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| **Title** | **Demonstrate knowledge of electrical principles in power engineering** | | |
| **Level** | **5** | **Credits** | **15** |

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| **Purpose** | People credited with this unit standard are able to, in power engineering, demonstrate knowledge of:<br>• direct current electrical terms, parameters and circuits<br>• nonlinear circuit resistance<br>• Kirchhoff's current and voltage laws<br>• the operation of a capacitor in a DC circuit<br>• sinusoidal and non-sinusoidal alternating voltages and currents<br>• electromagnetism<br>• induction and inductance<br>• the behaviour of reactive components in an AC circuit<br>• balanced three phase sinusoidal alternating voltage and currents in three phase circuits.<br><br>This standard provides electricity supply industry power technicians with the fundamental knowledge of power protection and control network theory, and hardware. |

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| **Classification** | Electricity Supply > Electricity Supply - Power System Maintenance |

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| **Available grade** | Achieved |

**Guidance Information**

1 Evidence presented for assessment against this unit standard must be consistent with safe working practices and be in accordance with applicable legislative and industry requirements.

2 Legislation, regulations and/or industry standards relevant to this unit standard include but are not limited to:
- Electricity Act 1992
- Health and Safety at Work Act 2015
- Electricity supply industry codes of practice and documented enterprise procedures, including *Safety Manual – Electricity Industry* (SM-EI) and relevant EEA guides available from www.eea.co.nz.

and any subsequent amendments and replacements.

3 Definitions

*AC* – alternating current.
*CR* – capacitance resistance.
*DC* – direct current.
*emf* – electromotive force.
*LCR* – inductance capacitance resistance.
*LR* – inductance resistance.
*PT100* – a type of temperature sensor made of platinum.
*RMS* – root mean square.

## Outcomes and performance criteria

### Outcome 1

Demonstrate knowledge of direct current electrical terms, parameters and circuits in power engineering.

### Performance criteria

1.1 Direct current terms, symbols and units used in electrical engineering are defined.

Range includes emf, voltage, current, resistance, energy, power.

1.2 The Ohms law relationship between resistance, voltage, and current in an electrical circuit is described.

1.3 Calculation and measurement techniques are demonstrated and compared for current, voltage, resistance and power in simple resistive electric circuits.

Range maximum of five resistive components in a series, a parallel and a serial parallel combination circuit.

1.4 Variations between measured and calculated values are explained in terms of component tolerance, and instrument and measurement accuracy.

1.5 The concept of insulation resistance of a cable is explained in terms of typical values and the effect of cable length.

### Outcome 2

Demonstrate knowledge of nonlinear circuit resistance in power engineering.

### Performance criteria

2.1 Resistance of a conductor is defined in terms of its electrical parameters.

Range includes but is not limited to – length, cross-sectional area, conductor material.

2.2 Resistance calculations involving practical conductors are demonstrated.

Range includes but is not limited to – electrical cables, printed circuit board track resistance.

2.3 The temperature coefficient of resistance is defined.

2.4 Resistance change with temperature is calculated for practical applications.

Range includes but is not limited to – motor windings, PT100.

**Outcome 3**

Demonstrate knowledge of Kirchhoff’s current and voltage laws in power engineering.

**Performance criteria**

3.1 Kirchhoff's current and voltage laws are defined.

3.2 Kirchhoff's current and voltage laws are applied to solve problems involving single and dual voltage sources in simple practical circuits.

Range includes but is not limited to – dual voltage divider network, dual voltage sources with three resistors.

**Outcome 4**

Demonstrate knowledge of the operation of a capacitor in a DC circuit in power engineering.

**Performance criteria**

4.1 Mechanism by which a capacitor stores charge is explained.

4.2 Calculation is performed to determine the capacitance of a capacitor.

4.3 Total equivalent capacitance of series, parallel, and simple series-parallel circuits is calculated.

4.4 The relationship between time constant, capacitor current and voltage is described, curves sketched and mathematically calculated.

Range charging C via R from constant voltage, discharging C via R.

4.5 Calculation is performed to determine the total energy stored by a capacitor.

**Outcome 5**

Demonstrate knowledge of sinusoidal and non-sinusoidal alternating voltages and currents in power engineering.

**Performance criteria**

5.1 Waveform terminology is defined.

Range peak, peak-to-peak, average (full/half wave), RMS, form factor, harmonics.

5.2 The relationship between RMS and average values in direct current and sinewave circuits is explained.

Range heating effect of AC and DC compared.

5.3 RMS, average, peak and form factor values are calculated for a sinewave and symmetrical square wave.

5.4 Waveforms are sketched showing how harmonically related sinusoids sum to produce complex waveforms.

**Outcome 6**

Demonstrate knowledge of electromagnetism in power engineering.

**Performance criteria**

6.1 Magnetic terms are defined and relationships between them derived and explained.

Range magnetomotive force, magnetising force, reluctance, magnetic flux and flux density, coil current.

6.2 Mechanical force on a current carrying conductor in a magnetic field is explained and calculated.

6.3 Flux density is calculated for simple magnetic circuits both with and without air gaps.

6.4 Faraday’s and Lenz's laws are stated, explained, and calculations are performed.

Range average voltage only for a conductor moving perpendicular to a constant magnetic field, a stationary conductor in a changing magnetic field.

**Outcome 7**

Demonstrate knowledge of induction and inductance in power engineering.

**Performance criteria**

7.1 Self-induction is explained in terms of industry applications.

Range motors, transformers, relays.

7.2 Induced emf and polarity of an inductor is defined and calculated.

7.3 The relationship between inductance of practical inductor and its magnetic parameters is explained and calculated.

7.4 The relationship between time constant, inductor current and voltage is described, curves sketched and mathematically calculated.

Range charging L via R from constant voltage, discharging L via R.

7.5 Mutual induction between coils is defined, explained and calculated.

Range series aiding, series opposing.

**Outcome 8**

Demonstrate knowledge of the behaviour of reactive components in an AC circuit in power engineering.

**Performance criteria**

8.1 Reactance is explained and calculated for inductors and capacitors.

8.2 The relationship between frequency, circuit current, reactive component voltages is explained, sketched and calculated.

Range series and parallel combination, CR, LR, LCR.

8.3 Impedance and admittance are explained and calculated.

Range series and parallel combination, CR, LR, LCR.

8.4 Analysis, calculation of series, parallel and combination circuits using complex notation and phasor diagrams is performed.

8.5 Resonance is explained and calculation for series resonance only is performed.

**Outcome 9**

Demonstrate knowledge of balanced three phase sinusoidal alternating voltage and currents in three phase circuits in power engineering.

Range Delta, 3 and 4 wire star.

**Performance criteria**

9.1 Three phase load configurations are sketched.

9.2 Circuit and phasor diagrams are sketched representing phase and line voltages and currents with resistive loads.

9.3 Phasor diagrams are drawn and calculations are performed on three phase systems with balanced resistive loads.

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| **Planned review date** | 31 December 2025 |

**Status information and last date for assessment for superseded versions**

| Process | Version | Date | Last Date for Assessment |
|---|---|---|---|
| Registration | 1 | 20 July 2017 | N/A |
| Rollover and Revision | 2 | 2 March 2023 | N/A |

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| **Consent and Moderation Requirements (CMR) reference** | 0120 |

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.