MODULE TITLE **ADVANCED AC GENERATORS**

Nominal Duration One Module

Module Code EA154

Module Purpose To enable students to describe, in detail:

- The construction, operation, characteristics and control of three phase alternating current generators.
- The construction and operation of the generator's auxilliary systems.
- Their use as island or interconnected systems.

Relationship to Competency Standards This module will be modified in line with the requirements of the national metals and Engineering Standards when they become available.

The module contains the knowledge and skills identified and agreed by all state/territories. It has been developed on the assumption that these will be reflected in the Standards.

Pre-requisites NE09 Single & Three Phase Circuits

Summary of Content

- Construction, installation, relative sizes and weights and methods of cooling.
- Operation as an island generator. synchronising to running machines.
- Construction and use of Reactive Capability diagrams.
- Need for, connections to and characteristics of Automatic Voltage Regulators (AVRs)
- Exporting power. Control of VArs using the AVR and OLTC transformers. Static and dynamic stability limits. Stability retention.
- Specific electrical protection applied to alternators.

Delivery

A large part of this module should be delivered in a classroom situation. The availability of the means to demonstrate the principles involved, using proprietary demonstration electrical machines, is highly desirable.

The following facets must be demonstrated, and preferably practiced individually, on appropriate rotating plant:

- Synchronising
- Pole slipping (using a triggered stroboscope)
- Alternator loading and rotor angle and (strobe)
- VAr circulation and control (using variable excitation).

Without access to notes or other material. With access to simulators or demonstration equipment.

Assessment Method

There must be some descriptive questions requiring a written answer. Some multiple choice questions may be included. Calculation questions must be included. Demonstration of practical skills should be included, with accompanying oral descriptions, where demonstration equipment or simulators are available.

Learning Outcomes On completion of this module the learner will be able to:

Learning Outcome 1 **Describe the mechanical features of AC generators.**

Assessment criteria

1.1 Identify the constructional features shaft aspect prime mover attachment, and the types of windings and their locations.

1.2 Describe the cooling mediums used and the reasons for their use.

1.3 Compare weights, lengths and diameters for the various machine types.

Learning Outcome 2 **Outline the operational features of a single machine supplying load and the principles of synchronising a machine to a system.**

Assessment criteria

2.1 Describe principles of "running up" differing types of prime movers.

2.2 Describe the principles of loading a generator, once at rated speed.

2.3 Describe the requirements for synchronising a generator to other operating generators.

Learning Outcome 3 **Construct a Reactive Capability diagram (or Performance Chart). Use it to predict a machine operative point.**

Assessment criteria

3.1 Recall the detail of a machine phasor diagram (the single phase case) including pu. values of X, and R. Construct and modify a current circle diagram.

3.2 Given load data, plot the operating point and calculate any/all or the following

- load power factor
- rotor angle
- pu output
- pu power
- pu reactive export/import
- pu excitation

Learning Outcome 4	**Identify the need for, and describe the principle of operation of, an automatic voltage regulator (AVR).**
Assessment Criteria	4.1 Explain the need for an AVR
	4.2 List the required attributes of a good AVR in terms of range and response time. Detail the constraints in terms of the rotor inductance.
	4.3 Outline other desirable features of AVR's including low power consumption, quadrature compensation and rotor stabilisation.
	4.4 Detail operational requirements including automatic change-over (to duplicate). Manual follow-up and initial field flashing.
	4.5 Detail the connections for inputs and outputs including stabilised supplies, VT's, CT's and CB/discharge resistors (where applicable).
Learning Outcome 5	**Detail the operation of a generator connected to a large system.**
Assessment criteria	5.1 Using a phasor diagram, explain the dependence of power on rotor angle and VAR'S on voltage magnitude.
	5.2 Construct a power/rotor angle diagram and calculate critical clearance angles (given the formula or graphically). Indicate the voltage dependant nature of stability.
	5.3 Plot the theoretical and practical stability limits on a given capability diagram.
	5.4 Explain how VAR'S are controlled using the generator AVR and the generator transformer OLTC.

Learning Outcome 6	**Identify the types of electrical protection applied to a range of different size generators.**
Assessment criteria	6.1 Recall the definitions of restricted, unrestricted primary, back-up and duplicate protection. 6.2 Given the names, describe the principle of operation of and reasons for the, the following forms of protection: • Overcurrent and short-circuit • Differential protection • Reverse power • Load unbalance • Rotor overload • Loss-of-field • Rotor earth fault • 2 types of station earth fault • Under frequency 6.3 Detail other types of fault, external to the generator, which must disconnect the generator from the system
Suggested Learning Resources	While no one text covers all the facets of the module, plant manuals, manufacturers data and suppliers handbooks are a valuable source of information. There are 2 texts which do give broad coverage. They are: "Electric Power Systems" by B M Weedy (3rd. Ed.) published by Wiley and, "Alternating Current Machines" by M G Say (5th Ed.) published by Longman. There are also 7 volumes of a text called "Modern Power Station Practice" which is now rather dated but has some good information.

