TRAINING STANDARDS

National Electrotechnology Training Package

Volume 9

Design

Units

UTE99 Electrotechnology Training Package

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Changes in units of competency and packaging of qualifications are reflected on the **National Training Information Service**, which displays only current information: **http://www.ntis.gov.au**

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Glossary

Italic typeface is used in this National Training Package and the associated competency standards indicates terms and variables that require further explanation. Explanation of terms and variables that have meaning in a particular unit are given in the range statements and should be referenced accordingly at all times. Those that have a common meaning throughout this standard are explained below.

In many instances, the explanations of relevant terms are direct extracts from or are derived from technical standards published by Standards Australia or jointly by Standards Australia and Standards New Zealand.

It should be noted that some Units of competency have unique features. Consequently, these units have additional glossary terms included within.

Common terms and variables

Accessories -

Any device associated with, and forming an integral part of, the wiring systems such as switch, fuse, plug, socket outlet, lampholder, fitting, adaptor, ceiling rose; connectors, clamps, splitters, termination posts, lugs, strips and blocks; clips, ties and bindings.

Apparatus -

Any equipment forming a component part of an installation used for a particular purpose. *Apparatus* includes, but is not limited to, that contained in the following divisions. It will necessarily include new and emerging technologies:

- **Audio/visual equipment** including televisions, radios, monitors, cameras, closed circuit television, mono and stereo sound systems, gaming machines, electronic display panels, cassette recorders, video cassette recorders, CDROM players, tape recorders, sound and video duplication equipment, digital versatile discs, digital audio tapes, professional and domestic speaker systems, mixer desks.
- **Air conditioning equipment** including room air conditioners, split systems, package units, ducted units, evaporative coolers, ventilation systems.
- **Appliances** including portable electric tools, motor driven pumps, vacuum cleaners, food preparation equipment, hair dryers, refrigerators, washing machines, dish washers, paper shredders, water coolers, clothes dryers, pest exterminators, electric motor driven industrial tools and equipment, sanitary disposal units, radial and tangential fans and blowers.
- **Business equipment** including facsimile machines, photocopiers, printers, scanners, modems, computers and peripherals, financial transaction devices and systems.
- **Communications equipment** including radio transmitters, television transmitters, microwave transmitters and receivers, repeaters, two way radios, antennae, satellite linkage equipment.

- **Computer systems** including personal computers, computer networks, peripherals, supervisory control and data acquisition systems, modems, bridges, servers, routers, automatic data capture equipment.
- **Electrical and electronic controllers and control systems** including switchboards and control centres, alternating and direct current regulated and unregulated power supplies, rectifiers and filters, electromechanical and solid state relays and contactors, programmable controllers, uninterruptable power supplies, oscillators, motor speed controllers, electromechanical and dynamic brakes, battery charging and electroplating equipment, lamp dimmers and flashers, transducers, frequency injection systems.
- **Electrical machines and associated drives** including single phase and polyphase alternating current cage and wound rotor induction motors and synchronous motors and generators, direct current motors and generators, amplidynes, dynamometers, stepper motors, servo motors and synchros, double wound and auto transformers, induction regulators, electronic variable speed and eddy current drives.
- **Energy management and sustainable energy equipment** including solar cells, stand-by batteries, inverters, wind generators, hybrid systems, stand-by alternators, power factor correction controllers.
- **Heating equipment** including single and polyphase instantaneous and quick recovery water heaters, space heaters, induction heaters, electric furnaces, commercial food warmers, microwave and dielectric heaters, electric ranges, stoves and oven tops.
- **Instrumentation/process control devices and equipment** including controllers, transmitters, final control elements, detectors, process loop auxiliary equipment, indicators and recorders, monitors and computer interface equipment.
- **Lighting** including incandescent, quartz halogen and vapour lamps, applications in domestic, commercial, industrial and sporting settings, advertising signs, security lighting, road and highway lighting.
- **Measuring instruments** including digital and analogue ammeters, voltmeters, watt and var meters, frequency meters, phase rotation devices, oscilloscopes, power factor indicators, energy meters, insulation resistance devices, continuity testers, chart recorders, voltage detectors, Wheatstone and double bridges, instruments to measure signal strength, harmonic distortion, electro-magnetic and electro-static fields.
- **Medical electronics and equipment** including x-ray machines, cardiographic monitoring equipment, electrophoresis equipment, electron microscopes, infra-red (deep heat) equipment, physical therapy equipment, CAT scan equipment, ultrasound equipment, defibrillators, infusion pumps, incubators, ventilators, foetal monitors, thermometric devices, anaesthetic units, gas monitors, dialysis equipment, pacemakers, lasers, endoscopes, blood warmers, physiological monitors.

- **Power distribution/transmission systems** including wood, concrete, steel and composite poles and structures, transmission towers, overhead and underground conductors and cables, electrical metering and recording devices.
- **Refrigeration systems** including refrigerators, freezers, icemakers, cool rooms, freeze rooms, beverage coolers, merchandising and display cabinets, blast freezers.
- **Scanning and detection systems** including: radar systems, sonar systems.
- **Security and fire detection systems** including sensors, controllers, alarm devices, telecommunications interfaces, closed circuit television cameras and monitoring systems.
- **Telecommunication equipment** including switching equipment, PABX, microwave transmitters and receivers, customer premises equipment, customer access networks, transmission equipment.

See also *wiring systems.*

Apparatus, fixed wired -

Apparatus (electrical/electronic) connected to a system of wiring in which cables protected or unprotected are fixed or supported in position.

Appliances -

A fixed (for support only), hand-held (held in hand during normal use), portable (moved whilst in operation or easily moved from one place to another while connected to the supply) or stationary (can be moved, but not easily) consuming device, other than a lamp.

Individuals with responsibilities for co-ordination, design installation, maintenance, production, or servicing activities. This can include:

- site managers
- project managers
- engineers and technicians
- technical experts
- line managers/supervisors
- regulatory personnel
- team leaders
- other personnel designated by an organisation or enterprise

Approval of equipment -

Acceptance by the relevant authority for an item of equipment to be used in a particular situation.

AQF -

Australian Qualifications Framework, which describes qualifications in terms of levels, characterised by the outcomes of vocational education and training.

Capacity, load and duty -

Flow rates of air, fluids and gases; current-carrying capacity; air, fluids and gas pressures; mechanical loading on piping, tubing or cables and supports; maximum demand and current ratings; duty cycles; frequency; environmental conditions.

Categories – general -

Competency can be achieved for any number of the following categories for which **formal endorsement** is to be provided, as prescribed in the evidence guide and critical aspects for each unit. These are:

a. Computer systems: The adaptation of Electrotechnology to the processing and control, communication and storage of information.

b. Electrical: Encompasses the systems associated with wiring reticulation, distribution centres, utilising devices and electrical machines for the conversion of electrical energy into other forms and conversely for the conversion of other forms of energy into electromotive force.

c. Electronics: The use of discrete solid state components and integrated circuits and devices and their associated circuits for application within process control systems, communication systems, computers, measurement, entertainment equipment, electro-medical equipment and the like.

d. Instrumentation: The measurement and control of process system data and parameters for industrial and commercial use. It includes the calibration and maintenance of instrument and processes in the chemical, energy, biotechnology, environmental, food processing and manufacturing industries.

e. Refrigeration and air conditioning: Air conditioning is the provision of clean air to an area at proper temperature and humidity. Refrigeration is the cooling of a space or its contents to a lower temperature than that of the surrounding space or of the ambient atmosphere.

f. Data communications: Encompassing the systems associated with communication distribution equipment, components, and the related devices for the distribution of audiovisual and data between points of transmission and reception.

Categories - relating to wiring systems -

g. **Cabling/wiring support and protection:** Including cable enclosure, ducts, trunking, roughing and cable trays and conduits, cable supports, aerial systems, catenary systems, underground systems, cable harnesses and looms.

h. **Network communications:** Including wiring systems and cables for the purpose of transmitting audio, visual or data information and may be associated with such things as twisted pair cables, telephone cables, screened and shielded cables, coaxial cables and optical fibre cables.

i. **Power and control – extra low voltage:** Including wiring systems and cables for the purposes of providing power and/or analogue or digital control and may be associated with such things as figure eight cables, unshielded twisted pair cables, ribbon cables, coaxial cables, and may include the production of printed circuit boards

j. **Power and control – low voltage:** Including wiring systems and cables for the purpose of providing power and/or analogue or digital control and may be associated with such things as thermoplastic/elastomer insulated/sheathed cable, multicore, armoured cable, mineral insulated metal sheathed (MIMS) cables, fire retardant cables, flexible cables, trailing cables and busways and includes those cables related to the category power and control extra low voltage.

Categories - relating to powerline switching -

k. **Low voltage switching:** The isolation and energising of low voltage powerlines for power distribution through approved switching and isolation procedures.

l. **High voltage switching:** The isolation and energising of high voltage powerlines for power transmission and distribution through approved switching and isolation procedures.

m. **System switching:** The isolation and energising of feeders in switchgear substations on low voltage and/or high voltage systems including load transfer and may include systems control room operations.

Categories - relating to business support -

n. **Administration:** Functions of record maintenance, quotation preparation, promotion of work and products, attending to customer and employees enquiries and complaints, preparation of invoices, business plans, service reports, maintenance reports and stock control.

p. **Technical:** Functions of estimating preparation of quotations, tenders related to installation, maintenance, repair and servicing of electrical/electronic apparatus and systems. Managing contracting projects and contracting business operation.

q. Wholesaling: Sales and supply of apparatus/equipment and electrical accessories to contractors and industrial end-users covering wholesaling-general or wholesaling-warehouse or wholesaling-point of sale.

Circuits -

Covers electrical, hydraulic, pneumatic, optical, magnetic, air flow, hydropic and refrigerant circuits.

Competency can be demonstrated in:

- basic circuits and associated apparatus
- complex circuits and associated apparatus
- systems' circuits and associated apparatus
- advanced circuits/systems and associated apparatus

A hierarchy of circuit complexity has been established within this document (independent of supply circuits) and are defined as follows:

Basic circuits: A basic circuit is defined as a single circuit with a single output.

A single circuit may be controlled by one or more devices and the output may control one or more devices.

Complex circuits: A complex circuit is defined as one made up of more than one interdependent circuit.

A complex circuit is made up of more than one circuit, controlling and processing inputs or outputs.

Systems' circuits: A systems' circuit is defined as one that interconnects between a number of interdependent apparatus.

A systems' circuit is made up of more than one interconnecting circuit controlling and processing apparatus inputs and outputs.

Advanced circuits/systems: Advanced circuits/systems may be complex circuits or systems circuits which contain complicated networks, hybrid circuits and which rely on digital or analogue closed loop feedback for the control of outputs.

Component -

That portion of a unit of *equipment*, which has been designed as a discrete unit and that can be identified as such.

Conditions and ratings -

Relates to flexible cables and plugs that are selected in accordance with Australian and New Zealand Standards and technical data including factors such as:

- Voltage rating
- Current rating

- Sheathing requirement
- Length of cable
- Pin configuration
- Control circuits
- Environmental conditions
- Weather proofing
- Fitting types – shielding, anchorage, earthing and polarity

Consistent performance -

Relates to sufficient evidence being present. This requires evidence that competence has been demonstrated for each element of each unit having been achieved at least three times autonomously and to *requirements.*

Design brief/proposal -

Instructions/specifications/outcomes defining the performance of circuits and associated apparatus, usually for the purpose of ensuring the optimum efficiency, environmental performance, economical effectiveness and operation of the system.

Endorsement: to be reported -

Refers to the endorsement on which an item of *apparatus, appliances, components, equipment, plant and machinery,* enclosures and the like that work can be performed on, (including any inspections, reports and risk assessment), as prescribed in regulations and/or by regulatory authorities, to which the unit applies.

Engineering data -

Refers to documents and other sources from which technical data and product specifications/characteristic are obtained, includes recognised standards publications, manufacturers product data publications and design features.

Environment -

The area surrounding the work site which can be directly or indirectly affected by occurrences at the work site. It includes the atmosphere, soils, drains, underground water tables, and the ecosystem. Protection of the environment would require the proper disposal of waste materials, restriction of burning off, the correct handling of toxic substances, the containment of CFCs and the like.

The protection of the environment would also include the minimisation of those factors that contribute, directly or indirectly, to the production of *greenhouse gases*.

These contributing factors might include the minimisation of waste materials, the correct use of enterprise vehicles and machinery, the re-use or recycling of trade

materials where possible and the overall reduction of energy usage through general awareness and the use of appropriate technologies.

Equipment (which is not apparatus) -

Any contributing part of an *installation* which may or may not be composed of *components.*

Established procedures -

Formal arrangements of an organisation, enterprise or statutory authority of how work is to be done. These may include, for example:

- quality assurance systems incorporating, for example:
  - specifications, requirements and procedures
  - work orders / instructions
  - reporting procedures
  - improvement mechanisms
  - compliance requirements
  - safety management
- work clearance systems incorporating, for example:
  - work permits
  - monitoring and clearance procedures
  - isolation procedures
- OH&S practices
- procedures for operating safety systems, operating plant and equipment and reporting work activities
- maintenance, modification or supply of relevant schematic drawings and technical data
- arrangements for dealing with emergency situations.

Greenhouse gases -

Gaseous components of the atmosphere contributing to the greenhouse effect. These gases are produced, for example, when fossil fuels are burned to produce electricity and in other industrial processes.

The greenhouse effect leads to global warming with its ecological and environmental problems.

The minimisation of the use of energy in the workplace, derived from burning fossil fuels, reduces the production of greenhouse gases.

See also *environment*

Initial audit -

An audit that is carried out initially to ascertain whether: a) appropriate procedures have been followed to ensure the safety of the area; b) equipment, systems and installation conform with the design specification and are free from damage; c) any modification have been properly documented and appropriately approved.

Installation -

Wiring systems, *apparatus* and other required items as they are fixed in place and connected as necessary to operate as intended.

Modifications -

To make changes to the physical parameters or operational function of a device, component or piece of equipment or apparatus.

Notification (notified) -

Can include verbal, written, electronic or recorded information at completion of work which may be required to be completed in accordance with established procedures.

OH&S policies and procedures -

Arrangements of an organisation or enterprise to meet their legal and ethical obligations of ensuring the workplace is safe and without risk to health. This may include:

- hazardous and risk assessment mechanisms
- implementation of safety regulations
- safety training
- safety systems incorporating,
  - work clearance procedures
  - isolation procedures
  - gas and vapour
  - monitoring/testing procedures
  - use of protective equipment and clothing
- use of codes of practice

Periodic audit -

An audit that is carried out periodically to ascertain whether: a) appropriate procedures have been followed to ensure the safety of the area; b) equipment, systems and installation conform with the design specification and are free from damage; c) any modification have been properly documented and appropriately approved.

Plant and machinery -

Devices or machines (not considered to be hand tools or hand held power tools) used to facilitate construction, installation or maintenance and are removed after the completion of the work. Examples include chain blocks, winches, compressors, ladders, elevated work platforms, explosive power tools, hand operated battery mobile lift and transfer equipment, accessories and attachments and the like.

Requirements -

That to which equipment and procedures and their outcomes must conform and includes statutory obligations and regulations and *standards* called-up by legislation or regulations. Requirements may also include:

- statutory regulations
- codes of practice
- job specifications
- transport documentation
- *standards* called-up in specifications be they Australian/New Zealand or International
- procedures and work instructions
- quality assurance systems
- manufacturers' specifications
- maintenance manuals, schedules and specifications/standards
- circuit/cable schedules
- design specifications
- customer/client requirements and specifications
- specified underpinning knowledge (specified in units' Evidence Guides)
- National and State guidelines , policies and imperatives relating to the *environment*

Representative range -

That which requires a sufficient body of evidence undertaken across a range of activities and work functions to be present in order that a valid, reliable, fair and timely judgement about an individual's performance for attributing competence can be made.

Sample audits -

A sample audit that is carried out to ascertain whether: a) appropriate procedures have been followed to ensure the safety of the area; b) equipment, systems and installation conform with the design specification and are free from damage; c) any modification have been properly documented and appropriately approved.

Servicing -

Undertaking routine inspection, repair and maintenance of circuits, systems or *apparatus*.

Specialisation -

Describes the work environment in which the core technical requirements of learning are to apply.

Standards -

Technical documents, which set out specifications and other criteria for equipment, materials, and methods to ensure they consistently, perform as intended. The s*tandards* referred to in this competency standard are those published by Standards Australia or in joint venture with Standards New Zealand. Competency in the use of other technical standards may be required in industries not restricted to Australian *requirements*. For example, shipping and off-shore petroleum industries are subject to standards agreed to by underwriters and enterprises or some other international convention.

Statutory Authority -

The person or body responsible for the implementation of legislation.

Sustainable Energy Principles and Practice -

Sustainable Energy Practice refers to workplace actions that contribute to the reduction of greenhouse gases. These are caused by the combustion of fossil fuels such as coal and gas. As most electricity is generated using fossil fuels, a reduction in the unnecessary use of electricity reduces the production of greenhouse gases. Also, most materials used in the workplace are manufactured using electricity or gas, so recycling and reducing the wastage of these materials also helps. There is a worldwide commitment to reducing greenhouse gases, which are considered to contribute to global warming. This User Guide promotes workplace strategies to assist in achieving the same goals.

Sustainable Energy Practice is closely related to the 'environment'. Sustainable energy practice aims to reduce the amount of wastage in electricity and other forms of energy that lead to the production of greenhouse gases. Many of the principles and practices that apply in the workplace also apply in the home and the general environment. These include:

- examining work practices that may use excessive electrical energy
- reducing energy by using energy efficient machines and appliances (eg. star ratings)
- switching off devices such as lights, machines and computers when not in use
- using power-save devices, such as those incorporated in photocopiers, business machines and the like
- replacing incandescent lamps with compact fluorescent lamps

- using natural light to replace artificial light
- regularly cleaning air conditioner filters
- closing windows and doors when climate control units are used
- insulating dwellings, offices and workplaces and preventing draughts
- using reflective curtains to control heat
- using natural or artificial shade to control sunlight
- using solar water heating
- using automatic processes to manage energy usage
- reusing materials used in construction, engineering and manufacturing
- recycling waste materials
- driving motor vehicles and other machines with care
- using natural gas for heating rather than oil or coal based fuels
- using devices to reduce water usage
- checking for leakage in hot water system pressure relief valves and elsewhere in plumbing systems
- sharing information about energy conservation with other workers

System -

A group or combination of inter-related, inter-dependent or interlocking elements forming a collective entity. Includes *circuits, apparatus, equipment* and the like.

Termination -

The act by means of which an electrical connection to an apparatus is established; specifically a prepared joint or connection between a cable, cord or conductor and a point in an electrical circuit such as a terminal or connection point. Such terminations include soldering, crimping, clamping, wire wrapping, insulation piercing/compression.

Testing devices -

Devices and instruments used to ensure safety requirements and operational functions are met, and to diagnose faults in apparatus, circuits or systems.

Utility -

The provision of energy services such as power, water, gas and telecommunications. In the case of UTE NES013 A it applies specifically to remote area essential services operations.

Wiring systems -

Permitted cables, enclosures, supports and *accessories* for power, measurement, control or communications purposes. (See also *Category*)

Work clearances -

Includes any system of permissions and notifications for safely working on or removing equipment/apparatus for service.

Additional glossary terms related to electrical equipment in hazardous area units of competency

Actions -

To limit risk of an explosion can include organisational arrangements for reporting and rectifying non-conformances; shutting down plant or machinery under emergency conditions; evacuating a hazardous area; reporting non-conformances and conditions of plant and machinery; monitoring the hazards area for presence of an explosive atmosphere; meeting OH&S obligations.

Authority -

Refers to documents from which explosive characteristics of products are obtained and include:

- recognised standards publications
- manufacturers product data publications

Certification documentation -

A formal certificate issued by a certifying body stating that an item of equipment/apparatus conforms to particular requirements of a standard. Documentation may include details of limitations of use and manufacturer's specifications and drawings.

Certification of equipment -

A means of verifying that equipment intended for use in a hazardous area complies with the accepted standards.

Classification of hazardous areas -

A concept, which is accepted internationally, of dealing with the risk of fire and explosion by area classification.

Competent person -

A person who has the relevant competencies described in this competency standard.

Electrical equipment -

Equipment used for power, measurement, control or communication purposes.

N. **Pre-assembled** Type 1 and Type 2 cold cathode Neon signs only.

P. A **single enclosed control device** contained in an enclosure which is not part of a Control Panel or Distribution/Switch Board.

Q. **Control devices,** e.g. solenoids, limit switches, pressure switches, thermostats.

R. Electrical heaters, such as water heaters, duct heaters, heaters incorporated as part of a machine or appliance. e.g. moulding machines, cooking appliances and the like.

S. Motors – refers to a single or three phase motor incorporated as part of plant or machinery. For example, a chiller unit, automated production and assembly unit, NC Machine; or independent motors driving such things as pumps, conveyors and other similar parts of plant and machinery.

Engineering assessments -

Using measurements, calculations and test results to determine whether an item of equipment complies with the relevant standard.

Equipment marking -

Information with regards to certification that is required to be marked on each item of equipment incorporating an explosion-protection technique.

Explosion properties of hazardous materials -

- for gases, vapours and mists; vapour pressure; boiling point; flash point; ignition energy; explosive limits relative to vapour density; minimum ignition energy
- for dusts; layer ignition temperature; cloud ignition temperature; minimum ignition temperature

Explosion-protection -

Technique of protection which is applied to equipment or parts of equipment to prevent the ignition of flammable vapours and gases or combustible dusts in hazardous areas. See *Explosion-protected equipment*.

Explosion-protected equipment -

Equipment using the technique which is applied to equipment or parts of equipment to prevent the ignition of flammable vapours and gases or combustible dusts in hazardous areas. Such equipment employs one or more of the following techniques:

T. Mixed explosion-protection techniques - Ex mixed: e.g. the use of one or more explosion-protection techniques for the following sub-endorsements. See *explosion-protection*.

- T1 – Ex “pD” – Pressurisation, dust
- T2 – Ex “mD” – Encapsulation, dust
- T3 – Ex “iD” – Intrinsic safety, dust

U. Pressurised enclosure - Ex p: e.g. rotating machines; specific products

V. Dust-exclusion ignition-proof - DIP: e.g. rotating machines; equipment within (DIP) enclosures

W. Non-sparking - Ex n: e.g. rotating machines; equipment within Ex n enclosures

X. **Intrinsic safety - Ex i:** e.g. specific products

Y. **Increased safety equipment - Ex e:** e.g. rotating machines; enclosures, equipment within Ex e enclosures

Z. **Flameproof enclosure - Ex d:** e.g. rotating machines; enclosures (eg. junction boxes; light fitting; stop-start statics); equipment within enclosures

Encapsulation - Ex m

Oil immersion - Ex o

Purging - Ex pl

Sand-filled - Ex q

Special protection - Ex s

Ventilation - Ex v

Hermetic sealing - Ex h

Functions and process equipment -

Activities that produce a potentially hazardous area and the equipment used in such activities.

Gas groups -

Classification of electrical equipment for use in gas or vapour atmosphere according to groups and sub-groups of gases and vapours.

Hazardous area documentation -

Auditable documentation that shows that a hazardous area has been appropriately classified and the electrical equipment complies with the appropriate certification and other explosion-protection requirements specific to the site.

Under Australian/New Zealand Standards or Codes these records are referred to as a 'Verification Dossier' and include:

- Hazardous area classification drawings and justifications
- The explosion-protection systems design drawings/specifications
- Certification documents for each item type of explosion-protected equipment
- Inspection, testing and maintenance schedules and reports
- Re-classification and authorised modifications documentation, where applicable
- Competent persons

Hazard and risk assessment -

Any recognised methodology of identifying hazards and assessing risks such as 'hazard and operability study' (Hazop) and 'fault tree analysis' (HAZAN).

Hazardous materials -

Flammable gases and vapours and combustible dusts.

Inspection, close -

An inspection which encompasses those aspects covered by a visual inspection and, in addition, identifies those non-conformances, (eg loose fasteners), which will become apparent when access equipment, (eg steps), and tools are used. Close inspections do not normally require an enclosure to be opened or equipment de-energised.

Inspection, detailed -

An inspection which encompasses those aspects covered by a close inspection and, in addition, identifies those non-conformances which only become apparent when an enclosure is opened up, or by use of tools and test equipment.

Inspection, maintenance schedules -

A program of periodic inspections and maintenance that follow set procedures and check lists for the purpose of ensuring the integrity of the explosion-protection and to comply with *requirements.* Details of a schedule will vary depending on the nature of the explosion-protection techniques used and environmental conditions.

Inspection, periodic -

Inspections of all equipment carried out on a routine basis, usually as part of scheduled maintenance.

Inspection, sample -

Inspection of a portion of installed equipment for the purposes of monitoring the effects of environmental conditions, vibration, inherent design weakness and the like.

Inspection, schedule -

A formal arrangement for conducting inspections which details the extent, grade and frequency of the inspections and the explosion-protected characteristics and compliances to be checked.

Inspection, visual -

An inspection which identifies, without the use of access equipment or tools, those non-conformances which are apparent to the eye.

Installation -

Explosion-protected equipment, wiring and other required items as they are fixed in place and connected as necessary to operate as intended.

Integrity of explosion-protected equipment -

Aspects of the equipment design and use that afford explosion-protection.

Load and duty requirements -

Wiring systems include: sufficient current-carrying capacity; maximum permitted voltage drop is not exceeded; temperature limits are not exceeded under normal or fault conditions.

Non-conformances -

Visual damage or corrosion of equipment and wiring and loose or missing fasteners.

Non-conformances and faults -

Equipment or wiring that does not conform to the design specification or other requirements.

Other items -

Those items that are not in themselves explosion-protected but have an influence on the integrity of the explosion-protection technique used. For example, an overload device for a motor or associated equipment in the case of intrinsic safety technique.

Pre-commission testing -

- tests specified by *requirement*, such as, performance and setting of protection devices and systems, earth loop impedance, insulation resistance, and earth continuity
- equipment connection and operation tests

Process specialist personnel -

To responsible persons with expertise in the technical aspects of the activities that produce the explosive hazard and include chemical engineers, process engineers, mining engineers, safety managers and the like.

Re-certification -

The submission of previously certified equipment to an approved testing body or authority to determine whether the equipment complies with the accepted standards after modification or where original certification is not fully known.

Recommended actions -

- non-connection of supply until a non-conformance or fault is rectified

- notice of period in which a non-conformance or fault is to rectified
- other actions within the scope of statutory regulations

Regulatory or statutory authority -

The person or body responsible for the implementation of legislation relating to the handling, processing or storage of materials constituting a hazard.

Servicing -

Maintaining, fault finding and repair of equipment, plant and machinery.

Special tools, equipment and testing devices -

Tools for the removal of enclosure covers and connecting conductors; measuring devices such as feeler gauges and micrometer; gas and vapour sensors; electrical testing devices approved for use in a particular hazardous area.

Specifications -

Can include: documentation of hazardous material; documentation of process pressures and temperatures; process flow diagrams.

Standards -

Technical documents which set out specifications and other criteria for equipment, materials and methods to ensure they consistently perform as intended. The *Standards* referred to in this competency standard are those published by Standards Australia or in joint venture with Standards New Zealand. Competency in the use of other technical standards may be required in industries not restricted to Australian/New Zealand *requirements*. For example, shipping and off-shore petroleum industries are subject to standards agreed to by underwriters and enterprises or some other international convention.

Temperature class -

Classification of electrical equipment according to its maximum surface temperature.

Verification dossier -

See *hazardous area records.*

Zones –

The zones into which hazardous areas are classified based upon the frequency of the appearance and the duration of an explosive gas atmosphere.

UTE NES701 (A to Z qualifier) A Redesign & develop modifications to apparatus & systems' circuits

Descriptor: Design and develop modifications to *electrical/electronic apparatus* and *systems.*

Alignment: This unit aligns to and is based on the National Electrotechnology Benchmark Standard EBS 501 – Design and develop modifications to apparatus and systems.

Specific unit outcomes

This is presented as a composite unit that has five specific units as outcomes, based on the *category* in which competence is achieved. This is done because of the high degree of commonality in process or function. Reporting the unit with the inclusion of a *category* allows for the identification of the necessary training outcomes in terms of the generic and transferable skills and at the same time reflects the work classification(s) generally understood by industry. The specific unit outcomes are:

UTE NES701A A	Redesign & develop modifications to apparatus & systems' circuits *(Computer systems)*
UTE NES701B A	Redesign & develop modifications to apparatus & systems' circuits *(Electrical)*
UTE NES701C A	Redesign & develop modifications to apparatus & systems' circuits *(Electronics)*
UTE NES701D A	Redesign & develop modifications to apparatus & systems' circuits *(Instrumentation)*
UTE NES701E A	Redesign & develop modifications to apparatus & systems' circuits *(Refrigeration & a/conditioning)*

Elements		Performance criteria	
701.1	Prepare for modification of equipment	701.1.1	Purpose of the modifications is established and expected outcomes of the work is confirmed with appropriate personnel
		701.1.2	OH&S requirements and environmental issues that may influence the modifications are determined
		701.1.3	Organisational policies and specifications for *electrical* systems are obtained or established with the *appropriate personnel*

Elements		Performance criteria	
701.2	Determine the level of modification	701.2.1	The limitations, use and operation of the apparatus/system to be modified is established from original specifications, manufacturers' data and the like
		701.2.2	The extent of modification is determined from measurements, tests, inspections, apparatus/system limitations and other relevant *requirements*
		701.2.3	Specifications and instructions for the modifications are documented in accordance with requirements and organisational procedures
701.3	Design modifications	701.3.1	Alternative modification arrangements are considered and discussed with *appropriate personnel*
		701.3.2	Safety, functionality and economic considerations are incorporated in the proposed modification design
		701.3.3	Proposed modification complies with all *requirements* and includes specifications and documentation for alteration of *apparatus/equipment*, accessories and wiring systems
		701.3.4	Changes in the use and operation of apparatus/system as a consequence of the proposed modification are included in the documentation
701.4	Check and finalise modification design	701.4.1	Proposed modification is checked under *established procedures* for compliance with all relevant *requirements*
		701.4.2	Proposed modification is submitted for appropriate organisational approval and, where applicable, statutory or regulatory approval
		701.4.3	Approved copies of the modification design documents are issued and copies retained in *records* in accordance with *established procedures* and *requirements*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Categories

This unit recognises the commonality of skills and knowledge that exists for the unit as well as the additional specific outcome; which is to be reported on. Therefore, competency can be displayed on one, some or all of the following categories and in addition to the respective common underpinning knowledge associated with the selected specialisation:

(A) Computer systems

(B) Electrical

(C) Electronics

(D) Instrumentation

(E) Refrigeration and air conditioning

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit in the related *category* and *specialisation* which is to be exhibited across a *representative range* of applications; autonomously and to *requirements*.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace for each of the *categories* and areas of *specialisation* undertaken from those listed in the Range statement or Evidence guide.

- demonstrating an understanding of the underpinning knowledge and skills identified for the *categories* and related *specialisation* undertaken in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of applications which includes such things as *apparatus*, *circuits*, *wiring systems*, *plant*, *equipment*, tools, *accessories*, *components* and the like relative to that required for the *category* undertaken within and relevant to this unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

Nil.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

This section includes that set of knowledge and skills additional to that specified in the above mentioned section titled 'Interdependent assessment of units'.

Since this unit covers a range of *categories* each having multiple *specialisations* a content listing is provided below. Each *category* has all of the required underpinning knowledge and skill listed even though this sometimes results in duplication between *categories*.

Category: Computer systems (A)

Common

Data link operations.

Use of asynchronous data link hardware and software

Awareness of occupational health and safety for mains operated electronic equipment when installing hardware

Start/stop protocol options: data rate, number of data bits, number of stop bits, even/odd/no parity bit

Use of synchronous data link hardware and software

Recognition of format for OSI high level data link control (HDLC) and 802.2 logical link control (LLC) including data flow control: receiver ready (RR), receiver not ready (RNR), Poll/final (P/F) bit, module counters

Recognition of format for link negotiation commands, link connection and disconnection commands, link layer control service access point (LSAP) and 802.1 defined addresses

OSI HDLC and 802.2 LLC protocol options: data rate, clock encoding, number of octets, half/duplex

Recognition of format for OSI HDLC and 802.2 LLC error procedures: frame reject (FRMR), frame discarding

Correlation of end user error messages with abnormal traffic

Computer networks.

Protocols and the OSI model: rationale for layered protocols; goals of layered protocols; network design problems; communication between layers; the layers

Terminal networks: terminal characteristics; character mode networks – terminal multiplexer; statistical multiplexer, terminal switching exchange; block-mode networks; multidrop lines, poll-select; terminal network protocols, binary synchronous control (BISYNC) formats, protocol operation, user interface, protocol performance; high-level data link control; frame formats, frame types

Delay analysis: introduction to queuing theory; the M/M/I queue in equilibrium; networks of M/M/I queues

Network layer: virtual circuits, datagram; routing algorithms; congestion; bridges, routers, brouters, gateways internetwork protocol, TCP, IPX, XNS

Local area networks: topologies; types of LAN's – ethernet, token ring, token bus, network installation, planning, performance outcomes

Operating system (multiuser).

Operating systems: history; functions of the system

Multiuser and multitasking operating systems: real time applications; interleaved processing techniques; multiprogramming; multitasking; time-sharing; virtual storage; multiprocessing

Language translators: compilers; interpreters; assemblers

File and disk organisation: files and directories; protection and permissions; listings; file location; classification

System command and calls: commonly used commands; retrieving; saving; deleting; copying; creating; printing; linking

Input/output redirection: meaning of; method of achievement

Batch, script or equivalent files: purpose; structure; commands

System utilities: sorting; windowing; device drivers

Computer systems architecture.

Historical milestones in computer architecture; Von Neumann architecture; non Von Neumann architecture; fetch decode execute cycle

Bus architectures: address, data and control; 8/16/32 wide buses; multiplexed and non multiplexed; Von Neumann bottleneck; synchronous, semi-synchronous and asynchronous data transfer; design considerations – reflections and termination, crosstalk, receivers, transceivers and hysteresis; drivers, open collector and tristate; single user and multiuser buses – IBM PC, VME, UNIBUS

System support: instruction pre-fetch pipeline, BIU, EU; DMA devices – cycle steal and burst modes; peripheral CHANNEL support; co-processors and bus interface; typical interrupt structures – intel, Motorola, PDP-II Zilog

CPU Architecture: registers, ALU and control unit; bit slice, Harvard, stack oriented CPUs; machine code and conventional machine; instruction set considerations; addressing modes – direct, indirect, indexed; the micromachine control unit and data pathways; hard wired and microcoded control unit; horizontal vs vertical microcode considerations; gate array, ASICS

Parallel processing: Flynns taxonomy – SISD, SIND, MISD AND MIMD; data pipeline, multiple functional units, interleaved memory, vector and array processors; parallel machines – transputer, hypercubes, connection machines, dataflow machines

Operating system considerations: multiprogramming systems, time-sharing; virtual memory – overlays, physical address space, virtual address space, paging, working set, thrashing, page replacement, segmentation

CACHE: memory, locality of reference principle, hit ratio; mapping techniques – associative, direct, set-associative; write-through, write-back

RISC Machines: RISC vs CISC; instruction set, register sets

Engineering mathematics.

Matrices: the operations – addition (subtraction), scalar multiplication, matrix multiplication up to 3x3 matrices; identity matrix, inverse matrix; elementary algebraic manipulation of matrices; solving linear equations using inverse matrices and determinants

Quadratic functions: graphs of quadratic functions represented by parabolas and significance of the leading coefficient; zeros represented graphically; solve quadratic equations by factoring and quadratic formula; solve simultaneously linear and quadratic equations algebraically and geometrically

Exponential and logarithmic functions: laws of indices; graph of $f(x) = ka^{bx}$, emphasising a = 10, e; definition of the logarithm to any base; graph of $f(x) = k \log_a bx$, emphasising a = 10, e; solve exponential and simple log equations using indices, logs, calculator, graphically; change of log base, emphasising 10 and e; growth and decay

Trigonometric functions: the ratios – sin, cos, tan, cosec, sec, cot; degrees, radians; graphs of k f(ax + b) where f(x) = sin x, cos x, tan x, and significance of k, a, b; trigonometric identities; solving trigonometric equations

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Meetings.

Convener skills; interpersonal skills; organising skills; reading and writing skills; meeting and convention processes; handling conflict

Category: Electrical (B)

Common

Applications of transducers.

Light and radioactivity detection: light sensors; units of light; light measurement terms; photoemissive light sensors; photoconductive light sensors; photovoltaic light sensors; x-ray sensors; nuclear radiation sensors; units of radiation measurement; units of radiation measurement; radiation sensors – photoelectric, ionisation

Temperature detection: temperature-sensing basics; units and terms used; bimetallic, fluid-pressure, resistive, semi-conductor, thermocouple, radiation pyrometer, oscillating-crystal

Fluid flow and pressure detection: fluid flow sensing; units of flow measurement, terminology; rate of flow sensors; quantity of flow sensors; fluid pressure sensing basics; units of pressure measurement; Bellows, Bourdon-tube, diaphragm, and capsule pressure sensors; pressure cell, differential-pressure sensors

Motion and force detection: motion and force sensing; sensors for linear motion; angular motion; speed of rotation; compression; tension, torque; acceleration, vibration; altitude

Moisture and humidity sensors: moisture and humidity measurements basics; moisture and humidity measurement units and terms; hygrometer-type sensors, resistive, dielectic-film, mechanical displacement, oscillating-crystal, aluminium-oxide; psychrometer-type sensors; dew point sensors, temperature-sensing, instant-of-condensation

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

Advanced PLCs.

Medium to high level PLC hardware and software: hardware configuration; addressing; memory map; programming instruction syntax; file manipulation; documentation; saving/restoring programs

Number systems and codes: common number formats (binary, octal, integer, hexadecimal); conversions between formats; codes (BCD, grey, ASCII)

Diagnostics: flags/status words (file); fault locations; scan considerations (fixed, variable, immediate update)

Data manipulation (word): binary word structure; single and double works; word devices; arithmetic instructions; word logical instructions; conversions (BCD to binary, binary to BCD); indirect addressing (image register to word, word to IR, word to word, word to table, table to table); word shift registers (LIFO, FIFO); masking; bit manipulation (bit set, bit clear, bit test); entering data constants; multiplexing

Analogue I/O: common signal types; module resolution; scaling; unscaling; signal offset

Sequencers/drum controllers

Specialisation: Power systems

Power systems analysis.

Impedance of three-phase load: complex analysis; measurement of impedance; conversion of impedance between star and delta

Analysis of mixed load three-phase circuits: star and delta systems; mixed single and three-phase loads; balanced and unbalanced loads; calculation of line and phase currents in both star and delta loads; total line current for mixed loads; power in three-phase systems, including the use of current transformers; power factor; prediction of current and voltage on the loss of the neutral

Measurement in three-phase circuits: measurement of voltage, current, power and power factor in mixed circuits; sources or error

Line voltage drops: cable losses; voltage drop; heat dissipation; Australian Standards and limitations of losses; methods to minimise line losses

Power Factor (P.F.) correction: requirement; calculation of reactive element to correct P.F.; synchronous machines for correction of P.F.

Electrical distribution.

Distribution system: systems of distribution used – primary and secondary; voltage levels; supply quality; load curve profiles – residential, industrial, commercial; types of feeders; distribution systems – urban, rural single phase systems – SWER

Overhead lines and installation: industry and safety regulations; overhead conductors – conductor material, current rating factors – heating, voltage drops, power losses, aerial bundled cables – HV and LV, covered conductors; overhead lines poles – types – wood, concrete and steel, installation of poles – tooling, rake, life, labelling, sinking, maintenance of poles – above and below ground, pole strength and loads; crossarms – types and standard sizes; insulators – insulation types, types – pin, suspension or disc, shackle, creepage – necessary clearances, acring horns – insulator mounting; structure types – mechanical properties – working strength, maximum tension, limiting size; stringing charts (use of) – sag – calculations, measurement and tension measurement, sight and wave sagging, sag correction; stays – components, anchorage; use of design

schedules – design problems – examples of common design practice line, voltage, structure types used, line deviation, span sag, crossarms, insulators and stays wind loading and line deviation loading basic surveying, measurement of levels, deviation angle and compass bearings, perform survey of short distribution line extension of produce filed notes

Underground cables: cables types – ratings, core material, design considerations, cable dielectrics, insulating materials and abbreviations, electric stress, cable volt drop and volt drop calculations, cable termination, joints and installation; induction and eddy currents; cable testing - cable fault location; cable drawing

Voltage regulations of feeders and associated equipment: terminology used – distribution system, service line, customer's terminals, customer voltage, utilisation voltage, base voltage, voltage variation and bandwidth; voltage limits and effects for voltage variation; causes of variation – inductance, capacitance and reactance of distribution lines, transformers; methods of voltage control – off-load, on-load tap changers, voltage regulating relays, line drop compensation, different types of voltage regulators; voltage profiles – principles, effect on voltage profiles, limits of voltage, voltage drops due to LV mains transformers, tapsettings feeder and service lines

Specialisation: Control systems

SCADA systems.

System requirements

Use, features and facilities of different SCADA packages

Hardware requirements

PLC interface requirements

Networking requirements of the system

Mimics and animated graphics: graphic designs; balance of layout

Trending: analysis of process to select data; sampling of the process in terms of temperatures, time, weight; viewing data and graphical representation of selected information; trend graphs and data matching

Alarm logging: analysing select data, applying limits and specification applied to processes; corrective action of alarm status

Recipes and scheduling: methods of producing libraries for different process conditions, required for varied production runs; analysis of different production runs; alarm limits/material specifications; scheduling, setting limits and evoking program changes

Data collection and databasing: producing a database of variables; conversion of raw data into appropriate databasing software package

Reports: types and layout of reports; analysis of data

Programming language: automation of tasks within the software package

Implementation and applications: networking; types of networks; co-ordination and access of networking by linking to mainframe or factory network

Transmitters and converters.

Pneumatics: principles of flapper nozzles, pneumatic transmitters

Supplementary pneumatic loop equipment: computing relays, lead/lag units, high and low selectors, air to current and high and low selectors, air to current and current to air converters, square root extractors, integrators, regulators, multipliers and dividers

Electronics: electronic transmitters, analogue computing, integrators, high and low signal selector, signal converters

Transducers I to P, P to I converters, analogue to digital and digital to analogue converters, RTD/I, mV/mA, frequency to I, square root extractors and integrators

Linear variable differential transformers

Intrinsic safety

Zener barriers

Explosion/flame proof enclosure

Specialisation: Drive systems

Variable speed drives.

Introduction to variable speed drives: advantages of variable speed drives – speed and direction control, acceleration control, torque control, energy savings; terminology used with variable speed drives – direction – forward and reverse, speed - $^{+}$ve and $^{-}$ve, torque - $^{+}$ve and $^{-}$ve, 4 quadrants of torque/speed operation, acceleration - $^{+}$ve and $^{-}$ve, load power – supply power, efficiency; power electronic converters – common electronic power control circuits for – AC/DC rectifier, un-controlled and controlled, DC/AC inverter, PWM and quasi-square wave AC/AC converters, rectifier linked to inverter and a matrix converter, DC/DC converters, PWM; input and output waveforms for power electronic converters – interference generated by circuits, electrical and audio; electromagnetic compatibility (EMC), introduction to harmonic distortion analysis using microprocessor based test equipment (not mathematical analysis), filtering techniques employed to optimise EMC switching frequency and effects on motor performance and EMC; control system for variable speed drives PWM (Pulse width modulated), VVVF drive (variable voltage variable frequency) – inverter control system, speed feedback and control system, current feedback and control system, external interface, selection of, and applications for PWM, VVVF drives; flux vector control drive – inverter control system, speed feedback and control system, current feedback and control system, select of, and applications for slip recovery drives; control system for soft starter – overview of operation of soft starter selection of, and application for soft starters; new development in AC variable speed drive technology – e.g. switched reluctance drive/motor

Protection of AC variable speed drives and motors: sources of failure – loss of cooling, overloading, frequent starting, supply problems, high ambient temperature; methods of protecting against sources of failure; protecting the frequency converter – current limit, over current trim; protecting the AC motor – motor thermal model

Commissioning: purpose; setting parameters; testing

Differentiation of common faults in systems: source of faults; methods to determine nature of fault; includes communications and external interface

Adjust settings: manufacturers specifications; load testing

Identify drive faults: source of faults; fault-finding methods

Selection, installation and fault-finding techniques: choosing size of frequency converter; motor loading and cooling; checking motor loading; over synchronous speed – advantages; mounting position and enclosures; supply and control cable selection and installation; environmental conditions; earthing

Category: Electronics (C)

Common

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Engineering mathematics.

Matrices: the operations – addition (subtraction), scalar multiplication, matrix multiplication up to 3x3 matrices; identity matrix, inverse matrix; elementary algebraic manipulation of matrices; solving linear equations using inverse matrices and determinants

Quadratic functions: graphs of quadratic functions represented by parabolas and significance of the leading coefficient; zeros represented graphically; solve quadratic equations by factoring and quadratic formula; solve simultaneously linear and quadratic equations algebraically and geometrically

Exponential and logarithmic functions: laws of indices; graph of $f(x) = ka^{bx}$, emphasising a = 10, e; definition of the logarithm to any base; graph of $f(x) = k \log_a bx$, emphasising a = 10, e; solve exponential and simple log equations using indices, logs, calculator, graphically; change of log base, emphasising 10 and e; growth and decay

Trigonometric functions: the ratios – sin, cos, tan, cosec, sec, cot; degrees, radians; graphs of k f(ax + b) where f(x) = sin x, cos x, tan x, and significance of k, a, b; trigonometric identities; solving trigonometric equations

Basic determinants and solution of 2/3 simultaneous linear equ by determinants exponents and logs

Time dependent trig functions - $\sin(\omega t+\theta)$

Trig of oblique triangles

Introduction to vectors

Complex numbers

Circuit analysis.

Phasors: time domain; frequency domain; frequency, angular frequency and units of measurement

Complex impedance: impedance diagram; resistance; reactance; admittance; conductance; susceptance; equivalent series circuit; equivalent parallel circuit

AC series/parallel circuits: Kirchhoff's laws; series equivalent impedance; parallel equivalent impedance; voltage divider rule; current divider rule; phasor diagrams

Complex power: true power; reactive power and apparent power; units of measurement – watt, volt-amp; reactive, volt amp; power triangle; power factor

Superposition theorem: power considerations

Thevenin and Norton theorems: voltage source models; current source models; practical sources; open circuit voltage; equivalent impedance; short circuit current; source conversion

Star/delta conversions: equivalent circuits; star/delta transformation formulae; selection of appropriate conversion

Specialisation: Communications

Communication fundamentals.

Basic communication system: radio wave as a T.E.M. wave; radio wave frequency band identification; relationship between frequency – wavelength and velocity of propagation for radio wave

Transmission media: metal cable; waveguide; optical fibre; radio wave paths

Noise: definition; categories; effect on communication systems; communication signals in both the time and frequency domain; fourier analysis of periodic complex waveforms; baseband signals; modulation signals

Modulation techniques: AM full carrier; double sideband; single sideband; vestigial sideband; frequency modulation; phase modulation

Demodulation techniques: AM full carrier; single sideband; frequency modulation; frequency division multiplexing (FDM) F.D.M hierarchy; F.D.M in stereo FM; time division multiplexing (TDM); TDM hierarchy; basic crystal set receiver; TRF receiver

Superheterodyne receiver: block diagram; advantages

Transmitters: AM full carrier; single sideband; FM; digital signals; sampled analogue signals; sampling theorem; pulse code modulation (PCM) – quantisation, quantisation noise, companding, encoding; digital signal transmission compared to analogue signal transmission; noise in communication systems; signal-to-noise ratio; noise figure; noise factor; noise temperature signal-to-noise bit error rate in digital

Receiver and transmitter circuits.

Receiver block diagrams: principles of dual conversion; DSBFC dual conversion receiver

RF amplifiers: intermodulation; cross modulation; RF amplifier performance

Intermediate frequency (IF) amplifiers: IF amplifier alignment; neutralisation; IF amplifier performance

Demodulation: SSBSC

AGC systems: SSBSC receivers

Phase locked loops (PLL): PLL noise; frequency synthesis using PLLs

Receiver performance criteria: sensitivity test - FM quieting, S/N ratio, SINAD measurements; spurious signal responses; receiver noise figure

NBFM transmitters: operation; tuning and adjustment; testing

Digital transmitters

Specialisation: Analogue and digital

Microprocessor system assembly language programming.

Operation of a microprocessor based computer system: ROM, RAM, IO and major system components

CPU architecture: registers; instruction set considerations – common and advanced instructions; addressing modes supported – direct, indirect, indexed; software interrupts and system calls

Processor and system support: instruction pre-fetch pipeline; system timer chip – function and programming; hardware interrupt programming considerations; DMA devices and support; co-processors and bus interface

Modular programming: separately compiled and linked assembly language modules; library modules; macros

Documentation and debugging: system specification and documentation; debugging and tracing program execution

Electronic instruments.

Loading and matching; connectors; decibels; storage and delay CROs; frequency synthesisers; frequency counters; spectrum analysers; noise and distortion meters; RF communications service monitor

Category: Instrumentation (D)

Common

Control programming style.

Control applications of software; software terminology; relevant programming languages currently available; flowcharts; pseudocode; nassi sniedeman charts; developing algorithms; programming style; programming structure; documentation

Installing a language compiler; using a text editor; compiling source code; generating executable files

Scalar and structured data types; constants and variables; reading from keyboard and writing to screen; arithmetic, relational and logical operations; making decisions using if/then, if/then/else, nested if/then and case; looping operations using while/go, repeat/until and for/do; subprograms; functions; procedures

Installation of computer interface circuit boards; programming to access external devices via I/O boards

Electrical control 'C' programming.

'C' language: uses; advantages and disadvantages

'C' development package: editor commands; the edit-compile-run cycle; compiler and linker options; header files

Language syntax: data types; arithmetic and logical operations; program structure

Control structure: sequential; repetition; selection

Functions: macros; global and local variables; intrinsic functions used in control; writing functions, linking in external functions to control hardware; numerical and character arrays; sequential file reading and writing

Control electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

On-stream analysis.

On-stream analysis: chromatography; spectroscopic methods; electrical methods; sampling systems

SCADA systems.

System requirements

Use, features and facilities of different SCADA packages

Hardware requirements

PLC interface requirements

Networking requirements of the system

Mimics and animated graphics: graphic designs; balance of layout

Trending: analysis of process to select data; sampling of the process in terms of temperatures, time, weight; viewing data and graphical representation of selected information; trend graphs and data matching

Alarm logging: analysing select data, applying limits and specification applied to processes; corrective action of alarm status

Recipes and scheduling: methods of producing libraries for different process conditions, required for varied production runs; analysis of different production runs; alarm limits/material specifications; scheduling, setting limits and evoking program changes

Data collection and databasing: producing a database of variables; conversion of raw data into appropriate databasing software package

Reports: types and layout of reports; analysis of data

Programming language: automation of tasks within the software package

Implementation and applications: networking; types of networks; co-ordination and access of networking by linking to mainframe or factory network

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Final control elements.

Control valve selection and sizing

Pneumatic controllers and positioners

Pumps and blowers

Variable speed drives

Dampers

Category: Refrigeration and air conditioning (E)

Common

Commissioning - HVAC systems.

General requirements: building codes; local government regulations; human comfort – comfort chart; reporting procedures; pre-commissioning checks

Air systems: air tab instruments (air flow, pressure, temperature); fan testing; air balancing procedures; leakage testing; system capacity calculations

Hydronic systems: hydronic tab instruments (fluid flow, pressure, temperature); pumps; pump curves and system curves; pump testing; hydronic (balancing procedures, general, compensation method); balancing valves; capacity calculations

Plant and equipment: controls; heat exchangers; chillers; boilers; cooling towers

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Meetings.

Convener skills; interpersonal skills; organising skills; reading and writing skills; meeting and convention processes; handling conflict

Specialisation: Control systems

Advanced HVAC control systems.

Control diagrams: electric/electronic control diagrams; electrical installation documents; pneumatic diagrams; DDC diagrams; controls/electrical power circuit interface; nomographs

Evaluate existing automatic control systems: specifications; briefs; descriptions of operation

Control requirements: standard and statutory requirements; economy of operation (energy management)

Building management systems.

Functions of a BMS: autonomous functions; input; output; general I/O; installation management items; energy management; risk management; information processing; objective; building running costs

BMS hardware: system architecture; communication devices; substations; PCs

Input and output functions: digital – input, outputs; digital output with status feedback; analogue input, output; sensors; alarms

Energy management: night cycle; optimum stop, start; time and event programs; night purge; outside air percentage control; enthalpy control; power demand control; duty cycle; presence detection; lighting control

Information processing functions: computer systems; central system management; programs; system configuration and security; operator – machine interface; data points

Risk and maintenance management: system files; fire – intruder control; access control

Energy management.

Energy sources and characteristics: supply authorities; standards units of measurement; electricity; steam; hot water; high temperature hot water; town gas; LP gas; solar; waste heat; petrochemical

Energy requirements: office lighting; air conditioning systems; refrigeration systems; security systems; computer systems; waste disposal systems; standby/emergency systems

Energy auditing process: energy costs and tariffs; energy consumption; predicting future costs; plotting consumption trends; historical data; collecting information using surveys; comparisons of actual to recorded usage; energy balance; instrumentation; estimating savings potential

System operation for energy efficiency: types of systems; efficiency in building structures; operation of a vehicle fleet; proportioning total energy consumption against individual systems; passive building design; preventative maintenance procedures; monitoring building management systems; operation of major and minor plant; inappropriate energy management procedures; building plant control systems

Implementing energy management procedures for a building: recording base year data; climatic conditions for locality; establishing energy costs and tariffs; building and systems surveys; pay back period; survey analysis; energy conservation procedures; implementation issues; monitoring

Methods of energy conservation: time schedules; lighting control

Maintenance practices: filters, fans, appropriate setpoints, dead bands, etc

HVAC system control: night cycle; optimum stop/start; purge cycles; chiller/boiler/cooling tower sequencing; economy cycles (based on temperature or enthalpy); supply air reset; supply water reset; condenser water temperature reset

Electrical load control: power demand control; load limiting; load shedding; set point relaxation; ventilation cycles

Tests and data collection procedures: use of BMS for data collection (trending); use of data recorders (loggers); monitoring building operations generally

Analyse results from test data: compare against standards (BOMA); review current practices against ideal; total consumption Vs peak load; electricity tariffs and implications

Methods of reducing energy usage: plant retrofits; controls; plant – fixed OA to economy boiler to electric reheat, constant volume to VAV; cost/benefit (payback)

Specialisation: HVAC systems

Commercial air conditioning system design.

Design parameters for commercial (single zone) air conditioning applications: e.g. offices, restaurants, hotels, bars; customer and objective; customer concept of environment desired; economics; client brief

Relevant design criteria: building purpose, location, orientation and shape; external environment ambient conditions; internal load diversity; thermal capacity behaviours; thermal load (full and partial)

Zoning and building usage: space and building; occupancies, single purpose, multi-purpose

System selection criteria: economics; environment; control requirements; existing structures; new structures; system components; space for equipment and system; selection of appropriate system, ductwork and components

Systems and applications: design features, engineering, controls and selection procedures for fan direct expansion RAC's, coil units, heat pump, package units, free blow and ducted

HVAC energy conversion techniques: heat recovery systems; night cycle; optimum stop/start; purge cycles; load limiting; load shedding; cost/benefit (payback)

HVAC load estimating.

Building survey: space characteristics; location of equipment; design conditions – outdoor, inside (type of installation); storage of heat in building structures; solar heat – direct and diffuse, glass types and factors, shading devices; film coefficients; heat and water vapour through structures – transmission coefficient; infiltration; ventilation; internal heat gains; system heat gains

Computer programs: ACAOS; TRANE; CARRIER

Psychrometrics – advanced.

Complex psychrometric processes: sensible cooling and heating and evaporative (adiabatic) cooling; cooling and dehumidfication; cooling and dehumidification with high latent load; cooling and dehumidification out door air; cooling and dehumidification all out door with dehumidified air requirements less than supply air; cooling with evaporative humidification; cooling with near isothermal humidification; spray processes to include cooling and dehumidification with heated spray water – heating and humidification;

partial load processes – reheat, by-pass of RA only and, mix of RA and OA; variable air volume; variable coil effective surface temperature; split coil - horizontal, vertical and intertwined

System performance: saturation efficiency of sprayers; system capacity calculated from air quantity and enthalpy change

Required plant capacity and airflow rates: effects of coil by-pass factor and ADP; calculation of dehumidified air quantity – using both TSH and ERSH methods

Psychrometric formulae and charts: properties of air; gas constants; derivation of air constants; combined gas laws; Dalton's law of partial pressures; Carrier's equation; psychrometric property tables; psychrometric charts; air mixing equations; air quantity equations

Commercial refrigeration systems design.

Calculation of capacity in heat exchangers

Evaporators: commercial types and applications; coil bypass factor; effects of evaporator TD on space humidity; effects on air circulation on product conditions; selection criteria and selection tables

Condensers: commercial types and applications; effects of ambient conditions; condenser control; heat rejection factor; condenser TD; selection criteria and selection tables

Compressors: types and applications; capacity; power; effect of operating conditions; actual requirements; post defrost loads; pull down torque requirements, high, medium and low back pressure compressors; selection tables, motor selection

Liquid expansion devices: types, operation and applications; effects from subcooling; distributor types, operation and applications; selection tables

System load balance point

Line sizing and design: velocity tables; pressure drop in lines and fittings; oil migration stabilisation; refrigerant velocity; effect of varying system capacity; oil traps; risers; double risers; liquid migration; design for parallel components and multiplex systems

Automatic controls: refrigerant regulating valves; solenoid valves; expansion valves; condenser pressure regulating valves; evaporator pressure regulating valves; crankcase pressure regulating valves; cycling controls; pressure-stats; thermostats; defrost controls; monitoring and alarm controls; refrigeration automation systems; control strategies; control modes

Specialisation: Refrigeration systems

Industrial refrigeration systems design.

Standards and codes: AS1677, detailed understanding; AS3666, overview; ozone protection regulations

Operating characteristics: Ph charts; refrigerating effect, relate back to air and fluid coolers; heat of compression, relate back to screw, rotary and reciprocating compressors; heat rejected on high side of the system, relate back to air cooled, evaporative, and water cooled condensers; required mass flow rate of refrigerant and volume; flow rate at various points in system; theoretical compressor power; required condenser capacity

Major system components: refrigerants, including R717 and R22; secondary refrigerants; component lubricant refrigerant compatibility evaporators; condensers, cooling towers; compressors; expansion valves; interconnecting piping and isolating valves; pilot operated valves; defrost system components for, air, water, recycled water, hot gas, electric, methods

Moderate and low temperature industrial refrigeration systems: direct – flooded and pumped liquid recirculation systems; evaporators; multistaged compression; direct staging; cascade staging; compound compressors; desuperheaters; liquid injection; direct expansion intercoolers; open and closed intercoolers; basic designs of accumulators/intercooler vessels; oil cooling methods; oil stabilisation – return and oil recovery in flooded systems

Multiple evaporators and multiple compressors: parallel evaporators; multiple temperature systems; evaporator pressure regulators; temperature control methods; parallel compressors; pipework layout; methods of establishing pressure drop in dry and wet suction lines

Indirect refrigeration systems: classification according to AS1677; applications; evaporators; heat exchangers – types, construction, selection; secondary refrigerants; brines; antifreeze solutions

Flooded systems: applications; equipment; accumulators; level controls; liquid recirculation pumps; liquid pressure relief valve

Cryogenic systems: applications and equipment; system components; refrigerants; design safety; economics

Basic control sequences: maintaining evaporator conditions; staging and suction pressure control; maintaining condenser conditions; control of intermediate pressure – methods of industrial refrigeration compressor capacity control

Noise and vibration control.

Fundamentals of sound: frequency; decibels; octave bands; direct sound; velocity; sound pressure level; sound power level; sound meters

Noise and people: physical measurement of sound; weighting networks; NR curves; noise damage to hearing; evaluate daily noise exposures; peak noise levels; attenuation of hearing protectors; excess noise levels permissible; Noise Abatement Act

Identify and analyse problems: one-dimensional sound waves; standing waves; energy in a sound wave; sources; effects of air turbulence; transmitters; amplifiers; absorptivity; reflectivity; room characteristics; acoustic design in buildings; fan and air noise transmission in ducts

Methods of control: natural attenuation; sound absorbing materials, placement; duct lining; lined plenums; lined duct splitters; duct attenuators; white noise; vibration isolators

Acoustic specifications: attenuator ratings

Energy management systems for commercial refrigeration.

Functions of a commercial refrigeration E.M.S: general control function; inputs; outputs; communications; graphing; supervising; data logging; scheduling; alarms; power consumption

E.M.S control components: identify components, pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensor; state the function and operating parameters of components – pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensors

Installation requirements and consideration: installation of controller(s); installation of refrigerant leak detector systems; installation accessory boards; installation of pressure transducers and wiring; installation of temperature sensors and wiring; control wiring considerations

System design and applications: select control components to suit given applications – determine system operating parameters, pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensors, defrost, alarm panel

Programming a control system: display terminal and keypad functions; calibration of sensors; changing original settings; program a given set of parameters to suit an application

Component testing and fault-finding: trouble shooting; testing components

UTE NES702 (A to Z qualifier) A
Design electrical/electronic apparatus & systems

Descriptor: Design in detail *electrical/electronic apparatus* and *systems* in which design solutions are pursued which are both economical and meet all requirements.

Alignment: This unit aligns to and is based on the National Electrotechnology Benchmark Standard EBS 502 – Design electrical/electronic apparatus and systems.

Specific unit outcomes

This is presented as a composite unit that has four specific units as outcomes, based on the *category* in which competence is achieved. This is done because of the high degree of commonality in process or function. Reporting the unit with the inclusion of a *category* allows for the identification of the necessary training outcomes in terms of the generic and transferable skills and at the same time reflects the work classification(s) generally understood by industry. The specific unit outcomes are:

UTE NES702A A	Design electrical/electronic apparatus & systems *(Computer systems)*
UTE NES702B A	Design electrical/electronic apparatus & systems *(Electrical)*
UTE NES702C A	Design electrical/electronic apparatus & systems *(Electronics)*
UTE NES702D A	Design electrical/electronic apparatus & systems *(Instrumentation)*

Elements		Performance criteria	
702.1	Establish design brief	702.1.1	OH&S requirements and environmental issues that may influence the design are determined
		702.1.2	Design concept and details are discussed with *appropriate personnel* in order to establish a detailed design brief
		702.1.3	Design parameters are established from organisational policies and specifications for *electrical* systems and other *requirements* that may influence the design
702.2	Design system and installation	702.2.1	Alternative designs are considered and discussed with *appropriate personnel*
		702.2.2	Circuit/system modelling is used in common stages applicable, to evaluate design proposals

Elements		Performance criteria	
		702.2.3	Safety, functionality and economic considerations are incorporated in the system design
		702.2.4	Design complies with all *requirements* and includes specifications and documentation for installation of *apparatus/equipment*, accessories and wiring systems
		702.2.5	Instructions for the use and operation of apparatus/system are documented where applicable
702.3	Check and finalise design	702.3.1	Design is checked under *established procedures* for compliance with all relevant *requirements*
		702.3.2	Design is submitted for appropriate organisational approval and, where applicable, statutory or regulatory approval
		702.3.3	Approved copies of design documents are issued and copies retained in *records* in accordance with *established procedures* and *requirements*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Categories

This unit recognises the commonality of skills and knowledge that exists for the unit as well as the additional specific outcome; which is to be reported on. Therefore, competency can be displayed on one, some or all of the following categories and in addition to the respective common underpinning knowledge associated with the selected specialisation:

(A) Computer systems

(B) Electrical

(C) Electronics

(D) Instrumentation

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit in the related *category* and *specialisation* which is to be exhibited across a *representative range* of applications; autonomously and to *requirements*.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace for each of the *categories* and areas of *specialisation* undertaken from those listed in the Range statement or Evidence guide.
- demonstrating an understanding of the underpinning knowledge and skills identified for the *categories* and related *specialisation* undertaken in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of applications which includes such things as *apparatus, circuits, wiring systems, plant, equipment,* tools, *accessories, components* and the like relative to that required for the *category* undertaken within and relevant to this unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

There is no interdependency associated with this unit. However, this unit has been designed as a natural progression from unit UTE NES701 A. Therefore, it is expected that to achieve this unit, without having gained competence in unit UTE NES701 A, will require that the relevant aspects of knowledge and skills related to unit UTE NES701 A be developed and form part of the requirements for achieving competence in this unit.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

This section includes that set of knowledge and skills additional to that specified in the above mentioned section titled 'Interdependent assessment of units'.

Since this unit covers a range of *categories* each having multiple *specialisations* a content listing is provided below. Each *category* has all of the required underpinning knowledge and skill listed even though this sometimes results in duplication between *categories*.

Category: Computer systems (A)

Common

Calculus.

Differential calculus: the limit concept – definition of the derivative of a function as the slope of a tangent line (the gradient of a curve), easy examples from 1st principles; the rules – derivative of sum (difference), product, quotient, chain (function of a function), use of at most 2 rules for any given functions; the 2nd derivative – implicit differentiation – applications – equations of tangents and normals, stationary points and curve, sketching, rate of change, rectilinear motion, Newton's method; verbally formulated problems involving related rates and maxima/minima

integral calculus: integration as the inverse operation to differentiation: the results – integral of k f(ax + b) where $f(x) = x^n$, six x, cos x, $\sec^2 x$, e^x the method of substitution; the definite integral; applications – areas between curves, rectilinear motion including displacement from acceleration and distance travelled

Data communications systems operations.

Data communications systems fundamentals; principles of operation of a modem; digital data transmission over voice grade lines; digital data transmission and packet switched data; network protocols such as - token ring, token bus, CSMA/CD (ethernet)

Point to point direct connection using serial and parallel protocols; LAN topologies related to – token ring, token bus, CSMA/CD (ethernet) techniques; typical LAN s/w packages (NOS') such as LANtastic and Novell Internet; network interface cards and/or other hardware for typical LAN s/w packages (NOS'); LAN s/w packages (NOS') for a particular situation based upon a finalised system definition

Typical modem operating parameters; physical links – twisted pairs, coaxial cable, infra red (IR), spread spectrum radio, microwave etc; principle features of voice link – DDS, AUSTRPAC and ISDN carrier services; principle features of "PC Anywhere" and "Carbon Copy" packages; functions of routers, bridges etc in order to connect between various types of remote LANs and PCs (ie token ring to ethernet, IBM to MacIntosh); hardware and software required in order to connect remote LANs above

Typical interfacing software such as kermit; physical links

LAN software packages (NOS') such as "LANtastic", "LANmanager"; hardware required for interfacing; select suitable physical lines

Specialised hardware for a LAN printer; serial and parallel printer links – serial, parallel, etc; printer buffer size selection; NOS printer queue management – considering buffer size, spooling and job priority

User priority levels; allocated buffer sizes

Use of a DC ohm-meter to check for short/open circuits in network cabling, network terminators, etc; use of time domain reflectometry (TDR) to locate the position(s) of short/open circuits and other faults in network cabling; use of manufacture supplied diagnostics to test suspected network interface cards; conflicts with I/O addresses, shared memory, DMA or interrupts at any station; typical NOS diagnostics, extended NOS diagnostics

Typical network dial in/out facilities – network cache buffering, network E-mail facilities, network chat facilities; network data security aspects – requirements and typical ways in which these may be implemented; different PC types – ie IBM and MacIntosh in a typical network; typical network remote users and to connect to other LANs'/WANs'

Typical network software backup and recovery files; consequences if typical network software backup and recovery files are absent or corrupted; configuring the way typical network software backup and recovery files are generated; use of typical network software backup and recovery files to recover from a system failure/crash

Analysis and design project.

Systems concepts: software and hardware systems; systems development life cycle; roles of the analyst and user

Feasibility analysis: problem definition – scope and objectives, schedules, preliminary report; fact finding interviews – surveys and questionnaires, observations, researching (new technology, similar systems etc); systems design options and alternatives – hardware technologies, batch or online processing, centralised or remote, user inputs and outputs, hardware inputs and outputs, interconnections, existing packages, off-the-shelf components and subsystems, prototyping, application generators, language selection; evaluation of hardware and software – sizing, performance, reliability, ergonomics, support, cost/benefit analysis, feasibility report

Systems analysis: software design tools and methodologies – system flowcharts, data flow diagrams, HIPO charts, data dictionary, ER diagrams, decision tables and decision trees, pseudocode or structured English, structured walkthroughs, application generators, CAS tools, hardware system design tools - manufacturers' data books, application notes, functional block diagrams, flowcharts, test specifications, standards

Internetworking operations.

Bridges: selection of bridges based on given data link types – ethernet to ethernet, token ring to token ring, ethernet to token ring, token ring to fibre distributed data interface (FDDI); bridge installation – network address tables, priority for forwarding of packets, filters to restrict broadcast packets

Routers: selection based on given backbone network layer protocols – ISO, internet; selection based on LAN protocol or multiprotocols to be routed; installation – network address tables, filters to restrict broadcast packets, priority and class of service for forwarding of packets; topology of internetworks using local and remote routers

Formats: IBM systems network architecture (SNA) protocol; DEC DECnet protocol

Topology of internetworks: using gateways with local and remote connection to hosts

Gateway installation: table linking end users to host recognised resources such as SNA controls points (CPs) and logical units (LUs)

Protocol formats: ISO – end system (ES)-to-intermediate system (IS) and IS-to-IS protocols; internet – control message protocol (ICMP), open shortest path first (OSPF) protocol, exterior gateway protocol (EGP); spanning tree bridge protocol data units (BPDUs); (Source) routing information field; route broadcast frame

Relationships: between ISO global network service access points (NSAPs) and local subnet points of attachment (SNPAs); between internet global internet protocol (IP) address and local network point of attachment (NPA)

Protocol formats: for hello – poll and redirect messages, holding time

Format error messages: recognition of – destination unreachable, time (to live) exceeded

Database and 4GL.

DBMS approach: non-database vs database approach; data models – advantages, limitations; user requirements; role of the DBMS administrator

Data analysis: entity – relationship and occurrence; E.R model; representing entities and relationships

Normalisation: tuple; first normal form; other normal forms; conversion to optimal forms

Design and/or specifications: design approaches; development of a corporate data model including long range information system plans; information requirements analysis; logical and physical database design; data dictionary; standards – documentation and security; distributed databases

Relational algebra: relational operators – union, intersection, cartesian product, selection, projection, join, division

Queries: producing enquiry reports; producing formatted output

Programming in 4GL: creation of databases; maintenance of databases; producing reports; formatting outputs

Network layer operations.

Use of CCITT X.25 packet level protocol (PLP) and packet assembler disassembler (PAD) hardware and software

Awareness of occupational health and safety: for mains operated electronic equipment when installing hardware

Recognition of format for CCITT X.25 PLP: "Q" bit PAD control; internet protocol

Recognition of format for network service access point (NSAP), CCITT X.21:

Recognition of format for IP addresses including: address resolution protocol (ARP)

Recognition of format for CCITT X.25 PLP including: quality of service; fast select; user facilities; PAD parameters; clear; reset; restart

Recognition of format for IP: type of service; time-to-live; options

Correlation of end user error messages with abnormal traffic

Network administration.

Network installation: review LAN server installation; system configuration; conflict avoidance; disk mirroring; file server preparation; fault tolerant systems; cable preparation; establishing workstations; boot disks; remote boot proms; documenting the network

Establishing network users: establishing accounts; establishing directories; access right and security; login scripts

Establishing printer servers: print spooling

Loading applications software: considerations for selecting and loading applications software

Network maintenance and troubleshooting: monitoring network usage; cable faults; workstation faults; server faults; system backup/restore; diagnostics

Data link planning.

Determination of data link cost/performance criteria

Error control techniques: idle repeat request, selective repeat request, go-back-N retransmission strategy ; calculations for data link utilisation

Data compression techniques: CCITT V.42

Data encryption techniques: data encryption standard (DES)

Data link user configuration factors: line speed – octets per frame, window size

Data link simulation

Analysis of non-OSI data link protocols: asynchronous byte-orientated – KERMIT, synchronous byte-orientated – IBM binary synchronous control (BSC), synchronous bit-orientated – IBM synchronous data link control (SDLC), ANSI advanced data communications control procedure – (ADCCP)

Data link technology trend analysis

System acquisition and evaluation.

Evaluation: typical electronics applications; establishing the need – objectives and requirements; performance specifications; evaluation criteria – performance effectiveness, performance efficiency, ease of use, flexibility, quality of documentation, manufacturer/supplier/support, cost/benefit analysis; techniques – performance evaluation, benchmarks, acceptance testing

Procurement: tenders, contracts; request for proposal; identifying and assessing suppliers; duties and taxes; importing regulations and procedures; purchasing options; maintenance contracts

Implementation: planning installation; training requirements; consumables; changeover

Data communications systems planning.

Network system performance: protocol parameters including – overhead, windowing; node parameters including – congestion, queue length, service time; load traffic estimation based on – number of users, type of application, bandwidth costs

Network system reliability: protocol parameters including – error recovery, link redundancy; node parameters including – component mean time between failure (MTBF); system MTBF with and without single point failure

Network system management: OSI defined functions including – fault, configuration, change, performance management, financial services, inventory control, security; concepts – hierarchical vs distributed, architecture, objects, agents, collection point, console, system manager, management information base (MIB); user interface – display of network topology, statistics and error conditions, commands to control remote nodes; system automation – programming language interfaces, alert filtering, software distribution of files and jobs

Help desks: procedures – adequate incident description, incident tracking, problem escalation; tools – view remote screen, file transfer, remote keyboard control

Network personnel: network manager; network administrator; network system engineer; field service technician; service centre technician; technical salesperson

Bandwidth management planning.

Illustrate a system of host to remote terminals via multiplexers showing the relative number of async host ports required; illustrate a system which utilises x.25 and provide for x.25 switches and PADs at the remote end; illustrate bandwith requirements for the two systems; illustrate the host end configuration for both systems; illustrate a resilient configuration; perform a cost/benefit analysis – describe the management benefits of the X.25 system; block schematic diagram for the mux/demux system; provide a block schematic of the X.25 system

Provide the standards and analyse

Provide a brief of the pricing structure of the services offered for DDS and ISDN; develop a simple cost/bandwidth matrix for the ISDN; provide brochures of various manufacturers' terminal adaptors and multiplexers for ISDN connection; develop a cost comparison; illustrate requirements for resilience and define the configuration and costs associated – show how disaster recovery may be planned into the WAN connections

Illustrate a typical LAN and WAN connection with and without resilience using DDS; illustrate a typical LAN and WAN connection with and without resilience using ISDN; show typical costing of hardware for both systems

Electrical engineering mathematics.

Basic determinants and solution of 2/3 simultaneous linear equation by determinants exponents and logs

Time dependent trig functions - $\sin(\omega t+\theta)$

Trig of oblique triangles

Introduction to vectors

Complex numbers

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation, operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

Problem solving and decision making: the difference between symptoms and causes of problems – defining problems, specifying problems in terms such as cost, quality and quantity; the contingency approach which differentiates between programmed and non-programmed decisions, as well as rational and bounded rationality problem solving decision making; the steps in the decision making process – brainstorming, group-think, how and when to involve groups such as nominal groups, the Delphi techniques; practical problem solving and decision making integration in the engineering workplace environment involving decision alternative of certainty risk and uncertainty

Introduction to human behaviour: understanding factors of human behaviour – definition of terms, physical and psychological factors, why people work in engineering industries; concepts and theories of motivation; content and process approaches – critical analysis of applicability of significant theories of motivation and human behaviour to the engineering workplace; people in organisations; individual and group behaviour; formal and informal groups, interpersonal relations and behaviours in organisations; managing/supervising people (as distinct from tasks or projects); the role of the manager/supervisor, applying the theory; situational and contingency approaches, including managing conflict; functional and dysfunctional aspects of conflict; resolving conflict using problem solving techniques

Leadership and discipline: theories – types and styles of leadership; appropriateness of styles, advantages and disadvantages; effective leadership in the engineering workplace – application and evaluation of leadership styles; managing and leading – differences; authority, responsibility, power, delegation; use of decision making processes – Meetings., advisory groups, consultative groups, executive groups; discipline and interpersonal, relations; manager/staff relations, disciplinary processes and purposes, self discipline in organisations

Staff selection and personnel procedures: engineering job analysis, design and description – duties, responsibilities, authority; job requirements – qualifications, specific aptitudes and experience, achievements; effect on award restructuring on engineering job descriptions; engineering staff selection processes; establishing appropriate process, panel, selection criteria; advertising vacancy, matching applicants to criteria; interviewing – preparation, the setting, questions, making the selection, modifying successful and unsuccessful applicants; appointment of engineering staff and conditions of employment; staff placement and induction; role and responsibility of engineering managers/supervisors in the application of relevant industrial awards

Category: Electrical (B)

Common

Advanced DC machines.

Basic DC machine construction and operation: application of DC machines; construction of DC machines; DC machine connections; insulation; ratings; cooling paths; bearings; general maintenance of DC machines

Construction and use of lap and wave windings: coils and elements; generated voltage equation for generator; generated voltage equation for motors; application of lap and wave windings

Process of communication: the use of interpoles; loading of machines; brush shifting

Armature reaction in DC machines: effect of armature reaction on DC machine characteristics; use of compensating winding

External characteristics of a DC generator: performance of generators supplying various loads; voltage regulation as a percentage or per unit value; operation in parallel

Torque equation for a DC motor: shape of motor speed/torque curves; reversal of machines

Starting of DC motors: types of DC motor starters in use; DC motor protection

Speed regulation and speed control of DC motors: methods in use; effect on motor design and operation caused by the use of SCR speed control equipment

Braking of DC motors: plugging; dynamic; regenerative; mechanical

Losses and efficiency

Acceleration of DC motors and loads: characteristics of typical loads; matching loads to a suitable motor; heating of windings; de-rating of motors

Permanent magnet materials and circuits: types of materials and characteristics; BH loop and demagnetisation; temperature effects; reversible losses; irreversible losses; high temperature effects; mechanical properties – handling and magnetisation; application; power density; temperature range; duty cycle

Special DC motors – construction, operation and applications: permanent magnet motors; brushless motors; coreless and moving coil motors; linear motors; printed circuit motor; stepping motors; voice-coil motors

Safety: safety aspects in relation to motors; safety aspects in relation to associated control circuits including the use of PLCs

Operating characteristics: obtaining nameplate details; measuring DC machine parameters; obtaining the magnetising characteristic of a DC generator; determining the external characteristic of DC generators; load characteristics of DC motors; determining the efficiency of a DC machine; speed control of DC motors; braking of DC motors; troubleshooting and repair techniques

Building management systems.

Functions of a BMS: autonomous functions; input; output; general I/O; installation management items; energy management; risk management; information processing; objective; building running costs

BMS hardware: system architecture; communication devices; substations; PCs

Input and output functions: digital – input, outputs; digital output with status feedback; analogue input, output; sensors; alarms

Energy management: night cycle; optimum stop, start; time and event programs; night purge; outside air percentage control; enthalpy control; power demand control; duty cycle; presence detection; lighting control

Information processing functions: computer systems; central system management; programs; system configuration and security; operator – machine interface; data points

Risk and maintenance management: system files; fire – intruder control; access control

Circuit analysis.

Phasors: time domain; frequency domain; frequency, angular frequency and units of measurement

Complex impedance: impedance diagram; resistance; reactance; admittance; conductance; susceptance; equivalent series circuit; equivalent parallel circuit

AC series/parallel circuits: Kirchhoff's laws; series equivalent impedance; parallel equivalent impedance; voltage divider rule; current divider rule; phasor diagrams

Complex power: true power; reactive power and apparent power; units of measurement – watt, volt-amp; reactive, volt amp; power triangle; power factor

Superposition theorem: power considerations

Thevenin and Norton theorems: voltage source models; current source models; practical sources; open circuit voltage; equivalent impedance; short circuit current; source conversion

Star/delta conversions: equivalent circuits; star/delta transformation formulae; selection of appropriate conversion

Fault calculations.

Norton's and Thevenin's theorems and their application to AC circuits: "J" notation and conversion between rectangular and polar – conjugate complex form for maximum power transfer; current and voltage divider rules and their application in AC circuits; theory and application of the "per unit" system; currents and voltages in 3 phase (balanced and unbalanced) circuits; representation of unbalanced currents and voltages using the method of symmetrical components; phasor diagrams for 3 phase circuits; power (P) –

vars (Q), apparent power(s) and power factor and their measurement; factors influencing the impedance of system components – cables, lines, buses and transformers

Calculation of fault currents: calculation/determination of positive, negative and zero sequence impedances; determination of fault current breaking and let-through energy capacities of circuit breakers and fuses; the importance of fault/arc impedances; the impedances operative for phase-to-phase and phase-to-earth faults; calculation of fault currents for phase-to-phase and phase-to-earth faults; "quick" (approximate) calculations by selecting the components with the major impedance

Advanced AC machines.

Three phase induction motor operating principles (wound and cage rotors): basic construction, windings; rotating magnetic field from stationary coils; EMF equation produced by a 3 phase stator winding and its significance; rotor impedance at a given value of slip given standstill values; rotor frequency; relationship between torque and speed for both small and large values of slip; slip for maximum torque; losses; relationship between air-gap power, gross torque, and net torque; definition of torque – starting, pull-up, pull-in, breakdown, maximum, full-load, no load

Analysis of a three phase induction motor using equivalent circuit: extract and approximate equivalent circuits and assumptions used; no-load test, locked rotor test and resistance tests; equivalent circuit component values from the no-load and locked rotor tests; motor performance parameters from the approximate equivalent circuit; slip for maximum torque; slip for maximum power output; motor performance from separation of losses test and load test

Three phase induction motor starting and braking techniques: supply authorities rules regarding direct on line starting; performance of the reduced voltage motor starting techniques; comparison of star/delta, primary resistance, auto-transformers, electronic "soft-start", secondary resistance starters, schematic diagrams; braking functions and methods, schematic diagrams

Three phase synchronous motors: construction and operating principles; cylindrical and salient pole rotors; excitation schemes; equivalent circuit ; measurement of synchronous impedance; causes of hunting and stability limits; power factor correction applications; paralleling and synchronisation techniques

Three phase synchronous motors starting and braking requirements: power, control circuitry and applications for starting; power, control circuitry and applications for braking circuits

Single phase induction motors: theory of operation and construction; counter rotating field theory and cross field theory; optimum impedance of start winding or capacitor; no-load and locked rotor test; equivalent circuit component values from the no-load and locked rotor test; motor parameters from the equivalent circuit values

Single phase shaded pole, reluctance, hysteresis and universal motors: construction, operation and applications of the various types of fractional kilowatt motors

Acceleration and deceleration time: moment of inertia; reflected inertia and torque through a gearbox; time estimations given motor and load speed/torque characteristics

Cyclic loading – RMS method: motor winding temperature; forward and braking power; peak torque capability; estimation of motor rating when subjected to a cyclic varying load which could be subjected to – discrete power steps, linear power ramps, periods when the rotor is stationary

Co-generation.

Heat and power production

Fuel types: advantages and disadvantages; topping, bottoming and combined co-generation cycles

Prime movers: applicability and relevant efficiencies; commercial viability, competition barriers and site environmental factors

Regulatory and contract issues

Safety requirements

Power system protection.

Identify the types of likely faults for overhead lines, strung buses, insulated buses, transformers and voltage control equipment considering various plant configurations

The principles of operation of over-current, earth fault, differential and impedance/admittance measuring protection

Define selectivity, discrimination (time and current), stability, sensitivity, reliability, security, primary protection, duplicate protection, back-up protection and protection zones

Components used including current/voltage transformers, summation and multi-tapped CTs and interposing transformer

Relays including all or nothing relays, induction disc relays “balanced beam” (and derivative) relays, induction cup/directional relays, biased relays and solid state/micro-processor based relays

Communication systems including hardwired (dedicated and telephone), power line carriers (PLCs), micro-wave and fibre optics

Protection schemes applied to lines, buses, transformers and other major plant items

Power transformers.

The principles of operation and construction of 3 phase transformers including shell or core type iron circuits, disc coils, sandwich or helix windings, transposition of windings; transportation of large transformers

Tests applied to transformers including tests to establish losses (open and short circuit tests) and the per unit or percentage impedance (voltage); use the results to develop the approximate equivalent circuit of a transformer; calculate referred values, efficiency, regulation and load sharing

Methods of connecting the windings including star, delta, zigzag and open delta; the grouping (on the basis of phase shift) and precautions to be taken for parallel operation; forward and backward roll; calculations involving parallel operating and load sharing

The use of off-load and on-load tap changing to compensate for voltage variation; comparison of fault current levels and voltage regulation requirements

Transformer temperature limitation: the equipment required and the means of cooling transformers; cooling nomenclature; changes of rating based on cooling and multi-rating transformers; oil testing and maintenance; conservator, desiccation, Buchholz relay operation

The choice and use of multi-winding, auto transformers and neutral earthing compensators; types of harmonics produced and methods of attenuation; the use of tertiary windings to suppress harmonics

Qualitative treatment of the effect of connecting single phase loads to three phase transformers

Power system operation.

Control of voltage: conditions leading to voltage collapse and system disintegration; effects on the system of high/low volts; voltage control devices including - voltage regulators applied to generators and synchronous phase modifiers, electromagnetic voltage regulators, series and parallel capacitors, OLTC transformers and static Var compensations (SVCs)

The range of devices covered by SVCs including: saturated reactor compensations (SRs), thyristor controlled reactor compensators (TCRs), combined TCR/TSCs and the production of wave-form distorting harmonics and control devices

The importance of the location in the system of voltage control devices

The use of graphical methods to calculate the size of Var regulating plant

Control of power including base load, spinning reserve, regulating machines, rapid start plant, phase shifting transformers and various forms of load shedding; principles and practices of automated control of individual machines, stations and transmission/tieline elements; synchronising power

The relationship between power and frequency: limiting values; machine stabilising including steam by-pass, rapid valving, slip stabilisers and overspeed

limiting; use of single pole generator CBs; use of machine AVRs as angular stabilisers; damped and un-damped system oscillations; relationship between fault clearance times and system stability; the calculation of critical clearance angles based on equal area criteria

Types of communication systems including telephone, power line carrier, dedicated cable, micro-wave links and fibre optics; quantities and signals to be communicated; advantages and disadvantages of the various systems; equipment requirements

Transient over-voltages in power systems; switching and lighting over-voltages and their effect on different plant items; transient over-voltage control and reduction using surge diverters, shield wires and CB are control; insulation systems, insulation co-ordination, insulation grading in plant items, bushings and capacitor bushings

Factors leading to the generation of corona; consequences of corona; reduction of corona including conductor bundling, grading rings and conductor surface treatment

Fault Calculations and "Power System Protection"; location of CTs in major plant items; earthing principles and devices; fault current control/limitation using neutral earthing compensators (NECs), neutral point earth impedances, high conductivity shield wires and parallel feed interlocking; application of different types of protection

PLC systems applications.

Introduction to alternative/enhancing programming methods: structured programming techniques (ie flow charts); limitations with ladder/statement list programming; introduction to other programming methods (ie step sequence special functions, and other high level languages); apply system diagnostic techniques

Regulated and PID loop control: regulated control; proportional + integral + derivative (PID) control; applications of PID control; advantages and disadvantages/limitations of PID control using a programmable controller; read, change and monitor data to achieve PID control using a PLC

Specialist instructions: interrupt driven applications; high speed counters; positional encoders; other specialist features

Communications: common protocols and interface standards; requirements when networking/interfacing PLCs; communication mediums; network types and topologies (LAN, WAN, ring, bus.); hierarchal networks; peer to peer networks; handshaking; open architecture communications; remote I/O

Control electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation, operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

Problem solving and decision making: the difference between symptoms and causes of problems – defining problems, specifying problems in terms such as cost, quality and quantity; the contingency approach which differentiates between programmed and non-programmed decisions, as well as rational and bounded rationality problem solving decision making; the steps in the decision making process – brainstorming, group-think, how and when to involve groups such as nominal groups, the Delphi techniques; practical problem solving and decision making integration in the engineering workplace environment involving decision alternative of certainty risk and uncertainty

Introduction to human behaviour: understanding factors of human behaviour – definition of terms, physical and psychological factors, why people work in engineering industries; concepts and theories of motivation; content and process approaches – critical analysis of applicability of significant theories of motivation and human behaviour to the engineering workplace; people in organisations; individual and group behaviour; formal and informal groups, interpersonal relations and behaviours in organisations; managing/supervising people (as distinct from tasks or projects); the role of the manager/supervisor, applying the theory; situational and contingency approaches, including managing conflict; functional and disfunctional aspects of conflict; resolving conflict using problem solving techniques

Leadership and discipline: theories – types and styles of leadership; appropriateness of styles, advantages and disadvantages; effective leadership in the engineering workplace – application and evaluation of leadership styles; managing and leading – differences; authority, responsibility, power, delegation; use of decision making processes – Meetings., advisory groups, consultative

groups, executive groups; discipline and interpersonal, relations; manager/staff relations, disciplinary processes and purposes, self discipline in organisations

Staff selection and personnel procedures: engineering job analysis, design and description – duties, responsibilities, authority; job requirements – qualifications, specific aptitudes and experience, achievements; effect on award restructuring on engineering job descriptions; engineering staff selection processes; establishing appropriate process, panel, selection criteria; advertising vacancy, matching applicants to criteria; interviewing – preparation, the setting, questions, making the selection, modifying successful and unsuccessful applicants; appointment of engineering staff and conditions of employment; staff placement and induction; role and responsibility of engineering managers/supervisors in the application of relevant industrial awards

Engineering project.

Tender documents and contracting; engineering project specifications; client interaction (interpersonal skills); assessment of client need; report writing; preliminary design sketches; preliminary design calculations; general arrangement drawing

Component design: sizing, material selection and brought outside selection of standard components; detailed drawings of parts and assemblies showing linear and geometric tolerancing (where necessary); final report – to contain client brief of requirements and specifications (as tender documents), all drawings, design calculations and any special/novel design problems and/or solutions, a written report; oral presentation

Category: Electronics (C)

Common

Calculus.

Differential calculus: the limit concept – definition of the derivative of a function as the slope of a tangent line (the gradient of a curve), easy examples from 1st principles; the rules – derivative of sum (difference), product, quotient, chain (function of a function), use of at most 2 rules for any given functions; the 2nd derivative – implicit differentiation – applications – equations of tangents and normals, stationary points and curve, sketching, rate of change, rectilinear motion, Newton's method; verbally formulated problems involving related rates and maxima/minima

integral calculus: integration as the inverse operation to differentiation: the results – integral of k f(ax + b) where $f(x) = x^n$, six x, cos x, $\sec^2 x$, e^x the method of substitution; the definite integral; applications – areas between curves, rectilinear motion including displacement from acceleration and distance travelled

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation, operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

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Specialisation: Analogue and digital

Electrical control 'C' programming.

'C' language: uses; advantages and disadvantages

'C' development package: editor commands; the edit-compile-run cycle; compiler and linker options; header files

Language syntax: data types; arithmetic and logical operations; program structure

Control structure: sequential; repetition; selection

Functions: macros; global and local variables; intrinsic functions used in control; writing functions, linking in external functions to control hardware; numerical and character arrays; sequential file reading and writing

Analysis and design project.

Systems concepts: software and hardware systems; systems development life cycle; roles of the analyst and user

Feasibility analysis: problem definition – scope and objectives, schedules, preliminary report; fact finding interviews – surveys and questionnaires, observations, researching (new technology, similar systems etc); systems design options and alternatives – hardware technologies, batch or online processing, centralised or remote, user inputs and outputs, hardware inputs and outputs, interconnections, existing packages, off-the-shelf components and subsystems, prototyping, application generators, language selection; evaluation of hardware and software – sizing, performance, reliability, ergonomics, support, cost/benefit analysis, feasibility report

Systems analysis: software design tools and methodologies – system flowcharts, data flow diagrams, HIPO charts, data dictionary, ER diagrams, decision tables and decision trees, pseudocode or structured English, structured walkthroughs, application generators, CAS tools, hardware system design tools - manufacturers' data books, application notes, functional block diagrams, flowcharts, test specifications, standards

Advanced analogue electronics.

Differential and instrumentation amplifiers

Integrators

Single supply operation – using blocking capacitors and norton amplifiers

Comparators with and without hysteresis; non-saturating comparators

Piece wise approximations to non-linear transfer curves – increasing and decreasing slopes and bipolar curves

Function generators

Precision rectifiers – half-wave and full-wave

Active filters – low-pass, high-pass and band-pass

Applications of power; amplifiers and definitions

Additional considerations related to large signal operations

Class A, B, AB, C and D power amplifiers

Distortion/feedback

Heat transfer and sinking

Data sheet usage related to typical characteristics of fully integrated power amplifiers

Specification and testing of power amplifiers

Advanced circuit analysis.

H-parameters: hybrid parameters; hybrid parameters for the bipolar junction transistor; voltage gain; current gain; dependent sources; input and output impedance

Complex waveforms: fourier series; odd and even functions; half wave symmetry; harmonic components; root mean square value of a complex wave; effect of frequency on inductive and capacitive reactance; effect of reactive components on harmonic component

Digital design.

Types of programmable logic devices; features of programmable array logic (PAL) devices; reprogrammable PALs (GALs); PAL combinatorial design; logic family characteristics; interfacing between logic families; interfacing to external devices; schmitt trigger devices

Project management; advanced state machines; system design considerations; timing analysis and hazards; testing and debugging; engineering standards; documentation

Digital signal processing.

DSP applications; signal sampling; impulse response of linear phase filter; FIR filters; adaptive filters; DSP chip architecture; DSP programming; integer arithmetic; analogue filtering

Simple IIR filter; high-order IIR filter; discrete fourier transform; complex signals; fast fourier transform; FIR filtering using the FFT; data-rate conversion; modulation and demodulation; applications; support chips

Electronic software tools.

Circuit analysis software: general description; documentation (written and on-line); common features – circuit entry, input data format, output data format; hardcopy of circuit and results; evaluation of package

Computer aided drafting (CAD) software: general description; documentation (written and on-line); common circuit schematic features – component selection, text and line selection, placement, movement, erasure, numbering; common printed circuit board design features – component selection, text and circuit trace selection, placement, movement, erasure, manual and auto-routing; hardcopy of results; evaluation of package

Microprocessor applications.

User interface devices (LEDs, 7 segment displays, LCDs, keypads

Serial I/O

Interrupts

Software development techniques (program structure and design, use of assembler features)

Project – operational minimum system

Digital to analogue converters

Analogue to digital converters

Interfacing actuators (relays, solenoids)

Controlling A.C. power

Linking assembly language modules with high level language modules (using C)

Project work

Specialisation: Communications

Electronic software tools.

Circuit analysis software: general description; documentation (written and on-line); common features – circuit entry, input data format, output data format; hardcopy of circuit and results; evaluation of package

Computer aided drafting (CAD) software: general description; documentation (written and on-line); common circuit schematic features – component selection, text and line selection, placement, movement, erasure, numbering; common printed circuit board design features – component selection, text and circuit trace selection, placement, movement, erasure, manual and auto-routing; hardcopy of results; evaluation of package

Communications engineering project.

Researching and analysing information related to a communications system

Generation and selection of solutions to a communications system problem

Comparison and evaluation of possible technical solutions

Organisation and management of research processes

Antenna systems.

Half wave dipole radiation, radiation resistance, input impedance, gain, beam width, effective radiated power, front to back ratio, TEM wave polarisation, VSWR, specifications

Surface wave propagation, loss factors, sky wave propagation, terrestrial space wave propagation

Radiation pattern diagrams for half wave, folded dipole quarter wave and longer ground plane, yagi antenna types, dimensions, input impedance, applications for these types of antennae

Characteristic impedance, load impedance, attenuation of transmission lines; Smith Charts, parallel wire, coaxial cable, stripline, waveguide mediums; load impedance mismatch, SWR at transmitter and load; impedance matching

Multi element Yagis (3-24): stacked and bayed Yagis; slot panel and bayed dipoles, corner reflector; log periodic; co-linear, end fed dipole; cardioid dipole; circular polarisation; paging antennae; mobile and portable radio antennae; vehicle antennae

Signal coverage, new sites, interference, environmental effects, sharing an existing system wind loading, weight; antennae on structures, mounting materials, coaxial cable connectors, isolation, physical separation, waterproofing, documentation inspections; corrosion, weather effects (wind, snow, rain); pollution; lighting protection, radiation hazard

Antenna separation, duplexers; different radiation patterns resulting from insufficient antenna spacing duplexers enable one antenna, one feeder to be utilised preserving the correct radiation pattern; bandpass, bandstop duplexers; method of connection to transmitters and receivers, waveguide cavity, ceramic types; insertion loss, rejection in transmit and receive legs, power handling, separation temperature range

Construction of a ferrite circulator DC field effects and their alteration of resonant frequencies; direction of signal flow; circularity for each port; permanent or electro-magnets for bias use as a circulator or isolator with a port matched load

Transmission lines.

Types of lines and their applications: microstrip, waveguides; line parameters using primary constants; standing wave patterns for any termination; line parameters, given terminations; DC transients on a transmission line; time-space diagrams and oscillograms; smith charts; single and double stub matching; waveguide propagation and field patterns therein; cavities and field patterns therein; launch/pickup of waves in waveguides and cavities; stripline structures

Optical fibre transmission; components of an optical fibre system; characteristics of optical fibre; safety and handling; attenuation measurements; optical cable installation; optical fibre joining; optical fibre connectors; optical sources and detectors

RF amplifiers.

Classes of amplifiers: class A; class B; class C; efficiency of amplifier classes

RF amplifier terminations: termination of ideal voltage current and RF amplifiers; resonant circuit principles

RF amplifier operation, alignment and neutralisation

RF amplifier coupling methods: impedance transformation/coupling; L and pi coupling circuits; double tuned transformer coupling

Decoupling of RF circuits: radio frequency coils (RFC); capacitor decoupling; ferrite beads

Microstrip amplifiers: stripline geometrics and impedances; application of stripline techniques; basic stripline design

Masthead amplifiers: noise considerations; characteristics

Transmitters and receivers.

Transmitters: block diagram of both high level and low level AM transmitters; class A, class B and class C amplifiers in AM transmitters; applications using AM transmitters; block diagram of the filter method SSB transmitter; block diagram of the phase method SSB transmitter; SSB transmitter stage frequencies; two tone testing of SSB transmitter; block diagram of the direct method FM transmitter; frequency multipliers and converters in FM transmitters; block diagram of the indirect method FM transmitter; classes of stage amplifiers in an FM transmitter; pre-emphasis and de-emphasis in FM systems; stereo FM principles; transmitter frequency stability requirements; transmitter spurious signal suppression; transmitter power level requirements; transmission modes; radiation exposure levels; measure output power of a transmitter; measure output carrier frequency; measure spurious output levels

Receivers: block diagram of a single conversion superheterodyne receiver; RF amplifier – filtering, gain, low noise, antenna match, AGC, stability, typical circuit; local oscillator – frequency stability, signal purity, synthesiser local oscillator, typical circuit; mixers – function, problems, typical circuits; IF strip – function, choice of frequency, IF selectivity, AGC, typical circuits; demodulation – AM, FM, SSB, BFO, DC for AGC, S Meters; image frequency; dual conversion superheterodyne; AM, SSB AND FM receivers; applications of AM, SSB and FM receivers

Microwave systems.

General microwave systems: radar; terrestrial microwave links; satellite microwave links; global positioning system (GPS); fleet management systems

Antenna systems: yagi and dipole arrays (including electronically steerable); slots and slotted arrays; microstrip arrays; horns; axial and offset reflector systems; metallic and dielectric lenses

Terrestrial link planning: K-factor; earth's bulge; refraction; knife-edge diffraction; fresnel zones; absorption; carrier frequency; distance; Tx EIRP; Rx antenna gain

Satellite link planning: tracking requirements and beamwidth; figure of merit; absorption distribution; outage causes; EIRP; C/N; process gain

Microstrip structures: matching circuits; filters; couplers; splitters; circulators

Matching techniques: single stub matching using smith chart; physical length of matching network

Microwave devices.

Waveguide propagation

Cavity devices: couplers; T; hybrid T; directional; diplexers; phase shifters; power splitters; circulators; horns

Stripline structures

Ferrite and dielectric devices

Therminoic microwave devices: klystrons; magnetrons; cross field amplifiers (CFA); travelling wave tubes (TWT)

Solid state microwave devices: diodes – tunnel, PIN, Gunn, TRAPPATT, BARRATT; stimulated emission devices – MASER; parametric amplifiers – Josephson devices (explain need for circulators with the above)

Matching systems: single stub match using Smith chart; determine physical length of matching network

Satellite communications.

Typical satellite communications systems, major sub-systems and critical components; antenna pointing parameters; up/down link considerations; figure of merit; EIRP; common types of baseband signal processing; process gain; types of system access – TDMA, FDMA, CDMA, DAMA, PAM; types of RF modulation – n-FSK, n-PSK, n-QAM

Digital radio.

Digital modulation concepts; baseband signal processing; effect of noise on digital systems; signalling methods; optimising multipath radio reception; digital radio systems

RF principles.

Oscillators and tuned circuits: barkhausen criteria; LC oscillators; crystal oscillators; phase locked loops (PLL)

Filters: butterworth, chebyshev and bessel filter networks; crystal filters; ceramic filters; mechanical filters; surface acoustic wave (SAW) filters

Modulation techniques: amplitude modulation (AM); phase modulation (PM); frequency modulation (FM); single sideband (SSB); double sideband (DSB); high and low level modulation methods; modulator alignment procedures

Demodulation techniques

Frequency multiplier techniques

Mixer circuit techniques 1

Characteristics of components at RF

Communication measurements and techniques.

Operation of digital storage oscilloscope (DSO): analogue – variable persistence mode; single shot storage; digital – saving and recalling set-ups and displays; hardcopy storage; signal processing function

TDR and OTDR operation: transmission line characteristics

Q-meter measurements: Q-meter operation – block diagram; measurement using following connection modes – direct, series, parallel; distributed capacitance

Spectrum analyser: frequency-domain identification of baseband and modulated signals; frequency-domain measurement of signals

Network analyser: component measurement; impedance measurement; insertion loss; load impedance variation with frequency

GPIB bus: GPIB operation; test procedure; equipment connection

Category: Instrumentation (D)

Common

Single chip microcontrollers.

Architecture CPU, RAM, PROM, I/O, Programming concepts, subroutines, instruction sets, arithmetic, stack operation, features of microcontrollers, interrupts, timers, clocks, on chip peripherals, serial buses and interfaces, expansion capability, cross assemblers and emulators, PROM loading, power supplies and mask options

Control electrical calculations.

Math software package e.g. matlab; series expressions; fourier series; linear functions and linearisation; difference equations; differentiation; integration

Rules of matrix algebra; vectors; matrix Fns (Det, Inv, exp); eigenvalues and eigenvectors; linear ordinary differential equations; time domain solution of 2nd order LODEs; state space forms; state space solution of LODES; review and test

Advanced telemetry.

Background to telemetry

Telemetry and its use with supervisory control and data acquisition (SCADA) systems

Data carriers and communication methods

Integration with existing systems

Analysis of system requirements and performance

Specification of systems

Commissioning and maintenance: person – machine interface and telemetry computers; communication front end and network; remote terminal units; single board (small) outstation; remote workstations including portables; Future trends

PLC systems.

Introduction to alternative/enhancing programming methods: structured programming techniques (ie flow charts); limitations with ladder/statement list programming; introduction to other programming methods (ie step sequence special functions, and other high level languages); apply system diagnostic techniques

Regulated and PID loop control: regulated control; proportional + integral + derivative (PID) control; applications of PID control; advantages and disadvantages/limitations of PID control using a programmable logic controller; read, change and monitor data to achieve PID control using a PLC

Specialist instructions: interrupt driven applications; high speed counters; positional encoders; other specialist features

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Control systems project development.

Project introduction: project selection criteria; industrial visit

Project model selection: brainstorming for project selection; preliminary report

Project model design: project management techniques; system design report

Project model construction

Project model comissioning: model demonstration/presentation; final report

Compensation (tuning) techniques.

History of control; system identification; feedback; tuning techniques; auto-tuning and model based control

Dynamic systems engineering.

Probability and monte carlo methods; queuing; dynamic response of systems; simulation

Transform techniques.

Convolution; laplace transform; transfer function and block diagrams; fourier transform; z transform; transformations; filters and windowing

Digital control using computers/micros.

Types of computer and their uses: on-off control; PID control; 'intelligent' control self tuning controllers, fuzzy logic controllers

PID control: the control algorithm; proportional control; integral control; derivative control

Writing the program for closed loop control: on-off control; PID control

Tuning a PID control loop: choosing the proportional constant; choosing the integral constant; choosing the derivative constant

Sampling rates: minimum sampling rates; nyquist criterion; factors that effect the sampling rate; measuring the sampling rate

Process data acquisition systems.

Industrial measurement applications and sensor characteristics; industrial computer systems and programming; standard computer input/output specifications; noise – grounding, shielding and filtering; signal conditioning; signal processing – analogue signals; signal processing – digital signals; signal transmission and isolation techniques

Advanced control using "C".

"C++" an introduction: history; relationship to "C"; advantages and disadvantages to other languages

Object orientated programming: concepts stage operation; encapsulation; inheritance; polymorphism

Windows programming: history; graphical user interfaces; consistent user interface; message driven architecture

Windows environment: windows; cursors and the mouse; dialogue boxes; menus; icons

The "C++" development package: editor commands; the edit-compile-run cycle; compiler and linker options; windows programming libraries

"C++" language syntax: differences between "C" and "C++"; data types; classes; program structure

Computer emulation and mimics: purpose of mimics; types of mimics

Interfacing of mimics to control loops: interfacing of mimics within control loops; preparing of data for display purposes

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation, operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

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UTE NES703 (A to Z qualifier) A Plan installation of electrotech apparatus & wiring/piping systems

Descriptor: Establish *capacity, load and duty* of *apparatus* and *circuits* within the scope of selecting size and type of cabling, piping or tubing and locating and positioning of *apparatus* and associated *accessories* and *circuit* routes.

Alignment: This unit aligns to and is based on the National Electrotechnology Benchmark Standard EBS 607 - Establish capacity, load and duty of apparatus and circuits specified for an installation.

Specific unit outcomes

This is presented as a composite unit that has five specific units as outcomes, based on the *category* in which competence is achieved. This is done because of the high degree of commonality in process or function. Reporting the unit with the inclusion of a *category* allows for the identification of the necessary training outcomes in terms of the generic and transferable skills and at the same time reflects the work classification(s) generally understood by industry. The specific unit outcomes are:

UTE NES703A A	Plan installation of electrotech apparatus & wiring/piping systems *(Computer systems)*
UTE NES703B A	Plan installation of electrotech apparatus & wiring/piping systems *(Electrical)*
UTE NES703C A	Plan installation of electrotech apparatus & wiring/piping systems *(Electronics)*
UTE NES703D A	Plan installation of electrotech apparatus & wiring/piping systems *(Instrumentation)*
UTE NES703E A	Plan installation of electrotech apparatus & wiring/piping systems *(Refrigeration & a/conditioning)*

Elements		Performance criteria	
703.1	Plan and prepare to determine *circuit* capacities, loads and duties	703.1.1	Circuit capacity, load and duty determinations are planned and prepared to ensure *OH&S policies and procedures* are followed and the work is appropriately sequenced in accordance with *requirements*
		703.1.2	*Appropriate personnel* are consulted to ensure determination of *circuit* capacities are co-ordinated effectively with others involved
		703.1.3	*Circuit* capacities, loads and duties to be determined are checked against *requirements*

Elements		Performance criteria	
		703.1.4	Measuring equipment and materials necessary to complete the determination of *circuit* capacities are identified in accordance with *established procedures* and checked against *requirements*
703.2	Establish capacities, loads and duties of apparatus and *circuits*	703.2.1	*OH&S policies and procedures* are followed
		703.2.2	*Circuit* capacities, loads and duties are detailed in accordance with *established procedures* and *requirements*
		703.2.3	Response to unplanned conditions are detailed in accordance with *established procedures*
		703.2.4	Approval to implement contingencies in accordance with *established procedures* from *appropriate personnel* are detailed
		703.2.5	On-going checks of the quality of the work in accordance with *established procedures* are detailed
703.3	Inspect and notify completion of work	703.3.1	Final inspections of *circuit* capacity determinations are undertaken in accordance with *established procedures*
		703.3.2	Completion of *circuit* capacity determinations are *notified* in accordance with *established procedures*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Categories

This unit recognises the commonality of skills and knowledge that exists for the unit as well as the additional specific outcome; which is to be reported on. Therefore, competency can be displayed on one, some or all of the following categories and in addition to the respective common underpinning knowledge associated with the selected specialisation:

(A) Computer systems

(B) Electrical

(C) Electronics

(D) Instrumentation

(E) Refrigeration and air conditioning

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit in the related *category* and *specialisation* which is to be exhibited across a *representative range* of applications; autonomously and to *requirements*.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace for each of the *categories* and areas of *specialisation* undertaken from those listed in the Range statement or Evidence guide.
- demonstrating an understanding of the underpinning knowledge and skills identified for the *categories* and related *specialisation* undertaken in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of applications which includes such things as *apparatus, circuits, wiring systems, plant, equipment,* tools, *accessories, components* and the like relative to that required for the *category* undertaken within and relevant to this unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

This unit should be addressed only after competency in unit UTE NES106 A of this standard has been achieved.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

This section includes that set of knowledge and skills additional to that specified in the above mentioned section titled ‘Interdependent assessment of units’.

Since this unit covers a range of *categories* each having multiple *specialisations* a content listing is provided below. Each *category* has all of the required underpinning knowledge and skill listed even though this sometimes results in duplication between *categories*.

Category: Computer systems (A)

Common

Occupational health and safety implementing and monitoring.

Legislation and Australian Standards: AS1470 – 1986; OHSC:7025 (1994); generic competencies A, B and C; relevant acts (electrical); general duty of care

Policy and program development: assigning accountability; focus on improvement

Consultative processes: OH&S committee; meetings and workshops; information gathering

Training and development: provision and type; dissemination of information; cultural considerations; literacy considerations

Hazard identification and assessment: safety audits; workplace inspections; injury and illness records, statistics; complaints and observations; contributing factors to a hazard (exposure, severity, human differences)

Risk assessment and management: hierarchy of control (elimination, substitution, design, mitigation)

Management and improvement: promoting OH&S activities; integration management structures; evaluation of control strategies; evaluation of educational and training programs

Engineering mathematics A.

Arithmetic: rational and irrational numbers, surds, SI units, conversion using unity, brackets, laws of indices (base 10), scientific and engineering notation; estimations, errors and approximations, significant figures

Algebra: substitution; +, -, x on simple polynomials, simple indices; expanding brackets; factorising quadratics, common factors, difference of two squares; simplifying algebraic fractions; transposition of engineering formulae; solving one variable equation; simple algebraic division

Geometry: pythagoras theorem; angles – degrees, radians, parallel lines cut by a transverse; triangles – sum of angles, properties of equilateral and isoceles triangles; congruent triangles; similar triangles – ratio of corresponding sides; sin, cos, tan – ratios of a right angled triangle; sine and cosine rules; circles – circumference, arcs, chords, tangents, circle theorems; area and perimeter mensuration on above figures

Co-ordinate geometry: 2D plane – x-y axes, s-t axes; graph of linear function – y = ax + b, functional notation – y = f(x); straight line given slope and one point or given two points; linear equations – solving algebraically and geometrically; line segment – length and mid point

Electrical control 'C' programming.

'C' language: uses; advantages and disadvantages

'C' development package: editor commands; the edit-compile-run cycle; compiler and linker options; header files

Language syntax: data types; arithmetic and logical operations; program structure

Control structure: sequential; repetition; selection

Functions: macros; global and local variables; intrinsic functions used in control; writing functions, linking in external functions to control hardware; numerical and character arrays; sequential file reading and writing

Interfacing applications using C.

Background: brief historical development of C, unix; K and R vs ANSII; program development environment

Program structure and compilation: top-down modular design methodology; program structure, functions, external functions; global, local, static, register and scope; linking with libraries; program compilation; memory models; using project 'make' facilities

Data types and operators: variables, constants, simple data types; statements, identifiers; arithmetic operators; pointers and their use; cast operator

Loop control: relational, equality and logical operators; compound operators; if-else, switch; while, do-while, for, break and continue

Complex data types and structures: pointers; arrays and strings; structures and unions; passing as parameters to functions

C and assembler: in-line assembly; bit manipulation in C; 10 port addressing

C++: objects, data abstraction, OOP; classes; parameters passed by reference

PC system interfacing.

Microprocessor system components: review of the operation of a microprocessor based computer system including the following system components ROM, RAM, timer, DMA, interrupt controller and IO interface; system reset/boot procedure

IO interfacing: detailed timing considerations of address, data and control bus; prototype development card interface (memory and IO address decoding map, bus signals); detailed timing considerations for memory and IO read/write cycle; electrical considerations (voltage, current etc.) of system address data and control bus and interfacing to the external world; wait state generation for slow peripherals or memory

Peripheral support chips: parallel ports, e.g. intel 8255; parallel printer timing considerations; serial USART, e.g. national semi-conductors 8250; serial printer or dumb terminal timing considerations; matrix keypad and seven segment display interfaces; special controller chips, CRTC, FDC, HDC, HDLC, etc; interfacing A/D and D/A, programming considerations

Documentation debugging and development equipment: application of CAD for documentation; system specification and documentation; debugging and tracing program execution in software; debugging and tracing in firm ware; producing romable code for embedded systems; in-circuit emulators

Specialisation: Control

Control concepts.

Advantages of control

Measurement terminology

Dimensional calculations

Basic transducer principles and physical variables

Control terminology

Type of controllers

Process characteristics

Controller principles

Control systems

Industrial computer interfacing.

Bus structures

Parallel I/O – memory mapped, polled I/O, interrupt driven I/O

Dedicated support devices: programmable peripheral interfaces; programmable timer counters; programmable interrupt controllers

Analogue to digital converters, digital to analogue converters

Serial and parallel ports

Keyboard and video displays

Advanced PLCs.

Medium to high level PLC hardware and software: hardware configuration; addressing; memory map; programming instruction syntax; file manipulation; documentation; saving/restoring programs

Number systems and codes: common number formats (binary, octal, integer, hexadecimal); conversions between formats; codes (BCD, grey, ASCII)

Diagnostics: flags/status words (file); fault locations; scan considerations (fixed, variable, immediate update)

Data manipulation (word): binary word structure; single and double works; word devices; arithmetic instructions; word logical instructions; conversions (BCD to binary, binary to BCD); indirect addressing (image register to word, word to IR, word to word, word to table, table to table); word shift registers (LIFO, FIFO); masking; bit manipulation (bit set, bit clear, bit test); entering data constants; multiplexing

Analogue I/O: common signal types; module resolution; scaling; unscaling; signal offset

Sequencers/drum controllers

SCADA systems.

System requirements

Use, features and facilities of different SCADA packages

Hardware requirements

PLC interface requirements

Networking requirements of the system

Mimics and animated graphics: graphic designs; balance of layout

Trending: analysis of process to select data; sampling of the process in terms of temperatures, time, weight; viewing data and graphical representation of selected information; trend graphs and data matching

Alarm logging: analysing select data, applying limits and specification applied to processes; corrective action of alarm status

Recipes and scheduling: methods of producing libraries for different process conditions, required for varied production runs; analysis of different production runs; alarm limits/material specifications; scheduling, setting limits and evoking program changes

Data collection and databasing: producing a database of variables; conversion of raw data into appropriate databasing software package

Reports: types and layout of reports; analysis of data

Programming language: automation of tasks within the software package

Implementation and applications: networking; types of networks; co-ordination and access of networking by linking to mainframe or factory network

Modems.

Interface: RS232, RS422; hayes compatibility; internal; external; control of data flow RTS/CTS (X-on, X-off); connect PC to PC; connect PC to Network; connect network to network

Software: kermit; procomm; proprietary

Modulation: PSK, FSK, QAM; DPSK, DAMQAM, QAM trellis coding

Protocols and standards: full-duplex, half-duplex; Xmodem; Ymodem; UUCP; V.22, V.32, V.42, X.25; connecting to ISDN

Data error detection/correction and compression: noise and distortion; error detection; error correction; data compression; security

Specialisation: Networks

Digital applications.

Boolean Algebra: generation of Boolean expressions and truth table for verbal logic descriptions and logic circuit schematics; simplification of Boolean expressions using Boolean algebra; complementation of a Boolean expression – De Morgan's laws

Karnaugh maps: construction of K maps for given functions of up to 4 variables; use of k mpas to derive the minimal and into or (S.O.P) form implementation for a given expression; conversion of and or (S.O.P) form into all NAND gate implementation; nature of "don't cares" and how they can be used to advantage by a designer

Propagation delays: definition - t_{plh} and t_{phl}; affect on operation of discrete devices – simple combinational circuits and ripple counters; set-up and hold times - definition and consequences of

Oscillators: schmitt-trigger action - V_{T+}, and V_{T-}, hysteresis; waveform smoothing; schmitt trigger oscillator - factors determining frequency; two gate R-C oscillator; two gate crystal oscillator; an integrated, crystal controlled, oscillator/frequency-divider chip - e.g. 4060

Monostables: basic operation - trigger conditions and pulse-width determination; response of non-re-triggerable vs re-triggerable one shots; duty cycle limitation; simple applications of one shots e.g. pulse stretching and delaying, switch debouncing/key pressed strobe and missing pulse detector

Asynchronous counters: characteristics of common i.e. "ripple" counters e.g. 7490 family; changing the counter modulus - frequency division and output duty cycle; cascading asynchronous counters to extend modulus; disadvantages - glitches and clocking frequency limitations

Synchronous counters: basic internal structure of a presettable synchronous I.C. counter; distinction between synchronous and asynchronous control inputs and their relative affects - e.g. load enable and clear inputs; use of counter (clock) enable inputs and terminal count outputs; analysis of a synchronous I.C. counter circuit (maximum of 2 counters) to determine count-cycle - modulus, frequency and form of output waveform

Memory: classification – RAM and ROM (historic), volatile and non-volatile memory; memory terminology - array structure, memory size data word, address; data - address and control buses; read and write modes of operation - basis steps in; memory timing:- access time and write (cycle) time; RAM devices - SRAM and DRAM - speed, density refresh and addressing differences; ROM devices - nature of masked ROM, PROM, EPROM, E^2ROM and NVRAM

Digital circuit applications: memory decoding - expansion of word size and address space; development of a memory map from a given memory decoding system (no images); control waveform generator using a MUX and counter; use of a ROM as a code converter - look-up table and character generator (ASCII code to dot pattern); use of a BDC to 7 segment decoder/latch to drive either a common anode or common cathode led display; display multiplexing - time sharing a single decoder between two display chips

Micro computer systems.

Software development for a micro-processor based system: using an assembler; using a debugging tool; producing documentation that includes algorithms and list file

Block diagram functions: programmable peripheral interface (PPI); programmable interval timer; universal asynchronous receiver transmitter (UART); programmable interrupt controller (PIC) – including the processing of single and multiple interrupts received; programmable memory access controller (DMAC); bus controller; floppy disk controller (FDC); cathode ray tube controller (CRTC) – including producing characters for output to the display device, display adaptor card using the CRTC

Function of pins of common micro processor peripheral ICs: programmable peripheral interface (PPI); programmable interval timer (PIT); universal asynchronous receiver transmitter (UART); programmable interrupt controller (PIC); programmable memory access controller (DMAC); bus controller; floppy disk controller (FDC); cathode ray tube controller (CRTC)

Software for initialisation: PPI to transfer data in modes 0, 1, 2 ; PIT in modes 0, 1, 2, 3; PIC to one of its 6 modes of operation; UART to transfer data; DMAC for single transfer and block transfer modes

Use of the operational mode: programmable peripheral interface (PPI); programmable interval timer (PIT); universal asynchronous receiver transmitter (UART); programmable interrupt controller (PIC); programmable memory access controller (DMAC); exercising the floppy disk drive; change the operational characteristics of the CRTC

Interfacing of IC peripherals: PPI – the use of the handshaking line with data transfer techniques used on 8 bit and 16 bit data buses; PCI – cascading the PIC; bus controller – to a micro processor

Modems.

Interface: RS232, RS422; hayes compatibility; internal; external; control of data flow RTS/CTS (X-on, X-off); connect PC to PC; connect PC to Network; connect network to network

Software: kermit; procomm; proprietary

Modulation: PSK, FSK, QAM; DPSK, DAMQAM, QAM trellis coding

Protocols and standards: full-duplex, half-duplex; Xmodem; Ymodem; UUCP; V.22, V.32, V.42, X.25; connecting to ISDN

Data error detection/correction and compression: noise and distortion; error detection; error correction; data compression; security

Data communications.

Data communications: brief history of communications; description of how information is transferred; types of codes used to transmit information; data terminal equipment and types; data communication equipment; DTE-DCE interface; data transmission – communications mode; baseband and broadband; transmission mode; error control – checking, parity, CRC

Messages and transmission channels: information as a quantity; information content of symbols; use of redundancy in communications; media used in information transmission; twisted pair – coaxial cable, waveguide, fibre optic, HF radio, satellite and cellular radio systems

Protocols: description of a protocol; simple protocols – teletypewriter, parity, X modem; half and full duplex

Modems and interface: definition – types of modems; modulation – speed, multiplexing; interface and signalling standards RS232C, V24 interface, current loop, RS422, RS423, RS449, RS485, V35, X21 and G703; limitations of interface standards – distance, speed, ground IEEE standards

Fibre optic communications: fundamentals of fibre optic systems; fibre composition; multimode – single mode propagation; types of index; bandwidth; sources – detectors of light; types of connectors; splicing fibre optic cable

Category: Electrical (B)

Common

Occupational health and safety implementing and monitoring.

Legislation and Australian Standards: AS1470 – 1986; OHSC:7025 (1994); generic competencies A, B and C; relevant acts (electrical); general duty of care

Policy and program development: assigning accountability; focus on improvement

Consultative processes: OH&S committee; Meetings. and workshops; information gathering

Training and development: provision and type; dissemination of information; cultural considerations; literacy considerations

Hazard identification and assessment: safety audits; workplace inspections; injury and illness records, statistics; complaints and observations; contributing factors to a hazard (exposure, severity, human differences)

Risk assessment and management: hierarchy of control (elimination, substitution, design, mitigation)

Management and improvement: promoting OH&S activities; integration management structures; evaluation of control strategies; evaluation of educational and training programs

Industrial computer systems.

Computer systems overview

PC hardware orientation

DOS commands

DOS set-up commands

Windows operations

Word processors

Spreadsheets

Databases as used for control applications

CAD/vector graphics

Control applications

Specialisation: Control

Amplifiers.

Small signal amplifier use: ideal small amplifier characteristics – input and output resistance, current gain, voltage gain; practical amplifier characteristics; voltage gain measurement; amplifier selection given system requirements and loads; bandwidth measurement

For ideal and practical operational amplifier: input/output impedance; open loop gain; gain-bandwidth product; ideal and practical comparator; inverting/non-inverting amplifiers, measurements and calculations

Programmable controllers - advanced procedures.

Installation procedures and precautions: personal safety; AS3000 and AS1543 implications; interpret manufacturer's installation specifications; basic commissioning procedures; environmental limitations/protection; physical positioning of CPU and I/O racks; routing signal/power cables; signal/power earthing requirements; selection of sink vs source modules; selection of relay vs transistor vs Triac modules

Advanced discrete programming: derived timers (off delay, self resetting, constant cycle); reversible counters; cascading timers; cascading counters; combining timers and counters; internal relays/flags/markers; latching relays (set/reset); jump instructions; master control instruction; bit shift registers; scan time considerations; one shot; retentive (power fail) functions; simple step sequence instructions

External program storage devices: IC storage (ROM, EPROM, E^2PROM); cassette tape; computer (hard/floppy) disks; save and retrieve a program to/from an external storage medium

Software design: use software to develop/edit a process control solution; use software to monitor the status of a process; use software to document a program; produce a hard copy (print-out) of a fully documented program

Basic diagnostics: use the force instruction to aid in fault-finding; use inbuilt hardware/software diagnostics to determine errors; using error codes locate and rectify a fault

Control concepts.

Advantages of control

Measurement terminology

Dimensional calculations

Basic transducer principles and physical variables

Control terminology

Type of controllers

Process characteristics

Controller principles

Control systems

Digital electronics.

Analogue and digital signal definition

Digital combinational circuit operation: binary numbering up to four variables; truth tables; Boolean representation; simplification of Boolean expressions; circuit implementation from Boolean expressions; logic probe/pulser usage for fault-finding

Hexadecimal, binary and decimal number systems and BCD code: hexadecimal numbering system and its BCD representation (up to two digits); binary to decimal conversion (16 bits max.); binary to hexadecimal conversion (16 bits max.); decimal to hexadecimal conversion (four hex digits max.); representation of alphanumeric characters using 7 BIT ASCII code

Electrostatic discharge precautions: effect of ESD; handling components; - wrist straps, protective mats, anti-static bags examples of design using ESD techniques

Operation and characteristics of displays: LED displays; types; calculating current limiting resistors; LCD displays –types; drive requirements

Power control devices.

Need for power control typical applications

Power control methods: switched control; rheostatic control; voltage control; simmerstatic control; thyristor control

Advantages and benefits of thyristor power control: efficiency; reliability; precision; overall cost

Silicon controlled rectifiers: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation; cooling and protection; testing for serviceability; applications

Gate turn off (GTO) thyristors: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation – gate turn off requirements; applications

BJT, IGBTs: construction and symbols; basic operating principles; characteristics; cut off; saturation and amplification

Triacs: construction and symbol; basic operating principles; characteristics; voltage ratings – blocking voltage, dv/dt rating; current ratings – rms current, latching and holding currents, di/dt rating; triggering requirements – modes of triggering and sensitivity; commutation; cooling and protection; testing for serviceability; applications

Unijunction transistors (UJT): construction and symbol; operating principles; intrinsic stand-off ratio and peak point voltage; revision of R.C constants; UJT relaxation oscillator circuit; UJT oscillator circuit operation – frequency, output pulse characteristic, waveforms

Programmable unijunction transistors (PUT): construction and symbol; operating principles; peak point voltage; programmable stand-off ratio; PUT relaxation oscillator circuit; PUT oscillator circuit operation – frequency, output pulse characteristic, waveforms

Diacs: construction and symbol; operating principles; breakover voltage – symmetrical and asymmetric diacs; diac trigger circuit; diac trigger circuit operation – frequency, output pulse characteristic, waveforms

Phase shift control: definition; triggering and conduction angles; relationship between output voltage and conduction angle; problems associated with phase shift control

Single phase half wave controlled rectifier: rectifier operation; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations

Single phase full wave controlled rectifier: half controlled bridge – circuit configuration, including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations; comparison with single phase half wave controlled rectifier

Single phase A.C. voltage control: half and full control circuits; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; use of triacs or inverse parallel SCR's; 'snap on' effect of phase control circuits – reduction of the snap on effect; load voltage determination – form circuit characteristic; applications and limitations

Single phase zero voltage switching (ZVS): operating principles; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; relationship between load power and conduction time; solid state relays types and ratings; applications and limitations

Fault-finding procedures: typical faults – power and trigger circuits; characteristics displayed by common faults; comparison of test data with expected data (voltage/current waveforms); location and replacement of faulty components

Advanced circuit development.

Advanced circuit design techniques

Documenting circuit design

Modifying circuits

An introduction and overview of CAD

Application of programmable controllers in circuit design

Sensors for machinery and product monitoring.

Operation and application of transducers: linear position and displacement; angular position; proximity and limits; vibration and acceleration; speed of rotation; strain

The application of mechanical measuring devices to monitor: industrial plant and manufacturing - processes; production line and material handling systems; the condition of plant and equipment

The statutory requirements: noise and vibration; monitoring techniques

Thyristor converters.

Single and three phase controlled rectifiers: purpose of function of a controlled rectifier; circuit configurations and applications - single and three phase half wave, single and three phase half controlled bridge, single and three phase fully controlled bridge; rectifier performance and operation on resistive and inductive loads; output voltage and waveform, determination of output voltage by both calculation and use of circuit characteristic; communication problems associated with inductive loads; comparison of single and three phase controlled rectifiers

Single phase AC controllers: purpose of function of an AC controller; circuit configurations and applications - single phase half controller, single phase full controller (triac control), single phase full controller (inverse parallel SCR's); circuit performance and operation on resistive and inductive loads; output voltage and waveform, determination of output voltage using circuit characteristic; range of control with inductive loads; triggering problems associated with inductive loads

Three phase AC controllers: circuit configurations and applications – three phase three wire controllers, three phase four wire controllers (circuit only); circuit performance and operation on resistive and inductive loads; output voltage and waveform, determination of output voltage using circuit characteristic; range of control with inductive loads; triggering problems associated with inductive loads

Thyristor controlled DC to DC converters: purpose and function of a DC to DC converter; voltage control methods – pulse width modulation, pulse rate modulation, modulating both pulse width and rate; output voltage and current levels and waveforms for both resistive and inductive loads; calculation of output voltage

Thyristor protection: protection techniques – snubber networks (dv/dt protection), series inductors (di/dt protection), amp trap (HRC) fuses, gate pulse suppression; need for heat sinking of power thyristor devices; heat sink features and types; installation methods for all types of thyristor packages; basic thermal model, only to demonstrate the effect of different heat sink types and profiles and installation methods on thyristor junction temperature

Series and parallel thyristor connection: need for series and/or parallel connection of thyristors; series, or high voltage operation – problems associated with series connection, transient voltage equalisation, steady state voltage equalisation, simultaneous triggering, heat sink mounting

Parallel, or high current operation: problems associated with parallel connection – current equalisation, junction temperature equalisation, simultaneous triggering, heat sink mounting

Specialisation: Energy supply

Amplifiers.

Small signal amplifier use: ideal small amplifier characteristics – input and output resistance, current gain, voltage gain; practical amplifier characteristics; voltage gain measurement; amplifier selection given system requirements and loads; bandwidth measurement

For ideal and practical operational amplifier: input/output impedance; open loop gain; gain-bandwidth product; ideal and practical comparator; inverting/non-inverting amplifiers, measurements and calculations

Programmable controllers - advanced procedures.

Installation procedures and precautions: personal safety; AS3000 and AS1543 implications; interpret manufacturer's installation specifications; basic commissioning procedures; environmental limitations/protection; physical positioning of CPU and I/O racks; routing signal/power cables; signal/power earthing requirements; selection of sink vs source modules; selection of relay vs transistor vs Triac modules

Advanced discrete programming: derived timers (off delay, self resetting, constant cycle); reversible counters; cascading timers; cascading counters; combining timers and counters; internal relays/flags/markers; latching relays (set/reset); jump instructions; master control instruction; bit shift registers; scan time considerations; one shot; retentive (power fail) functions; simple step sequence instructions

External program storage devices: IC storage (ROM, EPROM, E^2PROM); cassette tape; computer (hard/floppy) disks; save and retrieve a program to/from an external storage medium

Software design: use software to develop/edit a process control solution; use software to monitor the status of a process; use software to document a program; produce a hard copy (print-out) of a fully documented program

Basic diagnostics: use the force instruction to aid in fault-finding; use inbuilt hardware/software diagnostics to determine errors; using error codes locate and rectify a fault

Control concepts.

Advantages of control

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Control terminology

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Digital electronics.

Analogue and digital signal definition

Digital combinational circuit operation: binary numbering up to four variables; truth tables; Boolean representation; simplification of Boolean expressions; circuit implementation from Boolean expressions; logic probe/pulser usage for fault-finding

Hexadecimal, binary and decimal number systems and BCD code: hexadecimal numbering system and its BCD representation (up to two digits); binary to decimal conversion (16 bits max.); binary to hexadecimal conversion (16 bits max.); decimal to hexadecimal conversion (four hex digits max.); representation of alphanumeric characters using 7 BIT ASCII code

Electrostatic discharge precautions: effect of ESD; handling components; - wrist straps, protective mats, anti-static bags Examples of design using ESD techniques

Operation and characteristics of displays: LED displays; types; calculating current limiting resistors; LCD displays – types; drive requirements

Power control devices.

Need for power control typical applications

Power control methods: switched control; rheostatic control; voltage control; simmerstatic control; thyristor control

Advantages and benefits of thyristor power control: efficiency; reliability; precision; overall cost

Silicon controlled rectifiers: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation; cooling and protection; testing for serviceability; applications

Gate turn off (GTO) thyristors: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation – gate turn off requirements; applications

BJT, IGBTs: construction and symbols; basic operating principles; characteristics; cut off; saturation and amplification

Triacs: construction and symbol; basic operating principles; characteristics; voltage ratings – blocking voltage, dv/dt rating; current ratings – rms current, latching and holding currents, di/dt rating; triggering requirements – modes of triggering and sensitivity; commutation; cooling and protection; testing for serviceability; applications

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Programmable unijunction transistors (PUT): construction and symbol; operating principles; peak point voltage; programmable stand-off ratio; PUT relaxation oscillator circuit; PUT oscillator circuit operation – frequency, output pulse characteristic, waveforms

Diacs: construction and symbol; operating principles; breakover voltage – symmetrical and asymmetric diacs; diac trigger circuit; diac trigger circuit operation – frequency, output pulse characteristic, waveforms

Phase shift control: definition; triggering and conduction angles; relationship between output voltage and conduction angle; problems associated with phase shift control

Single phase half wave controlled rectifier: rectifier operation; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations

Single phase full wave controlled rectifier: half controlled bridge – circuit configuration, including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations; comparison with single phase half wave controlled rectifier

Single phase A.C. voltage control: half and full control circuits; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; use of triacs or inverse parallel SCR's; 'snap on' effect of phase control circuits – reduction of the snap on effect; load voltage determination – form circuit characteristic; applications and limitations

Single phase zero voltage switching (ZVS): operating principles; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; relationship between load power and conduction time; solid state relays types and ratings; applications and limitations

Fault-finding procedures: typical faults – power and trigger circuits; characteristics displayed by common faults; comparison of test data with expected data (voltage/current waveforms); location and replacement of faulty components

Distribution transformers.

Transformer principles: basic construction; operation

Voltage regulation: percentage impedance; testing

Tap changing switches: types; maintenance; solid state equipment

Losses, efficiency

Cooling methods: types of cooling; testing and maintenance of coolant

Auxiliary equipment: breathers; gauges; vents; electrical/mechanical safety devices

Testing: fault-finding; standard test procedures; methods of connection; vector grouping; tertiary windings

Parallel operation: transformer load sharing; vector group

Harmonics in transformers: causes; solutions

System operating characteristics.

Power distribution system electrical characteristics: inductance, capacitance and resistance

Voltage problems in a power distribution system: low-voltage; unbalanced voltages; voltage rises

Voltage regulation: autotransformers with on-load tap changer; transformers with on-load tap changer ; static capacitors; load control

Control of on-load tap changer: regulation relays; control circuits; line drop compensation

Power distribution system faults: type/classification of fault; typical causes/effects of faults; three-phase symmetrical fault levels; fault level limitation

Voltage surges in a power distribution system: lighting; switching; typical levels; impedance, typical values; significance of the system impedance

Protection and relaying.

System faults: type and classification of faults; three phase symmetrical fault levels

Protection fundamentals: purpose; features of a scheme

Instrument transformers for protection: current transformers; voltage transformers

Feeder protection: fuse; overcurrent and earth fault; sensitive earth fault; unit schemes; distance; trip/close sequences for feeders; recloser/sectionaliser systems

Transformer protection: overheating; overcurrent; restricted earth fault; differential; oil and gas devices

Busbar protection: types of fault; requirements of busbar protection; system; frame-earth

Surge protection: voltage surges; surge diverters; arcing horns

Specialisation: Hazardous areas

Amplifiers.

Small signal amplifier use: ideal small amplifier characteristics – input and output resistance, current gain, voltage gain; practical amplifier characteristics; voltage gain measurement; amplifier selection given system requirements and loads; bandwidth measurement

For ideal and practical operational amplifier: input/output impedance; open loop gain; gain-bandwidth product; ideal and practical comparator; inverting/non-inverting amplifiers, measurements and calculations

Programmable controllers - advanced procedures.

Installation procedures and precautions: personal safety; AS3000 and AS1543 implications; interpret manufacturer's installation specifications; basic commissioning procedures; environmental limitations/protection; physical positioning of CPU and I/O racks; routing signal/power cables; signal/power earthing requirements; selection of sink vs source modules; selection of relay vs transistor vs Triac modules

Advanced discrete programming: derived timers (off delay, self resetting, constant cycle); reversible counters; cascading timers; cascading counters; combining timers and counters; internal relays/flags/markers; latching relays (set/reset); jump instructions; master control instruction; bit shift registers; scan time considerations; one shot; retentive (power fail) functions; simple step sequence instructions

External program storage devices: IC storage (ROM, EPROM, E^2PROM); cassette tape; computer (hard/floppy) disks; save and retrieve a program to/from an external storage medium

Software design: use software to develop/edit a process control solution; use software to monitor the status of a process; use software to document a program; produce a hard copy (print-out) of a fully documented program

Basic diagnostics: use the force instruction to aid in fault-finding; use inbuilt hardware/software diagnostics to determine errors; using error codes locate and rectify a fault

Control concepts.

Advantages of control

Measurement terminology

Dimensional calculations

Basic transducer principles and physical variables

Control terminology

Type of controllers

Process characteristics

Controller principles

Control systems

Digital electronics.

Analogue and digital signal definition

Digital combinational circuit operation: binary numbering up to four variables; truth tables; Boolean representation; simplification of Boolean expressions; circuit implementation from Boolean expressions; logic probe/pulser usage for fault-finding

Hexadecimal, binary and decimal number systems and BCD code: hexadecimal numbering system and its BCD representation (up to two digits); binary to decimal conversion (16 bits max.); binary to hexadecimal conversion (16 bits max.); decimal to hexadecimal conversion (four hex digits max.); representation of alphanumeric characters using 7 BIT ASCII code

Electrostatic discharge precautions: effect of ESD; handling components; - wrist straps, protective mats, anti-static bags Examples of design using ESD techniques

Operation and characteristics of displays: LED displays; types; calculating current limiting resistors; LCD displays –types; drive requirements

Power control devices.

Need for power control typical applications

Power control methods: switched control; rheostatic control; voltage control; simmerstatic control; thyristor control

Advantages and benefits of thyristor power control: efficiency; reliability; precision; overall cost

Silicon controlled rectifiers: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation; cooling and protection; testing for serviceability; applications

Gate turn off (GTO) thyristors: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation – gate turn off requirements; applications

BJT, IGBTs: construction and symbols; basic operating principles; characteristics; cut off; saturation and amplification

Triacs: construction and symbol; basic operating principles; characteristics; voltage ratings – blocking voltage, dv/dt rating; current ratings – rms current, latching and holding currents, di/dt rating; triggering requirements – modes of triggering and sensitivity; commutation; cooling and protection; testing for serviceability; applications

Unijunction transistors (UJT): construction and symbol; operating principles; intrinsic stand-off ratio and peak point voltage; revision of R.C constants; UJT relaxation oscillator circuit; UJT oscillator circuit operation – frequency, output pulse characteristic, waveforms

Programmable unijunction transistors (PUT): construction and symbol; operating principles; peak point voltage; programmable stand-off ratio; PUT relaxation oscillator circuit; PUT oscillator circuit operation – frequency, output pulse characteristic, waveforms

Diacs: construction and symbol; operating principles; breakover voltage – symmetrical and asymmetric diacs; diac trigger circuit; diac trigger circuit operation – frequency, output pulse characteristic, waveforms

Phase shift control: definition; triggering and conduction angles; relationship between output voltage and conduction angle; problems associated with phase shift control

Single phase half wave controlled rectifier: rectifier operation; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations

Single phase full wave controlled rectifier: half controlled bridge – circuit configuration, including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations; comparison with single phase half wave controlled rectifier

Single phase A.C. voltage control: half and full control circuits; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; use of triacs or inverse parallel SCR's; 'snap on' effect of phase control circuits – reduction of the snap on effect; load voltage determination – form circuit characteristic; applications and limitations

Single phase zero voltage switching (ZVS): operating principles; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; relationship between load power and conduction time; solid state relays types and ratings; applications and limitations

Fault-finding procedures: typical faults – power and trigger circuits; characteristics displayed by common faults; comparison of test data with expected data (voltage/current waveforms); location and replacement of faulty components

Specialisation: Instrument and servicing

Amplifiers.

Small signal amplifier use: ideal small amplifier characteristics – input and output resistance, current gain, voltage gain; practical amplifier characteristics; voltage gain measurement; amplifier selection given system requirements and loads; bandwidth measurement

For ideal and practical operational amplifier: input/output impedance; open loop gain; gain-bandwidth product; ideal and practical comparator; inverting/non-inverting amplifiers, measurements and calculations

Programmable controllers - advanced procedures.

Installation procedures and precautions: personal safety; AS3000 and AS1543 implications; interpret manufacturer's installation specifications; basic commissioning procedures; environmental limitations/protection; physical positioning of CPU and I/O racks; routing signal/power cables; signal/power earthing requirements; selection of sink vs source modules; selection of relay vs transistor vs Triac modules

Advanced discrete programming: derived timers (off delay, self resetting, constant cycle); reversible counters; cascading timers; cascading counters; combining timers and counters; internal relays/flags/markers; latching relays (set/reset); jump instructions; master control instruction; bit shift registers; scan time considerations; one shot; retentive (power fail) functions; simple step sequence instructions

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Basic diagnostics: use the force instruction to aid in fault-finding; use inbuilt hardware/software diagnostics to determine errors; using error codes locate and rectify a fault

Control concepts.

Advantages of control

Measurement terminology

Dimensional calculations

Basic transducer principles and physical variables

Control terminology

Type of controllers

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Electrostatic discharge precautions: effect of ESD; handling components; - wrist straps, protective mats, anti-static bags Examples of design using ESD techniques

Operation and characteristics of displays: LED displays; types; calculating current limiting resistors; LCD displays – types; drive requirements

Sensors for machinery and product monitoring.

Operation and application of transducers: linear position and displacement; angular position; proximity and limits; vibration and acceleration; speed of rotation; strain

The application of mechanical measuring devices to monitor: industrial plant and manufacturing - processes; production line and material handling systems; the condition of plant and equipment

The statutory requirements: noise and vibration; monitoring techniques

Power control devices.

Need for power control typical applications

Power control methods: switched control; rheostatic control; voltage control; simmerstatic control; thyristor control

Advantages and benefits of thyristor power control: efficiency; reliability; precision; overall cost

Silicon controlled rectifiers: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation; cooling and protection; testing for serviceability; applications

Gate turn off (GTO) thyristors: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation – gate turn off requirements; applications

BJT, IGBTs: construction and symbols; basic operating principles; characteristics; cut off; saturation and amplification

Triacs: construction and symbol; basic operating principles; characteristics; voltage ratings – blocking voltage, dv/dt rating; current ratings – rms current, latching and holding currents, di/dt rating; triggering requirements – modes of triggering and sensitivity; commutation; cooling and protection; testing for serviceability; applications

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Single phase half wave controlled rectifier: rectifier operation; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations

Single phase full wave controlled rectifier: half controlled bridge – circuit configuration, including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations; comparison with single phase half wave controlled rectifier

Single phase A.C. voltage control: half and full control circuits; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; use of triacs or inverse parallel SCR's; 'snap on' effect of phase control circuits – reduction of the snap on effect; load voltage determination – form circuit characteristic; applications and limitations

Single phase zero voltage switching (ZVS): operating principles; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; relationship between load power and conduction time; solid state relays types and ratings; applications and limitations

Fault-finding procedures: typical faults – power and trigger circuits; characteristics displayed by common faults; comparison of test data with expected data (voltage/current waveforms); location and replacement of faulty components

Electrical installation requirements.

Cable selection for mains and submains using AS3000.1 for installation conditions where de-rating factors are required to apply

Voltage drop calculations using circuit impedance for various load power factors

Effects of harmonics on cable selection: methods of harmonic control

Determination of permissible short circuit currents and temperature limits

Cable selection for final subcircuits where de-rating factors need to be apply

Control and protection requirement, switchboard design including arrangement of equipment, CT metering, links, circuit protection and fault current protection

Determination of cable selection, control and protection using AS3000, AS3008.1, AS3001 and AS3004 for theatres, halls, controlled atmosphere rooms, caravans, caravan parks and boating marina installations

Specialisation: Mining

Amplifiers.

Small signal amplifier use: ideal small amplifier characteristics – input and output resistance, current gain, voltage gain; practical amplifier characteristics; voltage gain measurement; amplifier selection given system requirements and loads; bandwidth measurement

For ideal and practical operational amplifier: input/output impedance; open loop gain; gain-bandwidth product; ideal and practical comparator; inverting/non-inverting amplifiers, measurements and calculations

Programmable controllers - advanced procedures.

Installation procedures and precautions: personal safety; AS3000 and AS1543 implications; interpret manufacturer's installation specifications; basic commissioning procedures; environmental limitations/protection; physical positioning of CPU and I/O racks; routing signal/power cables; signal/power earthing requirements; selection of sink vs source modules; selection of relay vs transistor vs Triac modules

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Advantages of control

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Electrostatic discharge precautions: effect of ESD; handling components; - wrist straps, protective mats, anti-static bags Examples of design using ESD techniques

Operation and characteristics of displays: LED displays; types; calculating current limiting resistors; LCD displays –types; drive requirements

Power control devices.

Need for power control typical applications

Power control methods: switched control; rheostatic control; voltage control; simmerstatic control; thyristor control

Advantages and benefits of thyristor power control: efficiency; reliability; precision; overall cost

Silicon controlled rectifiers: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation; cooling and protection; testing for serviceability; applications

Gate turn off (GTO) thyristors: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation – gate turn off requirements; applications

BJT, IGBTs: construction and symbols; basic operating principles; characteristics; cut off; saturation and amplification

Triacs: construction and symbol; basic operating principles; characteristics; voltage ratings – blocking voltage, dv/dt rating; current ratings – rms current, latching and holding currents, di/dt rating; triggering requirements – modes of triggering and sensitivity; commutation; cooling and protection; testing for serviceability; applications

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Single phase half wave controlled rectifier: rectifier operation; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations

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Single phase A.C. voltage control: half and full control circuits; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; use of triacs or inverse parallel SCR's; 'snap on' effect of phase control circuits – reduction of the snap on effect; load voltage determination – form circuit characteristic; applications and limitations

Single phase zero voltage switching (ZVS): operating principles; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; relationship between load power and conduction time; solid state relays types and ratings; applications and limitations

Fault-finding procedures: typical faults – power and trigger circuits; characteristics displayed by common faults; comparison of test data with expected data (voltage/current waveforms); location and replacement of faulty components

Advanced circuit development.

Advanced circuit design techniques

Documenting circuit design

Modifying circuits

An introduction and overview of CAD

Application of programmable controllers in circuit design

Sensors for machinery and product monitoring.

Operation and application of transducers: linear position and displacement; angular position; proximity and limits; vibration and acceleration; speed of rotation; strain

The application of mechanical measuring devices to monitor: industrial plant and manufacturing - processes; production line and material handling systems; the condition of plant and equipment

The statutory requirements: noise and vibration; monitoring techniques

Thyristor converters.

Single and three phase controlled rectifiers: purpose of function of a controlled rectifier; circuit configurations and applications - single and three phase half wave, single and three phase half controlled bridge, single and three phase fully controlled bridge; rectifier performance and operation on resistive and inductive loads; output voltage and waveform, determination of output voltage by both calculation and use of circuit characteristic; communication problems associated with inductive loads; comparison of single and three phase controlled rectifiers

Single phase AC controllers: purpose of function of an AC controller; circuit configurations and applications - single phase half controller, single phase full controller (trial control), single phase full controller (inverse parallel SCR's); circuit performance and operation on resistive and inductive loads; output voltage and waveform, determination of output voltage using circuit characteristic; range of control with inductive loads; triggering problems associated with inductive loads

Three phase AC controllers: circuit configurations and applications – three phase three wire controllers, three phase four wire controllers (circuit only); circuit performance and operation on resistive and inductive loads; output voltage and waveform, determination of output voltage using circuit characteristic; range of control with inductive loads; triggering problems associated with inductive loads

Thyristor controlled DC to DC converters: purpose and function of a DC to DC converter; voltage control methods – pulse width modulation, pulse rate modulation, modulating both pulse width and rate; output voltage and current levels and waveforms for both resistive and inductive loads; calculation of output voltage

Thyristor protection: protection techniques – snubber networks (dv/dt protection), series inductors (di/dt protection), Amp trap (HRC) fuses, gat pulse suppression; need for heat sinking of power thyristor devices; heat sink features and types; installation methods for all types of thyristor packages; basic thermal model, only to demonstrate the effect of different heat sink types and profiles and installation methods on thyristor junction temperature

Series and parallel thyristor connection: need for series and/or parallel connection of thyristors; series, or high voltage operation – problems associated with series connection, transient voltage equalisation, steady state voltage equalisation, simultaneous triggering, heat sink mounting

Parallel, or high current operation: problems associated with parallel connection – current equalisation, junction temperature equalisation, simultaneous triggering, heat sink mounting

Specialisation: Process

Amplifiers.

Small signal amplifier use: ideal small amplifier characteristics – input and output resistance, current gain, voltage gain; practical amplifier characteristics; voltage gain measurement; amplifier selection given system requirements and loads; bandwidth measurement

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Need for power control typical applications

Power control methods: switched control; rheostatic control; voltage control; simmerstatic control; thyristor control

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Fault-finding procedures: typical faults – power and trigger circuits; characteristics displayed by common faults; comparison of test data with expected data (voltage/current waveforms); location and replacement of faulty components

Process control.

Open and closed loop system, identifying final element, process measuring, transmitter, converter, controller, controller setpoint, process, process signal

Control terminology: set point; offset; deviation; gain; proportional band; integral (reset); derivative (rate preact); process variable; feedback; conversion of gain to PB and vice verse; integral (repeats/min and min/repeat); process characteristics (process lag, resistive lag, capacitive, deadtime); on/off control; proportional control (amplitude, time); proportional plus integral control; proportional plus integral plus derivative control; reset wind-up

Response of systems to controller parameter (PI and D) changes and load change

Control valves.

Control valve body trims: body types; trim types; inherent and dynamic flow characteristics of characterised trim valves; inherent and dynamic flow characteristics of fixed characteristics valves; bonnets

Control valve terminology and calculations: control valves rating and sizing

Spring opposed diaphragm actuators: actuator characteristics

Valve positioners: applications of valve positioners; valve positioner types; calibration/adjustment

Self acting control valves: operation; performance characteristics of self-acting control valves; installation; calibration/adjustment

Piston actuators/power cylinders: types of piston actuators; characteristics of piston actuators; applications of piston actuators; testing and maintenance; calculation of thrust force of advance and retract strokes; installation and accessories

Position controllers (positioners) for use with piston actuators/power cylinders: types and application; characterised actuation; calibration/adjustment

Directional control valves (pilot operators) for piston actuators: types/porting arrangements; applications; actuation methods; air supply and lubrication

Water analysis.

Terminology/types: pH; conductivity; selection; redoc (ORP); turbidity/opacity

Sensing elements: construction; operation; test electrodes; design limitations; calibration

Measuring circuits

Installation considerations

Test equipment

Specialisation: AC machines

Sensors for machinery and product monitoring.

Operation and application of transducers: linear position and displacement; angular position; proximity and limits; vibration and acceleration; speed of rotation; strain

The application of mechanical measuring devices to monitor: industrial plant and manufacturing - processes; production line and material handling systems; the condition of plant and equipment

The statutory requirements: noise and vibration; monitoring techniques

A.C. stators - formed coil rewind.

Stripping stator core of old windings, data collection, preparation for rewind

Fitting of new coils to the stator core, wedging, bracing, connecting

Impregnating materials, procedures, tests, precautions

Static electrical testing: procedures, precautions

Electrical machine bearings.

Types of bearings used in electric motors: ball and roller bearings - deep groove, maximum capacity, angular contact, self aligning, special thrust

Ball and roller bearings-roller: cylindrical, tapered, spherical, special thrust

Plain bearings: full sleeve, split sleeve, thrust – fixed and tilting pad, carbon and sintered

Bearing clearances

Fitting bearings to shafts: hot oil bath, oven heating, induction heating, cooling, hydraulic, mechanical, adaptor sleeves

Fitting of bearings into housings: pressing, heating

Removal of bearings from shafts (mechanical, hydraulic, heating) and housings (pressing, heating)

Handling and storage of bearings

Methods of lubrication: grease, oil bath, oil circulating system, throw away system, oil mist

Seals: oil grooves, labyrinth, oil seals, v rings, mechanical

Calculation of bearing life

Dimensions of housing and shafts

Bearing damage and remedial action: brinelling, false brinelling, foreign material, corrosion, overload, electric current

Electric rotating machines - condition monitoring.

Routine maintenance and condition monitoring of: bearings, windings, cooling circuits, commutators, sliprings, couplings, pulleys, rotating components

Couplings and pulleys.

Types of couplings, applications

Fitting couplings to shafts, alignment

Types of belts, applications

Fitting of pulleys to shafts, alignment

Wave wound rotors – rewind.

Winding removal: details, measurements, calculations

Preparation of core for rewinding

Types of insulation

Half coils: forming, preparing the ends, insulating

Fitting coils to rotor core: wedge, connect, band

Impregnation methods

Static electrical testing: procedures, precautions

Sliprings and commutators.

Problems relating to sliprings and commutators

Brush selection

Brush gear servicing

Slipring servicing

Commutator servicing

Submersible motors.

Cable selection for underwater use

Stator rewinding

unit assembling and sealing

Testing of the complete units

unit repair

Specialisation: AC/DC machines

Sensors for machinery and product monitoring.

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Fitting of bearings into housings: pressing, heating

Removal of bearings from shafts (mechanical, hydraulic, heating) and housings (pressing, heating)

Handling and storage of bearings

Methods of lubrication: grease, oil bath, oil circulating system, throw away system, oil mist

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Dimensions of housing and shafts

Bearing damage and remedial action: brinelling, false brinelling, foreign material, corrosion, overload, electric current

Electric rotating machines - condition monitoring.

Routine maintenance and condition monitoring of: bearings, windings, cooling circuits, commutators, sliprings, couplings, pulleys, rotating components

Couplings and pulleys.

Types of couplings, applications

Fitting couplings to shafts, alignment

Types of belts, applications

Fitting of pulleys to shafts, alignment

DC armatures - coil forming and winding.

Armature stripping: tasks, procedures, precautions

Insulation: types, properties, applications, ratings

Forming coils and equalisers, preparing the ends, insulating

Fitting coils to armature core, wedge, connecting leads to commutator and band

Impregnation: precautions, materials, test procedures

Static electrical testing procedures

Sliprings and commutators.

Problems relating to sliprings and commutators

Brush selection

Brush gear servicing

Slipring servicing

Commutator servicing

Submersible motors.

Cable selection for underwater use

Stator rewinding

unit assembling and sealing

Testing of the complete units

unit repair

Category: Electronics (C)

Common

Occupational health and safety implementing and monitoring.

Legislation and Australian Standards: AS1470 – 1986; OHSC:7025 (1994); generic competencies A, B and C; relevant acts (electrical); general duty of care

Policy and program development: assigning accountability; focus on improvement

Consultative processes: OH&S committee; Meetings. and workshops; information gathering

Training and development: provision and type; dissemination of information; cultural considerations; literacy considerations

Hazard identification and assessment: safety audits; workplace inspections; injury and illness records, statistics; complaints and observations; contributing factors to a hazard (exposure, severity, human differences)

Risk assessment and management: hierarchy of control (elimination, substitution, design, mitigation)

Management and improvement: promoting OH&S activities; integration management structures; evaluation of control strategies; evaluation of educational and training programs

Industrial computer systems.

Computer systems overview

PC hardware orientation

DOS commands

DOS set-up commands

Windows operations

Word processors

Spreadsheets

Databases as used for control applications

CAD/vector graphics

Control applications

Specialisation: Communications - broadcast

Modulation techniques.

Multiplexing: time division multiplexing (TDM); frequency division multiplexing (FDM)

Specialised multiplexing: quadrature modulation (QUAM); compatible quadrature multiplexing (CQUAM); FM stereo multiplexing

Digital modulation: sampling theorem, bandwidth, filtering requirements; pulse code modulation (PCM); pulse width modulation (PWM); delta modulation; quantising noise; companding; aliasing

Spread spectrum techniques

Frequency selective amplifiers.

Band pass and band stop circuits; tuned amplifiers - using single L.C. load, calculation of gain; amplifiers using frequency selective feedback, active filters; gain stability; higher order filter circuits; multi stage tuned amplifiers; other filter networks - ceramic resonator, surface acoustic wave (SAW) filter, crystal, mechanical, other types; digital filters

Analogue electronics.

Inverting, non-inverting, voltage follower, transresistance and transconductance operational amplifier circuits

Limitations on power supply, input and voltage and output current

DC non-idealities – input bias current, input offset current, input, offset voltage

Slew rate

Noise calculation and measurement in operational amplifiers

Frequency compensation: gain and phase margin; single-pole, double pole and feedforward compensation

Analysis of single stage small signal BJT/FET amplifiers in the alternative modes of operation (e.g.. C.B; C.E; C.C) in order to determine the D.C. bias conditions and a.c

Determination of the low and high frequency composite gain and phase response of an amplifier

Multistage amplifiers - Coupling techniques and effect on system parameters

Advanced oscillators.

L.O. oscillators using discrete components, colpitts, clapp, hartley, butler, miller (single, multi and overtone operation); variable frequency oscillators; voltage controlled oscillators; synthesised tuning PLL; phase shift; wien bridge; non-sinusoidal - a stable and bistable circuits, 555 integrated circuit, discrete component, crystal, ceramic; buffer amplifiers

Receiver and transmitter circuits.

Receiver block diagrams: principles of dual conversion; DSBFC dual conversion receiver

RF amplifiers: intermodulation; cross modulation; RF amplifier performance

Intermediate frequency (IF) amplifiers: IF amplifier alignment; neutralisation; IF amplifier performance

Demodulation: SSBSC

AGC systems: SSBSC receivers

Phase locked loops (PLL): PLL noise; frequency synthesis using PLLs

Receiver performance criteria: sensitivity test (FM quieting, S/N ratio, SINAD measurements), spurious signal responses; receiver noise figure

NBFM transmitters: operation; tuning and adjustment; testing

Digital transmitters

Personal radio communications.

Spectrum usage; two-way radio; CB radio – 27 MHz, AM, SSB, UHF; repeaters; remote area communications – radio, radphone, selcall, satellite; common faults; installation; servicing; repair; regulations

Cellular broadcast systems.

Brief history of cellular mobile radio - car phone, AMPS, GSM

Need for GSM standard

Cellular radio frequency reuse: ideal hexagonal layout; frequency allocation for omni aerials

Tilting of aerials to allow spill over

Omni and sectorised aerials: base station location; frequency allocation (3 sector aerial)

Block diagram of cellular mobile radio system: functions and placement within the system of - MS - mobile station, BTS - base transceiver station, BSC -base station controller, BSS -base station system, MSC (or MSSC) - mobile services switching centre, HLR - home location register, VLR - visitor location register, AUC - authentication centre, PLMN - public land mobile network, PIN - personal identification number, PUK - personal unblocking key, IMSI - international mobile subscriber identity, TMSI - temporary mobile subscriber identity, SIM - subscriber identity module, TDMA - time division multiple access, EIR - equipment identity register, IMEI - international mobile station equipment identity, OMC - operations and maintenance centre, TRX – transceiver, MSISDN - mobile subscriber ISDN number

HLR, VLR: general concepts, worked example of use

Polling: demonstration of recorded announcements

Roaming: within home location, but to other carriers; within country (same carrier); overseas

Call placement to MS from PLMN

Call placement to PLMN from MS

Electromagnetic radiation: safe levels; safe work practices

TDMA and FDMA concepts

Frequency plan of Cabling Provider Rules GSM network: TX/RX offset; total spectrum allocation and TX/RX channel bandwidth; number of TRX channels per carrier; modulation method used; guard bands

Handovers (general concepts via AMPS network)

Mobile assisted handovers (c.f. AMPS)

GSM radio interface frame: total time per frame; general content; use of guard times; total bit rate and effective data rates; frequency hopping

Interleaving (brief concept)

Forward error correction (brief concept)

Encryption (brief concept)

Linear predictive coding (brief concept)

Line-of-sight: radio propagation concepts revised; multiple paths (rayleigh fading)

Demonstrate effect of signal loss with Faraday cage or attenuator

Measure output power in GSM MS (digital phone)

Demonstrate power level changes in MS

SIM card features

Basic phone operation: SIM card changing; PIN, PUK password changing; memory dialling (storing); toll restriction

Low earth orbit satellite concepts

Cellular satellite frequency bands: mobilesat (OPTUS); iridium (Motorola); inmarsat

DCS 1800 and CT2 (brief mention)

Comparison of AMPS to GSM: frequency spectrum; total number of channels; modulation; bandwidth per user channel; interference alignment cell size radius

Specialisation: Communications - broadcast station operations

Modulation techniques and circuits.

Multiplexing: time division multiplexing (TDM); frequency division multiplexing (FDM)

Specialised multiplexing: quadrature modulation (QUAM); compatible quadrature multiplexing (CQUAM); FM stereo multiplexing

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NBFM Transmitters: operation; tuning and adjustment; testing

Digital transmitters

Broadcast transmitters.

RF propagation: frequency spectrum; em waves; wave attenuation and absorption; ground and space wave propagation.

Satellite communications

Channel separation

Broadcast antennae: AM and FM; range; feeders; matching; change-over switch

Broadcast transmitters: radio; TV; controls; power supplies; output stages; remote control; standby

Digital broadcasting

Broadcast signal distribution.

Video distribution amplifier

Audio distribution amplifier

Routing switcher

Video patch panel

Audio jackfield

Repeaters

Audio signal processing.

Dynamic range

Non linear effects; compression; gating

Sound processing amplifier

Equalisers

Audio mixer

Stereo sound

Subjective loudness

Digital audio

Audio signal monitoring.

Listening environment

Loud speaker systems

Power amplifiers

Stereo image

Surround sound

Foldback and interrupted foldback

Audio signal measurements.

The audio signal; mic level; line level; standard level

Balanced and unbalanced circuits

Impedance matching

Decibels; dB; dBm; dBo; dBu

VU meter

Noise

Video signal processing.

Processing amplifier

Frequency response

Non linear effects

Frame synchroniser

Vision mixer

Video effects; keyers

Component video

Digital video

Video monitoring systems.

Picture monitors grade 1 and grade 3

Colour grading and grey scale

Off air reception

Waveform analysis

Viewing conditions

Video signal measurements.

Video signal; standard level; impedance matching

Chrominance and Luminance

Sync and blanking

Burst

Vertical interval

Waveform monitor

Vector monitor

Interval test signals

Noise

Digital broadcasting.

RF digital modulation schemes: n-QAM; QPSK; COFDM; CDMA; CDPD

Baseband signal processing: noise; BER; FER

Digital radio systems

Digital TV systems

Studio control systems.

Radio control systems

Studio talkback

Station talkback

Radio talkback; VHF; UHF

TV control systems

Specialisation: Communications - microwave

Modulation techniques.

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NBFM transmitters: operation; tuning and adjustment; testing

Digital transmitters

Waveguides and antenna devices.

Safety: RF leakage detection; RF leakage measurement; radio frequency hazards (RADHAZ) markings and precautions

Equipment: microwave test sets (network analysers); PP analysers; RF probes (nada probes); power meters; attenuators; directional couplers; detectors/crystals; build in test equipment (BITE); RF head (injection devices); special purpose RF test sets

Waveguides: frequencies; handling; e and h bends; propagation modes; couplings – RF type; rigid and flexible; rotating joints/bronski couplers (multiple waveguide rotating joints); circulators; dummy loads – air and water cooled; pressurisation and drying (including air, SF6, N2 and other inert gases); teflon; cleaning; RF gaskets and spacers; ferrites – properties and RF applications

Antenna devices: transmit/receive cells; rotary couplings and joints; feed horns; dipoles; reflectors; diplexers; duplexers; end feed slotted array; squint angle correction; squint angle alignment; squint angle compensation

Directional antenna devices: comparators; mechanical scanning (include conical scan on receive only); directional antennae, controllers and feed arrangements; stabilisation – stable elements (mechanical and optical), rate gyros; tracking loops – range and angle; operating modes – designation, search, acquisition and track; search patterns; advanced doppler/pulse doppler; monopulse tracking; RF to optical alignment; FFT and CFAR filters; software control; software elimination of blind/ambiguous ranges and velocities

Microwave devices.

Waveguide propagation

Cavity devices: couplers – T, hybrid-T, directional, diplexers, phase shifters, power splitters, circulators, horns

Stripline structures

Ferrite and dielectric devices

Thermionic microwave devices: klystrons – magnetrons, cross field amplifiers (CFA), travelling wave tubes (TWT)

Solid state microwave devices: diodes – tunnel, pin, gunn, TRAPPATT, BARRATT; stimulated emission devices – MASER; parametric amplifiers - Josephson devices (explain need for circulators with the above).

Matching systems: single stub match using Smith chart - determine physical length of matching network

Specialisation: Communications - satellite

Modulation techniques.

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Digital applications.

Boolean Algebra: generation of Boolean expressions and truth table for verbal logic descriptions and logic circuit schematics; simplification of Boolean expressions using Boolean algebra; complementation of a Boolean expression – De Morgan's laws

Karnaugh maps: construction of K maps for given functions of up to 4 variables; use of K maps to derive the minimal and into or (S.O.P) form implementation for a given expression; conversion of and or (S.O.P) form into all NAND gate implementation; nature of "don't cares" and how they can be used to advantage by a designer

Propagation delays: definition - t_{plh} and t_{phl}; affect on operation of discrete devices – simple combinational circuits and ripple counters; set-up and hold times - definition and consequences of

Oscillators: schmitt-trigger action - V_{T+}, and V_{T-}, hysteresis; waveform smoothing; schmitt trigger oscillator - factors determining frequency; two gate R-C oscillator; two gate crystal oscillator; an integrated, crystal controlled, oscillator/frequency-divider chip - e.g. 4060

Monostables: basic operation - trigger conditions and pulse-width determination; response of non-re-triggerable vs re-triggerable one shots; duty cycle limitation; simple applications of one shots e.g. pulse stretching and delaying, switch debouncing/key pressed strobe and missing pulse detector

Asynchronous counters: characteristics of common i.c "ripple" counters e.g. 7490 family; changing the counter modulus - frequency division and output duty cycle; cascading asynchronous counters to extend modulus; disadvantages - glitches and clocking frequency limitations

Synchronous counters: basic internal structure of a presettable synchronous I.C. counter; distinction between synchronous and asynchronous control inputs and their relative affects - e.g. load enable and clear inputs; use of counter (clock) enable inputs and terminal count outputs; analysis of a synchronous I.C. counter circuit (maximum of 2 counters) to determine count-cycle - modulus, frequency and form of output waveform

Memory: classification – RAM and ROM (historic), volatile and non-volatile memory; memory terminology - array structure, memory size data word, address; data - address and control buses; read and write modes of operation - basis steps in; memory timing:- access time and write (cycle) time; RAM devices - SRAM and DRAM - speed, density refresh and addressing differences; ROM devices - nature of masked ROM, PROM, EPROM, E^2ROM and NVRAM

Digital circuit applications: memory decoding - expansion of word size and address space; development of a memory map from a given memory decoding system (no images); control waveform generator using a MUX and counter; use of a ROM as a code converter - look-up table and character generator (ASCII code to dot pattern); use of a BDC to 7 segment decoder/latch to drive either a common anode or common cathode led display; display multiplexing - time sharing a single decoder between two display chips

Advanced analogue electronics.

Applications of power; amplifiers and definitions

Additional considerations related to large signal operations

Class A, B, AB, C and D power amplifiers

Distortion/feedback

Heat transfer and sinking

Data sheet usage related to typical characteristics of fully integrated power amplifiers

Specification and testing of power amplifiers

VCR advanced.

Chrominance processing principles: down converted colour recording. principles; specifications; colour cross talk and the need for phase rotation; functional block diagram in record mode; functional block diagram in playback mode; practical circuits; alignment of practical circuits

System control principles: system control requirements; serial and parallel data transmission in VCRs; input devices; functional block diagram; operating principles; display and timer operation; practical circuits; methods of testing practical system control circuits; variable speed and trick mode operation; and principles of operation during pause modes; principles of operation during, variable speed playback modes; application of variable speed and trick modes to servo systems

Advanced VCR techniques: practical circuit operation; Hi Fi systems; digital tracking systems; digital picture storage; digital still pictures; bar code systems; multi-standard VCR

VCR fault-finding.

Mechanical faults

Components: identification; location

VCR test equipment: waveform measurement; voltage measurement

Safe working practice

VCR faults: typical faults; analysis of symptoms; repairs; luminance processing faults; chrominance processing faults; system control faults; servo system faults; timer and display faults; power supply faults; sound faults; RF faults

Electronic signals and systems.

Electronic test signals: relation to instrumentation – audio, video, radio, data, process instrumentation, industrial control systems; electromagnetic spectrum - DC references, sine wave, rectangular wave, exponential rise and fall, sawtooth, triangular, staircase, noise sources, modulated sources, swept sources; sine waves - harmonic distortion, multiplication of different frequencies; analysers - non-distortion analysers, spectrum analysers; waveshapes and spectra of common signals

Deducing outputs from inputs: basic signal processing functions and subsystems – analogue, digital; deductions using – amplifiers, attenuators, transducers, buffers, limiters, rectifiers, comparators with hysteresis, comparators without hysteresis, DC shift integrator, differentiator, tuned circuits, filters (LP, HP, BP, BS), adders, mixers, multipliers, modulators, detectors, vcos, phase locked loops; digit functions – bits, bytes, words, codes, gates, flip-flops, clocks, counters, registers, memories, DACs, ADCs, samplers, sample and hold, keyboards, displays, modems, codes

Interpreting and drawing diagrams: functional diagrams; block diagrams; waveform diagrams; spectra diagrams; predicting signal waveform and spectra; circuit schematics; system written specifications; catalogues; handbooks; application notes

Electronic equipment: measuring instruments – multimeter, oscilloscope, signal generators, spectrum analyser; communications systems - modulation-demodulation, AM, DSCSC, SSB, FM, PM, QAM; transmission - noise interference, signal distortion, reflections/attenuations; shannon model – source, channel, destination, noise, bandwidth, information rates; radio - receivers and transmitters, superhets, AGC, phase locked loops; television – imaging, scanning, resolution, synchronising, luminance, chrominance

Advanced professional audio techniques.

Advanced audio systems interfaces; radio microphones; multi channel FM receiving systems; special sound effects; advanced mixing desks; new technologies; diagnosis and fault-finding techniques

High power speaker arrays and cables.

Cable: types; uses; placement; de-rating

Connectors – types; uses

Speaker arrays: selection; phasing; power; mounting

Frequency selective amplifiers.

Band pass and band stop circuits; tuned amplifiers - using single L.C. load, calculation of gain; amplifiers using frequency selective feedback, active filters; gain stability; higher order filter circuits; multi stage tuned amplifiers; other filter networks - ceramic resonator, surface acoustic wave (SAW) filter, crystal, mechanical, other types; digital filters

Specialisation: Entertainment - TV

Television and VCR installation.

Television and VCR installation: tuning televisions; adjustment of customer and technician controls

TV system faults: the switch on process; generic fault-finding procedures and techniques; location of faults to functional block; location of functional block on typical schematics; visual inspection; simple repairs; safety procedures when working with televisions

Safety procedures

Display devices.

Picture tubes: types; construction; operational principles; adjustments; drive voltages and waveforms; safety; disposal; EHT voltage measurement; tube rejuvenation and testing

LCD displays: types and operation; construction; scanning techniques; drive voltages and waveforms

Other display devices: plasma; light emitting plastics

Special display types: aspect ratios; HDTV

Projection techniques: front projection; rear projection; 3 tube; single light source; LCD projectors

TV micro controllers.

Micro controller: block diagram; I/O; typical faults; fault-finding

Remote controls: block diagram of transmitter and receiver; service; typical faults; fault-finding

On screen display: circuitry; adjustments; fault-finding

Field storage systems: circuitry; picture-in picture; typical faults

Teletext: operation; circuitry; typical faults

Television servicing practices.

Components and circuits: components and device functions; circuit functions;

interpretation of schematics

Fault-finding: techniques and strategies; analysis of symptoms; locations of faults to component level; repair

Test equipment: TV test signal generators; waveform and voltage measurement; specialised TV test equipment

Safety procedures

Introduction to camcorders.

Overview: camera block diagram; camcorder block diagram (basic); principles of operation

Standards and tape format: VHS; VHS compact; 8 mm; HI 8; digital (basic)

Pick up tubes and charge coupled devices: newvicon (principles of operation); charge coupled devices (principles of operation)

Lenses and light values: basic lens action; automatic focus (systems and devices); light measurement (light and colour temperature); zoom (optical and electronic)

Adjustment of tube type cameras (monochrome): beam current; focus; beam alignment; video adjustments

Colour separation: early systems; dichroic mirrors; single tube colour stripe filter; colour correction filters

Signal processing (single tube colour camera): static shading correction; dynamic shading correction; white balance (manual and automatic); R-Y/B-Y encoding

Signal processing. (CCD colour camera): CCD charge level; high speed shutter; R-Y/B-Y encoding; digital (basic)

Mechanical overview (basic): video head types – VHS, VHS-C; video 8mm; special tools and equipment

Camcorders power supplies and battery chargers: battery charging requirements; battery types

Digital versatile disc (video) principles.

DVD overview: disc drive unit; disc type and capacity; standard functions of a DVD player

Compression systems: principles of MPEG digital video processing; MPEG standards; reasons for data compression; MPEG2 profiles; hybrid encoding with three technologies - spatial axis compression-discrete cosine transform, time base competition, predictive encoding motion competition, image compression by predictive encoding for predicting motion from neighbouring frames; time base competition; sequence; bidirectional prediction; I,P and B picture sequence; Hoffman encoding - 4:2:0 encoding; data compression: CD ROM(MPEG 1 and 4) – DVD video, DVD ROM; DVD video image quality – variable transfer rate – high image recording efficiency; DVD video sound – 5.1 channel surround sound; Dolby AC3 encoding system, linear PCM

Other DVD features: multiple language – feature, dubbing, subtitles; stream and packet transmission - stream -data flow, packet multiplex transmission system; DVD video interactive features - title menu, DVD menu, multi story, multi angle, multiple aspect ratio, seamless playback, parental control

DVD video copyright protection system: reproduction control - regional codes; copy protection

DVD video software production: disc manufacture (overview)

DVD ROM and other standards: block diagram of a DVD player; RF block; data processor; decryption; buffer control; video decoder; letter box conversion; video equaliser and noise reduction; sub picture; PAL encoder; on screen display; audio detector; audio decoder; clock generation system control; interface control; laser operation principles

Service adjustments: set up, connection and operation of a DVD player

MATV – small commercial antenna distribution systems.

MATV distribution systems: wide band distribution amplifiers; single channel distribution amplifiers; directional couplers; trunked tee feed distribution system; signal equalisers; outlet isolation

Channelised distribution systems: single channel amplifiers; high level launch amplifiers; signal equalisers

Signal reticulation: VCR signals; signal combiners

System design: design factors; component specifications

Fault-finding: measurement; typical faults; symptoms

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TV system faults: the switch on process; generic fault-finding procedures and techniques; location of faults to functional block; location of functional block on typical schematics; visual inspection; simple repairs; safety procedures when working with televisions

Safety procedures

VCR basic principles.

VCR installation: typical installation methods; cables and connectors; VCR operation; VCR specification

Magnetic recording techniques: magnetic recording principles; specifications, limitations and terminology; audio recording principles; block diagram of simple audio recording process

Helical scanning principles: need for helical scanning; head and tape speeds; two head recording; zero guard band principles; azimuth recording; requirement for head switching; head drum assembly; VHS tape format and specifications

VHS mechanical systems: tools and equipment required for mechanical service; basic mechanical system layout; tape transport system; mechanical maintenance; mechanical adjustments; mechanical component replacement; safety

FM recording principles: review of FM principles; requirements for FM recording; basic block diagram of luminance processing

VHS electronic system overview: block diagram; E-E modes; system and servo control; colour under-recording

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Teletext: operation; circuitry; typical faults

VCR advanced.

Chrominance processing principles: down converted colour recording. principles; specifications; colour cross talk and the need for phase rotation; functional block diagram in record mode; functional block diagram in playback mode; practical circuits; alignment of practical circuits

System control principles: system control requirements; serial and parallel data transmission in VCRs; input devices; functional block diagram; operating principles; display and timer operation; practical circuits; methods of testing practical system control circuits; variable speed and trick mode operation; and principles of operation during pause modes; principles of operation during, variable speed playback modes; application of variable speed and trick modes to servo systems

Advanced VCR techniques: practical circuit operation; Hi Fi systems; digital tracking systems; digital picture storage; digital still pictures; bar code systems; multi-standard VCR

VCR fault-finding.

Mechanical faults

Components: identification; location

VCR test equipment: waveform measurement; voltage measurement

Safe working practice

VCR faults: typical faults; analysis of symptoms; repairs; luminance processing faults; chrominance processing faults; system control faults; servo system faults; timer and display faults; power supply faults; sound faults; RF faults

Introduction to camcorders.

Overview: camera block diagram; camcorder block diagram (basic); principles of operation

Standards and tape format: VHS; VHS compact; 8 mm; HI 8; digital (basic)

Pick up tubes and charge coupled devices: newvicon (principles of operation); charge coupled devices (principles of operation)

Lenses and light values: basic lens action; automatic focus (systems and devices); light measurement (light and colour temperature); zoom (optical and electronic)

Adjustment of tube type cameras (monochrome): beam current; focus; beam alignment; video adjustments

Colour separation: early systems; dichroic mirrors; single tube colour stripe filter; colour correction filters

Signal processing (single tube colour camera): static shading correction; dynamic shading correction; white balance (manual and automatic); R-Y/B-Y encoding

Signal processing. (CCD colour camera): CCD charge level; high speed shutter; R-Y/B-Y encoding; digital (basic)

Mechanical overview (basic): video head types – VHS, VHS-C; video 8mm; special tools and equipment

Camcorders power supplies and battery chargers: battery charging requirements; battery types

Specialisation: Scanning - radar

Analogue electronics.

Inverting, non-inverting, voltage follower, transresistance and transconductance operational amplifier circuits

Limitations on power supply, input and voltage and output current

DC non-idealities – input bias current, input offset current, input, offset voltage

Slew rate

Noise calculation and measurement in operational amplifiers

Frequency compensation: gain and phase margin; single-pole, double pole and feedforward compensation

Analysis of single stage small signal BJT/FET amplifiers in the alternative modes of operation (e.g.. C.B; C.E; C.C) in order to determine the D.C. bias conditions and a.c

Determination of the low and high frequency composite gain and phase response of an amplifier

Multistage amplifiers - coupling techniques and effect on system parameters

Digital applications.

Boolean Algebra: generation of Boolean expressions and truth table for verbal logic descriptions and logic circuit schematics; simplification of Boolean expressions using Boolean algebra; complementation of a Boolean expression – De Morgan's laws

Karnaugh maps: construction of K maps for given functions of up to 4 variables; use of K maps to derive the minimal and into or (S.O.P) form implementation for a given expression; conversion of and or (S.O.P) form into all NAND gate implementation; nature of “don’t cares” and how they can be used to advantage by a designer

Propagation delays: definition - t_{plh} and t_{phl}; affect on operation of discrete devices – simple combinational circuits and ripple counters; set-up and hold times - definition and consequences of

Oscillators: schmitt-trigger action - V_{T+}, and V_{T-}, hysteresis; waveform smoothing; schmitt trigger oscillator - factors determining frequency; two gate R-C oscillator; two gate crystal oscillator; an integrated, crystal controlled, oscillator/frequency-divider chip - e.g. 4060

Monostables: basic operation - trigger conditions and pulse-width determination; response of non-re-triggerable vs re-triggerable one shots; duty cycle limitation; simple applications of one shots e.g. pulse stretching and delaying, switch debouncing/key pressed strobe and missing pulse detector

Asynchronous counters: characteristics of common i.c "ripple" counters e.g. 7490 family; changing the counter modulus - frequency division and output duty cycle; cascading asynchronous counters to extend modulus; disadvantages - glitches and clocking frequency limitations

Synchronous counters: basic internal structure of a presettable synchronous I.C. counter; distinction between synchronous and asynchronous control inputs and their relative affects - e.g. load enable and clear inputs; use of counter (clock) enable inputs and terminal count outputs; analysis of a synchronous I.C. counter circuit (maximum of 2 counters) to determine count-cycle - modulus, frequency and form of output waveform

Memory: classification – RAM and ROM (historic), volatile and non-volatile memory; memory terminology - array structure, memory size data word, address; data - address and control buses; read and write modes of operation - basis steps in; memory timing - access time and write (cycle) time; RAM devices - SRAM and DRAM - speed, density refresh and addressing differences; ROM devices - nature of masked ROM, PROM, EPROM, E^2ROM and NVRAM

Digital circuit applications: memory decoding - expansion of word size and address space; development of a memory map from a given memory decoding system (no images); control waveform generator using a MUX and counter; use of a ROM as a code converter - look-up table and character generator (ASCII code to dot pattern); use of a BDC to 7 segment decoder/latch to drive either a common anode or common cathode led display; display multiplexing - time sharing a single decoder between two display chips

Waveguides and antenna devices.

Safety: RF leakage detection; RF leakage measurement; radio frequency hazards (RADHAZ) markings and precautions

Equipment: microwave test sets (network analysers); PP analysers; RF probes (nada probes); power meters; attenuators; directional couplers; detectors/crystals; build in test equipment (BITE); RF head (injection devices); special purpose RF test sets

Waveguides: frequencies; handling; e and h bends; propagation modes; couplings – RF type; rigid and flexible; rotating joints/bronski couplers (multiple waveguide rotating joints); circulators; dummy loads – air and water cooled; pressurisation and drying (including air, SF6, N2 and other inert gases); teflon; cleaning; RF gaskets and spacers; ferrites – properties and RF applications

Antenna devices: transmit/receive cells; rotary couplings and joints; feed horns; dipoles; reflectors; diplexers; duplexers; end feed slotted array; squint angle correction; squint angle alignment; squint angle compensation

Directional antenna devices: comparators; mechanical scanning (include conical scan on receive only); directional antennae, controllers and feed arrangements; stabilisation – stable elements (mechanical and optical), rate gyros; tracking loops – range and angle; operating modes – designation, search, acquisition and track; search patterns; advanced doppler/pulse doppler; monopulse tracking; RF to optical alignment; FFT and CFAR filters; software control; software elimination of blind/ambiguous ranges and velocities

Advanced test equipment.

Advanced test equipment: types; uses

Advanced CROs: block diagram; operating principles; triggering sources (chan ½ ext, V mode, starts after delay, etc); triggering coupling (AC, DC, video, LF reject, HF reject, etc); triggering modes (auto, triggering, normal, single); dual trace (chop/alternated/add); quad trace; delayed time base (A, Alt, A Int B, B delayed, X-Y)

CRO probes: compensated; voltage divider (1:1. 10:1, 100:1); high-voltage; active/passive; terminated (HF, audio, etc); current

Storage oscilloscopes: analogue; digital

Signal generators: sinewave; pulse (variable mark/space); sweep

Audio and mini volt meters

Noise and distortion meters

Counter timers/frequency meters

Chart recorders

A/D-D/A converters

Logic pulsers

Logic probes

Secondary radar.

Safety; principles of operation; transponders; decoding; air traffic control; modes – 1, 2, 3/A, 4, C; standards; slaved to primary; tactical air navigation (TACAN); instrument landing systems (ILS); beacons; frequencies; emergency codes

High voltage power supplies.

Safety: safety symbols (high voltages, ionising radiation hazards, non-ionising radiation hazards); signs (high voltages, ionising radiation hazards, non-ionising radiation hazards);· personnel safety in the vicinity of radiation hazards; personnel safety in the vicinity of high voltage sources; high voltage arcing; insulation breakdown; carbon tracking; ionisation; measurement of high and extra high voltages

Test equipment: applications (electrometers, high voltage probes, ionisation testers, insulation testers, discharge probes, DC and AC voltmeters, millivoltmeters, microvoltmeters, DC and AC ampmeters, milliampmeters, microampmeters, scaling networks, corona, spark gaps, creepage; tracking); calibration; errors of measurement and their effects;· charts and graphs used in assessing equipment and materials (dialectric characteristics, insulation characteristics, air ionisation gaps)

High voltage sources and components: voltage doublers,· voltage triplers and higher voltage multipliers;· Van Der Graaff generators;· cockcroft walton generators;· pulse transformers;· pulse forming networks;· modulators;· travelling wave linear accelerator;· cyclic accelerator;· gas tubes;· hydrogen thyratrons;· diodes/solid state thyratrons;· capacitors;· transformers;· bleed resistors

Routine maintenance procedures: schedules;· safety precautions; fault finding

EMI/EMC: causes; effects; standards

Category: Instrumentation (D)

Common

Occupational health and safety implementing and monitoring.

Legislation and Australian Standards: AS1470 – 1986; OHSC:7025 (1994); generic competencies A, B and C; relevant acts (electrical); general duty of care

Policy and program development: assigning accountability; focus on improvement

Consultative processes: OH&S committee; meetings and workshops; information gathering

Training and development: provision and type; dissemination of information; cultural considerations; literacy considerations

Hazard identification and assessment: safety audits; workplace inspections; injury and illness records, statistics; complaints and observations; contributing factors to a hazard (exposure, severity, human differences)

Risk assessment and management: hierarchy of control (elimination, substitution, design, mitigation)

Management and improvement: promoting OH&S activities; integration management structures; evaluation of control strategies; evaluation of educational and training programs

Analogue electronics.

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Slew rate

Noise calculation and measurement in operational amplifiers

Frequency compensation: gain and phase margin; single-pole, double pole and feedforward compensation

Instrument field practice.

Introduction: the roll of instrumentation in industry; application of instrumentation; managerial justification; trends in control of processes; responsibilities of instrument department

Types of instrument maintenance (breakdown, preventative and performance)

Personal safety

Hazardous atmospheres

Wiring (including intrinsic safety)

Enclosures and barriers

Mounting of instruments

Tubing and piping

Calibration and documentation

Industrial computer systems.

Computer systems overview

PC hardware orientation

DOS commands

DOS set-up commands

Windows operations

Word processors

Spreadsheets

Databases as used for control applications

CAD/vector graphics

Control applications

Control concepts.

Advantages of control

Measurement terminology

Dimensional calculations

Basic transducer principles and physical variables

Control terminology

Type of controllers

Process characteristics

Controller principles

Control systems

Power control devices.

Need for power control typical applications

Power control methods: switched control; rheostatic control; voltage control; simmerstatic control; thyristor control

Advantages and benefits of thyristor power control: efficiency; reliability; precision; overall cost

Silicon controlled rectifiers: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation; cooling and protection; testing for serviceability; applications

Gate turn off (GTO) thyristors: construction and symbol; basic operating principles; characteristics; voltage ratings – PRV, forward blocking voltage, dv/dt rating; current ratings – average forward current, latching and holding currents, di/dt rating; triggering requirements – gate pulse characteristics; commutation – gate turn off requirements; applications

BJT, IGBTs: construction and symbols; basic operating principles; characteristics; cut off; saturation and amplification

Triacs: construction and symbol; basic operating principles; characteristics; voltage ratings – blocking voltage, dv/dt rating; current ratings – rms current, latching and holding currents, di/dt rating; triggering requirements – modes of triggering and sensitivity; commutation; cooling and protection; testing for serviceability; applications

Unijunction transistors (UJT): construction and symbol; operating principles; intrinsic stand-off ratio and peak point voltage; revision of R.C constants; UJT relaxation oscillator circuit; UJT oscillator circuit operation – frequency, output pulse characteristic, waveforms

Programmable unijunction transistors (PUT): construction and symbol; operating principles; peak point voltage; programmable stand-off ratio; PUT relaxation oscillator circuit; PUT oscillator circuit operation – frequency, output pulse characteristic, waveforms

Diacs: construction and symbol; operating principles; breakover voltage – symmetrical and asymmetric diacs; diac trigger circuit; diac trigger circuit operation – frequency, output pulse characteristic, waveforms

Phase shift control: definition; triggering and conduction angles; relationship between output voltage and conduction angle; problems associated with phase shift control

Single phase half wave controlled rectifier: rectifier operation; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations

Single phase full wave controlled rectifier: half controlled bridge – circuit configuration, including trigger circuits; circuit operation and waveforms – resistive loads only; load voltage determination – calculation; applications and limitations; comparison with single phase half wave controlled rectifier

Single phase A.C. voltage control: half and full control circuits; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; use of triacs or inverse parallel SCR's; 'snap on' effect of

phase control circuits – reduction of the snap on effect; load voltage determination – form circuit characteristic; applications and limitations

Single phase zero voltage switching (ZVS): operating principles; circuit configuration – including trigger circuits; circuit operation and waveforms – resistive loads only; relationship between load power and conduction time; solid state relays types and ratings; applications and limitations

Fault-finding procedures: typical faults – power and trigger circuits; characteristics displayed by common faults; comparison of test data with expected data (voltage/current waveforms); location and replacement of faulty components

Control interfacing.

Introduction to the integrated control system: basic make-up of an integrated control system; hierarchy of an integrated control system; the five levels in a typical integrated control system

Field signals: standard control signals; transmitters (four wire, two wire and isolators)

Serial data communications: basic principles; simplex/duplex; asynchronous and synchronous; basic standards (RS232, RS423, RS422 and RS485)

Local area networks (level 1 only): OS1 model; topology – ring, star and bus

Protocols: basic principles; map, top, modbus, profibus etc

Industrial automation software: basic principles (drivers etc); examples (wizcon, citect, dmacs, factory link, process window, control view, genesis etc)

Programmable controllers - advanced procedures.

Installation procedures and precautions: personal safety; AS3000 and AS1543 implications; interpret manufacturer's installation specifications; basic commissioning procedures; environmental limitations/protection; physical positioning of CPU and I/O racks; routing signal/power cables; signal/power earthing requirements; selection of sink vs source modules; selection of relay vs transistor vs Triac modules

Advanced discrete programming: derived timers (off delay, self resetting, constant cycle); reversible counters; cascading timers; cascading counters; combining timers and counters; internal relays/flags/markers; latching relays (set/reset); jump instructions; master control instruction; bit shift registers; scan time considerations; one shot; retentive (power fail) functions; simple step sequence instructions

External program storage devices: IC storage (ROM, EPROM, E^2PROM); cassette tape; computer (hard/floppy) disks; save and retrieve a program to/from an external storage medium

Software design: use software to develop/edit a process control solution; use software to monitor the status of a process; use software to document a program; produce a hard copy (print-out) of a fully documented program

Basic diagnostics: use the force instruction to aid in fault-finding; use inbuilt hardware/software diagnostics to determine errors; using error codes locate and rectify a fault

Specialisation: Control

Advanced PLCs.

Medium to high level PLC hardware and software: hardware configuration; addressing; memory map; programming instruction syntax; file manipulation; documentation; saving/restoring programs

Number systems and codes: common number formats (binary, octal, integer, hexadecimal); conversions between formats; codes (BCD, grey, ASCII)

Diagnostics: flags/status words (file); fault locations; scan considerations (fixed, variable, immediate update)

Data manipulation (word): binary word structure; single and double works; word devices; arithmetic instructions; word logical instructions; conversions (BCD to binary, binary to BCD); indirect addressing (image register to word, word to IR, word to word, word to table, table to table); word shift registers (LIFO, FIFO); masking; bit manipulation (bit set, bit clear, bit test); entering data constants; multiplexing

Analogue I/O: common signal types; module resolution; scaling; unscaling; signal offset

Sequencers/drum controllers

Specialisation: Measurement

Advanced PLCs.

Medium to high level PLC hardware and software: hardware configuration; addressing; memory map; programming instruction syntax; file manipulation; documentation; saving/restoring programs

Number systems and codes: common number formats (binary, octal, integer, hexadecimal); conversions between formats; codes (BCD, grey, ASCII)

Diagnostics: flags/status words (file); fault locations; scan considerations (fixed, variable, immediate update)

Data manipulation (word): binary word structure; single and double works; word devices; arithmetic instructions; word logical instructions; conversions (BCD to binary, binary to BCD); indirect addressing (image register to word, word to IR, word to word, word to table, table to table); word shift registers (LIFO, FIFO); masking; bit manipulation (bit set, bit clear, bit test); entering data constants; multiplexing

Analogue I/O: common signal types; module resolution; scaling; unscaling; signal offset

Sequencers/drum controllers

Category: Refrigeration and air conditioning (E)

Common

Occupational health and safety implementing and monitoring.

Legislation and Australian Standards: AS1470 – 1986; OHSC:7025 (1994); generic competencies A, B and C; relevant acts (electrical); general duty of care

Policy and program development: assigning accountability; focus on improvement

Consultative processes: OH&S committee; Meetings. and workshops; information gathering

Training and development: provision and type; dissemination of information; cultural considerations; literacy considerations

Hazard identification and assessment: safety audits; workplace inspections; injury and illness records, statistics; complaints and observations; contributing factors to a hazard (exposure, severity, human differences)

Risk assessment and management: hierarchy of control (elimination, substitution, design, mitigation)

Management and improvement: promoting OH&S activities; integration management structures; evaluation of control strategies; evaluation of educational and training programs

Preventive maintenance.

Maintenance systems: maintenance terminology; preventive maintenance; predictive maintenance; corrective maintenance

Plant, machinery and equipment audit: identify critical equipment/components; assess plant performance and history; identify labour and material requirements

Creation of a preventive maintenance program: writing preventive maintenance tasks; scheduling preventive maintenance tasks; recording of information

Review of preventive maintenance program: collection of data; comparison of present information with prior history

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HVAC control systems.

Control fundamentals: control terminology; HVAC system characteristics; control system characteristics; control system components

Types of control equipment: pneumatic (terminology, symbols, pneumatic control systems, air supply equipment, thermostats, controllers, actuators, relays – switches); electrical (classification of circuits, two position control, floating control, sensors, controllers, flow control devices); electronic (operating principles, sensors, controllers, control systems)

DDC systems: terminology; controllers; controller software; basic controller programming, applications

Control systems applications: air handling system controls - ventilation, heating, humidification, cooling, dehumidification, heating; building airflow system control; airflow control - singles and multi–zones; chiller boiler and distribution system control - chilled water, boiler, distribution systems

Supervisory control systems: systems function; configurations; introduction building management

Specialisation: Control systems

HVAC air systems.

Air distribution principles: static and velocity pressures; measurements; terminology; laminar and turbulent fluid flows; system performance profiles

Air system design: method - velocity reduction, equal friction, static regain, computer aided; selection of duct fitting and diffusion fittings

Fans: types; fan laws; fan curves; installation criteria; applied system curves

Ventilation, dust extraction: system configuration; Australian standards; AS – 1668 Part 1 and 2; componentry; system selection; building regulations

Air systems: dual and single duct constant volume; variable volume; induction units; multi-zone

Applied psychrometrics.

Fundamentals and terms: sensible lie at factor - conditioned space, grand total; quantity of air; effective surface temperature; bypass factor

Coil characteristics: processes - sensible cooling, cooling, dehumidification, sensible heating

Spray processes: saturation efficiency; processes - adiabatic/evaporative cooling, cooling and humidification, sensible cooling, cooling and/or humidification

System analysis: partial load; reheat control; bypass control; volume control

Management of indoor air quality.

Indoor air quality factors: interactive nature of pollutants; comfort criteria; source of odours; pathway form source to occupants; occupant activities; impact on productivity

Cause of IAQ problems: moisture; mould and mildew; bacterial growths; asbestos and other particulate; volatile chemicals produced in the building; chemical products

HVAC systems: types of HVAC systems; system components; duct cleaning; system commissioning; operation of system; damper adjustment

Measurements: common parameters to measure; measurement devices available; instrument calibration; analysing and interpreting results; laboratory tests; standards

Resolving IAQ problems: conducting IAQ investigations; the walk-through; building history; HVAC system information; occupant interviews; troubleshooting

IAQ management: building IAQ profile; location of potential IAQ problems; procedures to control IAQ; communication; response to complaints; equipment preventive maintenance; chemical inventory

Energy management systems for commercial refrigeration.

Functions of a commercial refrigeration E.M.S.: control function; inputs; outputs; communications; graphing; supervising; data logging; scheduling; alarms; power consumption

E.M.S. control components: pressure sensors; temperature sensors; timeclocks; humidity sensors; liquid level sensors; leak detector sensor

Operating parameters of components and sensors for: pressure; temperature; time; humidity; liquid level; leak detection

Installation requirements and considerations for: controller(s); refrigerant leak detectors; systems pressure transducers, temperature sensors

System design and applications: control components selection

Programming of a control system: display terminal and keypad functions; calibration of sensors; changing original settings; application specific programming

Refrigeration/HVAC direct digital controls.

Computer based control fundamentals: definitions; principles

Controller configuration: equipment controllers; zone level controllers; system level controllers

Controller software: operating software; application software

Controller programming: system diagrams; control diagrams; configuration; programming; initialisation; EMS, BMS

Sensors and actuators

Applications: refrigeration systems; HVAC systems; logic analysis; energy management; energy conservation; asset management; life cycle

Refrigeration/HVAC electronic controls.

Control fundamentals: electronic control terminology; definitions

Electronic control basics: voltage supplies; analogue control; controller basics; inputs and outputs

Controllers: variable such as temperature; step; enthalpy; compensation; time proportional

Sensors: temperature; humidity; enthalpy; pressure; velocity

Actuators: water valves; dampers; relays

Control systems: refrigeration systems; ventilation systems; multi-zone A/C systems; variable air volume A/C systems; face and by-pass system; economiser system; chilled water systems; hot water systems

Refrigeration/HVAC pneumatic controls.

Control fundamentals: electronic control terminology; definitions

Control basics: air supply; pilot bleed system; signal amplifier; sensing elements; relays and switches

Air supply system: air drying methods; pressure regulating valves; pressure reducing valves

System controllers: thermostats; sensors; actuators; dampers

System control configurations: sequence control; limit control; changeover control; compensated control; recycling control; pneumatic – electric control

Control systems: refrigeration systems; ventilation systems; multi-zone A/C systems; variable air volume A/C systems; face and by-pass system; economiser system; chilled water systems; hot water systems

Specialisation: HVAC systems

Industrial air conditioning codes and regulations.

Fire and smoke control: AS1668.1; pressurisation

Mechanical ventilation for acceptable indoor air quality: AS1668.2; AS3666

Noise measurement and control: AS1055; AS1359.51

Building code of Australia: section E2, smoke control; section F4, light and ventilation; section G2, heating appliances, fireplaces; chimneys and flues

Regulations under state government acts: workplace health and safety act – provisions relating to workplace health and safety, general duties of employers, manufacturers etc., provisions concerning projects, provisions relating work place amenities, state environment protection acts, air and water pollution control regulations, local government by-laws; noise control; water consumption, disposal

Emergency services requirements

HVAC air systems.

Air distribution principles: static and velocity pressures; measurements; terminology; laminar and turbulent fluid flows; system performance profiles

Air system design: method velocity reduction, equal friction, static regain, computer aided; selection of duct fitting and diffusion fittings

Fans: types; fan laws; fan curves; installation criteria; applied system curves

Ventilation, dust extraction: system configuration; Australian standards; AS – 1668 Part 1 and 2; componentry; system selection; building regulations

Air systems: dual and single duct constant volume; variable volume; induction units; multi-zone

Refrigeration system analysis.

Pressure enthalpy definitions: sensible heat; saturated liquid; latent heat; pressure/temperature relationship; saturated vapour; quantity of heat; power; enthalpy; entropy; isothermal expansion and compression; adiabatic process

Refrigeration cycle: expansion process; vaporising process; compression process; condensing process; compression ratio

Enthalpy processes: coefficient of performance; effect of suction temperature on cycle efficiency; effect of condensing temperature on cycle efficiency

Actual refrigerating cycles: effects of superheating suction vapour; super heating without useful cooling; superheating that produces useful cooling; superheating in suction piping outside the refrigerated space; superheating the vapour inside the refrigerated space; effects of subcooling the liquid; liquid-suction heat exchangers; effects of pressure losses resulting from friction

Cooling plant maintenance procedures.

Cooling towers/evaporative condensers/humidifiers: types, applications; cleaning; decontamination

Condensate trays and drains: fall; cleaning

Water treatment: water tests. procedures; pH; micro-biological; suspended solids; corrosion; bleed; filtration; chemical treatment; cathodic protection

Air filters: types, applications; pressure drop; face velocity; cleaning, changing; fit

Maintenance programs: purpose; methods of establishing specific requirements; planning; manual and computer programs; log books

Personal safety, legal and regulatory requirements: risks to service personnel and public; safe practices; personal protective equipment; duty of care; regulation under workplace health and safety act; NH and MRC recommendations; AS3666

Applied psychrometrics.

Fundamentals and terms: sensible lie at factor - conditioned space, grand total; quantity of air; effective surface temperature; bypass factor

Coil characteristics: processes - sensible cooling, cooling, dehumidification, sensible heating

Spray processes: saturation efficiency; processes - adiabatic/evaporative cooling, cooling and humidification, sensible cooling, cooling and/or humidification

System analysis: partial load; reheat control; bypass control; volume control

Specialisation: Refrigeration systems

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Refrigeration and food storage technology.

Food spoilage and possible causes: physical damage; animal activity; chemical breakdown; enzyme activity; micro-organisms; effects of temperature change; effects of humidity change; effects of freezing on fresh produce; effects of slow freezing time; effects of refreezing

Food preservation: removing or taking out a reactant; removing or inactivating the catalyst; reducing temperature; changing the reaction system

Micro-organisms: conditions for growth; potentially hazardous foods; cross contamination

Identification of food spoilage: recognition and suggest possible cause; physical damage;

Animal activity; chemical breakdown; enzyme activity; micro-organisms

Types of heat processing techniques: heat processing using steam and water; blanching; pasteurisation; sterilisation; evaporation; heat processing using hot air; dehydration; baking and roasting

Types of chilling processing techniques: chilling and controlled atmosphere storage; freezing; freeze drying and freeze concentration

Heat load estimating (commercial refrigeration).

Heat transfer: factors effecting heat transfer; insulation material characteristics; vapour barriers(seals); ambient conditions; composite walls - heat flows; types of common insulation; thermal conductivity; film factors

Air change load: room volumes; room usage - average, medium, heavy; heat removed from cooling air to; refrigerated conditions; air curtains; temperature differences; door opening sizes

Product load: sensible heat; latent heat; heat of respiration; storage temperatures; unit running times; humidity; air flows; stacking of products

Miscellaneous loads: electrical; human; defrost; machinery

Total freezer/cool room loads: wall load; air change load; product load; miscellaneous; total load, safety factor and unit running times

Computer programs

Cabinet construction and design: deep freeze case; meat case; dairy case; fruit and vegetable case; drink cabinets

Commercial refrigeration system design.

Calculation of capacity in heat exchangers: Q=UATd; Q=mc⊗t; Q=m⊗h

Evaporators: commercial types and applications; coil bypass factor; effects of evaporator TD on space humidity; effects of air circulation on product conditions; selection criteria and selection tables

Condensers: commercial types and applications; effects of ambient conditions; condenser control; heat reject factor; condenser TD; selection criteria and selection tables

Compressors: types and applications; capacity – displacement, volume rate flow, mass flow rate, theoretical capacity, total volumetric efficiency, effect of operating conditions, including suction pressure drop and superheating, actual capacity; power – theoretical requirement, effect of operating conditions, actual requirements, post defrost loads, pull down torque requirements, high, medium and low back pressure compressors; selection tables; motor selection

Liquid expansion devices: types, operation and applications; effects from subcooling; distributor types, operation and applications

Selection tables

System load balance point: graphical representation

Line sizing and design: velocity tables; pressure drop in lines and fittings; oil migration stabilisation; refrigerant velocity; effect of varying system capacity; oil traps; risers; double risers; liquid migration; design for parallel components and multiplex systems

Commercial refrigeration system types: medium and low temperature applications; operating conditions; system operating and service requirements; refrigerant types; components; multiple evaporator systems; multiple temperature systems; multiple compressor (rack) systems; two stage compressors; multiplex systems; defrost requirements and methods; electric defrost systems; hot gas defrost systems; cool gas defrost systems

Manufacturer's data: rating tables; selection tables; catalogues

Operating characteristics: effects of temperature glide with blended; refrigerants; Ph charts; refrigerating effect; heat of compression; heat rejected on high side of the system; required mass flow rate of refrigerant; volume flow rate at various points in system; theoretical compressor power; required condenser capacity

Review automatic controls: refrigerant regulating valves; solenoid valves; expansion valves; pressure regulating valves; cycling controls; pressure-stats; thermostats; defrost controls; monitoring and alarm controls; energy management systems; refrigeration automation systems; control strategies; control modes

UTE NES704 A
Plan illumination systems

Descriptor: Plan illumination systems for domestic, commercial and industrial installations within the scope of selecting luminaire types and layout to meet *Australia Standards.*

Elements		Performance criteria	
704.1	Plan and prepare to determine illumination levels and layout	704.1.1	Illumination levels and layout are planned and prepared to ensure *OH&S policies and procedures* are followed and the work is appropriately sequenced in accordance with *requirements*
		704.1.2	*Appropriate personnel* are consulted to ensure determination of illumination levels and layout are co-ordinated effectively with others involved
		704.1.3	Illumination levels and layout to be determined are checked against *requirements*
		704.1.4	Measuring equipment and materials necessary to complete the determination of illumination levels and layout are identified in accordance with *established procedures* and checked against *requirements*
704.2	Establish illumination levels and layout	704.2.1	*OH&S policies and procedures* are followed
		704.2.2	Illumination levels and layout are detailed in accordance with *established procedures* and *requirements*
		704.2.3	Responses to unplanned conditions are detailed in accordance with *established procedures*
		704.2.4	Approval to implement contingencies in accordance with *established procedures* from *appropriate personnel* are detailed
		704.2.5	On-going checks of the quality of work in accordance with *established procedures* are detailed
704.3	Inspect and notify completion of work	704.3.1	Final inspections of illumination levels and layout are undertaken in accordance with *established procedures*
		704.3.2	Completion of illumination levels and layout are *notified* in accordance with *established procedures*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range Statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating *consistent performance* for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the underpinning knowledge and skills identified in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of activities and where required support the outcomes of other units within a qualification structure.

Interdependent assessment of units

Assessment in this unit is related to the knowledge associated with other units within a qualification structure, where appropriate.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

Lighting principles.

Nature of light: electromagnetic spectrum; visible and non-visible radiation; velocity, frequency and wavelength of light; spectral energy distribution diagrams; polarisation; infra-red and ultra-violet radiation – safety

Basic units of measurement: fundamental photometric concepts; definitions; inverse square law, reflection, refraction; solid angle; lighting calculations

Production and control of light: incandescence, luminescence, fluorescence and phosphorescence; lighting materials and luminaire designs; prisms, mirrors and lenses; control by louvers, refractors, diffusers, reflectors, absorbance and transmittance; critical angles and total internal reflection; colour and colour mixing

Visual appraisal: assessment of existing installations; analysis of the visual task; uniformity of illumination and quality; direction of light; shadows; effect of object size; contrast and colour; movement; subjective factors effecting the user; reflection factors

Quality and quantity of light.

Lighting codes - National (Australian): AS1680 Interior Lighting; AS2293 Emergency Lighting; AS2560 Sports Lighting; AS1158 Public Lighting

International codes sources: CIE/ISO; CIBSE: NAIES: NZ

Basic lighting calculations: Lumen method (room index, coeff. of utilisation, reflectance's, luminaire efficiency, application of limitations); point-by-point method (inverse square law, polar diagrams, Lumen loss factors); British and N.A. Zonal Method (NAIES Handbook)

Introduction to computers and their limitations: hardware; software, algorithms; photometric data formats (CIE and NAIES); interpretation

Field measurement - lighting measurement instruments: illuminance; luminance; equipment errors and calibrations; test report interpretations

Quality of light

Qualitative (AS 1680): mood; atmosphere, appearance; social impact, modeling

Basic glare considerations: discomfort glare; disability glare

Veiling reflection: contrast rending factor

Uniformity: ratios; upper and lower limits

UTE NES705 (A to Z qualifier) A Design & develop modifications to explosion-protected equipment

Descriptor: Design and develop *modifications* to *explosion-protected equipment*, conduct *engineering assessments* on the modifications and where applicable submit to a *testing authority* for *certification* of compliance with *standards.*

Alignment: This unit aligns to the Competency Standard 'Electrical equipment in hazardous areas' CS-EEHA-001-1998, unit NEE 007.

Specific unit outcomes

This is a composite unit that can be achieved in any of seven *endorsements* related to explosion protection techniques. This is done because of the high degree of commonality in knowledge, process and function. Reporting the unit with the inclusion of one or more *endorsements* will identify the necessary applied skills related to workplace outcomes and at the same time reflects the work classification(s) generally understood by industry. The specific unit *endorsements* are:

UTE NES705T A	Design & develop modifications to explosion-protected equipment *(Mixed explosion-protection techniques Ex mixed)*
UTE NES705U A	Design & develop modifications to explosion-protected equipment *(Pressurised enclosure Ex p)*
UTE NES705V A	Design & develop modifications to explosion-protected equipment *(Dust-exclusion ignition-proof Dip)*
UTE NES705W A	Design & develop modifications to explosion-protected equipment *(Non-sparking Ex n)*
UTE NES705X A	Design & develop modifications to explosion-protected equipment *(Intrinsic safety Ex i)*
UTE NES705Y A	Design & develop modifications to explosion-protected equipment *(Increased safety equipment Ex e)*
UTE NES705Z A	Design & develop modifications to explosion-protected equipment (*Flameproof enclosure Ex d)*

Elements		Performance criteria	
705.1	Prepare for *modification* of equipment	705.1.1	Instructions on modification are received and expected outcomes of the work confirmed with *appropriate personnel*
		705.1.2	*Certification documents* for the equipment are sought and received in order to check that the equipment complies with the certification
		705.1.3	Where *certification documents* for the equipment are not available arrangements are made to seek *re-certification* in accordance with *requirements*
		705.1.4	Tools, measuring/testing devices and equipment needed to check compliance with *certification* and determine the extent of the work are obtained and check for correct, accurate and safe operation
705.2	Determine the level of *modification*	705.2.1	Measurements, tests and inspections are carried out on the equipment in accordance with *OH&S policies and procedures* and other *established procedures*
		705.2.2	The extent of work to be done is determined from measurement, test and inspection results and the requirements of *standards*
705.3	Design *modifications*	705.3.1	Modifications are designed to comply with the requirements of *standards*
		705.3.2	Specifications and instructions for the modification work are documented and processed in accordance with *requirements*
705.4	Establish the need for *re-certification*	705.4.1	Need for *supplementary certification* or *re-certification* is determined in accordance with *requirements*
		705.4.2	Level of testing required after equipment is modified is determined in accordance with *requirements*
705.5	Arrange *modification* work	705.5.1	Arrangements are made for the modification work to be done in accordance with *established procedures*
		705.5.2	A copy of *modification* specifications and instructions is provided to personnel responsible for carrying out the work

Elements		Performance criteria	
705.6	Arrange assessment of modified equipment	705.6.1	Arrangements are made to obtain *supplementary approval* and/or *re-certification* for the modified equipment in accordance with *requirements*
		705.6.2	Arrangements are made for non-compliance and non-conformances found during testing and the assessment of modified equipment to be rectified in accordance with *established procedures*
705.7	Document certification of modified equipment	705.7.1	Equipment marking is checked and, where applicable, marked according to *certification documentation* and *requirements*
		705.7.2	*Modification* work is documented in accordance with *established procedures* and *requirements*
		705.7.3	Documentation of the modification work is filed in *hazardous area records* and a copy issued with the equipment

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Endorsements

Competency can be demonstrated in relation of the to any classified hazardous areas listed:

(T) Mixed explosion-protection techniques Ex mixed

(U) Pressurised enclosure Ex p

(V) Dust-exclusion ignition-proof DIP

(W) Non-sparking Ex n

(X) Intrinsic safety Ex i

(Y) Increased safety equipment Ex e

(Z) Flameproof enclosure Ex d

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range Statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the underpinning knowledge and skills identified in the section, of this unit titled 'Underpinning knowledge'.

Competence must be demonstrated in relation to the explosion-protected technique for which competency is sought. It is essential that the following aspects of competency be demonstrated:

- following OH&S procedures;
- interpreting certification documentation and standards;
- checking equipment for compliance with certification and standards;
- specifying modification design;
- documenting modification design;
- using quality management systems.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of *plant, equipment,* tools, *accessories, components* and the like for the *category* undertaken within a unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

Competency in this unit should be assessed only after the following competencies have been achieved:

Competencies related to the modification design of electrical equipment at AQF Certificate IV level

Competency unit UTE NES215 A of the Competency Standards. ('Overhaul and repair explosion-protected equipment')

Similar competencies and qualifications related to instrument and electronic equipment would be a sufficient pre-requisite where explosion-protected equipment operates at extra-low voltage.

Underpinning knowledge

Evidence of knowledge related to hazardous areas and to Ex d, Ex e, Ex n, Ex i and DIP, *explosion-protection techniques* and any other technique relevant to a particular workplace is required. The following is a summary of knowledge related to hazardous areas and explosion-protected equipment additional to that specified for Unit UTE NES215 A

Requirements and processes for managing and maintaining equipment overhaul modification records; specifications and requirements for design and construction of equipment; modification design processes and limitations; procedures for verifying that modified equipment complies with standards; purpose and arrangement for certifying explosion-protected equipment

UTE NES706 A
Classify hazardous areas

Descriptor: Determine the *classification* and delineation of *zones* of hazardous areas.

Alignment: This unit aligns to the Competency Standard 'Electrical equipment in hazardous areas' CS-EEHA-001-1998, unit NEE 009.

Elements		Performance criteria	
706.1	Determine the type and extent of *explosion hazard*	706.1.1	*Functions and process equipment* in the area are determined and *hazardous materials* identified from *specifications, hazard and risk assessment* and/or written consultation with *process specialist personnel*
		706.1.2	*Explosion* and physical *properties of hazardous materials* are listed, together with the title of the *authority* from which the data is obtained
		706.1.3	*Gas groupings* and *temperature class* of flammable gases and vapours that may be present in the area is established from collected data
		706.1.4	Potential sources of release are identified from *specifications, risk assessment* and/or *written consultation* with *process specialist personnel*
		706.1.5	Likely impact of any risk of an explosion affecting the environment is assessed in accordance with *requirements* and *established procedures*
706.2	Establish the type and extent of *classes/zones*	706.2.1	*Zones* are determined by similarity to examples in *standards* or from first principles
		706.2.2	Where first principles are used, grades, sources and magnitude of release are established from specifications and diagrams and reviewed with *process specialist personnel*
706.3	Document *classification* and delineation of *zones*	706.3.1	Area *classification documentation* is completed in accordance with requirements and submitted to *appropriate personnel*
		706.3.2	*Classification documentation* records are for future reference and in accordance with *requirements*

Range statement

Competency can be demonstrated in relation to any *hazardous areas* in which the classification cannot be directly identified by common situations but for which classification has been established.

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range Statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating *consistent performance* for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the underpinning knowledge and skills identified in the section, of this unit titled 'Underpinning knowledge'.

It is essential that the following aspects of competence be demonstrated:

- accessing necessary information and identifying hazardous products involved in a given process, explosive properties of materials involved in a given process, and potential sources and characteristics of release of hazardous products;
- analysing data in the context of explosion risk;
- determining area delineation and documenting area classifications.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of *plant, equipment,* tools, *accessories, components* and the like for the *category* undertaken within a unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

Competency in this unit should be assessed only after the competencies related to gathering and analysing technical data at *AQF* Certificate IV level have been achieved.

Underpinning knowledge

Evidence of knowledge related to hazardous areas and the need for explosion-protected electrical systems is required. The following is a summary of the knowledge required:

Safe working requirements and procedure; characteristics of a hazardous area; parameters that delineate classes and zones in a hazardous area; conditions that lead to an explosion; meaning of the terms "combustion", "detonation" and "propagation"; OH&S responsibilities; parties responsible for safety of hazardous areas; characteristics of an explosive atmosphere (LEL/UEL) and relationship to ignition energy; combustible properties and explosive range of specific materials; processes of classifying a hazardous area; risk assessment methods and processes; data required to classify a hazardous area; sources of data needed to classify a hazardous area; analysis of data in context of explosion hazard risk; requirements and processes for documenting classification decisions; requirements for establishing and maintaining classification records (site dossier)

UTE NES707 (A to Z qualaifier) A
Design electrical installations in hazardous areas

Descriptor: Design electrical installations for hazardous areas within the scope of: selecting and locating *explosion-protected equipment* and wiring systems and *other items* that may influence the explosion-protection technique/s; area *classifications* given in hazardous area layout drawings or area *classification* and *zonings* from similar situations previously classified, such as those given in *standards.*

Alignment: This unit aligns to the Competency Standard 'Electrical equipment in hazardous areas' CS-EEHA-001-1998, unit NEE 610.

Specific unit outcomes

This is a composite unit that can be achieved in any of seven *endorsements* related to explosion protection techniques. This is done because of the high degree of commonality in knowledge, process and function. Reporting the unit with the inclusion of one or more *endorsements* will identify the necessary applied skills related to workplace outcomes and at the same time reflects the work classification(s) generally understood by industry. The specific unit *endorsements* are:

UTE NES707T A	Design electrical installations in hazardous areas *(Mixed explosion-protection techniques Ex mixed)*
UTE NES707U A	Design electrical installations in hazardous areas *(Pressurised enclosure Ex p)*
UTE NES707V A	Design electrical installations in hazardous areas *(Dust-exclusion ignition-proof Dip)*
UTE NES707W A	Design electrical installations in hazardous areas *(Non-sparking Ex n)*
UTE NES707X A	Design electrical installations in hazardous areas *(Intrinsic safety Ex i)*
UTE NES707Y A	Design electrical installations in hazardous areas *(Increased safety equipment Ex e)*
UTE NES707Z A	Design electrical installations in hazardous areas (*Flameproof enclosure Ex d)*

Elements		Performance criteria	
707.1	Verify hazardous *classification* for the area	707.1.1	Nature and characteristics of *explosion hazards* in the area are identified from plant specifications
		707.1.2	In the absence of *classification documentation*, arrangements are made to ensure the *explosion hazard* in the area is assessed and the area classified

Elements		Performance criteria	
		707.1.3	*Classification*, extent of *zonings* of the area, *gas groups* and *temperature class* are verified by reference to classification documents or determined from *standards* in which the *explosion hazard*, area *classification* and *zonings* are clearly identified
		707.1.4	Area *classification* determined from *standards* in which the explosion hazard, area *classification* and *zonings* are clearly identified is documented in accordance with *requirements*
707.2	Select and check equipment, wiring and accessories	707.2.1	Equipment and accessories are selected to area activities and comply with *explosion-protection requirements*
		707.2.2	Wiring systems are selected to suit area activities, and comply with *explosion-protection, load and duty requirements*
		707.2.3	Equipment compliance *certification* is checked for suitability for the area *classification* and *zonings*
		707.2.4	Cables and accessories are checked for suitability for the area *classification* and *zonings* and load and duty requirements
707.3	Document design	707.3.1	Design and specifications are documented in accordance with *established procedures* and *requirements*
		707.3.2	Arrangements are made to file design documentation in *hazardous area records* in accordance with *established procedures* and *requirements*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Endorsements

Competency can be demonstrated in relation of the to any classified hazardous areas listed:

(T) Mixed explosion-protection techniques Ex mixed

(U) Pressurised enclosure Ex p

(V) Dust-exclusion ignition-proof DIP

(W) Non-sparking Ex n

(X) Intrinsic safety Ex i

(Y) Increased safety equipment Ex e

(Z) Flameproof enclosure Ex d

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range Statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating *consistent performance* for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the underpinning knowledge and skills identified in the section, of this unit titled 'Underpinning knowledge'.

Competency must be demonstrated in relation to the explosion-protection technique for which competency is sought. It is essential that the following aspects of competency be demonstrated:

- interpreting area classification documentation;
- classifying area from standards;
- documenting area classification;
- selecting equipment for a given classified area;
- selecting wiring systems for a given classified area;
- checking equipment certification for suitability for a given classified area.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of *plant, equipment,* tools, *accessories, components* and the like for the *category* undertaken within a unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

Competency in this unit should be assessed only after competency relating to the designing of electrical installations has been achieved at *AQF* Certificate III level. Similar competency and qualifications related to instrument and electronic installations would be sufficient pre-requisite where explosion-protected equipment operates at extra-low voltage.

Underpinning knowledge

Evidence of knowledge related to hazardous areas and to Ex mixed, Ex p, DIP, Ex n, Ex i, Ex e and Ex d and any other technique relevant to a particular workplace is required. The following is a summary of knowledge related to hazardous areas:

Safe working requirements and procedures; definition of a hazardous area; conditions that lead to an explosion; meaning of the terms "combustion", "detonation" and "propagation"; OH&S responsibilities; parties responsible for safety of hazardous areas; definition of classes and zones; identify classes, zones and groups from system design documentation; processes for classifying a hazardous area based on specific occupancy standards; interpretation of hazardous area classification documentation; characteristics of an explosive atmosphere (LEL/UEL) and relationship to ignition energy; combustible properties of materials.

The following is a summary of knowledge of explosion-protected equipment and applicable to an explosion-protection technique:

Method of explosion protection; mechanisms of explosion protection employed by a technique; interpretation of installation limitations specified in certification and approval documentation; requirements of electrical protection devices; equipment - application; limitations; identification of gas grouping and temperature class of equipment; temperature limitations of wiring and equipment; limitations on non-metallic and specific alloy enclosures; interpretation of equipment marking; application, selection and use of fasteners; requirements for testing circuits; requirements for initial inspection of installations; standards for terminating and connecting cables; standards and requirements for the installation of equipment and wiring; purpose, selection and application of sealing compounds; actions and conditions that will void explosion-protection; standards for of wiring systems in hazardous areas; requirements for establishing and maintaining hazardous area records (site dossier); arrangements for approval for use of equipment in a hazardous area; requirements and processes for selecting equipment; requirements and processes for selecting wiring systems and cables; purpose and arrangement for certifying explosion-protected equipment

UTE NES708 (A to Z qualifier) A
Design explosion-protected electrical systems

Descriptor: Design explosion-protected *electrical systems* in which economical design solutions are pursued and all *requirements* are met.

Alignment: This unit aligns to the Competency Standard 'Electrical equipment in hazardous areas' CS-EEHA-001-1998, unit NEE 012.

Specific unit outcomes

This is a composite unit that can be achieved in any of seven *endorsements* related to explosion protection techniques. This is done because of the high degree of commonality in knowledge, process and function. Reporting the unit with the inclusion of one or more *endorsements* will identify the necessary applied skills related to workplace outcomes and at the same time reflects the work classification(s) generally understood by industry. The specific unit *endorsements* are:

UTE NES708T A	Design explosion-protected electrical systems *(Mixed explosion-protection techniques Ex mixed)*
UTE NES708U A	Design explosion-protected electrical systems *(Pressurised enclosure Ex p)*
UTE NES708V A	Design explosion-protected electrical systems *(Dust-exclusion ignition-proof Dip)*
UTE NES708W A	Design explosion-protected electrical systems *(Non-sparking Ex n)*
UTE NES708X A	Design explosion-protected electrical systems *(Intrinsic safety Ex i)*
UTE NES708Y A	Design explosion-protected electrical systems *(Increased safety equipment Ex e)*
UTE NES708Z A	Design explosion-protected electrical systems (*Flameproof enclosure Ex d)*

Elements		Performance criteria	
708.1	Establish design brief	708.1.1	Site and plant specifications are obtained and reviewed to establish the system *requirements*
		708.1.2	*Classification* of the area is obtained from the hazardous area layout drawings or other *classification documents*
		708.1.3	Organisational policies and specifications for hazardous area *electrical* systems are obtained or established with the *appropriate personnel*

Elements		Performance criteria	
708.2	Design system and installation	708.2.1	Safety, functional and economic considerations are incorporated in system design
		708.2.2	Design complies with all hazardous area *requirements* and includes specifications and all other necessary documentation for explosion-protected equipment, accessories and wiring systems
708.3	Check and finalise design	708.3.1	Design is checked under *established procedures* for compliance with all relevant *requirements*
		708.3.2	Design is submitted for appropriate organisational approval and, where applicable, statutory or regulatory approval
		708.3.3	Approved copy of design documents are issued for retention in *hazardous area records* in accordance with *established procedures* and *requirements*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Endorsements

Competency can be demonstrated in relation of the to any classified hazardous areas listed:

(T) Mixed explosion-protection techniques Ex mixed

(U) Pressurised enclosure Ex p

(V) Dust-exclusion ignition-proof DIP

(W) Non-sparking Ex n

(X) Intrinsic safety Ex i

(Y) Increased safety equipment Ex e

(Z) Flameproof enclosure Ex d

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range Statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating *consistent performance* for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the underpinning knowledge and skills identified in the section, of this unit titled 'Underpinning knowledge'.

Competency must be demonstrated in relation to the explosion-protection technique in which competency is sought. It is essential that the following aspects of competency are demonstrated:

- accessing and interpreting relevant information;
- providing design options and justifications including, hazard risk, functionality and economic considerations;
- following checking and documentation procedures.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of *plant, equipment,* tools, *accessories, components* and the like for the *category* undertaken within a unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

Competency in this unit should be assessed only after the competencies related to design of electrical systems and installations at *AQF* Certificate IV level have been achieved.

Underpinning knowledge

Evidence of knowledge related to hazardous areas and Ex mixed, Ex p, DIP, Ex n, Ex i, Ex e and Ex d and any other technique relevant to a particular workplace is required. The following is a summary of knowledge related to hazardous areas:

Safe working requirements and procedures; conditions that lead to an explosion; meaning of the terms "combustion", "detonation" and "propagation"; OH&S responsibilities; parties responsible for safety of hazardous areas; characteristics of a hazardous area; parameters that delineate classes and zones in a hazardous area; characteristics of an explosive atmosphere (LEL/UEL) and relationship to ignition energy; combustible properties and explosive range of specific materials; processes of classifying a hazardous area

The following is a summary of knowledge of explosion-protected equipment and applicable to an explosion-protection technique:

Mechanisms of explosion protection employed by a technique; interpretation of installation limitations specified in certification and approval documentation; requirements of electrical protection devices; equipment - application; limitations; temperature limitations of wiring and equipment; limitations on non-metallic and specific alloy enclosures interpretation of equipment marking; procedures and requirements for inspecting and testing circuits requirements for initial inspection of installations; standards and procedures for terminating and connecting cables; relationship between equipment, cables and glands; standards and requirements for the installation of equipment and wiring; purpose, selection and application of sealing compounds; actions and conditions that will void explosion-protection; requirements for establishing and maintaining hazardous area records (site dossier); maintenance requirements for an explosion-protection technique; arrangements for approval for use of explosion-protected equipment; philosophies of explosion protection; interpretation of standards and requirement for explosion-protection techniques; application of standards and requirements to the design of explosion-protection systems; determination of gas grouping and temperature class required for a given area; requirements and processes for selecting equipment; requirements and processes for selecting wiring systems and cables; maintenance requirements for an explosion-protection technique; purpose and arrangement for certifying explosion-protected equipment

UTE NES709 A
Design a renewable energy system

Descriptor: Specify the component size, configuration, installation and maintenance requirements and cost of a renewable energy power system to meet a given load at a given location according to *standards.*

Elements		Performance criteria	
709.1	Plan and prepare to design the system	709.1.1	Circuit and apparatus capacity, load and duty determinations are planned and prepared to ensure *OH&S policies and procedures* are followed and the work is appropriately sequenced in accordance with *requirements*
		709.1.2	*Appropriate personnel* are consulted to ensure determination of capacities are co-ordinated effectively with others involved
		709.1.3	Capacities, loads and duties to be determined are checked against *requirements*
		709.1.4	Measuring equipment and materials necessary to complete the determination of capacities are identified in accordance with *established procedures* and checked against *requirements*
709.2	Design the system	709.2.1	*OH&S policies and procedures* are followed
		709.2.2	Capacities, loads and duties are detailed in accordance with *established procedures* and *requirements*
		709.2.3	Response to unplanned conditions are detailed in accordance with *established procedures*
		709.2.4	Approval to implement contingencies in accordance with *established procedures* from *appropriate personnel* are detailed
		709.2.5	On-going checks of the quality of the work in accordance with *established procedures* are detailed
709.3	Inspect and notify completion of work	709.3.1	Final inspections of capacity determinations are undertaken in accordance with *established procedures*
		709.3.2	Completion of capacity determinations are *notified* in accordance with *established procedures*

Range statement

General

Generic items in this unit are shown in italics, *e.g. established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the underpinning knowledge and skills identified in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of applications which includes such things as *apparatus, circuits, wiring systems, plant, equipment, tools, accessories, components* and the like relative to that required for the *category* undertaken within and relevant to this unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

Nil.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

This section includes that set of knowledge and skills additional to that specified in the above mentioned section titled 'Interdependent assessment of units'.

Occupational health and safety.

Occupational health and safety act: aims; acts; representatives; inspectors; offences

Personal safety: injuries and diseases in the workplace; repetitive strain injuries; manual handling procedures; handling of ladders; adequate lighting in the workplace; industrial radiation; chemical hazards; protective equipment; electrical hazards; thermal stress; exposure to excessive vibration; high level industrial noise

Workplace hazards: identification of potential workplace hazards; preventative measures

Working with electrically operated tools and equipment: nature of electric shock; causes of electrical accidents; working safely with electricity; safety items used in electrical environments

Rescue from a live electrical situation

Emergency first aid/resuscitation: procedures for performing emergency first aid and resuscitation for an electric shock victim; CPR

Use of tools.

Identification and application of tools for: marking out a measuring; cutting; shaping; drilling; threading; tapping; finishing; dismantling/assembling

Tool use: hazards; safety procedures; techniques

Fabrication: materials, types, applications; techniques, marking out, cutting, bending, drilling/punching, soldering, cutting mitres

Assembly/disassembly techniques

Electrical theory.

Fundamental and derived units: basic units; SI derived units, mechanical, electrical; multiples and sub-multiples

Power, work and energy: conservation of energy; torque; losses and efficiency; maximum efficiency of machines

Electrical characteristics of materials: electric theory, conductors, insulators, semi-conductors; electric charge; electric current; electromotive force

The simple circuit: source of electrical energy, load, current path, control; open-circuit; short-circuit

Resistance: Ohm's law; determine V, I, R; power dissipation

Effects of current: physiological effects; principles of protection from physiological effects

Effects of current: conversion of electrical energy to other forms, heating, light, magnetic, chemical; principles of protection from damaging effects

Sources of electrical energy: conversion of other forms to electrical energy; chemical reaction; magnetism and rotational motion; light; heat; force

Using measuring instruments: handling measuring instruments; selecting an instrument; setting-up and connecting into circuits; reading scales and read-outs; setting up a CRO

DC resistive circuits: series; parallel; series parallel; measurement of V, I and R; calculation of R, V, I, and P

Capacitance; concept: unit; time constant; capacitors - basic construction and types

Magnetism: magnetic and non magnetic materials; magnetic field patterns; force between magnetic fields; applications

Electromagnetism: magnetic field around a current-carrying conductor and solenoid; force between current-carrying conductors; applications

Electromagnetic induction: induced EMF; inductance; concept; unit; time constant; applications

AC Principles: sine waves; frequency; amplitude; peak voltage; peak to peak voltage; RMS voltage; single phase; three phase; generation of AC voltages; circuit measurement; earthing; electrical supply system

Transformers: construction; principles of operation; primary and secondary voltage and current; applications

Motors: motor action; generator action; DC motors; AC motors; applications

Electrical safety testing: regulations

Wiring techniques.

Electrical/electronic safety testing: isolation; testing; tagging; earthing; appliance electrical safety testing

Standards pertinent to industry sector: purpose; standards bodies; applications

Cables: types, power, signal; terms; colour coding; structure; identification cables; cable applications

Wiring systems: wiring looms; enclosures and supports; selecting wiring systems

Connectors and terminations: requirements; connectors, types and applications, assembly/disassembly; terminating conductors, extension cords

Accessories and fixings appropriate to industry sector: applications; fixing devices and methods

Parts and component selection.

Part/component identification: name; basic function; mounting/fixing arrangements

Information about parts and components: catalogues (structure of reference books, different and common features)

Computer access (starting the computer and moving around the screens)

Telephone inquiry (knowing who to ask for and posing the right question)

Each of the above with respect to the following: part codes (alpha numeric numbers) and what they mean; manufacturers and manufacturers supply outlets; availability and delivery times; price, including discounts, tax and delivery costs; alternative parts

Ordering procedures: customer approval; supplier requirements; in-house requirements

Receiving/dispatch procedures: supplier requirements; in-house (enterprise) requirements; handling and storage

Drawing interpretation and sketching.

Technical drawing standards appropriate to the industry sector, conventions and specifications to AS 1100, with strong emphasis on interpretation: sheet types, title block information, materials parts list, revision table, grid referencing scales, line types – visible outlines, hidden outlines, dimensioning lines, centre lines; orthogonal projection of views – 3rd angle (detail and assembly drawings); mechanical conventions; fabrication conventions; three dimensional view drawings – axonometric, isometric, oblique; sectioning standards and conventions – whole, part; engineering drawing symbols, components and equipment – mechanical, electrical, electronic, computer, instrument, refrigeration; dimensioning – orthogonal, isometric; layout and plans; geometric tolerance interpretation (straightness, flatness, squareness, parallelism and concentricity only); engineering abbreviations; drawing interpretation

techniques – detail drawings, orthogonal projection (3rd angle only) and three dimensional, assembly drawings and three dimensions exploded (e.g. as in equipment manuals)

Equipment and service manuals: flow charts; assembly/disassembly diagrams; schematic diagrams; block diagrams; trouble shooting guides

Freehand drawing skills appropriate to the industry sector: 3rd angle orthogonal projections; isometric; interpretation of drawing symbols; practical exercises

Occupational health and safety - Implementing and monitoring.

Legislation and Australian Standards: AS1470 – 1986; OHSC:7025 (1998); generic competencies A, B and C; relevant acts (electrical); general duty of care

Policy and program development: assigning accountability; focus on improvement

Consultative processes: OH&S committee; meetings and workshops; information gathering

Training and development: provision and type; dissemination of information; cultural considerations; literacy considerations

Hazard identification and assessment: safety audits; workplace inspections; injury and illness records, statistics; complaints and observations; contributing factors to a hazard (exposure, severity, human differences)

Risk assessment and management: hierarchy of control (elimination, substitution, design, mitigation)

Management and improvement: promoting OH&S activities; integration management structures; evaluation of control strategies; evaluation of educational and training programs

Industrial computer systems.

Computer systems overview; PC hardware orientation; basic DOS commands; DOS set-up and utilities; windows operations; word processors; spreadsheets; databases as used for control applications; CAD/vector graphics; introduction to an application package

Renewable energy technologies.

Non-technical issues: current economic, social, environmental and political issues, impact on a renewable energy technology; topic review

Energy services/demand: terminology; energy, temperature, power, symbols, units; energy conversion and efficiency; domestic dwelling - energy services, energy source selection; primary energy and end use energy

Solar radiation resource: terminology; units, symbols, conversions; sun position, sun path diagrams; solar radiation on fixed and tracking collectors

Wind energy resource and technology: terminology, units, symbols; wind patterns (Australia); local terrain, wind speed, direction, turbulence, wind power; maps, data sheets, measuring instruments, wind energy conversion systems (WECS); characteristics; applications; specifications, sizing

Micro-hydro resource and technology: terminology, units, symbols; flow rates, heads, assessment; turbines; operating characteristics; control requirements; specifications

Biomass resource and technology: terminology; common biofuels – types, energy contents, production, applications; resource assessment

Solar thermal systems: terminology; components; applications; types of hot water systems; system features, orientation, tilt angles, placement; system selection, size, cost

Energy efficient building design: terminology; climate and thermal comfort; thermal conductivity of building elements; solar heat gain; ventilation; glazing; thermal mass; insulation; shading devices; siting of buildings; active solar systems

RAPS system configuration: configuration; components – functions, efficiencies; regulators, inverters, battery chargers, generators

Photovoltaic arrays: terminology; modules (types, efficiency, applications); IV curve; irradiance and temperature effects; blocking and bypass diodes; wiring diagrams, configurations; specification and sizing

Energy storage: terminology; types and methods; battery life, temperature effects, charge and discharge rate; precautions, maintenance, safety; stratification; boosting and equalising charges; specification, capacity, configuration; operating characteristics; types, sizes

Photovoltaic power systems.

PV modules: PV technology types; structure; operating principles; manufacturing methods; efficiency; spectral response; module life; cost

Electrical characteristics: terminology; equivalent circuit; I-V curves, load lines; operating point,; ratings and standards; effect of temperature and irradiance, shading; power output; daily energy output; de-rating factors

ELV voltage limits, identifying ELV and LV circuits in PV systems, ELV cable and protection sizing: allowable voltage drops; cable current carrying capacity; sizing methods; acceptable fuse and circuit breaker types; fuse and circuit breaker sizing for inverter systems

Schematic and wiring diagrams: PV power systems for various applications; PV water pumping system; architectural diagrams and schedule of equipment; earthing requirements for PV systems

Batteries: Battery types for stand-alone power systems; basic battery chemistry; cycling and temperature effects; stratification; sulphation; charging regimes; factors affecting life (design, operating conditions and maintenance); safe handling practices; specifications and sizing; disposal

PV system components: types, operation, selection and sizing of: inverters; Maximum Power Point Trackers (MPPTs); regulators; battery chargers; generating sets, metering, cabling, protection devices; mechanical tracking devices; industry guest speakers or industry visits

PV powered water pumping systems: selection and sizing of pumps, pipes, fittings; power requirements; motors, mechanical transmissions; array size; selection of complete systems

Basic lighting design: introduction to lighting standards; lamp types and properties; luminaires; effect of decor, wall colour and windows; energy efficiency considerations (type, positioning, switching configuration); lamp sizing principles

Loads types and inverters: electronic equipment (transformer supply; switching power supply); microwave ovens; light dimmers; motors (universal, induction); start-up surge demand; effects of modified square wave supply; lighting inverters;

DC measuring instruments, ammeters, shunts; voltmeters, multiplier resistors; true RMS meters; AC power and power factor; significance of low power factor; power factor correction (principle);

Stand-alone PV system design: system configurations and operation; design according to AS4509; system voltage selection, component selection and sizing; DC control board layout; installation requirements; maintenance; costings, rebates and incentive schemes, load assessment, selection, sizing

Grid connected systems: testing and approval of inverters; standards for grid connection of inverters; islanding and anti-islanding function; circuit configuration: (metering, isolation, connection with respect to RCDs); signage; protection and isolation equipment for DC array circuits especially at LV; systems with UPS capability: (inverter ratings, system configuration, battery types, ratings and sizing); economic and other considerations (sizing of PV array; metering, tariffs and electricity purchase arrangements; institutional, legislative and regulatory environment; rebates and incentive schemes)

System installation and commissioning: site locations (array, batteries, components); array mounting frames; battery room layout; installation requirements; generating sets; shut-down and power up procedures; commissioning of systems; testing faults installation and maintenance to AS4509 and other relevant standards

Hybrid energy systems.

Energy demand: terminology; advantages/disadvantages of hybrid systems; end-use, primary energy demand assessment; system efficiency; energy source options; matching energy sources to services

System components, installation and maintenance: major system components; renewable energy generators; gensets; batteries; balance of system components; installation and maintenance; AS4509 and other relevant standards; maintenance contracts

Control systems: principles of control; control functions in a stand-alone power system; controller hardware; control strategies for genset control, load control and charge control

Data logging systems: purpose; hardware; software; logistics; retrieval; analysis and presentation of data

Interactive inverters: operation, programming; setting appropriate parameters

Load assessment: energy auditing and energy management for stand-alone systems

System configuration: series, switched and parallel systems; typical systems; options; operational characteristics

System costing: capital and on-going costs; life cycle costing methodology and standards; financial arrangements

System design: availability; complementarity; selection of renewable resources; design philosophy; design steps and criteria; system voltage selection; battery sizing for hybrids; system design software tools; optimisation

Wind energy conversion systems.

Characterises of wind: terminology; major global wind circulations; formation of major wind flows; local wind systems and patterns; extreme winds, wind shear; velocity profiles

Wind speed analysis: terminology; wind speed, direction; measurement of wind speeds and direction; calibration of anemometers; analysis of meteorological bureau data including wind speed data

Site selection: topography and vegetation; surface roughness, isolated obstacles; temperature inversion effects; speed-up effects; power transmission distance; environmental (visual, noise)

Wind energy conversion systems (WECS): lift and drag types; characteristics; categories; materials, construction; system configurations and components; control strategies

Selection of suitable WECS: analysis of site data, WECS selection; commercial WECS; energy output; optimum tower height; balance of system components; capital, costs, effectiveness

Installation and maintenance: mechanical (tower selection, tower raising, lightning protection; electrical (transmission voltage, cables, lightning and general circuit protection, battery room design; maintenance and safety

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Sustainability.

Definitions and basic principles of sustainability: ecologically sustainable development - definitions and misconceptions; basic principles; scope

Drivers - policy and the marketplace: international agreements and protocols; greenhouse policy and activities- federal, state and local government; public perception; consumer demand and green marketing; education

Sustainability in the energy sector: greenhouse contributions from the energy sector; fuel substitution; current and future contribution of energy efficiency and renewable energy; green power schemes; the de-regulated energy market

Specialisation: Energy management systems

Thermodynamic principles and applications for energy management.

Energy transfer in closed and open systems: definition of a closed system; calorimetry as an example of a closed system (with or without phase change); non-flow energy equation - typical applications such as stirring with simultaneous heating or cooling; definition of an open system; Mass and volume flow rate and continuity equation; steady flow energy equation (negligible change in kinetic or potential energy) leading to the concept of enthalpy - typical applications such as turbines, compressors, boilers and heat exchangers

Gases (and processes): definition of a perfect or ideal gas in terms of the molecular model; general gas equation; characteristic gas equation (equation of state); constant pressure process; constant volume process; isothermal process; polytropic process; adiabatic process

Heat engines: definition of a heat engine; essentials of a heat engine - heat source, heat sink, working substance, mechanical power output, working cycle; energy balance for a heat engine (as a black box) and efficiency; maximum possible efficiency (carnot efficiency); types of heat engines according to working substance, heat source, mechanical arrangement and working cycle; typical practical cycles - stirling, otto, diesel, dual, two stroke (spark and compression ignition. joule cycle

Combustion and fuels: the combustion process; fuels - desirable and undesirable characteristics, solid, liquid and gaseous types, their relative advantages and disadvantages and common methods of combustion; air/fuel ration - stoichiometric excess or insufficient air; emissions and pollutants and their control; combustion equations - element mass balance; combustion products - gravimetric basis;

Refrigeration/ heat pump: basic principles and terminology; vapour compression cycle; performance criteria; types of refrigerant - designation, properties advantages and disadvantages; refrigerant properties using the p-h diagram; ideal vapour compression cycle on the p-h diagram; energy balance and heat transfers in compressor, evaporator and condenser; actual vapour compression cycle and variations from the ideal - pressure loss in lines and non-ideal compression; superheating and subcooling with or without suction/liquid heat exchanger; carnot principle applied to refrigerator and heat pump; principles of evaporative refrigeration, absorption refrigeration, air cycle refrigeration and thermo-electric refrigeration

Energy management.

Identification of major energy consuming plant: review of HVAC system components; lighting systems; building energy profiles

Methods of energy conservation: review of energy conserving strategies; house keeping (time schedules, lighting control); good maintenance practices (filters, fans, appropriate setpoints, dead bands etc); HVAC system control (night cycle, optimum stop/start, purge cycles, chiller/boiler/cooling tower sequencing, economy cycles - based on temperature or enthalpy, supply air reset, condenser water temperature reset); electrical load control (power demand control, load limiting, load shedding, set point relaxation, ventilation cycles)

Tests and data collection procedures: use of BMS for data collection (trending); use of data recorders (loggers); monitoring of building operations generally

Analyse results from test data: compare against standards (BOMA); review current practices against ideal; total consumption vs peak load; electricity tariffs and implications

Methods of reducing energy usage: plant retrofits (controls - application of strategies in 2, plant - fixed OA to economy, boiler to electric, reheat, constant volume to VAV etc. cost/benefit - payback)

Typical energy sources and characteristics: supply authorities; standard units of measurement; electricity; steam; hot water; high temperature hot water; town gas; LP gas; solar; waste heat; petrol; diesel

Energy usage: office lighting; air conditioning systems; refrigeration systems; security systems; computer systems; standby/emergency systems; lifts and escalators

Energy auditing process: energy costs and tariffs; energy consumption; predicting future costs; plotting consumption trends; historical data; collecting information using surveys; comparisons of actual to recorded usage; energy balance; instrumentation; building management systems; estimating savings potential

System operation for energy efficiency: types of systems; efficiency in building structures; operation of a vehicle fleet; proportion total energy consumption against individual systems; passive building design; preventative maintenance procedures; monitoring building management systems; operation of major and minor plant; inappropriate energy management procedures; building plant control systems; Australian standards/local authority requirements; case studies

Implementing energy management procedures for a building: recording base year data; climatic conditions for locality; establishing energy costs and tariffs; building and systems surveys; pay back period; survey analysis; energy conservation procedures; informing stockholders; recommendations and documentation; implementation issues; monitoring, evaluation and follow up

Specialisation: Grid connected supplies

Grid connected systems.

Power distribution systems - operation

Protection and relaying

Guidelines for connection of energy systems via inverters: ESAA/ACRE/Standards Australia guidelines

Grid connected inverter systems with energy storage

Grid support issues

Regulatory, metering and policy, green power

Wind energy conversion systems.

Site assessment

Wind farm planning and regulatory issues

Wind resource assessment in complex terrain

System performance modelling techniques

Large wind turbines - construction and operating characteristics

Installation and maintenance requirements of large wind turbines

Wind diesel systems

Co-generation.

Heat and power production: fuel types: advantages and disadvantages; topping, bottoming and combined co-generation cycles; prime movers: applicability and relevant efficiencies; commercial viability, competition, barriers and site; environmental factors

Regulatory and contract issues: safety requirement

Specialisation: Energy efficient building design

Solar water heating systems.

Daily irradiation: angles, tables, maps; collector positioning; calculations

Energy balance: terminology; heat transfer mechanisms; collector materials, properties; collectors heat loss; heat loss equation

Solar collector: selection of materials; collector features, AS2712 (1993)

Performance of solar collectors: Australian Standards, performance testing methods, efficiency, efficiency curves; SHW types

Hydraulic systems: component selection and sizing; water quality; basic system configurations; balanced flow; safety energy and water conservation and efficiency

Domestic SHW heaters: components, system configurations; system performance; demand, sizing, installation and maintenance requirements; performance, costing; industry field visits

Commercial SHW heaters: components, system configurations; design, demand, installation and maintenance requirements; system performance, costing; industry field visits

Pool SHW systems: components, functions, configuration; performance

Energy efficient building.

Climate and thermal comfort: Australian climatic types; climate data; climate and comfort; calculations (heating degree days, thermal neutrality

Solar geometry and radiation: terminology; conversions (solar-local time); incidence, irradiation

Heat transfer: conduction, convection, radiation; U-valves; infiltration heat transfer; steady state performance

Glazing systems: special glasses; glazing systems, characteristics; shading devices; solar heat gain; daily irradiation, heat gain

Insulation: types, installation; R-valves

Thermal mass: advantages, disadvantages; location within buildings; terminology

Comfort control strategies: design strategies and selection

Energy efficiency in buildings: positions (north, sunset, sunrise); solar access; use of vegetation; cross ventilation

Thermal performance in buildings: heating degree day method; dynamic performance

Integration of active solar systems: types, components, storage, collector size; roof locations

Energy rating schemes: approaches; energy performance

Sustainable and safe building materials: embodied energy; sustainable raw materials (mining, logging); manufacturing processes and pollutants; release of dangerous substances from building materials; recycling and ultimate disposal

UTE NES710 A
Plan the installation of renewable energy apparatus and systems

Descriptor: Establish *capacity, load and duty* of *apparatus* and *circuits* within the scope of selecting size and type of cabling, piping, tubing or conduit and locating and positioning of *apparatus* and associated *accessories* and *circuit* routes.

Elements		Performance criteria	
710.1	Prepare to determine *circuit* capacities, loads, duties and placement of *apparatus*	710.1.1	Circuit capacity, load and duty determinations are planned and prepared to ensure *OH&S policies and procedures* are followed and the work is appropriately sequenced in accordance with *requirements*
		710.1.2	*Appropriate personnel* are consulted to ensure determination of *circuit* capacities are co-ordinated effectively with others involved
		710.1.3	*Circuit* capacities, loads and duties to be determined are checked against *requirements*
		710.1.4	Measuring equipment and materials necessary to complete the determination of *circuit* capacities are identified in accordance with *established procedures* and checked against *requirements*
710.2	Plan the installation of renewable energy *apparatus*	710.2.1	*OH&S policies and procedures* are followed
		710.2.2	*Circuit* capacities, loads and duties are detailed in accordance with *established procedures* and *requirements*
		710.2.3	Response to unplanned conditions are detailed in accordance with *established procedures*
		710.2.4	Approval to implement contingencies in accordance with *established procedures* from *appropriate personnel* are detailed
		710.2.5	On-going checks of the quality of the work in accordance with *established procedures* are detailed
710.3	Inspect and notify completion of work	710.3.1	Final inspections of *circuit* capacity determinations are undertaken in accordance with *established procedures*
		710.3.2	Completion of *circuit* capacity determinations are *notified* in accordance with *established procedures*

Range statement

General

Generic items in this unit are shown in italics, *e.g. established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit in the related s*pecialisation* which is to be exhibited across a *representative* range of applications; autonomously and to *requirements*.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace for the *specialisation* undertaken from those listed in the Range statement or Evidence guide.
- demonstrating an understanding of the underpinning knowledge and skills identified for the *specialisation* undertaken in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of applications which includes such things as *apparatus, circuits, wiring systems, plant, equipment, tools, accessories, components* and the like relative to that required for the *category* undertaken within and relevant to this unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

This unit should be addressed only after competency in units UTE NES106 A and UTE NES203 A of this standard has been achieved.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

This section includes that set of knowledge and skills additional to that specified in the above mentioned section titled 'Interdependent assessment of units'.

Since this unit covers a range of *specialisations* a content listing is provided below. Each *specialisation* has all of the required underpinning knowledge and skill listed even though this sometimes results in duplication between *specialisations*.

Occupational health and safety - Implementing and monitoring.

Legislation and Australian Standards: AS1470 – 1986; OHSC:7025 (1998); generic competencies A, B and C; relevant acts (electrical); general duty of care

Policy and program development: assigning accountability; focus on improvement

Consultative processes: OH&S committee; meetings and workshops; information gathering

Training and development: provision and type; dissemination of information; cultural considerations; literacy considerations

Hazard identification and assessment: safety audits; workplace inspections; injury and illness records, statistics; complaints and observations; contributing factors to a hazard (exposure, severity, human differences)

Risk assessment and management: hierarchy of control (elimination, substitution, design, mitigation)

Management and improvement: promoting OH&S activities; integration management structures; evaluation of control strategies; evaluation of educational and training programs

Industrial computer systems.

Computer systems overview; PC hardware orientation; basic DOS commands; DOS set-up and utilities; windows operations; word processors; spreadsheets; databases as used for control applications; CAD/vector graphics; introduction to an application package

Renewable energy technologies.

Non-technical issues: current economic, social, environmental and political issues, impact on a renewable energy technology; topic review

Energy services/demand: terminology; energy, temperature, power, symbols, units; energy conversion and efficiency; domestic dwelling - energy services, energy source selection; primary energy and end use energy

Solar radiation resource: terminology; units, symbols, conversions; sun position, sun path diagrams; solar radiation on fixed and tracking collectors

Wind energy resource and technology: terminology, units, symbols; wind patterns (Australia); local terrain, wind speed, direction, turbulence, wind power; maps, data sheets, measuring instruments, wind energy conversion systems (WECS); characteristics; applications; specifications, sizing

Micro-hydro resource and technology: terminology, units, symbols; flow rates, heads, assessment; turbines; operating characteristics; control requirements; specifications

Biomass resource and technology: terminology; common biofuels – types, energy contents, production, applications; resource assessment

Solar thermal systems: terminology; components; applications; types of hot water systems; system features, orientation, tilt angles, placement; system selection, size, cost

Energy efficient building design: terminology; climate and thermal comfort; thermal conductivity of building elements; solar heat gain; ventilation; glazing; thermal mass; insulation; shading devices; siting of buildings; active solar systems

RAPS system configuration: configuration; components – functions, efficiencies; regulators, inverters, battery chargers, generators

Photovoltaic arrays: terminology; modules (types, efficiency, applications); IV curve; irradiance and temperature effects; blocking and bypass diodes; wiring diagrams, configurations; specification and sizing

Energy storage: terminology; types and methods; battery life, temperature effects, charge and discharge rate; precautions, maintenance, safety; stratification; boosting and equalising charges; specification, capacity, configuration; operating characteristics; types, sizes

Photovoltaic power systems.

PV modules: PV technology types; structure; operating principles; manufacturing methods; efficiency; spectral response; module life; cost

Electrical characteristics: terminology; equivalent circuit; I-V curves, load lines; operating point,; ratings and standards; effect of temperature and irradiance, shading; power output; daily energy output; de-rating factors

ELV voltage limits, identifying ELV and LV circuits in PV systems, ELV cable and protection sizing: allowable voltage drops; cable current carrying capacity; sizing methods; acceptable fuse and circuit breaker types; fuse and circuit breaker sizing for inverter systems

Schematic and wiring diagrams: PV power systems for various applications; PV water pumping system; architectural diagrams and schedule of equipment; earthing requirements for PV systems

Batteries: Battery types for stand-alone power systems; basic battery chemistry; cycling and temperature effects; stratification; sulphation; charging regimes; factors affecting life (design, operating conditions and maintenance); safe handling practices; specifications and sizing; disposal

PV system components: types, operation, selection and sizing of: inverters; Maximum Power Point Trackers (MPPTs); regulators; battery chargers; generating sets, metering, cabling, protection devices; mechanical tracking devices; industry guest speakers or industry visits

PV powered water pumping systems: selection and sizing of pumps, pipes, fittings; power requirements; motors, mechanical transmissions; array size; selection of complete systems

Basic lighting design: introduction to lighting standards; lamp types and properties; luminaires; effect of decor, wall colour and windows; energy efficiency considerations (type, positioning, switching configuration); lamp sizing principles

Loads types and inverters: electronic equipment (transformer supply; switching power supply); microwave ovens; light dimmers; motors (universal, induction); start-up surge demand; effects of modified square wave supply; lighting inverters;

DC measuring instruments, ammeters, shunts; voltmeters, multiplier resistors; true RMS meters; AC power and power factor; significance of low power factor; power factor correction (principle);

Stand-alone PV system design: system configurations and operation; design according to AS4509; system voltage selection, component selection and sizing;

DC control board layout; installation requirements; maintenance; costings, rebates and incentive schemes, load assessment, selection, sizing

Grid connected systems: testing and approval of inverters; standards for grid connection of inverters; islanding and anti-islanding function; circuit configuration: (metering, isolation, connection with respect to RCDs); signage; protection and isolation equipment for DC array circuits especially at LV; systems with UPS capability: (inverter ratings, system configuration, battery types, ratings and sizing); economic and other considerations (sizing of PV array; metering, tariffs and electricity purchase arrangements; institutional, legislative and regulatory environment; rebates and incentive schemes)

System installation and commissioning: site locations (array, batteries, components); array mounting frames; battery room layout; installation requirements; generating sets; shut-down and power up procedures; commissioning of systems; testing faults installation and maintenance to AS4509 and other relevant standards

Electronics for renewable energy systems.

Power switching devices: transistors, darlington pairs, MOSFETs, IGBTs, thyristors (structure, operation and symbol, major device ratings)

Switchmode circuits compared to linear: features/ advantages and disadvantages; efficiency and sources of energy loss in electronic system components; simple photovoltaic voltage regulator; Pulse Width Modulation (PWM) - principles, renewable energy applications; Radio Frequency Interference (RFI) - causes and cures (basic)

DC/DC converters: concept and principles, maximum power point trackers (MPPTs) and other renewable energy applications

Inverters: concept of inversion; inverter bridges; functions and types (output waveforms, use of PWM techniques, block diagram structure single phase and three phase); harmonic content of inverter waveforms (significance in renewable energy systems, trouble shooting)

Differential controllers for SHW systems; hysteresis in switching components

AC load control: phase control, zero-voltage switching, devices for ac load control; SCRs, triacs

Maintenance: fault location and testing under the direction of an electronics technician; handling precautions for MOS circuits; PCB replacement; heat sink assemblies

Use of computers in commissioning, testing and maintenance: cabling, communications ports and protocols, modems, proprietary software

Programmable system components: logic trees; using menus to access parameter settings and information display

Generating sets.

Generating sets components

Internal combustion engines: construction; operation; fuel types and ignition methods

Generating sets types, ratings, operating characteristics: petrol, diesel, gas; high and low speed; advantages and disadvantages of different types; prime mover and alternator ratings; alternator waveform; voltage regulation; speed characteristics and governing; response to surge demand

Generating sets sizing: real and apparent power requirements; continuous and surge loads; de-rating factors

Installation requirements: ventilation (cooling and combustion air); exhaust system; vibration isolation; sound attenuation; modifications for long running

Maintenance requirements: fuel system; lubrication; filters; periodic maintenance, diagnose and rectify faults

Safety

Specialisation: Fuel cells

Fuel cells and advanced energy storage technology.

New energy storage technologies – overview: batteries; flywheels; hydrogen production and fuel cells

Redox batteries: principles; types; structure; characteristics

Zinc-bromide batteries: principles; types; structure; characteristics

Fuel cells: principles; types; structure; characteristics

Installation requirements

Maintenance requirements

Safety issues

Specialisation: Micro-hydro systems

Suitability for micro-hydro system application

Site selection: environmental issues; available power; water flow; head

Water wheels

Water turbines: (Kaplin, Peltin, Francis, propeller, crossflow etc)

Characteristic curves and interpretation

Structural consideration: sluices, flumes, penstocks; screens and screening systems; plumbing operations

System design: site data analysis, energy demand; turbine selection; frictional losses; balance of system components

Control systems and actuators; flow regulation

Electrical generators: characteristics, matching to turbines type, regulation, choice of voltage and type (ac/dc); synchronous and asynchronous operation; voltage conversion/transformation and inversion

Safety issues

Specialisation: Wind energy systems

Wind energy conversion systems.

Characterises of wind: terminology; major global wind circulations; formation of major wind flows; local wind systems and patterns; extreme winds, wind shear; velocity profiles

Wind speed analysis: terminology; wind speed, direction; measurement of wind speeds and direction; calibration of anemometers; analysis of meteorological bureau data including wind speed data

Site selection: topography and vegetation; surface roughness, isolated obstacles; temperature inversion effects; speed-up effects; power transmission distance; environmental (visual, noise)

Wind energy conversion systems (WECS): lift and drag types; characteristics; categories; materials, construction; system configurations and components; control strategies

Selection of suitable WECS: analysis of site data, WECS selection; commercial WECS; energy output; optimum tower height; balance of system components; capital, costs, effectiveness

Installation and maintenance: mechanical (tower selection, tower raising, lightning protection; electrical (transmission voltage, cables, lightning and general circuit protection, battery room design; maintenance and safety