Specification

Electrical SCADA System Remote Terminal Unit

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Standard governance

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Document history

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<td>1.0</td>
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Preface

The Asset Standards Authority (ASA) is an independent unit within Transport for NSW (TfNSW) and is the network design and standards authority for defined NSW transport assets.

The ASA is responsible for developing engineering governance frameworks to support industry delivery in the assurance of design, safety, integrity, construction, and commissioning of transport assets for the whole asset life cycle. In order to achieve this, the ASA effectively discharges obligations as the authority for various technical, process, and planning matters across the asset life cycle.

The ASA collaborates with industry using stakeholder engagement activities to assist in achieving its mission. These activities help align the ASA to broader government expectations of making it clearer, simpler, and more attractive to do business within the NSW transport industry, allowing the supply chain to deliver safe, efficient, and competent transport services.

The ASA develops, maintains, controls, and publishes a suite of standards and other documentation for transport assets of TfNSW. Further, the ASA ensures that these standards are performance-based to create opportunities for innovation and improve access to a broader competitive supply chain.

This specification defines requirements for electrical supervisory, control and data acquisition (SCADA) system remote terminal units (RTUs).

This document supersedes RailCorp standard EP 11 03 00 02 SP Electrical SCADA System Remote Terminal Unit Specification, version 1.0.

This document is a first issue.
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1. **Introduction**

The electrical supervisory, control and data acquisition (SCADA) system is used to monitor and control the high voltage electrical supply network for traction (1500 V dc up to 132 kV ac) and signals (2 kV and 11 kV) within the electrified area of the NSW heavy rail network. The master stations interface to the electrical network through a system of remote terminal units (RTUs) over the RailCorp telecommunications network. RTUs are typically located in traction substations, high voltage distribution substations (33 kV and above), underground station substations, 1500 V dc sectioning huts, safety or operationally critical 1500 V dc field switches and normally open mid-points of high voltage feeders (11 kV and above).

These locations contain equipment such as high voltage alternating current circuit breakers (ACCBs), direct current circuit breakers (DCCBs), rectifiers, transformers and other miscellaneous equipment.

A description of the electrical system is contained in T HR EL 00001 TI *RailCorp Electrical System General Description*.

2. **Purpose**

This specification defines requirements for electrical SCADA system RTUs. It establishes functional and performance requirements for the selection and system design of RTUs that are to be incorporated into the RailCorp electrical SCADA network.

2.1. **Scope**

This specification covers requirements for the design and purchase of RTUs. It also provides a brief description of the major components of the electrical SCADA system.

2.2. **Application**

This specification is applicable to all new RailCorp electrical SCADA system RTUs and to those that are replacing existing RTUs due to plant expansion or RTU obsolescence.

This specification is intended to be used by Authorised Engineering Organisations (AEOs) designing and purchasing electrical SCADA system RTUs and the suppliers of such products.
3. **Reference documents**

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

**International standards**

- IEC 60870-5-103 Telecontrol equipment and systems Part 5-103: Transmission protocols – Companion standard for the informative interface of protection equipment
- IEC 61810-1 Electromechanical elementary relays – Part 1: General and safety requirements
- IEC 61131-3 Programmable controllers – Part 3: Programming languages

**Australian standards**

- AS 2700S Colour Standards for general purposes - Swatches
- AS 60529 Degrees of protection provided by enclosures (IP Code)
- AS 60870.2.1 Telecontrol equipment and systems Part 2.1: Operating Conditions – Power supply and electromagnetic compatibility
- AS 60870.3–1998 Telecontrol equipment and systems Part 3: Interfaces (electrical characteristics)
- AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)

**Transport for NSW standards**

- EP 00 00 00 13 SP Electrical Power Equipment – Design ranges of Ambient Conditions
- EP 00 00 00 15 SP Common Requirements for Electric Power Equipment
- T HR EL 00001 TI RailCorp Electrical System General Description
- T HR EL 00002 PR Electrical Power Equipment – Integrated Support Requirements
- T HR TE 21003 ST Telecommunications for Traction Substations and Sections Hut
- T MU HF 00001 ST Human Factors Integration – General Requirements
- T MU MD 00006 ST Engineering Drawings and CAD Requirements
- TN 050: 2014 Electrical Type Approvals – Interim process
4. Terms and definitions

The following terms and definitions apply in this document:

ACCB alternating current circuit breaker
AEO Authorised Engineering Organisation
CPU central processing unit
DCCB direct current circuit breaker
DNP3 distributed network protocol
ESO electrical system operator
IED intelligent electronic device
I/O input/output
RTU remote terminal unit
SCADA supervisory control and data acquisition

substation an assembly of electrical equipment at one place, including any necessary housing, for the conversion or transformation of electric energy or for connection between two or more circuits. The following are locations within the RailCorp distribution network which are classified as substations:
- any location that includes a high voltage circuit breaker or high voltage fuse
- traction substation
- high voltage switching station
- high voltage switch room
- 2 kV locations
- 11 kV ring main unit locations
- pole top substations

TfNSW Transport for New South Wales
5. **Major components of the electrical SCADA system**

The three major components of the electrical SCADA system include the master station, the telecommunications network and the RTU. The following description does not include requirements for the master station or telecommunications network. It is intended to provide some contextual understanding of how RTUs interface to other components of the electrical SCADA system.

5.1. **Master station**

The SCADA master station provides the electrical system operator (ESO) with facilities to remotely monitor and control the electrical plant of the traction supply network.

There are two diverse master station locations. Either location is capable of operating the entire SCADA network. Since 2008, the Mosaic system, version 4.0 has been the master station in use on the TfNSW heavy rail network.

5.2. **Telecommunications network**

The telecommunications network connects the SCADA master station with all of the RTUs located in substations.

The telecommunications network is in the main a private network owned by RailCorp and operated by an AEO although various connecting links are provided by external suppliers. The network provides optical fibres between the master stations and RTU locations.

It is the intent that all RTUs purchased using this specification will connect through optical fibre to the telecommunications network, although there may be occasions where connection by pilot wire is required.

5.3. **Remote terminal units (RTUs)**

The RTUs interface to the electrical plant within a substation and monitors the status of the plant through digital and analogue inputs. This data is transferred to the master station when requested by the master station. The RTUs also provide for control outputs to switch plant such as circuit breakers and tap changers. In newer RTUs, serial links are provided to interface into intelligent electronic devices (IEDs) such as electrical protection relays.

There are RTUs at 240 locations in the RailCorp SCADA network. There are approximately five different models from three different suppliers and all have been either installed or replaced since 2002.
6. **RTU system design**

Substations shall have an RTU that is designed in accordance with this specification. The RTU shall be of proven design and suited for electric power transmission and distribution SCADA applications.

The RTU design shall aim to minimise power consumption and heat generation. It shall be designed to work in a high voltage electrical installation by being of robust physical construction with immunity to electrical noise.

The RTU shall be assembled from modular units. Modular units can include the following:

- power supply
- central processing unit (CPU) and communications
- communication interface
- input and output (I/O)

I/Os and serial cards shall be able to be arranged in the RTU rack in any order.

Modules shall be interconnected through a suitably robust plug and socket method. Faulty modules shall be replaceable without having the need to unscrew individual wires and cables, including both internal RTU wiring and I/O wiring. The failure of one module shall not affect the performance of any other module.

A marshalling terminal area shall be incorporated with each RTU to provide terminations for field cables. This area may be located in the RTU cubicle itself for an RTU replacement; however, for new locations, there shall be a separate marshalling cubicle. The RTU and marshalling cubicles shall be bolted together to form a two-bay cubicle suite. A separation plate may be located between the cubicles.

The RTU and the cubicles shall be designed to accommodate the total number of I/Os and IEDs at the specific substation and have spare capacity remaining.

Spare capacity includes equipped capacity, wired capacity and cubical capacity. The supplier shall detail the steps required to activate the spare capacity.

6.1. **Equipped capacity**

Equipped capacity shall include all electronic cards and output terminals. To activate this capacity, an I/O connection shall be made to the designated field terminals in the marshalling cubicle. This additional capacity is provided to cover the initial substation design and commissioning. It includes rounding up the quantities specified to the modulus of the number of points per card. Unless this is otherwise specified at the time of procurement, the initial equipped spare capacity shall be not less than 20% for each type of I/O used. Unless specified,
any I/O lists or quantities given for a particular RTU shall not include spare capacity. These quantities shall be increased by 20% in order to meet spare capacity requirements.

6.2. **Wired capacity**

Wired capacity means that a card slot is provided. To activate this capacity, in addition to connection of the field input, an additional input card or output card shall be supplied and fitted. The wiring shall also be arranged from the I/O card to the terminals in the marshalling cubicle. The wiring is usually done by a preformed cable. This capacity is specifically provided to cater for future requirements, which may be four to five years away. Unless otherwise specified at the time of procurement, this additional capacity shall be zero.

6.3. **Cubicle capacity**

Adequate cubicle space capacity is necessary for additional card files and terminations to be retrofitted at a future stage, possibly eight to ten years or more away. Unless otherwise specified at the time of procurement, this additional capacity shall be zero.

7. **RTU I/O structure**

The RTU I/O quantities shall be developed in accordance with the requirements specified at the time of order of the RTU.

Each RTU interfaces both directly and indirectly with substation electrical equipment and protection systems within the traction supply power distribution networks.

The direct interface is through wiring directly from digital and analogue sensors located within the substation equipment to the RTU and from relay outputs within the RTU to equipment panels in the substation. This wiring is routed through the marshalling cubicle.

The indirect interface is through a local communication network between the RTU and the IEDs in the substation.

Field cable terminations located within an RTU marshalling cubicle shall define the point of separation between the electrical SCADA RTU and the substation electrical system.

Restricted space within a substation building may necessitate location of the marshalling terminals within the RTU cabinet.
8. Performance requirements

The performance requirements specified in this section include minimum standards for a range of attributes for RTUs. These requirements provide a baseline for the RTU's performance.

8.1. Environmental conditions

The RTU shall be designed and supplied suitably for indoor equipment conditions as specified in EP 00 00 00 13 SP Electrical Power Equipment – Design Ranges of Ambient Conditions. For RTUs installed indoors, the ambient temperature range shall be -5 °C to +55 °C. RTUs installed in a cubicle on overhead wiring structures in the field (outdoors) are required to work successfully in an ambient temperature range of -10 °C to +65 °C.

Heat dissipation calculations shall be provided to demonstrate the RTU’s ability to comply with the temperature ratings of the equipment in the range specified. These calculations shall be done on the assumption that the maximum spare capacity has been implemented. See Section 6 of this document for spare capacity requirements.

8.2. Maintainability

RTUs shall not require routine or planned maintenance. Fans or moving parts shall not be used in the RTU. The RTU shall be constructed to resist the entry of dust.

A single technician shall be able to remove and replace, without special tools and test equipment, all equipment involved in the operation of an RTU in order to repair it.

It should not be necessary to dismantle (remove multiple pieces of) the RTU in order to replace a module.

The RTU shall by fully operational within 15 minutes of it being restored.

8.3. Reliability

The equipment will normally remain in continuous service to provide SCADA facilities. Failure can result in the interruption of the operation of the railway. A high level of reliability is therefore required.

The supplier shall provide the predicted mean time to failure and the mean time to repair of the equipment. Where insufficient historical data is available, the supplier shall state the methods used to determine the reliability performance.

The predicted availability of the equipment supplied should exceed the system availability shown in Table 1.
Table 1 – Predicted availability of equipment

<table>
<thead>
<tr>
<th>System function</th>
<th>System availability</th>
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<tbody>
<tr>
<td>Control and monitoring of any one breaker</td>
<td>99.99%</td>
</tr>
<tr>
<td>Monitoring of any one single alarm</td>
<td>99.99%</td>
</tr>
<tr>
<td>Monitoring of any one analogue input</td>
<td>99.99%</td>
</tr>
</tbody>
</table>

The supplier shall assume the following when calculating the equipment reliability:

- the availability of any interconnecting communication equipment or system supplied by others shall be assumed to be 100%
- an assumption of an average two hours for maintenance personnel to travel to site shall be made. Repair time shall be added to this travel time.

8.4. Service life

The equipment shall be capable of complying with this specification, including performing its intended purpose, for a minimum of 20 years from the date of supply.

The supplier shall indicate the following:

- the date at which the product was released for sale
- the anticipated date at which the product will be withdrawn from sale but support will continue to be supplied
- the anticipated date that product support will be withdrawn; that is, the date that spares will no longer be available and technical support is no longer provided

8.5. Interchangeability

RTU parts shall be interchangeable individually and as a whole. Any change or replacement shall not reduce the capability of the equipment to conform to the requirements of this specification.

9. RTU compliance with common requirements for electric power equipment

The RTU shall be designed and supplied in accordance with EP 00 00 00 15 SP Common Requirements for Electrical Power Equipment. Where the requirements of EP 00 00 00 15 SP and this specification differ, the requirements of this specification shall take precedence.
10. RTU power supply

The power supply to run the RTU will come from one of the following sources:

- 125 V dc or 48 V dc substation battery
- 240 V ac general purpose

The power source shall be specified at the time the RTU is ordered. The supplier shall provide the AEO with all power converters that are required to permit acceptance of the power supply specified.

10.1. Power source – 125 V dc or 48 V dc substation battery

The RTU shall be powered from the substation battery where installed. At most locations, the power source is 125 V dc (which is sometimes referred to as 120 V dc) although at some older sites the power source can be supplied at 48 V dc (which is sometimes referred to as 50 V dc).

At bulk supply points and major substations there are two battery systems. At these locations the RTU shall be supplied from Battery No.1. Battery No.1 shall also be the supply for most indications except for DCCBs. DCCBs will typically be split so that half are supplied from Battery No.1 and half are supplied from Battery No.2. There can also be some miscellaneous indications supplied from Battery No.2 such as rail earth contactor (REC), fire alarm or reactor. These requirements shall be specified by the substation designer.

The supply from a substation battery shall be a secure supply such that a battery backup system shall not be necessary for the RTU.

As this power supply is not earthed, isolation of the station battery supply to the RTU system shall be through two pole isolating switches.

The RTU power supply shall be designed to operate at full specified performance for direct current supplies conforming to AS 60870.2.1 Telecontrol equipment and systems Part 2.1: Operating Conditions – Power supply and electromagnetic compatibility for the following categories:

- voltage ripple – class VR3 (not more than 5% of nominal supply voltage, peak to peak)
- voltage tolerance – class DC3 (+15% / -20%)

The substation battery is sized to provide power to the RTU (and substation switch gear) for a period of 10 hours. In this period, supply shall remain within the class VR3 and class DC3 ranges; that is, 100 V dc to 143.7 V dc for a 125 V dc battery.

The RTU power supply shall be designed to operate at the fully specified performance for direct current supply earthing condition E+/E-/EC/EF (positive earth / negative earth / centre earth / floating) in accordance with AS 60870.2.1. As the supply is floating, power is still expected to be available for any single inadvertent earth connection.
10.2. **Power source – 240 V ac general purpose**

In some locations, usually control rooms, equipment rooms, stations, field switches, compressor rooms or pumping stations, a general purpose 240 V ac supply is used to power the RTU. At these sites, the RTU shall function for a period of at least 10 hours in case of a power supply failure. A combination battery charger and battery shall be provided by the supplier for this purpose. The RTU and its communication equipment shall be the only equipment to be powered from this source at these locations.

The batteries provided by the supplier shall be 12 V dc. Batteries shall be sealed absorbed glass mat (AGM) or gel type lead acid.

The batteries shall be supplied in a wall mounted cubicle, with venting to atmosphere of approximately 10 cm square. The power supply shall be 24 V dc (made of two 12 V batteries). The AEO may specify a need for a battery at these alternate voltage levels at a particular location at the time of order placement.

The supplier shall provide design calculations to demonstrate the battery capacity. The calculation of the battery capacity shall include a margin to ensure system integrity. This margin shall include a design allowance of 20% minimum, a temperature correction and an ageing factor for at least four years obtained from the battery manufacturer. The battery shall be suitable to be recharged from its design end-of-discharge voltage to full charge in five hours.

10.3. **General**

Galvanic isolation shall be provided on each power supply of the RTU that connects to the power supply source. Power supply isolation shall conform to AS 60870.2.1-1998, Table 18, Class VW3.

The RTU shall continue to perform in a reliable and predictable manner if the supply battery voltage undergoes a gradual decline to the lower specified limit due to lack of charger input. No false inputs shall be recorded or control outputs be executed by the RTU at any time. The supplier shall provide descriptions of design mechanisms that handle this requirement.
11. **RTU CPU**

The RTU shall be microprocessor based. Once power is supplied to the unit, it shall be designed to operate without manual intervention; additionally, it shall auto restart and be able to communicate with the master station without reporting spurious state changes on power resumption after a power failure. Suitable, reliable indicators such as light emitting diodes (LEDs) shall be provided for personnel to readily ascertain the status of the RTU.

The processor shall monitor the health of the RTU with built in diagnostics, which are capable of remote interrogation. Diagnostics that permit complete testing of the RTU with a portable computer shall be supplied.

Power supply and battery low volts or failure conditions shall be monitored.

The RTU shall possess memory to permit storage of events (input changes) locally for subsequent transmission to the SCADA master station. These events shall not be lost on buffer overflow. An indication shall be provided to signify that the buffer has overflowed. Events will be retained in the buffer until they are correctly read by the master station. Separate buffers shall be provided for digital and analogue events.

To enable fault finding to occur, there shall be a separate event list to record internal RTU events such as health, time synchronisation and any internal errors.

When memory is provided for the purposes of local control or communications routines, spare capacity shall be provided equal to the amount utilised.

The RTU shall have a real time clock, with a resolution of 1 millisecond. The RTU shall have the capability of time stamping events. The RTU clock shall be synchronised by the master station using DNP3 protocol. In the event that this does not occur, the RTU clock shall drift no more than 1 second in 24 hours.

Within the RTU, events shall be reported to an accuracy of ±1 millisecond.

The RTU clock shall be capable of linking to an external high accuracy real time clock.

The RTU shall be equipped with a controls isolate switch, which shall inhibit all control outputs from being executed. The status of this switch shall be monitored by the RTU.

The RTU shall be scanned by a CGI master station operating a Mosaic SCADA system. The protocol used is DNP3 Level 2 over UDP/IP. The supplier shall be able to demonstrate a significant history of satisfactory operation of the RTU connected to this master station or similar.

The RTU shall be capable of programming in a high level language to implement local control and logic routines. The RTU shall be capable of being programmed using structured text according to IEC 61131-3 *Programmable controllers – Part 3: Programming languages*. 

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12. Communication ports

The RTU shall be equipped and configured to communicate through either dual 10 BaseFL or dual 100 BaseFX Ethernet ports, to the main master station and the disaster recovery site. The SCADA master station interfaces with the RTUs utilising the telecommunications network. See T HR TE 21003 ST Telecommunications for Traction Substations and Sections Hut for more details on the connection to the telecommunications network.

Each RTU shall have permanent virtual circuits (PVC) for communications with both master stations using DNP3 Level 2 (minimum) over Ethernet with UDP/IP. The connection between the RTU cubicle and the communications cabinet within the substation shall be made by multimode optical fibre (62.5 μm / 125 μm) patch leads.

A common PC communications port, such as RS-232 serial, shall provide connection to a local PC for diagnostic and configuration purposes.

A specified number of RS-485 channels may be required to interface to local computing devices such as IEDs or other sub RTUs and be specified at the time of the placement of an order. Currently, these IEDs communicate using the Modbus protocol. Capability to use IEC 60870-5-103 Telecontrol equipment and systems Part 5 103: Transmission protocols – Companion standard for the informative interface of protection equipment and DNP3 shall be used for this purpose.

An RS-232/RS-485 port for communication to a local or dialup master station shall be specified at the time of order if it is required.

A port for connection of a slave RTU may be specified at the time of procurement. This port can be a V.23, RS-232/RS-485 or other port. A slave RTU is scanned by an RTU and has its database incorporated into the master RTU database. A slave RTU is not directly scanned by the master station. The supplier shall indicate what protocol variants are available for a slave RTU and any incremental costs associated with each protocol type. Either a publically available protocol or one already in use on the SCADA network, such as DNP3, Modbus and the proprietary protocol used by Kingfisher, shall be used.

The specific communications ports required shall be detailed when the RTU is specified.

Isolation of all communications circuits shall conform to AS 60870.2.1: 1998 Table 18 Class VW3. Galvanic isolation shall be provided for any port that is not based on a fibre interface. This is not required for the diagnostic port.

The two ports that communicate to the master stations are known as ‘A’ and ‘B’ port. Whichever communication standard is used, the equipment used for ‘A’ and ‘B’ port shall be separate such that the failure of one does not affect the other. The A and B communication equipment shall have separate power supplies.

The RTU shall reply on whichever port it is scanned.
13. **RTU I/O modules**

Direct or hardwired I/Os using individual copper wires are used to communicate the status of and control field equipment. Section 13.1, Section 13.2 and Section 13.3 specifies the requirements for direct wired I/O equipment.

13.1. **Digital inputs**

Digital inputs shall comprise both active and passive types. Where passive inputs are nominated, the power shall originate at the input module. Active inputs shall be powered from external equipment. Both the active and passive inputs shall have identical voltage ratings and types, which shall be the substation battery supply voltage. Some miscellaneous field equipment will require different voltage levels because they are supplied at mains voltage. Interposing relays mounted in the marshalling cubicle shall be used in these situations.

Digital input signals shall meet the requirements of Table 6 Class 3 in AS 60870.3-1998 *Telecontrol equipment and systems Part 3: Interfaces (electrical characteristics)*. Galvanic isolation shall be provided.

Inputs shall be provided with anti-bounce signal conditioning and noise filtering such that a value can be varied to adjust the sensitivity of the input from 0 milliseconds to 30 milliseconds. This ensures compatibility with older equipment with contacts that do not make solid contact initially.

Each input shall be able to detect a minimum change, from high to low or low to high, of 4 milliseconds. The threshold voltage shall be set so that an input will not change from low to high unless the input voltage is at least 35% of the nominal battery voltage. The threshold voltage shall not change from high to low unless the input voltage is less than 65% of the nominal battery voltage.

Each group of inputs shall be protected by fuses or equivalent. Fuse monitoring in groups shall be provided to detect whether fuses have failed and alert the ESO of this occurrence.

If a location has two battery systems, the digital inputs shall be clearly labelled to identify which battery system is used. There shall be separation of inputs from the two battery systems. The inputs shall be separated by being on different card and marshalling terminal strips which shall be labelled for identification.
13.2. Digital outputs

Digital outputs shall comprise voltage free contacts rated for switching. Relays shall conform to IEC 61810-1 *Electromechanical elementary relays – Part 1: General and safety requirements*. For non-latching outputs, the relay shall operate for 2 seconds.

Loads shall be typically those shown below:

- 125 V dc 1 A inductive
- 240 V ac 2 A
- 24 V dc 1 A

Appropriate relays shall be selected for the specific type of load. The minimum contact whetting current shall be specified for the relays selected.

Digital output signals shall meet the requirements of Table 6 Class 3 in AS 60870.3-1998. Galvanic isolation shall be provided.

Except for DCCBs, voltage free contacts for digital outputs shall be used; therefore, the field cabling for each control shall have two wires.

DCCBs use single-wire controls to maintain system-wide compatibility. For DCCBs, a +125 V dc supply is derived from a control bus in the RTU marshalling panel which is wired to the DCCB through the RTU output relay contact. The negative connection for the control circuit is made at the DCCB (that is, there is no return to the RTU).

13.3. Analogue inputs

Analogue input signals shall meet the requirements of Table 7 Class 2 in AS 60870.3-1998. Galvanic isolation shall be provided.

Analogue inputs shall be bipolar and able to be configured to accept one of the following current loops using full resolution:

- 0 mA dc to 20 mA dc
- ±20 mA dc
- ±10 mA dc
- ±2 V dc

Eleven bit plus sign resolution shall be provided as a minimum for analogue to digital conversion range.

The resistors used to convert the current loop to a voltage shall be precision resistors. The overall minimum accuracy of an analogue measurement shall be 0.25% over the full scale and...
full temperature range. This includes resistors, analogue to digital converters (ADC) and software accuracy.

14. Diagnostic and configuration utilities

The RTU shall be supplied with a port that provides connection for a laptop PC, using a common PC interface.

The supplier is required to provide diagnostic and configuration software to run on an off-the-shelf laptop PC to access the RTU. The software shall have the capability to perform the following functions:

- monitoring of all inputs, control of all outputs and testing of calculation logic
- monitoring of all inputs and logic at card level, logic level and DNP3 level
- displaying of communications statistics and eavesdropping of communications channels, including Ethernet, IP, DNP3 and Modbus
- downloading and uploading of RTU software, database configuration and calculations, uploading the complete configuration from RTU to modify and then downloading to RTU
- online help
- displaying of current firmware, software and configuration running in the RTU

Configuration and diagnostic software shall run on Windows 7 and subsequent operating systems.

The diagnostic and configuration utility software shall be provided on a CD/DVD that is compatible with off the shelf laptop PCs. The current version number of such software shall be provided. Any costs in upgrading to subsequent versions shall be included in the pricing.

14.1. Local logic control routines

Each RTU shall include the following I/O from miscellaneous equipment, which will be detailed in the I/O list provided at the time of placement of order:

- digital inputs from limit switches on substation doors, up to a maximum of six
- digital inputs from switches designated as staff access switches
- digital inputs from push buttons for bell silence
- digital output to drive audible alarms
- digital outputs for trip and close commands of a latched relay designated as the dummy circuit breaker, supplied as part of the RTU
• digital input to determine the open or closed status of the dummy circuit breaker, part of the RTU internal wiring

• digital input from the 'controls isolate' switch, supplied as part of the RTU, to determine its status

Local control logic routines shall be incorporated into the RTU by the supplier as summarised in Section 14.2, Section 14.3 and Section 14.4.

14.2. Substation telephones

All locations have voice over internet protocol (VoIP) telephones installed, but RTUs shall have some of the previous supervisory telephone functionality. Substations are normally fitted with at least two telephones.

For all locations, when an ESO wishes to contact staff in a substation, a control output shall be sent to the RTU to turn on the audible alarm. Local logic within the RTU shall turn off the alarm after three minutes or when the 'bell silence' local pushbutton is pressed.

14.3. Staff alarm

The RTU software shall implement the any of the following state logic in order to provide security of substation access:

• When a substation entry door is opened, the audible alarm (buzzer) shall sound, and the ESO shall receive notification by the SCADA system.

• When the staff access switch is turned off by the person entering the substation, the buzzer shall be stopped by local logic. The person in the substation shall then immediately notify the ESO by phone.

• When staff exit the substation, the staff access switch shall be turned on. If the doors are closed, the buzzer shall sound for one second after the switch is closed. While the doors are opened, the buzzer shall sound continuously. If the doors are closed within 45 seconds of closing the switch (exit delay), the buzzer shall silence and the ESO shall receive the alarm reset indication. If the doors are not closed within 45 seconds, the buzzer shall remain on.

14.4. Dummy circuit breaker

The dummy circuit breaker shall be a rail mounted magnetically latched relay, driven by a trip and close relay pair. This is a diagnostic device used to prove that telemetry to that RTU is functioning correctly, without the need to operate actual substation equipment.
15. **RTU and marshalling enclosure cubicles**

Marshalling terminals located within an RTU marshalling cubicle shall define the point of separation between the electrical SCADA RTU and the substation electrical system.

For some sites, restricted space within the substation building may necessitate location of the marshalling terminals within the RTU cabinet.

An RTU with marshalling terminals may be specified for purchase either with or without enclosing cubicles.

If an RTU is specified to be supplied with an enclosing cubicle, the RTU cubicle and a separate RTU marshalling cubicle shall be bolted side by side to form a cabinet suite. Details of dimensions, doors and cubicle access shall be contained in the particular specification for that RTU.

When an existing RTU is to be upgraded in the field, the usual method is to discard the internals of the RTU, and keep the existing enclosure within which the replacement RTU and marshalling terminals will be enclosed. In this situation, the RTU and marshalling terminals shall be mounted on a ‘gear plate’. A gear plate is a sheet of 3 mm thick aluminium (to ensure light weight), and may be double sided, onto which the RTU equipment shall be mounted. The gear plate shall be assembled by the supplier offsite, then transferred to site and mounted inside the existing cubicle.

Irrespective of how an RTU is supplied, the warranty provisions shall still apply. Any special wiring or assembly conditions or both required to ensure that these warranties are not compromised shall be clearly stated in the tender response.

15.1. **RTU cubicle**

Each RTU shall be supplied fully assembled together with all ancillary equipment, including wiring terminals, mounting rails, wiring ducts and wiring, to form a complete system, subject only to connection of substation equipment to field terminals.

The following ancillary equipment shall be supplied with the RTU:

- Two 48 V power supplies (125 V dc to 48 V dc converters, if there is a 125 V substation battery present; or, for 50 V substation batteries, 48 V to 48 V dc converters shall be used for isolation). These are used to power auxiliary communications equipment and optional I/O circuits and telephone circuits. Amtex type JWS100-48A or equivalent shall be used.

- Cubicle lighting and a 240 V ac socket-outlet. Although this circuit is fed from a separate circuit breaker, it shall contain residual current device (RCD) protection in accordance with AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules). The socket-outlet shall be mounted near the bottom of the RTU cubicle.
• One dummy circuit breaker in accordance with the requirements detailed in Section 14.4 of this document.

• Four 48 V dc isolating relays (type finder 40.52 48 V dc or equivalent) for monitoring circuits rated for different voltage levels. These four 48 V dc relays are used for the communications circuits. Others may be specified on specific sites.

15.2. RTU marshalling cubicle

The RTU marshalling cubicle shall incorporate cable marshalling terminals for all incoming field cables. Terminals shall be rail mounted vertically. A marshalling facility provides the following:

• A means of isolating plant from RTU in cases where either is in a power down mode, but fed from the other end. This will assist to prevent accidental electric shock.

• A means to easily upgrade the RTU in the future, by separation of the RTU from field cables.

• A simplified means of connecting field cables and RTU cables such that spares can be utilised, additions and alterations can be readily made, and different voltage sources can be utilised.

• A means of disconnecting untested field wiring on a point by point basis.

Terminals shall be provided for each core of all field cables. The number of field cables, and the number and size of all cores, shall be provided (based on the cable schedule) at time of order. The individual cores of a field cable shall be terminated in a row of adjacent terminals.

An adequate means of support for field cables shall be provided such as cable ladder, tray or ducting to which the field cables can be tied for support. Normal field cable access shall be bottom entry into the marshalling cubicle. Provision shall be made for both top and bottom entry for field cables, if specified at time of order.

Space shall be allocated between two groups of terminals where each group is allocated to different cables to provide adequate space for labelling – a minimum label width of 9 mm shall be provided.

Wiring looms shall be provided between each RTU I/O module in the RTU cubicle and the terminals in the RTU marshalling cubicle. One of two methods shall be used to connect to the field cables.

In the first method (method A), two separate rows of terminals, designated RTU terminals and field terminals shall be provided on vertical rails located adjacent to each other. The cables from the RTU will terminate on consecutive RTU terminals. These shall be arranged and labelled according to the module position in the RTU cubicle. The cables from the field will terminate on the field terminals, which shall be arranged in cable groups. The connections between the two
vertical rows of terminals shall be made in the factory to a separate cross wiring schedule. Only the row of field terminals shall be of the disconnect type.

In the second method (method B), where space may be at a premium, only one vertical row of terminals shall be provided. The cables from the RTU shall be stripped to individual cores at the top of the cubicle and wired to individual terminals as required by the termination schedules. Spare cores shall be wired to the bottom of the terminal strip so that future allocation to any point on the terminal strip is possible. For method B, the terminals shall be of the disconnect type. Terminals shall be arranged in cable order, with individual cores from the same field cable arranged together.

A space of at least 45 mm shall be provided between the cable ducts or cable ladder and the terminals (typically 140 mm between the two sets of cable ducts, including the terminal gives a space of 48 mm using WDU terminals of 44 mm width). This shall be provided to ensure the cores can be manipulated and that adequate space for ferrules is provided.

Where ducting is provided for locating cables, the duct size shall be large enough to hold all the cables permitting the duct lid to be fitted when cables are installed.

15.3. Cubicle construction

Cubicle construction shall comply with EP 00 00 00 15 SP.

The supplier shall provide cubicles with the following features:

- Cubicles shall be a wall or floor mounting type depending on available space and shall be of the cubicle manufacturer’s standard design and construction to IP42. Refer to AS 60529 Degrees of protection provided by enclosures (IP Code) for IP42 requirements.

- 1.6 mm sheet steel powder coated and textured storm grey (N42 in accordance with AS 2700S Colour Standards for general purposes - Swatches) shall be used outside and smooth white (N14 to AS 2700S) shall be used inside the cubicle.

- Cable entry shall be from the bottom; however, top entry (if required) may be specified at time of order. Non-ferrous gland plates are required for cable entry.

- Swing frame sections may be specified, to permit easier access to all equipment in certain configurations.

- Door hinges that permit the door to be lifted off.

- Full length pad-lockable doors placed at the front and rear.

- Door and gland plates shall be fitted with gaskets to provide a dust proof environment to IP51 and shall be suitably earthed with earth straps using 10 mm² flexible earth cable. Refer to AS 60529 for IP51 requirements.

- The main earth stud to be suitable for 70 mm² cable.
• The RTU power supply wiring shall be 2.5 mm².

• Cables between the RTU and marshalling cubicle shall be run in 150 mm duct through the cubicle top. In cases where top entry is required, ducting shall be located at the bottom to give clear ingress to field cables.

15.4. **Cubicle assembly**

Cubicle assembly shall comply with EP 00 00 00 15 SP. The cubicle shall be supplied as follows:

• wiring terminal strips shall be supplied for all power and signal connections to the RTU hardware

• marshalling terminals shall be supplied for cabling from the field and from the RTU

• field marshalling terminals shall be pivoting jack, Weidmuller disconnect type WTR 2.5 or equivalent, mounted in vertical columns

• RTU marshalling terminals shall be through type tunnel terminals, Weidmuller type WDU 2.5 or equivalent (this is used where there are two rows of terminals)

• incoming supply fuse terminals, and direct current power distribution terminals, shall be Weidmuller ASK1 (low profile) or equivalent, and fitted with the appropriate fuse

• earth terminals shall be Weidmuller type WPE 2.5 or equivalent

• labels shall be placed to describe each cable from the field and from the RTU. Terminals SCHT 5 S or equivalent shall be used. Suitable labels shall be used to clearly indicate columns of terminals and other components of the cubicle, for example the type of inputs, such as ‘analogue inputs’. For these, either type SCHT 5 or SCHT 5 S shall be used. Labels with cable number shall also identify the equipment that the cable is connected to, for example, 706 for 706 ACCB.

In addition, all major components shall be labelled.

All labels shall be traffolyte type labels. Labels shall have white background and be engraved with black letters. The height of letters shall be greater than 5 mm.

End clamps shall be installed at the end of each rail to ensure terminals are locked into place.

Barriers shall be placed in terminal strips to segregate different voltages.

The mounting rail shall be Weidmuller TS35 or equivalent. Mounting rails shall be sized to provide a minimum of 30% spare space for future expansion.

Ducting shall be used for wiring and cable containment. Slotted ducts are preferred, with adequate space to enable retention of all cables with the lid secure.
Indication wiring within the RTU and marshalling cubicles shall be multi-stranded, minimum 0.75mm² and maximum 2.5mm² with the preference being 1.5mm² (7/0.50). Control wiring shall be multi-stranded, minimum 1.5mm² and maximum 2.5mm² with the preference being 1.5mm² (7/0.50). Power distribution wiring shall be multi-stranded 2.5 mm². Crimp type boot lace ferrules shall be used on all wiring. Wiring shall be labelled at each end using sleeve type markers.

The cubicle shall be earthed with at least a 2.5 mm² cable.

Wiring used for cross marshalling shall be white. Wiring for 240 V ac shall be red/black (cubicle socket-outlet and lighting), 125 V dc red/black, 48 V dc orange/blue and 24 V dc black/white.

16. **Factory testing**

The RTU shall be supplied defect free. Defects found during site commissioning and within the warranty period will result in the parts concerned being returned to the supplier for immediate correction or replacement at the cost of the supplier.

Testing shall comply with EP 00 00 00 15 SP.

An inspection and test plan shall be submitted for approval, prior to the commencement of any tests.

Factory testing of each RTU shall be conducted at the manufacturer’s premises. Provision shall be made for witness testing of all equipment, although the AEO may elect to only undertake a visual inspection before accepting delivery. Two weeks notice shall be provided prior to testing.

Each RTU shall be fully assembled and configured for factory testing, prior to dispatch.

At a minimum, tests shall include the following:

- point to point wiring check
- serial numbers of all cards and modules shall be listed in a spreadsheet
- confirmation of all digital I/O from the field terminal through to the diagnostic laptop
- verification of analogue values received (at least zero, half full scale, full scale values and negative full scale values for bipolar analogues) using a direct current or voltage signal generator measured from the field terminals to the diagnostic laptop
- confirmation of control functions from the diagnostic laptop to the field terminals, including exercising the dummy circuit breaker and the controls isolate switch
- confirmation of effective communications between the RTU and other devices using the specified protocols
- all powered tests shall be carried out at the specified power supply rating of the RTU
Test results for each RTU showing tests undertaken, results and any corrective action taken shall be provided in an approved format and shipped with the RTU. Colour photographs shall be included in the test results to record the equipment layout.

17. Optional configuration

Generally, RTU configuration will be completed by the AEO. However, there are times when workload may not permit this activity.

An optional price shall be given to configure the RTU so that it will work with master stations. This configuration work will use as inputs the following:

- I/O schedule
- calculations as specified
- serial interfaces as specified to acquire data from programmable logic controllers (PLCs) and protection relays

This detail will be listed in any specific requirements at time of order.

In addition to a lump sum price for configuration, an hourly rate should be quoted for assistance with configuration and commissioning. This rate shall be used for telephone assistance where the person providing assistance is not required to be on-site.

18. Defects warranty period

All goods shall have a defects warranty period, which shall be for a period of 12 months from the date of supply. During the warranty period, defective parts shall be able to be returned to the supplier for replacement on an exchange basis.

The tender shall state what spares holding is maintained in Sydney and in Australia, and what policies apply to access this spares holding.

19. Delivery program

The supplier shall deliver RTUs to the nominated address as indicated in the schedules. Delivery costs shall be included in the tender. The full street address shall be detailed at time of placing an order. Deliveries shall only be made after agreement with the AEO to ensure staff are available to receive the goods.

All goods shall be suitably packed to prevent damage during loading, unloading and transportation. Equipment subject to damage due to vibration shall be removed and packed separately for transport.

Each RTU and associated equipment shall be labelled with its associated site; for example, 'Granville RTU' or 'Granville RTU marshalling cubicle'.
20. **Whole-of-life cost**

The selection of the most suitable RTU design will be made on the basis of minimising the whole-of-life cost. The following factors shall be considered in determining this:

- cost of decommissioning and disposal
- cost of installation
- cost of inventory spares
- cost of maintenance
- cost of modifications to other parts of the installation
- cost of special tools
- cost of staff training
- discount rate
- environmental costs
- initial purchase price
- lifetime of equipment
- reliability and cost of consequential damage after failure
- cost of optional tests

Alternative offers should be provided for consideration, if improved maintenance accessibility and performance can be achieved even if it will be at significant additional cost to the offered design.

If the RTU has not previously been type approved by the ASA in accordance with TN 050: 2014 *Electrical Type Approvals – Interim process*, the cost for this process shall be included in the whole-of-life cost.

21. **Data set associated with the equipment**

Data in the form of drawings and diagrams shall be supplied, in both the original software format and portable document format (PDF) format, by the manufacturer and maintained for the RTU. This data shall remain the property of TfNSW. Documentation shall comprise the supplier’s standard manuals and customised drawings for each RTU.

All drawings shall conform to the requirements of the T MU MD 00006 ST *Engineering Drawings and CAD Requirements*. The following drawings are required:

- General arrangement drawings. The following arrangement drawings shall be drawn:
  - cubicle or gear plate general arrangements showing RTU layout
22. Type approval of new equipment

Before being offered for use on the RailCorp network, new equipment shall be type approved by the ASA in accordance with TN 050: 2014. Only AEOs that hold delegated authority from TfNSW to complete design activities for the asset class concerned shall evaluate new products and submit them for type approval to the ASA. This authority is indicated on the AEO’s Engineering Services Matrix.

23. Integrated system support requirements

The RTU manufacturer shall establish and provide the information required to operate and maintain the equipment throughout its operational life in a cost effective manner. This includes the following:

- specifying maintenance requirements
- spares support according to T HR EL 00002 PR Electrical Power Equipment – Integrated Support Requirements
- operations, configuration and maintenance manuals according to this specification
- training – courses shall cover aspects of the RTU design sufficient for the maintainers to maintain the RTU over its design life. Contents shall include RTU operation and data communications protocols, diagnostic tools, failure modes and configuration of the RTU
- support equipment and tooling – the supplier shall provide an itemised price list of all special test equipment and tools required to undertake all preventative and corrective maintenance. The items shall be as defined in the maintenance manuals. All manuals and accessories shall be provided with the test equipment.

The integrated support requirements are a significant deliverable in the procurement of new equipment. Manuals, training, documentation and other support deliverables shall be in accordance with T HR EL 00002 PR.
24. Human factors

The RTU shall be designed in accordance with the human factors principles outlined in T MU HF 00001 ST Human Factors Integration – General Requirements.

The design of the RTU shall allow for good access and visibility to items that require access for operation and maintenance. The design shall consider the following:

- location and height of each piece of equipment in the cabinet
- location, visibility and legibility of signage