



SUPPLY, DESIGN, INSTALLATION AND COMMISSIONING OF RTU's AND GATEWAYS PROJECT SCOPE

SCADA EQUIPMENT INTERFACE STANDARD FOR HARDWIRED EQUIPMENT

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Contents

1	Introduction	6
2.	Normative References	7
3.	Terms, Definitions and Abbreviations	7
3.1	Terms and Definitions	7
3.2	Abbreviations	9
4.	Scope of Work	12
5.	REQUIREMENTS	14
5.1	General Requirements	14
5.2.	SCADA Component Requirements	16
5.2.1.	Remote Terminal Unit (RTU)	16
5.2.2.	Battery Charger, Batteries and DC Supply	Error! Bookmark not defined.
5.2.3.	Gateway	16
5.2.4.	Communication Network	16
5.3	RTU Design and layout requirement	17
5.3.1.	RTU Cabinet	17
5.3.2.	Cabinet racks	17
5.3.3.	Terminating blocks, connectors and cables	17
5.3.4.	Analogue Transducers	18
5.3.5.	Dummy relay	19
5.3.6.	CPU Module	19
5.4	Battery Charger, Batteries and DC Supply	20
5.5	Gateway Equipment	20
5.6	Master Station	21
5.7	Monitoring Requirements	21
5.8	Controlling Plant	22
5.9	System Performance	22

6.	Testing and Acceptance.....	23
6.1	Testing.....	23
6.2	Factory Acceptance Test (FAT).....	24
6.3	Site acceptance Test (SAT)	25
6.4	General.....	25
6.5	Witnessing of Tests	25
6.6	Routine Tests.....	26
7.	Documentation.....	26
7.1	Drawings	26
7.2	Instruction Manuals	27
7.3	Delivery of Drawings, Handbooks and Test Certificates	29
8.	Training.....	29
9.	QUALITY MANAGEMENT	30
10.	HEALTH AND SAFETY	30
11.	ENVIRONMENTAL MANAGEMENT	31
	Appendix A.....	33
	Basic SCADA Input and Output Functions.....	33
	APPENDIX B.....	Error! Bookmark not defined.
	SUB-STATION	Error! Bookmark not defined.
	ESTIMATED NUMBER of SUB-STATION.....	Error! Bookmark not defined.
	PRICE AS PER BOQ.....	Error! Bookmark not defined.
	TOTAL.....	Error! Bookmark not defined.
	Satellite Substation with IEDs	Error! Bookmark not defined.
	30	Error! Bookmark not defined.
	Satellite Substation without IEDs.....	Error! Bookmark not defined.
	30	Error! Bookmark not defined.
	Major Substations	Error! Bookmark not defined.
	30	Error! Bookmark not defined.

VAT **Error! Bookmark not defined.**

Total Cost **Error! Bookmark not defined.**

1 Introduction

The City Power SCADA system is used to monitor and control the Medium and High Voltage network within the City Power network. The Master station interfaces to the electrical network via a system of RTUs over the City Power communication network which can either be a fibre link, a radio link or a telephone line. The RTU normally interfaces with plant equipment such as circuit breakers, power transformers, current transformers, voltage transformers, capacitor banks etc. Many of the existing and older substations have combined protection schemes ranging from old electro-mechanical relays to new IED equipped schemes. All the inputs and outputs from these schemes need to be interfaced with the RTU/Gateway for monitoring and control purposes. Older schemes will typically be hardwired to the RTU, whereas new IED equipped schemes will be connected via a networked to the RTU/Gateway. City Power's SCADA Master Station interfaces to the electrical network via a system of RTUs over the City Power communication network.

Keywords: RTU, SCADA, Gateway, Analogue, Digital, Field Terminal, Krone Blocks.

2. Normative References

IEC 60529, Degrees of Protection Provided by Enclosures (IP Code).4

IEC 60870-6, Telecontrol Equipment and Systems.

IEC 61850, Communication Networks and Systems in Substations.

IEEE Std 525™, IEEE Guide for the Design and Installation of Cable Systems in Substations.

IEEE Std 1379™, IEEE Recommended Practice for Data Communications between Intelligent Electronic Devices and Remote Terminal Units in a Substation.

IEEE Std 1588™, IEEE Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.

IEEE Std 1613™, IEEE Standard Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations.

IEEE Std 1615™, IEEE Recommended Practice for Network Communication in Electric Power Substations.

IEEE Std 1646™, IEEE Standard Communication Delivery Time Performance Requirements for Electric Power Substation Automation.

IEEE Std C37.115™, IEEE Standard Test Method for Use in the Evaluation of Message Communications between Intelligent Electronic Devices in an Integrated Substation Protection, Control, and Data Acquisition System.

3. Terms, Definitions and Abbreviations

3.1 Terms and Definitions

Accuracy: The difference between the actual value of a measurement and the indicated value of the measurement.

NOTE—Accuracy is usually expressed in terms of percentage deviation from a reference value, commonly full scale of the measuring device and less commonly the actual value at the input. Note that accuracy for power measurements are expressed with an applicable power factor range. (Real power measured at less than 10% power factor or reactive power measured at greater than 90% power factor tend to have significant errors) Note also that if the “measuring device” is a current transformer, its full scale rating may be significantly larger than the displayed value (e.g., a 3000 Ampere 0.3% CT measuring a 300 Ampere load current). In this case, its accuracy is $0.3\% \times 3000$ or ± 90 A, so the accuracy of a 300A load measurement is actually 300 ± 90 A or $\pm 30\%$ of the measured value.

Availability: Availability (A) is defined in the following as the ratio of uptime to total time (uptime +downtime). It is customary to express availability in percentage, usually as 99.xxx, where xxx are numbers that complete the percentage.

Chatter filter: A facility that is used to disable a digital input point if the number of state changes of that point during a defined time interval is excessively high.

Clear time: The amount of time that the select relay will continue to operate after the master trip or close has operated. Clear time can also mean operating time.

Control arm time-out: The maximum amount of time that a device will wait to receive an execute command after receiving a select or arm command. Refer to select command.

Debounce period: The amount of time for which the state of a digital input point shall be detected in a valid “on” or “off” condition before it is considered to be in that position.

Diagnostics: Programs executed to check the health of the device on either a periodic or random interval.

Double-point status: A pair of digital input points that can assume four different states. States 1 and 2 may be described as NORMAL or VALID states, and states 3 and 4 may be described as TRAVELLING or ABNORMAL or INVALID states. Purpose is to detect complete changes of state (transitions), while ignoring any incomplete transitions.

Latency: The time between when sensor outputs are present at the physical interface of a measuring device until its value is available to the first user or program.

Local area network (LAN): A LAN is a network normally designed for a limited geographical area, such as a utility substation or an office area. It is generally capable of transmitting data, voice, and image and video information. In most cases a LAN is considered to be an integral part of the facility, and is owned by the facility owner. A substation LAN may have sub-networks or segments to manage information flow and access. Segments may also be added to accommodate passing messages over distances exceeding the basic messaging distance inherent in the media. Serial networks can often be implemented over a LAN by embedding the serial messages in a network protocol.

Lock-out period: A parameter that defines the length of time that a device or point will be disabled from operation after exceeding a pre-defined error condition.

Pseudo points: System data points generated internally by a software application. They often represent the results of a calculation, or the internal state of a process.

Recloser: Abbreviated name for automatic circuit recloser.

Resolution: The smallest increment of a value that can be resolved, often expressed as percent of full-scale. It is better expressed in engineering units of the measured value.

Scan (interrogation): The process by which a data acquisition system interrogates intelligent electronic devices (IEDs) for points of data.

Scan cycle: The time in seconds required to obtain a collection of data (e.g., all data from one IED, all data from all IEDs, or all data of a particular type from all IEDs).

Scan Enable: A feature that allows or disallows a particular input point to be scanned.

Select before Operate: Two-part command sequence used to achieve high communications security and hardware verification before the control is actually executed.

Single point/multiple point control: The control of a single point versus global control of multiple points.

Time skew: The elapsed time between when the first value in a set of measurements is taken until the last value of the same set of measurements is taken. The data set may consist of

measurements made in a close proximity, as within a single substation, or across a large geographic area as in the flow measurements for a large transmission network.

Unavailability: The ratio $\text{downtime}/(\text{uptime} + \text{downtime})$. The ratios of downtime to total time $(\text{uptime} + \text{downtime})$, or $\text{downtime}/(\text{uptime} + \text{downtime})$. It is often expressed as a maximum period of time during which the variable is unavailable, e.g., 4 h per month.

Update periodicity: The time between updates, sometimes expressed as the rate at which a measurement is updated (frequency).

Virtual input/output (I/O): An I/O point such as status, control, or analog that is not physically wired to an IED.

Wide area network (WAN): A WAN provides long-distance transmission of data, voice, and image and video information over a large geographical area. A WAN can be owned by a utility or WAN services can be leased from telecommunication providers. WANs connect LANs together.

3.2 Abbreviations

A.C.	- Alternating Current.
ARC	- Automatic Reclose Control.
BCD	- Binary Coded Decimal.
BDG	- Bulk Data Generator.
BME	- Bandwidth Management Equipment.
BLC	- Bay Level Controller
Bps	- Bits per second.
CASE	- Computer Aided Software Engineering.
CCITT	- Consultative Committee on International Telegraphing and Telephony.
CI	- Communications Interface.
CML	- Control and Monitoring Logic.
CMS	- Closed Mode Selection.
CPU	- Central Processing Unit.
CSMA/CD	- Collision Sensing Multiple Access / Collision Detection.
CT	- Current Transformer.
D.C.	- Direct Current.
DCE	- Data Communications Equipment.
DMS	- Distribution Management System.
DNP/DNP3	- Distributed Network Protocol, Version 3.0.
DTE	- Data Terminal Equipment.
DSP	- Digital Signal Processing.
EIA	- Electronic Industries Association.
EMC	- Electro-Magnetic Compatibility.
EMI	- Electro-Magnetic Interference.
EMS	- Energy Management System.
FAT	- Factory Acceptance Test.
FOC	- Fibre Optic Cable.
FSK	- Frequency Shift Keyed.
GPS	- Global Positioning System.
GUI	- Graphical User Interface.
HMI	- Human Machine Interface.
IBM	- International Business Machines ®.

IDF	- Intermediate Distribution Frame.
IEC	- International Electrotechnical Commission.
IED	- Intelligent Electronic device. Generic name given to all microprocessor based substation secondary devices e.g. Relays, tariff meters, etc.
I/O	- Input / Output.
IRIG-B	- Inter Range Instrumentation Group format B.
ISA	- Instrumentation, Systems and Automation Society.
ISO	- International Standards Organization.
kV	- Kilovolt.
kVAh	- Kilovolt Ampere Hours.
kVAr	- Kilovolt Ampere Reactive.
kW	- Kilowatt.
LAN	- Local Area Network.
LCD	- Liquid Crystal Display.
LED	- Light Emitting Diode.
LCP	- Local Control Panel.
MEASURAND	- Synonymous with Analogue.
ms	- Millisecond (10 ⁻³ of a second).
MTBF	- Mean Time Between Failures.
MTTR	- Mean Time to Repair.
NBLC	- New Bay Level Controller.
NERTU	- New ERTU, synonymous to ERTU.
NRTU	- New Remote Terminal Unit, synonymous to RTU
OSI-RM	- Open Systems Interconnect-Reference Model.
PC	- Personal Computer.
PID	- Protocol Implementation Document.
PLC	- Power Line Carrier.
PPS	- Portable Plant Simulator.
PSTN	- Public Switched Telephone Network.
RAM	- Random Access Memory.
RM	- Remote Metering.
RSA	- Republic of South Africa.
RTU	- Remote Terminal Unit.
RS232	- An EIA standard for the interfacing between DCEs and DTEs. It defines the electrical characteristics of the signals from such devices.
RS422	- An EIA recommended standard to extend the RS232 50ft limit and is electrically compatible with the CCITT V.11 standard.
SABS	- South African Bureau of Standards.
SAT	- Site Acceptance Test.
SC	- Serial Cable.
SCADA	- Supervisory Control And Data Acquisition.
SCS	- Substation Control System. Defined as an integrated and co-ordinated system that performs the tasks of SCADA, substation automation and offers a single point of control and alarm annunciation (HMI) to the substation operator.
SDM	- Structured Development Methodology.
SER	- Sequence of Events Recorder.
SOE	- Sequence of Events.
SOG	- System Operation Guidelines.
SVC	- Static VAR Compensator.
SVGA	- Super Video Graphics Adaptor.
SWC	- Surge Withstand Capability.
TCP/IP	- Transmission Control Protocol / Internet Protocol.

TNC	- Transmission National Contract
TPK	- Transfer Permission Key.
uF	- Micro Farad.
UPS	- Uninterruptable Power Supply.
UTP	- Unshielded Twisted Pair.
VDU	- Visual Display Unit.
VT	- Voltage Transformer.
VF	- Voice Frequency.
WAN	- Wide Area Network.

4. Scope of Work

City Power substations are categorised into Bulk substations, major substations, satellite substations with IEDs and satellite substations without IEDs. Only Major substations, satellite substations with IEDs and satellite substations without IEDs shall form part of the scope of this contract. The substations shall be integrated into the existing City Power SCADA Master station and shall be visible and controllable from this Master station. The successful Contractor shall provide all equipment, engineering, resources etc. to fulfil the SCADA obligations. The SCADA scope will include (but not be limited to):

- The supply, installation, cabling and configuration of a complete RTU/Gateway that forms part of an integrated substation protection and control system based on the Hardwired solution for older schemes and equipment, and network based for newer IED based schemes and equipment.
- All engineering to interface the RTU/Gateway to I/O modules and IEDs, the SCADA programming and the required software modification and testing compatibility with the existing SCADA master station will be the responsibility of the Contractor.
- The Contractor shall supply a complete and detailed communication architecture block diagram at tender stage, indicating the configuration of the RTU, Ethernet Switch with connected IEDs, Gateway and any other hardware that will be applicable to the installation.
- The supply, installation, cabling and configuration of complete SCADA RTU/Gateway, that forms part of an integrated substation protection and control system based on the IEC61850 protocol.
- Supply and installation of all IED to IED and RTU/Gateway network and communication equipment, all of which shall be DC powered from the station DC.
- The supply of all diagnostic and configuration software and licenses for the RTU/Gateway system shall be included in the offer.
- The provision of training to City Power SCADA technicians (12) in the use of all related software and system configuration shall be included in the offer.
- Supply and installation of all multicore and network cabling between the RTU/Gateway and Protection schemes devices.
- Factory acceptance testing of RTU/Gateway to Master station interface, confirmation of data quality flag support, time tagging support and overall control execution response time.
- SCADA software, configuration systems and software engineering shall be included within the scope of this specification.
- All protection relay and SCADA configuration, programming and settings application will be the responsibility of the Contractor. The Contractor shall be responsible for the configuration of all aspects of the offered equipment.
- The complete commissioning of all SCADA signals within the substation shall be included in the scope of the contract.

- Final end-to-end commissioning of the substation SCADA system to the City Power Master station shall be included and will be done in conjunction with City Power engineers and technicians.
- If required by City Power, any redundant/abandoned equipment shall be decommissioned, removed, loaded, transported and off-loaded at the City Power salvage yard or as specified by City Power.
- Wiring and cabling shall be allowed for all hardwired, potential free contacts and analogue transducers to the field terminal blocks in the RTU/Gateway cabinet, as well as network cabling from the IEDs to the RTU/Gateway.
- Testing will include the RTU/Gateway to the Master station interface, confirmation of time tagging support, data quality flag support and overall control execution response time.
- The Master station configuration will remain the responsibility of City Power, based on the configuration information provided by the contractor. The RTU/Gateway database must conform to the Master Station template.
- The contractor will be responsible and expected to modify Protection scheme circuits where I/O's are unavailable. This will include the installation of analogue transducers and CTs, should these not exist in the existing bay equipment, as well as micro switches where digital contacts are required. City Power shall approve all the proposed circuit modifications before installation can commence.
- As built drawings (hard and soft copies) of all commissioned panels shall be submitted to City Power within a month after the completion of the project.
- In the event where City Power did not supply the contractor with the old drawings prior to the project, the successful Tenderer / Contractor shall be expected to produce as-built drawings of the existing and new circuits.
- RTU / Gateway should have integrated software intelligent tool to force system point database to Control Centre without affecting normal operation of the plant.
- Contractor shall supply and install 10 pair armoured cable to all transformer Junction Cubicle (in the yard) per substation, for future Online Gas Monitoring System.
- All I/O modules shall have LEDs to view the status of the module, active indications/alarms and control pulse signal.

5. REQUIREMENTS

5.1 General Requirements

This standard specifies requirements for City Power's SCADA substation equipment. The said equipment shall be suitable for a combination of Inputs and Outputs such as hardwiring, serial and Ethernet as well as network based communication between IEDs for newer equipment, bays and the RTU/Gateway.

Communication and interfacing between the RTU and existing/older plant equipment shall be hardwired. The hardwiring shall make provision for all required Inputs and Outputs that includes Digital Inputs, Analogue Inputs, Accumulator Inputs as well as Digital Outputs. IEDs shall be interfaced to an IED interface module in the RTU, or an Ethernet switch that is connected to a gateway using the IEC61850 Protocol. Annexure A lists required Inputs and Outputs for different equipment and bays.

Equipment installation shall meet City Power's communication and functional requirements, and shall conform to industry standards as referenced in this document.

Equipment to be supplied shall comprise of the following:

- 4.1.1 Remote Terminal Units (RTUs).
- 4.1.2 Gateways.
- 4.1.3 Ethernet switches (industrial).
- 4.1.4 Peripheral equipment such as power supplies, cabinets, cabling, etc.

Implementation of the purchase equipment shall include and not be limited to minimum configuration of a stand-alone RTU/Gateway, interfacing the plant with a complete SCADA system via dedicated I/O cards, interfacing the plant with other secondary equipment via hardwired connectivity as well as network based (Ethernet) communication between Protection schemes (IEDs) and the RTU/Gateway cabinet using the SANS 61870 and SANS 61850 Protocols.

Integration and operation of the SCADA system with the substation's equipment shall be facilitated via RTU/Gateway. The system shall be capable of supervising hardwired functions as well as Ethernet based network communications. The functions shall include but not be limited to monitoring and control of equipment such as transformers, feeder bay equipment, fire detection, Load Management / Ripple control, optical fibre, battery chargers and AC changeover systems.

The RTU/Gateway and its accessories shall be supplied within its own steel cabinet. All hardwired functionalities shall be connected to the RTU/Gateway I/O modules through rail mounted field terminals. Connections for I/O modules shall be provided to allow future expansion and enable testing. The RTU/gateway shall have additional network ports to make provision for additional IEDs in the near future.

Additional protocol converters shall not form part of the SCADA network, only the gateway shall be used to interface with the SCADA system.

Should the main contractor choose to subcontract the SCADA System and all associated services, the main contractor shall remain responsible for the overall provision of all SCADA functionality as specified.

Data required for auto sequences and interlocking shall be available in the compliant device.

An interface between the IEC61850 infrastructure and the legacy IEDs shall be made available. The interface shall be used for engineering access and it shall in no way interfere with the protection and control system.

Interfaces between the compliant and non-compliant devices shall be hardwired in the interest of a single protocol solution. No non IEC61850 compliant interfaces between IEDs shall be accepted. Extended I/O either in the form of additional cards on a bus or a discreet device is not considered an IED for the single protocol purpose.

Fibre switches shall comply with the following specification: Dual redundant 48VDC rated power supplies, IEEE P1613 Environmental Standard for Electric Power Substations, IEC61850-3, temperature range up to 55°C, fast recovery.

RTU software required for administrating and changing the supplied IED configuration and settings shall be freely available from the OEM. All present and future revisions shall be freely available for download from the OEM website.

Conformance to the standard, as set out in standard IEC 61850 Part 10: Conformance Testing shall be proven by means of an independent auditor, proof of which is to be submitted with the tender.

The RTU shall support at least four simultaneous sessions to be active in order to support the dual redundant automation-oriented S-LAN, a maintenance engineering session and another session for such functions as statistical metering archival or other automated data collection function.

The RTUs (and therefore the Substation-LAN or S-LAN) shall operate on at least a fast-Ethernet link (i.e. 100Mbps).

Any protection device offered as part of the project that does not comply with the IEC 61850 standard shall not be accepted.

Each protection IED and each control IED shall provide one hardwired output contact, wired to the RTU or gateway to indicate a protection failure alarm in the event of the IED device failing or an MCB trip rendering the protection system inoperable. The protection fail alarm contacts of the different IEDs shall be wired in a fail safe manner as a series connection of normally closed contacts. Provision shall be made for a second hardwired, potential free, protection operated alarm (breaker tripped) contact from each bay IED, to the RTU or gateway.

Communications between IEDs and the gateway shall be by means of electrical or optical Ethernet networks using industrial grade switches or hubs (where applicable). Supply of all plant-side communication equipment is the responsibility of the Contractor.

The RTU or gateway shall communicate with the IEDs by addressing each IED on an individual and polled basis – that is, the system shall poll each IED as if it were a discrete module. This enables the RTU or gateway to apply quality flags to the data elements derived from an individual IED – should the unit fail or communication to the unit fail, the data shall be marked as off-line within the RTU or gateway real-time database and communicated as such to the master station.

To cater for the failure mode where the relay detects an internal fault, but is still able to communicate with the RTU/gateway - such failure status may be communicated to the RTU/gateway provided that all other potentially corrupt data from the IED is flagged as 'off-line' and communicated as such to the master station. Alternatively, if the IED detects an internal fault, it may be programmed to halt all communications to the RTU/gateway, whereupon the RTU/gateway shall mark the data as indeterminate, generate an 'IED faulty' alarm and communicate such to the master station.

Full support for data quality flags is required to ensure that indeterminate states are reported as such, and no possibility exists of communicating stale data to the SCADA master station as a result of the failure of a system component or the communication network.

5.2 Substation SCADA System Communication Architecture Requirements

The equipment installed at the various substations are different and therefore the communication architecture of the local SCADA system will vary and can be categorized as follows:

- Ethernet Communication
- Hard Wired Communication
- A combination of Ethernet and Hard Wired

5.2.1 Ethernet

Substations that have IEDs installed with Ethernet communication ports make the communication between the IEDs and SCADA system easily achievable. All the IEDs within the substation are connected to a managed switch which forms the Ethernet bus. The Ethernet bus is then connected to the RTU/Gateway where the data is stored, processed, managed and sent to the Master Station SCADA system.

5.2.2 Hard Wired

Substations that have electromechanical relays or IEDs without a communication port will be hard wired. The hard-wired communication philosophy provides for a physically hard-wired connection to an I/O Module. This is achieved with the use of multicore copper cables, to transmit signals from the switchgear / IEDs to the I/O module which is linked to the local SCADA system.

5.2.3 A combination of Ethernet and Hard Wired

Substations that have a combination of IEDs installed with Ethernet ports and electromechanical relays or IEDs without Ethernet ports will have a combination of Ethernet and Hard Wired communication architecture.

5.3 SCADA Component Requirements

The main components of the substation SCADA system shall be as follows:

5.2.1 Remote Terminal Unit (RTU)

The RTU, forms an interface between the electrical plants within the substation using both digital and analogue inputs. Information becomes transferrable to and from the master station using available protocol. The RTUs also provides for control outputs to switch plant equipment such as circuit breakers. The RTUs should be equipped with network ports for direct interfacing with Intelligent Electronic Devices (IEDs) such as protection relays. Older RTUs might not be equipped with network communication ports and a separate gateway shall be used for interfacing with IEDs.

5.2.2 Gateway

The Gateway shall have the capability of monitoring plant and equipment on a real-time basis. In addition, the Gateway shall have the capability of interfacing to protection relaying schemes or IEDs.

In substations where hardwired equipment is combined with network based equipment, and the RTU is not capable of interfacing directly with IEDs, a separate gateway shall be used. The gateway shall make provision for future basic hardwired inputs and outputs.

The gateway shall use the IEC61850 protocol for communicating with IEDs (through the Ethernet switch) and shall use the IEC60870-5-101 and IEC60870-5-104 protocol to communicate to the master station.

5.2.3 Communication Network

The communication network connects the SCADA master station to all RTUs and gateways in the City Power network. Communication to the master station shall be via two dual redundant standard, multi-dropped, serial communication channels, either RS232 over fibre/copper or RS232 to voice frequency (TETRA). IEC 61850 and IEC60870-5-104 protocol shall be used for communication between the SCADA Master Station and the different devices.

5.3 RTU Design and layout requirement

5.3.1. RTU Cabinet

City Power's standard specifies that the cabinets housing the 19-inch equipment racks shall be floor-mounted units. The cabinets shall have upper and lower gland plates to allow top and bottom cable access. These gland plates shall be interchangeable and shall have holes drilled for 20 mm cable glands. Each hole shall be closed with a suitable, removable plastic or rubber cover.

Doors shall have top and bottom louvers, which shall be covered on the inside of the door with, wire gauze. The doors shall be removable by lifting them off the hinges. The spindle of the bottom hinge shall be longer than the spindles of the middle and upper hinges to allow easy re-installation of the door. The doors shall have dust proof seals around the perimeter.

This cubicle and the components required (terminals, trunking, MCCBs and etc.) are to be supplied as part of this contract. The cubicle shall match those supplied under this contract for the protection and control equipment.

Two 16A 230VAC standard plug sockets with isolating/protection MCCB shall be fitted to the interior of the panel and connected to the building AC plug circuit included with the earth leakage system in the LV AC board.

The SCADA cubicle shall be equipped with a light bulb that shall be triggered by door open (Light ON), door close (Light OFF).

All cabinets shall permit easy access to the cable looms and plant interface connectors and shall be painted light grey and shall conform to colour RLA 7032 (Pebble Grey). The following enclosure options shall be offered:

- 5.3.1.1. A standard fixed frame cabinet with front and rear doors.
- 5.3.1.2. Width: 600 mm x1200mm swing frame cabinet.
- 5.3.1.3. Depth: 600 mm not including doors.
- 5.3.1.4. Height: 2100 mm overall, including 100 mm plinth.
- 5.3.1.5. These cabinets shall have front and rear access.

5.3.2. Cabinet racks

Three (3) types of racks shall be **provided** for as follows:

A single 19 inch sub rack with a preferred height of 7U (or less). The complete rack shall be mounted into the 19-inch floor or wall mount cabinet as a stand-alone unit.

A single 19 inch signal termination card sub rack shall have a preferred height of 4U (or less).

A single 19 inch sub rack shall have a preferred height of 11U (or less), comprising of 7U and 4U sub racks.

5.3.3. Terminating blocks, connectors and cables

Each connector and terminating block shall be clearly marked using a unique identification method accordance with the circuit diagram and/or logic diagram for hardwired Inputs and Outputs,

A mechanism shall be provided to logically group and route all I/O functions for suitable high-density termination connectors. All connectors used shall be terminated using mass termination techniques. Where possible, all plant-to-equipment connections shall be connected by use of cabling.

The field terminals shall be vertically rail mounted and disconnecting type with means for isolating plant from the RTU and prevent electrical shock in cases of power being down on one end, yet fed from the other end.

Field terminals shall be provided for each core of all field cables. The number of field cables, including the number of all cores, shall be provided by City Power at time of order. The individual cores of a field cable shall be terminated in a row of adjacent terminals.

The cable that shall be used shall be 1.5mm² Copper Multicore cables. The number of cores shall be determined by the IO count, and shall be rounded up to the next standard core number. Standard Multicore cables shall be one of the following:

- 4.3.3.1 4-Core
- 4.3.3.2 12-Core
- 4.3.3.3 19-Core
- 4.3.3.4 27-Core

Cable cores shall be individually numbered (printed on each core by the manufacturer) starting at 1.

Adequate means of support for field cables shall be provided. This shall typically be a section of cable ladder/tray/ducting to which the field cables can be tied for support. Cables shall enter the cabinet from the bottom. Provision shall be made for both top and bottom entry in accordance with City Power's specification.

Space with a minimum label width of 9 mm shall be allocated between sections of terminals allocated to different cables to provide adequate space for labelling.

Wiring looms shall be provided between each RTU I/O module in the RTU cubicle and the field terminals. 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 shall terminate on consecutive RTU terminals (Krone Blocks). These shall be arranged and labelled according to the module position in the RTU cubicle. The cables from the field shall 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.

Field terminals shall be arranged in cable order, with individual cores from the same field cable arranged together. The number of field terminals shall match the number of cores of the cable. Spare cores shall be wired to the bottom of the field terminal strip for each cable group such that future allocation to any point on the field terminal strip is possible. In this case, the terminals shall also be of the disconnect type.

A space of at least 50mm shall be provided between the cable ducts or cable ladder and the field terminals.

The field terminals shall be sized in such a way to accommodate cable core sizes of up to 2.5mm².

The duct size shall be large enough to hold all the cables permitting the duct lid to be fitted when cables are installed should ducting be provided to locating cables.

All analogue connectors that interface to transducer outputs shall permit in-circuit measurement of current, without disconnecting of any associated wiring.

5.3.4. Analogue Transducers

Where analogue signals are required, these signals shall be transmitted from field transducers. These transducers shall have standard output ranges of the following:

- 5.1.3.1 0 to 5mA
- 5.1.3.2 0 to ± 5 mA (Bipolar Input, typical for power flow direction)
- 5.1.3.3 0 to 20mA

5.1.3.4 4 to 20mA (For critical analogue values)

Analogue signals shall typically be applied for the following: Phase current magnitudes (R-W-B),
Bus bar Voltage (V), Apparent Power (VA, MVA), Real Power (W, MW), Reactive
Power (VAR, MVAR), Frequency (Hz) and Power Factor.

Where transducers do not exist, it shall be the responsibility of the Contractor to issue (as per bill of quantities quote) and install transducers as per City Power specification.

5.3.5. Dummy relay

A Dummy relay shall be installed in the RTU for testing purposes. The relay coil shall be activated from the Digital Output module, and the relay contact shall be wired to the Digital Input module. This shall purely be used for communication testing between the master station and the RTU.

5.3.6. CPU Module

The RTU shall be microprocessor based. it shall be designed to operate without manual intervention when powered up. It shall auto restart and 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 that is capable of remote interrogation including diagnostics for memory and bus errors, buffer overflows, local software routine health, communication ports status, input/output and 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 be equipped with sufficient 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 shall 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 1ms. It shall have the capability of time stamping events. The RTU clock is normally synchronised by the master station 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 +/-1ms.

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 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.

5.4 Battery Charger, Batteries and DC Supply

The DC Power Supply shall not result in equipment malfunctioning as a result of the following; loss or restoration of supply, under voltage or over voltage condition, either AC or DC supplies to the unit being switched "off" and "on" repeatedly at a random rate and short interruptions on any of the power supply voltages for not longer than 20ms occurring in a random sequence for a period of no longer than 20 seconds.

The power supplies shall also have the necessary current overload cut-outs and over voltage limiting, with automatic reset on removal of the fault.

Each unit shall include a power supply-isolating switch. Miniature circuit breakers are preferred in place of fuses.

An LED indication, with a check facility, shall be provided to indicate a supply healthy condition for all internal supply voltages.

The design shall allow for three isolated power sources, which shall supply the electronic logic circuitry, the output and the input circuitry. In addition the design shall provide a floating power supply regardless of any earthlin which may exist on the DC supply rails.

If the RTU/Gateway is supplied from a DC source the noise measured across the power supply terminals of the equipment under test shall not be greater than 2mV peak-to-peak or -58dBv (0dBv = 0.775V) measured.

5.5 Gateway Equipment

The gateway shall facilitate integration between the substation secondary plant and master station should an RTU not be able to perform the function. The gateway device shall also be capable of supervising a limited number of traditional hardwired functions, for the purpose of monitoring and controlling non-intelligent devices such as Load Management (ripple control), transformer gas monitoring, optical fibre, fire detection, battery charging and changeover systems. In the presence of a capable RTU, these hardwired inputs and outputs shall be done via the RTU, but the gateway shall make provision for future hardwired connections. The number of additional hardwired inputs and outputs, (independent of dedicated IEDs) comprising digital inputs, control outputs and analogue inputs, (0-5mA, -5-5mA, 0-20mA and 4-20mA) for connection to non-intelligent devices, is nominally estimated to be 32 Digital inputs, 8 Control outputs and 8 analogue inputs and shall be included as such in the price schedule.

The gateway device shall be powered from the station DC, which is functionally equivalent to providing an independent DC power supply system for the monitoring and control components of the substation. The supply shall be directly from the DC distribution board via dedicated MCCBs. No solutions requiring standalone UPS systems shall be accepted.

The SCADA gateway equipment shall be supplied within its own steel cabinet in the absence of an RTU cabinet, containing all equipment racks, IED communication equipment and the hardware and cabling required to support hard wired signals from auxiliary equipment. All hardwired functions shall be connected to the gateway input / output modules through rail mounted disconnect terminals, with facility to connect to I/O modules without restriction at a future date, and to enable testing of these functions.

No commercial PC based solutions shall be accepted. The Gateway equipment shall have a design life expectancy and vendor support term at least equal to that of the protection devices offered, and if based on a PC platform, shall be of the diskless variety and of industrial grade.

Gateway Configuration

The gateway configuration shall be the Contractor's responsibility. The point lists for both IEDs and hard-wired functions are to be presented by the Contractor and subsequently approved by City Power SCADA Branch.

Resulting point lists shall be agreed as the functional specification for SCADA, at the time of factory acceptance testing, and shall only be accepted for Master Station configuration purposes after all protection logic and auto changeover functionality has been programmed, tested and the software configuration frozen for all IEDs at the substation.

5.6 Master Station

The SCADA master station provides electrical operators with facilities to remotely monitor and control electrical plant in the network. The master station is configured, maintained and operated purely by City Power.

Redundant front end processors are used at the Master station, and redundant communication channels are standard to all substation Gateways. Gateways are therefore required to support redundant communication channels on a dual basis, (On both simultaneously) to more than one host Master Station. The complete integrated substation control solution shall interface directly with the existing Master Station, without the need for additional protocol converters in the data chain. The system shall interface to the Master Station using City power's fibre network as to IEC 61850.

Configuration changes which include software and firmware upgrade or downgrades required to ensure equipment's functionality shall be done remotely or in the equipment supplied, at no additional cost to City Power.

The system shall be capable of defining, and transmitting the relevant subsets of plant data (points), using the specified protocols, to the Master station. The RTU's or Gateway device shall be capable of filtering the data sent to SCADA, to avoid communication bottlenecks.

Double bit indications are used to determine the status of all primary plant switching devices. Single bit circuit breaker or isolator status indications are not supported and shall not be accepted.

The scope does not include Master Station engineering and integration.

5.7 Monitoring Requirements

5.7.1. General Requirements

The RTU/Gateway shall provide on-line monitoring of the status and operation of substation plant and equipment. The data, which is captured by the RTU/Gateway, shall be used to provide the basis for an on-line diagnostics and condition monitoring facility. The data captured shall also be packaged by the RTU/Gateway for transmission to the SCADA master station. The RTU/Gateway shall capture the status of measured data, and the sequencing of event data from protection schemes.

5.7.2. Digital Alarms

Digital input "alarms" shall be monitored and reported based on their individual or group priority. The individual alarm priorities shall be software defined at both the individual and group level.

5.7.3. Pseudo Variables

The logical grouping of inputs shall be unrestricted. It shall be possible to assign some or all of these groups to logical pseudo-variables which shall be processed as any other digital input. Pseudo-Variables shall be derived by means of Boolean operations performed on discrete digital inputs to provide a single output quantity.

5.7.4. Analogue Windows

Software configurable "moving window" analogue monitoring techniques shall be applied to all analogue inputs and pseudo-analogue values. The "moving window" concept implies that an analogue change shall not be reported or flagged as a change unless it exceeds a predefined "window". This "window" consists of an upper and lower limit around the current value of any analogue. The "window" shall remain static and shall only move to the new analogue value once the change has been reported.

5.7.5. Analogue Reporting

Analogue changes shall be reported under the following conditions:

When the analogue input exceeds the "window".

When the analogue input exceeds a predefined upper maximum or lower minimum limits. These limits are defined as high, high-high, low and low-low values.

5.8 Controlling Plant

A control sequence from a SCADA master station or HMI Client/Server to the RTU/Gateway, which has not been configured to provide the interlocking function, shall be performed as follows:

Upon receipt of the "Select and execute" message, the RTU/Gateway shall select the appropriate control output relay. After checking that the correct relay has been selected, it shall execute the control by applying a voltage to the control output relay.

Upon successful operation of the output relay, the RTU/Gateway shall send an "Execute Confirm" message to the master, in addition to the change of state message from the controlled device.

If the control operation failed, the RTU/Gateway shall send an "Execute Fail" message to the SCADA master station, as applicable.

5.9 System Performance

5.9.1. IEC 60870-5-101/104 Point Mapping Convention and Protocol Compatibility

The best match between the point-mapping scheme of the IEC60870-5-101/104 protocol used between the gateway and Master station and the point-mapping scheme of the IED to gateway shall be sought.

The hardwired points shall be interfaced to the Gateway by a conventional I/O module that uses one of the following open, standardised protocol interfaces, namely IEC 61850 or IEC 60870-5-103. Proprietary protocols between the Gateway and the I/O module shall not be accepted for this project.

It is important to distinguish between the level of resolution of data required by the SCADA system and that of the maintenance engineering system. Every data point which has a bearing on any engineering fault-finding or maintenance function shall be recorded in a time-stamped sequence of events recorder, including such items as over-current element pickups, communication link retries, etc, but only pertinent

plant status such as primary plant main and auxiliary statuses and secondary equipment alarms are to be provided to the SCADA system.

5.9.2. Time Tagging

Full support for time tagging of events to a resolution of at least 10 milliseconds, where the Master station provides time synchronization through the protocol to the gateway, and on to the IEDs shall be provided. Time-tagging applies only to the digital inputs defined as such in Annexure A.

5.9.3. Overall System Response Time

The system response time for a breaker control to be executed from the Master Station to the resulting change of state of the breaker being registered in the gateway's real time database and communicated to the Master Station shall not be more than 5 seconds. As it is the gateway that controls the polling cycles, every effort shall be made to configure the gateway to request for state changes immediately following the execution of a control.

5.9.4. Plant to IED Addressing Scheme

Where the IEDs are of the modular type that can be unplugged and swapped, a facility shall be provided to prevent the IED address, and corresponding device tags from following the IED to a different switch bay position. The device address in such cases shall be programmed into the IED frame and not the removable module to prevent misrepresentation of switchgear status on SCADA (Bay swapping issue). Alternative interlock schemes to prevent this from happening shall be considered.

6. Testing and Acceptance

6.1 Testing

After the Contractor has completed each module (object) during the System Implementation Stage, the Contractor shall carry out system tests on that module at the Contractor's works. The City Power may elect to witness such tests. These tests would constitute informal factory acceptance tests.

This will imply that the Contractor shall make available an RTU/Gateway and an IEC 60870-5-101/104 simulator to City Power for use in system testing directly connected to SCADA Master station. However, it shall be the responsibility of the Contractor to provide all equipment required to measure system performance. The Contractor must meet the following system performance requirements:

LCP (Local Control Panel) Performance Requirements

FUNCTION	MAXIMUM RESPONSE TIME (seconds)
Display Update	1
Detection and annunciation of an alarm	2

Analogue updates	4
Status indications update	3
Counter updates	30

The Contractor shall specify the methodology to measure and perform the above test.

Performance requirements are specified for the following RTU/Gateway configuration:

- 32 double control outputs.
- 192 digital inputs.
- 24 analogue inputs.
- 24 accumulator inputs.
- All monitoring functions fully operational.
- All control and data acquisition functions full operational.

The following RTU/Gateway test conditions shall apply:

- When no changes occur at any of the above digital, analogue or accumulator inputs.
- When a continuous change of state occurs simultaneously at 30% of the above digital, analogue and accumulator inputs.
- When a continuous change of state occurs simultaneously at 60% of the above digital, analogue and accumulator inputs.

6.2 Factory Acceptance Test (FAT)

After the Contractor is satisfied with the correct functioning of the prototype equipment, City Power shall be notified in writing. Within a two (2) week period from the date of this letter, and then City Power and the Contractor shall agree upon a date when formal factory acceptance testing shall commence. The testing shall then be carried out in accordance with the FAT procedure.

In the event of any tests malfunctioning, City Power may elect to restart the complete test procedure from the beginning. City Power shall also carry out an unstructured testing program (Free-Form-Tests), at its discretion, on the Contractor's premises for duration of two (2) weeks. The Contractor shall, at no extra charge to City Power, correct any errors detected. This two week period shall not include the time taken to repair any faults. After City Power has satisfied

itself that the system has passed the prescribed tests, the prototype units shall be officially handed over to City Power.

6.3 Site acceptance Test (SAT)

After delivery of the production unit to a City Power selected site, the Contractor assisted by City Power shall install the equipment in a substation in accordance with City Power's standards. City Power must be informed in writing of the completion of the installation. Within a three (3) week period or less, the SAT shall commence. These formal tests shall be defined in the SAT procedure. In the event of an error being detected, City Power may elect to restart the SAT.

For a period of one (1) month after the successful completion of the formal SAT the equipment shall undergo random testing while being subjected to a soak test. In the event of any non-conformance being detected the Contractor shall be required to commence the correction of the errors within a 48-hour period. Only on completion of the correction procedure shall the one-month test and soak test period commence.

Depending on the nature of the fault, City Power may at its sole discretion elect to restart the SAT. During this SAT the Contractor shall make available at no extra charge to City Power, the relevant hardware, software and/or system specialist.

6.4 General

All equipment shall be subjected to the Contractor's standard works test and inspection.

The equipment under test shall be switched on and allowed to soak (burn in) for 48 hours before the type tests are started.

A representative single sample of all types of equipment supplied shall be subjected to type tests which shall be continued for at least 10 hours at the extreme conditions specified by City Power standard.

6.5 Witnessing of Tests

City Power reserves the right to appoint a representative to inspect the equipment at any stage of manufacture or to be present at the specified tests.

The Contractor shall ascertain in writing whether inspection or witnessed tests, or both, are required. The Contractor shall then give City Power not less than seven (7) working days' notice in the case of local manufacture, and fourteen (14) working days' notice in the case of foreign manufacture, of when the equipment shall be ready for inspection or the witnessing of tests.

6.6 Routine Tests

All equipment shall be subjected to a routine test by the Contractor and which shall include the following tests:

- Each digital input shall be checked for correct operation. (No voltage changes outside the relevant range shall be detected).
- All control output points shall be fully tested for correct operation.
- Accumulator/counters inputs shall be tested for correct registration of input pulses.
- Accuracy of the measure and inputs and outputs shall be tested to 0, 25%, 50%, 75% and 100% of full scale in both directions.
- Alarm conditions, such as communications failure, power failure, etc., shall be simulated and all alarm, indication and discrepancy outputs specified shall be checked for correct operation. (For example the ARC operation).
- Each digital input shall be tested for spurious operation by applying an input pulse of 10 milliseconds to each input.
- A fleeting contact of 10ms duration shall be applied to each digital input in turn and the correct registration of this input shall be checked.
- The power supply to the equipment shall be interrupted for 100ms and the equipment shall be checked for false outputs and/or false presentation of inputs.
- The input voltage to the equipment power supply shall be varied between the operational limits specified in the specification and the output voltage regulation checked. The operation of any under voltage protection devices fitted should be checked.

All the tests mentioned above shall be successfully completed before the equipment is dispatched to City Power. Copies of the routine test certificates shall accompany the equipment.

7. Documentation

7.1 Drawings

Drawings shall be submitted in English and shall form an essential part of the contract.

Schematic diagrams shall be drawn and conform to the layout listed below. The schematics shall have a logical data flow left to right, and top to bottom. This implies that all inputs to the schematic are on the left-hand side of the page, and outputs on the right hand side. Inputs from

and outputs to other schematic pages are to be referenced accordingly. Logic symbols should be drawn such that inputs are on the left (or top) and outputs to the right (or bottom).

Duplicate copies of a schedule listing all drawings and circuit diagrams applicable to all equipment included in the contract, shall be supplied with or before the notification of readiness for acceptance testing.

The drawing package shall include at least the following:

- Block schematic diagrams showing the functional arrangement of the equipment.
- Detailed schematic diagrams.
- Functional drawing showing the overall operation of the equipment.
- Cabinet equipment layout.
- Module sub rack and cabinet wiring diagram including functions and designations of the terminal blocks.
- Details of terminals and terminal blocks.
- Outline dimensions of cabinets and fixing details.
- Bill of material for each cubicle plate.

Detailed drawings of all equipment shall be supplied not later than the notification of the first item of equipment readiness for Factory Acceptance Testing (FAT). The drawings shall not be submitted as separate drawings but shall be incorporated in the instruction manuals.

When changes to the equipment are envisaged, either by the Contractor or City Power, during the contract period, the Contractor shall submit details of these changes in writing together with modified drawings for City Power's approval, before proceeding with the implementation of these changes. A transparency or microfilm shall be supplied for each new drawing approved.

Drawings shall also be submitted in electronic form which will include DXF, DWG and PDF formats. The contractor shall ensure that the drawings are version controlled.

7.2 Instruction Manuals

Three (3) copies of the instruction manuals and related documentation shall be supplied, covering all equipment in the Contract, before the first items of equipment are dispatched to site.

Single sets of instruction manuals shall be made available as an option within the contract. The instruction book shall only cover the equipment variant supplied to City Power. Typical circuit

diagrams and descriptions are not acceptable in the instruction books. The diagrams shall correspond in exact detail with the equipment delivered.

The instruction books shall have a hard covered, ring file construction and they shall open flat at any page. Folders, which do not comply with these requirements, are not acceptable. Different sections of the handbooks shall be separated by means of thumb tab separators.

The equipment handbooks shall basically consist of the following sections:

- Index.
- Electrical and Mechanical specifications and parameters of the equipment.
- Basic description of the equipment and its operations.
- Basic mechanical designs of the equipment and the cabinet and inter sub rack wiring. Description, block schematic and wiring schematic of the complete equipment.
- Sub rack mechanical design and wiring.
- Individual Modules.
- Description, Parts layout, Electrical Schematic and Parts List.
- Installation, commissioning and maintenance procedures.

The instruction book shall contain a master key or block schematic, which shall clearly indicate the reference numbers of the individual detailed circuit diagrams against the appropriate blocks.

Block schematics of the complete equipment shall indicate clearly the interconnections between the various units. Wiring schematics with cable harnesses are not acceptable for this purpose.

The individual module description shall contain a written description of the operation of the module, the module test and commissioning procedures where applicable as well as the technical ratings of the unit. This shall be followed by the module schematic, the component layout and a component list giving the component values, rating, tolerance and manufacturer. The module schematic shall detail the nominal DC and AC voltages on the semiconductor devices. The function of various input and output points shall be given on the schematic.

All handbook drawings and descriptions shall conform to the international A4 series (295 x 220 mm). Larger drawings which cannot be accommodated on this size of drawing shall be folded in a single plane, along the 220 mm axis of the standard A4 series. Handbook drawings, which must be unfolded in two directions, are not acceptable.

In the event of any changes being made to the equipment, as detailed in the Documentation Section, three (3) sets of drawings and descriptions, if applicable, shall be provided to update the equipment handbooks.

7.3 Delivery of Drawings, Handbooks and Test Certificates

All drawings and handbooks shall be delivered to: The SCADA Manager, SCADA DEPARTMENT, 40 HERONMERE ROAD, BOOYSENS.

One copy of all routine test reports and one copy of the type test reports shall be sent to the above address as well.

All correspondence relating to equipment supplied shall be headed with the Project Contract number allocated by City Power. All technical inquiries shall be addressed to the SCADA Manager at the above address, and all commercial enquiries shall be addressed to The Procurement Advisor/Manager, City Power, P.O. Box 38766, Booysens, 2016.

Drawing and instruction manuals form an essential part of the Contract Works. No payment shall be made for any equipment supplied as part of the Contract Works until all drawings and handbooks have been supplied in accordance with the requirements detailed in the Contract.

8. Training

The Contractor shall provide training courses conducted in South Africa or Abroad. the training shall be given to at-least 12 City Power technicians/Engineers.

The training shall be targeted at three different user groups, and shall therefore be divided into three categories:

- System overview and operations guide:

The system overview shall provide an overall understanding of the system and its capabilities and limitations. In addition, system configuration must be covered in such a way that the user shall understand how to construct a system from the building blocks to meet his/her requirements.

- System configuration and system maintenance training:

This training would include computer system operation, hardware maintenance, computer Contractor software and relevant operating system aspects.

- Detailed system training on all hardware and software aspects:

It is intended that any person attending this course shall be in a position to maintain the system down to printed circuit board and/or component level.

All aspects of the training shall be supplemented with periods of practical training; this shall apply to all courses and be implemented where applicable.

All training shall be given directly through the medium of English.

City Power shall give the Contractor at least one (1) month prior notice before any training course is scheduled.

The Contractor shall provide the following information:

- Location of training centre in South Africa or Abroad.
- Duration of training course(s).
- Syllabus of training courses(s).
- Entrance or qualification requirements (basic knowledge required) for trainees.
- The preferred number of candidates per course.
- If training is outside South Africa, flight and accommodation costs shall be included.

The Contractor's quotation for training shall include the cost of tuition and documentation.

The tenderer shall quote separately as an option the cost of subsequent training courses during a period of five (5) years from start of the supply contract.

9. QUALITY MANAGEMENT

A quality management system shall be set up in order to assure the quality of RTU's and Gateways during design, development, production and servicing. Guidance on the requirements for a quality management system may be found in the following standards: ISO 9001. The details shall be subject to agreement between the purchaser and supplier.

10. HEALTH AND SAFETY

A health and safety plan shall be set up in order to ensure proper management and compliance of RTU's and Gateways during installation, operation, maintenance, and decommissioning phases. Guidance on the requirements of a health and safety plan may be found in OHSAS 18001 standards. This is to ensure that the asset conforms to standard operating procedures and City Power SHERQ Policy. The details shall be subject to agreement between City Power and the Supplier.

11. ENVIRONMENTAL MANAGEMENT

An environmental management plan shall be set up in order to ensure the proper environmental management and compliance of RTU's and Gateways during their entire life cycle (i.e. during design, development, production, installation, operation and maintenance, decommissioning as well as disposal phases). Guidance on the requirements for an environmental management system may be found in ISO 14001 standards. The details shall be subject to agreement between City Power and the Supplier. This is to ensure that the asset created conforms to environmental standards and City Power SHEQ Policy.

**SCOPE OF WORK FOR SUPPLY, INSTALLATION AND
COMMISSIONING OF SCADA RTU's AND
GATEWAYS**

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Appendix A

Basic SCADA Input and Output Functions

BASIC INPUT AND OUTPUT SCADA FUNCTIONS					
Function	Incomers / Feeders	Transformers	Bus Sections and Couplers	Busbars	Substation
ACCUMULATOR INPUTS					
Check Metering pulse Export MVARh	X				
Check Metering Pulse Export MWh	X				
Check Metering Pulse Import MVARh	X				
Check Metering Pulse Import MWh	X				
Eskom Meter Reset (Clock Signal)	X				
Main Metering Pulse Export MVARh	X				
Main Metering Pulse Export MWh	X				
Main Metering Pulse Import MVARh	X				
Main Metering Pulse Import MWh	X				
Power Usage Pulsing Signal (MWh)	X				
ANALOGUE INPUTS					
Ambient Air Temperature - Return					X
Ambient Air Temperature in Deg Celcius					X
Apparent Power - Return	X	X			
Apparent Power in MVA	X	X			
Eskom Real Power Supply - Return	X				
Eskom Real Power Supply in MW	X				
Frequency from Eskom in Hz	X				
Frequency from Eskom - Return	X				

Function	Incomers / Feeders	Transformers	Bus Sections and Couplers	Busbars	Substation
Frequency in Hz				X	
Frequency - Return				X	
Harmonic level				X	
Harmonic level - Return				X	
Oil temperature		X			
Oil temperature - Return		X			
Phase A Current in A	X	X	X		
Phase A Current - Return	X	X	X		
Phase B Current in A	X	X	X		
Phase B Current - Return	X	X	X		
Phase C Current in A	X	X	X		
Phase C Current - Return	X	X	X		
Phase A Voltage in V				X	
Phase A Voltage - Return				X	
Phase B Voltage in V				X	
Phase B Voltage - Return				X	
Phase C Voltage in V				X	
Phase C Voltage - Return				X	
Power Factor	X	X			
Power Factor - Return	X	X			
Reactive Power in MVAR	X	X			
Reactive Power - Return	X	X			
Real Power in MW	X	X			
Real Power - Return	X	X			
Sky brightness					X
Sky brightness - Return					X
Tap position indication		X			
Tap position indication - Return		X			

Function	Incomers / Feeders	Transformers	Bus Sections and Couplers	Busbars	Substation
Wind speed					X
Wind speed - Return					X
DIGITAL INPUTS					
110V Battery Charger Fail					X
110V Battery Earth Fault					X
110V Battery Low					X
110V DC/Battery Fail					X
220V Battery Charger Fail					X
220V Battery Earth Fault					X
220V Battery Low					X
220V DC/Battery Fail					X
48 V Battery Charger Non-Urgent Alarm					X
48 V Battery Charger Urgent Alarm					X
48V Battery Charger Fail					X
48V Battery Earth Fault					X
48V Battery Low					X
48V DC/Battery Fail					X
48V DC/Battery Fail					X
A.C. Supply Fail					X
A.C. Supply Fault					X
Alarm Panel Supply OFF					X
Auto Close Operated		X			
Auto Reclose Failure	X	X	X		
Auto Reclose Initiated	X	X	X		
Auto Reclose not Healthy	X	X	X		
Auxiliary Transformer Earth Fault		X			
AVR Fail		X			
AVR off Automatic		X			

Function	Incomers / Feeders	Transformers	Bus Sections and Couplers	Busbars	Substation
AVR Override ON		X			
Back-Up Protection Operated	X	X	X	X	
Buchholz Alarm (Main or Auxiliary)		X			
Buchholz Trip		X			
Busbar Fault				X	
Bushing Oil Pressure Low		X			
Buszone Protection Faulty				X	
Buszone Protection Operated				X	
Cable Basement Entry					X
Cable Earth Fault	X	X	X		
Cable Oil Pressure Low	X	X	X		
Carrier Received					X
Chamber Occupied					X
Circuitbreaker CLOSED	X	X	X		
Circuitbreaker Gas Pressure Low (SF6)	X	X	X		
Circuitbreaker Gas Pressure Minimum Level Reached (SF6)	X	X	X		
Circuitbreaker Gas Pressure Rising (SF6)	X	X	X		
Circuitbreaker OPEN	X	X	X		
Circuitbreaker Phase Discrepancy Operated	X	X	X	X	
Circuitbreaker Racked In	X	X			
Circuitbreaker Racked Out	X	X			
Circuitbreaker Trip Fail Timer Faulty	X	X	X	X	
Circuitbreaker Trip Failed	X	X	X		
Circuitbreakers Out of Step	X	X	X	X	
Compressor Excess Running Time					X
Compressor Fail					X
Control Room Entry					X
Cooler 1 Running		X			

Function	Incomers / Feeders	Transformers	Bus Sections and Couplers	Busbars	Substation
Cooler 2 Temperature Start		X			
Cooler not Available		X			
Coolers OFF		X			
D.C. fail on A.C. Changeover Panel					X
Dead Bar Trip Armed				X	
Differential Overcurrent		X			
Directional Earth Fault Operated	X		X		
Directional Overcurrent Operated	X		X		
Earth Switch Closed	X				
Earth Switch Open	X				
Emergency Load Reduction ON	X				
Emergency Load Shedding ON	X				
Eskom Auto Reclose Lockout	X				
Eskom Equipment Failure	X				
External 400V Supply Fail					X
Fibre Optic Battery Charger Fail					X
Fibre Optic DC Fail					X
Fibre Optic Non-Urgent					X
Fibre Optic Urgent					X
Fire Alarm					X
Fire Alarm (Building)					X
Fire Equipment Failure					X
Frame Relay Leakage Trip	X	X	X		
Freq. 1 Operated on U/F Relay 1				X	
Freq. 2 Operated on U/F Relay 1				X	
Freq. 3 Operated on U/F Relay 1				X	
General Alarm (Satellite)					X
General Alarm Operated					X

Function	Incomers / Feeders	Transformers	Bus Sections and Couplers	Busbars	Substation
High Load or 2nd Cooler Running		X			
High Set Overcurrent	X	X	X		
HV/LV Restricted Earth Fault		X		X	
Interlock Defeated	X	X	X	X	
Interlock Unit (PLC) Faulty	X	X	X		
Intertrip Received	X	X	X	X	
Intertrip Sent	X	X	X	X	
Intertrip Transmission Fail/Pilot Wire Fail	X				
Island Load Shedding	X				
Load Control (Ripple) Operated					X
Load Control (Ripple) Restore ON					X
Load Control Equipment Faulty					X
Load Control Watchdog Time Expired					X
Lockout 1 (Auto Reclose Lockout)	X	X	X	X	
Lockout 2 (Over Current, B/B or Emergency)	X	X	X	X	
Main Protection Operated	X	X	X	X	
Master Trip		X			
MCB Tripped	X	X	X		
Monitor Eskom Line OFF	X				
Monitor Eskom Line ON	X				
NEC Alarm		X			
Neutral Earth Fault Detected		X			
Non-Urgent Switchgear/Generator Operated	X	X	X		
Normal Load Reduction ON	X				
Oil & Winding Temperature High		X			
Oil Level Abnormal		X			
Oil Temperature High		X			
Oscillostore Triggered				X	

Function	Incomers / Feeders	Transformers	Bus Sections and Couplers	Busbars	Substation
Over Current or Earth Fault Trip	X	X	X		
Overcurrent Operated	X	X	X		
Perimeter Alarm					X
Phase Discrepancy	X	X	X	X	
Protection Equipment Failure	X	X	X	X	
Protection Power Supply					X
Protection Relay Comms Fail					X
Protection Urgent	X	X	X	X	
Radio Failure					X
Radio Switch Override ON	X	X	X		
Reverse Power Protection	X	X	X		
Standby Neutral Earth Fault Operated		X			
Standby Supply ON		X			
Station Intruder					X
Switchchamber Entry					X
Tank/Tap Change Overpressure Trip		X			
Tap Change Group A Selected		X			
Tap Change Group B Selected		X			
Tap Change Incomplete or Motor Fail		X			
Tap Change Mode (Follower)		X			
Tap Change Mode (Independent)		X			
Tap Change Mode (Master)		X			
Tap Change on Manual		X			
Tap change Supply Failure		X			
Tap Change Temperature High		X			
Tap Change Thermal Operated		X			
Tap Position Indication (Bit 1)		X			
Tap Position Indication (Bit 2)		X			

Function	Incomers / Feeders	Transformers	Bus Sections and Couplers	Busbars	Substation
Tap Position Indication (Bit 3)		X			
Tap Position Indication (Bit 4)		X			
Tap Position Indication (Bit 5)		X			
Temperature Trip		X			
Temperature/ Over Current Trip		X			
Tertiary Earth Fault		X			
Tertiary Overcurrent Operated		X			
Thermal Overload					X
Total Harmonic Distortion High				X	
Transformers Out of Step					X
Trip Circuit or Supply Faulty	X	X	X	X	
Trip Enable Received	X	X	X	X	
Trip Enable Transmission Fail	X				
Trip Inhibited	X	X	X	X	
Trip/Alarm Indication	X	X	X		
Under Frequency Trip Point Preselect				X	
Under Voltage Operated				X	
Under Voltage Stage 1 Trip	X	X	X	X	
Urgent Switchgear/Generator Operated	X	X	X		
Voltage Reduction ON		X			
Winding Temperature High		X			
Yard Entry					X
Yard Intruder					X
DIGITAL OUTPUTS					
Activate Emergency Load Reduction	X				
Activate Emergency Load Shedding	X				
Activate Selected Under Freq. Level				X	

Function	Incomers / Feeders	Transformers	Bus Sections and Couplers	Busbars	Substation
Activate Transformer Isolation		X			
Auto Reclose Re-Initiate	X	X	X		
AVR Override OFF		X			
AVR Override ON		X			
Charge Spring (Circuitbreaker)	X	X	X		
Check Synchronisation Override ON	X	X	X		
Circuitbreaker CLOSE	X	X	X		
Circuitbreaker TRIP	X	X	X		
Circuitbreaker Trip DISABLE	X	X	X		
Circuitbreaker Trip ENABLE	X	X	X		
De-Activate Emergency Load Reduction	X				
De-Activate Emergency Load Shedding	X				
Load Reduction OFF	X				
Load Reduction ON	X				
Lower Voltage		X			
Raise Voltage		X			
Reset General Alarm System					X
Select U/F Trip Level 0 - OFF				X	
Select U/F Trip Level 1 - HIGHEST FREQUENCY				X	
Select U/F Trip Level 2				X	
Select U/F Trip Level 3				X	
Select U/F Trip Level 4				X	
Select U/F Trip Level 5 - LOWEST FREQUENCY				X	
Start High Load Cooler		X			
Stop High Load Cooler		X			
Supervisory Control Alarm ON					X
Toggle Synchronism Mode	X	X			
Under Freq. Trip Point Select HIGH				X	

Function	Incomers / Feeders	Transformers	Bus Sections and Couplers	Busbars	Substation
Under Freq. Trip Point Select LOW				X	
Under Frequency Pre-Select ON				X	
Voltage Reduction OFF		X			
Voltage Reduction ON		X			

