EP 11 03 00 02 SP

ELECTRICAL SCADA SYSTEM
REMOTE TERMINAL UNIT
SPECIFICATION

Version 1.0

Issued July 2011
## Document control

<table>
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<tr>
<th>Version</th>
<th>Date</th>
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<td>1.0</td>
<td>July 2011</td>
<td>Adapted from RIC RTU specification 2003 and used to purchase RTUs since then. It was revised for use in the current RTU Supply Agreement.</td>
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1 Introduction

The electrical SCADA system is used to monitor and control the High Voltage (HV) electrical supply network for traction (1500V DC up to 132kV AC) and signals (2kV and 11kV) within the electrified area of the NSW rail network. The master stations interface to the electrical network via a system of RTUs over the RailCorp communication network. RTUs are generally located in traction substations, high voltage distribution substations (33kV and above), underground station substations, 1500V sectioning huts, safety or operationally critical 1500V field switches and normally open mid-points of high voltage feeders (11kV and above).

These locations contain equipment such as HV AC circuit breakers, DC circuit breakers, rectifiers, transformers and other miscellaneous equipment.

A description of the electrical system is contained in EP 00 00 00 01 T1, RIC Electrical System General Description.

1.1 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.

1.2 Purpose

This specification defines RailCorp’s requirements for an electrical SCADA System Remote Terminal Unit. It establishes functional and performance requirements for selection and system design of RTUs to be incorporated into the RailCorp electrical SCADA network.

1.3 Major components of the electrical SCADA system

The three major components of the electrical SCADA system are:

1.3.1 Master station

The SCADA master station provides electrical operators with facilities to remotely monitor and control electrical plant of the traction supply network.

There are two diverse master station locations, one at Prince Alfred substation near Central station, and the other at Broadmeadow, near Newcastle. Either location is capable of operating the entire SCADA network. The master station in use by RailCorp from 2008 is a Logica Mosaic system – version 4.

1.3.2 Communication network

The communications network connects the SCADA master station with all of the RTUs located in RailCorp’s substations.

The communication network is in the main, a private network owned and operated by RailCorp although various connecting links are provided by external suppliers. The network provides dedicated pilot wires between the master stations and RTU locations. The network is gradually being upgraded to a fibre optic cable connected ATM network and a fibre LAN in the region of the RTU sites.
It is the intent that all RTUs purchased using this specification would connect via optical fibre to the ATM network, although there may be occasions where connection by pilot wire is required.

1.3.3 Remote Terminal Units (RTUs):

The RTUs interface to the electrical plant within a substation and monitor the status of the plant via 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.

RailCorp owns RTUs of various ages up to 20 years old (2011 figures) at 230 locations. There are approximately 7 different models from 4 different suppliers. It is RailCorp’s intent to have no more than three makes of RTUs across the network.

2 References

2.1 Australian standards

AS 2700S: 1996 Colour Standards for General Purposes
AS 60529: 2004 Degrees of Protection provided by enclosures (IP Code)
AS 60870.2.1:1998 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: 2007 Electrical Installations (The Australian/New Zealand Wiring Rules)

2.2 International standards

IEC 60255-3 Electrical relays, (formerly IEC 255-4)
   Part 3: Single input energising quantity measuring relays
   with dependent and independent time
IEC 60870-5-103: 1997 Telecontrol Equipment and Systems
   Part 5-103: Transmission protocols
IEC 61131-3 ed. 2 Programmable controllers, (formerly 1131-3)
   Part 3: Programming Languages

2.3 RailCorp documents

EP 00 00 00 01 T1:2010 RailCorp Electrical System General Description
EP 00 00 00 12 SP:2010 Electrical Power Equipment – Integrated Support Requirements
EP 00 00 00 13 SP:2010 Electrical Power Equipment – Design ranges of Ambient Conditions
EP 00 00 00 15 SP:2010 Common Requirements for Electrical Power Equipment

2.4 Other documents

Logica SY000652: MOSAIC Master Station DNP Device Profile Document, June 2003
3 Definitions and abbreviations

ATM Asynchronous Transfer Mode – a type of communications system

Baker A communications protocol developed by the Baker/Basic Corporation, now obsolete; used in SCADA systems in 1970s

Conitel A communications protocol developed by Leeds & Northrup in the late 1960s and 1970s; now obsolete.

CPU Central Processing Unit

DNP3 Distributed Network Protocol – a communications protocol in current use in the SCADA industry. DNP is an open and public protocol, creating interoperability between master stations and RTUs. See www.dnp.org for further details

EOC Electrical Operating Centre – the locations of the SCADA master station.

GPO General Purpose Outlet - in Australia, supplies 240VAC electric power

IED Intelligent Electronic Device, such as a PLC, protection relay or an RTU. In the context of this standard, specifically refers to devices that communicate by a serial protocol to the main RTU at a substation. IEDs do not communicate directly to the SCADA master station.

I/O Input/ Output

IP42, IP51 Two protection standards for cubicles – see AS 60529

LED Light Emitting Diode

L/R Inductive/resistive – as used in electrical load measurement

Modbus A communication protocol developed by Modicon in 1979 and now managed by the Modbus Organisation

N14, N42 White and Storm Grey colour standards

NTU Network Termination Unit – a wall-mounted cubicle used for terminations for the fibre cable supplied by RailCorp for communications with the RTU.

PLC Programmable Logic Controller

RTU Remote Terminal Unit

SCADA Supervisory Control and Data Acquisition

Substation In general covers substations, switching stations, section huts and other electrical locations that might contain RTUs.

Supplier The supplier of the RTU

UDP User (or Universal) Datagram Protocol, is one of the core protocols in the Internet Protocol Suite; UDP does not guarantee ordering of packet delivery, and is thus faster and more time efficient.

VOIP Voice over Internet Protocol
4 RTU system design

RailCorp requires that each substation will 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.

In general the RTU design should aim to minimise power consumption and heat generation. It should be designed to work in a HV electrical installation by being of robust physical construction with immunity to electrical noise.

The RTU shall be assembled from modular units, for example, power supply module, CPU and communications module, communication interface modules and modules for input/output purposes. I/O and serial cards shall be able to be arranged in the RTU rack in any order.

Modules shall be interconnected via a suitably robust plug and socket method. It shall not be necessary to unscrew individual wires/cables, both internal RTU wiring and I/O wiring, to replace faulty modules. The failure of one module will 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 can be located in the RTU cubicle itself for an RTU replacement but for new locations there should be a separate marshalling cubicle. The RTU and marshalling cubicles shall normally be bolted together to form a 2-bay cubicle suite. A separation plate may be located between the cubicles.

The RTU and the cubicles shall be designed to accommodate the actual number of input/outputs and IEDs at the specific substation, plus spare capacity.

4.1 RTU spare capacity

The spare capacity, which includes equipped, wired and cubicle capacity, shall be supplied as described below. The supplier shall detail the steps required to activate the spare capacity.

4.1.1 Equipped capacity

Equipped capacity will include all electronic cards and output terminals. To activate this capacity, an input/output connection shall be made to the designated field terminals in the marshalling cubicle. This additional capacity is generally 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, the initial equipped spare capacity shall be not less than 20% for each type of input and output used. Unless specified, any I/O lists or quantities given for a particular RTU will not include spare capacity. Therefore these quantities will need to be increased by 20% to meet spare capacity requirements.

4.1.2 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 is required to be supplied and fitted, and wiring 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 some future known requirement, which may be 4-5 years away. Unless otherwise specified, this additional capacity shall be zero.
4.1.3 Cubicle capacity

Cubicle capacity is a requirement to provide adequate cubicle space capacity, such that additional card files and terminations could be retro-fitted at some stage in the future. This is to cater for expansions possibly 8-10 years or more away. Unless otherwise specified, this additional capacity shall be zero.

5 RTU I/O structure

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

The indirect interface is via 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.

6 Performance requirements

6.1 Environmental conditions

The RTU shall be designed and supplied suitable for indoor equipment conditions as specified in EP 00 00 00 13 SP Electrical Power Equipment - Design Ranges of Ambient Conditions, Section 4. For RTUs installed indoors, the ambient temperature range is -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 maximum spare capacity as defined earlier is implemented.

6.2 Maintainability

It is a requirement that all RTUs require no routine or planned maintenance. Therefore, no fans or moving parts shall be used in the RTU to avoid any need for maintenance. To ensure this requirement is met the RTU should be constructed to resist the entry of dust.

A single technician shall be able to remove and replace for repair purposes, without special tools and test equipment, all equipment involved in the operation of an RTU. Restoration of equipment to full operational use shall be possible within 15 minutes (nominally) of repairs being completed.

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

Predicted availability of equipment supplied should exceed the following:

<table>
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<tr>
<th>System Function</th>
<th>System Availability</th>
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<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>
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For the purposes of these calculations:

- the availability of any interconnecting communication equipment or system supplied by others shall be assumed to be 100%
- an assumption of an average 2 hours for maintenance personnel to travel to site shall be made. Repair time shall be added to this travel time.

6.4 Service life

RailCorp prefers that the equipment shall be capable of complying with this standard, 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, i.e. spares will no longer be available and technical support is no longer provided.

6.5 Interchangeability

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

7 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 requirements of EP 00 00 00 15 SP and this standard differ, then this standard shall have priority.
8 RTU power supply

The power supply to run the RTU will be provided by RailCorp and will come from one of a number of sources, as detailed in the following sections. The particular power source shall be specified at the time that the RTU is to be ordered. The supplier is required to inform RailCorp of, and supply all power converters required to permit acceptance of the power supply specified by RailCorp.

8.1 Power source – 125VDC or 48VDC substation battery

In the case of this supply source, the RTU shall derive its power requirements from the substation battery provided by RailCorp, which supplies essential equipment in the substation. At most locations, the power source is 125V DC (which is sometimes referred to as 120V DC) although at some older sites the power source may be supplied at 48V DC (which is sometimes referred to as 50V DC).

At bulk supply points and major substations there are two battery systems. At these locations the RTU will be supplied from Battery No.1. Battery No.1 will also be the supply for most indications. The exception to this is for DCCBs, which will normally be split so that half are supplied from Battery No.1 and half are supplied from Battery No.2. There may also be some miscellaneous indications supplied from Battery No.2 such as REC, fire alarm or reactor.

In locations where a 125V DC or a 48V DC power supply is provided, it shall be considered to be a secure supply and no other battery backup system is required for the RTU.

As this power supply is not earthed, isolation of the station battery supply to the RTU system shall be via 2 pole isolating switches.

The RTU power supply shall be designed to operate at full-specified performance for DC supplies conforming to AS 60870-2-1 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 range specified above, i.e. 100 – 143.7V DC for a 125V DC battery.

The RTU power supply shall be designed to operate at fully specified performance for DC supply earthing condition E+/E-/EC/EF (positive earth / negative earth/centre earth / floating) of AS 60870-2-1. As the supply is floating, power should still be available for any single inadvertent earth connection.

8.2 Power source – 240V AC general purpose

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

RailCorp prefers the batteries provided by the supplier to be 12VDC. Batteries shall be of the sealed AGM (absorbed glass mat) or gel type lead acid, and shall be supplied in a separate wall mounted cubicle, with venting to atmosphere of approximately 10cm square. RailCorp has previously used 48VDC, 24VDC and 12VDC batteries at various
sites, but the preference is to use 24V DC (made of two 12V batteries). RailCorp may specify a need for a battery at these alternate voltage levels. The battery voltage required at a particular location shall be specified by RailCorp at time of order placement.

The supplier is required to provide design calculations to demonstrate the battery capacity to be supplied. The calculation of the required 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 4 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 5 hours.

8.3 General

In all cases, 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, table 18, class VW3.

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

9 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 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 including diagnostics for memory and bus errors, buffer overflows, local software routine health, communication ports status, input/output card health. Diagnostics shall also be supplied that shall permit complete testing of the RTU with a portable computer. Diagnostic checking of the communication ports shall be provided to permit checking by a portable computer.

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

The RTU shall possess memory to permit storage of a minimum of 2000 events (input changes) locally for subsequent transmission to the SCADA master station and these events shall not be lost on buffer overflow; an indication shall be provided of this latter condition. Events will be retained in the buffer until they are correctly read by the master station. As a minimum, 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. This shall permit storage of up to 2000 events.

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 1msec. It shall have the capability of time stamping events. The RTU clock is normally synchronised by the master station using DNP3 protocol every 5 minutes. In the advent 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 +/-1msec.

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

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 LogicaCMG master station operating a Mosaic SCADA System. The protocol used is DNP3 over UDP/IP. See the reference in Section 2.4 – Logic SY000652 “MOSAIC Master Station DNP Device Profile Document”. The supplier must 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. It shall also be capable of being programmed using at least two IEC1131-3 programming languages.

## 10 Communication ports

The minimum requirement for communications is as follows:

- The RTU shall be equipped and configured to communicate via dual 10BaseFL Ethernet ports, and be capable of using 100BaseFX, to the master stations at Prince Alfred and Broadmeadow. The SCADA master station interfaces with the RTUs utilising RailCorp’s ATM network communications system. Each RTU shall have Permanent Virtual Circuits (PVC) for communications with Prince Alfred and Broadmeadow Master Stations using DNP3 Level 2 (minimum) over Ethernet with UDP/IP. The connection to the ATM based network communications shall be made by multi-mode optical fibre (62.5μm/125μm) patch leads provided by RailCorp. The patch leads connect to a communications switching panel provided by RailCorp within the substation.

- An RS-232 serial port shall provide connection to a local or dialup 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, if required, will 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 and DNP3 is required for this purpose.

- An RS-232/RS-485 port for communication to a local or dialup master station may be required and, if required, will be specified at the time of the placement of an order.

- Dual V.23 ports may be required for communications via the existing pilot wire communications network to the master station in lieu (temporarily) of the fibre ports. The protocol used on the V.23 ports will be either Baker or Conitel C2020 (RailCorp will provide further definition on request). This method of communication requires a 1200 baud VF modem, and if the modem offered to be supplied is not acceptable to RailCorp then RS232 ports to an externally supplied approved modem will be required.

- A port for connection of a slave RTU. This port may 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. RailCorp’s preference is to use a publicly available protocol, and on the grounds of training and familiarity, one of the existing protocols in use within RailCorp. These are public protocols DNP 3.0, Conitel/Baker, and Modbus, and the proprietary protocol used by Kingfisher.
The specific communications ports required shall be detailed when the RTU is specified as it is recognised that both RTU and communications network components may change in the future.

Isolation of all communications circuits shall conform to IEC 60870.2.1 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 (for Ethernet) and ‘A’ and ‘B’ pilot (for V.23). Whichever communication standard is used, the equipment used for ‘A’ and ‘B’ port/pilot must be separate such that the failure of one does not affect the other. Also, the A and B communication equipment should be off separate power supplies where possible.

The RTU must reply on whichever port it is scanned

The SCADA Master Stations interface with the RTUs utilising the existing RailCorp ATM network communications system. Each RTU has Permanent Virtual Circuits (PVC) for communications with Prince Alfred and Broadmeadow Master Stations.

11 RTU Input/Output modules

This section relates to direct wired input/output equipment.

11.1 Digital inputs

Digital inputs shall comprise both active & 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 normally have identical voltage ratings & types, which shall be the substation battery supply voltage. Some inputs, detailed at time of issue of specification, shall require different voltage levels which will usually be accommodated by the use of interposing relays, mounted in the marshalling cubicle.

Digital input signals will conform to AS60870.3 Table 6 Class 3, and galvanic isolation shall be provided.

Each input shall be provided with individual ‘anti-bounce’ signal conditioning and noise filtering such that a value can be varied to adjust the sensitivity of the input from 0-30ms. 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 4ms. The threshold voltage shall be set such that an input will not change from Low to High unless the input voltage is at least 35% of the nominal battery voltage and it will 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 master station operator of this occurrence.

For locations where there are two battery systems, digital inputs shall be clearly labelled to identify which battery system is used. There shall also be separation of inputs from the two battery systems. The inputs shall be separated by being on different card racks and marshalling terminal strips which shall be labelled for identification.
11.2 Digital outputs

Digital outputs shall comprise voltage free contacts rated for switching. Relays shall conform to IEC 60255-3 (formerly IEC 255-4).

Loads shall be typically:

- 125V DC 1 Amp inductive
- 240V AC 2 Amps
- 24V DC 1 Amp

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 conform to AS60870.3 Table 6 Class 3, and galvanic isolation shall be provided.

The preference is to use voltage free contacts for the digital outputs. This applies to all controls which therefore require 2 wires in the field cabling for each control. This requirement does not apply to DCCBs, which use single-wire controls to maintain system-wide compatibility. For DCCBs, a +125V DC supply is derived from a control bus in the RTU marshalling panel which is wired to the DCCB via the RTU output relay contact. The negative connection for the control circuit is made at the DCCB (i.e. there is no return to the RTU). An additional complication occurs with the Tap changer controls which use three wires for each up/down control pair. Voltage free control contacts are used, but only a single positive wire is used from the field equipment, requiring a loop between the two RTU control relay contacts.

11.3 Analogue inputs

Analogue input signals will conform to AS60870.3 Table 7 Class 2, and galvanic isolation shall be provided.

Analogue inputs shall be bipolar, but normally configured to accept 0-20mA DC or ±20mA DC or ±10mA DC or ±2V DC using full resolution. Eleven (11) bit plus sign resolution shall be provided as a minimum for analogue-to-digital conversion range.

Each input shall be provided with individual software filtering.

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

12 Diagnostic and configuration utilities

The RTU shall be supplied with a port that provides connection for a laptop PC. RailCorp currently uses general purpose PCs type Dell Latitude D800 with 15” screens. These are equipped as follows:

- Metal frame construction, supplied with robust carry cases for field use
- 15” screen TFT or better because these are used outdoors in sunlight and screen visibility is a sometimes difficult
- Separate serial port because some third party software used is incompatible with USB to serial converters
- CD writer
- Dial up modem for VF connection
- XP operating system (in the future this will be Windows 7)
• Possible to connect remotely to an Ethernet connection to access the RailCorp LAN

The supplier is required to provide diagnostic and configuration software to run in these laptops and access the RTU. This software shall include facilities for:

• 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.
• Display of communications statistics and eavesdropping of communications channels, including Ethernet, IP, DNP3, Modbus and Conitel/Baker.
• Download & upload of RTU software, database configuration and calculations, upload the complete configuration from RTU to modify and then download to RTU.
• On-line help.
• Display current firmware, software and configuration running in the RTU
• Configuration and diagnostic software must run on both Windows 2000, XP and Windows 7

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

13 Local logic control routines

This section outlines basic local logic control routines to be incorporated in the RTU.

Each RTU will include the following input/output from miscellaneous equipment, which will be detailed in the input/output list provided by RailCorp at the time of placement of order:

• Digital Inputs from limit switches on substation doors, up to a maximum of 6, supplied and connected by RailCorp.
• Digital Inputs from switches designated as “Staff Access Switches,” supplied and connected by RailCorp.
• Digital Inputs from push buttons for “Bell Silence,” supplied and connected by RailCorp.
• Digital Output to drive audible alarms supplied and connected by RailCorp.
• 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 the 3 items below.

13.1 Substation telephones

There are different arrangements for substation telephones depending on the age of the location and the SCADA equipment installed. Supervisory telephones (supy phones) are generally located in older locations. Newer locations have VoIP phones instead of supy phones, but still have some supy phone functionality.
Older substations are normally fitted with at least 2 telephones by RailCorp. One is designated as the supy phone, which shall provide a fixed connection to the EOC; this enables a call to be made from the substation to the EOC by picking up the handset and pressing a button. The other is a normal dialled number telephone service. Both telephones are connected to the communications network by RailCorp.

For all locations, when an EOC operator 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 3 minutes, when the “bell silence” local pushbutton is pressed or if the supy phone is off hook.

13.2 Staff alarm

The RTU local logic is required to implement the following sequences in order to provide security of substation access.

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

When the staff access switch is turned off by the person entering the substation, the buzzer is stopped by local logic. The person in the substation must then immediately notify the EOC operator by phone.

When staff exit the substation, the staff access switch is turned on. If the doors are closed, the buzzer will sound for 1 second after the switch is closed. While the doors are opened, the bell will sound continuously. If the doors are closed within 45 seconds of closing the switch (exit delay), the bell will silence, and the EOC will receive the alarm reset indication. If the doors are not closed within 45 seconds, the bell will not silence.

13.3 Dummy circuit breaker

The dummy circuit breaker shall be a rail mounted magnetically latched relay, driven by a trip/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.

14 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.

Note that 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 normal arrangement is for an RTU cubicle and a separate RTU marshalling cubicle bolted side by side to form a cabinet suite. Details of dimensions, doors and cubicle access will 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. For these cases, the RTU and marshalling terminals will be mounted on a “gear plate”. A gear plate is a sheet of aluminium (to ensure light weight) and may be double sided. The gear plate will be assembled by the supplier off site, then transferred to site and mounted inside the existing cubicle. The aim is to reduce the on site component of assembly and wiring work as much as possible.
A gear plate could comprise a single sheet, or 2 sheets mounted back to back, as required to mount all equipment. Gear plates shall preferably be made of 3mm thick (approximately) aluminium to make the assembly light enough for safe lifting and carrying into a substation.

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

14.1 RTU cubicle

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

Ancillary equipment to be supplied with the RTU includes the following:

- 2 x 48v power supplies (125V DC to 48V DC converters, if there is a 125V substation battery present, 48 V – 48V DC converters shall be used for isolation). These are used to power auxiliary communications equipment, and optionally input/output circuits and supervisory telephone circuits. Amtex type JWS100-48A or equivalent shall be used.
- Cubicle switch/lighting and a 240V AC GPO. Note that this circuit is fed from a separate circuit breaker, but shall require earth leakage protection as per Australian Wiring Rules. The GPO shall be mounted near the bottom of the RTU cubicle.
- A dummy circuit breaker as per clause 13.3
- 4 x 48V DC isolating relays (type Finder 40.52 48V DC or equivalent) for monitoring circuits rated for different voltage levels. These 4 x 48V DC relays are for the communications circuits. Others may be specified on specific sites.

14.2 RTU marshalling cubicle

The RTU marshalling cubicle shall incorporate cable-marshalling terminals for all incoming field cables. Terminals shall normally be rail mounted vertically. The reasons for providing a marshalling facility are to:

- Provide 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.
- Provide a means to easily upgrade the RTU in the future, by separation of the RTU from field cables.
- Facilitate commissioning, with ease of disconnecting untested field wiring on a point by point basis.
- Provide a simplified means of connecting field cables and RTU cables such that spares can be utilized, additions and alterations can be readily made, and different voltage sources can be utilised.

Terminals shall be provided for each core of all field cables. The number of field cables, including the number and size of all cores, shall be provided by RailCorp at time of order. The individual cores of a field cable will be terminated in a row of adjacent terminals.

Adequate means of support for field cables shall be provided. This will typically be a section of cable ladder/tray/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 by RailCorp at time of order.
Space shall be allocated between sections of terminals 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 2 vertical rows of terminals shall be made in the factory, to a separate “cross wiring” schedule. Note that only one of these rows of terminals, the 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. In this case, 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 such that future allocation to any point on the terminal strip is possible. In this case, the terminals shall be of the disconnect type. Terminals will be arranged in cable order, with individual cores from the same field cable arranged together.

A space of at least 50mm shall be provided between the cable ducts or cable ladder and the terminals (note that 140mm between the two sets of cable ducts, including the terminal, has been found to be adequate – this equates to 48mm using WDU terminals of 44mm 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.

The design of the marshalling cubicle layout shall be to RailCorp’s approval.

14.3 Cubicle construction

Cubicle construction shall comply with RailCorp Standard EP 00 00 00 15 SP Common Requirements for Electric Power Equipment.

The supplier shall provide cubicles with the following features:

- Cubicles shall be wall or floor mounting type depending on available space and of the cubicle manufacturer’s standard design & construction, to IP42
- 1.6mm sheet steel powder coated – storm grey N42 to AS2700 textured powder coat outside, white N14 to AS2700 smooth powder coat inside.
- Cable entry normally bottom only, but top entry may be specified by RailCorp at time of order. Non-ferrous gland plates are required for cable entry.
- Swing frame sections may be supplied with RailCorp approval, 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 at front and rear.
- Door & gland plates shall be fitted with gaskets, to provide a dust proof environment to IP51, and shall be suitably earthed with earth straps using 10mm² flexible earth cable.
- Main earth stud to be suitable for 70mm² cable.
- The RTU power supply wiring shall be 2.5mm²
• Cables between RTU and marshalling cubicle shall be run in 100mm duct via cubicle top. In cases where top entry is required, ducting should be located at the bottom to give clear ingress to field cables.

14.4 Cubicle assembly

Cubicle Assembly shall comply with RailCorp Standard EP 00 00 00 15 SP Common Requirements for Electric Power Equipment.

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 WDU2.5 or equivalent (this is used where there are two rows of terminals).
• Incoming supply fuse terminals, and DC power distribution terminals, shall be Weidmuller ASK1 (low profile) or equivalent, fitted with the appropriate fuse.
• Earth terminals shall be Weidmuller type WPE2.5 or equivalent.
• Labels shall be placed to describe each cable from the field and from the RTU. Terminals SCHT5S or equivalent shall be used. Suitable labels shall be used to clearly indicate columns of terminals, and other items, e.g. types of inputs, such as “analogue inputs.” For these, either type SCHT5 or SCHT5S shall be used.

In addition, all major items of equipment shall be labelled.

All labels shall be white-black-white ‘Traffolyte’ type labels, suitably engraved with lettering height greater than 5mm.

• End Clamps at least at the end of each rail to ensure terminals are locked into place.
• Barriers shall be placed in terminal strips to segregate different voltages
• 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/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 0.75mm² (24/0.20mm for example). Control wiring shall be multi-stranded 2.5mm². Power distribution wiring shall be multi-stranded 2.5mm². 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 2.5mm² cable.
• Wiring used for cross marshalling shall be white. Wiring for 240V AC shall be red/black (cubicle GPO and lighting), 125V DC red/black, 48V DC orange/blue, 24V DC black/white.

15 Factory testing

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

Testing shall comply with RailCorp Standard EP 00 00 00 15 SP Common Requirements for Electric Power Equipment.
An Inspection & 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 RailCorp may elect to only undertake a visual inspection before accepting delivery. Two weeks notice shall be provided to RailCorp prior to testing.

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

Tests shall include, but not be limited to:

- Point to point wiring check
- Serial numbers of all cards and modules shall be listed in an Excel spreadsheet
- Confirmation of all digital inputs & outputs, 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 DC 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.

16 Documentation associated with the RTU equipment

RTU Equipment documentation requirements shall comply with RailCorp Standard EP 00 00 00 15 SP Common Requirements for Electric Power Equipment.

Documentation comprises the supplier’s standard manuals and customised drawings for each RTU.

16.1 Manuals

The Supplier shall supply descriptive manuals for design, configuration, installation, commissioning and maintenance purposes. These shall be the Supplier’s standard documentation, modified if necessary for RailCorp’s purposes. Quantities shall be specified with each order.

16.2 Drawings

It is preferred that drawings of input/output circuits be provided be in “pro forma” form, such that they may be easily understood by field staff from a master set, rather than having multiple sets of drawings. Separate spreadsheets may be provided to contain additional information.

All drawings shall be produced using the latest version of Autocad or Microstation and the supplier shall allow 10 working days for review and approval by RailCorp. All drawings shall be provided in electronic form (both Autocad/Microstation and PDF formats). All drawings shall be fully version controlled. One set only is required.
Drawings as follows shall be submitted for the approval of RailCorp, for each RTU to be manufactured:

- Inspection & Test Plans
- Cubicle or gear plate General Arrangements showing RTU layout
- Dimensioned cubicle and/or gear plate drawings
- Bill of Material for each cubicle/gear plate set identifying all parts
- Power Distribution Schematic Diagrams for each RTU
- Schematic Diagrams for Inputs and Outputs for each RTU (preferably using pro forma principles)
- Calculations for RTU and I/O power consumption: An Excel spreadsheet shall be provided that calculates the maximum power consumption of the RTU. Inputs shall be the numbers and types of I/O and communications cards. The calculations shall compute the power at the primary voltage level into the RTU allowing for any power conversion efficiencies.

17 **Spare parts**

A set of recommended spare parts shall be detailed for each RTU. The set shall be sufficient to cover the complete range of RTUs supplied. Unit prices shall be supplied.

The list shall include the following:

- Item identification
- Recommended spares quantities
- Base price
- Procurement lead time Probability the required item is available given its MTBF based on recommended spares and procurement lead time.
- Quantity of item held in Sydney by Supplier as emergency spare parts
- Quantity of item held elsewhere in Australia as an emergency spare part

All spare parts shall be fully tested.

Note that RailCorp may elect to purchase any quantity of individual spare parts depending on their stock levels of such spares.

18 **Tools and test equipment**

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 service schedules in the maintenance plans and/or maintenance and fault finding manuals. All manuals and accessories shall be provided with the test equipment. All test equipment and special tools shall be covered by the same defects warranty as the RTUs.

Items of tools and test equipment may be purchased at any time at RailCorp’s sole discretion.

19 **Optional training**

19.1 **Training of RailCorp’s maintainers**

RailCorp may require training of SCADA System maintainers in the operation and maintenance of RTUs. This shall be required normally for any new RTU products, but may be required for familiarity training as part of a refresher course for both new and existing personnel.
The 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 provided with the RTU and test equipment to fault find an RTU
- Failure modes
- Configuration of the RTU

RailCorp may elect at its sole discretion to take up training on the RTUs offered. The supplier shall include with its offer the following:

- Lists of standard RTU courses offered and the cost per attendee or per course, detailing minimum and maximum number of attendees, located in Sydney
- A daily rate for conducting customised training at RailCorp premises in Sydney for up to 6 people

The training courses shall be broken into individual days. Depending upon the availability of staff to attend, the courses may be conducted on single days or multiple days, with multiple days not necessarily being consecutive days. The supplier shall advise the period of notice required to be given by RailCorp for any training courses.

19.2 Training course material

Training courses shall be conducted at EOC, Surry Hills or at an alternate location in Sydney. The Supplier shall provide all teaching aids for each attendee for the conduct of the courses, which shall be independent of any other material provided under this Agreement.

20 Optional configuration

It is RailCorp’s intention that all RTU configuration be done by RailCorp staff. Nevertheless, there are times when workload may not permit this activity to be done by RailCorp.

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

- I/O lists produced by RailCorp
- Calculations as specified by RailCorp
- Serial interfaces as outlined by RailCorp to acquire data from 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 will not be required to attend site.

21 Defects warranty period

All Goods shall have 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 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.
22 Delivery programme

The Supplier shall deliver RTUs to the nominated address as indicated in the schedules. Delivery costs will be included in the tender. Full street address will be detailed at time of placing an order. Deliveries may only be made after agreement with RailCorp, to ensure staff are available to receive the Goods.

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

Each RTU and associated equipment shall be labelled with its associated site, e.g. Granville RTU or Granville RTU Marshalling Cubicle.