Case Study: Efficiently Replace PLC Automation Systems by Integrating IEDs With Fiber-Optic and Ethernet Communications in the Substation

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CASE STUDY: EFFICIENTLY REPLACE PLC AUTOMATION SYSTEMS BY INTEGRATING IEDS WITH FIBER-OPTIC AND ETHERNET COMMUNICATIONS IN THE SUBSTATION

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ABSTRACT

This paper describes the successful replacement of an existing legacy PLC (programmable logic controller)-based substation automation design with integrated mission-critical protective intelligent electronic devices (IEDs). The new design replaces existing radios and leased-line modems with a hybrid serial and Ethernet local area network (LAN) with wide area network (WAN) connections. The new system exploits the full capabilities of communications processor technology to integrate existing protective relays and meters with new I/O (input and output) processors while also adding Ethernet connectivity to an expansion bay added to an existing substation.

The decision to replace the existing PLC-based control system was based primarily on the cost of the existing system, the difficulty of adding new capabilities (such as substation expansion or new communications methods), and inadequate product support. In addition to the high cost of the initial installation, the PLC design required substantial changes to the PLC hardware and software, termination panels and wiring, and field wiring, which made the cost of adding feeders to the existing system prohibitively expensive. Therefore, the primary drivers were to choose a system that was designed to support easy expansion and migration to new communications technologies from a vendor with demonstrated ability to provide timely product support.

Perhaps the most important desire was to choose a technology that could be added without ANY disruption to the existing systems. Engineers wanted to add automation to a substation expansion bay without adversely affecting the in-service PLC system controlling the original part of the substation. Engineers wanted to use the power of the IEDs rather than start a design from scratch, and they wanted the new system to be flexible enough to support the existing Supervisory Control and Data Acquisition (SCADA) data maps and screen template. This was necessary to minimize the effort of adding the new bay to the existing SCADA system while also making it appear the same as the other systems to the operators. Once the design is evaluated, engineers plan to use it in new bays as well as to replace the existing in-service PLC-based systems.

This case study explains integrating the existing protective relays to use their logic and control capabilities in making previously unavailable local automation decisions, along with providing remote access SCADA, which provides both monitoring and control. Innovative integration of an intelligent I/O processor performing transformer monitoring via analog and alarm inputs along with control outputs is also described. Methods of using communications processor technology to coordinate data to and from all substation IEDs, to meet remote SCADA requirements for monitoring and control, and to provide engineering personnel with remote access to IED nonoperational data and configuration settings are also discussed. All of this additional capability is added via settings, without the need for any custom code development or expense.

The various methods of communications connections provide unique implementation advantages and pose unique data access security challenges. To that end, this case study also includes a

description of the security methods employed to prevent unwanted electronic access to the substation, network, and IEDs.

INTRODUCTION

The City of Mesa Electric Division is responsible for the distribution of electric power to residential, business, and industrial customers located within the city limits. The existing distribution system includes 14 substations, four of which are 69 kV to 12 kV and are scheduled for protection and control upgrades. The remaining substations are 69 kV to 4.16 kV and will be retired over the next five years as a result of the upgrades to the other stations. The retirement and upgrade plan includes adding new bays to the four existing 69 kV to 12.5 kV substations, converting one 4.16 kV substation to 12 kV, improving the communications systems, and redesigning the integration and automation architecture.

The existing integration and automation system utilizes a PLC as the substation controller. Using discrete inputs and outputs interface modules, interposing relays, and serial communications to IEDs via a communications processor and direct connection, substation data are collected by the PLC and then passed from the PLC to the SCADA master via 9600 baud radios. A leased line and modem are connected directly to the communications processor, acting as a port switch that provides engineering access to the IEDs to which it is connected.

Rather than propagate the existing substation integration and automation design as substations are upgraded, Mesa engineers developed an alternative that incorporates existing IEDs and improves the integration and automation, while also simplifying the architecture. The result eliminates equipment and reduces configuration, installation, commissioning, and maintenance costs. The new design also adds capabilities including remote access to nonoperational data from all substation IEDs.

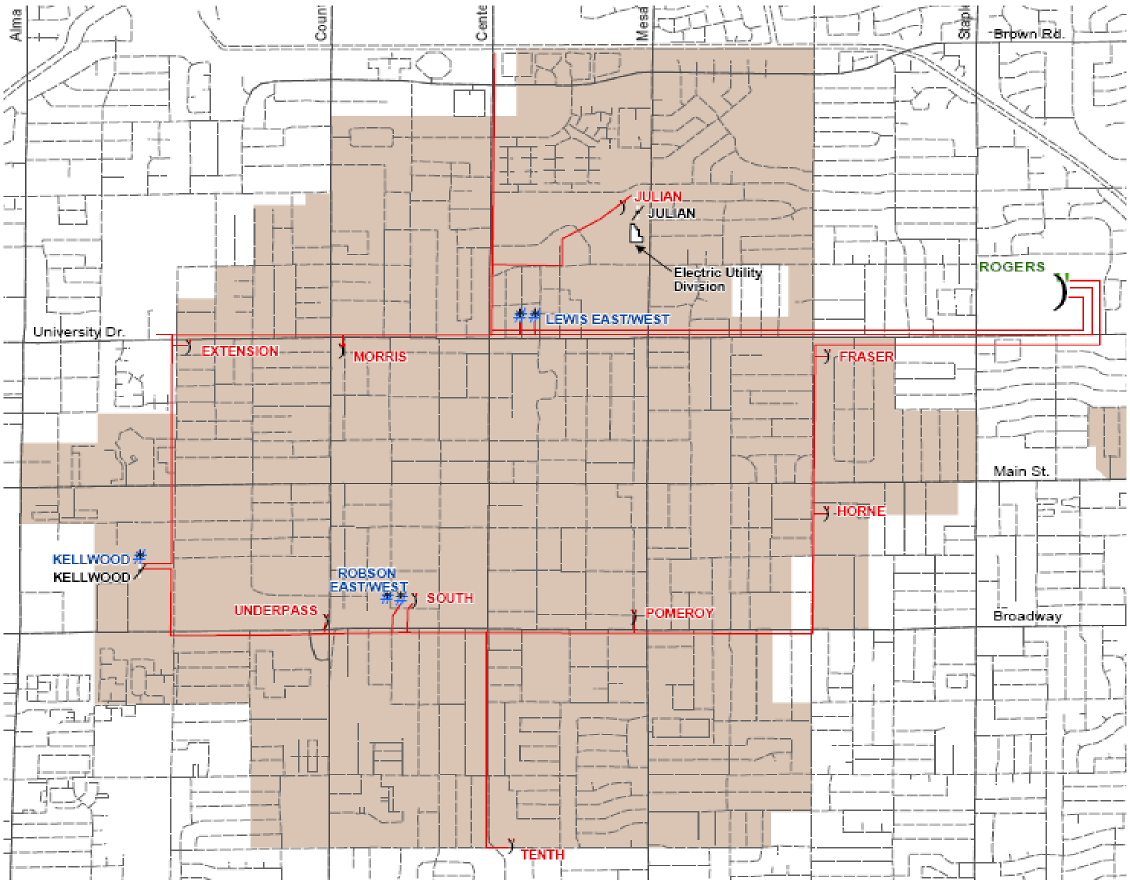


Figure 1 City of Mesa Substation Locations

Robson Substation Expansion

Robson is the City of Mesa's first new substation addition since 1999. A new bay with a second transformer and additional feeders was installed to increase capacity and reliability of the electrical system in the downtown and southern areas of the city. Improvements made at this station will be used as a model for all future substation upgrades. These include a fiber-optic network that transmits data back to the Utility Control Center (UCC) to support the SCADA master and provides engineering access to all substation IEDs. Now that the new system is installed, a positive evaluation of this pilot implementation will become the model for the ongoing conversion of the remaining 12 kV circuits.

Existing PLC-Centric Design

Prior to the upgrade, all substations used an integration architecture that included a combination of a PLC, direct-wired I/O via transducers, communications processor, microprocessor-based relays, and a revenue class meter. The PLC utilizes I/O modules and terminal blocks to hardwire all substation discrete inputs, including feeder alarms and statuses, transformer alarms, battery monitor alarms, and substation security alarms. Remote controls issued from the SCADA master use PLC control output modules and interposing relays. A communications processor, utilizing EIA-232 serial ports, collects instantaneous metering quantities and target statuses directly from the multiple connected relays, concentrates the data into a single database, and passes them to the PLC using a single serial Modbus® protocol connection. A revenue meter passes its data directly to the PLC via a serial Modbus protocol connection. The PLC, acting as a substation controller, concentrates the data from its input modules, the communications processor, and the revenue meter into a single station database and then passes it up to the SCADA master at the UCC. The PLC receives controls from the SCADA master and executes corresponding commands to hardwired output modules and interposing relays. The SCADA master to PLC communications link is a 9600 baud Modbus protocol connection via radio. A modem is connected directly to the communications processor, which provides dial-up engineering access to each of the relays connected to the communications processor, acting as a single-point-of-contact port switch.

Robson Upgrade Design

Because the PLC-centric design required extensive I/O wiring, interposing relays, additional protocol modules, and configuration expertise, Mesa engineers initiated a program to investigate alternatives. This included attending vendor seminars and interviewing other utilities with successful substation integration and automation systems. The results of this investigation produced the following requirements.

- Eliminate the PLC
- Reduce I/O wiring
- Use data within existing protection relays
- Use serial communications wherever possible to collect local SCADA data
- Use protection relays to implement local automation
- Use new fiber-optic network communications system for remote SCADA and engineering access
- Provide integrated communications compatible with the existing online SCADA master
- Ensure compatibility of integration and automation system with the new security system
- Provide an upgrade path to implement a future sequential events recorder (SER)

From these requirements, a new architecture was developed and a decision was made to implement a pilot project to redesign and upgrade the Robson integration and automation system. Upon completion and a successful evaluation period, this design will become the standard for the remaining substation upgrades.

The vendor was selected based on the City of Mesa's past experiences with their equipment and support, along with new product technologies that offered seamless integration with existing protection relays and capabilities to meet the additional requirements of the new integration and automation design.

The vendor submitted two proposals. The first was to provide a complete system, including equipment, integration configuration settings, installation, commissioning, and training. The second proposal provided up-front training on new equipment and configuration software followed by scheduled support to Mesa engineers during the configuration, installation, and commissioning process.

The second proposal was chosen for two reasons: first, by acquiring a detailed understanding of the equipment, configuration, and implementation (through application-specific training and hands-on experience), Mesa engineers and technicians would be in a position to lead the implementation of additional substation upgrades. Second, with a thorough understanding of equipment application capabilities and configuration, future application upgrades could be undertaken by Mesa personnel.

INTEGRATION AND AUTOMATION REPLACEMENT

Substation Controller

The first objective was to replace the substation controller. Mesa personnel had utilized only a few of the capabilities of the communications processor in the previously existing substation installations. Analysis of the remaining features, along with additional functionality offered in newer models, revealed that the communications processor was a flexible replacement for the PLC as the substation controller. This change simplified the system in three important areas:

1. Eliminating the PLC and using data communications interfaces to acquire SCADA data eliminated discrete I/O wiring, interposing relays, and termination work.
2. Selecting equipment from one manufacturer allowed full use of the additional integration features.
3. Common software applications and configuration management tools reduced development, testing, and commissioning time.

Communications Processor

The communications processor communicates directly to the protective relays using serial communications. This provides simple, robust access to relay metering, target elements, and I/O statuses. Once the communications processor acting as a client to the IEDs collects the data, additional processing is available, including analog scaling, arithmetic calculations, and Boolean logic. Delivering processed data to the SCADA master is accomplished by configuring a separate serial port to serve these system data via the master protocol. In this fashion, data resident in the new and preexisting relays and other IEDs are provided to the SCADA master via the communications processor acting as a client server on a substation LAN.

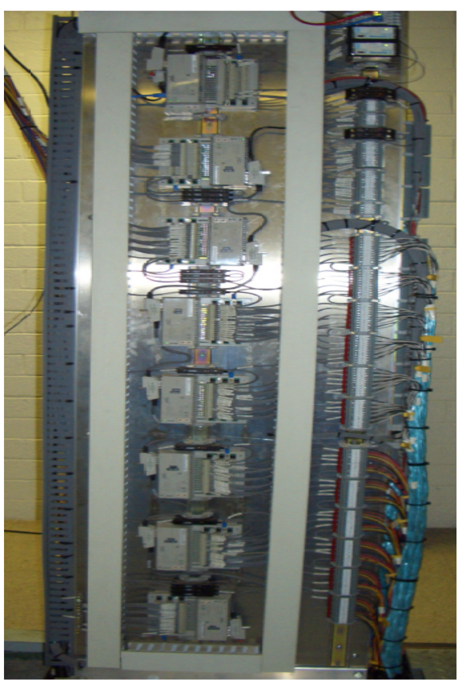
For the new 12 kV circuit in the Robson installation, the communications processor is configured to poll five protection relays for instantaneous metering, relay target elements, and I/O statuses. Once collected, station-specific algorithms created via settings, rather than code, are used to process the data and complete the station-wide database. Processing includes analog scaling, summing megawatts and megavars, and monitoring and recording the communications status to each relay. An additional serial port is configured as a Modbus protocol server for the station-wide database to send relay data directly to the SCADA master.

Providing I/O statuses directly from the relay eliminates redundant wiring previously used by the PLC to report the same data. The capability to flexibly configure the database layout allows the communications processor to present data in the same format, both data type and sequential order, as previously provided by the PLC in the existing system. This significantly reduced the configuration time and effort to integrate a new substation bay and associated substation controller into the existing SCADA master database and HMI displays.

Figure 2 Utilizing Relay I/O to Eliminate PLC I/O

Automation and Control

The traditional communications capabilities of the communications processor support existing remote breaker trip/close via relays, rather than the PLC, without requiring changes to the communications with the SCADA master. The communications processor's ability to accept and redistribute multiple control types in conjunction with the relay's capability to implement automation logic enhances the system by permitting the SCADA master to implement remote automation. Newly added remote automation functionality performs reclose enable/disable, ground enable/disable, and remote control enable/disable. The PLC control modules and interposing relays previously used for remote control were eliminated.



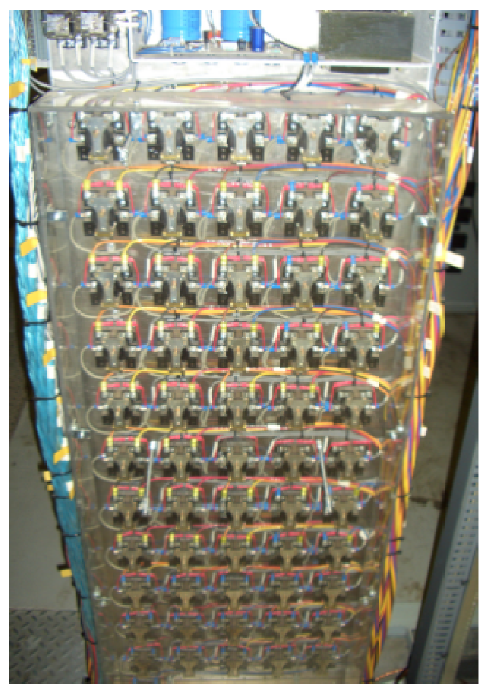


Figure 3 Using the Communications Processor's Multifunction Control Capabilities Eliminated all of the PLC Inputs, Control Outputs, and Interposing Relays Shown in These Two Photos

I/O Processor

The last hurdle in the PLC replacement process was to integrate the analog transducers, status inputs, and breaker control from the transformer monitor and report the results to the SCADA master. This was accomplished by instrumenting the analog and digital transformer information using an I/O processor IED that in turn communicated the measured and processed values directly to the communications processor using serial communications. The I/O processor utilizes configurable input and output cards, which allow Mesa personnel to satisfy the present installation, and also provide a path for future expansion. One analog input card with configurable input levels and two discrete inputs cards are used to acquire transformer temperatures and statuses, including oil temperature, low SF6, fan statuses, LTC operation counter, raise/lower limit, and temperature alarms. A remote controlled output was also implemented for breaker control from SCADA via the communications processor.

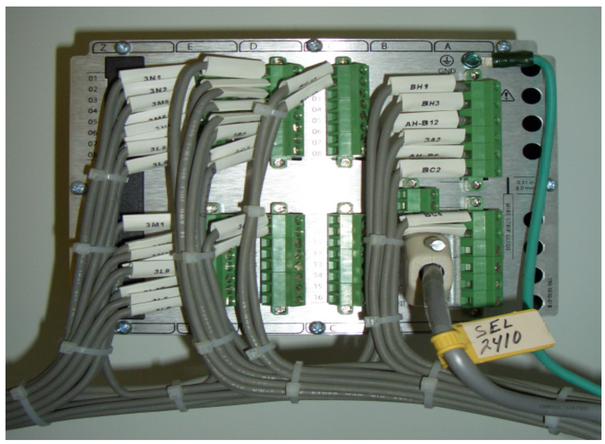


Figure 4 Transformer Monitor Wire Terminations to I/O Processor Analog and I/O Cards and Serial Connection to the Communications Processor

Revenue Meter

The previously existing revenue meter included a data communications interface directly connected to the PLC using Modbus protocol. The PLC included the meter data in its response to the polling SCADA master. As part of the upgrade, a new meter with more capabilities and improved integration features was chosen and connected directly to the communications processor. The communications processor now passes all required meter data to the SCADA master while also providing engineers with remote access to nonoperational data and meter configuration not accessible in the PLC-based system.

Engineering Access

In addition to acting as the real-time client server for the SCADA system, the communications processor also provides engineering access to each of the connected IEDs. Using this capability, Mesa engineers remotely access all nonoperational data, including relay events, energy and load profile reports, equipment diagnostics, as well as view and/or change IED settings without interrupting the collection of real-time SCADA functions.

```
=>LDP

FEEDER 1                         Date: 10/18/05    Time: 09:28:52.500
STATION A                                          Time Source: IRIG

FID=SEL-734-R111-V0-Z004001-D20050617       CID=0720

#          DATE      TIME        IA        IB        IC       VAB      VBC      VCA
11      10/18/2005 08:00:00   152.91    152.35    152.38    12.54    12.51    12.52
10      10/18/2005 08:15:00   177.46    176.86    176.77    12.54    12.51    12.52
9       10/18/2005 08:30:00   187.46    186.85    187.02    12.53    12.53    12.52
8       10/18/2005 08:45:00   199.42    198.83    198.94    12.53    12.52    12.51
7       10/18/2005 09:00:00   286.54    284.70    285.66    12.54    12.51    12.51
6       10/18/2005 09:15:00   527.59    522.92    524.36    12.53    12.51    12.52
5       10/18/2005 09:30:00   555.10    555.07    554.83    12.53    12.52    12.52
4       10/18/2005 09:45:00   193.99    193.42    196.70    12.53    12.51    12.52
3       10/18/2005 10:00:00   736.36    729.84    731.76    12.54    12.51    12.51
2       10/18/2005 10:15:00   750.56    743.69    746.83    12.53    12.52    12.51
1       10/18/2005 10:45:00   840.86    832.46    835.87    12.53    12.52    12.52
```

Figure 5 Example of Nonoperational Data Available to Engineers Using Remote Access Through the Communications Processor

The communications processor accepts an IRIG signal from a satellite clock and distributes it to the connected relays, I/O processor, and meter. These IEDs use this common time reference in both SCADA and nonoperational data reports. This provides a common time reference when reviewing data for post-disturbance analysis.

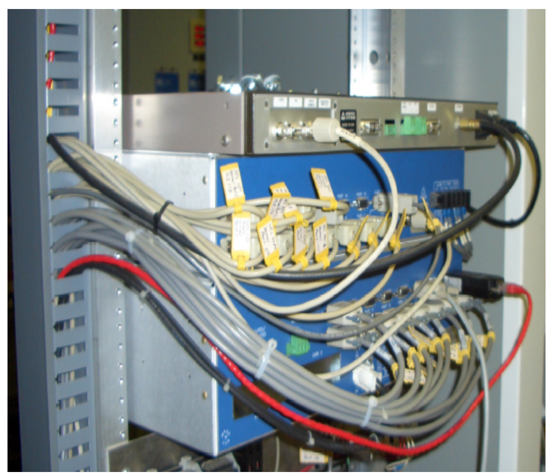


Figure 6 Satellite Clock, Communications Processors, and IED Data Communications

Communications

The previously existing 9600 baud radios communicated SCADA data from the PLC to the UCC. A leased line and modem previously connected to the existing communications processor provided engineering access to the associated protective relays. These connections have been replaced with a single one-gigabit fiber-optic Ethernet network. The first installation is Robson substation; additional installations will occur as the remaining substations are upgraded. Eventually, all substations will be on a single protected LAN with multiple subnets. This is accomplished by installing intelligent switches at the substations and the UCC. The initial implementation of this network is for use by the utility’s divisions for SCADA and engineering access only. Adding new applications will be based on the ability to maintain a secure network for these functions.

Even with the communications bandwidth significantly increased via the Ethernet network, Mesa planned to continue to use their existing serial communications at the SCADA front-end server during the transition period. Further, they chose to maintain serial interfaces to the engineering access equipment and software tools. Therefore, it was decided to use a technique referred to as “serial tunneling” to pass the existing, proven serial links over Ethernet links. SCADA connections continue at the existing data rates without requiring modification of the front-end server equipment. Also, utility engineers use a network Telnet connection to access nonoperational data and implement vendor software applications to remotely retrieve event reports and retrieve/send IED settings.

The SCADA connection is implemented using serial-to-Ethernet converters at both ends that allow the SCADA master front-end serial server interface to tunnel through the network to the communications processor. The engineering access connection uses a serial-to-Ethernet converter at the communications processor, which provides Telnet capabilities for application software access from anywhere on the utility’s network to all substation IEDs.

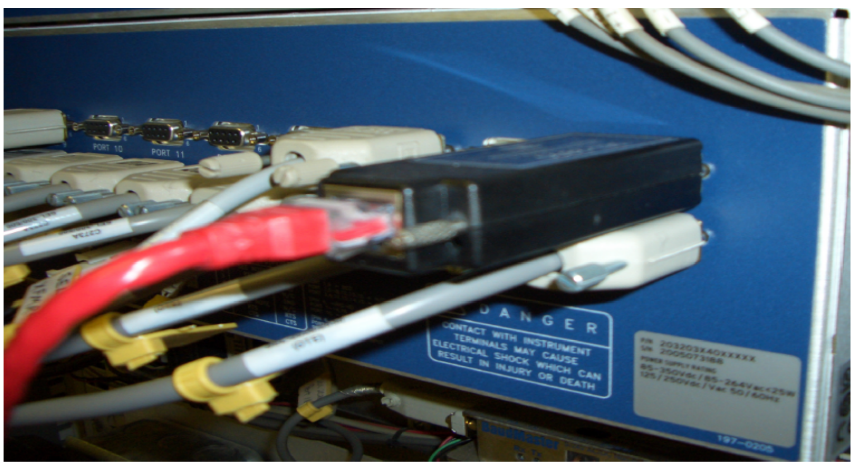


Figure 7 Serial-to-Ethernet Converter on the Communications Processor for SCADA Access

Configuration of the serial-to-Ethernet converters requires serial port communications parameters, IP address, and tunnel IP address. Once configured, one was connected directly to the communications processor, and the other was connected to a serial port at the SCADA master front-end server. Together, they provide a direct connection through the fiber-optic network.

```
#>show
PORT          = 23
TUNNEL        = TELNET
TUNNEL_IP     = 10.201.0.11
SPEED         = 9600
STOP          = 1
PARITY        = NONE
FLOW          = NONE
RTS_LOW       = N
IP            = 10.201.0.10
SUBNET_MASK   = 255.255.255.0
GATEWAY       = 0.0.0.0
```

Figure 8 Communications Processor Serial-to-Ethernet Transceiver Configuration

```
#>show
PORT        = 23
TUNNEL      = TELNET
TUNNEL_IP   = 10.201.0.10
SPEED       = 9600
STOP        = 1
PARITY      = NONE
FLOW        = NONE
RTS_LOW     = N
IP          = 10.201.0.11
SUBNET_MASK = 255.255.255.0
GATEWAY     = 0.0.0.0
```

Figure 9 SCADA Master Serial-to-Ethernet Transceiver Configuration

Control Center HMI

The City of Mesa Utility Control Center (UCC) includes operations for both water and power systems. Minimizing the impact on system operations was critical in determining the final substation integration and automation design. Important aspects of this integration included:

- Modbus database configuration at the substation controller
- Emulation of serial communications over a fiber-optic network
- Addition of new substation controllers in the bay expansions without disrupting existing systems
- Use of existing data maps in the new substation controller
- Support of existing SCADA screen templates by the new substation controller
- Addition of previously unavailable substation automation remotely controlled by SCADA via the substation controller
- Ability to quickly replace existing PLCs with the new substation controller without difficult and time-consuming changes to the SCADA master

Database Configuration

Minimizing the integration time of the communications processor required a database layout that emulates existing substation databases and screen templates. This included collecting data from the existing substation IEDs and the new IEDs included in the upgrade, concentrating and building a complete substation database, and then delivering it in a format that would allow easy integration with existing human-machine interface (HMI) display templates. This was accomplished using the communications processor's ability to collect, filter, concentrate, and flexibly organize data into any number of formats before communicating these data to the SCADA master. The communications processor now sends data that exactly match the requirements to support the existing screen templates so that new screens are uniform and simple to create.

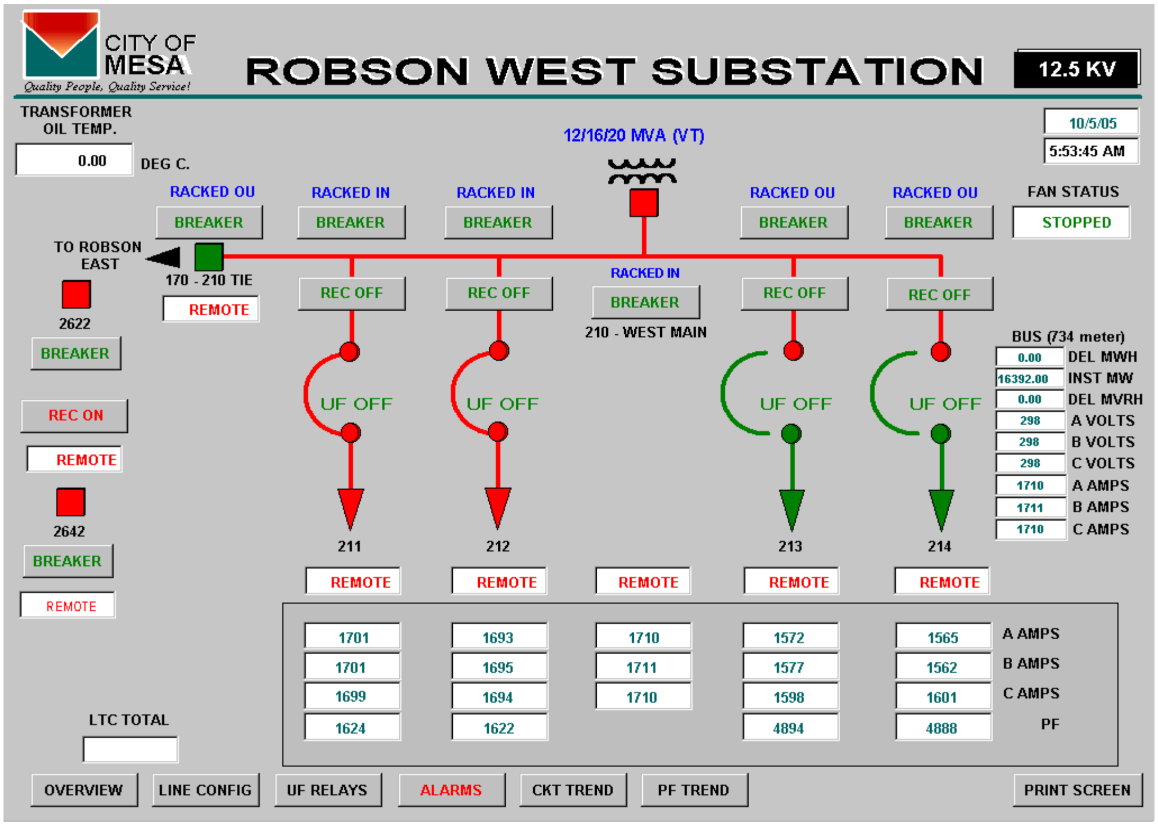


Figure 10 Robson SCADA HMI Display Using the New Communications Processor as the Data Source

Substation Security

Security for the existing substations consists of multilevel password protection for engineering access to substation IEDs. Because of the ongoing changes in substation security requirements, Mesa chose to upgrade to a system coordinating intrusion detection and multilevel passwords at the substation level, with security policy management at the UCC level. For the Robson upgrade, this includes the Ethernet switch and integrated security software at the substation working in conjunction with the security policy management software at the UCC. Details are intentionally removed from this public document.

Engineering Access

The switch software provides intrusion detection capabilities by inspecting all network traffic entering and leaving the substation, including the Data Link Layer (MAC address and Ether Type), Network Layer (IP address and IP protocol), and Transport Layer (TCP or UDP). The policy management software defines specific rule sets used by the substation switch to set up an individual access policy for all utility engineers and technicians. These rules incorporate MAC and IP addresses used to determine individual user authentication and access into the Robson substation switch. If the connection is allowed, the substation controller and connected IEDs use additional multilevel password protection and settings to determine which IEDs are accessible and at what level. Capabilities vary by access level and include connect only, read only, control implementation, and settings modification. Details are intentionally removed from this public document.

SCADA

Using the security software's capability to identify destination and source MAC and IP addresses and the ability to inspect individual message frames, Modbus polling messages can be monitored for abnormal conditions and alarms generated. Details are intentionally removed from this public document.

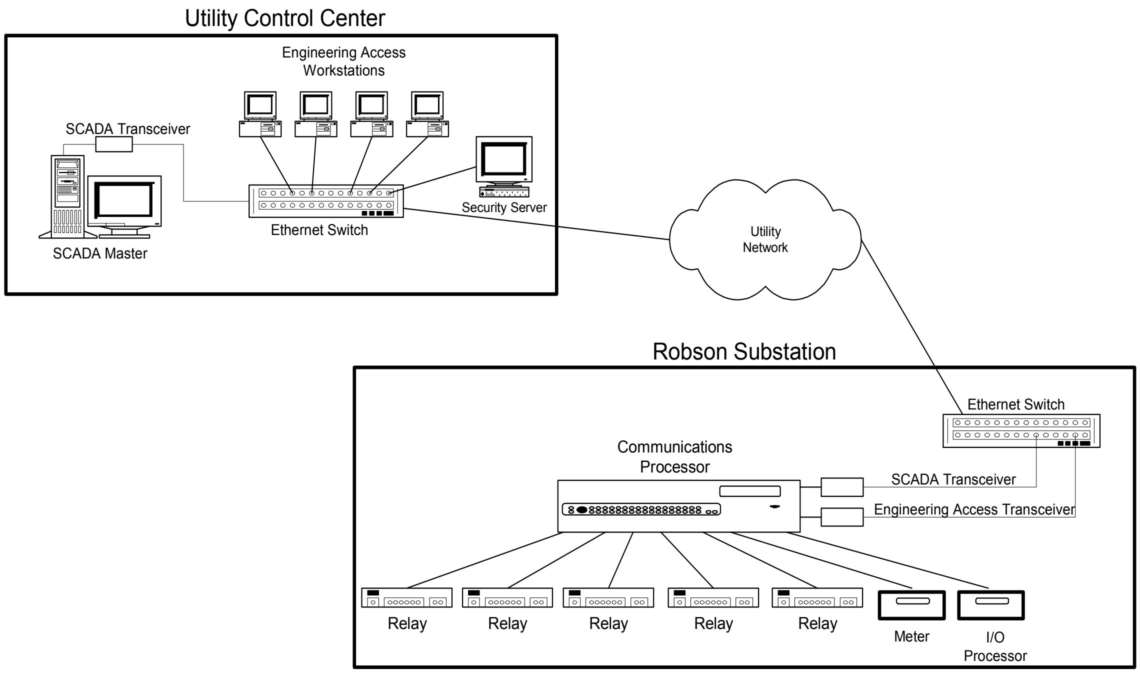


Figure 11 Robson Substation's New Integrated Communications With the Existing SCADA Master

FUTURE SEQUENTIAL EVENTS RECORDER UPGRADE

After the Robson substation pilot project evaluation period is complete and all remaining substations are upgraded, Mesa is planning to implement yet another communications processor feature at all substations to provide a system-wide SER. This will be easily done due to the choice of a communications processor that already supports IED SER. In order to get these SER data into the SCADA system, Mesa plans to change the SCADA communications to DNP LAN/WAN. This migration has been simplified because the communications processor being used is field upgradeable to network protocols via an optional interface card. Once DNP LAN/WAN is supported by the SCADA master front-end server, Mesa engineers simply need to create a DNP map in the communications processor modeled on the existing Modbus maps. This new communication will then be implemented by Mesa on their schedule and at their convenience with the knowledge that the existing Modbus SCADA communications will remain in service in the communications processor should they need it. Mesa plans to migrate to DNP because Modbus does not support a data type that contains both a status change and an associated time stamp required for SER.

The Robson protection relays, I/O processor, and meter all have the capability to record events and associated millisecond resolution time stamps that can be automatically passed to the communications processor. With a settings change, the communications processor will receive the events and time stamps and make them available to a SCADA master using DNP protocol.

Utilizing the network card option, the communications processor can report IED SER information as SCADA data using the integrated DNP LAN/WAN protocol.

Using this configuration, Mesa plans to install a DNP LAN/WAN server at the SCADA master, upgrade the communications processors with Ethernet cards, and modify the settings to change the protocol from Modbus to DNP LAN/WAN while maintaining the existing substation database. This will allow Mesa to collect and maintain a system-wide Sequence-of-Events (SOE) log at the UCC for post-disturbance analysis and system-wide diagnostics and troubleshooting. Added benefits include increasing the SCADA data and engineering access communications to a full 100-megabits connection and eliminating the serial-to-Ethernet conversions, as well as providing support for multiple simultaneous SCADA and engineering access connections.

CONCLUSION

Meeting a utility's substation integration and automation requirements by incorporating IED multifunction capabilities provides an innovative and cost-saving solution for substation integration and automation system upgrades.

Using this process, Mesa replaced old technologies and an unreliable, costly installation with one that untaps existing IED capabilities, new IED innovations, and adaptive communications equipment to integrate new substation integration and automation architecture into an existing SCADA system. Their design reduces equipment and installation costs, simplifies the implementation, testing, commissioning, and maintenance, and adds additional functionality that was not available with the previously existing architecture.

Utilizing the communications processor as the substation controller allows the SCADA master access to relay inputs and outputs previously hardwired directly to the PLC. Integrating the I/O processor with the communications processor simplified the integration of transformer transducer inputs, outputs, and expansion for future upgrades. Replacing the existing meter removed the need for an additional protocol module while providing the SCADA master with all required meter data. Using the inherent integration features in the substation IEDs, Mesa was able to remove the PLC, associated modules, and output interposing relays and terminations from the system.

In addition to replacing the PLC's SCADA functions, the communications processor also provides Mesa's engineers with remote access to all substation IEDs. This includes capabilities to view or modify IED settings using one suite of software applications, collect and record event reports and other nonoperational data from a remote workstation at the UCC, and maintain software configuration control for all substation IEDs.

With the fiber-optic communications and security system in place, Mesa utilized simple low-cost serial-to-Ethernet converters and intelligent substation switches for secure access to substation SCADA data while also providing remote engineer access to all IEDs. This implementation allowed for an easy transition of new substation integration and automation equipment into the existing SCADA system without interrupting ongoing utility operations.

With the increased bandwidth from the fiber-optic system, Mesa recognized they could implement additional applications once all the substations were upgraded. This influenced the equipment selection during the design phase, including the communications processor's capability to field upgrade an optional Ethernet card. Installing this option and making minor settings changes will allow Mesa to convert from Modbus to DNP LAN/WAN, providing UCC operators with faster SCADA polling rates, a system-side SER, and engineering access by multiple users simultaneously. The communications processor technology made the upgrade process successful for the following reasons:

- It was added as a substation controller in the bay expansions without disrupting existing systems
- It communicates in parallel to existing PLC systems until Mesa engineers decide to replace the PLCs with the same or an additional communications processor
- The flexible configuration supports virtually any data map, including those already in use by Mesa
- This flexibility allowed Mesa engineers to configure the communications processor to provide new data from the expansion in such a way that it seamlessly supports existing SCADA screen templates for a common look and feel for the operators
- It eliminated difficult and time-consuming changes to the SCADA master
- It provides previously unavailable substation automation, which is also remotely controlled by SCADA
- The flexible nature of the mix of protocols and communications media supports the initial requirement to match the existing SCADA protocol (serial Modbus) over a new communications media (Ethernet) without requiring changes to the SCADA front-end server
- The communications processor is field upgradeable to support future additions without requiring system changes, including:
  - DNP LAN/WAN
  - IED SER
  - Multiple simultaneous Telnet engineering access connections
- It leverages the available data and capabilities of the robust protection, metering, and I/O processing IEDs
- It represents a system that will be used for both new and replacement systems

BIOGRAPHIES

Dan Darms has over 27 years of experience in the electrical industry, covering nuclear generation construction field engineering, consultant-engineering services to electric utilities, and most recently, as electrical engineer for the City of Mesa Electric utility. This includes over 20 years of substation engineering, design, and construction experience, ranging from 525 kV transmission stations to 4.16 kV distribution stations.

Bryon Gurney began his career with the City of Mesa as lineman in 1994. Since then he has held several positions in support of SCADA communications and remote substation control. His current position is Utility Systems Analyst.

David J. Dolezilek received his BSEE from Montana State University in 1987 and is now the Technology Director of Schweitzer Engineering Laboratories. He is an electrical engineer with management and development experience in electric power protection, integration and automation, communications, control systems, SCADA and EMS design, and implementation. He is the author of numerous technical papers and continues to research and write about innovative

design and implementation affecting our industry. Dolezilek is a patented inventor and participates in numerous working groups and technical committees. He is a member of the IEEE, the IEEE Reliability Society, Cigre working groups, and two International Electrotechnical Commission (IEC) Technical Committees tasked with global standardization and security of communications networks and systems in substations.

Robin Jenkins received his BSET degree from California State University, Chico. From 1984 to 1988, he was employed as a systems integration engineer for Atkinson System Technologies. From 1988 to 1999, he was with the California Department of Water Resources, where he worked as an associate and then senior control system engineer. In 1999, he joined Schweitzer Engineering Laboratories, Inc., where he currently holds the position of integration application engineer, responsible for technical support, application assistance, and training for SEL customers in the Southwest United States.

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