound field and permanent magnet excitation
6 analyse the construction, operation and control of brushless dc machines
7 assess steady state performance of induction machines and use relevant
   a equations
   b equivalent circuits
   c phasor diagrams
8 understand the characteristics and constructional features of cage-rotor induction machines in
   a three-phase form
   b single-phase form
   (including capacitor-fed auxiliary winding configuration)
9 determine torque/speed relationship of induction machines
   a fixed supply
   b variable voltage supply
   c variable frequency supply
10 analyse open-loop variable speed operation and closed-loop controlled slip operation in induction machines to include
   a control block diagrams
   b V/f relationship

11 assess basic torque production mechanisms for stepper machines
   a reluctance effect machines
   b permanent magnet machines
12 determine the relationship between machine features and step angle
13 investigate the circuits required for current pulse control
14 analyse commutation sequences and control for stepper and reluctance machines

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Outcome 3 Appreciate general issues common to all drive systems

Knowledge requirements
The candidate knows how to:

1 use equations of motion for rotary dynamic drive systems

2 determine speed/time relationships for drives

3 determine the relevance to acceleration of length to radius ratio of machines

4 produce speed and torque curves including

- a regeneration
- b reverse rotation regions

5 assess torque, speed and position controlled drives

6 develop an awareness of drive requirements for the common application of electrical drives such as

- a machine tools
- b transport
- c lifts

7 develop an awareness of speed, current and torque transducers

8 investiage high-current and high-voltage device

- a characteristics (ratings, gate drives and switching characteristics) of
  - i diodes
  - ii thyristors including the GTO thyristor
  - iii semiconductor field effect thyristor (MOSFET)
  - iv insulated gate bipolar transistors (IGBT)
- b conduction and switching power losses

9 investigate circuits relevant to supplying electrical machines

- a dc to dc
- b dc to ac power conversions
- c ac to dc power conversions

10 assess limits placed on machine operation by converters including regeneration constraints

11 understand the pulse-width-modulation (PWM) of switching waveforms

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Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Basic Electrical Power & Machines	Bradley, Kluwer	Academic Pubs.	0412455404
Electric Motors and Drives	Hughes	Newnes	0750617411
Power Electronics	Mohan, Undeland, Robbins	John Wiley	0471584088
Electrical Machines and Drives	Slemon	Pergamon Press	201578859 o/p
Power Electronic Control of AC Motors	Murphy, Turnbull	Pergamon Press	0080226833 o/p