TRAINING STANDARDS

National Electrotechnology Training Package

Volume 7

Diagnose

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 NES501 (A to Z qualifier) A
Diagnose and rectify faults in apparatus & circuits

Descriptor: Diagnose and rectify faults in *apparatus* and associated *basic circuits,* includes wiring, piping, tubing and components.

Alignment: This unit aligns to and is based on the National Electrotechnology Benchmark Standard EBS 402 - Diagnose faults in apparatus and associated circuits.

Specific unit outcomes

This is presented as a composite unit that has six 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 NES501A A	Diagnose and rectify faults in apparatus & circuits *(Computer systems)*
UTE NES501B A	Diagnose and rectify faults in apparatus & circuits *(Electrical)*
UTE NES501C A	Diagnose and rectify faults in apparatus & circuits *(Electronics)*
UTE NES501D A	Diagnose and rectify faults in apparatus & circuits *(Instrumentation)*
UTE NES501E A	Diagnose and rectify faults in apparatus & circuits *(Refrigeration & a/conditioning)*
UTE NES501F A	Diagnose and rectify faults in apparatus & circuits *(Data communications)*

Elements		Performance criteria	
501.1	Plan and prepare for diagnosis of faults	501.1.1	Diagnosis of faults is planned and prepared to ensure *OH&S policies and procedures* are followed the work is appropriately sequenced in accordance with *requirements*
		501.1.2	*Appropriate personnel* are consulted to ensure the work is co-ordinated effectively with others involved on the work site
		501.1.3	*Apparatus* faults are checked against job *requirements*

Elements		Performance criteria	
		501.1.4	Materials necessary to complete the work are obtained in accordance with *established procedures* and checked against job *requirements*
		501.1.5	*Tools, equipment* and *testing devices* needed to carry out the work are obtained in accordance with *established procedures* and checked for correct operation and safety
		501.1.6	Preparatory work is checked to ensure no unnecessary damage has occurred and that is complies with *requirements*
501.2	Diagnose faults in *apparatus* and associated *circuits*	501.2.1	*OH&S policies and procedures* are followed.
		501.2.2	Reported fault(s) is/are confirmed and normal functions of *apparatus* and associated *circuits* are ascertained in accordance with *requirements*
		501.2.3	*Circuits* are checked as being isolated where necessary using specified testing procedures
		501.2.4	*Apparatus* faults is/are diagnosed in accordance with *requirements,* without damage or distortion to the surrounding environment or services
		501.2.5	Unplanned events or conditions are responded to in accordance with *established procedures*
		501.2.6	Approval is obtained in accordance with *established procedures* from *appropriate personnel* before any contingencies are implemented
		501.2.7	On-going checks of the quality of the work are undertaken in accordance with *established procedures*
501.3	Rectify faults in *apparatus* and associated *circuits*	501.3.1	*OH&S policies and procedures* are followed.
		501.3.2	*Apparatus* and associated *circuits* are isolated, where necessary, in accordance with *established procedures*
		501.3.3	Adjustments are made in accordance with *established procedures*, where necessary, to return *apparatus* and associated *circuits* to normal operating conditions
		501.3.4	Faulty component(s) are rectified or replaced, without damage or distortion to the surrounding environment or services

Elements	Performance criteria
	501.3.5 Unplanned events or conditions are responded to in accordance with *established procedures*
	501.3.6 Approval is obtained in accordance with *established procedures* from *appropriate personnel* before any contingencies are implemented
	501.3.7 On-going checks of the quality of the work are undertaken in accordance with *established procedures*
	501.3.8 *Apparatus* and associated *circuits* are tested to ensure safety of the installation
	501.3.9 *Apparatus* and associated *circuits* are returned to service in accordance with *established procedures*
501.4 Provide status report(s)	501.4.1 Arrangements are made for maintenance and/or repair(s), where necessary, with relevant *authorised personnel* in accordance with *requirements*
	501.4.2 Status report(s) is/are completed and *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

(F) Data communications

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 NES402 A. Therefore, it is expected that to achieve this unit, without having gained competence in unit UTE NES402 A, will require that the relevant aspects of knowledge and skills related to unit UTE NES402 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

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; multiples and sub-multiples

Power, work and energy: conservation of energy; torque; losses and efficiency; maximum efficiency of machines

Electrical characteristics of materials: conductors, insulators, semi-conductors; electric charge; electric current; electromotive force

The simple circuit: source, load, current path and 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; conversion of electrical energy to other forms (heating,

light, magnetic, chemical)Sources of electrical energy - conversion of other forms to electrical energy

Using measuring instruments: handling measuring instruments; selecting an instrument; setting-up and connecting into circuits; reading scales and read-outs; setting up a CRO

Factors effecting resistance: length, csa and resistivity; temperature change; influence on practical circuits

Resistors: types and applications; value and rating

Series circuits (single source):   determine V, I, R, P; Kirchhoff's Voltage Law; voltage dividerParallel circuits: determine V, I, R, P; Kirchhoff's Current Law; current divider

Series/parallel circuits: determine V, I, R, P; bridge networkResistance measurement: hazards; characteristics of instruments and loading effect; direct, volt-ammeter and bridge method; typical field instruments and applications

Capacitance: concept; units; time constant relationshipCapacitors: hazards; factors effecting capacitance; in series; in parallel; measuring/testing/hazards

Inductance: concept; units; time constant relationship

Inductors: factors effecting inductance

Single phase AC principles.

Sinusoidal alternating voltage and current: generation of a sinusoidal waveform; sinusoidal waveform characteristics; measuring and calculating values; phase relationships

Phasors: phase relationship terms; phasor representation conventions; phase relationships using phasors

Resistance in A.C. circuits: determine V, I, R, P; relationship between voltages and currents

Inductance in A.C. circuits: reactance; inductance in series; inductance in parallel; inductive components in power circuits and systems

Capacitance in A.C. circuits: reactance; capacitance in series; capacitance in parallel; capacitive components in power circuits and systems

AC circuits: impedance; relationship between resistive and reactive components; series, parallel and series-parallel RLC circuits; determine V, I, R, P in RLC circuits; phasor diagrams of RLC circuits

Resonance: conditions; resonance and frequency; effects on current

Ideal transformer: operating principles; primary and secondary voltage and current; applications

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

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

Analysis of digital sub-systems – timing diagrams (decoders): operation - discrete components, 2 line; practical MSI devices and applications -2 line and 3 line devices; seven segment display decoder -binary and BCD; priority encoders; multiplexers – operation -discrete component, 2 line; truth table implementation using MSI devices up to eight inputs – folding not required; demultiplexers – operation -discrete component, 2 line input; practical MSI devices

Digital sub-systems examples using up to four MSI devices e.g. keyboards/display, data transfer – timing diagrams/data sheet usage to be emphasised: flop-flop operation – discrete and MSI, SR, D and JK; level and edge triggered flip-flops, synchronous and asynchronous inputs, flip-flop applications based on MSI devices for shift registers – serial and parallel loading and output, shift left, shift right; counters – based on D and JK flop-flops to a maximum of four states, ripple and counters synchronous; modulus counters, up/down counters, limitations on count speed, IC counters (MSI devices) –

presentable counters (up/down), cascading counters (include BCD applications), ring counters – advantages and types; astable and monostable multivibrators

Logic device terminal characteristics: logic levels, supply voltages; power dissipation; input/output drive currents and voltage levels; loading calculations; propagation delays; noise margins; switching speed limitations and speed/power product; open collector/drain outputs; tristate logic and buffers; interfacing of different logic families (include the use of pull-up, pull-down resistors); Schmitt trigger device input output; characteristics

Microprocessors.

Basic 8-bit microprocessor system: semi-conductor RAM ICs; semi-conductor ROM ICs

Microprocessor architecture: central processing unit (CPU); register array; instructions register/decoder; arithmetic logic unit (ALU); accumulator and flags; instruction cycle timing; control lines; index register; general purpose registers

Systems clock circuits fetch and execute: timing cycle; timing relationships to system clock; logic levels of system buses for each clock period of an instruction cycle

Program listing terms: instruction; instruction mnemonic; operation code (op code); address, operand, label, mnemonic and comment fields; machine code and assembly language, high and low level language

Single chip dedicated microprocessors

Regulated power supplies.

Regulated power supplies: principles of operation; advantage/disadvantages – linear shunt, linear series, switchmode

Linear power supplies: block diagram; principles of operation; series transistor; integrated circuits – types, specifications, protection; testing; faultfinding and repair

Switched mode power supplies: block diagram; principles of operation – with/without transformers, step up/step down/inverter; terminology; components; suppression techniques; testing; repair/replacement

DC power supplies.

Power supplies

Block diagrams

Waveform measurements; uses

Ideal an practical diodes; Ge and Si diodes

Half-wave and full-wave rectifier circuits; average voltages for half-wave and full-wave rectifier circuits

Capacitive filtering

Ripple voltages: based on load variations; based on capacitor choice; current limiting resistors

Zener diode applications

Three terminal regulators

Power supply faults and repair**Electronics fault-finding.**

Customer relations; testing to ascertain actual fault; select appropriate repair agency; packaging of damaged equipment; observe equipment for signs of visual damage; check power supplies; observe circuit board for obvious signs of damage; split half method; test equipment; functional testing after repair; invoicing; warranty item

Graphical user interface.

The graphical user interface environment: mouse; icons; windows; menus; drop-down menus; pointer icons; dialogue boxes; command buttons; check boxes; option switches; list boxes; test boxes; scrolling; background and foreground

Mouse operations: selecting icons; selecting menu choices; selecting a group of items; selecting a block of text; opening windows; starting programs; dragging

Using a graphical disk management program to manage files and directories: creating and removing directories; creating, copying, deleting, moving and renaming files

Re-sizing windows: starting programs; making programs inactive; reactivating programs

Running multiple applications

Using keystroke alternatives to mouse operations

Accessing and using manuals, third party references and on-line help

Command line interface.

Operations: copying; moving; deleting and renaming files; initialising disks; using paths; running applications; identifying, accessing and using information from on-line help or a manual

Data communications.

Standards: elements of data communication system; transmission modes (simplex, half and full-duplex); transmission techniques; voice transmission fundamentals; interfacing devices and standards; OSI seven layer model; modem fundamentals; modem modulation techniques; integrated services digital network (ISDN); packet switching services, X.25

Local area networks.

Local area networks (LANs): concepts; cabling arrangements; network standards; network operating systems; LAN access control methods; installation of a PC based network (file servers, workstations, print servers); LAN management; LAN internet working; metropolitan area networks; wide area networks; TCP/IP concepts; virtual LANs; network maintenance and troubleshooting

Network operating systems.

Network systems: mainframe; mini computers; microcomputers

WANs: protocols; protocol stacks; interconnectivity

LANs: protocols; terminal emulation

Operating systems: NT; UNIX; LINUX; Netware; Windows 95; other OS

Administration: duties; responsibilities; procedures; user access; managing and configuring attached devices

TCP/IP: protocols; services; IP addressing scheme; routing; OSI model relationship; network address; broadcast address; multicast; fragmentation; PPP implementation; bridging; network address translation

Equipment installation: driver loading; testing; troubleshooting

Application software.

Introduction to computers: types of computers; hardware identification; peripherals; common computer terminology

Introduction to computer operating systems: MS Windows – current versions; Windows NT; Macintosh; other operating systems

Computer usage: load and run a simple program; enter data; save data; retrieve data; manipulate data

Software applications: office support – word processing, database, spread sheet, graphics, record keeping (stores, bill back); communication – email, schedule, fax; networks; machine control

Specialisation: Building services – fire protection

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

Basic PLC operation: definitions, terminology and block diagram; scan cycle; basic programming rules; addressing for I/O; halt; run

Programming (using a hand programmer): flowcharts/steps to use when programming; clearing memory; ladder format; Boolean/mnemonic/statement list format; series circuits; parallel circuits; latching circuits; stack register operation; combination series/parallel circuits; inversion elements; timers (DOE); counters; monitor discrete I/O and timer/counter values; edit (insert and delete elements)

Connect discrete input and output devices to a PLC

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

Personal computer servicing.

Introduction to computers: types/models/classes; hardware components; definitions and terminology; introduction to software; minimum system configuration

Computer PC hardware: motherboard/s and their major components; power supplies; keyboards; monitors and adaptors; disk drives; printer; sundry devices

Operating systems: types of operating systems and versions thereof; file and data structures; file naming conventions; directory structures and access; operating system bootstrapping process; operating system commands; basic concepts of Batch (startup) files and their use; basic concepts of configuration files

Building automation fire protection installation.

Purpose of automatic fire detection and alarm systems: preservation of life; protection of buildings and equipment

Standards and codes: general legislation and codes; specific legislation – Halon systems, ionisation smoke detectors; legal liability

Fire characteristics: principles of fire detection – fire growth; principles of fire suppression

Generic automatic fire detection and alarm system: overview of automatic fire detection and alarm system

Fire detection actuating devices: fire detector classification; detector patterns; detector types, principles of operation and performance; heat detectors – electro-pneumatic, fusible alloy, bimetallic, solid state, thermo-plastic; smoke detectors – ionisation, photo-electric, beam light obscuration, sampling light scatter (aspirating); flame detectors – infra-red, ultra-violet, manual call points; special purpose detectors – flammable vapour/gas detectors, explosion detectors

Control and indicating equipment (CIE): fire panels; classification; types; principles of operation; installation; commissioning report as per AS 1670

Emergency warning and intercommunication system (EWIS): purpose; types; installation; codes and requirements; manufacturers' specifications and requirements – AS3000 series, AS1670, AS2220, AS1668

Alarms: local alarms – purpose, types, installation; transmitted alarms – purpose, types, installation; control outputs – purpose, types, installation; pump control – purpose, pump actuation; codes and requirements – manufacturers' specifications, manufacturers' requirements for handling; building codes Australia – AS1668, AS1670, AS1851

Suppression systems: sprinkler systems; sequence of operation; purpose of interfacing devices; special purpose gaseous, dry chemical, foam, explosion suppression; suppression actuating devices; purpose; sequence of operation; purpose of interfacing devices; types of interfacing devices; installation of interfacing devices; purpose of actuation devices; types of actuation devices; installation of actuation devices; codes and requirements – manufacturers' specifications, manufacturers' requirements for handling; building codes Australia – AS1670, AS1851, AS1668

Cabling: types of fire cables – mineral insulated metal sheathed cable (MIMS), radox cable, data cable, fibre optic cable; codes and requirements – manufacturers' specifications and requirements, AS3000 series, AS1670, ACA standards; installation of fire cables; detector selection – detector installation; detection systems – conventional, distributed, network; detection system installation; codes and requirements; manufacturers' specifications; manufacturers' requirements for handling; building codes Australia – AS1670, AS1851, AS3000

Specialisation: Building services – security

Security systems.

Regulations applicable to the security industry

Design of domestic security system

Building construction

Mechanical detectors: pressure pads; trip wires; window tape; screens; switches; vibration

Electro-mechanical detectors: ultra sonic; microwave; glass break; smoke; active infra-red beams; passive infra red; strain system; electromagnetic; optical fibre cable

Batteries: types; applications; maintenance

Relays: types, applications

Security panels

Communication systems

Close circuit television (CCTV)

Locking devices

Lighting

CCTV.

Safety; principles; uses; field of view determination; depth of field; definition vs broad view; electronic and auto iris; focussing; setting up; picture sleeping; coaxial connections; mounting – location, sealed housings, unsealed housings, heated housings; adjusting a monitor; mutiplexors – setting up, adjusting; pan/tilt devices – auto pan, pan/tilt controller; microprocessor based CCTV systems; analysing picture quality; test equipment – vector scope, signal generator, portable or hand held monitors for setting up cameras

Security systems programming and diagnostics.

Logic circuits; microprocessor driven circuits; upgrading – firmware, software; detectors – types, features, common problems, continuity, voltage; devices – detector options, count, sensitivity; control equipment; test equipment – digital meters, analogue meters, tone generators (F set), continuity tester; Laptop computers – DOS, Win 3.11, Win 95, Code pads

Advanced security systems.

Fibre optics – applications, terminations, physical properties; intrinsically safe wiring – where needed, alternatives; modems – commands, uses

Specialisation: Business equipment

Photocopier operating principles.

Photocopiers: general operating processes, block diagram, operation of the major functional blocks, use of service manual

Copy processes: analogue photocopier (image scanning process, development process, transfer process, cleaning process, fusing process, process control/compensation techniques) digital photocopier (image scanning process, image capture process, image storage techniques, image manipulation process); comparison of digital and analogue photocopiers

Paper feed and transportation: paper types, paper handling, methods of paper feed, paper transportation

Maintenance procedures: photocopier adjustment for correct operation, replacement of consumable items, cleaning procedures

Colour photocopying principles.

Principles of colour and colour separation: effects of light on the eye, colour principles, colour separation, colour mixing processes, colour wheel

Colour separation in colour photocopying: three scan process, four scan process, under colour removal

Principles of colour photocopying: reflected light paths, block diagrams of, photocopiers, principles of operation

Scanning processes of colour photocopiers: CCD, pre amps, auto gain, image, processing unit, laser unit, exposure processes

Printing processes of colour photocopiers: laser diode unit, polygon mirrors, laser synchronising and detector, cylindrical lens

Routine maintenance and servicing: optics, paper feeds, developer unit, drum unit, belts and rollers, fusing unit

Business machine transducers.

Introduction to transducers: definition and basics, linear position and velocity, angular position measurement, angular velocity measurement, temperature sensors, humidity sensors, current sensors, piezo sensors

Temperature sensors: introduction, thermocouples, resistance temperature detectors (RTD), thermistors, bimetal temperature sensors, applications

Optoelectronic devices: introduction, photoresistors, photodiodes, phototransistors, LASCR, photovoltaic devices, optocouplers, laser, applications

Facsimile machines.

Fundamental concepts: CCITT standards, analogue and digital transmissions, transmission process, phases of facsimile calls

Scanning operations: single photosensor, CCD operations, area image sensors, lighting systems, optical systems

Signal processing: picture reduction, modems

Printing processes: thermal, plain paper, carbon transfer. ink jet

Dialling parameters: pulse (decadic) dialling, DTMF, manual dial, blind dial, line and dial detect, redial and listen to dial

Coding systems: data compression, modified Hauffman (MH) systems, modified read (MR) systems, modified read (MMR) systems, “K” factor, error correction modes (ECM)

Operational principles: transmission, reception, copying

Installation, operation, maintenance and servicing procedures: disassembly and assembly, consumable replacement, cleaning, fault identification, machine faults, line faults

Facsimile services: faxstream, duet

Business machine accessories.

Input: paper trays, high capacity bins, document feeders, duplex unit, manual bypass, coin boxes, card readers, raster image processing unit

Output: sorters, staplers, collators, folders, stackers

Colour cartridges

Basic telephony/switching systems overview.

Sound: characteristics; wave forms; distortion and resonant frequency; voice and audio frequency; pressure; level

Transmission: principles; speed; mediums; limits; telephone functions

Telephone transmitter: function; types; microphones

Telephone receiver: functions; types; operation

Circuit operation of a telephone: facilities; basic operation

Customer switching systems (CSS) services: extension; extension to extension; extension to PSTN; PSTN to extension; operator; phones; modems; switch boards; connection to telephone exchange; public line coming in; enquiry calls; paging; call back; conferencing; hold music; night switching; bip tones

Development of customer switching systems: generations of CSS

Installation procedures: regulations; ACA

Hazards associated with printed circuit board: physical – card damage, vibration; chemical – cleanliness, heman acids, foot, dust, water; electrical – electrical static discharge; other – environmental (UV radiation); safety procedures; storage and packaging of components; electrostatic equipment – leads, earthing mats; protective clothing - gloves

Personal computer servicing.

Computers: types/models/classes; hardware components; definitions and terminology; introduction to software; minimum system configuration

Computer PC hardware: motherboard/s; power supplies; keyboards; monitors and adaptors; disk drives; printers; sundry devices

Operating systems: types of operating systems; file and data structures; file naming conventions; directory structures and access; operating system bootstrapping process; operating system commands; basic concepts of batch (start-up) files; usage; configuration files

Editors: concepts of editors; create/modify delete file

Hardware/software system configuration: operating system configuration commands and files; start-up/bootstrap files; disk formatting and partition concepts; memory set-up and memory management; I/O port configurations

Installing options: optional cards; optional software drives and installation; optional devices; upgrading the standard PC

Troubleshooting techniques: ‘first level’ servicing (modular approach); cost-effectiveness of repairs; ‘chip level’ servicing; test equipment ; typical diagnostics

Installation application packages: types; installation procedures; copyright protectors; backup procedures; upgrading packages

Preventative maintenance and environment: daily operating routines and shutdown; cleanliness; packing equipment for transport; static problems

Computer peripherals.

Introduction to peripherals: definition; types/models/classes; terminology; interfacing techniques

Visual display units: types; applications; basic block diagram; detailed block diagram; colour standards

Printers: types; uses; printing quality; basic block diagram; detailed block diagram; connectivity; configuration

Other peripherals: types; applications; configuration

Operational concepts of business machines.

Photocopiers: copy processes; copier components; maintenance procedures

Facsimile machines: components; transmission methods; maintenance procedures

Personal computers: components; operating systems; software; input/output devices; CD ROM

Printers: printer types, processes; basic components; maintenance procedures

Visual display units VDU: operating processes; display types; compatibility

Scanners: types; scanning methods; components; software

Other business equipment: calculators and typewriters; micrographic and electronic storage; integrated office equipment; applications

Chemicals handling: corrosive substances; flammable materials; safety

DC stepper motors

Laser devices: types; wavelength; safety

Electronic communications between business machines.

Digital signals: identification; measurement

Modem communications: modem protocols; measurement

Ports and plugs: functions; identification

Multiplexing/de-multiplexing techniques

Facsimile protocols: test sheets; test results

Computer interfaces: interpretation of readings; faults

Electronic memories: number systems; packages; terminology

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

BJT and FET symbols: PNP, NPN; JFET; MOSFET; device characteristics BJT and JFET; biasing – need for circuit types; calculation and measurement of bias conditions; DC stability for BJT and JFET circuits; Quiescent point selection for BJT and JFET

Data sheet usage for BJT, JFET and MOSFET: small signal characteristics for single stage BJT and JFET circuits; fault conditions for single stage BJT and JFET circuits

Coupling and bypass capacitors: applications for single stage BJT and JFET circuit; frequency response, effect of coupling and bypass capacitors –

measurement only; factors effecting selection – based on practical demonstration

Feedback, filters and oscillators.

Positive and negative feedback

Effects of negative feedback on voltage amplifier

Ideal filters: high pass, low pass, band pass, band stop, example of practical filters in audio and HF systems

Analogue and digital oscillators: Barkhausen criteria; phase shift oscillator, three stage; Colpitts oscillator – BJT or JFET; oscillator characteristics – applications of phase shift and Colpitts oscillators

Concepts of instrumentation.

Flow, temperature, pressure and other appropriate measurements

Appropriate terminology: span, range, accuracy, precision, errors, zero, repeatability, sensitivity, hysteresis, etc. (select from AS1541)

Development of SI units, engineering and scientific notation, imperial and metric conversion using calculations, mm Hg, mm Hg, Pa (hPa, Kpa, Mpa etc.), inches water, PSI, etc. also non-standard SI units – kgcm2, etc.

Instrumentation standards (brief overview only): ISA (Instrumentation Society of America); ISO (International Standards Organisation); SAMA (Scientific Apparatus Manufacturers America); BSI (British Standards Institution); AS (Australian Standards); ANSI (American National Standards Symbols and Terminology); Manufacturer Calibration Standards; fluids in process piping colour coding

Identification and purpose of instruments measuring processes directly and those measuring indirectly

Signal transmission of two-wire, 20-100 kPa, 4-20 mA, 1-5V, other applicable standards

Principles of levers, links and calibration of indicator recorder instrument

Application of safety standards at all times (tools, lifting techniques, electrical safety and CPR, pressure lines, housekeeping)

Interpretation of appropriate graphs and tables associated with instrumentation

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/do, repeat/until and for/do; subprograms; functions; procedures

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

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 windows, control view, genesis etc)

Practical exercises

Digital subsystems.

Digital to analogue conversion: typical applications; DA performance characteristics; types – summing type DA converter, R2R ladder DA converter

Analogue to digital conversion: typical applications; AD performance characteristics; types – digital ramp AD converter, successive approximation AD converter, dual slope AD converter, simultaneous (flash) AD converter

Advanced interfacing techniques: logic interface circuits – driving a load (sink and source) from a logic circuit, transistor switches, relays, opto input and output isolation, driver ICs; sensor interfacing

Programmable array devices: applications; types – PLA (programmable logic array), PAL (programmable array logic), PEEL (programmable electrically erasable logic); circuit operation; programming requirements

Amplifier applications.

Coupling methods in multistage amplifiers: capacitance; transformer; direct; characteristics of each method; frequency response; stage gain

Negative feedback: voltage shunt feedback; voltage series feedback; current shunt feedback; current series feedback; effect of feedback on gain, bandwidth, distortion input/output resistance

Power amplifier principles: classes of amplification; conduction angle; efficiency

Transformer coupled power amplifiers: circuit schematics; class A; class B; reflected resistance; efficiency; bias requirements; thermal stability

Complimentary symmetry power amplifiers: quasi complimentary; circuit schematics; class B; class AB; efficiency; bias requirements; cross over distortion; thermal stability; DC balance

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

Basic PLC operation: definitions, terminology and block diagram; scan cycle; basic programming rules; addressing for I/O; halt; run

Programming (using a hand programmer): flowcharts/steps to use when programming; clearing memory; ladder format; Boolean/mnemonic/statement list format; series circuits; parallel circuits; latching circuits; stack register operation; combination series/parallel circuits; inversion elements; timers (DOE); counters; monitor discrete I/O and timer/counter values; edit (insert and delete elements)

Connect discrete input and output devices to a PLC

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: Data capture

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

BJT and FET symbols: PNP, NPN; JFET; MOSFET; device characteristics BJT and JFET; biasing – need for circuit types; calculation and measurement of bias conditions; DC stability for BJT and JFET circuits; Quiescent point selection for BJT and JFET

Data sheet usage for BJT, JFET and MOSFET: small signal characteristics for single stage BJT and JFET circuits; fault conditions for single stage BJT and JFET circuits

Coupling and bypass capacitors: applications for single stage BJT and JFET circuit; frequency response, effect of coupling and bypass capacitors – measurement only; factors effecting selection – based on practical demonstration

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

Basic PLC operation: definitions, terminology and block diagram; scan cycle; basic programming rules; addressing for I/O; halt; run

Programming (using a hand programmer): flowcharts/steps to use when programming; clearing memory; ladder format; Boolean/mnemonic/statement list format; series circuits; parallel circuits; latching circuits; stack register operation; combination series/parallel circuits; inversion elements; timers (DOE); counters; monitor discrete I/O and timer/counter values; edit (insert and delete elements)

Connect discrete input and output devices to a PLC

Feedback, filters and oscillators.

Positive and negative feedback

Effects of negative feedback on voltage amplifier

Ideal filters: high pass, low pass, band pass, band stop, example of practical filters in audio and HF systems

Analogue and digital oscillators: Barkhausen criteria; phase shift oscillator, three stage; Colpitts oscillator – BJT or JFET; oscillator characteristics – applications of phase shift and Colpitts oscillators

Automatic data capture systems.

Introduction to automatic data capture, (ADC): definition of ADC; reasons for using ADC; labelling types including – barcodes, RF tags, magnetic strips, touch memory, finger prints, visual and voice recognition and smart cards

Barcoding standards and symbologies: including – UPC, EAN, ITF, CODABAR, code 39 code 128, 2D barcodes

Equipment: general input equipment; including pens, wands, CCD scanners and laser scanners; printers and print quality standards; include thermal/laser, dedicated Vrs pre-print codes; ancillary equipment; keyboard wedge, TTL/wand emulation and OCIA software; RF systems; equipment required, applications of RF, cost issues, RF interfacing issue

Interfacing problems: identifying customer needs requirements for system; hardware/hardware – hardware/software, software/software type interfacing, problems with case studies, updating hardware/software issues

Systems examples: point-of-sale, asset management, warehousing, manufacturing, traceability and security systems

Designing a system: input design; interface design; debugging

Filters and resonance.

Resonance in circuits: impedance vs frequency for series resonant circuit; ‘bandwidth’; energy exchange L and C

Parallel resonance: currents in parallel circuit; current, above and below resonance; line current vs frequency; impedance, above, below and at resonance; phasor diagrams for R–L–C circuits; phase angles; power factor correction

Phasor diagrams for L–R, C–R, and R–L–C circuits: impedance of series R–L–C circuits above, below and at the resonant frequency; circuit currents; component voltages; Q factor; introduction, definition; relationship between Q ‘bandwidth’ and the resonant frequency

Capacitive – resistive filters: output voltage vs frequency for a capacitive resistive filter; principles of inductive – resistive filters, for sinewave input signals; graphical representation

Low pass filters: principles of capacitive – resistive filters; principles of inductive – resistive filters; graphical representations

Band stop filters: principles of series resonant circuits as band stop filters for sinewave signals; principles of parallel resonant circuits as band stop filters, for sinewave signals; graphical representations

Band pass filters: principles of series resonant circuits as band pass filters; graphical representation; parallel resonant circuits as band pass filters; graphical representations; circuits using more than one resonant circuit

Other devices used in filter circuits: quartz crystals; ceramic filters; mechanical filters; comb filters; SAW devices; cavity resonators

Control interfacing.

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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 windows, control view, genesis etc)

Practical exercises

Digital subsystems.

Digital to analogue conversion: typical applications; DA performance characteristics; types – summing type DA converter, R2R ladder DA converter

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Telemetry.

Telemetry systems

Advantages and limitations of analogue, digital, pneumatic and fibre optic types

Standards pertaining to telemetering including the International Standard CCI TT V24

Standard signals in common use

Analogue signal converters, signal conditioners, isolators, lighting protection, barrier modules to hazardous areas, analogue multiplexers, transmitters and receivers

Comparison of analogue and digital signals including accuracy and discrimination

Digital word and message structures

Series used in fibre optic systems, physical construction of fibre for light transmission, types of fibre and cladding

Types and characteristics of light sources

Types and characteristics of light detectors

Safety procedures in handling fibre and light sources

Types of transmission lines and links

Digital data links and database lines RS232, RS422, transmission rates and signals acceptable for use

Specialisation: Networks

Computer monitors.

Standards: compatibility; VGA; SVGA

Video adaptors and video drivers: requirements; principles of operation; compatibility of SVGA to VGA; graphics accelerators

Multi sync monitors: synch detection; display mode

CRTs: principles of operation; thermionic emission; electron gun; basic raster scanning; synchronisation; typical electrode voltages; safety; in-line delta; high contrast/brightness; flat screen

Flat panel displays: super twisted nematic (STN); neutralised super twisted nematic (NTN); film compensated super twisted nematic (FTN); passive matrix; active matrix; new technologies

Shielding: safety; radiation; magnetic

Input signal levels: voltage levels

Digital controls and control circuitry: picture size; picture centring; picture symmetry

Basic telephony/switching systems overview.

Sound: characteristics; wave forms; distortion and resonant frequency; voice and audio frequency; pressure; level

Transmission: principles; speed; mediums; limits; telephone functions

Telephone transmitter: function; types; microphones

Telephone receiver: functions; types; operation

Circuit operation of a telephone: facilities; basic operation

Customer switching systems (CSS) services: extension; extension to extension; extension to PSTN; PSTN to extension; operator; phones; modems; switch boards; connection to telephone exchange; public line coming in; enquiry calls; paging; call back; conferencing; hold music; night switching; bip tones

Development of customer switching systems: generations of CSS

Installation procedures: regulations; ACA

Hazards associated with printed circuit board: physical – card damage, vibration; chemical – cleanliness, heman acids, foot, dust, water; electrical – electrical static discharge; other – environmental (UV radiation); safety procedures; storage and packaging of components; electrostatic equipment – leads, earthing mats; protective clothing - gloves

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/do, repeat/until and for/do; subprograms; functions; procedures

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

Microprocessor programming.

Addressing modes: block diagram of a computer system; internal architecture of a microprocessor (uP); overview of instruction set; revision of addressing modes studied so far; immediate, direct, indirect, register and indexed addressing modes; moving blocks of data

Branch instructions: use of flags in decision making; conditional and non-conditional jumps, with relative and direct addressing modes; relationship of clock cycles required for an instruction to the period of the system clock; writing timing loop programs in machine code flow charts

Flag setting: use of masking with logical instructions to allow bit testing using flags; flag setting and testing instructions; bit testing a data byte; use of rotate and shift instructions, relationship to carry flag; compare instructions, use of carry and zero flags to test equality/non-equality of two data bytes; development of flow diagrams and algorithms

Subroutines: need for, and advantages in using subroutines within a program; stack and stack pointer instructions; need for saving registers when using subroutines; conditional subroutine entry and exit instructions

Interrupts: need for interrupts; input polling Vs use of interrupts; maskable and non-maskable interrupts; interrupt modes; interrupt priorities; writing interrupt service routines

Multimedia computer systems.

Multimedia systems: multimedia PC (MPC) 1 standard; multimedia PC (MPC) 2 standard; new multimedia standards; pixel resolution; scanning resolution; output resolution; printer resolution

Mother boards: microprocessor speeds; INTEL ICOMP index rating; cache memory speeds; system bus transfer speeds (VL-bus, PCI bus, ISA 8 bit, EISA bus, micro channel bus, other bus systems); configuration of a mother board; fault-finding

Multimedia storage devices: RAM, hard disk drive; multimedia storage devices; removable storage hard disk drive; floppy disk drive; CD-ROM drive; digital tape (DAT) drive; other devices

Video cards: video processor; graphic processing; video RAM; bus interfaces; resolution; full motion video; still image

Sound cards: sound card standards; MIDI interface sound card applications; sound card connectors; FM synthesis; wave table; sound card file formats

CD-ROMs: CD-ROM standards; CD-ROM cache memory; CD-ROM drive transfer speeds; CD-ROM interfaces; photo CD compatible; CD recordable; multi-session compatible; CD-ROM publisher; CD-ROM archiving

Colour printers: types of colour printers

Colour scanners: types of scanners; one pass, three pass; scanning software

Category: Electrical (B)

Common

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; multiples and sub-multiples

Power, work and energy: conservation of energy; torque; losses and efficiency; maximum efficiency of machines

Electrical characteristics of materials: conductors, insulators, semi-conductors; electric charge; electric current; electromotive force

The simple circuit: source, load, current path and 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; conversion of electrical energy to other forms (heating,

light, magnetic, chemical)Sources of electrical energy - conversion of other forms to electrical energy

Using measuring instruments: handling measuring instruments; selecting an instrument; setting-up and connecting into circuits; reading scales and read-outs; setting up a CRO

Factors effecting resistance: length, csa and resistivity; temperature change; influence on practical circuits

Resistors: types and applications; value and rating

Series circuits (single source): determine V, I, R, P; Kirchhoff's Voltage Law; voltage dividerParallel circuits: determine V, I, R, P; Kirchhoff's Current Law; current divider

Series/parallel circuits: determine V, I, R, P; bridge networkResistance measurement: hazards; characteristics of instruments and loading effect; direct, volt-ammeter and bridge method; typical field instruments and applications

Capacitance: concept; units; time constant relationshipCapacitors: hazards; factors effecting capacitance; in series; in parallel; measuring/testing/hazards

Inductance: concept; units; time constant relationship

Inductors: factors effecting inductance

Electromagnetism.

Magnetism: field patterns; magnetic induction and screening; applications

Electromagnetism: magnetic field around a current-carrying conductor; Fleming's right-hand rules; forces between current carrying-conductors

Magnetic quantities: units (magnetomotive force, magnetising force, flux density, reluctance); permeability

Magnetisation curve: magnetic characteristics of materials; saturation and hysteresis; comparing magnetic materials

Induced voltage: factors required to induce an emf; forces acting on a conductor

Inductance: concept; unit; factors effecting inductance; self-inductance and mutual inductance

Application of electromagnetic principles: generator action; motor action; applications; unwanted effects

Single phase AC principles.

Sinusoidal alternating voltage and current: generation of a sinusoidal waveform; sinusoidal waveform characteristics; measuring and calculating values; phase relationships

Phasors: phase relationship terms; phasor representation conventions; phase relationships using phasors

Resistance in A.C. circuits: determine V, I, R, P; relationship between voltages and currents

Inductance in A.C. circuits: reactance; inductance in series; inductance in parallel; inductive components in power circuits and systems

Capacitance in A.C. circuits: reactance; capacitance in series; capacitance in parallel; capacitive components in power circuits and systems

AC circuits: impedance; relationship between resistive and reactive components; series, parallel and series-parallel RLC circuits; determine V, I, R, P in RLC circuits; phasor diagrams of RLC circuits

Resonance: conditions; resonance and frequency; effects on current

Ideal transformer: operating principles; primary and secondary voltage and current; applications

Three phase AC principles.

Power and power factor: true, apparent and reactive power; effects of low power factor; improvement

Multiphase systems: comparison of multiphase system; advantage of three phase system

Three phase principles: generation; relationship between generated voltages; phase sequence

Three phase star-connections: connections; line and phase voltages and currents

Three phase four wire systems: purpose of neutral conductor; line and phase voltages and currents; neutral current

Three phase delta-connections: connections; line and phase voltages and currents

Energy and power requirements of A.C. systems: purpose of energy, power, power factor and demand measurement; methods; power factor improvement

Harmonics: harmonics and selective resonance; sources in A.C. systems; problems

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

Wiring requirements - low current.

Mains and submains: selection of cables (suitable cables, maximum demand, installation conditions, conductor size based on current carrying capacity, conductor size based on voltage drop); circuit/protection

Final subcircuits: selection of cables (number of points, maximum demand, installation conditions, conductor size based on current carrying capacity, circuit protection)

Control and protection: requirements; earthing arrangements; supplementary protection

Switchboards: location; equipment requirements; arrangements of equipment

Damp situation: earthing; wiring system; equipment

Construction and demolition site: supply arrangements; installation requirements; testing

Aerial and underground wiring: cable types; aerial line data; underground wiring systems

Electric motors.

Three phase motors: construction; operating principles; performance characteristics

Motor protection: short duration overloads; sustained overloads; locked rotor; under-voltage supply; repetitive starting or reversing; high operating temperature; high operating temperature; high humidity or moisture; enclosures; protection devices

Purpose of limiting starting current of machines: requirements of SAA and local authorities; three phase starters operation and application; motor vs load: speed torque relationships

Connection methods of three phase starters: methods of breaking AC motors; reversal of rotation of AC motors

AS3000 and service rule requirements: connection; control switches; limitation of transient current; automatic starting; protection against over-temperature

Fault testing: balanced line current; terminal voltage; insulation resistance; winding resistance/continuity; control and power circuit testing

Motor principles and characteristics: "rotating" magnetic field; production of torque; split phase motor; shaded-pole motor; capacitor types; universal motor curves; reversal of rotation

Construction: windings, stators and rotors; starting current devices; protection devices

Applications: comparison of torque/power/speed characteristics; calculation of power, torque speed and efficiency; applications

Fault and fault-finding: common faults; diagnostic testing; fault-finding procedures

Circuit protection.

Earthing and earthing systems: reasons for earthing; AS3000 requirements for an effective earthing system; direct, MEN and ELCB - voltage operated earthing system; principles of operation of each earthing system; layouts of typical earthing of electrical installations; advantages of each earthing system

Circuit protection: causes and effects of excess circuit current and voltage; high level short circuit current - fault current; overload protection requirements; understand circuits protection terminologies relative to prospective fault current, discrimination, inverse and definite minimum time; methods of providing arc control in protection devices - both AC and DC; circuit protection devices, their operating parameters and ratings; voltage dependent circuit protection devices - surge protection

Supplementary earthing protection: isolation; operating principles of RCDs; circuit arrangement for RCDs, single and three phase

Specialisation: Control

Electrical wiring and equipment.

Standards: purpose; standards bodies; applications

Using standards: terms; numbering systems; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Wiring requirements - high current.

Mains and submains: using AS3008.1; installation conditions; current carrying capacity; voltage drop

Final subcircuits: number of points; maximum demand; protection; installation conditions; cable selection

Control and protection: requirements; switchboard equipment (arrangement, CT metering, links, circuit protection and control, fault protection)

Hazardous areas: classifications; wiring systems; methods of explosion protection; fault protection

Special installations requirements: theatres and halls; controlled atmosphere rooms; caravans and caravan parks; boating marinas

Electrical installation safety testing.

Legislated regulations: regulations; responsibilities; testing requirements

Testing installations: insulation; earthing continuity; polarity; transposition of earth and neutral; identification of circuit conductors; operation of installation; operation of RCDs

Documentation: reporting tests; minimum requirements

Electrical drawings and their interpretation.

Purpose and use of block, circuit and wiring diagrams

Use of drawing symbols and Australian Standard 1102

Electrical diagram conventions

Use and construction of switching charts

One-way, two-way and multi-position control of lighting circuits

Circuit wiring methods using sheathed cables and looping terminals

The features, purpose and use of site and floor plans and details and standard drawings

Locating the position of electrical services from architectural drawings

Interpretation of wiring and schematic diagrams.

Construction and operation of relays, contactors and starters

Contact ratings of contactors

Power and control circuits

Control circuit symbols and drawing conventions

Conversion of wiring diagrams to ladder diagrams

Control circuit components and their operation

Selection of circuit components from manufacturers' catalogues

Basic control circuit wiring: push-button on-off control; remote stop-start operation; timer circuits; circuits with interlocks; jogging (inching) circuits (non-latching); press safety circuits

Fault-finding techniques

Advanced circuit design techniques: documenting circuit design; modifying circuits

Application of programmable controllers in circuit design

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 (3^{rd} 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: 3^{rd} angle orthogonal projections; isometric; interpretation of drawing symbols; practical exercises

Transformers.

Core construction and winding styles used in transformers

Principles of operation of single and double-wound and single phase transformers

The characteristics of the four basic types of transformers

Insulation resistance, continuity, winding identification, polarity marks

Lighting.

Lighting concepts: terms and units; inverse square law; essential factors to produce visual comfort

Luminaires: types; maintenance of luminaires; use of reflectors and/or diffusers

Lamp types: incandescent, gas discharge and high voltage; characteristics, circuit connections and special features; miscellaneous lamp types; auxiliary control; light dimming; RF interference; common faults; testing of circuits; fault-finding

Special lighting situations: special requirements/rules regarding security; safety and emergency lighting; use of standards appropriate to these situations

DC machines.

DC machine principles: generated emf, lap and wave windings; control of output voltage; armature reaction; commutation; interpoles and compensating windings; back emf, torque and speed; losses and efficiency

DC machine types and connections: permanent magnet; separately excited; shunt, series, compound and series universal; reversal

DC machine characteristics and applications for shunt, series and compound: excitation/voltage; speed/voltage; load voltage/load current; torque/load current; torque/speed; speed/load current; applications

DC motor starters: starting current; concept of current limitation; calculation of resistance for limiting starting current; operation of common types of starters

Specialised DC machines: tachogenerator; servomotors; stepper motors

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

Basic PLC operation: definitions, terminology and block diagram; scan cycle; basic programming rules; addressing for I/O; halt; run

Programming (using a hand programmer): flowcharts/steps to use when programming; clearing memory; ladder format; Boolean/mnemonic/statement list format; series circuits; parallel circuits; latching circuits; stack register operation; combination series/parallel circuits; inversion elements; timers (DOE); counters; monitor discrete I/O and timer/counter values; edit (insert and delete elements)

Connect discrete input and output devices to a PLC

Basic power supplies (D.C.).

Rectifier diode: P-N junction; silicon and germanium characteristics; diode specifications; terminal identification; diode ohm meter testing

Half wave rectifier: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Centre tapped full wave: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Bridge rectifier: basic circuit; VAC/VDC relationship; measurement and testing

Three phase rectifiers: half wave; full wave; waveforms; % ripple; calculations of V and I for resistive loads

Basic filter circuits: capacitor; inductive; L section; Pi section

Zener regulators: zener diode characteristics; shunt regulator circuit; regulator specifications; line/load regulation; series resistor calculations; applications

Three-terminal regulators: characteristics and specifications; connection diagram; circuit stability requirements; reverse voltage protection methods

Dual polarity supplies: need for dual polarity; basic IC dual polarity regulator

Basic power supply protection: fuses; VDR’s; LCR networks

Power control systems.

Methods of power control and phase angle control

Pulsed power control: bimetal thermostat heaters; half-wave/full-wave control - duo temperature soldering irons; series resistor control – continuously variable

Power control devices, symbols and specification and in-circuit operation: operation of typical half-wave and full wave power control circuits; limitations of phase angle control and noise reduction methods; fault-finding and safety problems

Cells and batteries.

Primary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Secondary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Cell configurations: series; parallel; terminal voltage; battery capacity

Secondary batteries: charge/discharge process; charge condition monitoring; internal resistance; commissioning procedures

Storage battery banks: applications; charging methods; change over/on line methods; ventilation requirements; types of batteries; capacities; routine maintenance; handling procedures; first aid requirements

Transducers.

Types of transducers and their applications: thermistor (NTC and PTC); light dependent resistor (LDR); photo-transistor; opto-coupler; speaker – electro magnetic, dynamic, Piezzo; magnetic pick up cartridge; light emitting diode; strain gauge; hall effect device; thermocouple; Peltier effect device; Piezzo electric device; microphone

Synchronous machines.

Principles of operation: construction details; cooling; excitation methods; effect of load alternator voltage; voltage regulation; ratings; parallel operation

Portable alternators: constructional details of common types; ratings

Three-phase synchronous motors: construction details; principles of operation; effect of load; effect of varying field excitation; starting methods; applications

Single-phase synchronous motors: common types; constructional details; applications

Concepts of instrumentation.

Flow, temperature, pressure and other appropriate measurements

Appropriate terminology: span, range, accuracy, precision, errors, zero, repeatability, sensitivity, hysteresis, etc. (select from AS1541)

Development of SI units, engineering and scientific notation, imperial and metric conversion using calculations, mm Hg, mm Hg, Pa (hPa, Kpa, Mpa etc.), inches water, PSI, etc. also non-standard SI units – kgcm2, etc.

Instrumentation standards (brief overview only): ISA (Instrumentation Society of America); ISO (International Standards Organisation); SAMA (Scientific Apparatus Manufacturers America); BSI (British Standards Institution); AS (Australian Standards); ANSI (American National Standards Symbols and Terminology); Manufacturer Calibration Standards; fluids in process piping colour coding

Identification and purpose of instruments measuring processes directly and those measuring indirectly

Signal transmission of two-wire, 20-100 kPa, 4-20 mA, 1-5V, other applicable standards

Principles of levers, links and calibration of indicator recorder instrument

Application of safety standards at all times (tools, lifting techniques, electrical safety and CPR, pressure lines, housekeeping)

Interpretation of appropriate graphs and tables associated with instrumentation

Specialisation: Energy supply

Electrical wiring and equipment.

Standards: purpose; standards bodies; applications

Using standards: terms; numbering systems; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Wiring requirements - high current.

Mains and submains: using AS3008.1; installation conditions; current carrying capacity; voltage drop

Final subcircuits: number of points; maximum demand; protection; installation conditions; cable selection

Control and protection: requirements; switchboard equipment (arrangement, CT metering, links, circuit protection and control, fault protection)

Hazardous areas: classifications; wiring systems; methods of explosion protection; fault protection

Special installations requirements: theatres and halls; controlled atmosphere rooms; caravans and caravan parks; boating marinas

Electrical installation safety testing.

Legislated regulations: regulations; responsibilities; testing requirements

Testing installations: insulation; earthing continuity; polarity; transposition of earth and neutral; identification of circuit conductors; operation of installation; operation of RCDs

Documentation: reporting tests; minimum requirements

Electrical drawings and their interpretation.

Purpose and use of block, circuit and wiring diagrams

Use of drawing symbols and Australian Standard 1102

Electrical diagram conventions

Use and construction of switching charts

One-way, two-way and multi-position control of lighting circuits

Circuit wiring methods using sheathed cables and looping terminals

The features, purpose and use of site and floor plans, details and standard drawings

Locating the position of electrical services from architectural drawings

Interpretation of wiring and schematic diagrams.

Construction and operation of relays, contactors and starters

Contact ratings of contactors

Power and control circuits

Control circuit symbols and drawing conventions

Conversion of wiring diagrams to ladder diagrams

Control circuit components and their operation

Selection of circuit components from manufacturers' catalogues

Basic control circuit wiring: push-button on-off control; remote stop-start operation; timer circuits; circuits with interlocks; jogging (inching) circuits (non-latching); press safety circuits

Fault-finding techniques

Advanced circuit design techniques: documenting circuit design; modifying circuits

Application of programmable controllers in circuit design

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, material 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

Transformers.

Core construction and winding styles used in transformers

Principles of operation of single and double-wound and single phase transformers

The characteristics of the four basic types of transformers

Insulation resistance, continuity, winding identification, polarity marks

Lighting.

Lighting concepts: terms and units; inverse square law; essential factors to produce visual comfort

Luminaires: types; maintenance of luminaires; use of reflectors and/or diffusers

Lamp types: incandescent, gas discharge and high voltage; characteristics, circuit connections and special features; miscellaneous lamp types; auxiliary control; light dimming; RF interference; common faults; testing of circuits; fault-finding

Special lighting situations: special requirements/rules regarding security; safety and emergency lighting; use of standards appropriate to these situations

DC machines.

DC machine principles: generated emf, lap and wave windings; control of output voltage; armature reaction; commutation; interpoles and compensating windings; back emf, torque and speed; losses and efficiency

DC machine types and connections: permanent magnet; separately excited; shunt, series, compound and series universal; reversal

DC machine characteristics and applications for shunt, series and compound: excitation/voltage; speed/voltage; load voltage/load current; torque/load current; torque/speed; speed/load current; applications

DC motor starters: starting current; concept of current limitation; calculation of resistance for limiting starting current; operation of common types of starters

Specialised DC machines: tachogenerator; servomotors; stepper motors

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

Basic PLC operation: definitions, terminology and block diagram; scan cycle; basic programming rules; addressing for I/O; halt; run

Programming (using a hand programmer): flowcharts/steps to use when programming; clearing memory; ladder format; Boolean/mnemonic/statement list format; series circuits; parallel circuits; latching circuits; stack register operation; combination series/parallel circuits; inversion elements; timers (DOE); counters; monitor discrete I/O and timer/counter values; edit (insert and delete elements)

Connect discrete input and output devices to a PLC

Basic power supplies (D.C.).

Rectifier diode: P-N junction; silicon and germanium characteristics; diode specifications; terminal identification; diode ohm meter testing

Half wave rectifier: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Centre tapped full wave: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Bridge rectifier: basic circuit; VAC/VDC relationship; measurement and testing

Three phase rectifiers: half wave; full wave; waveforms; % ripple; calculations of V and I for resistive loads

Basic filter circuits: capacitor; inductive; L section; Pi section

Zener regulators: zener diode characteristics; shunt regulator circuit; regulator specifications; line/load regulation; series resistor calculations; applications

Three-terminal regulators: characteristics and specifications; connection diagram; circuit stability requirements; reverse voltage protection methods

Dual polarity supplies: need for dual polarity; basic IC dual polarity regulator

Basic power supply protection: fuses; VDR's; LCR networks

Power control systems.

Methods of power control and phase angle control

Pulsed power control: bimetal thermostat heaters; half-wave/full-wave control - duo temperature soldering irons; series resistor control – continuously variable

Power control devices, symbols and specification and in-circuit operation: operation of typical half-wave and full wave power control circuits; limitations of phase angle control and noise reduction methods; fault-finding and safety problems

Cells and batteries.

Primary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Secondary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Cell configurations: series; parallel; terminal voltage; battery capacity

Secondary batteries: charge/discharge process; charge condition monitoring; internal resistance; commissioning procedures

Storage battery banks: applications; charging methods; change over/on line methods; ventilation requirements; types of batteries; capacities; routine maintenance; handling procedures; first aid requirements

Transducers.

Types of transducers and their applications: thermistor (NTC and PTC); light dependent resistor (LDR); photo-transistor; opto-coupler; speaker –electro magnetic, dynamic, Piezzo; magnetic pick up cartridge; light emitting diode; strain gauge; hall effect device; thermocouple; Peltier effect device; Piezzo electric device; microphone

Energy supply.

Generation: definition; primary energy sources; power stations; power station output; acts and legislation relating to generation

Transmission: system requirements; principle components of a power system; voltage levels; grid systems; acts/legislation relating to transmission; future trends

Distribution: high voltage distribution systems; medium/low voltage distribution systems; radial feeders; parallel feeders; ring main feeders; acts/legislation relating to distribution

Substations: purpose; location; layout

Overhead and underground systems: relative merits; applications; planning; installation

Metering and load control.

Metering: purpose

Metered quantities: energy; maximum demand

Accuracy classes for metering systems

Kilowatt hour meter: construction; operation; adjustments; testing

Demand meter: construction; operation

Metering circuits: direct metering; instrument transformer metering

Electronic metering systems: types; applications; connections

Recording meters: types; applications; connections

Load control: purpose; methods

Specialisation: Fire protection

Electrical wiring and equipment.

Standards: purpose; standards bodies; applications

Using standards: terms; numbering systems; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Wiring requirements - high current.

Mains and submains: using AS3008.1; installation conditions; current carrying capacity; voltage drop

Final subcircuits: number of points; maximum demand; protection; installation conditions; cable selection

Control and protection: requirements; switchboard equipment (arrangement, CT metering, links, circuit protection and control, fault protection)

Hazardous areas: classifications; wiring systems; methods of explosion protection; fault protection

Special installations requirements: theatres and halls; controlled atmosphere rooms; caravans and caravan parks; boating marinas

Electrical installation safety testing.

Legislated regulations: regulations; responsibilities; testing requirements

Testing installations: insulation; earthing continuity; polarity; transposition of earth and neutral; identification of circuit conductors; operation of installation; operation of RCDs

Documentation: reporting tests; minimum requirements

Electrical drawings and their interpretation.

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Control circuit components and their operation

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Fault-finding techniques

Advanced circuit design techniques: documenting circuit design; modifying circuits

Application of programmable controllers in circuit design

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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

Transformers.

Core construction and winding styles used in transformers

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The characteristics of the four basic types of transformers

Insulation resistance, continuity, winding identification, polarity marks

Lighting.

Lighting concepts: terms and units; inverse square law; essential factors to produce visual comfort

Luminaires: types; maintenance of luminaires; use of reflectors and/or diffusers

Lamp types: incandescent, gas discharge and high voltage; characteristics, circuit connections and special features; miscellaneous lamp types; auxiliary control; light dimming; RF interference; common faults; testing of circuits; fault-finding

Special lighting situations: special requirements/rules regarding security; safety and emergency lighting; use of standards appropriate to these situations

DC machines.

DC machine principles: generated emf, lap and wave windings; control of output voltage; armature reaction; commutation; interpoles and compensating windings; back emf, torque and speed; losses and efficiency

DC machine types and connections: permanent magnet; separately excited; shunt, series, compound and series universal; reversal

DC machine characteristics and applications for shunt, series and compound: excitation/voltage; speed/voltage; load voltage/load current; torque/load current; torque/speed; speed/load current; applications

DC motor starters: starting current; concept of current limitation; calculation of resistance for limiting starting current; operation of common types of starters

Specialised DC machines: tachogenerator; servomotors; stepper motors

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

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Connect discrete input and output devices to a PLC

Basic power supplies (D.C.).

Rectifier diode: P-N junction; silicon and germanium characteristics; diode specifications; terminal identification; diode ohm meter testing

Half wave rectifier: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Centre tapped full wave: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Bridge rectifier: basic circuit; VAC/VDC relationship; measurement and testing

Three phase rectifiers: half wave; full wave; waveforms; % ripple; calculations of V and I for resistive loads

Basic filter circuits: capacitor; inductive; L section; Pi section

Zener regulators: zener diode characteristics; shunt regulator circuit; regulator specifications; line/load regulation; series resistor calculations; applications

Three-terminal regulators: characteristics and specifications; connection diagram; circuit stability requirements; reverse voltage protection methods

Dual polarity supplies: need for dual polarity; basic IC dual polarity regulator

Basic power supply protection: fuses; VDR's; LCR networks

Power control systems.

Methods of power control and phase angle control

Pulsed power control: bimetal thermostat heaters; half-wave/full-wave control - duo temperature soldering irons; series resistor control – continuously variable

Power control devices, symbols and specification and in-circuit operation: operation of typical half-wave and full wave power control circuits; limitations of phase angle control and noise reduction methods; fault-finding and safety problems

Cells and batteries.

Primary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Secondary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Cell configurations: series; parallel; terminal voltage; battery capacity

Secondary batteries: charge/discharge process; charge condition monitoring; internal resistance; commissioning procedures

Storage battery banks: applications; charging methods; change over/on line methods; ventilation requirements; types of batteries; capacities; routine maintenance; handling procedures; first aid requirements

Transducers.

Types of transducers and their applications: thermistor (NTC and PTC); light dependent resistor (LDR); photo-transistor; opto-coupler; speaker – electro magnetic, dynamic, Piezzo; magnetic pick up cartridge; light emitting diode; strain gauge; hall effect device; thermocouple; Peltier effect device; Piezzo electric device; microphone

Building automation fire protection installation.

Purpose of automatic fire detection and alarm systems: preservation of life; protection of buildings and equipment

Standards and codes: general legislation and codes; specific legislation – Halon systems, ionisation smoke detectors; legal liability

Fire characteristics: principles of fire detection – fire growth; principles of fire suppression

Generic automatic fire detection and alarm system: overview of automatic fire detection and alarm system

Fire detection actuating devices: fire detector classification; detector patterns; detector types, principles of operation and performance; heat detectors – electro-pneumatic, fusible alloy, bimetallic, solid state, thermo-plastic; smoke detectors – ionisation, photo-electric, beam light obscuration, sampling light scatter (aspirating); flame detectors – infra-red, ultra-violet, manual call points; special purpose detectors – flammable vapour/gas detectors, explosion detectors

Control and indicating equipment (CIE): fire panels; classification; types; principles of operation; installation; commissioning report as per AS 1670

Emergency warning and intercommunication system (EWIS): purpose; types; installation; codes and requirements; manufacturers' specifications and requirements – AS3000 series, AS1670, AS2220, AS1668

Alarms: local alarms – purpose, types, installation; transmitted alarms – purpose, types, installation; control outputs – purpose, types, installation; pump control – purpose, pump actuation; codes and requirements – manufacturers' specifications, manufacturers' requirements for handling; building codes Australia – AS1668, AS1670, AS1851

Suppression systems: sprinkler systems; sequence of operation; purpose of interfacing devices; special purpose gaseous, dry chemical, foam, explosion suppression; suppression actuating devices; purpose; sequence of operation; purpose of interfacing devices; types of interfacing devices; installation of interfacing devices; purpose of actuation devices; types of actuation devices; installation of actuation devices; codes and requirements – manufacturers' specifications, manufacturers' requirements for handling; building codes Australia – AS1670, AS1851, AS1668

Cabling: types of fire cables – mineral insulated metal sheathed cable (MIMS), radox cable, data cable, fibre optic cable; codes and requirements – manufacturers' specifications and requirements, AS3000 series, AS1670, ACA standards; installation of fire cables; detector selection – detector installation; detection systems – conventional, distributed, network; detection system installation; codes and requirements; manufacturers' specifications; manufacturers' requirements for handling; building codes Australia – AS1670, AS1851, AS3000

Specialisation: Installation and servicing

Electrical wiring and equipment.

Standards: purpose; standards bodies; applications

Using standards: terms; numbering systems; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Wiring requirements - high current.

Mains and submains: using AS3008.1; installation conditions; current carrying capacity; voltage drop

Final subcircuits: number of points; maximum demand; protection; installation conditions; cable selection

Control and protection: requirements; switchboard equipment (arrangement, CT metering, links, circuit protection and control, fault protection)

Hazardous areas: classifications; wiring systems; methods of explosion protection; fault protection

Special installations requirements: theatres and halls; controlled atmosphere rooms; caravans and caravan parks; boating marinas

Electrical installation safety testing.

Legislated regulations: regulations; responsibilities; testing requirements

Testing installations: insulation; earthing continuity; polarity; transposition of earth and neutral; identification of circuit conductors; operation of installation; operation of RCDs

Documentation: reporting tests; minimum requirements

Electrical drawings and their interpretation.

Purpose and use of block, circuit and wiring diagrams

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Basic control circuit wiring: push-button on-off control; remote stop-start operation; timer circuits; circuits with interlocks; jogging (inching) circuits (non-latching); press safety circuits

Fault-finding techniques

Advanced circuit design techniques: documenting circuit design; modifying circuits

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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

Transformers.

Core construction and winding styles used in transformers

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Lighting.

Lighting concepts: terms and units; inverse square law; essential factors to produce visual comfort

Luminaires: types; maintenance of luminaires; use of reflectors and/or diffusers

Lamp types: incandescent, gas discharge and high voltage; characteristics, circuit connections and special features; miscellaneous lamp types; auxiliary control; light dimming; RF interference; common faults; testing of circuits; fault-finding

Special lighting situations: special requirements/rules regarding security; safety and emergency lighting; use of standards appropriate to these situations

DC machines.

DC machine principles: generated emf, lap and wave windings; control of output voltage; armature reaction; commutation; interpoles and compensating windings; back emf, torque and speed; losses and efficiency

DC machine types and connections: permanent magnet; separately excited; shunt, series, compound and series universal; reversal

DC machine characteristics and applications for shunt, series and compound: excitation/voltage; speed/voltage; load voltage/load current; torque/load current; torque/speed; speed/load current; applications

DC motor starters: starting current; concept of current limitation; calculation of resistance for limiting starting current; operation of common types of starters

Specialised DC machines: tachogenerator; servomotors; stepper motors

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Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

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Three-terminal regulators: characteristics and specifications; connection diagram; circuit stability requirements; reverse voltage protection methods

Dual polarity supplies: need for dual polarity; basic IC dual polarity regulator

Basic power supply protection: fuses; VDR’s; LCR networks

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Cell configurations: series; parallel; terminal voltage; battery capacity

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Substations: purpose; location; layout

Overhead and underground systems: relative merits; applications; planning; installation

Electrical heating.

Temperature: heat energy; specific heat capacity; heat transfer; thermal conductivity; electrical equivalent (kWh) of heat energy

Control of heating: manual; automatic control; electronic and other forms of heat control

Heating process: water heating; space heating; cooking; industrial process heating

Specialisation: Maritime installation

Electrical wiring and equipment.

Standards: purpose; standards bodies; applications

Using standards: terms; numbering systems; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Wiring requirements - high current.

Mains and submains: using AS3008.1; installation conditions; current carrying capacity; voltage drop

Final subcircuits: number of points; maximum demand; protection; installation conditions; cable selection

Control and protection: requirements; switchboard equipment (arrangement, CT metering, links, circuit protection and control, fault protection)

Hazardous areas: classifications; wiring systems; methods of explosion protection; fault protection

Special installations requirements: theatres and halls; controlled atmosphere rooms; caravans and caravan parks; boating marinas

Electrical installation safety testing.

Legislated regulations: regulations; responsibilities; testing requirements

Testing installations: insulation; earthing continuity; polarity; transposition of earth and neutral; identification of circuit conductors; operation of installation; operation of RCDs

Documentation: reporting tests; minimum requirements

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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

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Lighting concepts: terms and units; inverse square law; essential factors to produce visual comfort

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Special lighting situations: special requirements/rules regarding security; safety and emergency lighting; use of standards appropriate to these situations

DC machines.

DC machine principles: generated emf, lap and wave windings; control of output voltage; armature reaction; commutation; interpoles and compensating windings; back emf, torque and speed; losses and efficiency

DC machine types and connections: permanent magnet; separately excited; shunt, series, compound and series universal; reversal

DC machine characteristics and applications for shunt, series and compound: excitation/voltage; speed/voltage; load voltage/load current; torque/load current; torque/speed; speed/load current; applications

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Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

Basic PLC operation: definitions, terminology and block diagram; scan cycle; basic programming rules; addressing for I/O; halt; run

Programming (using a hand programmer): flowcharts/steps to use when programming; clearing memory; ladder format; Boolean/mnemonic/statement list format; series circuits; parallel circuits; latching circuits; stack register operation; combination series/parallel circuits; inversion elements; timers (DOE); counters; monitor discrete I/O and timer/counter values; edit (insert and delete elements)

Connect discrete input and output devices to a PLC

Basic power supplies (D.C.).

Rectifier diode: P-N junction; silicon and germanium characteristics; diode specifications; terminal identification; diode ohm meter testing

Half wave rectifier: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Centre tapped full wave: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Bridge rectifier: basic circuit; VAC/VDC relationship; measurement and testing

Three phase rectifiers: half wave; full wave; waveforms; % ripple; calculations of V and I for resistive loads

Basic filter circuits: capacitor; inductive; L section; Pi section

Zener regulators: zener diode characteristics; shunt regulator circuit; regulator specifications; line/load regulation; series resistor calculations; applications

Three-terminal regulators: characteristics and specifications; connection diagram; circuit stability requirements; reverse voltage protection methods

Dual polarity supplies: need for dual polarity; basic IC dual polarity regulator

Basic power supply protection: fuses; VDR's; LCR networks

Power control systems.

Methods of power control and phase angle control

Pulsed power control: bimetal thermostat heaters; half-wave/full-wave control - duo temperature soldering irons; series resistor control – continuously variable

Power control devices, symbols and specification and in-circuit operation: operation of typical half-wave and full wave power control circuits; limitations of phase angle control and noise reduction methods; fault-finding and safety problems

Cells and batteries.

Primary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Secondary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Cell configurations: series; parallel; terminal voltage; battery capacity

Secondary batteries: charge/discharge process; charge condition monitoring; internal resistance; commissioning procedures

Storage battery banks: applications; charging methods; change over/on line methods; ventilation requirements; types of batteries; capacities; routine maintenance; handling procedures; first aid requirements

Transducers.

Types of transducers and their applications: thermistor (NTC and PTC); light dependent resistor (LDR); photo-transistor; opto-coupler; speaker – electro magnetic, dynamic, Piezzo; magnetic pick up cartridge; light emitting diode; strain gauge; hall effect device; thermocouple; Peltier effect device; Piezzo electric device; microphone

Marine electrotechnology.

Marine electrical layouts: main switchboard; emergency switchboard; shore supply; interconnections between them; important components and instruments; indicating lights; meters

Alternators: constructions; voltage; regulation; characteristic excitation; AVR systems

Paralleling: auto and manual synchronizing and paralleling of alternators including machines of different capacities; operation of synchronizing equipment

Switchboards: operation; testing and maintenance of ACB, MCCB and MCB including opening and closing systems; arcing control; procedure for removal

Marine lighting systems

Batteries: layout of ships battery system; connections; types of batteries; maintenance and safety aspects

UPS systems: operating principles; power management and fault diagnosis

Cathodic protection: types; operating parameters and corrosion factors

Safety: components; regulations and safe practices for tankers with hazardous cargo's

Management: plant performance evaluation; commissioning new systems and electrical surveys

Specialisation: Mining

Electrical wiring and equipment.

Standards: purpose; standards bodies; applications

Using standards: terms; numbering systems; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Wiring requirements - high current.

Mains and submains: using AS3008.1; installation conditions; current carrying capacity; voltage drop

Final subcircuits: number of points; maximum demand; protection; installation conditions; cable selection

Control and protection: requirements; switchboard equipment (arrangement, CT metering, links, circuit protection and control, fault protection)

Hazardous areas: classifications; wiring systems; methods of explosion protection; fault protection

Special installations requirements: theatres and halls; controlled atmosphere rooms; caravans and caravan parks; boating marinas

Electrical installation safety testing.

Legislated regulations: regulations; responsibilities; testing requirements

Testing installations: insulation; earthing continuity; polarity; transposition of earth and neutral; identification of circuit conductors; operation of installation; operation of RCDs

Documentation: reporting tests; minimum requirements

Electrical drawings and their interpretation.

Purpose and use of block, circuit and wiring diagrams

Use of drawing symbols and Australian Standard 1102

Electrical diagram conventions

Use and construction of switching charts

One-way, two-way and multi-position control of lighting circuits

Circuit wiring methods using sheathed cables and looping terminals

The features, purpose and use of site and floor plans and details and standard drawings

Locating the position of electrical services from architectural drawings

Interpretation of wiring and schematic diagrams.

Construction and operation of relays, contactors and starters

Contact ratings of contactors

Power and control circuits

Control circuit symbols and drawing conventions

Conversion of wiring diagrams to ladder diagrams

Control circuit components and their operation

Selection of circuit components from manufacturers' catalogues

Basic control circuit wiring: push-button on-off control; remote stop-start operation; timer circuits; circuits with interlocks; jogging (inching) circuits (non-latching); press safety circuits

Fault-finding techniques

Advanced circuit design techniques: documenting circuit design; modifying circuits

Application of programmable controllers in circuit design

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

Transformers.

Core construction and winding styles used in transformers

Principles of operation of single and double-wound and single phase transformers

The characteristics of the four basic types of transformers

Insulation resistance, continuity, winding identification, polarity marks

Lighting.

Lighting concepts: terms and units; inverse square law; essential factors to produce visual comfort

Luminaires: types; maintenance of luminaires; use of reflectors and/or diffusers

Lamp types: incandescent, gas discharge and high voltage; characteristics, circuit connections and special features; miscellaneous lamp types; auxiliary control; light dimming; RF interference; common faults; testing of circuits; fault-finding

Special lighting situations: special requirements/rules regarding security; safety and emergency lighting; use of standards appropriate to these situations

DC machines.

DC machine principles: generated emf, lap and wave windings; control of output voltage; armature reaction; commutation; interpoles and compensating windings; back emf, torque and speed; losses and efficiency

DC machine types and connections: permanent magnet; separately excited; shunt, series, compound and series universal; reversal

DC machine characteristics and applications for shunt, series and compound: excitation/voltage; speed/voltage; load voltage/load current; torque/load current; torque/speed; speed/load current; applications

DC motor starters: starting current; concept of current limitation; calculation of resistance for limiting starting current; operation of common types of starters

Specialised DC machines: tachogenerator; servomotors; stepper motors

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

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Basic filter circuits: capacitor; inductive; L section; Pi section

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Three-terminal regulators: characteristics and specifications; connection diagram; circuit stability requirements; reverse voltage protection methods

Dual polarity supplies: need for dual polarity; basic IC dual polarity regulator

Basic power supply protection: fuses; VDR’s; LCR networks

Power control systems.

Methods of power control and phase angle control

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Secondary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Cell configurations: series; parallel; terminal voltage; battery capacity

Secondary batteries: charge/discharge process; charge condition monitoring; internal resistance; commissioning procedures

Storage battery banks: applications; charging methods; change over/on line methods; ventilation requirements; types of batteries; capacities; routine maintenance; handling procedures; first aid requirements

Transducers.

Types of transducers and their applications: thermistor (NTC and PTC); light dependent resistor (LDR); photo-transistor; opto-coupler; speaker – electro magnetic, dynamic, Piezzo; magnetic pick up cartridge; light emitting diode; strain gauge; hall effect device; thermocouple; Peltier effect device; Piezzo electric device; microphone

Mining electrical systems.

Mine reticulation: trailing cables; types; connection and disconnection; handling and storage; examination and testing

Electrical control and protection

Ventilation fans: types; installation; protection requirements; electrical interlocking

Static electricity: sources and containment

Gas sensing devices: types (methane, hydrogen sulphide, oxides of nitrogen, carbon monoxide, carbon dioxide

Battery powered vehicles: drive types, control, dynamic and regenerative braking; charging

Communication and control equipment

Mines winders and haulage systems

Codes of practice and safety

Specialisation: Plant servicing

Electrical wiring and equipment.

Standards: purpose; standards bodies; applications

Using standards: terms; numbering systems; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Wiring requirements - high current.

Mains and submains: using AS3008.1; installation conditions; current carrying capacity; voltage drop

Final subcircuits: number of points; maximum demand; protection; installation conditions; cable selection

Control and protection: requirements; switchboard equipment (arrangement, CT metering, links, circuit protection and control, fault protection)

Hazardous areas: classifications; wiring systems; methods of explosion protection; fault protection

Special installations requirements: theatres and halls; controlled atmosphere rooms; caravans and caravan parks; boating marinas

Electrical installation safety testing.

Legislated regulations: regulations; responsibilities; testing requirements

Testing installations: insulation; earthing continuity; polarity; transposition of earth and neutral; identification of circuit conductors; operation of installation; operation of RCDs

Documentation: reporting tests; minimum requirements

Electrical drawings and their interpretation.

Purpose and use of block, circuit and wiring diagrams

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Fault-finding techniques

Advanced circuit design techniques: documenting circuit design; modifying circuits

Application of programmable controllers in circuit design

Drawing interpretation and sketching.

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Lighting.

Lighting concepts: terms and units; inverse square law; essential factors to produce visual comfort

Luminaires: types; maintenance of luminaires; use of reflectors and/or diffusers

Lamp types: incandescent, gas discharge and high voltage; characteristics, circuit connections and special features; miscellaneous lamp types; auxiliary control; light dimming; RF interference; common faults; testing of circuits; fault-finding

Special lighting situations: special requirements/rules regarding security; safety and emergency lighting; use of standards appropriate to these situations

DC machines.

DC machine principles: generated emf, lap and wave windings; control of output voltage; armature reaction; commutation; interpoles and compensating windings; back emf, torque and speed; losses and efficiency

DC machine types and connections: permanent magnet; separately excited; shunt, series, compound and series universal; reversal

DC machine characteristics and applications for shunt, series and compound: excitation/voltage; speed/voltage; load voltage/load current; torque/load current; torque/speed; speed/load current; applications

DC motor starters: starting current; concept of current limitation; calculation of resistance for limiting starting current; operation of common types of starters

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Synchronous machines.

Principles of operation: construction details; cooling; excitation methods; effect of load alternator voltage; voltage regulation; ratings; parallel operation

Portable alternators: constructional details of common types; ratings

Three-phase synchronous motors: construction details; principles of operation; effect of load; effect of varying field excitation; starting methods; applications

Single-phase synchronous motors: common types; constructional details; applications

Concepts of instrumentation.

Flow, temperature, pressure and other appropriate measurements

Appropriate terminology: span, range, accuracy, precision, errors, zero, repeatability, sensitivity, hysteresis, etc. (select from AS1541)

Development of SI units, engineering and scientific notation, imperial and metric conversion using calculations, mm Hg, mm Hg, Pa (hPa, Kpa, Mpa etc.), inches water, PSI, etc. also non-standard SI units – kgcm2, etc.

Instrumentation standards (brief overview only): ISA (Instrumentation Society of America); ISO (International Standards Organisation); SAMA (Scientific Apparatus Manufacturers America); BSI (British Standards Institution); AS (Australian Standards); ANSI (American National Standards Symbols and Terminology); Manufacturer Calibration Standards; fluids in process piping colour coding

Identification and purpose of instruments measuring processes directly and those measuring indirectly

Signal transmission of two-wire, 20-100 kPa, 4-20 mA, 1-5V, other applicable standards

Principles of levers, links and calibration of indicator recorder instrument

Application of safety standards at all times (tools, lifting techniques, electrical safety and CPR, pressure lines, housekeeping)

Interpretation of appropriate graphs and tables associated with instrumentation

Specialisation: Process

Electrical wiring and equipment.

Standards: purpose; standards bodies; applications

Using standards: terms; numbering systems; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Wiring requirements - high current.

Mains and submains: using AS3008.1; installation conditions; current carrying capacity; voltage drop

Final subcircuits: number of points; maximum demand; protection; installation conditions; cable selection

Control and protection: requirements; switchboard equipment (arrangement, CT metering, links, circuit protection and control, fault protection)

Hazardous areas: classifications; wiring systems; methods of explosion protection; fault protection

Special installations requirements: theatres and halls; controlled atmosphere rooms; caravans and caravan parks; boating marinas

Electrical installation safety testing.

Legislated regulations: regulations; responsibilities; testing requirements

Testing installations: insulation; earthing continuity; polarity; transposition of earth and neutral; identification of circuit conductors; operation of installation; operation of RCDs

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Interpretation of appropriate graphs and tables associated with instrumentation

Pressure measurement.

Pressure, density, height, force, area units: calculation of pressure required to support liquid columns; calculation of related values of pressure, force and area

Absolute, gauge and differential pressure scales and their interrelationship: reference point for scales; atmospheric pressure value using all common measurement units

Absolute, pressure measurement devices for sub-atmosphere range and typical application of these devices

Gauge pressure measurement by means of U-tube, single limb and inclined liquid columns: calculation of wet leg effects

Gauge pressure measurement by means of elastic deformation type gauges: Bourdon types (C/spiral/helix) and ranges

Other mechanical pressure elements: bellow, capsule, slack/stiff diaphragms: pressure gauge installations: tapping points, valves (isolation and bleed), loop seals, snubbers

Pressure calibration devices: pneumatic, hydraulic, electronic

Precautions in calibrating oxygen and chlorine gauges (no oil)

Use of a dead-weight tester to calibrate pressure gauges; gauge and mechanical recorder adjustments for span, zero and linearity. Backlash, hysteresis, repeatability

Electrical sensors for pressure measurements: capacitive, piezo, inductive, strain gauge; calibration adjustments for pneumatic and electrical type pressure measurement and signal transmission devices

Installation requirements for pressure measurement in liquid and gas systems, with and without sealing liquid; isolation, seal, vent, drain and bypass valves location and operation sequence

Temperature measurement.

Heat and temperature: Differentiation between heat and temperature, SI and non-SI temperature scales and units and conversions between scales

Non-electrical thermometers: the principles of operations characteristics and construction of liquid-in-gas, bi-metallic and filled system thermometers

Electrical thermometers: the laws and effects associated with electrical temperature primary elements; the principles of operations, characteristics and construction of thermometers, resistance thermometers (RTDs), thermistors, and semi-conductor and integrated circuit thermometers; compensation and protection devices and associated measuring circuits; circuit connections for average temperature and temperature differences should be able to be examined regarding installation and measuring circuit consideration which vary from the norm

Radiation thermometers: the laws governing radiation thermometers and the properties of a 'black body'; the theory of operation, characteristics and construction of disappearing filament, partial radiation and total thermometers; total and spectral emissivity

Other measurement techniques: the operation and characteristics of pyrometric cones, temperature sensitive pigments and liquid crystals (brief mention only)

Test equipment: the theory of operation, operation and use of Wheatstone bridges, millivolt potentiometers and other test equipment associated with temperature measurement

Errors: the errors specific to temperature measurement - these include thermal lag, fabrication heating conductive cooling and cavitation

Specialisation: Security

Electrical wiring and equipment.

Standards: purpose; standards bodies; applications

Using standards: terms; numbering systems; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Wiring requirements - high current.

Mains and submains: using AS3008.1; installation conditions; current carrying capacity; voltage drop

Final subcircuits: number of points; maximum demand; protection; installation conditions; cable selection

Control and protection: requirements; switchboard equipment (arrangement, CT metering, links, circuit protection and control, fault protection)

Hazardous areas: classifications; wiring systems; methods of explosion protection; fault protection

Special installations requirements: theatres and halls; controlled atmosphere rooms; caravans and caravan parks; boating marinas

Electrical installation safety testing.

Legislated regulations: regulations; responsibilities; testing requirements

Testing installations: insulation; earthing continuity; polarity; transposition of earth and neutral; identification of circuit conductors; operation of installation; operation of RCDs

Documentation: reporting tests; minimum requirements

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The features, purpose and use of site and floor plans and details and standard drawings

Locating the position of electrical services from architectural drawings

Interpretation of wiring and schematic diagrams.

Construction and operation of relays, contactors and starters

Contact ratings of contactors

Power and control circuits

Control circuit symbols and drawing conventions

Conversion of wiring diagrams to ladder diagrams

Control circuit components and their operation

Selection of circuit components from manufacturers' catalogues

Basic control circuit wiring: push-button on-off control; remote stop-start operation; timer circuits; circuits with interlocks; jogging (inching) circuits (non-latching); press safety circuits

Fault-finding techniques

Advanced circuit design techniques: documenting circuit design; modifying circuits

Application of programmable controllers in circuit design

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

Transformers.

Core construction and winding styles used in transformers

Principles of operation of single and double-wound and single phase transformers

The characteristics of the four basic types of transformers

Insulation resistance, continuity, winding identification, polarity marks

Lighting.

Lighting concepts: terms and units; inverse square law; essential factors to produce visual comfort

Luminaires: types; maintenance of luminaires; use of reflectors and/or diffusers

Lamp types: incandescent, gas discharge and high voltage; characteristics, circuit connections and special features; miscellaneous lamp types; auxiliary control; light dimming; RF interference; common faults; testing of circuits; fault-finding

Special lighting situations: special requirements/rules regarding security; safety and emergency lighting; use of standards appropriate to these situations

DC machines.

DC machine principles: generated emf, lap and wave windings; control of output voltage; armature reaction; commutation; interpoles and compensating windings; back emf, torque and speed; losses and efficiency

DC machine types and connections: permanent magnet; separately excited; shunt, series, compound and series universal; reversal

DC machine characteristics and applications for shunt, series and compound: excitation/voltage; speed/voltage; load voltage/load current; torque/load current; torque/speed; speed/load current; applications

DC motor starters: starting current; concept of current limitation; calculation of resistance for limiting starting current; operation of common types of starters

Specialised DC machines: tachogenerator; servomotors; stepper motors

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

Basic PLC operation: definitions, terminology and block diagram; scan cycle; basic programming rules; addressing for I/O; halt; run

Programming (using a hand programmer): flowcharts/steps to use when programming; clearing memory; ladder format; Boolean/mnemonic/statement list format; series circuits; parallel circuits; latching circuits; stack register operation; combination series/parallel circuits; inversion elements; timers (DOE); counters; monitor discrete I/O and timer/counter values; edit (insert and delete elements)

Connect discrete input and output devices to a PLC

Basic power supplies (D.C.).

Rectifier diode: P-N junction; silicon and germanium characteristics; diode specifications; terminal identification; diode ohm meter testing

Half wave rectifier: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Centre tapped full wave: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Bridge rectifier: basic circuit; VAC/VDC relationship; measurement and testing

Three phase rectifiers: half wave; full wave; waveforms; % ripple; calculations of V and I for resistive loads

Basic filter circuits: capacitor; inductive; L section; Pi section

Zener regulators: zener diode characteristics; shunt regulator circuit; regulator specifications; line/load regulation; series resistor calculations; applications

Three-terminal regulators: characteristics and specifications; connection diagram; circuit stability requirements; reverse voltage protection methods

Dual polarity supplies: need for dual polarity; basic IC dual polarity regulator

Basic power supply protection: fuses; VDR’s; LCR networks

Transducers.

Types of transducers and their applications: thermistor (NTC and PTC); light dependent resistor (LDR); photo-transistor; opto-coupler; speaker – electro magnetic, dynamic, Piezzo; magnetic pick up cartridge; light emitting diode; strain gauge; hall effect device; thermocouple; Peltier effect device; Piezzo electric device; microphone

Security systems.

Regulations applicable to the security industry

Design of domestic security system

Building construction

Mechanical detectors: pressure pads; trip wires; window tape; screens; switches; vibration

Electro-mechanical detectors: ultra sonic; microwave; glass break; smoke; active infra-red beams; passive infra red; strain system; electromagnetic; optical fibre cable

Batteries: types; applications; maintenance

Relays: types; applications

Security panels

Communication systems

Close circuit television (CCTV)

Locking devices

Lighting

Specialisation: Signalling (rail)

Electrical wiring and equipment.

Standards: purpose; standards bodies; applications

Using standards: terms; numbering systems; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Wiring requirements - high current.

Mains and submains: using AS3008.1; installation conditions; current carrying capacity; voltage drop

Final subcircuits: number of points; maximum demand; protection; installation conditions; cable selection

Control and protection: requirements; switchboard equipment (arrangement, CT metering, links, circuit protection and control, fault protection)

Hazardous areas: classifications; wiring systems; methods of explosion protection; fault protection

Special installations requirements: theatres and halls; controlled atmosphere rooms; caravans and caravan parks; boating marinas

Electrical installation safety testing.

Legislated regulations: regulations; responsibilities; testing requirements

Testing installations: insulation; earthing continuity; polarity; transposition of earth and neutral; identification of circuit conductors; operation of installation; operation of RCDs

Documentation: reporting tests; minimum requirements

Electrical drawings and their interpretation.

Purpose and use of block, circuit and wiring diagrams

Use of drawing symbols and Australian Standard 1102

Electrical diagram conventions

Use and construction of switching charts

One-way, two-way and multi-position control of lighting circuits

Circuit wiring methods using sheathed cables and looping terminals

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Rail signal systems.

Need for rail signal systems, overall layout of systems, codes and requirements

Input devices and output devices interlocks, circuits, wiring systems used earthing of system components, protection of systems wiring and components

Specialisation: Appliances

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

Appliance timers and controllers.

Application and operation: timer types (mechanical, electrical, electronic, microprocessor); controllers (thermostats, safety cut outs, solenoids, drain valves, water level control); relevant standards

Fault-finding: typical faults from symptoms; manufacturers' circuits diagrams; maintenance manuals; testing procedures; electrical safety

Heating appliances.

Codes, acts and regulations; gas and electrical isolation procedure; leak testing; electrical safety tests; rating plate; potential hazards (combustible materials, flueing and ventilation); safety devices

Construction and operation: gas components (ignitors, regulators, burners, thermostats, automatic controls/timers, safety devices); electrical components (heating elements, thermostats, automatic controls/timers, safety devices); space heaters; hot water systems (gas, electric, solar)

Fault-finding: manufacture's service manuals; fault locations

Cooking appliances.

Codes, regulations and acts: electrical; water; gas; building; health

Construction and operation: gas stoves, ovens and ranges (ignition system, regulator, burner assembly, temperature controllers, safety controls, overall unit operation); electrical stoves, ovens and ranges (hot plates, elements, temperature controllers, accessories, overall unit operation

Installation and commissioning

Service and fault-finding

Washing appliances.

Washing machines: washing actions; transmissions; couplings; motors; pumps; water inlet solenoids; water level controls; sud saver; draining actions; heaters and temperature control; cycle controls; installation procedures

Dryers: types (tumble/airing); motors; drives; heating elements and temperature control; cycle controls; installation procedures

Dishwashers: water control devices; pumps (wash and drain); washing action; elements; temperature control; safety devices; overall unit operation

Service and fault-finding: manufacturers' service instructions; circuit diagrams; operating sequences; typical symptoms

Small kitchen appliances.

Construction and operation: garbage disposal units; food mixer/processors; small heating appliance; small heating appliances; small motor driven appliances; range hoods (knowledge of types, purpose and function, interpretation of manufacturers' specifications)

Service and fault-finding

Refrigeration.

Heat, pressure and temperature: heat low; heat transfer (condition, convection, radiation); gas law; heat measurement; operation of the vapour compression cycle

Components: compressor; evaporator; condenser

Flow control

Pressure temperature relationships: saturation; subcooling; superheating; pressure temperature chart

Absolute and gauge pressure: plotting, basic cycles; saturation curves; subcooling; superheating; measuring heat content

Applications: domestic; commercial; industrial; transport/marine; comfort air conditioning; industrial air conditioning

Refrigeration procedures.

Tubing: types; tubing; annealing

Use of dry nitrogen

Bending methods spring bending tools (lever type) measurement and marking out gain correction

Flaring: types of block; types of flare nut

Pipework: expanding; tube expanders; swaging; recognition of fittings and threads; thread sealants

Silver brazing: joint preparation; fluxes

Job preparation refrigerant isolation/pump down; protection of cabinets from flame brazing in tight corners; use of mirrors pressure testing

Gauges: types; care and maintenance

Valves: service; shredder; piercing

Gauges: fitting; purging; reading; using P.T. chart

Gaskets: types of material; thickness; measuring and marking out

Refrigerants.

Refrigerants: cylinder identification; properties; applications; codes and regulations; safety and ozone depleting substances

Refrigerant handling

Refrigerant recover systems

Evacuation methods

Leak detecting: pressure testing – safe pressure

Leak testing: fluorocarbon systems; ammonia systems

Contamination: moisture in systems; refrigerant breakdown; system clean up; cold traps

Oils: properties of refrigeration oil; types; selection

Refrigeration system components.

Compressor: types (reciprocating, rotary, centrifugal, scroll)

Condenser: types (air cooled, water cooled, evaporative); pumps; cooling tower/water regulator valve; water treatment; liquid receiver (horizontal, vertical)

Evaporator: types; secondary refrigerants

Flow control: types (hand expansion, low side float, high side float, automatic expansion, thermostat expansion, thermo-electric, capillary tube); refrigerant distributors (venturi, weir, pressure drop, centrifugal)

Domestic refrigerators and freezers.

Operation and function of refrigerators/freezers and components: static plate condensers; static fin and tube; forced and induced air condensors; capillary tube; plate evaporators; bare pipe evaporators; forced and induced air evaporators; accumulators; heat exchangers; hermetic compressors; thermostats; defrost systems; fans; charging adapters (b-p valves, etc)

Electrical and refrigeration faults

Replacement of door liners, gaskets and fittings

Gas appliances.

Safe working practice: detecting and handling unburnt gases; procedures in a carbon monoxide gas environment; safety equipment; appliance isolation

Components and operation: safety controls; ignition devices; appliance regulators; thermostats; controllers; burners; flues; fans; adjustments for optimum performance

Test equipment: manometer; leak testers; gas and electrical safety tests; tests and/or adjustments

Gas identification: types of gases and their application; methods of identification

Capillary systems.

Capillary tube system: types of tubes; application; characteristics; function; system unloading; calculating system; operating pressures; critical length; critical charge

Repair/replacement of a capillary tube: use of vacuum pumps/correct refrigerant charging procedure

Use of manufacturers catalogues: the use of refrigeration catalogues/service manuals to select replacement capillary tubes

Commissioning procedures

Codes of practice

Specialisation: Machines

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

DC machines.

DC machine principles: generated emf, lap and wave windings; control of output voltage; armature reaction; commutation; interpoles and compensating windings; back emf, torque and speed; losses and efficiency

DC machine types and connections: permanent magnet; separately excited; shunt, series, compound and series universal; reversal

DC machine characteristics and applications for shunt, series and compound: excitation/voltage; speed/voltage; load voltage/load current; torque/load current; torque/speed; speed/load current; applications

DC motor starters: starting current; concept of current limitation; calculation of resistance for limiting starting current; operation of common types of starters

Specialised DC machines: tachogenerator; servomotors; stepper motors

Transformers.

Core construction and winding styles used in transformers

Principles of operation of single and double-wound and single phase transformers

The characteristics of the four basic types of transformers

Insulation resistance, continuity, winding identification, polarity marks

Synchronous machines.

Principles of operation: construction details; cooling; excitation methods; effect of load alternator voltage; voltage regulation; ratings; parallel operation

Portable alternators: constructional details of common types; ratings

Three-phase synchronous motors: construction details; principles of operation; effect of load; effect of varying field excitation; starting methods; applications

Single-phase synchronous motors: common types; constructional details; applications

Rotating machines - maintenance and repairs.

Machine faults and testing procedures: faults (run hot, sparks at brushes, runs fast, slow, voltage variation in generators, nameplate data vs actual operating values); testing (insulation, continuity, current-tong test, volt drop, ‘growler’, heat run, dynamometer, polarity, inductive kick, vibration and noise, load testing of generators); inspecting (commutation and slip ring condition, winding condition)

Dismantling/assembling and repair procedures: marking of electrical connections; recording positions of gears/pulleys/couplings; removal; bearing removal/replacement; ball/roller bearing; plain bearing white metal/bronze; importance of cleanliness; method of lubrication; grease and oil selection; assembly; test run; ventilation, cooling, environment protection

Machining: commutator skimming; undercutting; slip ring repair

Brushes: characteristics; types; selection

Removal and installation: marking of winding connections; importance of alignment; alignment procedures, dowel pins, shims; rubber couplings; chain couplings; direct couplings

Stator winding - three phase.

Winding procedures (universal fields): data collection and recording; winding stripping procedures; measurement of wire size; identification of insulation material types, class, temperature rating and applications; stator insulation methods; coil former sizing from stator iron and/or old coil measurements

Testing procedures (universal fields): continuity of coils; insulation resistance to earth; polarity of coils

Checking for mechanical faults: broken/damaged components; missing components; damaged or bent shafts; causes of noisy rotation; worn bearings, shafts and/or housings; bearing fits and tolerances

Dismantling procedures: recording nameplate data; marking electrical connections and components; marking mechanical components; disassembly

Rewinding procedures: identification of various windings; coil former sizing from stator iron measurements; identification of various coil shapes; former manufacture; coil winding; placement of coils in stator and shaping

Testing procedures: continuity of windings; short circuit between turns (growler); insulation resistance to earth; insulation resistance between phases; polarity (compass); assembly and test run, recording current per phase and speed on data card; reversing direction of rotation; record keeping

Stator winding - single phase.

Checking for mechanical faults: broken or damaged components; missing components; damaged or bent shaft; worn bearings and/or housings; noisy rotation; operation of centrifugal switch

Rewinding procedures: data collection and recording; winding techniques; placing of coils in slots and shaping; insulating and wedging; connection of coils and attachment of flexible leads; binding of coil overhangs using various methods, e.g.. taping and tying

Split phase motor starting devices: three types, e.g.. centrifugal switch, current relay, solid state switch; principles of operation of each type; connection of each type in a motor circuit and test running

Capacitors in single phase motors: types of capacitors; testing capacitors for electrical faults; determination of capacitance values using voltage and current readings

Single phase capacitor motors: motor types, advantages and applications; drawing circuit diagrams of each type; connection and running of each type

Small armature winding.

Winding procedures (small armatures): definition of winding terms; location of lead position; determining winding progression; data collection and recording; data diagram development; winding stripping procedures; commutator preparation and testing; insulation of armature; winding armature of coils; wedging and tying of coils; connection of coils to commutator; armature banding procedures; turning and undercutting a commutator

Balancing armatures: methods of balancing; static balancing an armature

Testing procedures: growler testing; voltage drop testing; insulation resistance testing; test running and records; reversal of direction of rotation

Varnishes: types, applications, properties and methods

Single phase wiring modifications.

Single phase dual voltage motors: types of windings; connection diagrams

Effects of voltage changes on motors: power output, torque, motor current, temperature rise and speed; calculation of new torque for a supply voltage change; demonstration of the effect of voltage changes on motor torque

Rewinding for a change in supply voltage

Rewinding for a change in supply frequency

Rewinding for a combined change in supply voltage and frequency

Two speed motors (single winding): the factors which govern motor speed; the method of obtaining a 2:1 speed ratio

Two speed motors (multi-winding): connection diagram of a three winding two speed motor showing internal and external switching connections

Three phase winding modifications.

Chord factor

Odd coil grouping

Changing a two layer to a basket winding

Dual speed single winding motors

Dual voltage three phase star motors

Reconnecting a three phase winding for a new voltage

Rewinding for a new voltage

Rewinding for a new frequency (calculations only)

Rewinding for a combined new voltage and frequency

Rewinding for a change in poles

Stators – winding development.

Calculating data for a bare split phase stator; rewinding the split phase stator; calculating data for a bare three phase stator; rewinding in three phase stator; pulse amplitude modulation windings – slot diagrams showing magnetic polarities for each speed; precautions necessary when data taking

Rotor windings.

Three phase rotor windings; rotor winding calculations and diagrams for a two tier wire wound rotor; rewinding a wire wound rotor; rotor winding calculations and diagrams for two tier wire wound rotor with a “dog leg” coil; rewinding a wire wound rotor with a ‘dog leg’ coil using ‘pull through’ technique; squirrel cage rotor faults; testing and repairing squirrel cage rotors with copper bars; testing and repairing stator irons

Specialisation: Maritime maintenance

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)

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Dismantling/assembling and repair procedures: marking of electrical connections; recording positions of gears/pulleys/couplings; removal; bearing removal/replacement; ball/roller bearing; plain bearing white metal/bronze; importance of cleanliness; method of lubrication; grease and oil selection; assembly; test run; ventilation, cooling, environment protection

Machining: commutator skimming; undercutting; slip ring repair

Brushes: characteristics; types; selection

Removal and installation: marking of winding connections; importance of alignment; alignment procedures, dowel pins, shims; rubber couplings; chain couplings; direct couplings

Cells and batteries.

Primary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Secondary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Cell configurations: series; parallel; terminal voltage; battery capacity

Secondary batteries: charge/discharge process; charge condition monitoring; internal resistance; commissioning procedures

Storage battery banks: applications; charging methods; change over/on line methods; ventilation requirements; types of batteries; capacities; routine maintenance; handling procedures; first aid requirements

Electrical heating.

Temperature: heat energy; specific heat capacity; heat transfer; thermal conductivity; electrical equivalent (kWh) of heat energy

Control of heating: manual; automatic control; electronic and other forms of heat control

Heating process: water heating; space heating; cooking; industrial process heating

Lighting.

Lighting concepts: terms and units; inverse square law; essential factors to produce visual comfort

Luminaires: types; maintenance of luminaires; use of reflectors and/or diffusers

Lamp types: incandescent, gas discharge and high voltage; characteristics, circuit connections and special features; miscellaneous lamp types; auxiliary control; light dimming; RF interference; common faults; testing of circuits; fault-finding

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Marine electrotechnology.

Marine electrical layouts: main switchboard; emergency switchboard; shore supply; interconnections between them; important components and instruments; indicating lights; meters

Alternators: constructions; voltage; regulation; characteristic excitation; AVR systems

Paralleling: auto and manual synchronizing and paralleling of alternators including machines of different capacities; operation of synchronizing equipment

Switchboards: operation; testing and maintenance of ACB, MCCB and MCB including opening and closing systems; arcing control; procedure for removal

Marine lighting systems

Batteries: layout of ship battery system; connections; types of batteries; maintenance and safety aspects

UPS systems: operating principles; power management and fault diagnosis

Cathodic protection: types; operating parameters and corrosion factors

Safety: components; regulations and safe practices for tankers with hazardous cargo’s

Management: plant performance evaluation; commissioning new systems and electrical surveys

Specialisation: Switchgear

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

DC machines.

DC machine principles: generated emf, lap and wave windings; control of output voltage; armature reaction; commutation; interpoles and compensating windings; back emf, torque and speed; losses and efficiency

DC machine types and connections: permanent magnet; separately excited; shunt, series, compound and series universal; reversal

DC machine characteristics and applications for shunt, series and compound: excitation/voltage; speed/voltage; load voltage/load current; torque/load current; torque/speed; speed/load current; applications

DC motor starters: starting current; concept of current limitation; calculation of resistance for limiting starting current; operation of common types of starters

Specialised DC machines: tachogenerator; servomotors; stepper motors

Electrical drawings and their interpretation.

Purpose and use of block, circuit and wiring diagrams

Use of drawing symbols and Australian Standard 1102

Electrical diagram conventions

Use and construction of switching charts

One-way, two-way and multi-position control of lighting circuits

Circuit wiring methods using sheathed cables and looping terminals

The features, purpose and use of site and floor plans and details and standard drawings

Locating the position of electrical services from architectural drawings

Interpretation of wiring and schematic diagrams.

Construction and operation of relays, contactors and starters

Contact ratings of contactors

Power and control circuits

Control circuit symbols and drawing conventions

Conversion of wiring diagrams to ladder diagrams

Control circuit components and their operation

Selection of circuit components from manufacturers' catalogues

Basic control circuit wiring: push-button on-off control; remote stop-start operation; timer circuits; circuits with interlocks; jogging (inching) circuits (non-latching); press safety circuits

Fault-finding techniques

Advanced circuit design techniques: documenting circuit design; modifying circuits

Application of programmable controllers in circuit design

Transformers.

Core construction and winding styles used in transformers

Principles of operation of single and double-wound and single phase transformers

The characteristics of the four basic types of transformers

Insulation resistance, continuity, winding identification, polarity marks

Switchboards.

Regulations

Control circuits: types; applications

Connections: types; applications

Screened cables: types; applications

Current transformers: purpose; applications; connections

Potential transformers: purpose; application; connections

DC Power circuits: purpose; features

Earthing: purpose; types; connections

Interlocks: purpose; types

Metering circuits: purpose; types

Motor start circuits: special requirements

PLC circuits: purpose; function; application

Switchboard equipment: purpose; types; function

Switchboard materials: purpose; types; application

Electrical tests: general switchboard; control circuits

Switchboard, design and construction.

Fabrication: sheet metal; bus bar; switchgear; metering

Wiring: DOL starter; star delta starter; reversing starter; control circuits

Testing: insulation; starter circuits; control circuits; fault-finding

Cells and batteries.

Primary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Secondary cells: definition; basic composition and construction; common types; terminal voltage; typical applications; storage, handling and disposal

Cell configurations: series; parallel; terminal voltage; battery capacity

Secondary batteries: charge/discharge process; charge condition monitoring; internal resistance; commissioning procedures

Storage battery banks: applications; charging methods; change over/on line methods; ventilation requirements; types of batteries; capacities; routine maintenance; handling procedures; first aid requirements

Basic power supplies (D.C.).

Rectifier diode: P-N junction; silicon and germanium characteristics; diode specifications; terminal identification; diode ohm meter testing

Half wave rectifier: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Centre tapped full wave: basic circuit; VAC/VDC relationship; peak inverse voltage; measurement and testing

Bridge rectifier: basic circuit; VAC/VDC relationship; measurement and testing

Three phase rectifiers: half wave; full wave; waveforms; % ripple; calculations of V and I for resistive loads

Basic filter circuits: capacitor; inductive; L section; Pi section

Zener regulators: zener diode characteristics; shunt regulator circuit; regulator specifications; line/load regulation; series resistor calculations; applications

Three-terminal regulators: characteristics and specifications; connection diagram; circuit stability requirements; reverse voltage protection methods

Dual polarity supplies: need for dual polarity; basic IC dual polarity regulator

Basic power supply protection: fuses; VDR's; LCR networks

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

Basic PLC operation: definitions, terminology and block diagram; scan cycle; basic programming rules; addressing for I/O; halt; run

Programming (using a hand programmer): flowcharts/steps to use when programming; clearing memory; ladder format; Boolean/mnemonic/statement list format; series circuits; parallel circuits; latching circuits; stack register operation; combination series/parallel circuits; inversion elements; timers (DOE); counters; monitor discrete I/O and timer/counter values; edit (insert and delete elements)

Connect discrete input and output devices to a PLC

Category: Electronics (C)

Common

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; multiples and sub-multiples

Power, work and energy: conservation of energy; torque; losses and efficiency; maximum efficiency of machines

Electrical characteristics of materials: conductors, insulators, semi-conductors; electric charge; electric current; electromotive force

The simple circuit: source, load, current path and 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; conversion of electrical energy to other forms (heating, light, magnetic, chemical)Sources of electrical energy - conversion of other forms to electrical energy

Using measuring instruments: handling measuring instruments; selecting an instrument; setting-up and connecting into circuits; reading scales and read-outs; setting up a CRO

Factors effecting resistance: length, csa and resistivity; temperature change; influence on practical circuits

Resistors: types and applications; value and rating

Series circuits (single source): determine V, I, R, P; Kirchhoff's Voltage Law; voltage dividerParallel circuits: determine V, I, R, P; Kirchhoff's Current Law; current divider

Series/parallel circuits: determine V, I, R, P; bridge networkResistance measurement: hazards; characteristics of instruments and loading effect; direct, volt-ammeter and bridge method; typical field instruments and applications

Capacitance: concept; units; time constant relationshipCapacitors: hazards; factors effecting capacitance; in series; in parallel; measuring/testing/hazards

Inductance: concept; units; time constant relationship

Inductors: factors effecting inductance

Single phase AC principles.

Sinusoidal alternating voltage and current: generation of a sinusoidal waveform; sinusoidal waveform characteristics; measuring and calculating values; phase relationships

Phasors: phase relationship terms; phasor representation conventions; phase relationships using phasors

Resistance in A.C. circuits: determine V, I, R, P; relationship between voltages and currents

Inductance in A.C. circuits: reactance; inductance in series; inductance in parallel; inductive components in power circuits and systems

Capacitance in A.C. circuits: reactance; capacitance in series; capacitance in parallel; capacitive components in power circuits and systems

AC circuits: impedance; relationship between resistive and reactive components; series, parallel and series-parallel RLC circuits; determine V, I, R, P in RLC circuits; phasor diagrams of RLC circuits

Resonance: conditions; resonance and frequency; effects on current

Ideal transformer: operating principles; primary and secondary voltage and current; applications

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

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

Analysis of digital sub-systems – timing diagrams (decoders): operation - discrete components, 2 line; practical MSI devices and applications -2 line and 3 line devices; seven segment display decoder -binary and BCD; priority encoders; multiplexers – operation - discrete component, 2 line; truth table implementation using MSI devices up to eight inputs – folding not required;

demultiplexers – operation -discrete component, 2 line input; practical MSI devices

Digital sub-systems examples using up to four MSI devices e.g. keyboards/display, data transfer – timing diagrams/data sheet usage to be emphasised: flop-flop operation – discrete and MSI, SR, D and JK; level and edge triggered flip-flops, synchronous and asynchronous inputs, flip-flop applications based on MSI devices for shift registers – serial and parallel loading and output, shift left, shift right; counters – based on D and JK flop-flops to a maximum of four states, ripple and counters synchronous; modulus counters, up/down counters, limitations on count speed, IC counters (MSI devices) – presentable counters (up/down), cascading counters (include BCD applications), ring counters – advantages and types; astable and monostable multivibrators

Logic device terminal characteristics: logic levels, supply voltages; power dissipation; input/output drive currents and voltage levels; loading calculations; propagation delays; noise margins; switching speed limitations and speed/power product; open collector/drain outputs; tristate logic and buffers; interfacing of different logic families (include the use of pull-up, pull-down resistors); Schmitt trigger device input output; characteristics

Microprocessors.

Basic 8-bit microprocessor system: semi-conductor RAM ICs; semi-conductor ROM ICs

Microprocessor architecture: central processing unit (CPU); register array; instructions register/decoder; arithmetic logic unit (ALU); accumulator and flags; instruction cycle timing; control lines; index register; general purpose registers

Systems clock circuits fetch and execute: timing cycle; timing relationships to system clock; logic levels of system buses for each clock period of an instruction cycle

Program listing terms: instruction; instruction mnemonic; operation code (op code); address, operand, label, mnemonic and comment fields; machine code and assembly language high and low level language

Single chip dedicated microprocessors

Regulated power supplies.

Regulated power supplies: principles of operation; advantage/disadvantages – linear shunt, linear series, switchmode

Linear power supplies: block diagram; principles of operation; series transistor; integrated circuits – types, specifications, protection; testing; faultfinding and repair

Switched mode power supplies: block diagram; principles of operation – with/without transformers, step up/step down/inverter; terminology; components; suppression techniques; testing; repair/replacement

DC power supplies.

Power supplies

Block diagrams

Waveform measurements; uses

Ideal an practical diodes; Ge and Si diodes

Half-wave and full-wave rectifier circuits; average voltages for half-wave and full-wave rectifier circuits

Capacitive filtering

Ripple voltages: based on load variations; based on capacitor choice; current limiting resistors

Zener diode applications

Three terminal regulators

Power supply faults and repair

Electronic hand soldering.

Quality concepts: introduction to electrical connections including mechanical, chemical and thermal; concepts of reliability, quality and process control

Preparation of printed circuit boards: assembly tools and equipment used; soldering tools and equipment; maintenance of soldering irons and tips; materials including solder and alloys, thermal bonding and metallurgical properties; flux types, resin flux and properties; cleaning materials (chemical and other); component types, identification and handling techniques; printed circuit board materials including the characteristics of copper cladded boards; visual inspection of printed circuit board assemblies prior to soldering; contamination of materials; standards and testing of cleanliness

Component mounting considerations: lead bending and stress relief of components; mounting of resistors, capacitors, diodes, transistors, integrated circuits and a selection of terminals; component lead termination methods, e.g. fully clinched, semi-clinched and unclinched (rigid lead)

Component mounting and soldering - principles of soft soldering: heat transfer, minimum and maximum heat loads for components and board materials, thermal shock and coefficient of expansion; filleting and heat bridging

Wetting, de-wetting and non-wetting: metallurgical bonding and the formation of inter metallic alloys

Manual soldering of bare copper and plated single and double-sided printed circuit boards (include consideration of layer interconnection using rivets, or through cladding)

Joint validation by visual inspection criteria and common joint non-conformances associated with single and double-sided printed circuit boards; the solder rework of single and double-sided printed circuit boards

Preparation of single and multi-strand insulated wire for lead termination

Terminating coaxial cable

Preparation and termination of coaxial cable by crimped and soldered connection

Reworking soldered connections: soldering of insulated wire to printed circuit board pads and pins; pierced, hooked and cup terminals

Effects and prevention of electrostatic discharge (ESD) and its effects on static sensitive components; precautions in the handling and use of static sensitive components and the materials and techniques available to set up a static-free environment

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

BJT and FET symbols: PNP, NPN; JFET; MOSFET; device characteristics BJT and JFET; biasing – need for circuit types; calculation and measurement of bias conditions; DC stability for BJT and JFET circuits; Quiescent point selection for BJT and JFET

Data sheet usage for BJT, JFET and MOSFET: small signal characteristics for single stage BJT and JFET circuits; fault conditions for single stage BJT and JFET circuits

Coupling and bypass capacitors: applications for single stage BJT and JFET circuit; frequency response, effect of coupling and bypass capacitors – measurement only; factors effecting selection – based on practical demonstration

Digital subsystems.

Digital to analogue conversion: typical applications; DA performance characteristics; types – summing type DA converter; R2R ladder DA converter

Analogue to digital conversion: typical applications; AD performance characteristics; types – digital ramp AD converter, successive approximation AD converter, dual slope AD converter, simultaneous (flash) AD converter

Advanced interfacing techniques: logic interface circuits; driving a load (sink and source) from a logic circuit; transistor switches; relays; opto input and output isolation, driver ICs; sensor interfacing

Programmable array devices: applications; types – PLA (programmable logic array), PAL (programmable array logic), PEEL (programmable electrically erasable logic); circuit operation; programming requirements

Resonance, filters and oscillators.

Frequency selective networks: low pass, high pass, band pass, band stop; symbols; resistor capacitor low pass and high pass networks; resistor inductor low pass and high pass networks; inductor capacitor networks; introduction to resonance; parallel LC networks; series LC networks; bandwidth, 'Q" factor, effective series and parallel resistance; impedance of series and parallel LC networks

Repetitive complex waveforms: definition of fundamental and harmonic; simple frequency analysis – square wave, triangular wave etc; effect of a high pass, low pass and band pass filter on complex wave; forms

Introduction to feedback: positive – definition, applications; negative – definition, applications

Oscillators: definition; application; types

Sine wave oscillators: barkhausen for sine wave oscillation; types – colpitts, clapp, hartley, crystal (single mode operation only); basic circuit diagram; relaxation

Communications fundamentals.

Basic communication systems: time and frequency – domain waveforms; modulation; baseband signal vs bandwidth; electromagnetic wave characteristics/spectrum; wavelength; commercial radio frequency spectrum users

Antennae and electromagnetic wave propagation characteristics: horizontal half wave antenna; vertical half and quarter wave antennae; polarisation; radiation patterns; EM wave propagation at MF, HF, VHF/UHF; polarisation

Modulation systems and requirements: double sideband full carrier amplitude modulation; single sideband suppressed carrier modulation; vestigial sideband modulation; frequency modulation; phase modulation

Amplitude modulation and demodulation: carrier power; sideband power; total power; bandwidth; modulation index; overmodulation; diode detector

Frequency modulation and demodulation: frequency deviation; modulation index; bandwidth; pre-emphasis and de-emphasis; phase modulation; frequency domain diagrams; frequency modulation detectors; limiter amplifier

Single conversion superheterodyne receivers: the TRF receiver; selectivity; sensitivity; AM superheterodyne receiver; frequencies within the AM receivers; superheterodyne advantages; image frequencies; FM superheterodyne receiver; frequencies within common IF frequencies; mixer input and output signals; measurement of sensitivity, selectivity and image rejection; relationships between fr, fo and fif

Receiver specialist circuits: simple AGC; delayed AGC; RF and audio derived AGC; limiter amplifiers; noise blankers; AFC; mute; squelch; RD and IF amplifiers; filters and bandwidth

Amplifier applications.

Coupling methods in multistage amplifiers: capacitance; transformer; direct; characteristics of each method; frequency response; stage gain

Negative feedback: voltage shunt feedback; voltage series feedback; current shunt feedback; current series feedback; effect of feedback on gain, bandwidth, distortion input/output resistance

Power amplifier principles: classes of amplification; conduction angle; efficiency

Transformer coupled power amplifiers: circuit schematics; class A; class B; reflected resistance; efficiency; bias requirements; thermal stability

Complimentary symmetry power amplifiers: quasi complimentary; circuit schematics; class B; class AB; efficiency; bias requirements; cross over distortion; thermal stability; DC balance

Electronics fault-finding.

Customer relations; testing to ascertain actual fault; select appropriate repair agency; packaging of damaged equipment; observe equipment for signs of visual damage; check power supplies; observe circuit board for obvious signs of damage; split half method; test equipment; functional testing after repair; invoicing; warranty item

Specialisation: Communication - broadcast

Antennae installation and servicing.

Electro-magnetic waves, wavelength, reflection, refraction, diffraction, polarisation

Antennae: radiation and reception; electro-magnetic wave transmission including the induction and radiated fields

Use of manufacturers' data to select suitable antennae

Use of field strength meters

Optimum antennae placement

Minimising interference

Installation methods

Application of masthead amplifiers: distribution amplifier; splitters; termination

Modulation.

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

Receivers.

Receiver block diagrams: single conversion image reception problems; FM dual conversion receiver; SSBSC receiver

RF amplifiers: purpose; BJTs as RF amplifiers; FETs as RF amplifiers; input and output coupling

Mixer stages: requirements; mixing techniques; noise figure and conversion gain; local oscillator injection; calculation of first order mixer output frequencies

Intermediate frequency (IF) amplifiers: choice of IF; input and output coupling; filters; limiter requirement with FM; limiter operation concepts; limiter performance

Demodulation: AM; FM

AGC systems: need for AGC; AGC in FM receivers; AGC for DSBSC receivers

Phase locked loops (PLL): PLL basics; loop frequency response and bandwidth; frequency synthesis basics

Transmitters.

DSBFC transmitters: operation; tuning and adjustment; testing

SSBSC transmitters: operation; tuning and adjustment; testing

Transmission lines and antennae.

Time domain reflectometry measurements: function of a transmission line; balanced and unbalanced lines; lumped constant model of a transmission line; velocity factor; surge impedance; characteristics impedance Z of a transmission line

Radio frequency characteristic of transmission lines: voltage and current distribution along a transmission line; SWR and VSWR; SWR bridge; slotted line

Losses in transmission lines: radiation loss; resistance loss; dielectric loss; relationship of losses to operating frequency

Radiation characteristics of antennae: E and H field directions in relation to the driven element E as the reference field (polarisation); Hertz and Marconi antenna polar patterns; isotropic radiator as a reference; radiation efficiency; antenna gain

Directional antennae: Yagi-Uda parasitic array; broadside array; phrasing elements; log-periodic antenna; colinear antennae; non-resonant antennae

Antenna matching: resistance-reactance model of a shortened antenna; resistance-reactance model of whips and centre fed; matching antennae; loading components; baluns; quarter wave transformers; stub matching

UHF and microwave antennae – satellite and terrestrial: circular polarisation; helix antennae; parabolic dishes – horn feed and Cassegrain feed; gain of parabolic dish antennae

Specialisation: Communications - microwave

Introduction to microwave communications.

Microwave components: effects of stray and inherent inductance and capacitance; passive devices (chip components); PCB; printed components

Active devices: diodes (PIN, gunn, impatt, tunnel, step-recovery); transistors (bipolar, GaAs Fet, HEMT, MMIC); valves (triodes and tetrodes, magnetrons, TWT, klystrons); other devices (DRO, YIG, circulator, isolator, cavity resonator); safety practices

Transmission lines: coaxial cable (rigid, semi-rigid hardline, flexible); connectors (N type, TNC, SMA, B, C); waveguide (modes, coupling, bends and tees, attenuators and termination, directional couplers); microstrip and stripline; antennae

Propagation: free space and atmospheric losses; refraction; reflections; knife-edge diffraction; near-field absorption; satellite communications; linear, circular and cross polarisation

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UHF and microwave antennae – satellite and terrestrial: circular polarisation; helix antennae; parabolic dishes – horn feed and Cassegrain feed; gain of parabolic dish antennae

Microwave devices.

Safety; microwave valve theory; magnetrons; klystrons; focussing coils (permanent and electromagnetic); gunn diodes; tunnel diodes; cross field amplifiers; travelling wave tube amplifier; solid state amplifier; local oscillator/reflex klystron; mixer stages; balanced mixers (magic Ts)

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Active devices: diodes (PIN, gunn, impatt, tunnel, step-recovery); transistors (bipolar, GaAs Fet, HEMT, MMIC); valves (triodes and tetrodes, magnetrons, TWT, klystrons); other devices (DRO, YIG, circulator, isolator, cavity resonator); safety practices

Transmission lines: coaxial cable (rigid, semi-rigid hardline, flexible); connectors (N type, TNC, SMA, B, C); waveguide (modes, coupling, bends and tees, attenuators and termination, directional couplers); microstrip and stripline; antennae

Propagation: free space and atmospheric losses; refraction; reflections; knife-edge diffraction; near-field absorption; satellite communications; linear, circular and cross polarisation

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Microwave Devices.

Safety; microwave valve theory; magnetrons; klystrons; focussing coils (permanent and electromagnetic); gunn diodes; tunnel diodes; cross field amplifiers; travelling wave tube amplifier; solid state amplifier; local oscillator/reflex klystron; mixer stages; balanced mixers (magic Ts)

Specialisation: Data communications

Organisation of resources.

Supply and storage of equipment and material; third party supply; specifications; labour resources; standard installation times; required skill levels; site access and safety; safety measures for installation team; safety measures for customer; security considerations; liaising with third parties; equipment supply; network facilities; cutover requirements; regulating bodies; organising cutover; acceptance trials

Computer awareness.

Describing software in common use including word processor, spreadsheet, accounting, database and communications software; computer system components; system and application software; computer system care and maintenance; loading and exiting from software; backup and restore procedures; viruses and anti-virus practices; computer terminology; commands to create, save and modify a word processed document; using the on-line help and software manuals for word processing; terms associated with single table databases; creating, saving and retrieving a single table database; modifying data in an existing database; querying a single database with at most two arguments; using on-line help and manuals for database; terminology associated with spreadsheets; entering labels and values; using simple formulas for summing and averaging; using on-line help and manuals for spreadsheets; previewing and printing spreadsheets; editing existing spreadsheets

Advanced communications.

The telecommunications system, its elements and the categories of information sources; frequency and wavelength; time and frequency domains; categories of transmission media; bands of frequencies; the concept of modulation and its application to the above media; the digital and analogue signal; multiplexing – a comparison of TDM and FDM; noise and interference; signal power in a communication system; the relationship of signal to noise and its effects of communication systems; estimating bandwidth requirements for various signals; key parameters effecting signal quality; “echo” in transmission systems; impedance mismatch; controlling system parameters; power ratio to Db, signal level and signal to noise ratio in systems; modulation and demodulation; practical transmitters and receivers; digital communications; practical digital systems

Installation for configuration for CPE.

Installation preparation and execution processes; communication skills; CPE system facilities; public switching network facilities; CPE equipment and system types available; practical/physical installation cabling and restrictions;

cable preparation; importance of capacitances, versions and issues of system types; structure of CPE and external/add-on items such as voicemail and call accounting devices; importance of system specifications and limitations; estimating using “average installation times; standard items used in general installation; variables which affect installation; consequences of interrupting customer communication services; site restoration processes after CPE installation; administrative processes after CPE installation and site records; processes for the disposal of recovered material; minor installation and alteration key systems using system manuals; minor installation and alterations on PABX’s using system manuals; interface cabling on key systems using system manuals; interface cabling on PABX’s using system manuals; outline of radio-based CPE; outline of CPE cutover processes and procedures; installation warranty, manufacturer warranty, maintenance contracts and agreements; reasons for customer training; assessing appropriate customer training

Principles of CPE.

CPE equipment overview: types; differences; advantages

CPE test systems: types; facilities; operations; night service; programming procedures; remote diagnostics and maintenance

CPE cabling overview: PSTN vs ISDN; cabling differences in PABX and keysystems; least-coast-routing; ancillary equipment

Terminating and distributing: types of distribution points; terminating types; using systems manuals

CPE facilities overview: fail safe devices; call management; accounting

Safety

Recording requirements.

The nature and purpose of reports; selection of relevant information; organisation of information; summarising information; note taking awareness of the reader; structure of reports; appropriate language; planning; writing; editing

Network operations and facilities.

Switching systems within the network: PSTN (public switched telephone network); ISDN (integrated services digital network); mobiles; IN (intelligent network)

Network customer facilities: PSTN services; ISDN services

Network business services: analogy of PABX to business group; business group concept

Network testing and supervision facilities: command testing; command controlled test calls; test blocking; call path tracing; traffic supervision; blocking supervision; load supervision

Switching principles.

Switching principles: analogue; digital; information signals; line signals

Types of switching centres: electromechanical; processor controlled

Switching centre facilities

Switching centre block diagram and functions of the parts: AXE; S12

Supervisory tones

Connections: MDF; DDF

Testing of customer lines

Specialisation: Entertainment – audio - analogue

Sound and acoustics.

Theory of sound wave propagation: refraction; compression; frequency; wavelength; velocity of sound wave in air and other mediums

Sound: fundamental frequency; pitch; loudness; timbre; harmonic frequency; complex wave; decade; octave

Effect of the medium of sound waves: reflection; diffraction; refraction; echoes; attenuation

Characteristics of the human ear: basic atonomy; sensitivity of human ear; in signa; pressure level; interpret equal loudness contour curves

Mono and stereo sound: speaker phasing; echo and reverberation; methods of modifying reverberation time; causes and cures for acoustic feedback; effect of different sound delays in multiple speaker systems

Audio electronics.

Analysis of audio amplifier circuits: pre amplifiers; RIAA equalisation; passive and active tone control circuits; loudness circuits; power amplifiers integrated and discrete; DC stabilisation circuits; output current overload protection circuits; output DC protection circuits; negative feedback

Adjustment of power output stage bias

Definition and testing of: output power; damping factor; signal to noise ratio; stereo separation; distortion harmonic and intermodulation; frequency response and phase distortion; slew rate; transient response; tone control response; loudness control response

Location of faults in audio amplifiers: replacement of components; component data; circuit analysis and component location

Interpretation of specification for various equipment

Professional audio electronics.

Sketched plan and elevation drawings of the physical layout of auditorium audio system

Audio system interfaces: balanced lines; phantom power for microphones; cables and connectors; patch panels; grounding and earthing techniques in complex systems

Architecture, gain structure, and block diagram and circuits of a multi channel mixing desk

Monitoring of audio signal levels by VU; definition of VU and standard levels for signals

Purpose, specification, and block diagrams of signal processing units: noise gates; compressors; limiters; graphic equalisers; parametric equalisers; active crossovers; power amplifiers using 100v/70v lines

Diagnosis and fault-finding techniques

AM and FM tuners.

Superheterodyne receiver concepts: circuit diagrams

Comparison of AM and FM: definition of terms; electromagnetic radiation

Signal requirements for AM reception: aerials; interference; mobile operation

Stereo FM reception: aerials; interference; mobile operation

Types of cables – balun

Frequency modulation and demodulation: pre and de-emphasis; FM stereo encoding and decoding techniques; frequency distribution of encoded stereo signal; FM type stereo decoder

Principles of amplitude modulation and demodulation

Fault-finding

Tape recorders – audio.

Magnetic recording principles: magnetic materials – hard and soft – recording applications; use of magnetic tape – emulsions, backing storage, print-through; replay, record and erase heads; tape transport systems

Components and circuitry: single transport systems, speed stability; bias and erasure; cross talk, equalisation, head wear, multi-purpose vs dedicated heads, adjustments points; Dolby B noise reduction; dual tape systems

Tape transport fault-finding: mechanical components; electrical component involved in tape movement; component adjustment, removal, replacement and realignment

Heads: phasing vs frequency; frequency response vs tape speed; maximum output level vs tape speed; head contact, 'squealing'; head gap – compromise vs optimise – headwear, oxide build up

Audio path electronics: replay – noise and distortion, high frequency (HF) and low frequency (LF) equalisation; record head impedance, bias filters and traps, equalisation, input levels, record levels; signal level indication (meters)

Erase and bias: DC vs AC; bulk erasure; inadvertent erasure; erase bias oscillators, effect of waveform on noise and inter-modulation (IM) products; bias vs maximum output level dynamic range vs tape type/brand bias adjustment

Noise management: maximum output level dynamic range vs tape type/brand; Dolby B, S, C and dBx; noise system testing and alignment

Loud speakers and microphones.

Permanent magnet loudspeaker: construction and componentry

Infinite baffle: bass reflex; damping factor; woofer; mid range; tweeter; frequency response; efficiency

Crossover networks: CR low pass, high pass, and band pass filters; LR low pass, high pass and band pass filters; LCR filters; power dissipation

Sound wave reflection and absorption: furnishings and room shape; graphic equalisation; principles of surround sound (speaker phasing); speaker layouts in a domestic installations (simple stereo; surround sound and bass presence speaker; ideal listening positions); speaker layouts in professional installations (movie theatres; pop music concerts; live theatre; public address)

Microphones: types use for both domestic and professional applications; construction; principles of operation; principle of FM radio microphone; care and repair of microphones including the methods of lead connection and retention; set up of microphones for use in public address (public address applications –balanced lines, theatre applications, popular music concerts); use of graphic equalisation to minimise feedback effects

Fault-finding

Specialisation: Entertainment - audio - digital

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Fault-finding

Compact disc players.

Introduction: overview of audio compact disc player standards; block diagram

System control (SYSCON): description of operation; flowcharts

Principles of optics: compact disc applications; types of laser optical units

Principles of control loops: block diagram; terminology; focus servo loop; spindle motor servo loop; radial tracking servo loop

Ancillary circuits: internal DC power supplies; remote control; subcode output; headphone output; keyboard input; display

Digital audio fundamentals.

Digital audio system: basic encoder block diagram, basic decoder block diagram

Digital signal processing – encoder: sampling theorem; A/D conversion; error correction, CIRC encoding, cross interleaving, control and parity; modulation, non return to zero inverted (NRZI), eight to fourteen (EFM)

Digital signal processing – decoder: EFM demodulation; de-interleaving; error correction; sample and hold; oversampling/digital filtering; low pass filters

Digital audio tape recorders.

Rotary head digital audio tape system (R-DAT): R-DAT and VCR (VHS system); drum mechanism and tape wrap; record erase/erase heads; cassette tape cartridge

Basic DAT specifications: tape format – rec/pb and pre-recorded, options; sampling frequency; quantisation bit number; transmission rate; subcode capacity; modulation system; error correction system; tracking system; drum rotations (rpm); tape specifications; head azimuth angle

Azimuth recording and modulation system: cross talk; overwrite (erasure); 8 - 10 modulation

Revision (if required); pulse code modulation; quantisation; reed solomon error correction

Signal format and processing: track format – 16 signal areas; PCM block format; sub-code block format; RF signal waveshape; sync signal system; time axis compression and expansion; error correction; signal processing circuitry (typical LSI's)

System control: microcomputer; data bus; reel; mechanism; level; remote

Servo control systems: servo control systems in play, fast forward and reverse modes; drum servo; FG and PF pulses; capstan servo; operation during record and playback; automatic track finding (ATF); reel servo; forward reverse operation; circuit diagrams, LSI chips; speed adjustment

Specialisation: Entertainment - electronic appliances

Microwave appliances.

Basic oven fundamentals: microwave cooking basics; properties of microwaves; biological effects of microwaves; fundamental microwave oven operation; safety considerations

Microwave oven performance: radiation leakage; power output measurement; oven leakage safety system; magnetron tests and measurements; interlocks; thermal cut outs and thermostats; stirrer cooling and turntable systems

Power control systems: high/low power selection; duty cycle control systems

"Auto-cook" facilities: temperature control cooking systems; humidity sensor cooking systems; infra red sensor cooking systems; convection microwave oven system

Control systems: basic block diagram; functions of each block; initialisation; pulse oscillator circuits; door signal check; keyboard and input matrix; buzzers and displays

Introduction to television.

Broadcast TV system: transmitter; camera; receiver; propagation; channel allocation – RF bandwidth, carrier frequencies

Australian standards: VHF; UHF; IF

Transmitter: block diagram of a current television transmitter showing – video and sound signal inputs, modulation – one line of video, vestigial sideband filter and PA (basic sync only); negative vestigial sideband modulation of video signal; frequency modulation of sound signal; monochrome step test pattern and modulation levels; grey scale test waveforms – system input, system output, signal waveform, percentage modulation

Camera: scanning principles; synchronisation; video signal

Receiver: simplified block diagram of typical television receiver; including the following as single blocks – RF input, tuner, IF, video, AGC, AFT, sync separation, scanning and EHT, generation, sound stages, video amplifier, blanking, DC lamps, luminance matrix, RGB drives and outputs, colour decoder, power supply, picture tube

TV picture tube: principles of operation; thermionic emission; electron gun; basic raster scanning; synchronisation; monochrome tubes – typical electrode voltages, drive waveforms, phosphor

Colour principles: signal format; forward and reverse compatibility; luminance signal; light and colour theory; visual perception; signals; colour bar test pattern; RGB; luminance; 3 tube colour cameras – simple block diagram, derivation of luminance and colour difference signals; principles of suppressed carrier quadrature amplitude modulation (QAM); vector diagram of primary and complimentary colours on NTSC line; principles of PAL encoding – swinging burst, diagram of primary and complimentary colours on the PAL line; frequency interleaving; block diagram of a simplified PAL encoder (integrated into transmitter block diagram)

VHF and UHF signal propagation and distribution: signal levels; characteristic impedance; test equipment; test patterns

Safety: TV picture tubes; high voltages; manual handling

Chrominance and luminance.

Chrominance and luminance signal processing: chroma signal; principles of PAL encoding; frequency interleaving; description and function of the 'colour burst'; the colour encoder; weighting; gamma correction; constant luminance; standard colour bar test pattern

Luminance signal processing in the receiver: video buffer; traps and filters; video amplifiers; frequency compensation; video output stages; brightness circuit; contrast circuit; black level clamps/DC restoration; retrace blanking; automatic beam current limiting

Chrominance signal processing in the receiver: chroma decoder; subcarrier regeneration; chroma signal processing; final matrix/output; typical circuits

Fault-finding

Scanning and deflection.

The sync separator: composite sync information; level clipping; vertical sync pulse derivation; horizontal sync pulse derivation

Horizontal oscillators: oscillator types; AFC principles; operation of a simple two diode AFC circuit; driver circuits

Horizontal output stage operation: horizontal scanning sawtooth current; flyback transformer; resonant tuning; EHT generation; scan derived D.C. power supplies

Safety: overvoltage and x-ray protection; automatic beam current limiting sensing: safe measurement of EHT voltages; safe EHT discharge

Vertical output stage: trapezoidal deflection waveform; vertical oscillator types; linear sawtooth waveform generation; complimentary symmetry output stages; linearity correction feedback loops

Digital countdown deflection systems: block diagram; horizontal deflection system; vertical deflection system

Raster distortion reduction: pincushion distortion; "S" correction; E-W pincushion correction; N-S pincushion correction

Fault-finding

Power supplies – TV and VCR.

Transformerless TV power supplies: regulation; rectifiers; hot chassis design; isolation transformers; RFI considerations; ripple effects

Series regulated TV/VCR power supplies: operation; protection; preset controls

Switch mode power supply: variable duty cycle type; variable frequency type; series switching regulators; shunt switching regulators; SOPS switching regulators; synchronised SMPS

SMPS control circuitry: protection; kick start circuits; slow start circuits; variable duty cycle control; VCO type control; current overload sense and control; overvoltage protection; optocouplers with SMPS/SOPS

Self-oscillating power supplies: series SOPS; shunt SOPS; shunt synchronised SMPS

SMPS and SOPS fault-finding: waveform measurements; preset controls; regulation testing

Fault-finding

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

Television RF stages.

The television tuner: tuner functions; the RF amplifier; the mixer; the oscillator; AFT; tuner types; antenna isolating circuits

Tuning Systems: simple tuning; voltage synthesis tuning (VST); frequency synthesis tuning (FST)

Vision I. F. amplifiers: IF amplifier operation; IF response; vestigial sideband compensation; SAW Filter

Vision detectors: simple square law detector; square law detector and colour transmission; synchronous demodulators

AGC: AGC operation; peak level AGC; gated AGC; synctip AGC; forward/reverse AGC; delayed AGC

Specialisation: Entertainment - video

Television antenna systems.

TV signal reception: inadequate/optimum/excessive signal level; multipath transmission; interference

TV antennae: types; operating characteristics; TV antenna terminology; multiple antennae

Transmission lines: types; characteristic impedance; attenuation; bandwidth; standing waves

Antenna distribution systems: identical and adjacent channel interference; masthead/distribution amplifiers; diplexors; triplexors; splitters and couplers; "T" networks and existing loop wired networks; practical small distribution system design; field strength meters; attenuators; VCR output injection

Satellite receivers: block diagram; operating characteristics

Antenna fault-finding

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Specialisation: Scanning systems - radar

Data communications fundamentals.

Data communication standards; basic elements of data communication system; transmission modes – simplex, half and full-duplex; transmission techniques; voice transmission fundamentals; interfacing devices and standards; OSI seven layer model; modem fundamentals; modem modulation techniques; Integrated Services Digital Network (ISDN); packet switching services, X.25

Radar principles and applications.

Purpose and uses: mnemonic; environment conditions; design factors that affect performance

Safety aspects: warning labels; conditions that result from electric shock; high voltages; RF radiation; radioactive valves; toxic substances; waveguides; CRT

Electromagnetic wave propagation: transverse waves; transmission lines; impedance matching; standing waves; energy losses

Waveguides: limiting factors; coupling; waveguide parts and types; resonant cavity characteristics; cavity tuning; waveguide shutters; impedance matching; magic T waveguide section; joint waveguide

Pulse forming circuits: four basic types; multivibrators

Typical radar transmitter: types; high-power oscillator; master timing unit; pulse forming network; modulators; switching – thyratrons; master oscillator power amplifier type

Typical radar transmitter: typical block diagram; receiver parameters; heterodyning; mixers; local oscillators; AFC; IF amplifier; diode detector; frequency response; paralysis; fast time circuit; instantaneous AGC; STC; logarithmic receiver

Types of display: inputs required; CRT; deflection; focusing; A-scan display; brilliance control; planned position indicator display (PPI); deflection; rotation synchronisation; raster scan deflection; composite video; raster scan

Types of antenna: RF radiation process; half-wave dipole; parabolic reflectors; cosecant squared reflector; energy feeding devices; cassegrain antenna; dielectric lens; metal plate lens; slotted waveguide radiators; squint angle; measure radiation pattern

Calculations: maximum and minimum theoretical range; true bearing; relative bearing; bearing conversions; slant range; ground range; height

Microwave devices: oscillators; amplifiers; additional RF devices

Continuous wave radars: use

Doppler effect: description

Moving target indicator: function; operation using pulse-to-pulse; PRF agility; frequency agility

Tracking radar: monopulse radar; manually lock onto a target; automatic search and track targets

Secondary radar system (IFF): principles – uses; pulse train

Fault-finding

Radar and sonar displays.

Safety; CRT principles – EHT, focussing, deflection; PPI displays/A-scope/B-scope; LCD displays – colour, monochrome; touch screens – magnetic field, infra red; raster scan – operation, removal, disposal, dangers of phosphors; plasma display; high voltage DC power supplies; NMEA 0183; GPS; data transmission techniques – RS232, RS422; gyro synchro; LED displays; digital processing of radar information (centroiding etc); video distribution and switching

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Principles of underwater sound transmission.

Propagation; doppler; sound speed of water – temperature, pressure/depth, salinity, biological interference, impurities in water; isothermal/exothermal layers; reflection; refraction; convergence zones; surface duction; deep sound channels/VLF

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Sonar systems principles.

Safety; fish finders; oceanography; exploration; echo sounding; block diagram of sonar systems – transmitter, receiver, amplifiers, displays; types of transmission – Omni, steered, phased, CW/FM, AM; underwater communications; beam forming/arrays; frequency – range, applications, classification; beam steering; active/passive; recording devices – tape, pen, chart, disk

Sonar transducers.

Theory; types; construction; mounting; medium – salt water, fresh water, castor oil; testing – impedance, phase relationship; arrays – transducer, staves, elements, piezo electric; hydrophones

Category: Instrumentation (D)

Common

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; multiples and sub-multiples

Power, work and energy: conservation of energy; torque; losses and efficiency; maximum efficiency of machines

Electrical characteristics of materials: conductors, insulators, semi-conductors; electric charge; electric current; electromotive force

The simple circuit: source, load, current path and 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; conversion of electrical energy to other forms (heating, light, magnetic, chemical)Sources of electrical energy - conversion of other forms to electrical energy

Using measuring instruments: handling measuring instruments; selecting an instrument; setting-up and connecting into circuits; reading scales and read-outs; setting up a CRO

Factors effecting resistance: length, csa and resistivity; temperature change; influence on practical circuits

Resistors: types and applications; value and rating

Series circuits (single source): determine V, I, R, P; Kirchhoff's Voltage Law; voltage dividerParallel circuits: determine V, I, R, P; Kirchhoff's Current Law; current divider

Series/parallel circuits: determine V, I, R, P; bridge networkResistance measurement: hazards; characteristics of instruments and loading effect; direct, volt-ammeter and bridge method; typical field instruments and applications

Capacitance: concept; units; time constant relationshipCapacitors: hazards; factors effecting capacitance; in series; in parallel; measuring/testing/hazards

Inductance: concept; units; time constant relationship

Inductors: factors effecting inductance

Single phase AC principles.

Sinusoidal alternating voltage and current: generation of a sinusoidal waveform; sinusoidal waveform characteristics; measuring and calculating values; phase relationships

Phasors: phase relationship terms; phasor representation conventions; phase relationships using phasors

Resistance in A.C. circuits: determine V, I, R, P; relationship between voltages and currents

Inductance in A.C. circuits: reactance; inductance in series; inductance in parallel; inductive components in power circuits and systems

Capacitance in A.C. circuits: reactance; capacitance in series; capacitance in parallel; capacitive components in power circuits and systems

AC circuits: impedance; relationship between resistive and reactive components; series, parallel and series-parallel RLC circuits; determine V, I, R, P in RLC circuits; phasor diagrams of RLC circuits

Resonance: conditions; resonance and frequency; effects on current

Ideal transformer: operating principles; primary and secondary voltage and current; applications

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

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

DC power supplies.

Power supplies

Block diagrams

Waveform measurements; uses

Ideal an practical diodes; Ge and Si diodes

Half-wave and full-wave rectifier circuits; average voltages for half-wave and full-wave rectifier circuits

Capacitive filtering

Ripple voltages: based on load variations; based on capacitor choice; current limiting resistors

Zener diode applications

Three terminal regulators

Power supply faults and repair

Operational amplifiers.

The differential amplifier: operating conditions; circuit configurations and applications

Op amp configurations: characteristics; inverting and non-inverting amplifiers; the inverting summer; differential amplifier circuits

OP amp limitations: manufacturers' specifications; practical limitations

Comparators: principles of operation; applications of comparators

Op amp applications: clipping circuits; precision rectifiers; oscillators; integrator/differentiator circuits; function generators; active filter circuits

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

Analysis of digital sub-systems – timing diagrams (decoders): operation - discrete components, 2 line; practical MSI devices and applications -2 line and 3 line devices; seven segment display decoder -binary and BCD; priority encoders; multiplexers – operation -discrete component, 2 line; truth table implementation using MSI devices up to eight inputs – folding not required; demultiplexers – operation -discrete component, 2 line input; practical MSI devices

Digital sub-systems examples using up to four MSI devices e.g. keyboards/display, data transfer – timing diagrams/data sheet usage to be emphasised: flop-flop operation – discrete and MSI, SR, D and JK; level and edge triggered flip-flops, synchronous and asynchronous inputs, flip-flop applications based on MSI devices for shift registers – serial and parallel loading and output, shift left, shift right; counters – based on D and JK flop-flops to a maximum of four states, ripple and counters synchronous; modulus counters, up/down counters, limitations on count speed, IC counters (MSI devices) – presentable counters (up/down), cascading counters (include BCD applications), ring counters – advantages and types; astable and monostable multivibrators

Logic device terminal characteristics: logic levels, supply voltages; power dissipation; input/output drive currents and voltage levels; loading calculations; propagation delays; noise margins; switching speed limitations and speed/power product; open collector/drain outputs; tristate logic and buffers; interfacing of different logic families (include the use of pull-up, pull-down resistors); Schmitt trigger device input output; characteristics

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

BJT and FET symbols: PNP, NPN; JFET; MOSFET; device characteristics BJT and JFET; biasing – need for circuit types; calculation and measurement of bias conditions; DC stability for BJT and JFET circuits; Quiescent point selection for BJT and JFET

Data sheet usage for BJT, JFET and MOSFET: small signal characteristics for single stage BJT and JFET circuits; fault conditions for single stage BJT and JFET circuits

Coupling and bypass capacitors: applications for single stage BJT and JFET circuit; frequency response, effect of coupling and bypass capacitors – measurement only; factors effecting selection – based on practical demonstration

Electronic hand soldering.

Quality concepts: introduction to electrical connections including mechanical, chemical and thermal; concepts of reliability, quality and process control

Preparation of printed circuit boards: assembly tools and equipment used; soldering tools and equipment; maintenance of soldering irons and tips; materials including solder and alloys, thermal bonding and metallurgical properties; flux types, resin flux and properties; cleaning materials (chemical and other); component types, identification and handling techniques; printed circuit board materials including the characteristics of copper cladded boards; visual inspection of printed circuit board assemblies prior to soldering; contamination of materials; standards and testing of cleanliness

Component mounting considerations: lead bending and stress relief of components; mounting of resistors, capacitors, diodes, transistors, integrated circuits and a selection of terminals; component lead termination methods, e.g. fully clinched, semi-clinched and unclinched (rigid lead)

Component mounting and soldering - principles of soft soldering: heat transfer, minimum and maximum heat loads for components and board materials, thermal shock and coefficient of expansion; filleting and heat bridging

Wetting, de-wetting and non-wetting: metallurgical bonding and the formation of inter metallic alloys

Manual soldering of bare copper and plated single and double-sided printed circuit boards (include consideration of layer interconnection using rivets, or through cladding)

Joint validation by visual inspection criteria and common joint non-conformances associated with single and double-sided printed circuit boards; the solder rework of single and double-sided printed circuit boards

Preparation of single and multi-strand insulated wire for lead termination

Terminating coaxial cable

Preparation and termination of coaxial cable by crimped and soldered connection

Reworking soldered connections: soldering of insulated wire to printed circuit board pads and pins; pierced, hooked and cup terminals

Effects and prevention of electrostatic discharge (ESD) and its effects on static sensitive components; precautions in the handling and use of static sensitive components and the materials and techniques available to set up a static-free environment

Concepts of instrumentation.

Flow, temperature, pressure and other appropriate measurements

Appropriate terminology: span, range, accuracy, precision, errors, zero, repeatability, sensitivity, hysteresis, etc. (select from AS1541)

Development of SI units, engineering and scientific notation, imperial and metric conversion using calculations, mm Hg, mm Hg, Pa (hPa, Kpa, Mpa etc.), inches water, PSI, etc. also non-standard SI units – kgcm2, etc.

Instrumentation standards (brief overview only): ISA (Instrumentation Society of America); ISO (International Standards Organisation); SAMA (Scientific Apparatus Manufacturers America); BSI (British Standards Institution); AS (Australian Standards); ANSI (American National Standards Symbols and Terminology); Manufacturer Calibration Standards; fluids in process piping colour coding

Identification and purpose of instruments measuring processes directly and those measuring indirectly

Signal transmission of two-wire, 20-100 kPa, 4-20 mA, 1-5V, other applicable standards

Principles of levers, links and calibration of indicator recorder instrument

Application of safety standards at all times (tools, lifting techniques, electrical safety and CPR, pressure lines, housekeeping)

Interpretation of appropriate graphs and tables associated with instrumentation

Pressure measurement.

Pressure, density, height, force, area units: calculation of pressure required to support liquid columns; calculation of related values of pressure, force and area

Absolute, gauge and differential pressure scales and their interrelationship: reference point for scales; atmospheric pressure value using all common measurement units

Absolute, pressure measurement devices for sub-atmosphere range and typical application of these devices

Gauge pressure measurement by means of U-tube, single limb and inclined liquid columns: calculation of wet leg effects

Gauge pressure measurement by means of elastic deformation type gauges: Bourdon types (C/spiral/helix) and ranges

Other mechanical pressure elements: bellow, capsule, slack/stiff diaphragms: pressure gauge installations: tapping points, valves (isolation and bleed), loop seals, snubbers

Pressure calibration devices: pneumatic, hydraulic, electronic

Precautions in calibrating oxygen and chlorine gauges (no oil)

Use of a dead-weight tester to calibrate pressure gauges; gauge and mechanical recorder adjustments for span, zero and linearity; backlash, hysteresis, repeatability

Electrical sensors for pressure measurements: capacitive, piezo, inductive, strain gauge; calibration adjustments for pneumatic and electrical type pressure measurement and signal transmission devices

Installation requirements for pressure measurement in liquid and gas systems, with and without sealing liquid; isolation, seal, vent, drain and bypass valves location and operation sequence

Fluid flow.

Law and characteristics of fluid flow, Bernoulli's theorem, conservation of energy, Reynold's numbers, turbulent and laminar flows, S.I. units

Operation of quantity meters: oval meters, gear meters, reciprocating piston, rotating disc, gas meter

Operation and characteristics of differential head flow rate meters which includes the orifice plate, venturi tube and annular: dall tube, flow nozzle, pitot tube

Characteristics: flow/DP relationship, pressure losses and effects of laminar flow or excessive turbulence on the accuracy of the meter

Construction of typical examples of P flow rate meter: materials, shapes of orifice, gas and liquid drains, tapping points and mounting position of DP transmitter and pipe work

Operation and characteristics of flow rate meters: turbine meter vortex meter and magnetic flow meter

Operation and characteristics of shapes of flumes and weirs

Construction and installation of flumes and weirs; sources of error

Square root extraction in reference to DP meters, integration of low rate, mass flow computations (coriolis effect) from flow rate and other measurements

Temperature measurement.

Heat and temperature: Differentiation between heat and temperature, SI and non-SI temperature scales and units and conversions between scales

Non-electrical thermometers: the principles of operations characteristics and construction of liquid-in-gas, bi-metallic and filled system thermometers

Electrical thermometers: the laws and effects associated with electrical temperature primary elements; the principles of operations, characteristics and construction of thermometers, resistance thermometers (RTDs), thermistors, and semi-conductor and integrated circuit thermometers; compensation and protection devices and associated measuring circuits; circuit connections for average temperature and temperature differences should be able to be examined regarding installation and measuring circuit consideration which vary from the norm

Radiation thermometers: the laws governing radiation thermometers and the properties of a ‘black body’; the theory of operation, characteristics and construction of disappearing filament, partial radiation and total thermometers; total and spectral emissivity

Other measurement techniques: the operation and characteristics of pyrometric cones, temperature sensitive pigments and liquid crystals (brief mention only)

Test equipment: the theory of operation, operation and use of Wheatstone bridges, millivolt potentiometers and other test equipment associated with temperature measurement

Errors: the errors specific to temperature measurement - these include thermal lag, fabrication heating conductive cooling and cavitation

Interpretation drawing.

Symbols: electrical; electronic; instrument

Types of drawing: schematic; single line; wiring; process flow; process loop diagrams

Projection and dimensions

Interpretation of manufacturers data

Quantity take off and parts list

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

Process control systems.

Operation of controller types: hierarchy

Applications: on/off control; proportional; integral; derivative; direct – reverse action; local – remote set points; ratio; output limits: anti – reset windup; alarms; self tuning; adaptive gain

Typical alignment methods

System response to changes

Selection of controller type, action and modes

Effect of loop and process characteristics

Typical programming and tuning methods: open loop; closed loop

Feedforward: feedforward vs feedback; need for feedforward; difficulties in application; feedforward with feedback trim

Cascade control: need; application to processes; problems with multi-cascading

Ratio control: need for ratio control; application to processes

Batch control: need; specific requirements needed in controller; reset windup; use of PLCs

Installation methods and techniques for loop calibration

Effects of control value characteristics on loop: characterisation; sizing and rangeability; cavitation, flashing and noise; control valve selection considerations

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: Control

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

Basic PLC operation: definitions, terminology and block diagram; scan cycle; basic programming rules; addressing for I/O; halt; run

Programming (using a hand programmer): flowcharts/steps to use when programming; clearing memory; ladder format; Boolean/mnemonic/statement list format; series circuits; parallel circuits; latching circuits; stack register operation; combination series/parallel circuits; inversion elements; timers (DOE); counters; monitor discrete I/O and timer/counter values; edit (insert and delete elements)

Connect discrete input and output devices to a PLC

Density/level measurement.

Definitions: density; relative density (sg); factors effecting density (effect of depth and density on pressure in liquids, Archimedes principle, calculations of pressure in various fluids)

Measuring devices: float type (open and closed tanks); sight gauges; air pure (bubble pipe); differential pressure cells; SMART transmitters; 1:1 repeater; level repeater; diaphragm box; electronic hydrostatic head; ultrasonic; capacitance; resistance; nucleonic

Calculation of range, span, elevation and suppression; calibrate electronic and pneumatic differential pressure cell transmitters to suit level or density application; configure a differential pressure transmitter

Connection into a two wire system; connection of pneumatic systems

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

Industrial processes.

Types of processes and process quantities

Heat exchangers

Boiler and furnace control

Water treatment

Instrument air systems

Reactors

Distributive control systems (DCS).

DCS concepts: definition of DCS; types

DCS architecture: information collection (historical, management; control (programmable, dedicated); communication (data highway, data control, interfacing); storage (disk, tape, solid state); interaction (I/O, VDU, M/A station); interface (operations, engineering)

DCS configuration: types of function blocks; function codes; control algorithms

Specialisation: Measurement

Density/level measurement.

Definitions: density; relative density (sg); factors effecting density (effect of depth and density on pressure in liquids, Archimedes principle, calculations of pressure in various fluids)

Measuring devices: float type (open and closed tanks); sight gauges; air pure (bubble pipe); differential pressure cells; SMART transmitters; 1:1 repeater; level repeater; diaphragm box; electronic hydrostatic head; ultrasonic; capacitance; resistance; nucleonic

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Telemetry.

Telemetry systems

Advantages and limitations of analogue, digital, pneumatic and fibre optic types

Standards pertaining to telemetering including the International Standard CCI TT V24

Standard signal in common use

Analogue signal converters, signal conditioners, isolators, lighting protection, barrier modules to hazardous areas, analogue multiplexers, transmitters and receivers

Comparison or analogue and digital signals including accuracy and discrimination

Digital word and message structures

Series used in fibre optic systems, physical construction of fibre for light transmission, types of fibre and cladding

Types and characteristics of light sources

Types and characteristics of light detectors

Safety procedures in handling fibre and light sources

Types of transmission lines and links

Digital data links and database lines. RS232, RS422, transmission rates and signals acceptable for use

Indicators and recorders.

Pneumatic indicator mechanism including the flapper and nozzle system

Types of displays

Current signals, interface resistors and offset voltage supplies

Potentionmetric indicators and voltage signals

Cathode ray tubes (CRT) as an indicator

Connection of typical indicators and precautions to ensure accuracy

Recorder charts and recorder architecture

Recorder chart drives

Recorder pens and pen drives including pneumatic, potentiometric, moving coil and moving iron multipoint, hot wire and hot point pens

Ranging and calibration of recorders and indicators

Microprocessor based indicators/recorders

Disk/tape storage and recording of data

Gas analysis.

Combustion theory: analyser types (reagent analysers, electrolytic analysers); oxygen analysers (paramagnetic - magnetic, dumbbell, zirconia oxide); thermal conductivity analyser; thermal reaction analysers; infra-red

Humidity: types of; types of detectors - hygrometers (organic (hair), wet and dry bulb – psychrometer, sling psychrometer, assmann psychrometer); dew point; conductive (lithium chloride); coulmetric method

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

Scientific analysis.

Electromagnetic radiation: spectrum; transmission and absorption

Refraction: lenses; dispersion and prisms; filters, coloured and interference; diffraction gratings

Absorption spectrometers: single and double beam; visible, ultra-violet and infra-red

Emission spectrometers: flame; arc and spark; sampling

Atomic absorption spectrometers: hollow cathode lamps; choppers

Gas chromatography: carrier gas; columns; sampling; detection

Sample preparation: separation of samples; (centrifuge, preparative chromatographs); fraction collection; automatic sampling devices

Load cells and weight measurement.

Definitions: force and weight

Lever principles: mechanical lever; spring balance scales; load cell

Factors effecting weighing system performance: temperature; vibration; ambient conditions

Load cell selection and installations of assemblies

Principles of strain gauge measurement tension and compression and materials used

Principles of operation and application of: mechanical lever scales; hydraulic and pneumatic load cells; inductive weight sensors; linear voltage differential transformers (LVDT)

Weight feeders – mechanical and scale operated: methods of weighing materials in motion; conveyor belt weighing systems (construction, weigh span, methods of loading, factors effecting accuracy, calibration)

Nuclear radiation sensors: isotopes; application; safety precaution

Category: Refrigeration and air conditioning (E)

Common

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; multiples and sub-multiples

Power, work and energy: conservation of energy; torque; losses and efficiency; maximum efficiency of machines

Electrical characteristics of materials: conductors, insulators, semi-conductors; electric charge; electric current; electromotive force

The simple circuit: source, load, current path and 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; conversion of electrical energy to other forms (heating,

light, magnetic, chemical)Sources of electrical energy - conversion of other forms to electrical energy

Using measuring instruments: handling measuring instruments; selecting an instrument; setting-up and connecting into circuits; reading scales and read-outs; setting up a CRO

Electrical concepts and applications.

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

Refrigeration.

Heat, pressure and temperature: heat low; heat transfer (condition, convection, radiation); gas law; heat measurement; operation of the vapour compression cycle

Components: compressor; evaporator; condenser

Flow control

Pressure temperature relationships: saturation; subcooling; superheating; pressure temperature chart

Absolute and gauge pressure: plotting, basic cycles; saturation curves; subcooling; superheating; measuring heat content

Applications: domestic; commercial; industrial; transport/marine; comfort air conditioning; industrial air conditioning

Refrigeration procedures.

Tubing: types; tubing; annealing

Use of dry nitrogen

Bending methods spring bending tools (lever type) measurement and marking out gain correction

Flaring: types of block; types of flare nut

Pipework: expanding; tube expanders; swaging; recognition of fittings and threads; thread sealants

Silver brazing: joint preparation; fluxes

Job preparation refrigerant isolation/pump down; protection of cabinets from flame brazing in tight corners; use of mirror pressure testing

Gauges: types; care and maintenance

Valves: service; shredder; piercing

Gauges: fitting; purging; reading; using P.T. chart

Gaskets: types of material; thickness; measuring and marking out

Refrigerants.

Refrigerants: cylinder identification; properties; applications; codes and regulations; safety and ozone depleting substances

Refrigerant handling

Refrigerant recover systems

Evacuation methods

Leak detecting: pressure testing – safe pressure

Leak testing: fluorocarbon systems; ammonia systems

Contamination: moisture in systems; refrigerant breakdown; system clean up; cold traps

Oils: properties of refrigeration oil; types; selection

Refrigeration system components.

Compressor: types (reciprocating, rotary, centrifugal, scroll)

Condenser: types (air cooled, water cooled, evaporative); pumps; cooling tower/water regulator valve; water treatment; liquid receiver (horizontal, vertical)

Evaporator: types; secondary refrigerants

Flow control: types (hand expansion, low side float, high side float, automatic expansion, thermostat expansion, thermo-electric, capillary tube); refrigerant distributors (venturi, weir, pressure drop, centrifugal)

Air conditioning.

Air conditioning: definitions; classification and application; comfort zone; basic system layout; air conditioning processes; basics of ventilation; SAA codes

Psychrometerics: terminology/definitions; sling psychrometer; psychrometric chart

Heat load estimation: elements of heat load; industry check figures; calculations

Appliance motors and circuits.

Dangers and safety precautions: identify causes; predict electrical hazards; safe working practices; earthing and insulation; polarity and insulation; handling PCBs; isolation, testing and tagging; appliance electrical safety testing; AS3000; AS3100 series; AS3300 series; other relevant codes

Alternating current: single and three phase supply; impedance, inductive and capacitive; reactance; power and power factor

Single phase appliance motors: shaded pole; synchronous; universal series; standard split phase; capacitor start, induction run; capacitor start, capacitor run; permanently split; terminal identification; rotation reversal; speed control; typical applications; electrical symbols and circuits; manufacturers specification tables; testing; faulting

Single phase appliance motor starters and overloads: centrifugal switch; current relay; potential relay; solid state relay; over-current protection; over-temperature protection; applications; electrical symbols and circuits; testing; fault-finding

Three phase motors: three phase induction motors; delta and star connection; terminal identification; rotation reversal; typical applications; electrical symbols and circuits; testing; fault-finding

Three phase motor direct-on-line starters and protection devices: DOL motor starters; fuses and circuits breakers; thermal overloads; magnetic overloads; under and over voltage relays; electronic; timers

Refrigeration system operation.

Pressure enthalpy chart zones represented on chart: sub-cooled; latent; superheated

Interpretation of chart lines

Plotting systems cycle

Calculation of values from chart information: refrigeration effect; flow rate; specific volume; system capacity; discharge temperature; total heat rejection; heat of compression

Refrigerant oil properties types of lubrication systems: splash; forced

Methods of system capacity control: oil pressure; refrigerant bypass; air flow; water flow

Compressor calculations: piston displacement; compressor displacement; compression ratio; compressor efficiency

Heat exchange design

Heat exchange calculation

Water treatment code requirement

Types of motor drives: belt drive; direct drive

Calculation of speed Vs pulley size

Alignment requirements: belt drive; direct coupling

Refrigerant controls.

Types, operation and application of liquid flow controls: liquid line solenoids; capillary tubes; high side floats; low side floats; manual expansion valves; automatic expansion valves; thermostatic expansion valves, including internal equalised, externally equalised, M.O.P., crossed charged, gas charged, direct operated, pilot operated, thermal-electric, evaporator control systems and distributors

Types, operation and application of vapour flow controls: EPR valves; CPR valves; reversing valves; solenoid valves; condenser bypass

Liquid control testing procedures

Vapour control testing procedures

Selection criteria: plant capacity; pressure drop caused through installation of components evaporator operating temperature; refrigerant condensing temperature

Capillary systems.

Capillary tube system: types of tubes; application; characteristics; function; system unloading; calculating system; operating pressures; critical length; critical charge

Repair/replacement of a capillary tube: use of vacuum pumps/correct refrigerant charging procedure

Use of manufacturers catalogues: the use of refrigeration catalogues/service manuals to select replacement capillary tubes

Commissioning procedures

Codes of practice

System control.

Standard symbols used in electrical circuits: control terminology; electrical symbols; electrical diagrams – block, wiring, circuit, control, power

Components of basic control circuits: relays (starting); relays (control); thermostats; pressure controls; humidistats; flow switches; proportional controls (mod motors); contactors; installation, setting and testing controls; test equipment; safety instruction

Three phase motor starting methods (power and control circuits):   D.O.L; primary resistance; star delta; auto transformer; part winding; solid state (soft starting)

Operating refrigeration/air conditioning plants: safety instruction; ozone conservation instruction; components for removal/installation

Use/application of timers: defrosting; plant cycling; starts, limiting; transition

Methods for anticipating control settings: design conditions - comfort storage; ambient conditions; pressure/temperature relationships

Air conditioning controls.

Control system fundamentals

Circuit diagrams: air conditioning circuit diagrams

Types of control systems: electrical; electronic; pneumatic

Fluid flow control: sensors; actuators; control systems

Energy management: running costs; capacity control; economiser system; night purge; thermal storage

Commissioning procedures

Domestic refrigerators and freezers.

Operation and function of refrigerators/freezers and components: static plate condensers; static fin and tube; forced and induced air condensors; capillary tube; plate evaporators; bare pipe evaporators; forced and induced air evaporators; accumulators; heat exchangers; hermetic compressors; thermostats; defrost systems; fans; charging adapters (b-p valves, etc)

Electrical and refrigeration faults

Replacement of door liners, gaskets and fittings

Residential air conditioning.

System operation: construction, operation and application of (room air conditioners, split systems, evaporative, ducted, cassette); reverse; refrigeration system; control system

Air distribution: fans; ducts; filters; registers; noise; vibration

Heat load calculations: design conditions; residence survey; heat load sources; load calculations; equipment sizing; air distribution selection

Installation and commissioning

Service and fault-finding

Retrofitting refrigeration systems.

Refrigerant phaseout: montreal protocol; ANZECC “Revised Strategy for Ozone Protection in Australia 1994”; Kyoto Summit; Ozone layer; global warning; codes of practice; state codes and regulations

System analysis: equipment identification; refrigerant usage audit; system options; refrigerant management program

Refrigerant selection: ANSI/ASHRAE standard 34; AIRAH refrigerant selection guide; transition and drop-in refrigerant; refrigerant selection considerations; system performance testing; refrigerant recovery, recycling and reclaim; lubrication selection considerations

Retrofit procedure: flushing procedures; retrofit procedure for CFC to HCFC refrigerants; retrofit procedure CFC or HCFC to HFC refrigerants

Performing a retrofit: refrigerant recovery; flushing the system; oil and drier replacement; evacuation; refrigerant charging; refrigerant control adjustment; pressure control adjustment; system labelling

Ventilation.

Ventilation systems

Fan classifications and applications

Conducting an air balance

Filtration applications and service requirements of ventilation – air conditioning systems

Noise and vibration sources in a ventilation – air conditioning system

Site work/architectural drawings

Auxiliary equipment

Layout and zoning of duct work system

Occupational health aspects

Air conditioning systems.

Air conditioning system components: types; applications safety, environmental and legislative issues; terminology; design features; component characteristics; ancillary equipment; symbols

Air conditioning systems: types; design features and heat loads; system characteristics; system layout and constructional drawing interpretation

Air conditioning systems servicing: routine scheduled; fault tracing; rectification

Coolrooms/freezer rooms.

Food spoilage: effects of storage conditions; controlled atmosphere; relative humidity; evaporator temperature difference

Walk-in coolrooms and freezer rooms: construction; insulation; vapour barrier; frost heave; interior fittings

Layouts and installation: location of equipment; power supply and electrical services; arrangement of piping

Components and features: refrigerant controls; evaporators; solenoid valves; crankcase pressure regulators; defrosting method and mullions; drain facilities and heaters; pressured relief valves; door hardware; lighting and germicidal lamps

System and defrost controls: operating conditions; thermostat and pressure controls; defrost timers and controllers; overloads and safety control; electrical control circuits

Commissioning procedures

Specialisation: Commercial air conditioning

Maintain and service air handling plant.

Filter cleaning methods: cleaning water nozzels, drain trays; humidifies; electrical and water requirements; condensate and drainage points; cooling coils; electrostatic air filters

Identify sludge, scale water contaminates: replacement of cleaning of air filters, water nozzels, ball float; air quantity; location; dust – VAV systems

Accumulated moisture: drainage; terminal units; spray coils

Responsibilities under the ACT: regulators and standards; AS3666, AS1851, AS, AS1470, AS1657, AS1715 and AS2865, ordinance 70, AS1668 part 1; disinfectants; fever – humidifies, portia; fire dampers; paintin AS3665 rust prevention

Installation and commissioning of air handling plant.

Introduction: benefits; reasons for training

Safety: water supply and drainage requirements; electrical requirements; special site requirements; location and securing of equipment

Reading manufacturer's drawings and specifications: methods of assembly; fixing; running test

AS3666, AS1851, AS, AS1470, AS1657, AS1715 and AS2865, ordinance 70,: local authority requirements; relevant legislation; legal obligations; development/building approvals

Specialisation: Commercial refrigeration

Merchandising and display cabinets.

Types and construction: deep freeze meat, dairy, fruit and vegetables; multi deck display type; single deck, well type and island cases; glass door/reach-in merchandiser

Components and features: condensing units; refrigerant controls; evaporators and fans; defrosting method and mullions; drain facilities and drain heaters; air distribution and air flow curtains; cabinet air temperature, velocity and direction lighting

Layouts and installation

System and defrost controls: operating conditions; alarm systems; thermostats and pressure controls; defrost timers and controllers; electrical control circuits

Multiple Systems: multiple compressors; multiple evaporators; heat reclaim systems; multi-temperature accessories; controls and sequencing

Commissioning service and maintenance

Post mix and dairy products and refrigeration systems.

Dispensing application: name various types of post mix dispensers, soft ice cream dispenser and milk vats, plate cooling; list typical applications; commercial considerations

Operating cycle: type; water quality, sludge, scale, contaminates; operating temperatures; water nozzles, ball float; storage temperatures; location; refrigeration systems

Responsibilities under the Act: regulators and standards; cleaning; electrical and water requirements; condensate and drainage points

Installation requirements: electrical; water supply; drainage; refrigeration service, fault-finding, maintenance requirements

Commercial ice making systems.

Applications: name various types e.g. cube, flake, cylinder; continuous, intermittent

Operation: operating cycle, harvest cycle; type of ice, clear, opaque; water quality, sludge, scale, water contaminates; operating temperatures; water nozzles, ball float; ice storage; location; refrigerating systems

Responsibilities under the Act: regulators and standards; cleaning; electrical and water requirements; condensate a drainage point

Installation requirements: connecting services, electrical, water supply, drainage; operating conditions; controls; circuit diagrams, electrical, water, drainage, refrigeration; service; fault-finding; maintenance requirements

Specialisation: Domestic appliances

Service clothes washers and clothes dryers.

Codes and regulations: plumbing – water supply drainage, back siphoning; electrical insulating, earthing; manufacturers data

Types and applications: types of washing machines – automatic washers, top load and front load, wringer washers, twin tub washers; application and significant differences: types of clothes dryers – tumble, application

OH&S: OH&S act; manufacturers data; test instruments; tools; service report, customer advice; electrical testing, motors, controllers; timers, operational and safety thermostats; mechanical testing, safety locks, soiled clothes, out of balance, not draining, or filling noisy

Repair/replace faulty components: access to appliance; confirm fault diagnosis; disconnect services, water, electricity; select components from manufacturers data service vehicle, supplier; removal and replacement of electrical controls, motors, capacitors, thermostats, switches, heaters, lead, plug, timer, wiring; removal and replacement of various mechanical items, belts, bearings, door locks, filters, hoses, pumps, float switch, clutch, brakes, dispenser leveling feet, balance control, gaskets, lint screens – adhesives and water sealant, cleaning of cabinets and components, removing rust and minor repairs to cabinets, touching up paint work

Test: set operational and safety controls; check electrical components; operate system and adjust cycle controls etc; carry out leak tests

Service report: information and advice to equipment owners; equipment labels; service report; documentation

Service refrigerators, freezers and room air conditioners.

Codes and regulations: rating; location; ventilation; dangers and safety precautions; predict electrical hazards; safe working practices; earthing and insulation; testing and making safe

Types, operational features, application and installation requirements: refrigerators, freezers – single door, two door, all refrigerator, combination cabinet, cool water and ice dispensing, chest freezer; air conditioners – window mounted, wall mounted, roof mounted (drop in), split unit, portable

Fault-finding: test instruments and equipment; safety electrical, ventilation; electrical circuit – interpretation of wiring diagrams, sequence of operation, relevant electrical symbols, fuses, making safe, earthing, flash back, fans and fan motors, controllers, time clocks

Service: access to the appliance; confirm fault diagnosis; obtain required components; disconnect services to the appliance; remove faulty component; repair or replace component; reassemble; reconnect services

Safety: set operational and safety controls; check electrical components; operate appliance and adjust cycle controls; carry out leak test; check water supply and drainage leaks

Service reports: information and advice to equipment owners; equipment labels; service reports; documentation

Specialisation: Hotel/club refrigeration

Beverage dispensers.

Types of construction: hotel/club dispensing; balanced beer dispensing

Components and features: operating principles; condensing units; evaporating control; refrigerant control; safety features; hygiene awareness

Layout and installation: location of equipment; installation considerations

System and control methods: operation – conditions; thermostat, pressure controls and evaporator pressure regulating valve, solenoid valves; electrical and piping circuits

Commission: determine design operating conditions; check and adjust controls

Servicing: normal and abnormal operation; fault-finding charts – maintenance charts; repair and replacement of parts; maintenance

Post mix and dairy products and refrigeration systems.

Dispensing application: name various types of post mix dispensers, soft ice cream dispenser and milk vats, plate cooling; list typical applications; commercial considerations

Operating cycle: type; water quality, sludge, scale, contaminates; operating temperatures; water nozzles, ball float; storage temperatures; location; refrigeration systems

Responsibilities under the Act: regulators and standards; cleaning; electrical and water requirements; condensate and drainage points

Installation requirements: electrical; water supply; drainage; refrigeration service, fault-finding, maintenance requirements

Commercial ice making systems.

Applications: name various types e.g. cube, flake, cylinder; continuous, intermittent

Operation: operating cycle, harvest cycle; type of ice, clear, opaque; water quality, sludge, scale, water contaminates; operating temperatures; water nozzles, ball float; ice storage; location; refrigerating systems

Responsibilities under the Act: regulators and standards; cleaning; electrical and water requirements; condensate a drainage point

Installation requirements: connecting services, electrical, water supply, drainage; operating conditions; controls; circuit diagrams, electrical, water, drainage, refrigeration; service; fault-finding; maintenance requirements

Specialisation: Industrial refrigeration

Industrial refrigeration.

Applications: blast freezers; food production; wine/beer production; abattoirs; bulk food storage and markets

Refrigerants: types and applications; codes and regulations; safety and handling

Components: compressors; evaporators; metering devices; auxiliary equipment

Industrial systems: liquid recirculation; dry expansion and flooded; eutectic solutions; continuous ice making; freezing; air blast; liquid immersion; surface contact; chillers

Servicing: testing; commissioning; maintenance; fault-finding and repairs

Commercial ice making systems.

Applications: name various types e.g. cube, flake, cylinder; continuous, intermittent

Operation: operating cycle, harvest cycle; type of ice, clear, opaque; water quality, sludge, scale, water contaminates; operating temperatures; water nozzles, ball float; ice storage; location; refrigerating systems

Responsibilities under the Act: regulators and standards; cleaning; electrical and water requirements; condensate a drainage point

Installation requirements: connecting services, electrical, water supply, drainage; operating conditions; controls; circuit diagrams, electrical, water, drainage, refrigeration; service; fault-finding; maintenance requirements

Compound systems.

Applications

Refrigerants

Special low temperature components: compressor problems; suction pressures; compressor ratios; discharge temperatures; capacity; P.H. diagrams

Low temperature systems (application): two stage; cascade; indirect

Typical low temperature systems (construction): operation; accumulators; solenoid valves; oil separators; intercoolers; RMDs; press regulators; brines; pumps

Advantages of low temperature systems: comparisons; characteristics; calculations

Specialisation: Transport refrigeration and air conditioning

Transport/marine refrigeration.

Construction of refrigeration containers: insulation; vapour barriers; systems including containers with their own units, pre-chilled, liquid nitrogen systems, marine holds, marine cold rooms, rail car refrigerated storage, aircraft refrigerated containers, refrigerated pantechnicons and transport storage depots; preparation and storage requirements for transporting refrigerated food products; legislation, security and insurance aspects; electrical power sources; maintenance procedures and fault-finding techniques

Automotive air conditioning.

Heat, pressure and temperature; heat flow; heat transfer; pressure temperature relationships vapour compression; cycle conditioning of refrigerants throughout cycle

Compressors (auto); evaporators (auto); condensers (auto); refrigerant controls (auto); receiver dryer (auto); fitting service gauges; service valves; reclaim units; CFC regulation; vacuum pumps – evacuation; refrigerant contaminants; graduated charging cylinders; liquid charging; vapour charging; thermostats; relays; electro magnetic clutches; basic control circuits; P.O.A. valves; H.P. and L.P. switches; thermistors; pressure testing; leak detecting (halide, electronic, soap bubbles); condenser and evaporators temperature differences; restrictions; compressor valve efficiency; filter driers and strainers; TX valve faults; air filters (heavy equipment)

Specialisation: Vending equipment refrigeration

Merchandising and display cabinets.

Types and construction: deep freeze meat, dairy, fruit and vegetables; multi deck display type; single deck, well type and island cases; glass door/reach-in merchandiser

Components and features: condensing units; refrigerant controls; evaporators and fans; defrosting method and mullions; drain facilities and drain heaters; air distribution and air flow curtains; cabinet air temperature, velocity and direction lighting

Layouts and installation

System and defrost controls: operating conditions; alarm systems; thermostats and pressure controls; defrost timers and controllers; electrical control circuits

Multiple Systems: multiple compressors; multiple evaporators; heat reclaim systems; multi-temperature accessories; controls and sequencing

Commissioning service and maintenance

Post mix and dairy products and refrigeration systems.

Dispensing application: name various types of post mix dispensers, soft ice cream dispenser and milk vats, plate cooling; list typical applications; commercial considerations

Operating cycle: type; water quality, sludge, scale, contaminates; operating temperatures; water nozzles, ball float; storage temperatures; location; refrigeration systems

Responsibilities under the Act: regulators and standards; cleaning; electrical and water requirements; condensate and drainage points

Installation requirements: electrical; water supply; drainage; refrigeration service, fault-finding, maintenance requirements

Drink vending cabinets.

Types and construction: glass door; coin operated

Components and features: condensing units; refrigerant controls; evaporators and fans; defrosting method and mullions; electronic controls; drain facilities and drain heaters; air distribution and air-flow curtains; cabinet air temperature, velocity and direction; accessories; lighting

Installation requirements: location; access and obstructions; power supply and electrical services

System and defrost controls: operating conditions; thermostats and pressure controls; defrost timers and controllers; electrical control circuits

Commission, service and maintain: check and adjust control devices; determine correct air flows; leak testing; normal and abnormal operation; basic servicing techniques

Category: Data communications (F)

Common

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; techniques (marking out, cutting, bending, drilling/punching, joining, cutting meters)

Fitting techniques: dismantling; assembling

Electrical theory.

Fundamental and derived units: basic units; SI derived units; multiples and sub-multiples

Power, work and energy: conservation of energy; torque; losses and efficiency; maximum efficiency of machines

Electrical characteristics of materials: conductors, insulators, semi-conductors; electric charge; electric current; electromotive force

The simple circuit: source, load, current path and 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; conversion of electrical energy to other forms (heating,

light, magnetic, chemical)Sources of electrical energy - conversion of other forms to electrical energy

Using measuring instruments: handling measuring instruments; selecting an instrument; setting-up and connecting into circuits; reading scales and read-outs; setting up a CRO

Factors effecting resistance: length, csa and resistivity; temperature change; influence on practical circuits

Resistors: types and applications; value and rating

Series circuits (single source): determine V, I, R, P; Kirchhoff's Voltage Law; voltage dividerParallel circuits: determine V, I, R, P; Kirchhoff's Current Law; current divider

Series/parallel circuits: determine V, I, R, P; bridge networkResistance measurement: hazards; characteristics of instruments and loading effect; direct, volt-ammeter and bridge method; typical field instruments and applications

Capacitance: concept; units; time constant relationshipCapacitors: hazards; factors effecting capacitance; in series; in parallel; measuring/testing/hazards

Inductance: concept; units; time constant relationship

Inductors: factors effecting inductance

Electromagnetism.

Magnetism: field patterns; magnetic induction and screening; applications

Electromagnetism: magnetic field around a current-carrying conductor; Fleming's right-hand rules; forces between current carrying-conductors

Magnetic quantities: units (magnetomotive force, magnetising force, flux density, reluctance); permeability

Magnetisation curve: magnetic characteristics of materials; saturation and hysteresis; comparing magnetic materials

Induced voltage: factors required to induce an emf; forces acting on a conductor

Inductance: concept; unit; factors effecting inductance; self-inductance and mutual inductance

Application of electromagnetic principles: generator action; motor action; applications; unwanted effects

Single phase AC principles.

Sinusoidal alternating voltage and current: generation of a sinusoidal waveform; sinusoidal waveform characteristics; measuring and calculating values; phase relationships

Phasors: phase relationship terms; phasor representation conventions; phase relationships using phasors

Resistance in A.C. circuits: determine V, I, R, P; relationship between voltages and currents

Inductance in A.C. circuits: reactance; inductance in series; inductance in parallel; inductive components in power circuits and systems

Capacitance in A.C. circuits: reactance; capacitance in series; capacitance in parallel; capacitive components in power circuits and systems

AC circuits: impedance; relationship between resistive and reactive components; series, parallel and series-parallel RLC circuits; determine V, I, R, P in RLC circuits; phasor diagrams of RLC circuits

Resonance: conditions; resonance and frequency; effects on current

Ideal transformer: operating principles; primary and secondary voltage and current; applications

Wiring techniques.

Isolation and tagging

Standards: purpose; standard bodies; applications

Using standards: terms; numbering system; sections and clauses

Cables: terms; colour coding; structure; identification cables; cable applications

Wiring systems: enclosures and supports; selecting wiring systems; segregation; physical positioning

Terminations: requirements; terminating conductors; extension cords

Accessories and fixings: applications; licencing for explosive powered tools; fixing devices and methods

Electrical drawings and their interpretation.

Purpose and use of block, circuit and wiring diagrams

Use of drawing symbols and Australian Standard 1102

Electrical diagram conventions

Use and construction of switching charts

One-way, two-way and multi-position control of lighting circuits

Circuit wiring methods using sheathed cables and looping terminals

The features, purpose and use of site and floor plans, details and standard drawings

Locating the position of electrical services from architectural drawings

Installation and configuration for CPE 1.

Installation preparation and execution processes; communication skills; CPE system facilities; public switching network facilities; CPE equipment and system types available; practical/physical installation cabling and restrictions; cable preparation; importance of capacitances, versions and issues of system types; structure of CPE and external/add-on items such as voicemail and call accounting devices; importance of system specifications and limitations; estimating using "average" installation times; standard items used in general installation; variables which affect installation; consequences of interrupting customer communication services; site restoration processes after CPE installation; administrative processes after CPE installation and site records; processes for the disposal of recovered material; minor installation and alterations on key systems using system manuals; Minor installation and alterations on PABX's using system manuals; interface cabling on key systems using system manuals; interface cabling on PABX's using system manuals; outline of radio-based CPE; outline of CPE cut-over processes and procedures; installation warranty, manufacturer warranty, maintenance contracts and agreements; reasons for customer training; assessing appropriate customer training

Principles of CPE 1.

CPE equipment overview: types; differences; advantages

CPE test systems: types; facilities; operations; night service; programming procedures; remote diagnostics and maintenance

CPE cabling overview: PSTN vs. ISDN; Cabling differences in PABX and key-systems; least-cost-routing; ancillary equipment

Terminating and distributing: types of distribution points; terminating types; using systems manuals

CPE facilities overview: fail safe devices; call management; accounting

Safety

Network operations and facilities.

Switching systems within the network: PSTN (Public Switched Telephone Network); ISDN (Integrated Services Digital Network); mobiles; IN (Intelligent Network)

Network customer facilities: PSTN Services; ISDN Services

Network business services: analogy of PABX to business group; business group concept

Network testing and supervision facilities: command testing; command controlled test calls; test blocking; call path tracing; traffic supervision; blocking supervision; load supervision

Switching principles.

Switching principles: analogue; digital; information signals; line signals

Types of switching centres: electromechanical; processor controlled

Switching centre facilities

Switching centre block diagram and functions of the parts: AXE; S12

Supervisory tones

Connections: MDF; DDF

Testing of customer lines

Testing equipment.

Cable performance parameters: short circuit, open circuit, foreign battery, DC continuity; characteristic impedance and impedance regularity; NEXT (near end crosstalk) and FEXT (far end crosstalk); attenuation per unit length; shunt capacitance per unit length; loop resistance per unit length; impulse noise and average noise

Range of tests and their purpose

Standard colour coding of sockets and termination modules and standards connectors used with twisted pair, coaxial cable and optical fibre

Equipment types-principles of operation, uses: cable and pair locater; continuity testers; megger; multimeters; MTDR; category 5 testers; OTDR; O/F light source and power meter; techniques to ensure accuracy and repeatability; instrument suitability and accuracy; calibration procedures; conformity to AS3902

Sampling to AS1199

Compliance testing: category 5 compliance to AS3080-95. IS11801 and TSB67; optical fibre cabling to AS3080-95 and IS11801; coaxial cable to IEEE802.3

Third party testing

Documentation

DC power supplies.

Power supply applications: power supply block diagram (not switch mode); waveform measurements; use of laboratory power supply

Ideal and practical diodes: Ge and Si diodes; current limiting resistors; half-wave and full-wave rectifier circuits – Si diodes; average voltages for half-wave and full-wave rectifier circuits

Capacitive filtering: ripple voltages; based on load variations; based on capacitor choice

Zener diode applications

Three terminal regulators

Power supply faults and repair

Local area networks.

LAN concepts; cabling arrangements; standards; network operating systems; LAN access control methods; LAN network components – PCs, file servers, network printer; LAN management; wide area networks; LAN internet working; TCP/IP concepts; virtual LANs; network maintenance and fault-finding

Standards and Regulations – Telecommunications.

Australian Communication Authority (ACA): role; Telecommunication Act 1997

Cabling provider rules, regulations, standards, codes: cabling provider rules; regulations; AS standards; other technical standards; codes; labelling; Certified Components List (CCL)

Registration: mandatory (open, restricted, lift); voluntary; competency requirements and training for registration

Telecommunications cables and installation methods.

Telecommunication cable types, construction, characteristics and applications

Cable identification, labelling and documentation (plans and drawing)

Cable installation: hazards; cable damage prevention; cable dispensers

Building construction: domestic buildings; commercial buildings

Fixing devices

Cable enclosures: types; fixing; regulations

Distribution boxes and back mounts: systems; termination boundaries and devices

Electrical connections: hazards; regulations

Cable preparation and terminations

Hauling mechanisms: indoor; outdoor; methods

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

Telecommunications systems overview.

Principles and characteristics of sound

Transmission of sound

Telephone transmitters

Telephone receivers

Telephone circuits: components; operation of basic telephone; operation of basic facsimile machine; cables used, colour and termination types

Overview earthing and protection

Customer switching systems (CSS), interfaces and devices: System Distribution Frames (SDF)/Test Point Frames (TPF), power fail and line interface requirements (eg indial, rotary groups, extension and tie-line circuits)

Installation of CSS

Installation and termination requirements overview: ACA regulations and requirements; technical standards; programming of CSS

Hazards: electronic components and circuits; printed circuit boards; physical; static discharge; chemical

Telecommunications earthing and protection.

Telecommunication overvoltage protection system: operating principles; overvoltage and surge/spike suppression protection techniques; overvoltage protection devices; installation of overvoltage protection systems

Earthing protection system: MEN system; TELEX functional earth system; telecommunication system earthing; communication earth system; protective earth barriers for segregation, cable tray, duct and metal equipment enclosures

Electrical interference: types – RFI, EMI; sources of interference; techniques in reducing interference; earthing cable shields

Testing of systems: earth testing instruments; earth testing procedures

Earthing hazards: safety issues to be considered with earthing and bonding

Telecommunications structured cabling.

Category 5 structured cabling design principles

Category 5 structured cabling installation systems

Category 5 structured cabling performance requirements

Selecting cable and cabling hardware

Testing category 5 cabling

Local area network cabling systems

Coaxial cables

Coaxial cable installation systems

Twisted pair cable installation systems

Telecommunications optical fibre cabling.

Operating principles of fibre optical cable

Installation of fibre optical cable

Termination and splicing techniques

Transmission testing

Fault-finding

Testing according to requirements and OH&S guidelines

Application software.

Introduction to computers: types of computers; hardware identification; peripherals; common computer terminology

Introduction to computer operating systems: MS Windows – current versions; Windows NT; Macintosh; other operating systems

Computer usage: load and run a simple program; enter data; save data; retrieve data; manipulate data

Software applications: office support – word processing, database, spread sheet, graphics, record keeping (stores, bill back); communication – email, schedule, fax; networks; machine control

Specialisation: Fire protection

Building automation fire protection installation.

Purpose of automatic fire detection and alarm systems: preservation of life; protection of buildings and equipment

Standards and codes: general legislation and codes; specific legislation – Halon systems, ionisation smoke detectors; legal liability

Fire characteristics: principles of fire detection – fire growth; principles of fire suppression

Generic automatic fire detection and alarm system: overview of automatic fire detection and alarm system

Fire detection actuating devices: fire detector classification; detector patterns; detector types, principles of operation and performance; heat detectors – electro-pneumatic, fusible alloy, bimetallic, solid state, thermo-plastic; smoke detectors – ionisation, photo-electric, beam light obscuration, sampling light scatter (aspirating); flame detectors – infra-red, ultra-violet, manual call points; special purpose detectors – flammable vapour/gas detectors, explosion detectors

Control and indicating equipment (CIE): fire panels; classification; types; principles of operation; installation; commissioning report as per AS 1670

Emergency warning and intercommunication system (EWIS): purpose; types; installation; codes and requirements; manufacturers' specifications and requirements – AS3000 series, AS1670, AS2220, AS1668

Alarms: local alarms – purpose, types, installation; transmitted alarms – purpose, types, installation; control outputs – purpose, types, installation; pump control – purpose, pump actuation; codes and requirements – manufacturers' specifications, manufacturers' requirements for handling; building codes Australia – AS1668, AS1670, AS1851

Suppression systems: sprinkler systems; sequence of operation; purpose of interfacing devices; special purpose gaseous, dry chemical, foam, explosion suppression; suppression actuating devices; purpose; sequence of operation; purpose of interfacing devices; types of interfacing devices; installation of interfacing devices; purpose of actuation devices; types of actuation devices; installation of actuation devices; codes and requirements – manufacturers' specifications, manufacturers' requirements for handling; building codes Australia – AS1670, AS1851, AS1668

Cabling: types of fire cables – mineral insulated metal sheathed cable (MIMS), radox cable, data cable, fibre optic cable; codes and requirements – manufacturers' specifications and requirements, AS3000 series, AS1670, ACA standards; installation of fire cables; detector selection – detector installation; detection systems – conventional, distributed, network; detection system installation; codes and requirements; manufacturers' specifications; manufacturers' requirements for handling; building codes Australia – AS1670, AS1851, AS3000

Programmable controllers.

Introduction to control systems: block diagram of any control system (input, process, output); methods of control (relay, static logic, programmable); introduction to PLC systems; advantages and disadvantages of PLCs; block diagram of PLC system

Basic PLC operation: definitions, terminology and block diagram; scan cycle; basic programming rules; addressing for I/O; halt; run

Programming (using a hand programmer): flowcharts/steps to use when programming; clearing memory; ladder format; Boolean/mnemonic/statement list format; series circuits; parallel circuits; latching circuits; stack register operation; combination series/parallel circuits; inversion elements; timers (DOE); counters; monitor discrete I/O and timer/counter values; edit (insert and delete elements)

Connect discrete input and output devices to a PLC

Specialisation: Networks

Telecommunications underground cabling.

Underground construction: man hole and pit; location; capacity; purpose; duct seal; conduit

Ducts: capacity (number of cables and size); types of ducts (concrete, plastic, earthen ware, metallic)

Cable types: cable types (optical fibre, plastic, lead, CATV, other); cable details (size, type, depth, duct and cable, amplifiers, existing joints); labelling cable

Hazards: dangerous gases; toxic fumes; sharpes; ventilation; maintenance of working environment; precautions

Working environment: light and ventilation; road way and footway guarding; debris; temporary cables/services; regulations (total fire ban, discharge of water, vehicle parking restrictions, tree lopping/trimming)

Mechanical and manual aids: mechanical aid; manual aid; storage; inspection

Telecommunications aerial cabling.

Safe working environment: protective suits; masks; safety boots; head protection; safety glasses; knee pads, gloves (plastic, rubber, leather), ear muffs; witches hats; flashing lights; guards; warning signs and tapes; traffic signs and vehicle positioning; weather conditions; pole voltage (high and/or low)

Soundness of pole: authority markings; tests (push, knock, visual, dig and visual); public and private property requirements

Safety practices: safety belt; safety line; ladder

Pole top rescue: personal safety; first aid techniques (heart lung resuscitation, emergency procedures)

Aerial construction: purpose and connection/fixing requirements; types of construction (power, telephony, broadband, cable TV); suspension types and systems; pole types (wood, concrete, steel, composite); regulations (ACA, power authorities, local council); standards and codes of practice

Cable plans: size; type; existing and new joints

Data communications.

Standards: elements of data communication system; transmission modes (simplex, half and full-duplex); transmission techniques; voice transmission fundamentals; interfacing devices and standards; OSI seven layer model; modem fundamentals; modem modulation techniques; integrated services digital network (ISDN); packet switching services, X.25

Network operating systems.

Network systems: mainframe; mini computers; microcomputers

WANs: protocols; protocol stacks; interconnectivity

LANs: protocols; terminal emulation

Operating systems: NT; UNIX; LINUX; Netware; Windows 95; other OS

Administration: duties; responsibilities; procedures; user access; managing and configuring attached devices

TCP/IP: protocols; services; IP addressing scheme; routing; OSI model relationship; network address; broadcast address; multicast; fragmentation; PPP implementation; bridging; network address translation

Equipment installation: driver loading; testing; troubleshooting

Specialisation: Security systems

Security systems.

Regulations applicable to the security industry

Design of domestic security system

Building construction

Mechanical detectors: pressure pads; trip wires; window tape; screens; switches; vibration

Electro-mechanical detectors: ultra sonic; microwave; glass break; smoke; active infra-red beams; passive infra red; strain system; electromagnetic; optical fibre cable

Batteries: types; applications; maintenance

Relays: types; applications

Security panels

Communication systems

Close circuit television (CCTV)

Locking devices

Lighting

Advanced security systems.

Fibre optics – applications, terminations, physical properties; intrinsically safe wiring – where needed, alternatives; modems – commands, uses

UTE NES502 (A to Z qualifier) A
Diagnose & rectify faults in apparatus & complex circuits

Descriptor: Diagnose and repair faults in *apparatus* and associated *complex circuits*, includes wiring, piping, tubing and components.

Alignment: This unit aligns to and is based on the National Electrotechnology Benchmark Standard EBS 403 – Diagnose faults in apparatus and complex circuits.

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 NES502A A	Diagnose & rectify faults in apparatus & complex circuits *(Computer systems)*
UTE NES502B A	Diagnose & rectify faults in apparatus & complex circuits *(Electrical)*
UTE NES502C A	Diagnose & rectify faults in apparatus & complex circuits *(Electronics)*
UTE NES502D A	Diagnose & rectify faults in apparatus & complex circuits *(Instrumentation)*
UTE NES502E A	Diagnose & rectify faults in apparatus & complex circuits *(Refrigeration & a/conditioning)*

Elements		Performance criteria	
502.1	Plan and prepare for diagnosis of faults	502.1.1	Diagnosis of faults is planned and prepared to ensure *OH&S policies and procedures* are followed the work is appropriately and sequenced in accordance with *requirements*
		502.1.2	*Appropriate personnel* are consulted to ensure the work is co-ordinated effectively with others involved on the work site
		502.1.3	*Apparatus* faults are checked against job *requirements*
		502.1.4	Materials necessary to complete the work are obtained in accordance with *established procedures* and checked against job *requirements*

Elements		Performance criteria	
		502.1.5	*Tools, equipment* and *testing devices* needed to carry out the work are obtained in accordance with *established procedures* and checked for correct operation and safety
		502.1.6	Preparatory work is checked to ensure no unnecessary damage has occurred and that it complies with *requirements*
502.2	Diagnose faults in *apparatus* and *complex circuits*	502.2.1	*OH&S policies and procedures* are followed
		502.2.2	Reported fault(s) are confirmed and normal function of *apparatus* and associated *complex circuits* are ascertained in accordance with *requirements*
		502.2.3	*Complex circuits* are checked as being isolated where necessary using specified testing procedures
		502.2.4	*Apparatus* faults are diagnosed in accordance with *requirements,* without damage or distortion to the surrounding environment or services
		502.2.5	Contingency measures are implemented in accordance with *established procedures* to ensure that the *apparatus* operates as intended/designed
		502.2.6	Unplanned events or conditions are responded to in accordance with *established procedures*
		502.2.7	On-going checks of quality of the work are undertaken in accordance with *established procedures*
502.3	Rectify faults in *apparatus* and associated *complex circuits*	502.3.1	*OH&S policies and procedures* are followed
		502.3.2	*Apparatus* and associated *complex circuits* are isolated, where necessary, in accordance with *established procedures*
		502.3.3	Adjustments are made in accordance with *established procedures*, where necessary, to return *apparatus* and associated *complex circuits* to normal operating parameters
		502.3.4	Faulty component(s) is/are rectified or replaced, without damage or distortion to the surrounding environment or services

Elements		Performance criteria	
		502.3.5	Unplanned events or conditions are responded to in accordance with *established procedures*
		502.3.6	Approval is obtained in accordance with *established procedures* from *appropriate personnel* before any contingencies are implemented
		502.3.7	On-going checks of the quality of work are undertaken in accordance with *established procedures*
		502.3.8	*Apparatus* and associated *complex circuits* are tested to ensure safety of the installation
		502.3.9	*Apparatus* and associated *complex circuits* are returned to service in accordance with *established procedures*
502.4	Provide status report(s)	502.4.1	Arrangements are made for maintenance and/or repair(s), where necessary, with relevant *authorised personnel* in accordance with *requirements*
		502.4.2	Status report(s) is/are completed and *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 units UTE NES501 A of this standard has been achieved.

Additionally, this unit has been designed as a natural progression from unit UTE NES403 A. Therefore, it is expected that to achieve this unit, without having gained competence in unit UTE NES403 A, will require that the relevant aspects of knowledge and skills related to unit UTE NES403 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

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 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: graphics 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 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.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 BDCto 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 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 date 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

Measurement terminology

Dimensional calculations

Basic transducer principles and physical variables

Control terminology

Type 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

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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 date 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 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 date 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

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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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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 date 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

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;

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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

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 date 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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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

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

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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 date 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.

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

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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; fitting of pulleys to shafts, alignment

Types of belts, applications

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; compounding; 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

Digital modulation: sampling theorem (bandwidth; filtering requirements); pulse code modulation (PCM); pulse width modulation (PWM); delta modulation; quantising noise; companding; aliasing.

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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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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; compounding; aliasing

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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: comparitors; 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 waveforin 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 BDCto 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; digital 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; bi-directional 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

Specialisation: Entertainment - VCR

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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

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

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

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; simplifcation 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 BDCto 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: comparitors; 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.

Inverting, non-inverting, voltage follower, transresistance and transconductance operational amplifier circuits

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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 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 date 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

Industrial computer systems.

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Control applications

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 from 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 test 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

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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 erected 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 NES503 (A to Z qualifier) A Diagnose & rectify faults in apparatus & systems' circuits

Descriptor: Diagnose and rectify faults in interconnected *apparatus* and associated *systems' circuits;* includes wiring, piping, tubing and components.

Alignment: This unit aligns to and is based on the National Electrotechnology Benchmark Standard EBS 404 - Diagnose faults in apparatus and associated systems' circuits.

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 NES503A A	Diagnose & rectify faults in apparatus & systems' circuits *(Computer systems)*
UTE NES503B A	Diagnose & rectify faults in apparatus & systems' circuits *(Electrical)*
UTE NES503C A	Diagnose & rectify faults in apparatus & systems' circuits *(Electronics)*
UTE NES503D A	Diagnose & rectify faults in apparatus & systems' circuits *(Instrumentation)*
UTE NES503E A	Diagnose & rectify faults in apparatus & systems' circuits *(Refrigeration & a/conditioning)*

Elements		Performance criteria	
503.1	Plan and prepare for diagnosis of faults in *systems' apparatus* and associated *systems' circuits*	503.1.1	Diagnosis of faults is planned and prepared to ensure *OH&S policies and procedures* are followed and the work is appropriately sequenced in accordance with *requirements*
		503.1.2	*Appropriate personnel* are consulted to ensure the work is co-ordinated effectively with others involved on the work site
		503.1.3	*Systems' apparatus* faults are checked against job *requirements*
		503.1.4	Materials necessary to complete the work are obtained in accordance with *established procedures* and checked against job *requirements*

Elements		Performance criteria	
		503.1.5	*Tools, equipment* and *testing devices* needed to carry out the work are obtained in accordance with *established procedures* and checked for correct operation and safety
		503.1.6	Preparatory work is checked to ensure no unnecessary damage has occurred and complies with *requirements*
503.2	Diagnose faults in *systems' apparatus* and associated *systems' circuits*	503.2.1	*OH&S policies and procedures* are followed
		503.2.2	Reported fault(s) are confirmed and the normal function of *systems' apparatus* and associated *systems' circuits* are ascertained in accordance with *requirements*
		503.2.3	*Systems' circuits* are checked as being isolated where necessary using specified testing procedures
		503.2.4	*Systems' apparatus* faults are diagnosed in accordance with *requirements*, without damage or distortion to the surrounding environment or services
		503.2.5	Contingency measures are managed and implemented in accordance with *established procedures* to ensure the system operates as intended or designed
		503.2.6	Where applicable, *appropriate personnel* and resources are determined and co-ordinated to effect rectification of fault(s)
		503.2.7	Unplanned events or conditions are responded to in accordance with *established procedures*
		503.2.8	On-going checks of the quality of work are undertaken in accordance with *established procedures*
503.3	Rectify faults in *systems' apparatus* and associated *systems' circuits*	503.3.1	*OH&S policies and procedures* are followed
		503.3.2	*Systems' apparatus* and associated *systems' circuits* are isolated, where necessary, in accordance with *established procedures*
		503.3.3	Adjustments are made in accordance with *established procedures*, where necessary, to return *systems' apparatus* and associated *systems' circuits* to normal operating parameters

Elements		Performance criteria	
		503.3.4	Faulty component(s) are rectified or replaced, without damage or distortion to the surrounding environment or services
		503.3.5	Unplanned events or conditions are responded to in accordance with *established procedures*
		503.3.6	Approval is obtained in accordance with *established procedures* from *appropriate personnel* before any contingencies are implemented
		503.3.7	On-going checks of the quality of work are undertaken in accordance with *established procedures*
		503.3.8	*Systems' apparatus* and associated *systems' circuits* are tested to ensure safety of the installation
		503.3.9	*Systems' apparatus* and associated *systems' circuits* are returned to service in accordance with *established procedures*
503.4	Provide status report(s)	503.4.1	Arrangements are made for maintenance and/or repair(s), where necessary, with relevant *authorised personnel* in accordance with *requirements*
		503.4.2	Status report(s) are completed and *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 NES502 A 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

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

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 internet work 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 architectures; 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; 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: 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: graphics 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 selected 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, uncontrolled 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

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 (PF) correction: requirement; calculation of reactive element to correct PF; synchronous machines for correction of PF

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: Renewable energy

Renewable energy technologies.

Sustainable energy imperatives: current economic, social, environmental and political issues, impact on a renewable energy technology

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); terminology; characteristics; applications; specifications, sizing

Micro-hydro resource and technology: terminology, units, symbols; flow rates, heads, assessment; turbines; operating characteristics; control requirements; specifications, sizing

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; specifications and sizing

Energy storage: terminology; types and methods; battery life, temperature effects, charge and discharge rates; precautions, maintenance, safety; stratification; boosting and equalising charges; specifications, capacity, configuration; operating characteristics; types, sizes

Power electronics for renewable energy.

Single phase controlled rectifiers – function; circuit configurations (single phase half wave; single phase half controlled bridge; single phase fully controlled bridge); resistive and inductive load operation; output voltage and waveform, inductive load commutation problems

Single phase AC controllers – function, circuit configurations (single phase half controller, single phase full controller (triac control); single phase full controller (inverse parallel SCR's); resistive and inductive load operation (output voltage, waveforms); inductive loads (control range, triggering problems)

DC to DC converters – function; voltage control methods (pulse width modulation (PWM); pulse rate modulation (PRM), combined PWM and PRM), resistive and inductive loads (output voltage, current, waveforms)

Inverters – basic operation, half - and full-bridge voltage source inverters; voltage control techniques; PWM single phase inverters; three phase inverters

Thyristor protection – techniques (snubber networks, series inductors, amp trap (HRC) fuses, gate pulse suppression); heat sinking (installation methods, basic thermal model)

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 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; pumps 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; standard 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 conversation 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 watervapour through structures – transmission coefficient; 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, 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 interwined

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 condensor 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 of 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 a 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 NES504 (A to Z qualifier) A
Diagnose & rectify faults in advanced systems & apparatus

Descriptor: Diagnose and rectify faults in advanced systems and associated *apparatus;* includes computing, electrical, electronics and instrumentation.

Alignment: Nil.

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 NES504A A	Diagnose & rectify faults in advanced systems & *apparatus* *(Computer systems)*
UTE NES504B A	Diagnose & rectify faults in advanced systems & *apparatus* *(Electrical)*
UTE NES504C A	Diagnose & rectify faults in advanced systems & *apparatus* *(Electronics)*
UTE NES504D A	Diagnose & rectify faults in advanced systems & *apparatus* *(Instrumentation)*

Elements		Performance criteria	
504.1	Plan and prepare for diagnosis of faults in advanced *systems* and associated *apparatus*	504.1.1	Diagnosis of faults is planned and prepared to ensure *OH&S policies and procedures* are followed and the work is appropriately sequenced in accordance with *requirements*
		504.1.2	*Appropriate personnel* are consulted to ensure the work is co-ordinated effectively with others involved on the work site
		504.1.3	*Systems* and *apparatus* faults are checked against job *requirements*
		504.1.4	Materials necessary to complete the work are obtained in accordance with *established procedures* and checked against job *requirements*

Elements		Performance criteria	
		504.1.5	*Tools, equipment* and *testing devices* needed to carry out the work are obtained in accordance with *established procedures* and checked for correct operation and safety
		504.1.6	Preparatory work is checked to ensure no unnecessary damage has occurred and complies with *requirements*
504.2	Diagnose faults in advanced systems and associated *apparatus*	504.2.1	*OH&S policies and procedures* are followed
		504.2.2	Reported fault(s) are confirmed and the normal function of *systems* and associated *apparatus* is ascertained in accordance with *requirements*
		504.2.3	*Systems* are checked as being isolated where necessary using specified testing procedures
		504.2.4	*Systems* and associated *apparatus* faults are diagnosed in accordance with *requirements,* without damage or distortion to the surrounding environment or services
		504.2.5	Contingency measures are managed and implemented in accordance with *established procedures* to ensure the system operates as intended or designed
		504.2.6	Where applicable, *appropriate personnel* and resources are determined and co-ordinated to effect rectification of fault(s)
		504.2.7	Unplanned events or conditions are responded to in accordance with *established procedures*
		504.2.8	On-going checks of the quality of work are undertaken in accordance with *established procedures*
504.3	Rectify faults in advanced *systems* and associated *apparatus*	504.3.1	*OH&S policies and procedures* are followed.
		504.3.2	*Systems* and associated *apparatus* are isolated, where necessary, in accordance with *established procedures*
		504.3.3	Adjustments are made in accordance with *established procedures* where necessary, to return *systems* and associated *apparatus* to normal operating parameters
		504.3.4	Faulty component(s) are rectified or replaced, without damage or distortion to the surrounding environment or services

Elements	Performance criteria
	504.3.5 Unplanned events or conditions are responded to in accordance with *established procedures*
	504.3.6 Approval is obtained in accordance with *established procedures* from *appropriate personnel* before any contingencies are implemented
	504.3.7 On-going checks of the quality of work are undertaken in accordance with *established procedures*
	504.3.8 *Systems* and associated *apparatus* are tested to ensure safety of the installation
	504.3.9 *Systems* and associated *apparatus* are returned to service in accordance with *established procedures*
504.4 Provide status report(s)	504.4.1 Arrangements are made for maintenance and/or repair(s), where necessary, with relevant *authorised personnel* in accordance with *requirements*
	504.4.2 Status report(s) are completed and *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

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 NES503 A. Therefore, it is expected that to achieve this unit, without having gained competence in unit UTE NES503 A, will require that the relevant aspects of knowledge and skills related to unit UTE NES503 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.

Data communication 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 back 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; calbe 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.

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; colling 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

Thee 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, desication, 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

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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 1^{st} 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 2^{nd} 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, terrestial 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 and 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 a 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

Specialisation: Medical equipment

Frequency selective amplifiers.

Band pass and band stop circuits

Tuned amplifiers: single LC load, gain calculation

Amplifiers using frequency selective feedback: active filters

Gain stability

Higher order filter circuits

Multi stage tuned amplifiers

Advanced filter networks: ceramic resonator; SAW; crystal; mechanical

Digital filters

Basic principles of anatomy and physiology.

Clinical terminology

Primary anatomy: surface anatomy

Cellular organisation: tissues; organs; organ systems

Neurophysiology

Muscle physiology

Sensory physiology

Cardiovascular physiology

Pulmonary physiology

Endocrine physiology

Gastrointestinal physiology

Renal physiology

Reproductive physiology

The integument

Homeostasis: homeostatic malfunction

Vital signs: significance; detection; physiological basis for measurement; pathology

Infection control – equipment safety.

Introduction to general terminology: pathogen; transmission; infection; opportunistic; reservoirs

Causal agents of infection and general detection methods: fungi; protozoa; bacteria (nomenclature); viruses; prions

Conditions favouring survival and growth of pathogens in vitro eg nutrient needs and availability: temperature and humidity; pH; aerobic or anaerobic conditions

Transmission of pathogens and transmission of diseases: modes of transmission; portals of entry and exit; nosocomial infections

Control of micro-organisms eg: septic and aseptic techniques: disinfection; decontamination; sanitisation; pasteurisation; sterilisation; barrier techniques; cleaning procedures; pyrogens; use of radiation; waste disposal guidelines

Types of infectious diseases in the health care setting eg: influenza and colds; hepatitis A; B and C; HIV; tuberculosis; tetanus

Risk assessment and management: identification of the microbiological risks; evaluation of the microbiological risks; special risk cases; control of microbiological risk; routine monitoring such as blood tests and X-rays; immunisation

Electrophysiology.

The cell and excitable tissues

Neurophysiology and neural potentials

Muscle physiology

Cardiac physiology and the ECG

Renal physiology and electrolyte balance

Measurement of biological potentials

Analysis of biological potentials and diagnosis

Vital sign monitoring

Safety and Safety Standards in a clinical setting

Safety devices used in a clinical setting

Monitoring and maintaining safety devices

Common medical equipment.

Physiological monitors: function; physiological parameters monitored in the following medical areas; GP rooms; hospital outpatient department; A and E department; general ward areas; coronary care unit; intensive care unit (adult); intensive care unit (neonatal); respiratory laboratory; epilepsy assessment laboratory; cardiac investigation laboratory; maternity unit; dental and oral surgical unit; vascular clinic; urological investigation unit; eye clinic; clinical neurophysiology unit ; gastroenterology unit; hyperbaric medicine unit; dialysis unit; operating theatre (general); operating theatre (cardio-thoracic); operating theatre (neurosurgery); hazards; monitoring configurations; modular; configured; display and recording methods; common faults; functional verification to AS3551

Defibrillators: development and application; function; principles of operation; waveforms; hazards; functional verification to AS3551

Infusion pumps: clinical function; delivery mechanisms (advantages and disadvantages; cartridges; peristaltic tubes; rigid piston/floppy bag; syringes; flow-rate and occlusion pressure verification; functional verification to AS3551)

Incubators: function; temperature control; principles of operation; transport requirements; common faults; functional verification to AS3551

Foetal monitors - clinical application; principles of operation; common faults; functional verification to AS3551

Anaesthetic units - clinical application; principles of operation; hazards (patient; operator); common equipment faults; functional verification to AS3551 and AS4059

Gas monitors: clinical application; principles of operation; application; hazards; common faults; functional verification to AS3551

Physical therapy equipment: clinical function; types (ultrasonic, interferential, transcutaneous nerve stimulation, therapeutic diathermy), principles of operation; hazards; common faults; functional verification to AS3551

Electrocardiograph (ECG): signals; principles of operation; methods of electrical patient isolation; causes of unsatisfactory recording; interpretation; storage; retrieval and distribution; functional verification to AS3551

Thermometry: thermoregulation; function; principles of operation; clinical application of different sensing methods (alcohol, mercury, thermistor, platinum resistance, thermocouple, infra-red); clinical thermometry devices; functional verification to AS3551

Electrosurgical generators: function; operating principles; operating modes (cut, coagulate, blend, monopolar, bipolar); hazards; common faults; functional verification to AS3551

Blood warmers: function; application; principles of operation; hazards; common faults; functional testing to AS3551

NIBP: function; application; operating principles; common faults; functional testing to AS3551

Pulse oximeter: function; principles of operation; application; common faults; functional testing to AS3551

Respiratory Humidifiers: function; principles of operation; application; common faults; functional testing to AS3551

Dialysis: function; principles of operation; haemodialysis machine; peritoneal machine; water quality requirements; dialysate (chemistry, concentration, temperature, pressure); hazards; common faults; functional verification to AS3551

Laboratory equipment: function; principles of operation (centrifuge, microtome, laminar flow cabinet, incubator, microscope); hazards; common faults; functional verification to AS3551

Pacemakers: function; physical and electrical specification (internal and external); application; common faults; hazards; functional verification to AS3551

EEG: signals; principles of operation; application; interpretation; hazards; common faults; functional verification to AS3551

Lasers: function; principles of operation; application; hazards; common faults; functional verification to AS3551

Endoscopes: function; principles of operation; application; hazards; common faults; functional verification to AS3551

Ventilators: function; principles of operation; ventilation monitoring; hazards; functional testing to AS3551

Medical gas installations: function; application; hazards; common faults; functional testing to AS3551

Biomedical electronics.

Transducers/sensors – pressure; temperature; transcutaneous monitoring; fuel cells

Patient isolation circuits: level and standards

Defibrillation protection: standards and circuitry

Interference and noise reduction: equipment installation; 50Hz; RF; earthing; shielding

Measurement techniques

Data acquisition and sampling

Telemetry

Battery management

Biomedical electro-mechanics.

Material mechanics: classes of material, properties of solids, gases and liquids in terms of mechanical testing and quantification, measurement of gas flow and pressure

Material properties: physical characteristics of medical-grade materials (metals, plastics, rubbers, biologically derived materials); material requirements for surgical implantation; surgical instrumentation; topical application; deterioration of commonly used medical materials

Elementary mechanics: levers; pulleys and devices utilised in physical therapy and orthopaedic equipment; physical therapy equipment (potential hazards in the event of malfunction); physical parameters monitored and controlled in physical rehabilitation and physical therapy

Units of measurement: scientific and physiological, and their conversion

Elementary hydraulics: flow measurement (renal dialysis and human circulatory systems); diffusion and osmosis

Monitoring and control of medical gases.

Gas delivery hardware: gas supply system; hazards; security requirements; common sources of failure

Gases and volatile agents used in modern anaesthesia: types and clinical function

Monitoring requirements: anaesthetic unit; anaesthetic gas; patient

Common hazards: operator errors; equipment malfunction; inappropriate gas mixture and delivery; patient response

Functional testing to AS3551

Cardiac electrotechnology.

Cardiac catheterisation: imaging system; monitoring system (transducers - pressure, flow, temperature, signal processing and displays, multi-channel recorders, hard copy devices); hazards (patient, operator, standards, microelectrocution protection); common problems (patient complication, catheter placement, instrumentation); functional verification to AS3551 and AS3003

Electrophysiological studies: clinical application and procedures; equipment (electrodes and cardiac stimulators); functional verification of electrophysiological stimulators to AS3551

Cardiac output measurement: clinical conditions and procedures; measurement principles (flow, dilution – optical, thermal, history); hazards, common faults; functional verification to AS3551

Intra-aortic balloon pump (IABP): clinical conditions and procedures; operational principles; common faults; functional verification to AS3551

Heart lung machine: clinical conditions; operating principles; patient connection; pumps; oxygenators; common problems, safety devices (alarms, cutouts, power backup, gas backup); functional verification to AS3551

Cardiac pacemakers: hazards; maintenance; repair

Cardiac defibrillators: hazards; maintenance; repair

Medical imaging systems.

Physics of ultrasonic waves: characteristics; generation; doppler principles; signal absorption and attenuation; transmission and reflection

Ultrasound equipment: block diagram; block functions; principles of operation; hazards and safety; imaging techniques

Physics of X-rays: properties; generation; effects of radiation; radiation adsorption

X –ray tubes: types and applications; principles of operation; hazards and safety

X-ray equipment: block diagram; block functions; principles of operation; high voltage generation; image intensification; digital subtraction; contrast mediums; image processing; mobile equipment; hazards and safety

Computerised axial tomography (CT scan); block diagram; principles of operation; imaging systems; data storage; hazards and safety

Magnetic resonance imaging (MRI): gradient magnetic fields; relaxation time T1 and T2; X,Y and Z imaging; block diagram; principles of operation; common faults; hazards and safety; localised heating; patient implants; equipment interference; factors effecting image quality

Nuclear medicine: radiation types; sources; half lives; clinical applications; hazards and safety; positron emission tomography (PET)

Digital image archiving: picture archiving communication system (PACS); digital image communications system for medical (DICOM); laser digitisers; network and computer hardware requirements

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 2^{nd} 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

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 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 commissioning: 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 of 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

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

UTE NES505 (Z to A qualifier) B
Locate & rectify fault(s) in electrical equip 1kVac/ 1.5kVdc by procedures

Descriptor: Locate and rectify fault(s) in *electrical equipment* intended to operate to a connected supply up to 1,000 volts A.C. or 1,500 volts D.C., incidental to a principle function in the workplace following *prescribed procedures.*

Alignment: This unit is based on the National Electrotechnology Benchmark Standard EBS 703 Locate and rectify faults in equipment connected to a single phase 250 volt supply and EBS 704 Locate and rectify faults in equipment connected to supply up to 650 volts.

Specific unit outcomes

This is presented as a composite unit that has five specific units as outcomes. There are five distinct *endorsable* outcomes in which competence can be achieved. This is done because of the high degree of commonality in knowledge, process or function. Reporting the unit with the inclusion of an *endorsement* allows for the formal identification of 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 outcomes are:

UTE NES 505N B	Locate & rectify fault(s) in electrical equip 1kVac/1.5kVdc by procedures (Pre-Assembled Neon Signs)
UTE NES 505P B	Locate & rectify fault(s) in electrical equip 1kVac/1.5kVdc by procedures (Single Enclosed C/Device)
UTE NES 505Q B	Locate & rectify fault(s) in electrical equipment 1kVac/1.5kVdc by procedures (Control Devices)
UTE NES 505R B	Locate & rectify fault(s) in electrical equipment 1kVac/1.5kVdc by procedures (Electrical Heaters)
UTE NES 505S B	Locate & rectify fault(s) in electrical equipment 1kVac/1.5kVdc by procedures (Motors)

Elements		Performance criteria	
505.1	Prepare to identify fault(s)	505.1.1	Nature of the fault(s) are confirmed in accordance with *established procedures* and *appropriate personnel*
		505.1.2	The work is planned to ensure *OH&S policies and established procedures* are followed
		505.1.3	*Tools, equipment and testing devices* needed to carry out the work are obtained in accordance with *established procedures* and checked for correct operation and safety
		505.1.4	*Appropriate personnel* are consulted to ensure the work is co-ordinated effectively with others involved on the work site
		505.1.5	Possible *electrical equipment* fault(s) are checked against job *requirements* and *in accordance with established procedures*
		505.1.6	Preparatory work is checked to ensure no unnecessary damage has occurred and complies with *requirements*
		505.1.7	*Electrical characteristics* of *electrical equipment* and electrical supply are determined and recorded in accordance with *established procedures*
		505.1.8	*Electrical equipment* and associated *circuits* are identified for isolation purposes, where necessary, in accordance with *established procedures*
505.2	Locate fault(s) in the *electrical equipment*	505.2.1.	*Electrical equipment* and associated *circuits* are isolated, where necessary, in accordance with *prescribed procedures*
		505.2.2	Other *OH&S policies and procedures* are followed
		505.2.3	Visual checks of the *electrical equipment* and components are carried out in accordance with *prescribed procedures* to detect any abnormal or obvious damage or fault
		505.2.4	Safety tests and c*ircuit* continuity are progressively carried out to assure isolation, and to detect operational, electrical or other non-conformances or fault(s)

Elements		Performance criteria	
		505.2.5	*Electrical equipment* is dismantled and/or removed, where necessary, and components stored in accordance with *established procedures* to protect them against loss or damage
		505.2.6	Fault(s) are confirmed and components to be replaced or adjusted are determined and details recorded in accordance with *prescribed procedures*
		505.2.7	On-going checks of the quality of work are undertaken in accordance with *established procedures*
505.3	Rectify fault(s)	505.3.1	Isolation of e*lectrical equipment* and associated *circuits* is confirmed in accordance with *requirements* and *prescribed procedures*
		505.3.2	Materials and resources necessary to complete the work are obtained in accordance with *established procedures* and checked against job *requirements*
		505.3.3	Adjustments are made in accordance with *prescribed procedures*, where necessary, to ensure *electrical equipment* operates in accordance with intended parameters
		505.3.4	Fault(s) are rectified in accordance with *prescribed procedures,* where necessary.
		505.3.5	Approval is obtained in accordance with *prescribed procedures* from *appropriate personnel*, before any contingencies are implemented
		505.3.6	Tests on the *electrical equipment* are in accordance with *prescribed procedures* performed to ensure safe return to service and operation of the *electrical equipment*
505.4	Provide status report(s)	505.4.1	Status report(s) are completed and *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.

Additional definitions

Electrical characteristics – refers to voltage, current rating, power rating, direction of rotation, phase sequence/polarity, name plates information and duty.

Electrical equipment – refers to the following items:

- **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.
- **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.
- **Control devices**, e.g. solenoids, limit switches, pressure switches, thermostats.
- A **single controlled device** contained in an **enclosure** which is not part of a control panel or distribution/switch board.
- **Pre-assembled** Type 1 and Type 2 cold cathode **Neon Signs** only.

Endorsement – describes the item(s) of *electrical equipment* competency has been demonstrated on. Competency can be achieved on any one, more than one or all of the items of *electrical equipment*. Formal endorsement for each is to be provided separately as prescribed in the evidence guide and critical aspects.

- Motors
- Electrical heaters
- Control devices
- Single enclosed control device
- Pre-assembled neon signs

Fixed wiring – a system in which cables are fixed or supported in position in accordance with the requirements determined by Australian/New Zealand Standards for wiring. This also includes catenary, open and underground wiring systems.

Accessory - any device such as a switch, fuse, plug, socket-outlet, lampholder, fitting, adaptor or ceiling rose which is associated with wiring, luminaries, switchboards or appliances.

Scope of work

This unit describes competency within the scope of:

- the relevant item of *electrical equipment* so defined.
- isolating *electrical equipment* for safe disconnection/reconnection.
- disconnecting/reconnecting *electrical equipment.*
- replacement of *electrical equipment* like for like.
- *electrical equipment* connected to fixed wired supply up to 1,000 volts A.C. or 1,500 D.C.

the relevant work being carried out in *non-hazardous areas* and on *electrical equipment* that is not part of an explosion protection technique.

Conditions specified

This unit is not intended to cover:

- competencies associated with high current faults.
- complex electrical work.
- nor competencies associated with fixed wiring (other than to disconnect and reconnect *electrical equipment).*
- work on luminaires.

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 across a *representative range* of specified *electrical equipment* in the scope of work and for which *endorsement* of competency for the specified *electrical equipment* is being sought; autonomously and to requirements. To requirements means meeting all relevant safe working practices, manufacturers specifications, codes of practice, statutory and regulatory requirements, Standards both Australian and International and OH&S Standards.

- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace for the *endorsement* sought and scope of work in the Range Statement.
- demonstrating an understanding of the underpinning knowledge and skills identified for the scope of work 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 specified *electrical equipment* for the *endorsement* and scope of work for which competency is being sought; autonomously and to requirements. Equivalent evidence from other sources, e.g., formal assessment, is also acceptable. Although it is preferred that assessing competency be carried out in the workplace it can be undertaken in a simulated work environment approved for that purpose by the industry.

Interdependent assessment of units

Competency in this unit should be determined only after competency has been achieved in:

- UTE NES208 A
- a relevant field to which the electrical work is incidental, this is expected to include a broad application of skills and knowledge related to occupational health and in the selection, knowledge and use of general hand tools and power tools.
- additional competencies will be required where conditions in the workplace are such that specific precaution and techniques must be used to ensure safety. For example, situations where high fault currents are possible; hazardous areas where explosion-protection techniques must be used; damp situations and the like.

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 would ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments within the scope for which competency is being sought.

This section includes that set of knowledge and skills additional to that specified in each pre-requisite unit, see point 3 above ‘Interdependent assessment of units’.

Occupational health and safety: Act and regulations; identification of personal safety; workplace hazards; working with electrically operated tools and equipment; emergency first aid/resuscitation; rescue from a live electrical situation; enterprise policies and procedures

Drawing: differentiation between symptoms, faults and causes in malfunctioning equipment; fault-finding techniques and procedures

Fundamental electrical concepts: effects of current; practical resistors; sources of emf; series, parallel and series-parallel circuits; electrical measurement; capacitors; inductors; magnetism

General appliances: basic principles of appliances (non mathematical); appliance identification; appliance ratings; basic principles of operation of control equipment and protection devices; fault conditions and symptoms; safe isolation procedures; test equipment; safe testing procedures, including continuity; fault types in appliances; fault-finding procedures (prescriptive)

Single phase induction motors: basic principles of operation (non mathematical); motor identification; motor ratings; basic principles of operation of control equipment and protection devices; fault conditions and symptoms; safe isolation procedures; test equipment; safe testing procedure, including continuity; fault types in “phase splitting” and universal type motors; fault-finding procedures (prescriptive)

Three phase induction motors: basic principles of operation (non mathematical); motor identification; motor ratings; motor starter principles; basic principles of operation of control equipment and protection devices; fault conditions and symptoms; safe isolation procedures; safe testing procedure; fault-finding procedures (prescriptive)

Single and three phase electrical heaters: basic principles of operation; types of electrical heaters; electrical heater identification; electrical heater ratings; basic principles of operation of control and protection devices; fault conditions and symptoms; safe testing procedure; fault-finding procedures (prescriptive)

UTE NES506 A
Diagnose and rectify faults in renewable energy apparatus and systems

Descriptor: Diagnose and rectify faults in renewable energy *apparatus* and associated *systems*. Includes wiring, piping, tubing and components.

Elements		Performance criteria	
506.1	Plan and prepare for diagnosis of faults	506.1.1	Diagnosis of faults is planned and prepared to ensure *OH&S policies and procedures* are followed the work is appropriately and sequenced in accordance with *requirements*
		506.1.2	*Appropriate personnel* are consulted to ensure the work is co-ordinated effectively with others involved on the work site
		506.1.3	*Apparatus/systems* faults are checked against job *requirements*
		506.1.4	Materials necessary to complete the work are obtained in accordance with *established procedures* and checked against job *requirements*
		506.1.5	*Tools, equipment and testing devices* needed to carry out the work are obtained in accordance with *established procedures* and checked for correct operation and safety
		506.1.6	Preparatory work is checked to ensure no unnecessary damage has occurred and that it complies with *requirements*
506.2	Diagnose faults in *apparatus* and *complex circuits*	506.2.1	*OH&S policies and procedures* are followed
		506.2.2	Reported fault(s) are confirmed and normal function of *apparatus/systems* and associated *circuits* are ascertained in accordance with *requirements*
		506.2.3	*Circuits* are checked as being isolated where necessary using specified testing procedures
		506.2.4	*Apparatus/systems* faults are diagnosed in accordance with *requirements*, without damage or distortion to the surrounding environment or services
		506.2.5	Contingency measures are implemented in accordance with *established procedures* to ensure that the *apparatus/system* operates as intended/designed

Elements		Performance criteria	
		506.2.6	Unplanned events or conditions are responded to in accordance with *established procedures*
		506.2.7	On-going checks of quality of the work are undertaken in accordance with *established procedures*
506.3	Rectify faults in *apparatus* and associated *complex circuits*	506.3.1	*OH&S policies and procedures* are followed
		506.3.2	*Apparatus* and associated *circuits* are isolated, where necessary, in accordance with *established procedures*
		506.3.3	Adjustments are made in accordance with *established procedures,* where necessary, to return *apparatus/systems* and associated *circuits* to normal operating parameters
		506.3.4	Faulty component(s) is/are rectified or replaced, without damage or distortion to the surrounding environment or services
		506.3.5	Unplanned events or conditions are responded to in accordance with *established procedures*
		506.3.6	Approval is obtained in accordance with *established procedures* from *appropriate personnel* before any contingencies are implemented
		506.3.7	On-going checks of the quality of work are undertaken in accordance with *established procedures*
		506.3.8	*Apparatus/system* and associated *circuits* are tested to ensure safety of the installation
		506.3.9	*Apparatus/system* and associated *circuits* are returned to service in accordance with *established procedures*
506.4	Provide status report(s)	506.4.1	Arrangements are made for maintenance and/or repair(s), where necessary, with relevant a*uthorised personnel* in accordance with *requirements*
		506.4.2	Status report(s) is/are completed and *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 each of the 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 *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 NES501 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

UTE NES507 A

Evaluate performance of motor control systems

Descriptor: Diagnose and rectify faults in motor control systems.

Elements		Performance criteria	
507.1	Plan and prepare for diagnosis of faults	507.1.1	Diagnosis of faults is planned and prepared to ensure *OH&S policies* and *procedures* are followed the work is appropriately sequenced in accordance with *requirements*
		507.1.2	*Appropriate personnel* are consulted to ensure the work is co-ordinated effectively with others involved on the work site
		507.1.3	*Apparatus* faults are checked against job *requirements*
		507.1.4	Materials necessary to complete the work are obtained in accordance with *established procedures* and checked against job *requirements*
		507.1.5	*Tools, equipment and testing devices* needed to carry out the work are obtained in accordance with *established procedures* and checked for correct operation and safety
		507.1.6	Preparatory work is checked to ensure no unnecessary damage has occurred and that is complies with *requirements*
507.2	Diagnose faults in motor control systems	507.2.1	*OH&S policies and procedures* are followed.
		507.2.2	Reported fault(s) is/are confirmed and normal functions of *apparatus* and associated *circuits* are ascertained in accordance with *requirements*
		507.2.3	*Circuits* are checked as being isolated where necessary using specified testing procedures
		507.2.4	*Apparatus* faults is/are diagnosed in accordance with *requirements,* without damage or distortion to the surrounding environment or services
		507.2.5	Unplanned events or conditions are responded to in accordance with *established procedures*

Elements	Performance criteria
	507.2.6 Approval is obtained in accordance with *established procedures* from *appropriate personnel* before any contingencies are implemented 507.2.7 On-going checks of the quality of the work are undertaken in accordance with *established procedures*
507.3 Rectify faults in motor control systems	507.3.1 *OH&S policies and procedures* are followed. 507.3.2 *Apparatus* and associated *circuits* are isolated, where necessary, in accordance with *established procedures* 507.3.3 Adjustments are made in accordance with *established procedures*, where necessary, to return *apparatus* and associated *circuits* to normal operating conditions 507.3.4 Faulty component(s) are rectified or replaced, without damage or distortion to the surrounding environment or services 507.3.5 Unplanned events or conditions are responded to in accordance with *established procedures* 507.3.6 Approval is obtained in accordance with *established procedures* from *appropriate personnel* before any contingencies are implemented 507.3.7 On-going checks of the quality of the work are undertaken in accordance with *established procedures* 507.3.8 *Apparatus* and associated *circuits* are tested to ensure safety of the installation 507.3.9 *Apparatus* and associated *circuits* are returned to service in accordance with *established procedures*
507.4 Provide status report(s)	507.4.1 Arrangements are made for maintenance and/or repair(s), where necessary, with relevant *authorised personnel* in accordance with *requirements* 507.4.2 Status report(s) is/are completed and *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 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 undertaken from those listed in the Range statement or Evidence guide.
- 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

Assessment in this unit should include related underpinning specified knowledge and skills associated with other units within the respective endorsed qualification structure, where appropriate.

Additionally, this unit should be assessed in conjunction with or after competency has been demonstrated in UTE NES 501 Diagnose and rectify faults in apparatus & circuits and/or UTE NES502 Diagnose and rectify faults in apparatus and associated complex circuits.

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'.

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 date with expected data (voltage/current waveforms); location and replacement of faulty components

Power Converters

Rectifier circuits (revision only): single and three phase circuit configurations; resistive and inductive loads; output voltages and waveforms; ripple voltage and frequency; peak reverse voltages; effects of inductive loads.

Single phase controlled rectifiers: purpose or function of a controlled rectifier; circuit configurations and applications: single phase half wave, single phase half controlled bridge, single 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; commutation problems associated with inductive loads.

Three phase controlled rectifiers: purpose of function of a controlled rectifier; circuit configurations and applications: three phase half wave, three phase half controlled bridge, 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.

Power Control Devices controlled DC to DC convertors: purpose and function of a DC to DC convertor; 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.

Power Control Devices 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 Power Control Devices connections: need for series and/or parallel connection of Power Control Devices; 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.

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.

UTE NES508A
Find and repair faults in fire protection systems

Descriptor: This competency standard unit covers fault finding and repair of fire protection systems that include multiple connected detection, warning and fire control devices and remote monitoring to the sub-assembly level. The unit encompasses safe working practices, interpreting circuit diagrams, applying logical fault finding procedures, conducting repairs, safety and functional testing and completing the necessary service documentation.

Elements		Performance criteria	
508.1	Prepare to find and rectify faults.	508.1.1	OHS procedures for a given work area are obtained and understood.
		508.1.2	OHS risk control measures and procedures in preparation for the work are followed.
		508.1.3	The likely extent of work to be undertaken is envisaged from fault/breakdown reports and/or discussions with appropriate person(s).
		508.1.4	Advice is sought from the work supervisor to ensure the work is co-ordinated effectively with others.
		508.1.5	Sources of materials that may be required for the work are established in accordance with established procedures.
		508.1.6	Tools, equipment and testing devices needed to locate faults are obtained in accordance with established procedures and checked for correct operation and safety.
508.2	Find and repair faults.	508.2.1	OHS risk control measures and procedures for carrying out the work are followed.
		508.2.2	The need to test or measure live is determined in strict accordance with OHS requirements and when necessary conducted within established safety procedures.
		508.2.3	Circuits/machines/plant/system interfaces are checked as being isolated where necessary in strict accordance OHS requirements and procedures.
		508.2.4	Safety hazards resulting from the fault or breakdown are documented and risk control measures devised and implemented in consultation with appropriate personnel.

Elements		Performance criteria	
		508.2.5	Fault finding is approached methodically drawing on knowledge of fire protection systems and components using measured values of system parameters.
		508.2.6	System components are dismantled where necessary and parts stored to protect them against loss or damage.
		508.2.7	Faulty system/components are rechecked and their fault status and confirmed.
		508.2.8	Materials/replacement parts required to rectify faults are sourced and obtained in accordance with established procedures.
		508.2.9	Effectiveness of the repair is tested in accordance with established procedures.
		508.2.10	Apparatus is reassembled, finally tested and prepared for return to service.
		508.2.11	Unexpected situations are dealt with safely and with the approval of an authorised person.
		508.2.12	Fault finding and repair activities are carried out without unnecessary damage to apparatus, circuits, the surrounding environment or services and using sustainable energy practices.
508.3	Completion and report fault finding and repair activities.	508.3.1	OHS work completion risk control measures and procedures are followed.
		508.3.2	Reusable, faulty or worn components are tagged and dispatched for repair to maintain adequate spares.
		508.3.3	Fault finding and repair work activities are documented 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.

This competency standard unit shall be demonstrated in relation to:

Both a fire alarm and warning systems that include at least the following system components:

- Fire alarm system with at least 50 input devices, 20 output device and 2 system interface controls
- Fire warning system with at least 50 speakers, 5 interface communication devices and 2 warning indicators.
- Voice message facilities

Note:
1. Input devices can be conventional, analogue or analogue addressable fire detectors, flow switch connections or switch connections and the like.
2. Output devices can be shutdown signal, door or system release controls, solenoid valve controls and the like.
3. System interface controls can be communication signals to remote Control and indicating equipment, Building monitoring systems, paging system, Colour graphics and or the like.
4. Interface communication devices can be Warden Incommunication phones, Remote PA inputs and the like.
5. Warning Indicators are flashing lights for hearing impaired persons, fire brigade building indication and the like.

Finding and repairing any six of the following faults in fire alarm and warning systems:

- Open-circuit
- Short-circuit
- Incorrect connections
- Insulation failure
- Program failure
- Apparatus/component failure
- Related mechanical failure
- Electrical induced interference

Currency in unit of competence

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

Evidence for competence in this unit shall be considered holistically. Each element and associated performance criteria shall be demonstrated on at least two occasions in accordance with the "Assessment Guidelines". Evidence shall also comprise:

- A representative body of performance criteria demonstrated within the timeframes typically expected of the discipline, work function and industrial environment. In particular this shall incorporate evidence that shows a candidate is able to:
  - Implement Occupational Health and Safety workplace procedures and practices including the use of risk control measures as specified in the performance criteria and range; and
  - Apply sustainable energy principles and practices as specified in the performance criteria and range; and
  - Demonstrate an understanding of the essential knowledge and associated skills as described in the Underpinning Knowledge of this unit; and
  - Demonstrate an appropriate level of skills enabling employment; and
  - Conduct work observing the relevant Anti Discrimination legislation, regulations, polices and workplace procedures; and
- Demonstrated performance across a representative range of contexts from the prescribed items below:
  - Find and repair faults in fire protection systems as described in Range: and including:

    A Envisaging the likely extent of work from fault/breakdown reports and discussion with appropriate person(s).

    B Using methodical fault finding techniques.

    C Finding faults efficiently.

    D Rectifying faults effectively.

    E Completing documentation correctly.

    F Dealing with unplanned events by drawing on essential knowledge and skills to provide appropriate solutions incorporated in the holistic assessment with the above listed items.

Note:
Successful completion of relevant vendor training may be used to contribute to evidence on which competency is deemed. In these cases the alignment of outcomes of vendor training with performance criteria and critical aspects of evidence shall be clearly identified.

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.

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

Problem solving techniques

Evidence shall show an understanding of problem solving concepts and techniques as they apply in the workplace, to an extent indicated by the following aspects:

a) Identify problems

Note.
Examples may include: Process and quality problems; Equipment selection, availability and failure; Teamwork and work allocation problems; Safety and emergency situations and incident; Performance gaps; Profit improvement and the like.

b) Mathematical Tools

Note.
Examples may include: Average, Standard deviation and the like.

c) Use of analytical techniques in problem solving

Note.
Examples may include: Brainstorming; Fishbone diagrams/cause and effect diagrams; Logic trees; Process logic/process requirements; Similarity/difference analysis; Pareto analysis;

Force field/SWOT analysis.

d) Using tools to assistance in problem solving

Note.
Examples may include: Procedures and work instructions; Safety data sheets; Job cards; Maintenance logs; Plant drawing.

e) Determine corrective action encompassing:

- Tools
- Mode of communication procedure used within each enterprise
- Established work procedures and policies
- Size and structure of the teams/enterprise
- Group goals - team, section, enterprise
- Enterprise specific conflict resolution procedures
- Action plans
- Priority requirements
- Measurable objectives
- Resource requirements
- Methods for reaching objectives
- Timelines
- Safety requirements
- Risk assessment
- Environmental requirements

f) Communicate recommendations

Note.
Examples may include: Feedback requirements; Corrective action and analysis; Following up recommendations and the like.

g) Implement Monitoring encompassing:

- Identifying components to be measured
- Measurement and monitoring techniques
- Measurement and monitoring tools

Fault finding techniques

Evidence shall show an understanding of technical fault finding to an extent indicated by the following aspects:

a) Factors to consider in clarifying the nature of a fault encompassing —

- Initial fault report
- Confirmation of symptoms of the fault
- Comparison of symptoms with normal operation

b) Effect to cause reasoning — assumptions of possible causes

c) Methods for testing assumptions encompassing —

- Visual inspection
- Sectional testing
- Split-half tests
- Component isolation

d) Dealing with intermittent faults

Note:
Typical causes of intermittent faults are vibration, shock, changes in temperature and electromagnetic interference.

Fire protection systems faults

Evidence shall show an understanding of locating faults in fire protection systems to an extent indicated by the following aspects:

a) Sub-system components (ie functional blocks) and their operating parameters

b) Factors effecting system performance

c) Typical faults, their symptoms and cause.

d) Fault diagnosis procedures and testing

e) Sub-system adjustments

Occupational Health and Safety principles

Evidence shall show an understanding of Occupational Health and Safety to an extent indicated by the following aspects

a) The basic legal requirements covering occupational health and safety in the workplace encompassing:

- general aims and objectives of the relevant state or territory legislation relating to OHS.;
- employer and employee responsibilities, rights and obligations
- major functions of safety committees and representatives); and
- powers give to Occupational Health and Safety Inspectors.

b) The requirements for personal safety in the workplace encompassing:

- the safety precautions that are required to ensure personal safety in the workplace
- potential hazards in relation to improper industrial housekeeping; and

- sources of pollution in an engineering environment and outline control measures

c) Workplace safety check, identifying potential workplace hazards and suggested measures for accident prevention encompassing:

- safety checklist for a typical workplace environment,
- identifying and reporting potential workplace hazards
- methods of prevention of safety hazards within a typical workplace environment

d) working safely with electrical tools or equipment encompassing:

- causes of electrical accidents and state the effects that electric shock can cause.);
- purpose of circuit protection devices, such as fuses, circuit breakers and Residual Current Devices (RCDs), and
- safe isolation of an electrical supply.

e) emergency procedures for the rescue of an electric shock victim equipment

f) emergency first aid for an electric shock victim

Note:
Emergency first aid is limited to first-on-the scene assistance to a victim of electric shock , and basics of CPR.

Fire protection equipment working practices

Evidence shall show an understanding of working safely on or around fire protection equipment through the application of risk management principles and control measures for dealing with electrical, chemical and other hazards. The following aspects indicate the extent of understanding required.

a) Risk management and assessment of risk encompassing

- Principle and purpose of risk management, and
- Processes for conducting a risk assessment

b) Hazards associated with low-voltage, extra-low voltage and high-currents encompassing

- Arrangement of power distribution and circuits in an electrical installations
- Parts of an electrical system and equipment that operate at low-voltage and extra-low voltage,
- Parts of an electrical system and equipment where high-currents are likely.

c) Risks and control measures associated with fire protection equipment encompassing

- Procedures for isolating/reinstating and disconnection and reconnection of supplies in excess of extra-low voltage

Note.

1. Isolation and disconnection and reconnection is required to be performed by an appropriately qualified and authorise persons.

- Arrangements for isolating/reinstating fire protection systems to inhibit back-to-base signals to monitoring station.
- Arrangements for isolating/reinstating fire protection systems to inhibit alarms operating fire protection suppression equipment
- Arrangements for isolating/reinstating sections or parts of a fire protection system to inhibit alarms during building maintenance or system testing.
- Interface arrangements to isolate control functions between different fire protection building service systems
- Documentation and licensing requirements for working on fire protection systems
- Identification of personal and environmental hazards in working on fire protection systems.
- Control measures used for dealing with the hazards related to fire protection systems