

 Eskom	Standard	Technology
---	----------	------------

Title: **SEL-3555 SUBSTATION
GATEWAY COMMISSIONING
GUIDE**

Unique Identifier: **240-170000092**

Alternative Reference Number: **<n/a>**

Area of Applicability: **Engineering**

Documentation Type: **Standard**

Revision: **1**

Total Pages: **26**

Next Review Date: **September 2025**

Disclosure Classification: **Controlled
Disclosure**

Compiled by	Approved by	Authorised by
		
Tjaart Visser	Rishi Hariram	Richard McCurrach
Engineer – Control Automation	Acting Manager – Control Automation	Senior Manager – PTMC
Date: 28/08/2020	Date: 28/08/2020	Date: 31 Aug 2020
		Supported by SCOT/SC
		
		Marlini Sukhnandan
		Telecontrol and SCADA SC Chairperson
		Date: 28/08/2020

Content

	Page
1. Introduction	4
2. Supporting clauses	4
2.1 Scope	4
2.1.1 Purpose	4
2.1.2 Applicability	4
2.2 Normative/Informative references	4
2.2.1 Normative	4
2.2.2 Informative	4
2.3 Definitions	5
2.3.1 General	5
2.3.2 Disclosure classification	5
2.4 Abbreviations	5
2.5 Roles and responsibilities	6
2.6 Process for monitoring	6
2.7 Related/Supporting documents	6
3. SEL-3555 Substation Gateway commissioning procedure	6
3.1 Prerequisites	6
3.2 Requirements	6
3.3 Commissioning plan	7
4. Required tools and equipment	7
4.1 Hardware	7
4.2 Software	7
4.3 Pre-commissioning checks	7
4.3.1 Drawings	7
4.3.2 Check hardware build	7
4.3.3 SEL-3555 Substation Gateway front panel	7
4.3.4 SEL-3555 Substation Gateway rear panel	9
4.3.5 Panel inspection	9
4.3.6 Check physical interfaces and cable connectors	10
4.3.7 Check external DC power connections and MCBs	10
4.3.8 Check external AC power connections and MCBs	11
4.3.9 Check fail-safe alarm connections	11
4.3.10 Power supply	11
4.4 Commissioning checks	12
4.4.1 Energisation tests	12
4.4.2 Setting up the SEL-3555 Substation	12
4.4.3 SEL-3555 Substation Gateway commissioning	13
4.5 Troubleshooting	16
5. Authorisation	17
6. Revisions	18
7. Development team	18
8. Acknowledgements	18
Annex A – Commissioning checklist	19

Figures

Figure 1: SEL-3555 Substation Gateway front panel8
Figure 2: SEL-3555 Substation rear panel9
Figure 3: Layout of SEL-3390S8 card14

Tables

Table 1: Front-panel LED indicators8
Table 2: Power supply input tolerances.....11
Table 3: SEL-3555 troubleshooting procedures16

1. Introduction

This document outlines the required steps to adequately commission the SEL-3555 Substation Gateway and associated peripherals in accordance with the design.

2. Supporting clauses

2.1 Scope

This document covers the commissioning procedures for the SEL-3555 Substation Gateway and associated peripherals.

2.1.1 Purpose

The purpose of this document is to detail the guidelines to be followed after the physical installation of the gateway and associated peripherals in a substation control room. The guideline covers connections to other systems to ensure the safe and proper functioning of the equipment prior to energising and to ensure correct operation after energisation.

2.1.2 Applicability

This document shall apply to all personnel working on this equipment throughout Eskom Holdings SOC Limited's Transmission Division.

2.2 Normative/Informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

- [1] ISO 9001 Quality Management Systems
- [2] 240-64100247 – Standard for Earthing of Secondary Plant in Substations
- [3] SEL-3555 Substation, Instruction Manual
- [4] SDR, Eskom Transmission Integrated Protection and Substation Automation Solution System Design Report
- [5] 20-FDS, Functional Design Specification of Substation Gateway and Station RTU/IED for EHV Substations
- [6] 20-DDS, Detailed Design Specification of Substation Gateway and Station RTU/IED for EHV Substations
- [7] 23-Commissioning, SEL-2488 GPS Time Synchronising Unit Commissioning Guideline
- [8] 20-Configuration, SEL-3555 Substation Gateway Configuration Guideline

2.2.2 Informative

None.

2.3 Definitions

2.3.1 General

Definition	Description
ASE2000 Test Set	Protocol test unit that provides the user with a powerful and flexible tool for testing and maintaining SCADA RTU and SCADA IED equipment and diagnosing communication problems.
EIA-232 or EIA-485	A standard interface for data terminal equipment.
Ping	Computer network administration software utility used to determine whether a specific IP address is accessible.

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law or discretionary).

2.4 Abbreviations

Abbreviation	Description
AC	Alternating current
ACT	Activity
AUX	Auxiliary
CD	Compact disc
DC	Direct current
DVD	Digital versatile disc
FTP	File Transfer Protocol
HDD	Hard disk drive
IEC	International Electrotechnical Commission
IED	Intelligent electronic device
IP	Internet Protocol
IRIG	Inter-Range Instrumentation Group
ISO	International Organization for Standardization
LED	Light-emitting diode
LNK	Link
MAC	Media access control
MCB	Miniature circuit breaker
NTP	Network Time Protocol
PC	Personal computer
RTAC	Real-time automation controller
RTU	Remote terminal unit
RX	Receive

ESKOM COPYRIGHT PROTECTED

Abbreviation	Description
SCADA	Supervisory control and data acquisition
SEL	Schweitzer Engineering Laboratories
SNMP	Simple Network Management Protocol
SNTP	Simple Network Time Protocol
TCP	Transmission Control Protocol
TX	Transmit
VAC	Volts alternating current
VDC	Volts direct current
VLAN	Virtual local area network

2.5 Roles and responsibilities

Work roles and responsibilities are allocated according to requirements and individual competencies. All Eskom Holdings Limited Transmission Division managers will ensure that there is compliance with this document with respect to all SEL-3555 Substation Gateway application commissioning.

2.6 Process for monitoring

Not applicable.

2.7 Related/Supporting documents

Not applicable.

3. SEL-3555 Substation Gateway commissioning procedure

3.1 Prerequisites

Only personnel who are deemed competent to work on the SEL-3555 Substation Gateway are permitted to perform visual inspection, carry out diagnostics, and commission the device.

This procedure is applicable to each SEL-3555 Substation Gateway that may be installed in a substation. Typically, there are two SEL-3555 Substation Gateway schemes per substation, which are designated as Main 1 and Main 2.

3.2 Requirements

- 1) Commissioning of the SEL-3555 Substation Gateway shall be performed per a predetermined commissioning plan as prepared by the relevant commissioning team.
- 2) A commissioning report outlining all completed works, as well as any outstanding work, shall be completed by the commissioning team.
- 3) The as-commissioned signal list and configuration files shall be stored in the Eskom standard configuration management system in operation at the time.
- 4) All SEL-3555 Substation Gateways installed at the substation shall adhere to the relevant installation and earthing standards [2].

3.3 Commissioning plan

- 1) A commissioning plan is necessary to ensure the successful commissioning of the SEL-3555 Substation Gateway.
- 2) The final commissioning plan shall be distributed to all stakeholders prior to commissioning. These parties include, but are not limited to:
 - a) control centre managers;
 - b) protection, metering/measurement, and substation control commissioning teams involved in the project;
 - c) the project manager; and
 - d) the substation control applications engineer.

4. Required tools and equipment

4.1 Hardware

- 5 m Ethernet cable
- Laptop with the software listed below

4.2 Software

- SEL AcSELerator RTAC v139 software
- Web browser, for example, Google Chrome, Internet Explorer, or Mozilla Firefox
- Command Prompt – included in Windows

4.3 Pre-commissioning checks

All pre-commissioning checks are to be performed **PRIOR TO** powering up of the SEL-3555 Substation Gateway panel.

4.3.1 Drawings

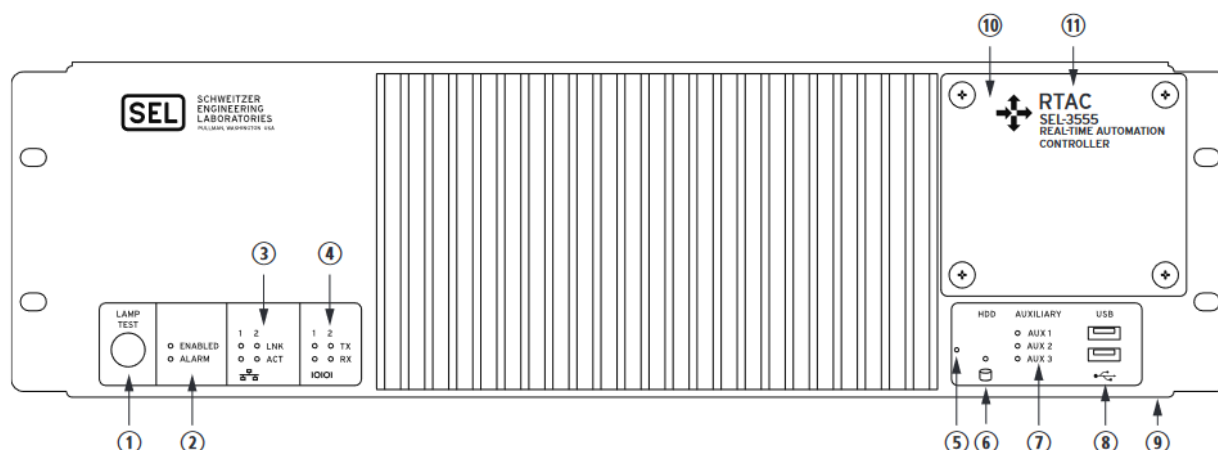
- 1) Ensure that the latest revision of the application drawings has been issued to the commissioning team.
- 2) Any changes that may be necessary must first be verified with the applications engineer. All modifications are to be marked up on the issued drawings. A copy of all marked-up drawings must be submitted to the responsible applications engineer, so that the as-built revision of the drawings can be generated.

4.3.2 Check hardware build

Check that the installed SEL-3555 unit has the correct build and port interfaces. The part number for the SEL-3555 Substation Gateway is indicated on a label that is affixed to the side of the unit and must be 3555#8MHG.

4.3.3 SEL-3555 Substation Gateway front panel

- 1) The front panel of the SEL-3555 Substation Gateway provides access to the status indicators, user connections, lamp test push button, and diagnostic LEDs.



- ① LEDs may all be tested by holding down the LAMP TEST button.
- ② ENABLED LED provides operational status. Green indicates normal operation, and red indicates that the system is halted or booting, or that an alarm condition has occurred. The ALARM LED indicates a non-optimal system condition exists. The ALARM LED illuminates red whenever the alarm contact operates.
- ③ LINK and ACTIVITY LEDs indicate link status and network activity for each Ethernet port.
- ④ Transmit (TX) and Receive (RX) LEDs indicate activity on serial ports.
- ⑤ RESET pinhole may also be configured as a power button in the BIOS.
- ⑥ See SATA drive activity at a glance with the HDD LED indicator.
- ⑦ Program three bicolor AUXILIARY LEDs for your custom application.
- ⑧ Attach mouse and keyboard to any of the USB ports.
- ⑨ Rugged enclosure withstands EMI, RFI, shock, and vibration.
- ⑩ Easily access removable solid-state drive behind the front panel.
- ⑪ High contrast, white-on-blue lettering is highly legible even in dark areas.

Figure 1: SEL-3555 Substation Gateway front panel

SEL-3555 Substation panel LEDs

The front panel of the SEL-3555 Substation Gateway is equipped with LEDs to indicate the health and status of the device. Table 1 provides a description of each LED.

Table 1: Front-panel LED indicators

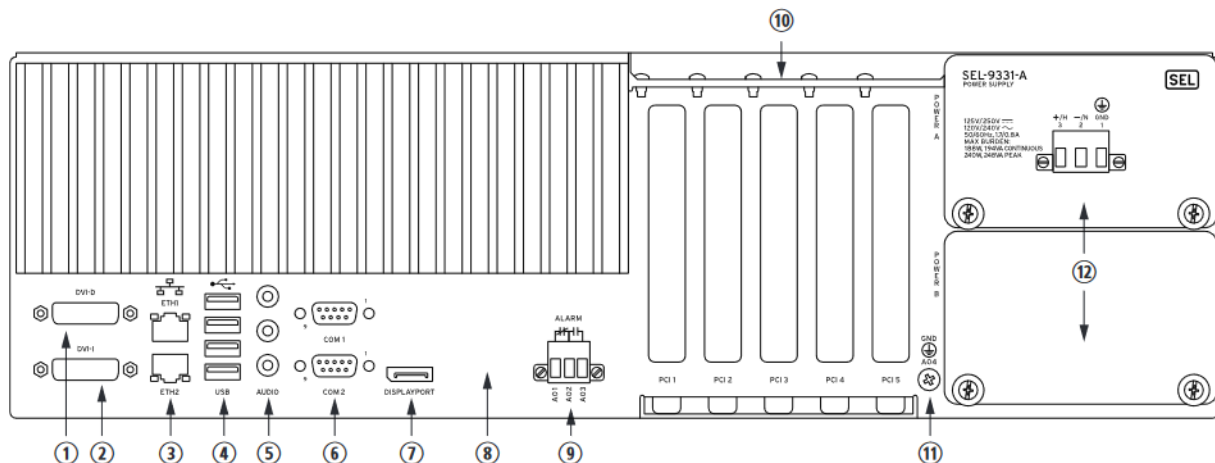
LED	State	Description
ENABLED ALARM	Green	Indicates that the unit has passed self-tests and is operational.
	Red	Indicates that the system is halted or booting or that an alarm condition has occurred. The ALARM LED indicates that a non-optimal system condition exists.
AUX 1 AUX 2 AUX 3	Bicolour	Three bicolour AUXILIARY LEDs are customisable for the application. By default, these are applied as follows: The AUX 1 LED is used to indicate the communications status to all three control centres, namely, National Control, STABNAC, and Regional Control. (Green = all three control centres are online; red = one or more control centres are offline.) The AUX 2 LED is used to indicate whether the Substation Gateway is the main or the standby device. (Green = main; red = standby; off = synchronisation status between the Main 1 and Main 2 Substation Gateways is offline.) The AUX 3 LED is used to indicate the time synchronisation status. (Green = synchronised from the SEL-2488 GPS clock; red = not synchronised from the SEL-2488 GPS clock.)

ESKOM COPYRIGHT PROTECTED

LED	State	Description
LNK ACT	Green	Indicates link status. The LED is off when there is no active link.
	Amber	Indicates network activity for each Ethernet port. The LED is off when there is no network activity.
TX RX	Green	Indicates activity on serial ports. The LED is off when there is no serial communications activity.
	Red	Indicates activity on serial ports. The LED is off when there is no serial communications activity.
HDD	Amber	Indicates SATA drive activity.

4.3.4 SEL-3555 Substation Gateway rear panel

- 1) The rear panel of the SEL-3555 Substation Gateway provides access to the communication ports, field wiring connections, status indicators, user connections, and power supply units.



- 1 Connect digital displays to the DVI-D video port.
- 2 Connect digital or analog (VGA) displays to the DVI-I video port.
- 3 Network with two high-speed Gigabit Ethernet ports. Ports may be bonded for redundancy or used individually.
- 4 Use any of the four USB 2.0 ports for keyboard and mouse connections.
- 5 Audio output is not used in the RTAC at this time.
- 6 Two built-in EIA-232 ports are BIOS configurable for +5 Vdc port power.
- 7 Connect compatible monitors to the DisplayPort video port for higher video performance.
- 8 Serial number label.
- 9 Wire a Form C alarm contact output either normally closed or normally open. The ALARM LED on the front provides indication of the alarm contact state.
- 10 Use SEL rugged PCI Express expansion cards for additional networking, serial, and IRIG-B input.
- 11 Attach chassis to ground.
- 12 Choose single or dual power supplies, and attach power from independent sources for even higher availability. Supplies load share and are hot-swappable for maximum online serviceability.

Figure 2: SEL-3555 Substation rear panel

4.3.5 Panel inspection

Before powering up the SEL-3555 Substation Gateway panel, visually inspect the equipment for any physical damage, and perform the following quality checks:

- 1) Inspect the SEL-3555 Substation Gateway for physical damage.
- 2) The interior of the panel must be clean and dry.
- 3) Ensure that there is free airflow to the SEL-3555 Substation Gateway, with no obstructions.

ESKOM COPYRIGHT PROTECTED

-
- 4) All metal parts, equipment, and blanking plates must be earthed to the panel earth bar, and the continuity of all earths must be confirmed.
 - 5) The earthing cable used to bond the SEL-3555 Substation Gateway panel to the substation earth bar must not exceed 0,5 m. The continuity of this earth must be confirmed, and the impedance must not exceed 0,1 Ω .
 - 6) Ensure that all the rack-mounted equipment, including the SEL-3555 Substation Gateway, is securely mounted and that no equipment has come loose during transportation and placement in the substation control room.
 - 7) All identifying details, including the name, serial numbers, or type codes of equipment must be checked and/or recorded.
 - 8) All labels are to be in accordance with the scheme drawing.
 - 9) All terminations shall be checked for tightness in compliance with the panel design.
 - 10) All circuits must be verified as per the electrical schematics (application drawings) for the scheme.
 - 11) All communication circuits must be verified as per the application drawings for the scheme.

4.3.6 Check physical interfaces and cable connectors

- 1) Check that all connectors are securely connected to the cables.
- 2) Check that the power terminal blocks are tightly fitted to the unit and that the securing screws for the terminal blocks are tightened.
- 3) Check that the terminal block protective covers are installed (as applicable).
- 4) Where applicable, check that both Power Supply 1 and Power Supply 2 are connected.
- 5) Inspect the connectors and cables between equipment, and ensure that their connections to the SEL-3555 Substation Gateway are firm. The use of strain relief mechanisms must be verified (for example, thumbscrews).
- 6) Ensure that the serial-to-fibre connector for the heartbeat cable between the Main 1 and Main 2 SEL-3555 Substation Gateways is installed and correctly fastened to the SEL-3555.
- 7) Check that all cables are firmly fitted to their correct interface on the networking hardware as per the connection diagram.
- 8) The integrity of any protective shielding connection (for communications cables) must be checked and must be correctly earthed.
- 9) Check that the physical interfaces on all units are not damaged/obstructed in any way.
- 10) Ensure that unused fibre-optic interfaces have their dust covers in place.

4.3.7 Check external DC power connections and MCBs

- 1) Verify that the DC power cable is connected to the correct circuit on the correct DC distribution board and that the supply voltage is as indicated in the drawings. Ensure that the MCB at the DC distribution board is off.
- 2) Confirm that the DC power cable number and wire ferrule numbers are correct with respect to the application drawings.
- 3) Check that the DC power supply cable has enough slack and is correctly installed, glanded, and terminated.
- 4) Verify that the rating of the DC MCB is correct.
- 5) Check that the DC power cable is connected to the correct input terminals.

4.3.8 Check external AC power connections and MCBs

There are two AC supply cables that are connected to the gateway panel. One cable is used to illuminate the Panel Not Healthy (PNH) lamp, and the other is used to supply the plug socket. The difference between the two supplies is that the AC supply powering the plug socket is earth leakage protected.

4.3.8.1 Unprotected AC supply

- 1) Verify that the AC power cable is connected to the correct circuit at the AC distribution board. Ensure that the MCB at the AC distribution board is off.
- 2) Confirm that the AC power cable number and wire ferrule numbers are correct with respect to the application drawings.
- 3) Check that the AC power supply cable has enough slack and is correctly installed, glanded, and terminated.
- 4) Verify that the rating of the AC MCB is correct.
- 5) Check that the AC power cable is connected to the correct input terminals.

4.3.8.2 Protected AC supply

- 1) Verify that the AC power cable is connected to the correct circuit at the AC distribution board. Ensure that the MCB at the AC distribution board is off.
- 2) Confirm that the AC power cable number and wire ferrule numbers are correct with respect to the application drawings.
- 3) Check that the AC power supply cable has enough slack and is correctly installed, glanded, and terminated.
- 4) Verify that the rating of the AC MCB is correct.
- 5) Check that the AC power cable is connected to the correct input terminals.

4.3.9 Check fail-safe alarm connections

Check that the SEL-3555 alarm contact is correctly connected to the NC (normally closed) and common terminals on the fail-safe relay terminal block.

4.3.10 Power supply

The SEL-3555 Substation Gateway allows for dual, redundant power supply configurations to maximise availability in critical facility situations. Ensure that the correct power supply modules are installed.

- 1) Verify that the input voltage matches the rating on the SEL-3555 power supplies. The input voltage ratings for the standard RTAC power supplies are detailed in Table 2 below.
- 2) Ensure that the two thumbscrews that secure each power supply to the SEL-3555 chassis are secured.
- 3) Confirm that the power supply wiring for both power supplies is connected to the input DC MCB (designated DCI(GW)) with the correct polarity.

Table 2: Power supply input tolerances

Power supply module	Input voltage range
SEL-9331 160 W HV	125/250 VDC or 120/220/240 VAC; 50/60 Hz
SEL-9331 160 W LV	48 VDC

4.4 Commissioning checks

4.4.1 Energisation tests

- 1) At the AC board, close the MCB feeding the earth leakage protected AC circuit to the gateway panel.
- 2) At the gateway panel, measure the AC supply at the input terminals (as per the application drawings), and confirm the presence of 230 VAC. Test the plug socket using a laptop power supply plug inserted into the socket.
- 3) At the AC board, close the MCB feeding the unprotected (no earth leakage protection) AC circuit to the gateway panel.
- 4) At the gateway panel, measure the AC supply at the input terminals (as per the application drawings), and confirm the presence of 230 VAC. If the voltage is correct, close the AC MCB.
- 5) Verify that the Panel Not Healthy (PNH) light illuminates, as the fail-safe alarm contacts for all the equipment should be in the normally closed position.
- 6) At the DC board, close the MCB feeding the DC supply to the gateway panel.
- 7) At the gateway panel, measure the DC supply at the input terminals (as per the application drawings). Confirm the correct DC voltage and the correct polarity before switching on the DC MCB for the SEL-3555 Substation Gateway at the gateway panel. The MCB should be labelled DCI(GW).
- 8) Confirm that the SEL-3555 Substation Gateway energises by monitoring the LEDs at the front panel. After completing the booting process, the ENABLED LED will illuminate.

4.4.2 Setting up the SEL-3555 Substation

4.4.2.1 Ethernet ports

The SEL-3555 Substation Gateway is equipped with two onboard high-speed Gigabit Ethernet 10/100/1000BASE-T copper ports labelled ETH1 and ETH2. The factory default communication settings for these ports are as follows:

- Auto-negotiation is enabled.
- Both ports are enabled.
- Each port is independent of the other (that is, no bridging or teaming is enabled).
- The default IP address for ETH1 is 192.168.1.2/24.
- The default IP address for ETH2 is 192.168.2.2/24.

Confirm whether the unit had a configuration installed prior to installation and, if so, what the configured IP addresses are.

4.4.2.2 Secure web access

The SEL-3555 Substation Gateway has a built-in web browser for secure access to the SEL-3555 Substation Gateway. The web interface allows the application-specific network parameters to be configured in addition to a number of other configuration and diagnostic options.

If the SEL-3555 Substation Gateway has factory default settings:

- 1) Set the IP address of the Ethernet port on the configuration PC to 192.168.2.3 with a subnet mask of 255.255.255.0, and connect to the ETH2 interface of the SEL-3555 Substation using an Ethernet cable.
- 2) Open a browser, and connect to the URL <https://192.168.2.2>.
- 3) If no user has previously been configured, a user with appropriate credentials must first be defined. The username and password must be as specified by the applications engineer.

- 4) Reconnect to the SEL-3555 Substation Gateway's web interface, and log in with the correct credentials.
- 5) Configure the network parameters, as well as any other parameters that must be configured, as specified by the application design documentation and drawings. Ensure that ping is enabled on the network interfaces to facilitate troubleshooting.
- 6) On completion of the initial configuration settings, connect the SEL-3555 to the network as shown in the application drawings.
- 7) Set the IP address of the Ethernet port on the configuration PC to be obtained automatically.

If the SEL-3555 Substation Gateway network interfaces have already been configured, the SEL-3555 Substation Gateway should be available for connection using a web browser over the substation network from a port configured in the Engineering VLAN.

4.4.2.3 Installation of AcSElerator RTAC software

If the configuration/commissioning PC does not have the AcSElerator RTAC software (SEL-5033) installed, it must be installed prior to commencing with the SEL-3555 Substation Gateway commissioning process.

Using the appropriate installation media, install the R139 version of the AcSElerator RTAC software on the configuration PC.

If the installation medium is a CD, perform the following steps:

- Step 1: ensure that all software applications are closed.
- Step 2: place the CD in the computer CD/DVD-ROM drive.
- Step 3: if Windows autorun is enabled, the file will load automatically. If Windows autorun is not enabled, run setup.bat from the CD.
- Step 4: click on the link for AcSElerator RTAC software in the window that appears.
- Step 5: follow the on-screen instructions to complete the installation.
- Step 6: close the window when the installation has been completed.

4.4.3 SEL-3555 Substation Gateway commissioning

4.4.3.1 Verify network reachability of IEDs

- 1) Connect the commissioning PC to the network using an Engineering access port. The Engineering ports are configured to operate in the Engineering VLAN, and the commissioning PC should be able to obtain an IP address automatically from the router.
- 2) Confirm that all IEDs are physically connected to the network as indicated in the network diagram. It is assumed that all IEDs are powered on and configured with their correct IP address, mask, and gateway settings.
- 3) Open a Command Prompt window on the configuration PC, and using the ping utility, confirm reachability of all the IEDs and the RTACs on the network.

4.4.3.2 Confirm the firmware version on the SEL-3555 Substation

- 1) Connect to the SEL-3555 Substation Gateway's web interface, and log in with the correct credentials.
- 2) Navigate to the dashboard display page, and confirm that the firmware version is correct.

4.4.3.3 Load the SEL-3555 Substation project file onto the SEL-3555 Substation Gateway

If the SEL-3555 Substation Gateway does not have an existing project, or to load an updated project:

- 1) Using the AcSELerator RTAC software, open the correct RTAC project file for the device as supplied by the applications engineer.
- 2) Using the AcSELerator RTAC software, connect to the SEL-3555 Substation Gateway using the device's IP address and the previously configured user credentials.
- 3) The project is loaded onto the SEL-3555 Substation Gateway by clicking on the Go Online icon, which will compare the currently open project with the project loaded on the SEL-3555 Substation Gateway unit (if any). Follow the prompts to load the project.

If the SEL-3555 Substation Gateway has an existing project loaded, the project can be read from the device using the "Read" menu option.

4.4.3.4 Time synchronisation

- 1) The SEL-3555 Substation Gateway is fitted with a serial adapter card, which allows the SEL-3555 Substation Gateway to accept a demodulated IRIG-B signal from the SEL-2488 GPS clock. Verify that the serial DB9 adapter cable is connected to COM 1 of the SEL-2488 GPS clock in the gateway panel and the first port on the first SEL-3390S8 serial expansion card.

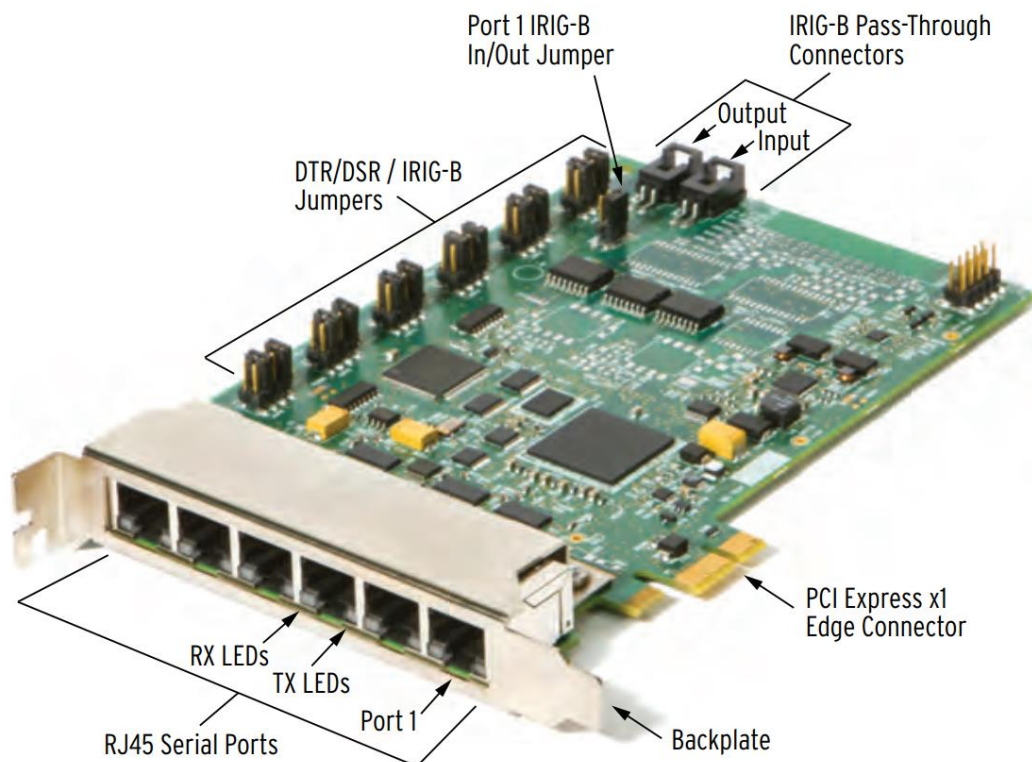


Figure 3: Layout of SEL-3390S8 card

- 2) Commission the SEL-2488 GPS clock as per the commissioning guide for the device [7].
- 3) Ensure that the SEL-2488 GPS clock in the gateway panel is synchronised and is correctly distributing time using IRIG-B to the SEL-3555 Substation Gateway as per the commissioning guide for the device [7]. As described above, the AUX 3 LED indicates the GPS time synchronisation status. Time synchronisation can also be verified via the web interface on the SEL-3555 Substation Gateway [8].

4.4.3.5 Heartbeat between gateways

The SEL-3555 Substation Gateway configured as the Main 1 unit must exchange state information with the SEL-3555 Substation Gateway configured as the Main 2 unit for redundancy purposes. This connection is known as the heartbeat and is implemented using SEL's mirrored bits technology. The mirrored bits data exchange is performed between Serial Port 1 on each of the SEL-3555 Substation Gateways. Serial RS-232-to-fibre converters are used to convert the serial data exchange to fibre-optic signalling.

- 1) Confirm that the serial-to-fibre converter is connected to Serial Port 1 on the SEL-3555 Substation Gateway and is fastened with its thumbscrews. The converter is powered from the serial port.
- 2) Verify that the ST connector of the ST/LC multimode fibre-optic patch lead is connected to the serial-to-fibre converter. Verify that the LC connector of the ST/LC multimode fibre-optic patch lead is connected to the patch panel. The transmit and receive fibres may need to be swapped if the link does not indicate activity.
- 3) The AUX 1 LED on the SEL-3555 Substation Gateway will illuminate if the heartbeat signalling between the devices is healthy.

4.4.3.6 Confirm that devices are online

The SEL-3555 Substation Gateway is designed to concentrate all information received from the substation IEDs and to transmit this information to remote SCADA master stations and external SCADA HMI clients.

- 1) Using the AcSElerator RTAC software, connect to the SEL-3555 Substation Gateway using the device's IP address and the previously configured user credentials.
- 2) If the correct project has been loaded, the software will go online and show the online data on the SEL-3555 Substation Gateway.
- 3) Verify that each IED is online and communicating with the SEL-3555 Substation Gateway by selecting the IED device in the tree structure. Click on the "Controller" menu item to confirm whether the IED is online. Click on the "Tags" menu item to confirm the received data.
- 4) Should an IED not be online, follow the appropriate troubleshooting procedure to resolve the issue.

4.4.3.7 Simulate master station

- 1) Connect the ASE2000 Test Set to simulate a master station as per the configuration parameters that have been defined by the Substation Control Applications Department.
- 2) The substation network diagram and application details will provide addressing details, protocol information, and the relevant signal list for the master station, which can be used to configure the test set and simulate the master.
- 3) Establish the connection between the SEL-3555 Substation Gateway and ASE2000 Test Set.
- 4) Perform the plant I/O testing procedure as listed in section 4.4.3.9 below.
- 5) Note that the SEL-3555 Substation Gateway allows data items to be substituted (or forced) for testing purposes. This is performed by entering the "Tags" menu for the master station in question and setting a value in the "Prepared Value" column. Use F6 to activate the substituted value. Shift-F6 will remove the forced value and return to the process value.

4.4.3.8 Connect to a control centre

- 1) Ensure that the SEL-3555 Substation Gateway is correctly connected to the master station circuit as per the necessary application drawings and documentation. The connection via the Eskom telecommunications infrastructure is typically implemented using an RS-422 connection to the BME or time-division multiplexer.
- 2) Verify that each master station is online and communicating with the SEL-3555 Substation Gateway by selecting the device in the tree structure. Click on the "Controller" menu item to confirm whether the master station is online. Click on the "Tags" menu item to confirm the data.

ESKOM COPYRIGHT PROTECTED

- 3) Perform the plant I/O testing procedure as listed in section 4.4.3.9 below.
- 4) Note that the SEL-3555 Substation Gateway allows data items to be substituted (or forced) for testing purposes. This is performed by entering the "Tags" menu for the master station in question and setting a value in the "Prepared Value" column. Use F6 to activate the substituted value. Shift-F6 will remove the forced value and return to the process value.

4.4.3.9 Plant I/O testing

- 1) The status of the actual plant must be verified against the indication on the SEL-3555 Substation Gateway.
- 2) All bays at the substation are to be switched off supervisory for the duration of the commissioning. This is to ensure that no inadvertent plant operation occurs.
- 3) Once all bays are off supervisory, local testing may begin.
- 4) The status of the actual plant must be verified against the indication on the SEL-3555 Substation Gateway and the connected control centre(s).
- 5) All alarms must be initiated from the furthest point. Protection personnel must be available to simulate the alarms.
- 6) All controls will be tested to the actual plant.
- 7) All analogue points are to be tested by injecting to the IED using an injection test set via the test blocks. The analogue value must then be verified on the IED's display panel, and the analogue value displayed in the SEL-3555 Substation Gateway must be compared with the value injected to the relay. The analogue value deadbands must also be tested.
- 8) Successful testing of all analogue values, digital points, and controls will be ticked off on the commissioning tick sheets.
- 9) When testing to the control centres, control centre staff must tick off each point successfully tested on the commissioning tick sheets, and field staff are to indicate the same in the space provided on the signal list.
- 10) Points that cannot be simulated directly from plant can be forced from within the AcSELeRator RTAC software.
- 11) Once all bays have been tested, they will be deemed ready to be put into service.

4.5 Troubleshooting

Table 3 below lists the common issues and indicators with the SEL-3555 Substation Gateway that can be used to help identify and resolve common issues.

Table 3: SEL-3555 troubleshooting procedures

Issue/Indicator	Possible causes	Solution
Front-panel ENABLED LED is dark.	Input power is not present; power supply is not fully seated.	Remove power source. Verify power cabling and connections. Check fuse.
	Invalid logic project installed.	Reload a known good project with AcSELeRator RTAC software.
Front-panel ENABLED LED remains unlit after start-up.	Device has experienced a diagnostics failure that prevents it from operating.	Please refer to the maintenance guide [9].
	Incorrect IP address.	Verify IP address.
	Invalid subnet.	Verify subnet and subnet mask.

ESKOM COPYRIGHT PROTECTED

Issue/Indicator	Possible causes	Solution
The SEL-3555 does not respond to a device connected to Ethernet (ETH 1 or ETH 2).	Incorrect or disconnected cable.	Verify that cable is crossover, if needed.
	Ethernet port disabled.	Verify settings via web interface.
	More than one port configured for the same subnet.	Use a different subnet for each Ethernet port on the SEL-3555.
The SEL-3555 does not work correctly with a device connected to a serial port.	Cable not connected.	Verify that cable is secure.
	Cable is incorrect type.	Verify the cable pinout and type needed.
	The SEL-3555 and other device have mismatched communications parameters. One device has received an XOFF, halting communications.	Verify communications parameters. Verify that XON/XOFF is not used, unless needed.
The SEL-3555 does not synchronise with IRIG-B.	Configuration incorrect.	Verify configuration in the AcSELeRator RTAC project, and reload into the SEL-3555.
	Incorrect serial port used.	Verify that IRIG-B input is on Serial Port 1 of the first serial expansion card.
	Cable disconnected.	Verify that cable is secure.
Unable to download a project with ACSELERATOR RTAC.	Version mismatch between SEL-3555 firmware and AcSELeRator RTAC PC software.	The version of the AcSELeRator RTAC software on the PC must be the same as the version of the RTAC firmware. Verify that versions match. Use web interface with SEL-3555 and About AcSELeRator RTAC on PC software.
Unable to go online with project or other network-related issues occurring.	Certain needed network ports (TCP or UDP ports) are closed.	Enable use of these ports by either turning off or adding exceptions to the firewall and antivirus software.
Password not accepted in web interface and during project download.	Incorrect password.	Use correct password. If password has been lost or forgotten, please contact the relevant organisational support department.
User cannot log in.	The user's account is missing or disabled.	Log into the SEL-3555 as an administrator or user manager, and verify the details for the subject's account on the Local Users page.
Front-panel ENABLED LED is dark, ALARM LED illuminated.	SEL-3555 has an invalid project.	Normally, the SEL-3555 will reset an invalid project to the factory-default project. If the SEL-3555 remains in this disabled state, the unit will generate an error log, which will describe the issue that caused the alarm. Please contact the relevant organisational support department.

5. Authorisation

This document has been seen and accepted by:

Name and surname	Designation
Avhaphani Luvhengo	Secondary Plant Manager – Central Grid
Bosaletse Mpesi	Secondary Plant Manager – Free State Grid
David Seholo	Secondary Plant Manager – East Grid
Ellan Phaahla	Secondary Plant Manager – North West Grid

ESKOM COPYRIGHT PROTECTED

Name and surname	Designation
Gilbert Valentyn	Secondary Plant Manager – Southern Grid
Humbulani Tshisevhe	Secondary Plant Manager – North East Grid
Keineetse Rankunyane	Secondary Plant Manager – Western Grid
Regi George	Secondary Plant Manager – Northern Cape Grid
Selby Mudau	Secondary Plant Manager – Northern Grid

6. Revisions

Date	Rev	Compiler	Remarks
Sept 2020	1	Tjaart Visser	First issue

7. Development team

The following people were involved in the development of this document:

- Ian Naicker
- James Ranyane
- Dumisani Gojela

8. Acknowledgements

- CONCO Energy Solutions (Pty) Ltd

Annex A – Commissioning checklist

Substation	Grid
Device name	Device IP
SEL-3555 Substation Gateway	

Section	Description	Pass (✓)/ Fail (X)	Notes
3.2	Commissioning of the SEL-3555 Substation Gateway shall be performed per a predetermined commissioning plan as prepared by the commissioning team.		
	A commissioning report outlining all completed works, as well as any outstanding work, shall be completed by the commissioning team.		
	The as-commissioned signal list and configuration files shall be stored in the Eskom standard configuration management system in operation at the time.		
4.3.1	Ensure that the latest revision of the application drawings has been issued to the commissioning team.		
	Any changes that may be necessary must first be verified with the applications engineer. All modifications are to be marked up on the issued drawings. A copy of all marked-up drawings must be submitted to the responsible applications engineer, so that the as-built revision of the drawings can be generated.		
4.3.2	Check hardware build.		
	Check that the installed SEL-3555 unit has the correct build and port interfaces.		
4.3.5	Gateway panel inspection		
1)	Inspect the SEL-3555 Substation Gateway for physical damage.		
2)	The interior of the panel must be clean and dry.		
3)	Ensure that there is free airflow to the SEL-3555 Substation Gateway, with no obstructions.		
4)	All metal parts, equipment, and blanking plates must be earthed to the panel earth bar, and the continuity of all earths must be confirmed.		

ESKOM COPYRIGHT PROTECTED

Section	Description	Pass (✓)/ Fail (X)	Notes
5)	The earthing cable used to bond the SEL-3555 Substation Gateway panel to the substation earth bar must not exceed 0,5 m. The continuity of this earth must be confirmed, and the impedance must not exceed 0,1 Ω .		
6)	Ensure that all the rack-mounted equipment, including the SEL-3555 Substation Gateway, is securely mounted and that no equipment has come loose during transportation and placement in the substation control room.		
7)	All identifying details, including the name, serial numbers, or type codes of equipment must be checked and/or recorded.		
8)	All labels are to be in accordance with the scheme drawing.		
9)	All terminations shall be checked for tightness in compliance with the panel design.		
10)	All circuits must be verified as per the electrical schematics (application drawings) for the scheme.		
11)	All communication circuits must be verified as per the application drawings for the scheme.		
4.3.6	Check physical interfaces and cable connectors.		
1)	Check that all connectors are securely connected to the cables.		
2)	Check that the power terminal blocks are tightly fitted to the unit and that the securing screws for the terminal blocks are tightened.		
3)	All metal parts, equipment, the rear chassis plate, and the enclosure door must be earthed to the panel earth bar, and the continuity of all earths must be confirmed.		
4)	Check that the terminal block protective covers are installed (as applicable).		
5)	Check that Power Supply 1 is connected.		
6)	Inspect the connectors and cables between equipment, and ensure that their connections to the SEL-3555 Substation Gateway are firm. The use of strain relief mechanisms must be verified (for example, thumbscrews).		

Section	Description	Pass (✓)/ Fail (X)	Notes
7)	Ensure that the serial-to-fibre connector for the heartbeat cable between the Main 1 and Main 2 SEL-3555 Substation Gateways is installed and correctly fastened to the SEL-3555.		
8)	Check that all cables are firmly fitted to their correct interface on the networking hardware as per the connection diagram.		
9)	The integrity of any protective shielding connection (for communications cables) must be checked and must be correctly earthed.		
10)	Check that the physical interfaces on all units are not damaged/obstructed in any way.		
11)	Ensure that unused fibre-optic interfaces have their dust covers in place.		
4.3.7	Check external DC power connections and MCBs.		
1)	Verify that the DC power cable is connected to the correct circuit on the correct DC distribution board and that the supply voltage is as indicated in the drawings. Ensure that the MCB at the DC distribution board is off.		
2)	Confirm that the DC power cable number and wire ferrule numbers are correct with respect to the application drawings.		
3)	Check that the DC power supply cable has enough slack and is correctly installed, glanded, and terminated.		
4)	Verify that the rating of the DC MCB is correct.		
5)	Check that the DC power cable is connected to the correct input terminals.		
4.3.8	Check external AC power connections and MCBs.		
4.3.8.1	Unprotected AC supply		
1)	Verify that the AC power cable is connected to the correct circuit at the AC distribution board. Ensure that the MCB at the AC distribution board is off.		
2)	Confirm that the AC power cable number and wire ferrule numbers are correct with respect to the application drawings.		

Section	Description	Pass (✓)/ Fail (X)	Notes
3)	Check that the AC power supply cable has enough slack and is correctly installed, glanded, and terminated.		
4)	Verify that the rating of the AC MCB is correct.		
5)	Check that the AC power cable is connected to the correct input terminals.		
4.3.8.2	Protected AC supply		
1)	Verify that the AC power cable is connected to the correct circuit at the AC distribution board. Ensure that the MCB at the AC distribution board is off.		
2)	Confirm that the AC power cable number and wire ferrule numbers are correct with respect to the application drawings.		
3)	Check that the AC power supply cable has enough slack and is correctly installed, glanded, and terminated.		
4)	Verify that the rating of the AC MCB is correct.		
5)	Check that the AC power cable is connected to the correct input terminals.		
4.3.9	Check fail-safe alarm connections.		
	Check that the SEL-3555 alarm contact is correctly connected to the NC (normally closed) and common terminals on the fail-safe relay terminal block.		
4.3.10	Power supply		
1)	Verify that the input voltage matches the rating on the SEL-3555 power supplies. The input voltage ratings for the standard RTAC power supplies are detailed in the table below.		
	Power supply module	Input voltage range	
	SEL-9331 160 W HV	125/250 VDC or 120/220/240 VAC; 50/60 Hz	
	SEL-9331 160 W LV	48 VDC	
2)	Ensure that the two thumbscrews that secure each power supply to the SEL-3555 chassis are secured.		
3)	Confirm that the power supply wiring for both power supplies is connected to the input DC MCB (designated DCI(GW)) with the correct polarity.		

Section	Description	Pass (✓)/ Fail (X)	Notes
4.4	Commissioning checks		
4.4.1	Energisation tests		
1)	At the AC board, close the MCB feeding the earth leakage protected AC circuit to the gateway panel.		
2)	At the gateway panel, measure the AC supply at the input terminals (as per the application drawings), and confirm the presence of 230 VAC. Test the plug socket using a laptop power supply plug inserted into the socket.		
3)	At the AC board, close the MCB feeding the unprotected (no earth leakage protection) AC circuit to the gateway panel.		
4)	At the gateway panel, measure the AC supply at the input terminals (as per the application drawings), and confirm the presence of 230 VAC. If the voltage is correct, close the AC MCB.		
5)	Verify that the Panel Not Healthy (PNH) light illuminates, as the fail-safe alarm contacts for all the equipment should be in the normally closed position.		
6)	At the DC board, close the MCB feeding the DC supply to the gateway panel.		
7)	At the gateway panel, measure the DC supply at the input terminals (as per the application drawings). Confirm the correct DC voltage and the correct polarity before switching on the DC MCB for the SEL-3555 Substation Gateway at the gateway panel. The MCB should be labelled DCI(GW).		
8)	Confirm that the SEL-3555 Substation Gateway energises by monitoring the LEDs at the front panel. After completing the booting process, the ENABLED LED will illuminate.		
4.4.3	SEL-3555 Substation Gateway commissioning		
4.4.3.1	Verify network reachability of IEDs.		
2)	Confirm that all IEDs are physically connected to the network as indicated in the network diagram. It is assumed that all IEDs are powered on and configured with their correct IP address, mask, and gateway settings.		

Section	Description	Pass (✓)/ Fail (X)	Notes
3)	Open a Command Prompt window on the configuration PC, and using the ping utility, confirm reachability of all the IEDs and the RTACs on the network.		
4.4.3.2	A.1.1.1 Confirm the firmware version on the SEL-3555 Substation.		
2)	Navigate to the dashboard display page, and confirm that the firmware version is correct.		
4.4.3.4	A.1.1.2 Time synchronisation		
1)	Verify that the serial DB9 adapter cable is connected to COM 1 of the SEL-2488 GPS clock in the gateway panel and the first port on the first SEL-3390S8 serial expansion card.		
2)	Ensure that the SEL-2488 GPS clock in the gateway panel is synchronised and is correctly distributing time using IRIG-B to the SEL-3555 Substation Gateway as per the commissioning guide for the device [7].		
4.4.3.5	Heartbeat between gateways		
1)	Confirm that the serial-to-fibre converter is connected to Serial Port 1 on the SEL-3555 Substation Gateway and is fastened with its thumbscrews. The converter is powered from the serial port.		
2)	Verify that the ST connector of the ST/LC multimode fibre-optic patch lead is connected to the serial-to-fibre converter. Verify that the LC connector of the ST/LC multimode fibre-optic patch lead is connected to the patch panel. The transmit and receive fibres may need to be swapped if the link does not indicate activity.		
3)	The AUX 1 LED on the SEL-3555 Substation Gateway will illuminate if the heartbeat signalling between the devices is healthy.		
4.4.3.6	Confirm that devices are online.		
3)	Verify that each IED is online and communicating with the SEL-3555 Substation Gateway by selecting the IED device in the tree structure. Click on the "Controller" menu item to confirm whether the IED is online. Click on the "Tags" menu item to confirm the received data.		

Section	Description	Pass (✓)/ Fail (X)	Notes
4.4.3.7	Simulate master station.		
3)	Establish the connection between the SEL-3555 Substation Gateway and ASE2000 Test Set.		
4)	Perform the plant I/O testing procedure as listed in section 4.4.3.9 below.		
4.4.3.8	Connect to a control centre.		
1)	Ensure that the SEL-3555 Substation Gateway is correctly connected to the master station circuit as per the necessary application drawings and documentation.		
2)	Verify that each master station is online and communicating with the SEL-3555 Substation Gateway by selecting the device in the tree structure. Click on the "Controller" menu item to confirm whether the master station is online. Click on the "Tags" menu item to confirm the data.		
3)	Perform the plant I/O testing procedure as listed in section 4.4.3.9 below.		
4.4.3.9	Plant I/O testing		
2)	All bays at the substation are to be switched off supervisory for the duration of the commissioning.		
4)	The status of the actual plant must be verified against the indication on the SEL-3555 Substation Gateway and the connected control centre(s).		
5)	All alarms must be initiated from the furthest point. Protection personnel must be available to simulate the alarms.		
6)	All controls will be tested to the actual plant.		
7)	All analogue points are to be tested by injecting to the IED using an injection test set via the test blocks. The analogue value must then be verified on the IED's display panel, and the analogue value displayed in the SEL-3555 Substation Gateway must be compared with the value injected to the relay. The analogue value deadbands must also be tested.		
10)	Points that cannot be simulated directly from plant can be forced from within the AcSElerator RTAC software.		

Field Engineer/Technician	Senior Supervisor	Secondary Plant Manager
Name:	Name:	Name:
Date:	Date:	Date:
Signature:	Signature:	Signature: