Title	**Demonstrate knowledge of electrical principles in an electrotechnology or telecommunications environment**		
Level	**3**	**Credits**	**15**

Purpose	This unit standard covers basic electrical principles for technicians working in an electrotechnology or telecommunications environment. People credited with this unit standard are able to: − demonstrate knowledge of electrical conductors, insulators, and semiconductors; − demonstrate knowledge of methods for emf production; − demonstrate knowledge of magnets, magnetism, and the application of magnetism to the generation of ac and dc; − demonstrate knowledge of resistors and capacitors used in simple circuits; − demonstrate knowledge of semiconductor diodes; − analyse and calculate values in simple ac and dc circuits; and − demonstrate knowledge of the supply of electricity in New Zealand and the use of the Multiple Earth Neutral (MEN) system of supply.

Classification	Electrical Engineering > Electrotechnology

Available grade	Achieved

Guidance Information

1 This unit standard has been developed for learning and assessment off-job.

2 The knowledge covered by this unit standard is expected to be at a fundamental level, with the objective of introducing relevant terminology and fundamental principles, which include the relevant mathematics for technicians in electrical engineering and telecommunications. Conventional current flow direction (positive to negative) is implied. Candidates should be aware of the opposite direction of electron flow.

3 References
AS/NZS 3000:2007, *Electrical installations (known as the Australia/New Zealand Wiring Rules),* including Amendment 1 and 2;
Electricity Act 1992;
Electricity (Safety) Regulations 2010;
and all subsequent amendments and replacements.

4 Definitions

ac – alternating current.
*d*c – direct current.
emf – electromotive force.
EWRB – Electrical Workers Registration Board.
Fundamental principles – covers knowledge of the underlying factors, logic, laws, and essential formulae to develop an understanding of electricity, and forms the basis for further development and knowledge in the subject.
Industry practice – those practices that competent practitioners within the industry recognise as current industry best practice.
LDR – light dependent resistor.
MEN – Multiple Earth Neutral.
NTC – negative temperature co-efficient.
PIV – peck inverse voltage.
PTC – positive temperature co-efficient.
PVC – polyvinyl chloride.
r.m.s. – root-mean-square.
VDR – voltage dependent resistor.
VRRM – Maximum Repetitive Reverse Voltage.

5 Range

a Use of a calculator during assessment is permitted.
b Candidates are expected to express calculated values in the relevant Système Internationale (SI) units, including multiples and sub-multiples, for example: pico (p) 10^{-12}; nano (n) 10^{-9}; micro (μ) 10^{-6}; milli (m) 10^{-3}; kilo (k) 10^{3}; mega (M) 10^{6}; Giga (G) 10^{9}; and to be able to convert between them, and, where required, convert from Imperial units into SI units.
c Performance in relation to the outcomes of this unit standard must meet the needs at an introductory level of competencies 1 to 10 and 16 to 18 of the 55 Essential Capabilities for Electrical Registration defined by the EWRB.
d All activities and evidence presented for all outcomes and performance criteria in this unit standard must be in accordance with:
    i legislation;
    ii policies and procedures;
    iii ethical codes;
    iv Standards – may include but are not limited to those listed in Schedule 2 of the Electricity (Safety) Regulations 2010;
    v applicable site, enterprise, and industry practice;
    vi where appropriate, manufacturers' instructions, specifications, and data sheets.

6 Assessment notes

a Candidates must be supplied with formulae involving more than three quantities.
b Candidates must be supplied with data tables and colour code charts.

Outcomes and performance criteria

Outcome 1

Demonstrate knowledge of electrical conductors, insulators, and semiconductors.

Performance criteria

1.1 Explain the nature of conductors, insulators, and semiconductors in terms of their atomic structure.

1.2 Explain typical uses of conductors and insulators.

1.3 Explain conductor and insulator materials suitable for given environmental conditions and reasons for their suitability.

Range conductors – copper, silver, aluminium, tungsten, carbon, nichrome, brass, gold, lead, tin;
insulators – glass, mica, oil, ceramics, rubber, PVC;
environmental conditions – heat, moisture, corrosive materials, dust, tension, compression, vibration;
evidence is required of one conductor and one insulator material for each environmental condition.

1.4 Explain the effect that factors have on resistance in a conductor and the relationship between them.

Range factors – length, cross-sectional area, resistivity of material, temperature, temperature co-efficient of resistance;
relationship – $R = \frac{\rho l}{A}$.

1.5 Identify and list materials commonly used for conductors, insulators, and semiconductors in order of their resistivity.

Range conductors – copper, brass, silver, gold, aluminium, steel, tungsten, carbon, nichrome, lead, tin;
insulators – rubber, PVC, ceramics, mica, glass;
semiconductors – silicon, germanium.

1.6 Explain the concept of insulation resistance of a cable in terms of typical values and the effect of cable length.

1.7 Calculate insulation resistance for a specified length of cable from the known insulation resistance of a different length of the same cable.

Outcome 2

Demonstrate knowledge of methods for emf production.

Range electrochemical, magnetic, friction, piezoelectric, photoelectric, thermocouple.

Performance criteria

2.1 Briefly explain methods of producing an emf in terms of how it is achieved and the relative magnitude of the voltage produced.

2.2 Explain each method of generation with reference to an example of a common device that uses it.

2.3 Explain construction and operation of batteries with the aid of labelled sketches.

Range primary cell, secondary cell, electrolyte, specific gravity, electrodes, cathode, anode, charging, discharging; details of chemical reactions are not required.

2.4 Explain the characteristics, typical applications, and safety requirements of batteries.

Range characteristics – voltage, capacity, charge/discharge characteristics, series connection to achieve higher voltage; safety – disposal;
batteries may include but are not limited to – lead-acid, deep-cycle lead-acid, lithium iron phosphate, mercury, nickel-cadmium, nickel-iron, nickel metal hydride;
evidence of at least four types of batteries is required.

Outcome 3

Demonstrate knowledge of magnets, magnetism, and the application of magnetism to the generation of ac and dc.

Range magnetic terms – permanent magnet, magnetic field strength, lines of force, magnetic poles, magnetic flux, flux density;
values as appropriate – resistance, applied emf, volt-drop, current, branch current, power, energy, time constant, frequency.

Performance criteria

3.1 Determine the direction of the magnetic field surrounding a current carrying conductor using any popular rule.

3.2 Demonstrate the induction of an emf in a conductor being moved in a magnetic field using Fleming's right-hand rule.

3.3 Explain the basic operation of devices using electromagnetic and magnetic properties.

Range any two devices of – speaker, microphone, moving coil instrument, toroid, solenoid, transformer.

3.4 Explain the transformer principle in terms of induced emf resulting from changing flux linkages.

Range single-phase, three-phase.

3.5 Compare the generation of ac and dc with the aid of sketches.

Range simple ac alternator – simple single-loop, two-pole alternator with slip-rings and brushes;
simple dc generator – permanent magnet, single loop of wire, two-segment commutator, carbon brush.

3.6 Compare alternator output to generator output for each quarter-cycle through one revolution with the aid of a sketch, and show a completed resultant waveform.

Range cycle, period, frequency, peak, average, instantaneous, r.m.s.

3.7 Explain the reason for using r.m.s. values of an ac wave form in terms of the equivalence of r.m.s. and steady dc values for resistive heating effect.

3.8 Calculate values from ac voltage and current wave form data.

Range peak, average, r.m.s., frequency, period.

3.9 Explain the purpose and application of magnetic screening in terms of protection of sensitive meters and circuitry from magnetic interference.

Outcome 4

Demonstrate knowledge of resistors and capacitors used in simple circuits.

Performance criteria

4.1 Explain briefly linear and non-linear resistors with reference to their construction, operating characteristics, symbols, connections, and applications.

Range linear resistors include – carbon, metal film, wire-wound, slider potentiometer, rotary carbon potentiometer, rheostat;
non-linear resistors include – NTC thermistor, PTC thermistor, VDR, LDR;
evidence of two linear and two non-linear resistors is required.

4.2 Explain the meanings of the terms tolerance, preferred values, stability, power rating, power dissipation, voltage rating, and current rating, as used in connection with resistors.

4.3 Interpret resistor markings relating to resistance, rating, and tolerance.

Range evidence of three different linear resistors is required. Use of resistor colour code chart is permitted.

4.4 Briefly explain capacitors with reference to their construction, operating characteristics, symbols, connections, and factors that affect capacitance.

Range construction includes – stacked-plate, rolled, electrolytic, variable, ceramic;
factors – area, distance between plates, dielectric permittivity, charge and discharge curves.

4.5 Explain simple practical applications for air, paper, mica ceramic, electrolytic, and solid dielectric capacitors.

4.6 Identify capacitance and voltage rating from capacitor markings.

4.7 Explain the safety precautions necessary to prevent electric shock from charged capacitors.

Outcome 5

Demonstrate knowledge of semiconductor diodes.

Performance criteria

5.1 Identify and name diode types and terminals.

Range types – small signal diode, zener diode, power diode;
terminals – anode and cathode.

5.2 Explain diode behaviour under forward and reverse bias conditions in terms of the voltage versus current characteristics with the aid of a sketch.

5.3 Define diode terms and explain typical values during normal and abnormal operation.

Range forward bias, voltage drop, reverse breakdown, peak inverse voltage (PIV, VRRM), average forward current, power dissipation, junction temperature, leakage current.

5.4 Explain the operation of single-phase rectifier circuits with the aid of diagrams, in terms of input and output waveforms, currents, and voltages.

Range half-wave, centre-tapped transformer full-wave, bridge full-wave.

5.5 Identify examples of applications other than rectification.

Range applications may include but are not limited to – free wheeling diodes on solenoids, diode matrices in lamp test circuits, voltage reference;
evidence of three uses is required.

5.6 Test diodes in accordance with industry practice and document results.

Range diode tests include – forward resistance, reverse mode resistance, in-circuit testing of forward voltage drop and reverse leakage current.

5.7 Interpret test results to determine serviceability in terms of measured versus expected values.

5.8 Explain the potential for damage to diodes when carrying out insulation resistance tests and the procedures employed to prevent such damage.

Outcome 6

Analyse and calculate values in simple ac and dc circuits.

Range circuits – series, parallel and series-parallel combinations of up to five components, a single source of emf, internal resistance;
components – resistors, capacitors, inductors;
values – resistance, capacitance, inductance, impedance, charge, applied emf, volt-drop, current, branch current, power, energy, time constant, frequency.

Performance criteria

6.1 Define Ohm's Law and Kirchoff's Laws for voltage and current.

6.2 Explain the relationship between resistance, voltage, and current in terms of the effect that a change in any one quantity has on the other two.

6.3 Develop simple circuits to match given requirements.

Range depict physical interconnection of components.

6.4 Calculate values from given data for series circuits, parallel circuits, and series-parallel circuits.

6.5 Explain factors that may cause variations between measured and calculated values.

Range component tolerance, supply variations, non-linear components, instrument and measurement accuracy.

Outcome 7

Demonstrate knowledge of the supply of electricity in New Zealand and the use of the MEN system of supply.

Performance criteria

7.1 Explain the operation of the New Zealand transmission system from power station to consumer, using a fully labelled diagram.

Range diagram shows – alternator, transformers, transmission lines, typical voltages before and after transformation, connection details for single-phase, two-phase, and three-phase consumers.

7.2 Explain reasons for using ac instead of dc for generation, transmission, and distribution to end users in terms of ease of transformation and simplicity of electric motors.

7.3 Explain advantages of three-phase over single-phase supply systems in terms of economies in generation, transmission, and induction motors.

7.4 Calculate values for input and output voltages of transformers.

Range transformers – single-phase, three-phase;
three-phase connections – star/star, star/delta, delta/star, delta/delta;
values – phase voltage, line voltage, phase current, line current.

7.5 Show a typical distribution system from supply transformer to consumer's main switchboard to explain the MEN system of supply, using a fully labelled diagram.

7.6 Explain four reasons for earthing the neutral at multiple points.

Planned review date	31 December 2027

Status information and last date for assessment for superseded versions

Process	Version	Date	Last Date for Assessment
Registration	1	18 July 2013	31 December 2022
Review	2	14 December 2017	31 December 2024
Review	3	2 March 2023	N/A

Consent and Moderation Requirements (CMR) reference	0003

This CMR can be accessed at http://www.nzqa.govt.nz/framework/search/index.do.

Comments on this unit standard

Please contact Waihanga Ara Rau Construction and Infrastructure Workforce Development Council at qualifications@waihangaararau.nz if you wish to suggest changes to the content of this unit standard.