SEL-2032

Communications Processor

Instruction Manual

20151028

SCHWEITZER ENGINEERING LABORATORIES, INC.

⚠CAUTION
Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

⚠ATTENTION
Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.

⚠CAUTION
There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac® no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.

⚠ATTENTION
Une pile remplacée incorrectement pose des risques d'explosion. Remplacez seulement avec un Ray-O-Vac® no BR2335 ou un produit équivalent recommandé par le fabricant. Voir le guide d'utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d'incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.

⚠WARNING
Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.

⚠AVERTISSEMENT
Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.

⚠WARNING
This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

⚠AVERTISSEMENT
Cet appareil est expédié avec des mots de passe par défaut. A l'installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accés non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accés non-autorisé.

⚠DANGER
Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

⚠DANGER
Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.

⚠DANGER
Contact with instrument terminals can cause electrical shock that can result in injury or death.

⚠DANGER
Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.

PM2032-01

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Preface

Manual Overview

This instruction manual will help you through all phases of your SEL-2032 Communications Processor application. This instruction manual will help you understand how to design systems with the SEL-2032 and how to apply the SEL-2032, and it provides a detailed reference to all commands, functions, installation, and operation of the SEL-2032.

Revisions

We revise this instruction manual periodically as we enhance the SEL-2032. It is important to use a version of this manual that is appropriate for the version of your SEL-2032. Use *Appendix A: Firmware and Manual Versions* for descriptions of SEL-2032 modifications and corresponding modifications to this manual.

Manual Contents

Following is an overview of the sections in this instruction manual.

Safety Information and Warnings. The back of the cover sheet contains important safety information and warnings about applying this product.

How to Use This Manual. These pages provide information about manual contents and conventions used in this manual.

Section 1: Introduction and Specifications.

- SEL-2032 features and applications are introduced.
- The general topic of integration and how the SEL-2032 fits into integrated systems are discussed.

Section 2: Installation. This section includes physical installation instructions such as mounting drawings and jumper setup. Also included is an explanation of how to power up, configure, and operate the SEL-2032 in a simple example system.

Section 3: Job Done Examples. Examples of integration systems including SEL-2032 configuration are presented.

Section 4: SELogic Control Equations. This section explains how to write SELogic® control equation settings used in the SEL-2032.

Section 5: Message Strings. This section explains how to write special message strings used in the SEL-2032.

Section 6: Database. This section explains the internal information storage structure of the SEL-2032.

Section 7: Settings. This is a reference guide for SEL-2032 settings.

Section 8: Serial Port Communications and Commands. This is a reference guide for SEL-2032 commands.

Section 9: Protocols. Protocols implemented in the SEL-2032 including DNP3 and Modbus® are described.

Section 10: Testing and Troubleshooting.

- ➤ This section explains how to test and troubleshoot SEL-2032 operation including initial checkout.
- ➤ This is a guide to SEL-2032 maintenance including firmware upgrades and battery replacement.

Appendix A: Firmware and Manual Versions. This appendix lists and describes all firmware versions as well as the changes for each release of this instruction manual.

Appendix B: Firmware Upgrade Instructions. This appendix gives detailed instructions for installing firmware upgrades.

Appendix C: SEL IED Compatibility. Consult this appendix for a list of SEL relays and firmware versions that are compatible with the SEL-2032.

Appendix D: System Planning Sheet. Use this handy sheet to plan and document your SEL-2032 installation.

Appendix E: ASCII Reference Table. This appendix is a guide to ASCII characters and codes.

Quick Reference Cards. This pull-out reference, printed on blue card stock, lists SEL-2032 commands and SEL-2032 message strings.

Task Guide

The following paragraphs provide suggestions for which manual sections will be helpful for specific tasks. In the electronic document form of this manual, the items below are hyper-linked into the document to provide quick and easy navigation.

If this is your first use of the SEL-2032 Instruction Manual, please review the Safety Information and Warnings and this section. This information will prepare you to perform the following listed tasks. This subsection also contains references to additional documents not included in the SEL-2032 Instruction Manual, but available from SEL. Many of these documents are available via our Web site at www.selinc.com.

Specify Part Number to Order an SEL-2032.
SEL-2032 Model Option Table (available at www.selinc.com)

Physical Installation.
Section 2: Installation
Initial Checkout on page 10.4

Learn How to Apply the SEL-2032 in a System.
Section 1: Introduction and Specifications
Section 3: Job Done Examples

Review Features and Specifications.
Section 1: Introduction and Specifications
SEL-2032 Data Sheet
SEL-2032 Product Information Sheet

Collect Data From SEL Relays.
Section 1: Introduction and Specifications
Section 3: Job Done Examples

Collect Data From Non-SEL Devices.
Section 1: Introduction and Specifications
Example 4: Collect Unsolicited Write (Synchrophasor) Data on page 3.18
SEL Application Guides

Provide Data to a Modbus Master.
Section 1: Introduction and Specifications
Example 6: Modbus Job Done on page 3.25
Port Configuration (SET P) and Communication Settings on page 7.2
Modbus RTU Protocol on page 9.8

Provide Data to a DNP 3.0 Master (Serial).
Section 1: Introduction and Specifications
Port Configuration (SET P) and Communication Settings on page 7.2
Serial Distributed Network Protocol (Serial DNP3) on page 9.27
Distributed Network Protocol 3.0 (DNP3) LAN/WAN on page 9.43

Provide Data to a DNP 3.0 Master (Ethernet).
Section 1: Introduction and Specifications
Distributed Network Protocol 3.0 (DNP3) LAN/WAN on page 9.43

Install Protocol Cards.
SEL-2701 Instruction Manual
SEL-2711 Instruction Manual (no longer available)

Upgrade Firmware.
Appendix B: Firmware Upgrade Instructions

Replace Battery.
Battery Replacement on page 10.5

Provide Ethernet Connections.
SEL-2701 Product Information Sheet
SEL-2701 Instruction Manual
SEL-2890 Product Information Sheet
SEL-2890 Instruction Manual

Use SEL-2032 as a Port Switch.
Intelligent Port Switch on page 1.2
Example 2: Using the SEL-2032 as a Port Switch on page 3.4
Port Configuration (SET P) and Communication Settings on page 7.2

Time Synchronize Relays.
Time Synchronization Source on page 1.2
SEL Relay Instruction Manuals
SEL-5801 Cable Selector Software (available at www.selinc.com)

Factory Assistance

We appreciate your interest in SEL products and services. If you have any questions or comments, please contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 USA
Phone: +1.509.332.1890
Fax: +1.509.332.7990
Internet: www.selinc.com
E-mail: info@selinc.com

Typographic Conventions

Example	Description
ACCESS or ACC	Commands you type appear in bold/uppercase. You need to type only the first three letters of a command.
<Enter>	Computer keys you press appear in bold/brackets.
SET	Relay front-panel pushbuttons you press appear in bold/uppercase/curly brackets.
<Ctrl+D>	Multiple computer keys you press appear in bold/brackets and are separated by a “+” sign.

Output screen images appear boxed and in the following format:

```
COMMUNICATIONS PROCESSOR - S/N 95012004   Date: 03/02/95  Time: 15:38:33
```

Section 1
Introduction and Specifications

Introduction

The SEL-2032 Communications Processor provides many special features needed in today's substations to communicate with a variety of microprocessor-based devices. The SEL-2032 can function as a simple, but intelligent, port switch; or it can provide sophisticated communication and data handling capability required for advanced substation integration projects. This section provides the following:

- Introduction to the SEL-2032 and information on features, applications, and specifications.
- Introduction to the terminology, concepts, and operation of integrated substations and communications processors.

Applications

The functions of the SEL-2032 make it extremely versatile and powerful. You can combine basic functions of the SEL-2032 to meet the requirements of your application. Often the cost of the SEL-2032 is justified based on a single major function, and other features add additional value to your application. Several of the most popular applications are listed below.

Substation Integrator

The communication processing and database capability of the SEL-2032 are designed to collect and store data from numerous devices, parse it into useful pieces, and distribute just the needed data to other devices or systems. This is the fundamental purpose of substation integration, making the SEL-2032 a natural choice for this application. Its networking capabilities allow it to be the communication network for small substation integration projects, or it can serve as a subnetwork integrator with one or more ties to a larger substation network.

SCADA and HMI Interface

The SEL-2032 can be interfaced with a variety of devices, including RTUs and HMIs. The SEL-2032 can serve as a data concentrator, to be polled by a local RTU, or it can be connected to a dedicated SCADA communication circuit and polled by a central device.

Intelligent Port Switch

Flexible communications parameters make the SEL-2032 a great choice for almost any port switching application. The multitasking/multiuser capability and data handling capability make the SEL-2032 more of a self-contained network hub than a port switch, but it is still an economical choice for port switching applications. The time synchronization capabilities of the SEL-2032 add to its value in this application.

Time Synchronization Source

The SEL-2032 transmits a demodulated IRIG-B signal on Ports 1–16. You can connect this signal to SEL and non-SEL devices. The SEL-2810 multiplexes the IRIG-B signal on the single fiber pair along with other communications. The source for the transmitted IRIG-B signal is either the IRIG-B input to the SEL-2032 or the SEL-2032 internal clock. You can time synchronize the SEL-2032 clock in several different ways.

You can set the SEL-2032 clock using the **TIME** and **DATE** commands. A battery maintains the clock operation during loss of power to the SEL-2032. You can also synchronize the SEL-2032 via a modulated or demodulated IRIG-B signal input on the BNC connector labeled IRIG-B IN. There is also a jumper that allows you to configure the IRIG-B pins on Port 15 as a demodulated IRIG-B input (see *Jumper Settings on page 2.1*).

You can also use time synchronization through serial protocols such as DNP3 and hardware protocol cards (see *Section 9: Protocols*) or the instruction manual for your protocol card for more information.

Substation Integration

The term integration is defined as the process of blending disparate parts into a unified whole. In a substation environment this means providing communications pathways so that the individual IEDs (Intelligent Electronic Devices) function as a single substation monitoring, control, protection, and automation system.

Since SEL introduced the first microprocessor-based protective relay as a standard product to substation engineers, devices within the substation have become more and more intelligent. Substation IEDs include protective relays, battery chargers, equipment monitors, weather stations, and many other devices. IEDs now perform multiple functions and can contain measurement data, status, control, settings, historical information, and alarms. Each IED often performs the functions of several devices within a substation, but for a portion of the substation associated with a single bay or circuit breaker. A function that is performed by many devices each working on a small part of the whole is called a distributed function.

Substation integration is the process of providing communication and other connections between IEDs to take advantage of distributed functions that the IEDs offer. The paragraphs below describe distributed functions that are common in integrated substations. *Figure 1.1* is a diagram of a typical integrated substation. The IEDs are integrated into a system by the SEL-2032.

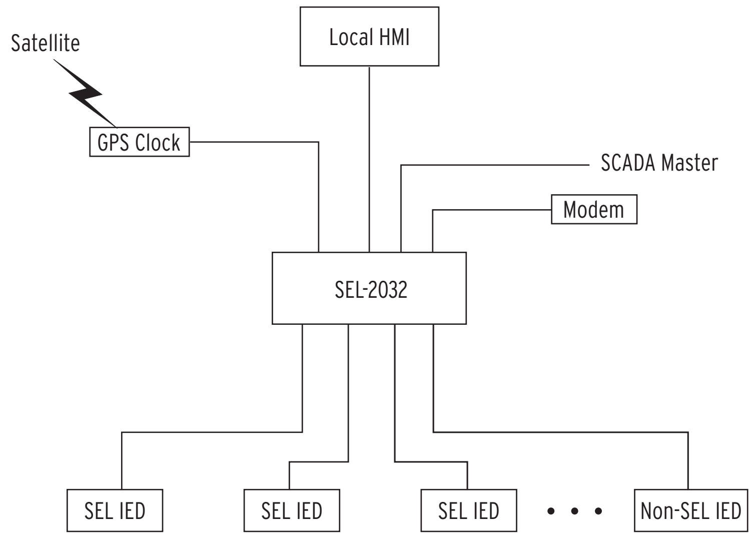

Figure 1.1 Typical Integrated Substation System

Distributed Functions

Before microprocessor-based IEDs, engineers used large single-function devices to perform specific substation monitoring, control, and data collection tasks for the entire substation. For example, if you wanted to collect fault event records (oscillography of fault conditions observed from the substation), you installed a fault recorder with many analog input channels. The fault recorder required additional input wiring and added significantly to the expense of the protection system.

The expense of dedicated fault recorders made it prohibitive to record faults in typical distribution substations. While fault recorders are still used in very demanding transmission substation applications, the fault recording capabilities of microprocessor-based protective relays are rapidly approaching those of separate fault recorders. Fault recording in inexpensive distribution relays allows a new level of fault analysis capability throughout the utility.

Another example of a distributed function is the collection of status and measurement data from remote control or SCADA (Supervisory Communications and Data Acquisition). SCADA systems in the past have been constructed as shown in *Figure 1.2* using an MTU (Master Terminal Unit) and many RTUs (Remote Terminal Units).

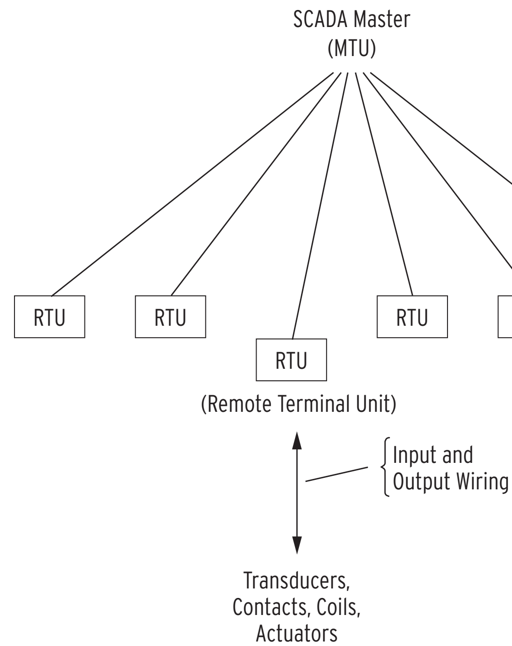

Figure 1.2 Traditional SCADA System

The RTU is the data collection and control interface for the local station. Traditionally, data collection and control were performed by connecting inputs and outputs on the RTU to station equipment. This wiring is complex, expensive, and makes substations more expensive to build and test and less reliable.

Multifunction IEDs require inputs and outputs in order to perform their primary function. For example, relays require connections to PTs (potential transformers) and CTs (current transformers) to observe the power system and perform protection functions. The RTU requires the same voltages and currents in order to display analog measurements to system operators. The RTU also must collect status data for the circuit breaker and other substation equipment monitored by the relays.

It is possible to replace the input and output wiring to the RTU with data communications to the IEDs as shown in *Figure 1.3*.

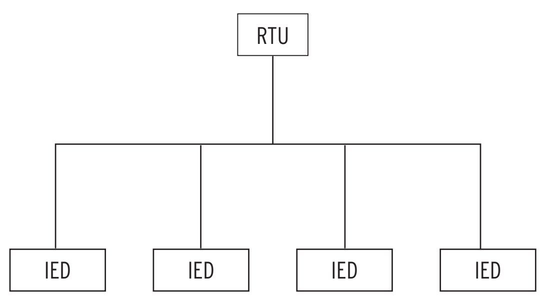

Figure 1.3 IEDs Communicating With RTU

One might be tempted to describe the system in *Figure 1.3* as an integrated substation, but it is only an example of a distributed RTU system. There are more distributed functions that can be integrated as well as other functions that integrated substations perform.

Integrated Substation Functions

In order to design an integrated substation, you must start by defining the jobs that you wish the integrated substation system to perform. The list below summarizes the most popular functional categories that integrated systems perform:

- **Remote status and measurement data collection and control for SCADA.** Collecting data from the IEDs and additional inputs for display to operators through a SCADA system. Coordinating controls from SCADA with local permissives.
- **Local HMI (Human Machine Interface).** Display of local status and measurement and control often used for local maintenance operation or backup local operation in the event of a SCADA failure.
- **Time synchronization.** Synchronizing the time clocks of the IEDs so that time referenced data can be compared between IEDs.
- **Distributed automation.** Basic station automation and control performed in IEDs rather than a central automation processing platform like an RTU or PLC (Programmable Logic Controller). This may also include dedicated control such as capacitor bank control.
- **Engineering and maintenance information management.** The collection, storage, and communication of historical, event, and collected data that are used for fault analysis, maintenance scheduling, system planning, and other engineering tasks. For example, fault records and circuit breaker monitoring reports are collected by protective relays and made available for engineering through the system.

Integration With the SEL-2032

The SEL-2032 combined with SEL relays, non-SEL IEDs, and SEL software solutions forms a comprehensive approach to substation integration. If we consider the five basic functional categories listed in *Integrated Substation Functions on page 1.5* and construct a system out of conventional components, we start with the system shown in *Figure 1.3*. In *Figure 1.4* we use a multidrop network to connect the IEDs to the RTU and provide basic control and SCADA monitoring functions.

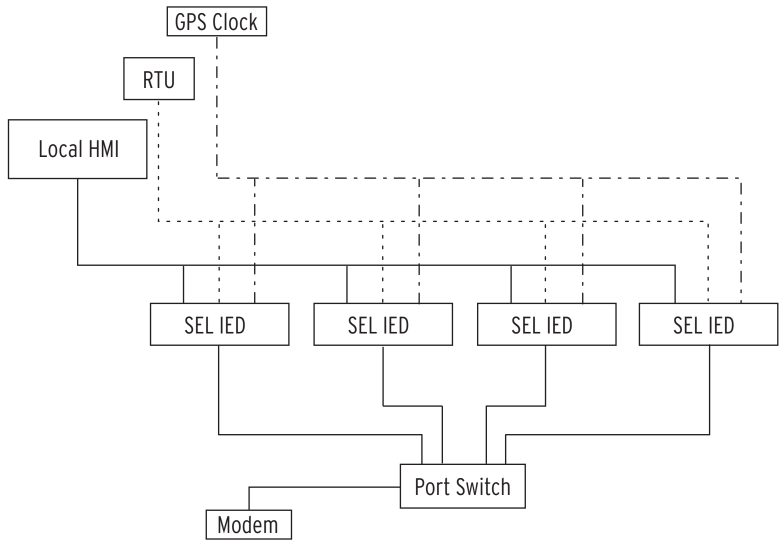

Figure 1.4 Integrated Substation Without a Communications Processor

In addition to the RTU connection, we add a substation PC for local HMI functions and connect it via a separate multidrop network to the IEDs. We provide time synchronization through an IRIG-B signal from a GPS clock. We must connect the clock to each device with an IRIG-B input. This requires that we run coaxial cable to all devices in a third multidrop connection.

After we apply the first three networks, we still have no connection for engineering and analysis information. In this case we will assume that engineering connections are to be made via a dial-up modem connection. We then connect the modem to a port switch and connect the port switch to each IED.

Next, we create a system that performs the same functions using the SEL-2032 and a similar number of IEDs. In the example shown in *Figure 1.5*, we use SEL IEDs, but you will see as we look more closely at the SEL-2032 that you can utilize many non-SEL IEDs with the SEL-2032.

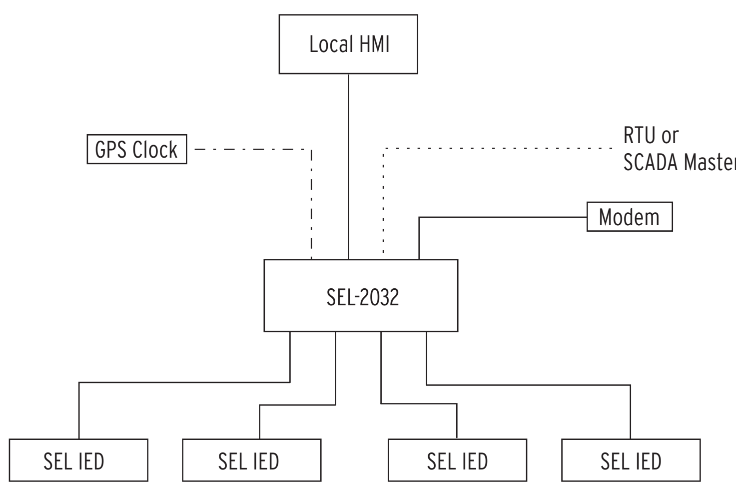

Figure 1.5 System Integrated Using the SEL-2032 Communications Processor

SEL Protocol

In the system shown in *Figure 1.5,* there is one cable between the SEL IEDs and the SEL-2032. The communications protocol used on this link is the SEL family of binary and ASCII messages sometimes called SEL Interleave. This powerful protocol and the combination of IRIG-B on the 9-pin serial ports of the IEDs and SEL-2032 allow you to use one cable and provide functions in all of the basic integration areas.

Because the messaging is interleaved, an engineering connection through the modem does not halt the collection of status and measurement data for SCADA. The ASCII engineering connection shares the cable with the binary data collection and control messages.

Using this SEL protocol, you can take advantage of a feature of the SEL-2032 called auto-configuration. When you connect an SEL IED to the SEL-2032, you can initiate an auto-configuration process where the SEL-2032 learns about the IED and what information and control points are available to the SEL-2032.

Star Network

The SEL solution is a star network. This means that the system is inherently more reliable. The star network is not subject to the same modes of failure as a multidrop network that can cause all network operation to cease. Unlike RTUs, industrial PCs, and other integration solutions, the SEL-2032 is built and tested to the same standards as SEL protective relays.

In a star network architecture, the central node can be a possible single point for failure. Because the SEL-2032 is many times more reliable than traditional integration solutions, the SEL-2032 system is many times more reliable than systems constructed of multiple single-purpose networks. You can also increase reliability by adding a second SEL-2032 and making independent connections to the IEDs. This increased reliability configuration is still simpler to cable, install, and design than the solution shown in *Figure 1.4*.

The star network is also less expensive to build. First, there is only one cable per device requiring less wiring and fewer chances for mistakes and future failures. Second, you can use fiber-optic cables and SEL fiber-optic transceivers to provide the ultimate in noise immunity and electrical isolation without expensive and unreliable star couplers. The SEL solution is the only integration system that allows you to distribute high-accuracy IRIG-B timing signals via fiber-optic cables rather than coaxial cable.

If you are integrating non-SEL devices, the independent point-to-point connections of the star network allow you to integrate devices with different protocols and different communication speeds and media without having to convert all devices to a common connection type and protocol.

Benefits of the SEL-2032 Solution

Supports Multiple Data Consumers

The elegance of the SEL solution is the capability of the SEL-2032 to supply independent data or connections to different data consumers. For example, the data that you send to the SCADA system may be different than the data that you send to the HMI. The protocol and physical interface may also be different. Rather than connecting each system to the IEDs, you can collect data once from the IEDs and then prepare a concentrated, aggregated, independent data set for each data consumer.

Insulates IEDs From Integration Issues

When you use the SEL-2032, you perform many integration tasks and provide integration interfaces to the SEL-2032 rather than directly to the IEDs. This means that you have the best possible chance of leaving the IEDs undisturbed as your integration system evolves or changes.

For example, the field of substation integration is changing rapidly. The SEL-2032 allows you to integrate a system today and provide serial links to data consumers. In the future you can upgrade the SEL-2032 to provide additional protocols or install a communications card and add new connections without disturbing the IEDs. This is a key concern if the alternative system would require upgrading and recomissioning protection functions within IEDs in order to enhance your integration system.

You can also use the SEL-2032 to provide high-speed network connectivity rather than pay for it on each individual device. This means that your system will be much more economical and lets you take advantage of existing serial EIA-232 IEDs rather than replacing IEDs when upgrading a system.

Improves System Performance

When you replace a multidrop network with the SEL-2032, the SCADA data reaches the RTU or SCADA master more quickly. The reason is that the star network collects data from all IEDs in parallel rather than round-robin polling. Testing with an example system shows the difference. For a substation with seven IEDs, the data latency (time from field event to data available in master device) from the IED to an HMI is 1.5 seconds for a multidrop network and 1.1 seconds for an SEL-2032 star network.

Scales to Substation Size

The number of ports on a single SEL-2032 is not a limit to the size of the system that you can construct. The SEL-2032 contains special features that allow multitiered systems such as the one shown in *Figure 1.6* to let you integrate large numbers of station IEDs.

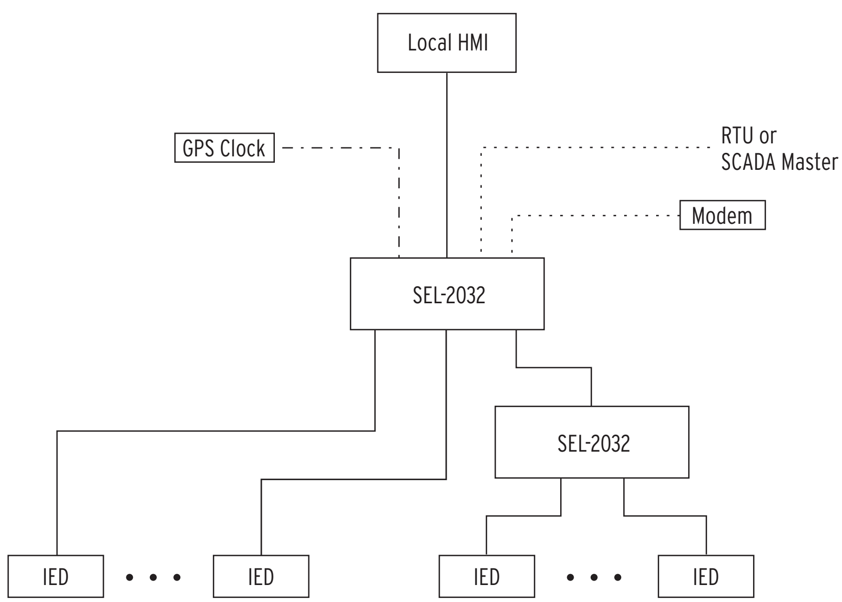

Figure 1.6 Multitiered SEL-2032 System

Integration Process

There are many ways to design and implement integrated substations. Many engineers attempt to design systems by choosing a communications protocol rather than designing a system that meets the needs of the various data consumers that will depend on it. Follow the design process below to help you successfully integrate your substation using the SEL-2032.

Step 1. **Determine data requirements.** List data consumers that require time synchronization, measurement, status, engineering, and control pathways.

Step 2. **Compile station IED information.** Station IEDs typically are chosen by function like protective relays, battery chargers, weather stations, and others. Make a list of these devices and collect communications information including protocols, communications media, and data transmission rates.

Step 3. **Design station architecture.** Lay out the devices and begin to connect them with communications paths. Connect IEDs to SEL-2032 Relays using a star network. Master devices may have specific protocol or connection requirements. Also, this is a good time to decide on fiber-optic cables or metallic cables for your SEL-2032-to-IED connections. See the SEL Web site for *Application Guide AG2001-06 Avoiding Magnetic Induction Issues in Communication Cabling* for important information. For more information on connecting IEDs to the SEL-2032, see the SEL-5801 PC software available for free download from the SEL Web site.

Step 4. **Determine IED protocol information.** For SEL devices, use the SEL protocol and take advantage of autoconfiguration and interleaved protocols. For non-SEL devices, determine the protocol information necessary to collect the data that your data consumers require. See *Using the SEL-2032 With Non-SEL IEDs on page 1.10* for more information.

Step 5. **Determine detailed information lists for master devices.** For connections to masters like SCADA systems and HMIs, determine exactly what information points are required and how they will be scaled and presented. This will allow you to configure the SEL-2032 to move and scale collected data into an optimized data set for each master.

Step 6. **Determine required** SEL-2032 **port configurations.** Use the information about the IEDs and communications links to determine communications link parameters including communications speed, parity, stop bits, and handshaking.

Step 7. **Determine** SEL-2032 **data collection messages.** For SEL IEDs, use the shorthand “20” messages to collect and parse data automatically. For non-SEL devices use the information gathered in *Step 4* to determine the outgoing control and data request messages and response parsing methods.

Step 8. **Determine** SEL-2032 **data math/movement settings.** This step connects the data collected in *Step 7* to the master data requirements from *Step 5*. Math/movement settings concentrate, scale, and manipulate collected data for master devices.

Step 9. **Install and commission system.** See *Section 2: Installation* for more information.

Using the SEL-2032 With Non-SEL IEDs

In order to implement connections to non-SEL IEDs, it is helpful to understand the basic data collection mechanism of the SEL-2032. With transparent mode and direct transparent mode, the SEL-2032 can provide port switch services to almost any device with an EIA-232 interface. Cables for use with many non-SEL IEDs are included in the SEL-5801 Cable Selector Software available for free download from the SEL Web site. The SEL-2032 automatic message settings are the primary mechanism for communicating with IEDs and collecting data. You can handle unsolicited messages from IEDs with user-defined messages.

Automatic Messages

Automatic message settings include the SEL “20” messages for SEL devices, but also allow you to construct outgoing messages and define how the response is stored (parsed into data) in the SEL-2032. Then you can manipulate, scale, and move the data to areas of the SEL-2032 to make it available to master devices like HMIs and SCADA systems.

Devices with serial ports use some kind of communications protocol. A protocol is a defined set of commands and responses. For example, a simple power meter may allow you to send the command **METER** and respond with a list of currents and voltages. This example might use standard human readable computer characters called ASCII or the whole exchange may use binary numbers to represent the commands and markers.

Use the SEL-2032 automatic message settings to program the outgoing message and configure the SEL-2032 to collect and store the response. In the power meter example, you can program the SEL-2032 to send the command **METER** every five seconds and then store the results as numbers. Then you can configure the SEL-2032 to configure and move the numbers so that a master device such as an HMI can collect the data.

The SEL-2032 has eight outgoing messages that you can use to collect and parse the response. There are also three more messages that you can use for outgoing messages only.

Collecting data from ASCII devices is relatively easy and simple. Some additional effort is required if the protocol is a binary protocol. See *Section 7: Settings* for more information on automatic message settings (SET A) and user-defined message settings (SET U).

The SEL-2032 does not have a Modbus® master setting, but you can program the automatic message settings to emulate a Modbus master and collect data from Modbus slave devices.

User-Defined Messages

Sometimes devices send unsolicited messages—messages not requested by the master device. You can use the user-defined message settings in the SEL-2032 to detect an unsolicited message and respond. The SEL-2032 cannot parse or collect data from unsolicited messages from non-SEL IEDs.

Getting More Information

If you are going to use a non-SEL device with the SEL-2032, we suggest that you check our extensive library of application guides available on the SEL Web site for information about various specific devices and connections. You can also contact the factory to reach your SEL Integration Application Engineer for local assistance with the details of your specific application.

Other SEL Integration Products

Several SEL products are available to help you configure, integrate, communicate, and operate your substation. For more information on the products listed below, please contact us or see our Web site.

Protection Networking and Expansion

Use SEL MIRRORED BITS® communications to connect relays and increase protection system performance or to add remote I/O relays.

- **SEL-2100 Logic Processor**: Hub for MIRRORED BIT communications links between protective relays. Allows high-speed, high-security exchange and combination of logic inputs from relays and sends results to SEL relays or SEL-2505 remote I/O modules.
- **SEL-2505 Remote I/O Module**: Remote I/O module with eight inputs and eight outputs for SEL relays that uses MIRRORED BITS protocol.

Network Interfaces

SEL offers solutions for connecting your systems to popular networks including Ethernet and Modbus Plus.

- **SEL-2701 Ethernet Processor**: Ethernet processing card for the SEL-2032 that provides DNP3, UCA2, FTP, and Telnet access to the SEL-400 series relays and the SEL-2032 with connected IEDs.
- **SEL-2711 Modbus Plus Protocol Card**: Modicon certified Modbus Plus network connection for the SEL-2032. This card is no longer available for purchase.
- **SEL-2890 Ethernet Transceiver**: Economical and powerful Ethernet interface for serial EIA-232 devices including SEL relays and communications processors. This device includes e-mail client, html Web pages, and serial tunneling capabilities.

Communications Enhancement Products

SEL offers several solutions for enhancing and protecting communications systems using fiber-optic cables, EIA-232 to EIA-485 converters and port isolators.

- **SEL-2800 Fiber-Optic Transceivers**: Complete line of multimode and single mode transceivers that allows you to implement point-to-point data communications for a variety of purposes including SCADA, engineering, and peer-to-peer protection messaging via SEL MIRRORED BITS communications.
- **SEL Multimode Fiber-Optic Cable**: Multimode hard-clad silica cables available with overall jacketing or without in precut terminated lengths or bulk spools with termination kits.
- **SEL-2884 and SEL-2885 EIA-232 to EIA-485 Transceivers**: Rugged transceivers with electrical isolation and intended for application in substation environments so you can connect SEL devices with EIA-232 interfaces to EIA-485 networks.
- **SEL-2910 Port Isolator**: Provides electrical isolation for data and IRIG-B connections between SEL relays and the SEL-2032.

Software Solutions

SEL offers a wide range of software products to enhance SEL equipment.

- **SEL-5010 Relay Assistant Software**: Personal computer software that allows you to create, store, and manage relay settings for the entire enterprise.
- **SEL-5020 Settings Assistant Software**: Personal computer software that allows you to create and store SEL-2032 settings.
- **ACSELERATOR QuickSet® SEL-5030 Software**: Advanced relay settings creation and storage software for selected SEL protective relays.
- **ACSELERATOR® Report Server SEL-5040 Software**: Software that automatically collects and stores relay event records and compiles a summary database for protection events. Implement the software within a single substation or from a central location to collect data for an entire system.
- **ACSELERATOR® Analytical Assistant SEL-5601 Software**: Software that helps with graphical analysis of SEL event records and converts SEL format event records to COMTRADE format.
- **SEL-5801 Cable Selector Program**: Software that lists the cables you use between SEL devices and between SEL and non-SEL devices. The software provides both SEL part numbers and wiring configurations so that you can order cables from SEL or construct your own. Equipment for fiber-optic cable connections is listed as assemblies including SEL-2800 transceivers and fiber-optic cables. You can download the SEL-5801 Cable Selector free at the SEL Web site.

Functions

The unique design and powerful features of the SEL-2032 make it useful for a variety of substation integration tasks. The major functions of the SEL-2032 are listed below.

Communications Processor. The SEL-2032 can send and receive message strings and codes in several different formats, permitting communication with a variety of devices, including SEL relays, PCs, modems, RTUs, printers, other IEDs, and other SEL-2032 Relays. The built-in command set facilitates communication to and through the SEL-2032 using any communication software that supports ASCII terminal emulation. You can also develop user-defined command strings to communicate to and from non-SEL devices.

Automatic Database. The SEL-2032 is unique in its ability to receive, parse, store, and distribute data. The SEL-2032 automatically parses data from SEL relays. Several parsing options are available to parse data from devices other than SEL relays. Selected portions of the parsed data can be collected from each port’s region to reduce the processing burden for downstream devices.

Network Gateway. The SEL-2032 can connect to a variety of networks. Natively, the SEL-2032 can communicate as a Slave on a Modbus RTU or DNP3 network. It also supports two plug-in protocol cards for connection to high-speed networks. These features make the SEL-2032 an ideal gateway between IEDs and networks.

SELOGIC Control Equations for Programmable Control. The SEL-2032 includes powerful SELOGIC® control equations that can be used to trigger messages, commands, and control functions.

Intelligent Port Switch. The SEL-2032, in its most basic role, is a port switch. Several features of the SEL-2032 improve significantly on that role, such as its multitasking/multi-user capability, auto-configuration, wide range of settable baud rates (300–38400 bps), and complete selection of communication parameters (data bits, parity, stop bits, RTS/CTS, and XON/XOFF).

Synchronizing Time Source. The SEL-2032 distributes a demodulated IRIG-B signal through Ports 1–16. This signal can be used by any attached device that recognizes the IRIG-B code by connecting the proper cable to the SEL-2032. The signal can be distributed to SEL relays that accept IRIG-B input, by using a special cable designed for both communication and IRIG-B signals. The SEL-2032 internally generates the IRIG-B signal, unless you connect an external source of modulated or demodulated IRIG-B to the SEL-2032. You can also perform low-accuracy time synchronization of the SEL-2032 using a serial protocol or an installed protocol card. See your protocol card instruction manual for details. If the connected device does not accept IRIG-B, you can program the SEL-2032 to send a date and time message to the device.

Communications Processor

The SEL-2032 has a distinct and significant advantage over simple port switches because of its sophisticated and powerful communications processing capabilities. *Figure 1.7* shows a typical application that includes several of the communication processing types described below. *Table 1.1* describes the communications on each type of link shown in *Figure 1.7*.

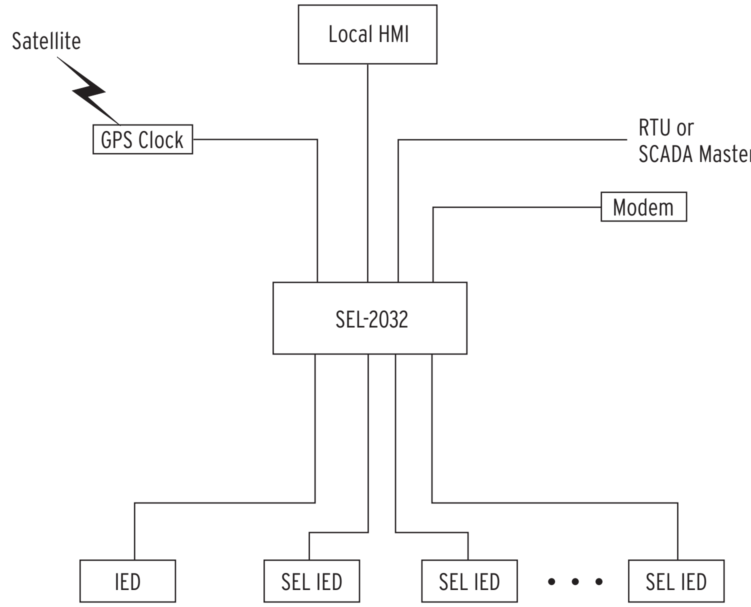

Figure 1.7 SEL-2032 Manages Communications With Multiple Master and Slave Devices

Table 1.1 Communications Type

From	To	Description
IED	SEL-2032	Messages That Emulate Native IED Protocol
SEL IED	SEL-2032	Autoconfiguration, SEL “20” Messages
Modem	SEL-2032	SEL-2032 Command Set, User-Defined Messages
RTU or SCADA Master	SEL-2032	DNP3 Slave Level 2 or Modbus
Local HMI	SEL-2032	Ethernet High-Speed Network
GPS Clock	SEL-2032	IRIG-B Time Synchronization

Use SELOGIC control equations to control when the SEL-2032 sends messages. You can use data from other IEDs, periodic and time of day functions, commands from protocol masters, and calculated data within the SEL-2032 as arguments in SELOGIC control equations. When the result of the SELOGIC control equation transitions from logical 0 to logical 1 (a rising edge), the SEL-2032 sends the message.

SEL Interleaved Protocols

The SEL-2032 simplifies substation network design and construction by interleaving several conversations on one cable between the relay and the SEL-2032. First, the SEL-2032 uses Fast Meter, Fast Operate, and Fast SER (Fast Message Protocol) for data collection and control. Second, you can use a transparent connection from one of the SEL-2032 ports for ASCII communications with the relay for configuration, diagnostics, and report collection. Third, the SEL-2032 generates an IRIG-B signal on each port for time synchronization.

Because all three conversations are interleaved, it is often unnecessary to connect more than one communications cable to the relay to accomplish engineering connections, data collection, and time synchronization. If you use an SEL-2810 Fiber-Optic Transceiver, all three conversations occur over a single fiber pair.

Auto-Configuration

Setting the SEL-2032 communication parameters for a port is simplified through the auto-configuration process of the SEL-2032. This process determines the proper data communication rate to communicate with the connected device. The SEL-2032 also determines the startup string, relay type, Fast Meter capability, and relay ID for any SEL relay connected to its port. You should use the **SET P** command to activate and configure each port that has a connected device.

When you connect the SEL-2032 to an SEL relay, you do not have to configure the individual messages, parsing, and control activation messages. The SEL-2032 connects to the relay and collects configuration data through a process called auto-configuration. When you connect the cable and configure the port for an SEL device, you will be prompted to start auto-configuration.

Once auto-configuration is complete, you can enable control messages from the SEL-2032 to the relay, configure the relay to accept control messages, and trigger them automatically through SELOGIC control equations. Whenever a remote bit or breaker bit changes state, the SEL-2032 automatically sends a control message to the relay. You do not have to configure or write the outgoing message.

“20” Messages

When you connect to an SEL relay and have completed auto-configuration, you can collect data from the relay using “20” messages. The SEL-2032 automatically creates request messages, parses the incoming data, and labels the data in the SEL-2032 database. The most frequently used “20” messages are 20METER and 20TARGET. The 20METER message collects metering and measurement data, while the 20TARGET message collects binary status data from inputs, outputs, and relay protection elements.

Send Messages

Messages sent from the SEL-2032 can be used to request data from other devices, or to control other devices. Use “20” messages, such as 20METER and 20TARGET, to request SEL relay data that are recognized by the SEL-2032 and are automatically parsed upon arrival. Use non-“20” messages for other data collection and control purposes. On SEL IED ports, you can also have relay operate commands and other remote control commands sent automatically.

Receive Messages and Data

The SEL-2032 can receive, buffer, parse, store, and act upon solicited and unsolicited messages and data.

SEL-2032 Command Set

The SEL-2032 command set consists of predefined messages that you can use to interact with the SEL-2032. You can send these commands, such as **ACCESS**, **PORT**, and **VIEW**, from an ASCII terminal or PC using any communication program that supports ASCII terminal emulation. You can also disable the SEL-2032 command set on a port where you use only user-defined commands.

IED Auto-Messages

IEDs may send data to the SEL-2032 without it being requested. These messages can be buffered and activities can be triggered based on specific messages. SEL relays send auto-messages to report specific activity or conditions. These include the SEL Event Report Summary issued through the SEL relay auto port when an event record is stored, the SEL Status Report issued to report a warning or failure, and the SEL Group Switch Report issued when a change in group settings occurs on a relay with multiple groups.

User-Defined Commands

You can define commands using the **SET U** command procedure. Receipt of one of these commands sets a command element that can be used in a SELOGIC control equation to initiate action defined in an associated message string. You can set the SEL-2032 to use these commands on IED ports to watch for unsolicited messages or on Master ports to supplement or replace the standard SEL-2032 command set. Use the **SET U** command to create user-defined commands. **SET U** can also be used to instruct the SEL-2032 to watch for one, or more, of the standard SEL relay auto-messages (see *Section 7: Settings*).

Modbus Protocol

You can select Ports 12, 14, and 16 of an SEL-2032 as Modbus ports. The network master (receiver) can access the database of all SEL-2032 ports through a Modbus port.

DNP3 Protocol

The SEL-2032 supports Distributed Network Protocol 3.0 (DNP3) Level 2 Slave serially on Port 16. DNP3 over Ethernet is supported by the optional SEL-2701 Ethernet Processor. DNP3 can be used for data acquisition and for control.

"20" Message Response

The SEL-2032 uses the auto-configuration information to parse "20" message responses automatically. The SEL-2032 uses these messages with SEL relays to collect relay data such as meter, target, event, and history. Meter and target data are transferred from the SEL relay to the SEL-2032 in binary format.

Non-"20" Messages

Non-"20" responses can be ignored or parsed using any one of six parsing options: ASCII Integer, ASCII Floating Point, Character String, Integer String, Integer String with XON/XOFF encoding, and Flexible Parsing. Non-"20" messages primarily are used with devices other than SEL relays (see *Section 5: Message Strings* for more information).

You can use the **SET A** command to create SELOGIC control equations for message triggering and the associated message strings. Also use **SET A** to set the AUTOBUF switch that determines if unsolicited messages will be stored or ignored.

Automatic Database

Database Structure

The SEL-2032 Data Area includes a database structured as shown in *Figure 1.8* consisting of the following defined regions: Global (GLOBAL), Local (LOCAL), Unsolicited Message Buffer (BUF), Data (D1–D8), Archive Data (A1–A3), and User (USER). For a more complete description of the database, see *Section 6: Database*.

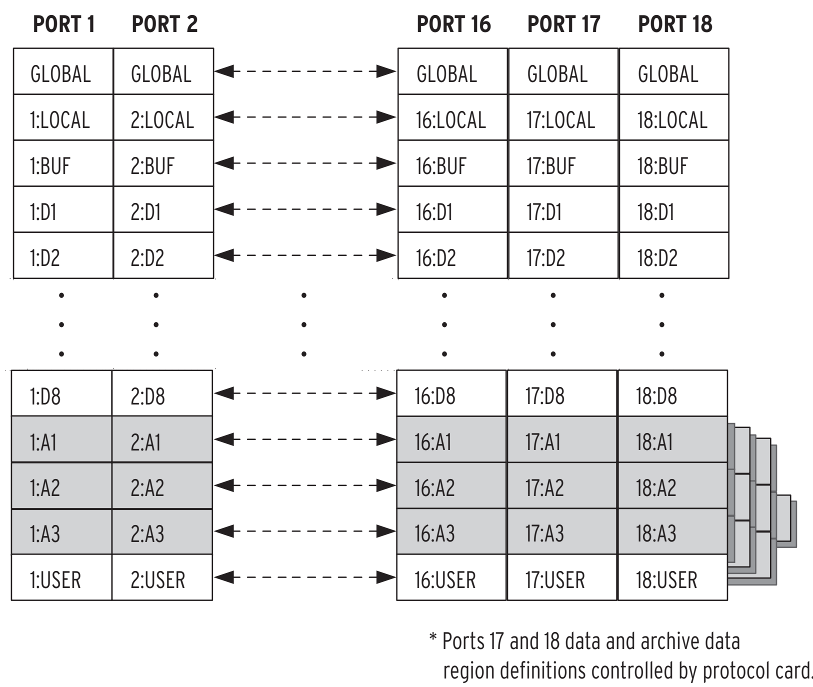

Figure 1.8 SEL-2032 Database Structure

Global Region

The Global region includes the following data that are common to all ports:

- SEL-2032 FID String
- Status and Configuration Information
- Date and Time
- Global Elements
- Protocol Card Status
- Port F Status

Global elements are logical 1 when asserted or true and logical 0 if deasserted or false. The Global elements are stored in the Global region, which is available for use by all ports. These elements can be used in any SELOGIC control equation to define a trigger condition. When the condition is true, the SEL-2032 sends the message associated with the SELOGIC control equation, such as requesting data or issuing a control command.

Local Region

The Local region includes the following information that is unique to each serial port (1–16) and each network port (17–18):

- Status and Configuration
- Archive Counter (nonvolatile Flash memory only)
- Local Elements
- Special Command Registers (SBO and CMD)
- FID String of Attached Device
- Port Identification String

Local elements are logical 1 when asserted or true, and logical 0 if not asserted or false. The Local elements reside in the Local region on each port. These elements can be used in any SELOGIC control equation to define a trigger condition. When the condition is true, the SEL-2032 will send the message associated with the SELOGIC control equation, such as requesting data or issuing a control command.

BUF Region

The BUF region contains buffered unsolicited messages from its associated port if you have set AUTOBUF to Yes. The buffer accumulates messages until it is full, at which point the newest message overwrites the oldest message. The buffer can be read and cleared in a number of ways both manually and automatically. The Buffer primarily is used when developing new settings and troubleshooting operations.

D1 to D8 Regions

For all ports, except the front port, the database includes Data regions D1–D8, allocated for data solicited by the SEL-2032. The first four registers of each region hold the date and time the data were collected. The remainder of each region is for the collected data. How the information is parsed, or separated into useful groups, depends on the type of data and how it is collected. Each region is associated with a message created using the **SET A** command. For example, the response from Message 1 will be captured in Data region D1 and the Message 2 response in Data region D2.

Responses from “20” messages are parsed automatically. Data received in response to non-“20” messages are parsed according to the parsing option you selected in the SET A automatic message settings. Each response is time-tagged by the SEL-2032 at the time it begins receiving the message. Data collected in regions D1–D8 are held until the next data are received; the new data overwrite the old data. The SEL-2032 will assign a data label to each region, depending on the message content and parsing method you choose. For example, if you set Message 1 on Port 1 to collect meter data from an SEL relay using the **20METER** command, the region 1:D1 will be assigned a data label of METER. This label can be very helpful when you address the region to **MAP** or **VIEW** the data, or to retrieve specific data items from the region.

A1 to A3 Regions

The Archive data regions, A1–A3, are designed for long-term storage of information, such as SEL relay long event reports and meter demand data. Each Archive data region works on a First-In-First-Out (FIFO) basis. The number of records that can be stored in each region depends on the size of each record. Individual records can be viewed, retrieved, and cleared.

User Region

The User region gives you access to the power of the SEL-2032 to collect data, combine data, and provide optimized data sets to multiple master devices. Each port has a User region allowing you to write SET M settings to create a custom set of scaled, concentrated, and aggregated data for each master. This process is shown in *Figure 1.9*.

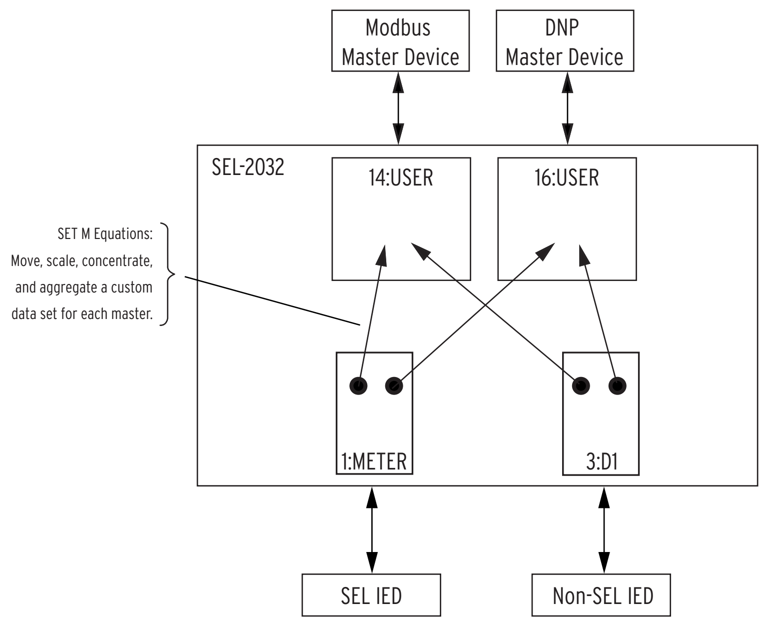

Figure 1.9 User Region/SET M Setting Operation

Database Tools

The SEL-2032 command set contains several commands to help you check that requested data are placed in the proper database location and to prevent interference between data requests and responses.

AUTO

This SEL-2032 command provides a list of supported operate and “20” commands on auto-configured SEL IED ports. Use this to confirm that the desired commands exist for the relay you are using.

MAP

This SEL-2032 command provides a method to look at the structure and addresses of a database region on a port-by-port basis or at specific regions within each port’s database. When this command is applied to a port, the SEL-2032 responds with a list of database regions, their data names, and the number of archive records. Also use the **MAP** command to look at the database structure within a region. When this command is applied to a region, the SEL-2032 responds with a list of data item labels, their addresses, and the type and number of data.

VIEW

This SEL-2032 database tool enables you to look at the data that are being collected, parsed, and stored in a database region on a specific port. Several variations of this command allow you to view all, part, or specific items within the region.

TARGET

You can use the **TARGET** command to view the status of the SEL-2032 Global and Local elements and the status of any relay elements that are received from an SEL relay. The relay elements will appear to be appended to the Local elements. The **TARGET** command, like the SEL relay **TARGET** command, includes variations that permit you to request all elements or a selected row of elements and to repeat the request automatically a specified number of times.

CARD

Use the **CARD** command to display the value of the Control Input and Control Output elements for the protocol card ports. Parameter *n* specifies the port (17 or 18). Append the Bit Label flag BL to display the control bit labels.

STATUS

The **STATUS** command provides you with an overview of the SEL-2032 performance and a port-by-port analysis of communication and database performance. Any problems with data collection or database delays occurring in any specific region will be identified on this report. This information will help you determine if data are being requested faster than can be accommodated by the attached device, or if multiple requests are interfering with each other. The status display also identifies ports in transparent communication.

MEM

The **MEM** command indicates the status of the RAM, Shared RAM, EEPROM, and Flash memory pools. You can use this to determine if you are in danger of running out of memory.

Data Parsing Options

The SEL-2032 database stores data that are parsed, or separated, into the smallest useful items. Parsing data in the SEL-2032 reduces communication and processing burdens for other devices or systems that use these data by permitting them to request and transfer only the specific data they need.

"20" Message Response

The SEL-2032 automatically parses data that are recognized. These data are requested using the "20" message format. The type of response will depend on the attached device's capability. If it has Fast Meter capability, the responses to 20METER messages are in binary format and the responses to 20DEMAND and 20TARGET messages may also be in a binary format.

Non-"20" Message Response

Message responses that are not recognized as SEL data can be ignored or parsed by one of five techniques:

ASCII Integer (Parse = 1). Parses numbers only.

ASCII Float (Parse = 2). Parses numbers only, including decimal points.

Character String (Parse = 3). Retains all characters.

Integer String (Parse = 4). Stores each pair of received bytes in a register, most-significant-byte first.

Integer String with XON/XOFF encoding (Parse = 5). Same as Integer String except special 2-byte encoding sequences are used to represent XON (11h) and XOFF (13h) characters.

Flexible Parsing (Parse = 6). Parses received bytes based on the DECODE equation. This option is especially useful when the incoming data types can be either numbers or text.

Network Gateway

The SEL-2032 has two plug-in slots where you can install protocol cards. This allows the SEL-2032 to connect up to 16 serial devices to two high-speed networks. Contact SEL or check our Web site at www.selinc.com for information on available network cards.

The SEL-2032 also supports virtual terminal connections through the optional communications card slots. For example, with an SEL-2701 Ethernet Processor installed, Ethernet users can establish Telnet sessions through the card, issue a **PORT** command, and communicate with an IED connected to the SEL-2032.

SELOGIC Control Equations for Programmable Control

You can trigger messages and control action with SELOGIC control equations.

The SEL-2032 issues messages when a user-defined condition for issuing the message is true. The condition is defined for each message by a SELOGIC control equation using:

- Time (Thh:mm:ss.s)
- Period (Phh:mm:ss.s with optional start and stop time)
- Internal trigger using any bit in the SEL-2032 Database, including:
  - Global elements: Day-of-week, intermediate logic elements (V, W, X, Y, Z, VT, WT, XT, YT, and ZT), remote bits, alarm bit, protocol card failure bit, and external inputs (from optional I/O board)
  - Local elements: User-defined command elements, select-before-operate elements, database triggers, and relay operate elements
  - Relay elements: from SEL TARGET data
- Connected IEDs:
  - Incoming data from data and user regions
  - Incoming control and data from Modbus, DNP3, and protocol communication card networks

or any logical combination of the above.

SELOGIC control equations use Boolean OR (+), AND (*), and NOT(!) operations to combine terms. The SEL-2032 Global region includes intermediate variables V, W, X, Y, and Z to provide additional SELOGIC control equation message capability. The intermediate variables have associated timers to provide even greater control capability and flexibility (see *Section 4: SELOGIC Control Equations*).

Twelve message groups are available per port. Messages 1–8 have associated data buffers to store responses. Four message groups, Messages 9–12, are for messages only, having no associated data buffer.

The **SET A**, automatic message setting command, establishes the message count, 0–12, of active triggering equations and message strings used on each port. You are then prompted to create the SELOGIC control equations for message triggering and associated messages within the framework of the **SET A** setting (see *Section 7: Settings*).

The SEL-2032 also supports 16 remote bits and 16 breaker bits on each port. These bits can be controlled by SELOGIC control equations, or directly using Modbus, DNP3, or Fast Operate protocols (see *Section 9: Protocols*). Define the SELOGIC control equation with the **SET L** command (see *Section 7: Settings*).

The plug-in card ports (17 and 18) each have 64 Control Input bits that are set by the plug-in card and are accessed as local elements by SELOGIC control equation. Ports 17 and 18 each have 64 Control Output bits; define their SELOGIC control equations with the **SET O** command. See your protocol card instruction manual for more information.

Intelligent Port Switch

You can configure the SEL-2032 as a port switch. An example of this application is shown in *Figure 1.10*. First, activate and configure each port connected to a device. Port F on the front and Port 8 on the rear panel are configured as Master ports at the factory, so you can connect your PC or terminal to either of these to communicate with the SEL-2032.

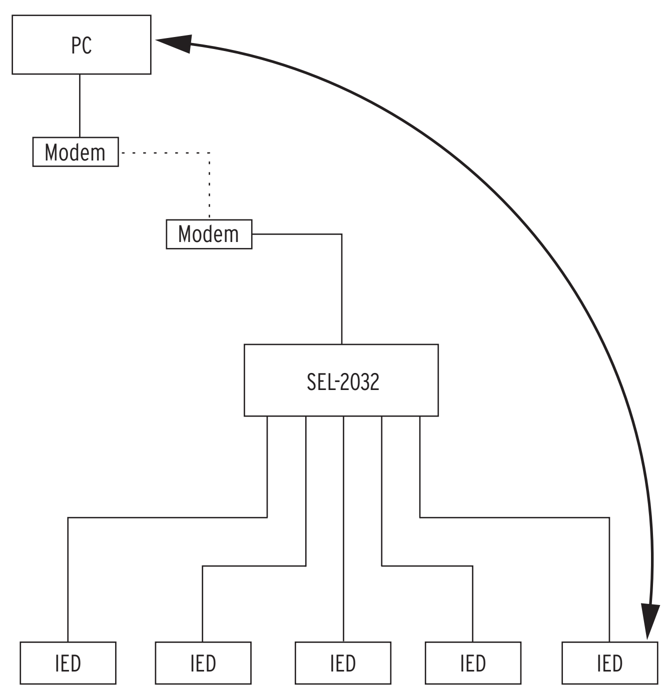

Figure 1.10 Transparent Connection Provides Direct Access to Many IEDs Through a Single Connection Point (Modem)

Once you have configured each port using the **SET P** command, you can enter transparent communication with the device on any port using the **PORT *n*** command, where *n* is the number of the port. To quit transparent communication, simply use the default disconnect sequence, **<Ctrl+D>**, by holding down the **Ctrl** key and pressing **D** on your keyboard.

The following features make the SEL-2032 a very intelligent port switch.

EIA-232 Front and Rear Ports

One front and 16 rear ports provide connection space for numerous types of devices, including SEL relays, other types of IEDs, PCs, printers, modems, and other SEL-2020 and SEL-2032 Communications Processors. You can independently configure each port of the SEL-2032 to match the communication parameters of the attached device. All communication parameters are software settable.

Multitasking/Multi-User Operating System

The powerful SEL-2032 operating system allows operations to occur on all ports simultaneously. This capability allows multiple users to communicate with, or through, the SEL-2032 at the same time; other functions, like printing and modem dial-out, can also occur on different ports. In addition, on ports connected to SEL relays that support Fast Meter data collection, the SEL-2032 continues to collect meter data while the port is being used for normal ASCII operation: either ASCII data collection or transparent operation.

Port Directory

The **WHO** command provides you with a list of all of the ports, the type of relay or device connected to each port, the current communication parameters, and a port ID string that describes the device or application. The device type and port ID string are entered automatically during the auto-configuration process when the connected device is an SEL relay.

Multilevel Password Security

Passwords are required to gain access to the various communication levels of the SEL-2032. Access Level 1 allows interrogation of settings and data only. Entry into Access Level 2 is required to change settings.

Synchronizing Time Source

You can synchronize the attached devices to an external time source or to the SEL-2032 built-in battery-backed clock. An example of this application is shown in *Figure 1.11*.

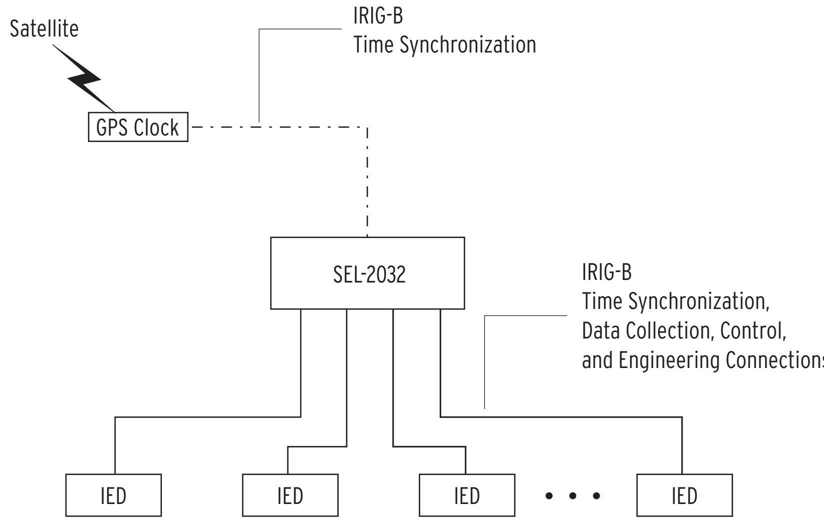

Figure 1.11 SEL-2032 Distributes Time Synchronization Using IRIG-B Over Star Data and Control Network Connections

Accepts External IRIG-B Input

The SEL-2032 accepts a modulated or demodulated IRIG-B signal through a rear-panel BNC connector. A setting, available with **SET G**, selects between modulated and demodulated IRIG-B operation. An internal database element asserts when the SEL-2032 receives an IRIG-B signal.

Accepts External Protocol Input

You can also perform low-accuracy time synchronization of the SEL-2032 using a serial protocol or an installed protocol card. See the protocol card instruction manual for details.

Generates IRIG-B Internally

If no external IRIG-B signal is applied, the SEL-2032 internal clock/calendar generates an IRIG-B signal. The SEL-2032 includes an internal battery-backed clock/calendar that maintains correct time with or without external power. The lithium-type battery has an expected life of 10 years. The internal clock is accurate to within 1 minute per year with power applied. You can reset the clock and calendar using the SEL-2032 **TIME** and **DATE** commands.

Distributes IRIG-B Through Ports 1–16

The SEL-2032 distributes a demodulated IRIG-B signal through all of its 16 rear ports. You can use this to synchronize any type of device, such as a relay, fault recorder, or meter, that can decode the IRIG-B signal. To use this feature, you need only to connect the device to the desired SEL-2032 port using a special cable designed for both communication and IRIG-B signal. For devices that do not have an IRIG-B port or cannot decode the IRIG-B signal, the SEL-2032 can send time and date messages on a periodic or time basis to keep their clocks synchronized.

Details

Settings

SET command variations allow you to configure and control SEL-2032 operation. See *Section 7: Settings* for more detailed information about this group of commands.

SET P—Port Configuration

You can use the SET P settings to establish each port's configuration and communication parameters. The configuration options are designed to make the SEL-2032 compatible with almost any device that has an EIA-232 port. This is the only setting command required to use the SEL-2032 as a port switch.

You should use the **SET P** command to configure each port. The first prompt from the SEL-2032 asks you to identify the type of device connected to the port. Port F can only be configured as a Master port. Ports 17 and 18 correspond to the protocol cards and are set automatically to match the installed card.

SET A—Auto-Message Settings

Use SET A settings to control the following automatic messaging settings:

- Initialization message to be sent to the IED when communication begins
- Fast Operate message enable
- Outgoing messages for control and data collection
- Size of the User region

SET U—User-Defined Commands

Use the **SET U** command (Ports 1–16) to create user-defined commands that other devices send to the SEL-2032. You can also use this setting to trigger action from selected SEL relay auto-messages (Event, Status, and Group). The user-defined commands can supplement or replace the preprogrammed SEL-2032 command set. This may be helpful if the device sending messages has some of the same commands as the SEL-2032 but different action is desired from the SEL-2032.

SET L—Logic

Use the **SET L** command (Ports 1–18) to define control equations for all port-specific set and clear bits (SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, and CRB1–CRB16).

SET M—Data Movement

Use the **SET M** command (Ports 1–18) to scale and move data to a User region. You can customize data scaling and organization in a central location. This can significantly reduce data access time by reducing the number of requests necessary to get the data of interest. On Port 16, the **SET M** command also defines what data is visible to DNP3.

SET G—Global Settings

Use the **SET G** command to set global parameters that are used by all ports including the SEL-2032 ID string, intermediate logic variable settings, general logic timer settings, and the control equations for optional I/O board output contacts.

Use the TIME_SRC setting to specify the source for setting the time.

SET R—Sequential Events Recorder Elements

Use the **SET R** command to specify the SEL-2032 contact inputs to include in the Sequential Events Recorder.

SET O–Output Logic

Use the **SET O** command (Ports 17–18) to define SELOGIC control equations for the 64 CCOUT bits (CCOUT1–CCOUT64).

Options

Three options are available to meet additional customer needs:

Input/Output Board

Sixteen optoisolated input terminals and four output contacts provide additional sensing and control capability to the SEL-2032. The input voltages are selected based on your ordering options. Output contacts are trip rated and can be individually configured as Form A or Form B using soldered board jumpers.

Plug-In Protocol Cards

The SEL-2032 supports up to two optional plug-in protocol cards. Contact SEL for information on available network cards.

SEL-2030 and SEL-2032 Comparison

The SEL-2032 has several features not included in the SEL-2030. Basic operation and settings are identical in the SEL-2030 and SEL-2032.

Table 1.2 Differences Between the SEL-2030 and SEL-2032

SEL-2030	SEL-2032
Optional 2 MB archive memory.	1.75 MB archive memory included.
Adequate setting storage space for most applications.	Significantly increased setting storage space for heavy SET M math/movement setting use.
DNP3 event time stamps assigned by SEL-2030.	SER quality time stamps from SEL IEDs that support Fast SER available for SEL-2032 DNP3.
No nonvolatile storage.	Ten nonvolatile storage registers per User region.

Robust Design

The SEL-2032 is designed to provide reliable service in a wide variety of electrical, physical, and environmental conditions.

Wide Temperature Operating Range

The SEL-2032 is designed for operation with an ambient temperature between –40° and +185° F (–40° and +85° C). Plug-in protocol cards may have more restrictive temperature ranges. Check the instruction manual of any plug-in protocol card to confirm its temperature range.

Wide Voltage Range Power Supply

Two power supply voltage ranges are available. The 125/250 volt power supply will operate with a voltage range of 85–350 Vdc or 85–264 Vac. The 24/48 volt power supply will operate with a voltage range of 20–60 Vdc.

Meets Tough IEEE and IEC Standards

The SEL-2032 is designed to meet tough IEEE and IEC electrical, environmental, and vibration standards, making the SEL-2032 suitable for application in hostile environments such as substations and power plants, in relay and control houses, or in outdoor cabinets and enclosures.

Specifications

Compliance

ISO 9001:2008 Certified

General

Rear Screw-Terminal Tightening Torque

Minimum:	0.8 Nm (7 in-lb)
Maximum:	1.4 Nm (12 in-lb)

Terminal Connections

Terminals or stranded copper wire. Ring terminals are recommended. Minimum temperature rating of 105°C.

Power Supply

Rated:	125/250 Vdc or Vac
Range:	85–350 Vdc or 85–264 Vac
Burden:	<25 W
Rated:	48/125 Vdc or 125 Vac
Range:	38–200 Vdc or 85–140 Vac
Burden:	<25 W
Rated:	24/48 Vdc
Range:	20–60 Vdc polarity dependent
Burden:	<25 W

Output Contacts

Make:	30 A
Carry:	6 A
MOV Protected:	250 Vac RMS/330 Vdc continuous

Note: Make per *IEEE C37.90 Tripping Output Performance Requirements*. MOV per IEC 60255-0-20:1974, using the simplified method of assessment. 50 A for one second.

Optoisolated Input Ratings

Level-sensitive inputs (16 inputs total, with optional I/O board)

24 Vdc:	Operate (pickup) 15–30 Vdc
48 Vdc:	Operate (pickup) 38.4–60 Vdc; Dropout 28.8 Vdc
125 Vdc:	Operate (pickup) 105–150 Vdc; Dropout 75 Vdc
250 Vdc:	Operate (pickup) 200–300 Vdc; Dropout 150 Vdc

Note: The optoisolated inputs each draw 4 mA when nominal control voltage is applied.

Serial Ports

1 front-panel/16 rear-panel ports, DB-9 connectors, MOV protected.

Time-Code Input

Connector:	Female BNC and pin-in port 15 connector
Time Code:	Modulated IRIG-B 1000 Vdc isolation Demodulated IRIG-B TTL-compatible

Note: Automatically sets SEL-2032 real-time clock/calendar.

Time-Code Output

Pinout:	Pin 4 TTL-level signal Pin 6 Chassis ground reference
Connectors:	All 16 rear DB-9 port connectors

Note: Outputs are generated from IRIG-B input (when present) or generated by CPU from real-time clock/calendar.

Operating Temperature Range

–40° to +85° C (–40° to +185° F)

Unit Weight

3U rack unit weight: 3.50 kg (7.75 lb)

Production Dielectric Strength

Power supply, logic inputs, and output contacts: 3100 Vdc for 10 seconds

Type Tests and Standards

Electromagnetic Compatibility Immunity

Electrostatic Discharge:	IEC 60255-22-2:1996 [BS EN 60255-22-2:1997] IEC 61000-4-2:1995 [EN 61000-4-2:1995] 2, 4, 6, 8 kV contact 2, 4, 8, 15 kV air
Fast Transient/Burst:	IEC 60255-22-4:1992 4 kV at 2.5 kHz and 5 kHz IEC 61000-4-4:1995 [EN 61000-4-4:1995] 4 kV, 2.5 kHz power supply 2 kV, 5 kHz I/O, signal. data, control lines
Radiated Radio Frequency:	IEC 60255-22-3:1989 10 V/m Exception: 4.3.2.2 freq. sweep approx. with 200 freq. steps per octave IEC 801-3:1984 10 V/m Exception: 9.1 freq. sweep approx. with 200 freq. steps per octave IEEE C37.90.2-1995 35 V/m
Surge Withstand Capability:	IEC 60255-22-1:1988 2.5 kV peak common mode 1.0 kV peak differential mode IEEE C37.90.1-1989 3.0 kV oscillatory 5.0 kV fast transient

Environmental

Cold:	IEC 60068-2-1:1990 + A1:1993 + A2:1994 [BS EN 60068-2-1:1993 + REAF:2005] 16 hours at –40°C
Damp Heat, Cyclic:	IEC 60068-2-30:1980 25° to 55°C, 6 cycles, relative humidity: 95% Exception: 6.3.3 humidity not less than 94%

Dry Heat:	IEC 60068-2-2:1974 + A1:1993 + A2:1994 [BS EN 60068-2-2:1993 + REAF:2005] 16 hours at +85°C
Vibration:	IEC 60255-21-1:1988 [BS EN 60255-21-1:1996 + A1:1996] Class 1 Endurance Class 2 Response IEC 60255-21-2:1988 [BS EN 60255-21-2:1996 + A1:1996] Class 1 Shock Withstand, Bump Class 2 Shock Response IEC 60255-21-3:1993 [BS EN 60255-21-3:1995 + A1:1995] Class 2 Quake Response

Safety

Dielectric Strength:	IEC 60255-5:1977 IEEE C37.90-1989 2500 Vac on contact inputs, contact outputs, and analog inputs 3100 Vdc on power supply 1 minute test
Impulse:	IEC 60255-5:1977 0.5 Joule, 5 kV

Real-Time Clock/Calendar

Battery Type:	IEC no. BR2335 lithium
Battery Life:	10 years
Clock Accuracy:	±20 minutes/year at 25°C (without power applied) ±1 minute/year at 25°C (with power applied) ±1 ms with IRIG-B time-code input

Serial Data Speeds

300, 600, 1200, 2400, 4800, 9600, 19200, 38400 bps

Memory

Base Memory:	1 MB shared RAM, 64 KB EEPROM, 1.75 MB Flash

Plug-In Card Slots

2 card slots; SEL standard shared memory data interface, and virtual terminal support.

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Section 2
Installation

Introduction

This section of the SEL-2032 Communications Processor instruction manual includes information and procedures to install the SEL-2032 safely and effectively. Safe and effective installation of the SEL-2032 requires proper mounting, connection, communications, and setup. This section concludes with steps for performing an initial check of your SEL-2032 and configuring it for data collection.

Jumper Settings

This subsection describes the hardware jumper selections available on the SEL-2032, and the recommended procedures for making the jumper setting changes.

Main Board Jumpers

Set the main board jumpers to meet your requirements. See *Table 2.1* for jumper functions and positions. See *Figure 2.4* for jumper locations on the main board.

Table 2.1 Main Board Jumper Positions

Function	Install Jumpers At:
Connect +5 Vdc to pin 1 on:	
Port 3/ /Port 4 Port 11/ /Port 12 Port 14/ /Port 16 (factory setting = all off)	J**11,** Position **A/** /J**11,** Position **C** J**11,** Position **B/** /J**11,** Position **D** J**20,** Position **B/** /J**20,** Position **A**
Alarm Contact Form	JMP3
Form A Form B (factory setting)	(20 AWG wire) **A** to Common (20 AWG wire) **B** to Common
Port 15 IRIG-B Direction	
Input Output (factory setting)	JMP**1** Position 2-3; JMP**2** Position 2-3 JMP**1** Position 1-2; JMP**2** Position 1-2
Port F Baud Rate	(This jumper is read on power-up.)
2,400 baud, RTS/CTS = N, XON/XOFF = Y Selected by SET P settings (factory setting)	J**17 A** Installed J**17 A** Removed
Password Disable Password Enable (factory setting)	J**17 B** Installed J**17 B** Removed
Unused	J**17 C** J**17 D**

Input/Output Connections

If your SEL-2032 is equipped with the optional I/O board, it has a terminal strip that extends nearly the full width of the SEL-2032, near the top of the rear panel.

Configure the Inputs for 24 V, 48 V, 125 V, or 250 V

The selection of input operating range is made at ordering time and cannot be modified by the user. The inputs on the SEL-2032 are level-sensitive; they will not operate if the input is inadvertently grounded.

Configure the Output Contact Form

The SEL-2032 I/O board is shipped from the factory with Form A output contacts. You may reconfigure the contacts by desoldering and then resoldering the 20 AWG jumper wire for each contact. *Table 2.2* and *Figure 2.5* show the jumper positions required to configure the contacts.

Table 2.2 Optional I/O Board Contact Form Jumper Positions

Output Contact	Jumper	Jumper Setting	
		Form A contact	Form B contact
OUT1 OUT2 OUT3 OUT4	JMP36 JMP35 JMP34 JMP33	Connect A to Common with 20 AWG wire (factory setting)	Connect B to Common with 20 AWG wire

Access and Set Internal Jumpers

⚠DANGER
Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

⚠CAUTION
Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

After you have decided on the appropriate SEL-2032 hardware configuration, you are ready to reconfigure the SEL-2032 if the default configuration does not meet your needs. Perform the following steps to gain access to internal jumpers:

Step 1. Disconnect power from the SEL-2032.

Step 2. Remove the screws attaching the front panel and remove the front panel.

Step 3. If the optional I/O board is installed, disconnect any cables joining the I/O board to the main board and disconnect the power cable from the SEL-2032 main board. Disconnect any cables connected to the rear of the SEL-2032.

Step 4. Remove the main board by sliding it out. Remove the I/O board by sliding it out.

Step 5. Configure main board jumpers according to the options given in *Table 2.1*.

See *Figure 2.4* for main board jumper locations.

Step 6. Configure I/O board jumpers according to the options given in *Table 2.2*.

See *Figure 2.5* for I/O board jumper locations.

Reassemble the SEL-2032

After configuring jumpers, reassemble the SEL-2032 as follows:

Step 1. Replace the main and I/O boards.

Step 2. Reconnect any cables that were disconnected.

Step 3. Replace the front panel and front-panel screws and tighten them securely.

Mounting and Connections

This subsection provides details about the physical mounting and connection requirements for the SEL-2032.

Mounting

Rack Mount

We offer the SEL-2032 in a rack-mount version that bolts easily into a standard 19-inch rack (see *Figure 2.6*). From the front of the SEL-2032, insert four rack screws (two on each side) through the holes on the SEL-2032 mounting flanges.

Reverse the mounting flanges to cause the communications processor to project 2.75 inches (69.9 mm) from the front of your mounting rack and provide additional space at the rear of the SEL-2032 for applications where the SEL-2032 might otherwise be too deep to fit.

Panel Mount

We also offer the SEL-2032 in a panel-mount version for a clean look. Panel-mount communications processors have sculpted front-panel molding that covers all installation hole (see *Figure 2.6*). Cut your panel and drill mounting holes according to the dimensions in *Figure 2.6*. Insert the SEL-2032 into the cutout, aligning four mounting studs on the rear of the SEL-2032 front panel with the drilled holes in your panel, and use nuts to secure the communications processor to your panel.

The projection panel-mount option covers all installation holes and maintains the sculpted look of the panel-mount option; the SEL-2032 projects 1.75 inches (69.9 mm) from the front of your panel. This ordering option increases space at the rear of the SEL-2032 for applications where it would ordinarily be too deep to fit your cabinet.

Frame Ground Connection

You must connect the grounding terminal labeled “GND” on the rear panel to a frame ground, preferably using a half-inch flat braid, for proper safety and performance. This terminal connects directly to the internal chassis ground of the instrument.

Power Connections

The terminals labeled “POWER” on the rear panel must be connected to a power source that matches the power supply (POW SUP) characteristics specified on the rear-panel nameplate of your SEL-2032. If you provide a dc power source, you must connect the source with the proper polarity as indicated by the “+” and “–” labels on the power connector. The SEL-2032 internal power supply has very low power consumption and a wide voltage tolerance. See *Specifications on page 1.28* for complete power supply specifications.

Alarm Contact Connection

The SEL-2032 includes an alarm output contact connected to pins 1 and 3 on the rear panel. At the factory, the alarm contact is configured to be closed for an alarm condition, and open for normal operation. This is a Form B contact because it is closed when there is no power. To invert the alarm output to close under normal conditions, change soldered jumper, JMP3, on the main board to select Form A contact usage. See *Table 2.1* and *Figure 2.4* for jumper settings.

The alarm contact asserts when no power is connected to the SEL-2032, the power supply fails, or self-test diagnostics detect a failure. Self-test diagnostic failures include memory failures, power supply failures, and invalid setting failures. See *STATUS on page 8.21* for a discussion on these failures. With the default ALARM setting (Global Settings), the alarm contact is pulsed when Level 2 communication is accessed, or when an SEL-2032 setting change is accepted.

The ALARM LED illuminates whenever the alarm contact asserts.

IRIG-B Input Connection

The SEL-2032 accepts a modulated or demodulated IRIG-B signal through a rear-panel BNC connector labeled “MODULATED/DEMODULATED IRIG-B IN.” An internal setting selects between modulated and demodulated IRIG-B (Global Settings). The factory-default setting is demodulated IRIG-B time input.

The SEL-2032 can also accept IRIG-B on the IRIG-B pins of Port 15. By default, the IRIG on Port 15 is configured as an output, but it can also be used as a demodulated IRIG-B input. To do this, set JMP1 and JMP2 in the 2-3 position. Also, the IRIG setting must be set to demodulated. See *Table 2.1* and *Figure 2.4* for the main-board jumper positions for setting-up the Port 15 IRIG-B.

Use a modulated IRIG-B signal for the input to the SEL-2032 if it is available. The modulated signal is isolated by a transformer. The demodulator in the SEL-2032 includes automatic gain control. You can use a demodulated signal, but it may not be adequate if the cable to the source is too long.

An internal element asserts in the SEL-2032 Global database region when an adequate IRIG-B input signal is received. If no external IRIG-B input signal is applied, the SEL-2032 generates an IRIG-B signal. The SEL-2032 includes an internal battery-backed clock/calendar that maintains correct time with or without external power.

IRIG-B Output Connection

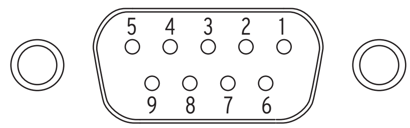
The SEL-2032 distributes a demodulated IRIG-B output signal through all of its 16 rear ports. You can use this feature to synchronize any type of device, such as a relay, fault recorder, or meter that can decode the IRIG-B signal; you need only to connect the device to the desired SEL-2032 rear serial communication port using a special cable designed for both communication and IRIG-B signal. The IRIG-B signal is on pins 4 and 6 of the 9-pin, subminiature “D” connector (see *Figure 2.1* and *Table 2.3*).

Where distance between the SEL-2032 and a device exceeds the cable length recommended for conventional EIA-232 metallic conductor cables, you can use transceivers to provide isolation and to establish communications to remote locations. Unfortunately, conventional short-haul, fiber-optic, and telephone modems do not support IRIG-B signal transmission, so their use requires that you use some other method to synchronize the remote IED. However, special fiber-optic transceivers (like the SEL-2810) include a channel for the IRIG-B time code; these transceivers enable you to more precisely synchronize devices that are capable of receiving IRIG-B time code, with a single-pair fiber-optic communication link.

The IRIG-B signal includes code for day-of-the-year and time-of-day. It does not include a code to identify the year. To set the device calendar to the proper year, you need to set the date on each device receiving an IRIG-B signal. Most SEL relays store the year for the set date with the relay settings in nonvolatile memory, so once the date is properly set, the relay will maintain the proper year even if relay power is cycled off and on.

Communication Circuit Connections

The SEL-2032 is equipped with 16 rear-panel serial communication ports, labeled **PORT 1**–**PORT 16** and one front-panel serial communication port, labeled **PORT F**. The data connection for each SEL-2032 serial communication port uses EIA-232 standard signal levels in a 9-pin, subminiature "D" connector (see *Figure 2.1* and *Table 2.3*). EIA-232 interfaces are supported by almost all modern relays, meters, computers, and communications devices.



Female chassis connector, as viewed from outside panel.

Figure 2.1 9-Pin Connector Pin Number Convention

The communication circuits are protected internally by low-energy, low-voltage MOVs and passive RC filters.

You should keep the length of the communication cables as short as possible to minimize communication circuit interference and also to minimize the magnitude of hazardous ground potential differences that can develop during abnormal power system conditions. See *Communication Cables on page 2.6* for additional details and restrictions.

Table 2.3 Serial Port Connector Pin Definitions

Pin	Ports 1–16	Port F
1	Various[a]	N/C
2	RXD	RXD
3	TXD	TXD
4	Various[b]	N/C
5, 9	GND	GND
6	Various[c]	N/C
7	RTS	RTS
8	CTS	CTS

[a] Port 1, 9 = DCD; Port 2, 5–8, 10, 13, 15 = N/C; Port 3, 4, 11, 12, 14, 16 = N/C or +5 Vdc if appropriate internal jumper is installed.
[b] Port 1–14, 16 = +IRIG-B Output; Port 15 = +IRIG-B Input or Output depending on internal jumper configuration.
[c] Port 1–14, 16 = -IRIG-B Output; Port 15 = -IRIG-B Input or Output depending on internal jumper configuration.

Port Isolators

SEL offers a data-line-powered isolator for use with EIA-232 ports and metallic communication cables. The SEL-2910 Port Isolator also isolates IRIG-B time code inputs on the same communication port. These isolators break cable ground loops and are useful in existing applications of metallic cables in switchgear. SEL does not recommend using port isolators for circuits outside the control house. Fiber should be used in such applications. Refer to SEL Application Guide AG2001-06, *Avoiding Magnetic Induction Issues in Communication Cabling*, for detailed information.

Fiber-Optic Cables

A benefit of applying the SEL-2032 is that as the hub of a star topology, it enables low cost, point-to-point fiber-optic connections. The SEL-2800 family of Fiber-Optic Transceivers connects directly to the serial port connectors on the rear of the SEL-2032. Fiber-optic links improve safety by isolating the equipment from hazardous and damaging ground-potential rise, eliminate instrumentation system ground-loop problems, reduce susceptibility to RFI and EMI, and allow longer signal paths than metallic EIA-232 connections.

Communication Cables

Several of the most popular SEL communication cables available for your use with the SEL-2032 are listed in *Table 2.4*. For a complete list of SEL cables and recommended applications, see the SEL-5801 Cable Selector software available on the SEL Web site. Using an improper cable can cause numerous problems, so you must be sure to specify the proper cable for the application.

Table 2.4 Communication Cables for Devices Attached to SEL-2032

SEL Cable #	Connect SEL-2032 to:	Remote Connector (on cable)	Port Type	RTS/CTS Supported	IRIG-B Included
C234A	9-pin DTE devices: Standard computer. Use for SEL-2032 configuration.	DB-9S	DTE	no	no
C239	9-pin DTE devices w/IRIG-B: SEL-200/321 series relays	DB-9P, DB-9P	DTE/ IRIG-B	yes	yes
C272A	9-pin DTE devices without IRIG	DB-9P	DTE	no	no
C273A	9-pin DTE devices w/ IRIG: SEL-500 series, SEL-300 series except SEL-321	DB-9P	DTE/ IRIG-B	yes	yes

NOTE: Never use standard null-modem cables with the SEL-2032. Using any non-SEL cable can cause severe power and ground problems involving pins 1, 4, and 6 on the SEL-2032 communication ports.

Please call the SEL factory if you have any questions about cables and cable connections.

The following list provides additional rules and practices you should follow for successful communication using EIA-232 serial communication devices and cables:

- You should keep the length of the communication cables as short as possible to minimize communication circuit interference and also to minimize the magnitude of hazardous ground potential differences that can develop during abnormal power system conditions.
- EIA-232 communication cable lengths should never exceed 50 feet, and you should always use shielded cables for communication circuit lengths greater than 10 feet.
- Modems are required for communication over long distances and to provide isolation from ground potential differences between device locations.

- ➤ Route communication cables well away from power and control circuits. Switching spikes and surges in power and control circuits can cause noise in the communications circuits if not adequately separated.
- ➤ Lower baud rate communication is less susceptible to interference and will transmit greater distances over the same medium than with higher baud rates. You should use the lowest baud rate that provides adequate data transfer speed.

Network Connections

See your plug-in protocol card instruction manual to determine appropriate network connection methods.

Cable Pinout Configuration

Figure 2.2 shows the cable pinout configuration for cables that connect the SEL-2032 to a local PC for configuration. Use this cable type with a terminal emulation program or the SEL-5020 Settings Assistant software.

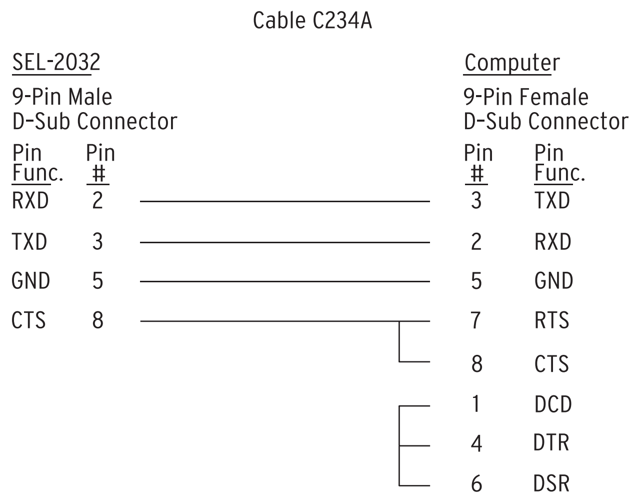


Figure 2.2 Cable C234A Pinout Configuration

Communications

This subsection describes how you can optimize the communications interface between the SEL-2032 and other devices.

Modems and Transceivers

If electrical interference is a problem, consider using point-to-point fiber-optic transceivers to provide electrical isolation and noise immunity. We recommend the SEL-2800/2810 Fiber-Optic Transceivers for these applications. The connection between the SEL-2032 and the modem is EIA-232. The connection between the remote transceiver and the remote device is also EIA-232. Optical fibers connect the two transceivers.

You must provide power to any modem that you install between the SEL-2032 and another device. You can use the SEL-2032 to power some types of modems connected to its rear-panel ports. With the proper jumper connections, the EIA-232 outputs of Ports 3, 4, 11, and 12 on the SEL-2032 support modems that accept +5 Vdc power. This also applies to Ports 14 and 16 for units manufactured after September 1999. The total current drawn by all of the external modems powered by one SEL-2032 should not exceed 0.5 A. See *Table 2.1* for the +5 Vdc power jumper settings for each port. None

NOTE: You must disconnect power from the SEL-2032 before connecting devices that require +5 Vdc power.

of these jumpers are installed at the factory. Modems that receive power from the control and data lines do not require connection to the +5 Vdc power supply.

Telephone Line Communications

A telephone dial-up link is one option for off-site communications with an SEL-2032. Use a modem to convert from the audio telephone line to an EIA-232 interface on the SEL-2032. You can use an external modem connected to any of the rear-panel ports. (Ports 1 and 9 have a DCD control line in addition to the RTS/CTS control lines, so these two ports will work best with external modems.) You can set the SEL-2032 to answer the phone and to initiate calls based on conditions that you select.

You should use telephone line protection equipment where the line enters the building for improved personnel safety and reduced damage to equipment from ground-potential rise and other hazardous conditions. Connect the line protection equipment to the modem following standard commercial telephone wiring standards.

If you use one telephone line for both voice and SEL-2032 communications, set the SEL-2032 modem port to ignore a specified number of rings before answering, so that personnel at the site can answer the phone before the modem answers. You can also provide a hook-switch in the phone line, so on-site personnel can disconnect the telephone line from the modem; however, you may want to use some type of timer instead to disconnect the line to prevent them from leaving the modem disconnected.

If you have one telephone line to communicate with a mix of telephones and modems in a site, you typically use a telephone port switch. Connect the protection equipment to the telephone port switch, and the telephone port switch to the SEL-2032 modem and other devices with standard telephone wiring.

Data Flow Control

All SEL devices, including the SEL-2032, support XON/XOFF software data flow control. You should select this option, or accept the XON/XOFF = Y default for any communication setting where the SEL-2032 is connected to another SEL device. Set RTS/CTS = N to connect an SEL-2032 to any SEL device.

The SEL-2032 also supports RTS/CTS hardware data flow control. You should select the RTS/CTS option only if the connected device uses RTS/CTS, and does not use XON/XOFF flow control. Consult the instruction manual or contact the device vendor to determine the proper flow control technique for each non-SEL device. If you select RTS/CTS hardware data flow control, make sure that the cable you are using to connect the device to the SEL-2032 has conductors for RTS/CTS.

Baud Rate

The default baud rate for the SEL-2032 front port, Port F, is 2400 baud. You can change the Port F baud rate and the other Port F communication parameters using the **SET P** command. You can force the Port F baud rate to 2400 baud by hardware jumper selection (see *Table 2.1*).

The default baud rate for all rear-panel communication ports is 9600 baud. You can change the baud rate for each of these ports and the associated communication parameters with the **SET P** command. With an SEL relay attached to one of the rear ports, the SEL-2032 will automatically set the baud rate to match the relay baud rate when you request the SEL-2032 to perform auto-configuration. With other IEDs attached to the ports, the SEL-2032 baud rate may be automatically set to match the attached IED baud rate when you request the SEL-2032 to perform the auto-baud function.

To change the communication baud rate with a device, you should change the baud rate on the device first, either by baud rate jumper, dip switch or software setting, then you should change the baud rate setting on the associated SEL-2032 port using the **SET P** command. See *Section 7: Settings* for more information on making settings changes.

Master Device to SEL-2032 Communication

Some Master devices, such as RTUs, cannot accept unsolicited messages, requiring that they only receive a response to a request they send. When you interface the SEL-2032 with such a device, you must make sure that the SEL-2032 does not send any auto-messages to the device unless the SEL-2032 first receives a request. Use the **SET U** command to create user-defined commands that will trigger the appropriate auto-message response.

You must use the same precaution when you interface the SEL-2032 with a master device using the LMD protocol.

Passwords

⚠WARNING
This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

You can set your own passwords with the **PASSWORD** command, or you can disable the password protection with jumper selection (see *Table 2.1*). See *Example 1: Connect to the Front Port and Change Default Passwords on page 3.1* for more information on access levels and password control.

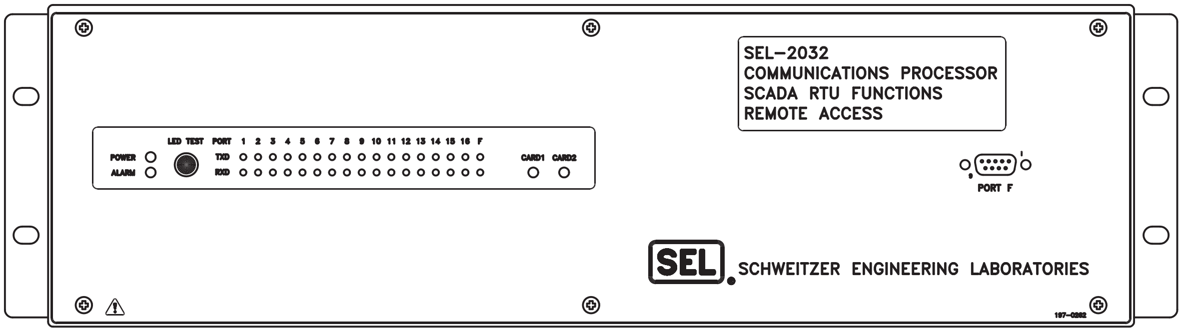
Data Collection Periods

You can set the SEL-2032 to collect data from attached devices on an exception basis, i.e., only when an event occurs, and you can set the SEL-2032 to collect data on a regular, periodic basis. Each SEL-2032 port collects data independently, based on your settings, and you can set each port to collect data in different ways using separate message trigger conditions and data request messages. Likewise, each SEL-2032 port responds to requests for data independently, based on your settings. In either case, the SEL-2032 will not issue or respond to another request for data on the same port until the previous request has been satisfied. If the data response has not been completed before the same message trigger condition occurs again, the second trigger will be missed completely. The SEL-2032 will acknowledge this missed trigger by setting a delay bit in the port register, which is reported in the SEL-2032 status report.

Although both exception and periodic data collection can encounter this type of delay, you can control the periodic collection period, and thereby minimize the possibility of collection delays and missed triggers. You should consider first if the attached device is capable of transferring data in binary format or only in ASCII character format, and second, the type of data you plan to request, i.e., meter, target, demand, or another type.

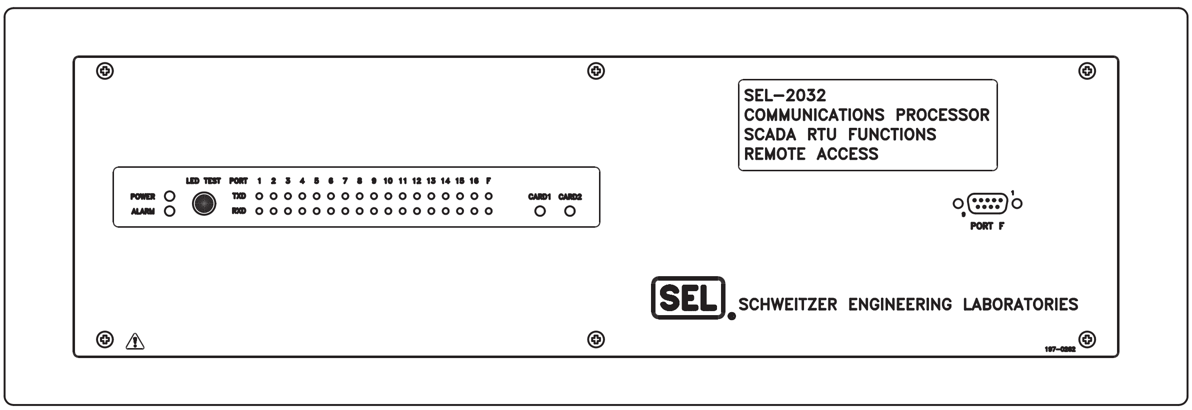
When connecting to SEL-100 and SEL-200 series relays that have Fast Meter binary data capability, always connect to Port 2 on the relay. Binary data transfer is not supported on Port 1 of these relays.

Drawings



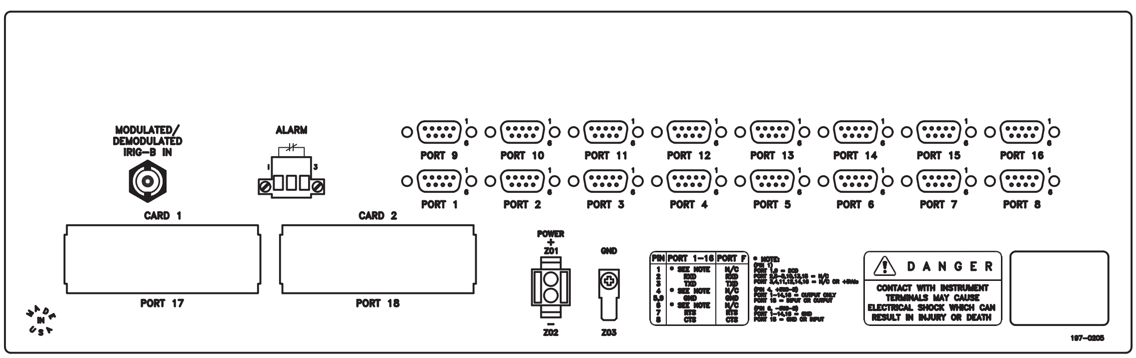
Front-Panel Rack Mount

i3555a



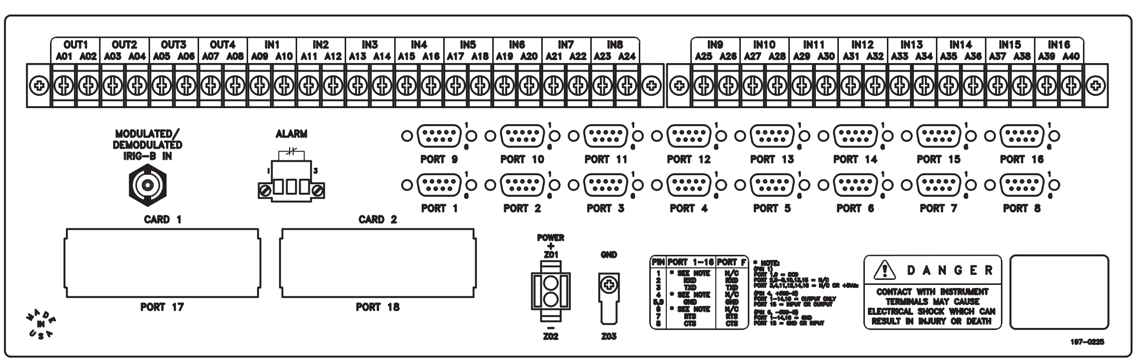
Front-Panel Panel Mount

i3556a



Rear Panel, Without I/O Board

i3005b



Rear Panel, With I/O Board

i3006b

Figure 2.3 SEL-2032 Front and Rear Panels

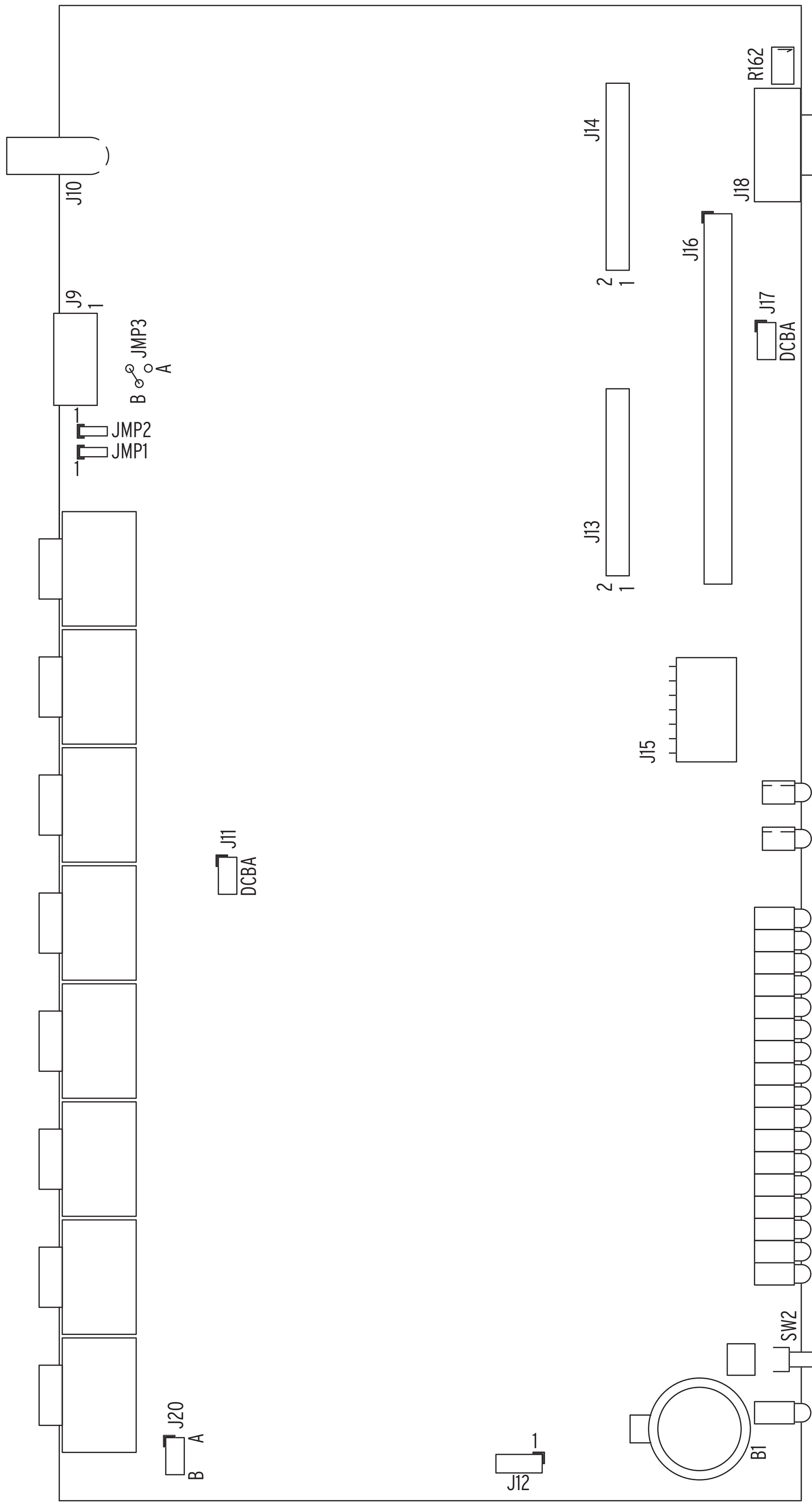


Figure 2.4 SEL-2032 Main Board Jumper Location

NOTE: Jumper J20 was added to units manufactured after September 1999.

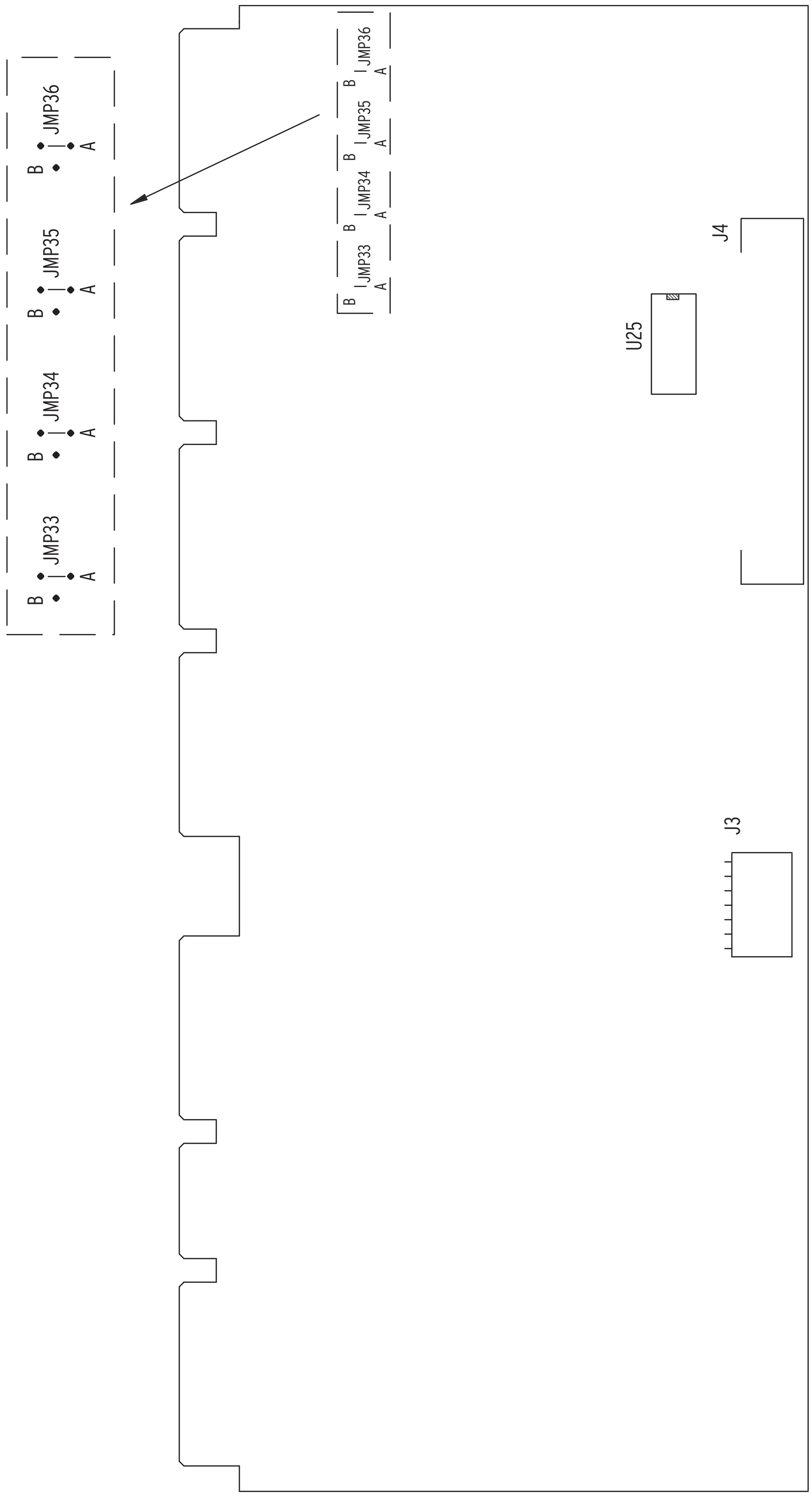


Figure 2.5 SEL-2032 Optional I/O Board Jumper Location

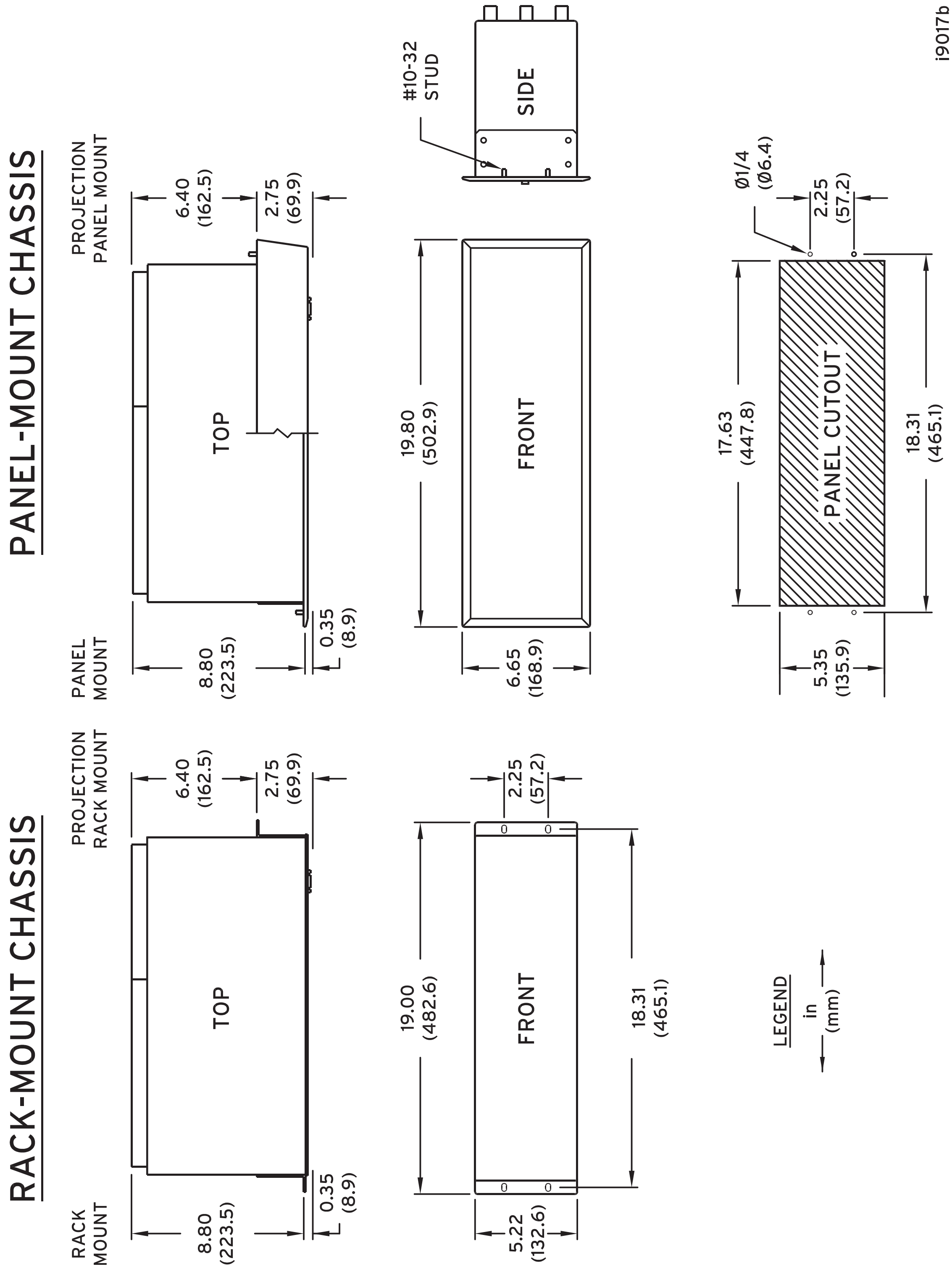


Figure 2.6 SEL-2032 Dimensions and Panel-Mount Cutout

Getting Started

Power up the SEL-2032 and follow the steps in *Initial Checkout*. Connect the SEL-2032 to your station IEDs and configure it to collect data; see *Collect Data With the SEL-2032 on page 2.15*.

Initial Checkout

Perform the following steps:

Step 1. Visually inspect the SEL-2032 for loose or damaged parts.

Step 2. Connect and apply power to the SEL-2032; see the POWER SUPPLY field on the rear-panel nameplate for power requirements.

If you do not have the proper voltage source available, use a power supply, like the SEL-LPS, to power the unit.

If you wish, connect the SEL-2032 to a 120 Vac, US style 3-prong outlet, use SEL cable C5305.

Step 3. Press and hold the LED TEST button and confirm that all LEDs illuminate.

Step 4. Connect a computer equipped with terminal emulation software to the front-panel connector Port F of the SEL-2032 using an SEL C234A cable or equivalent.

Connect the end of the cable labeled SEL (DTE) to the SEL-2032 and the end labeled Computer/Terminal to your computer 9-pin serial port.

Step 5. Set the computer terminal emulation software to operate at the following settings:

- 2400 bits per second (sometimes called baud)
- 8 data bits
- 1 stop bit
- no parity

Step 6. Press **<Enter>** and verify that the SEL-2032 returns an asterisk (*) prompt.

Step 7. Type **ACCESS <Enter>** to change to Access Level 1.

If you have not yet changed the password, enter the factory-set password, which is OTTER, and press **<Enter>**. You will see a screen similar to *Figure 2.7*.

The password is case sensitive. Either enable **<Caps Lock>**, or use the **<Shift>** key during password entry.

```
*ACCESS <Enter>
Password: ? ****** <Enter>
EXAMPLE 2030 - S/N 94153001            Date: 10/31/97    Time: 13:45:03
Level 1
*>
```

Figure 2.7 ACCESS Command Screen

Step 8. Type **STATUS <Enter>** and verify that a status report similar to the one in *Figure 2.8* appears on your terminal.

Verify the following from the report:

➢ RAM memory size is 512 kb.

➢ Shared-RAM size is 1024 kb.

➢ Flash (ARCH) is 1792 kb.

➢ IRIG-B input and I/O board match your configuration.

➢ Any plug-in protocol cards are displayed as expected for Port 17 or 18.

```
*>>STATUS <Enter>
COMMUNICATIONS PROCESSOR - S/N 95012004     Date: 10/31/01    Time: 13:46:43
FID=SEL-2032-R100-V0-Z000000-D20021222 FID=SLBT-2030-R103-V0-Z000000-D20010122
SELF-TESTS
RAM      SRAM     CODE     ARCH     EEPROM   P.S. SET      BATTERY
512 kb   1024 kb  OK       1792 kb  OK       OK       OK       OK
IRIG-B Input: Absent
I/O Board: Absent
Port   Status           Success Rate   SET M     Database
1      Active               100%       None
2      Inactive                        None
3      Inactive                        None
4      Inactive                        None
5      Inactive                        None
6      Inactive                        None
7      Inactive                        None
8      Active                          None
9      Active                          None
10     Inactive                        None
11     Inactive                        None
12     Inactive                        None
13     Inactive                        None
14     Inactive                        None
15     Inactive                        None
16     Inactive                        None
17     Sole Node(100h)      NORM       None
F      Active               100%       None

*>>
```

Figure 2.8 STATUS Command Screen

Collect Data With the SEL-2032

Step 1. Connect the SEL-351S Relay to an SEL-2032 port; this example uses Port 2.

Use either an SEL C272A or SEL C273A cable to connect the relay to the SEL-2032.

If you are using an SEL C272A cable:

➢ Connect the end labeled SEL-300/500 series to Port 2 on the SEL-351S.

➢ Connect the other end of the cable to Port 2 on the SEL-2032.

If you are using an SEL C273A cable:

➢ Connect the end labeled SEL-300/500 series w/IRIG to Port 2 on the SEL-351S.

➢ Connect the other end of the cable to Port 2 on the SEL-2032.

You can connect to any port on the SEL-351S that is configured for the SEL protocol. The factory-default setting for the relay ports is SEL protocol. To verify that the port you select is set to SEL protocol, use the following procedure.

a. Press **SET** on the SEL-351S front panel.

b. Use arrow buttons to select the PORT option; press **SELECT**.

c. Use arrow buttons to select the port number; press **SELECT** twice.

   The second line of the LCD displays PROTO=SEL if the relay port is set to SEL protocol. If your relay port is set to a different protocol, you can either connect the SEL-2032 to a different relay port which uses SEL protocol, or consult your relay instruction manual to change your relay port settings.

d. Continue to press **SELECT** until EXIT SETTINGS appears on the LCD display.

e. Use arrow buttons to select YES; press **SELECT** to exit.

Step 2. Enter Access Level 2 on the SEL-2032.

- ➢ Enter the command **2ACC <Enter>**.
- ➢ Enter the factory-set Access Level 2 password, TAIL, and press **<Enter>**.
- ➢ To begin configuring the communications port for the SEL-351S, type **SET P 2 <Enter>**.

Step 3. Respond to the SEL-2032 prompt for the type of device connected to the port.

- ➢ Type **S** for SEL IED, **Y** to auto-configure the port, and press **<Enter>** to confirm the configuration prompts.

  The SEL-2032 establishes communication with the relay; determines the type of relay, relay ID, and communication baud rate; and determines if the relay is capable of Fast Meter, Fast Operate, and Fast Messages. This process can take a few minutes depending on the baud rate.
- ➢ To accept settings changes, type **END** and press **<Enter>** at the first setting prompt after auto-configuration is complete.
- ➢ Enter **Y** to save port configuration changes at the final prompt.

Step 4. Issue the **AUTO 2** command to see what Fast Message features are supported by the SEL-351S. *Figure 2.9* shows an example output for the **AUTO 2** command.

```
*>>AUTO 2 <Enter>
FID:       FID=SEL-351S-7-R106-V0-Z003003-D20010110
DEVICE ID: FEEDER 1
BAUD RATE: 19200
OPERATE SUPPORT: Binary (1 Breakers, 16 Remote Bits S-C-P)
LEVEL 1 PASSWORD: OTTER
COMMANDS SUPPORTED:
  B 20METER
  B 20DEMAND
  B 20TARGET
  A 20HISTORY
  A 20STATUS
  A 20EVENT
  A 20EVENTS
  A 20EVENTL

*>>
```

Figure 2.9 AUTO 2 Command Displays Fast Message Features

Step 5. Enter the **Port 2** command to establish a transparent connection to the relay. Press **<Enter>** and verify that you receive an equal sign (=) relay prompt.

Step 6. Enter the **ACCESS** and **2 ACCESS** command to enter Access Level 2 on the SEL-351S. The default passwords for the SEL-351S are the same as the SEL-2032.

Step 7. Enter the **SET P** command and change the SPEED setting to 19200 bits per second. When you enter **Y** to save changes, you will lose communication with the relay. This changes the baud rate for the relay.

Step 8. Press **<Ctrl+D>** to end the transparent connection to the relay.

Step 9. Use the **SET P 2** command to change the baud rate on Port 2 of the SEL-2032 to 19200 bits per second.

Step 10. Next, issue the command **SET A 2** to set an auto-message to collect relay meter and target data.

- ➢ Press **<Enter>** to respond to prompts about saving unsolicited messages (**AUTOBUF**), the startup string (**STARTUP**), operate command enable (**SENDOPER**), and receive SER enable (**RECSER**).
- ➢ Enter **2** when prompted for the message count.
- ➢ At the ISSUE1 prompt, enter **P00:00:01** to set the message to trigger once every second.
- ➢ At the MESG1 prompt, enter **20METER** to send the request for meter data to the SEL relay.
- ➢ At the ISSUE2 prompt, enter **P00:00:01** and at the MESG2 prompt enter **20TARGET** to collect relay target data.
- ➢ Type **END <Enter>** to accept the default for remaining settings and **Y <Enter>** to save changes.

As soon as the SEL-2032 accepts the setting change, the TXD and RXD Port 2 LEDs on the SEL-2032 begin to flash as the SEL-2032 requests and receives meter data every second.

Step 11. Verify connection, configuration, and data transfer using SEL-2032 commands **WHO**, **MAP**, **VIEW**, and **STATUS**.

a. Verify that the relay is connected to the desired port and configured properly by issuing the **WHO** command.

The SEL-2032 responds to this command with some basic information about the SEL-2032 and a list of the devices and device identification strings associated with each port. In this case, the list shows that an SEL-351S is connected to Port 2.

```
*>>WHO <Enter>
                                                Date: 11/19/01    Time: 14:56:16
FID=SEL-2032-R100-V0-Z000000-D20021222 FID=SLBT-2030-R103-V0-Z000000-D20010122
Port#  Device    Protocol   Parameters  Identification
1      Master    SEL        9600,8,2,N
2      SEL-351S  SEL        19200,8,2,N FEEDER 1
3      SEL IED   SEL        9600,8,2,N
4      SEL IED   SEL        9600,8,2,N
5      SEL IED   SEL        9600,8,2,N
6      SEL IED   SEL        9600,8,2,N
7      SEL IED   SEL        9600,8,2,N
8      SEL IED   SEL        9600,8,2,N
9      SEL IED   SEL        9600,8,2,N
10     SEL IED   SEL        9600,8,2,N
11     SEL IED   SEL        9600,8,2,N
12     SEL IED   SEL        9600,8,2,N
13     SEL IED   SEL        9600,8,2,N
14     SEL IED   SEL        9600,8,2,N
15     SEL IED   SEL        9600,8,2,N
16     SEL IED   SEL        9600,8,2,N
17     SEL-2701  Ethernet   VTm:HS,CTl:HS,TIm:S,SBt:S
F*     Master    SEL        9600,8,2,N

*>>
```

Figure 2.10 Issue the WHO Command to Verify Relay Port Connection

The displayed response to the **WHO** command also identifies that Master port currently in use by placing an asterisk (*) next to its port number, Port F in the current example.

b. Issue the command **MAP 2** to verify the location and type of data being collected on Port 2 of the SEL-2032.

The SEL-2032 responds with a database map of the Port 2 data regions (see *Figure 2.11*). This map shows that meter data are being collected in Port 2 region D1, which is associated with Port 2 Message 1. The B in front of METER indicates that the SEL-2032 is receiving binary, or Fast Meter, data from the SEL-351S. You can refer to the specific region by the region name, D1, or the data name, METER.

```
*>>MAP2 <Enter>
Port 2 Database Assignments
  Region    Data Type   # Records
  GLOBAL    --
  LOCAL     --
  BUF       --
  D1      B METER
  D2      B TARGET
  D3        Unused
  D4        Unused
  D5        Unused
  D6        Unused
  D7        Unused
  D8        Unused
  A1        Unused
  A2        Unused
  A3        Unused
  USER      Unused

*>>
```

Figure 2.11 MAP 2 Command Verifies Data Types and Locations

c. Verify the various metering quantities that are being collected and stored in the SEL-2032 by issuing the command string **MAP 2:METER** or **MAP 2:D1**.

The SEL-2032 responds with a map of the specific region (*Figure 2.12*), including a listing of the data item names, the starting address for each data item, and the type of data stored at each address.

```
*>>MAP2:METER <Enter>
Port 2,  Data Region METER  Map
Data Item    Starting Address   Type
_YEAR        2000h              int
DAY_OF_YEAR  2001h              int
TIME(ms)     2002h              int[2]
MONTH        2004h              char
DATE         2005h              char
YEAR         2006h              char
HOUR         2007h              char
MIN          2008h              char
SECONDS      2009h              char
MSEC         200Ah              int
IA           200Bh              float[2]
IB           200Fh              float[2]
IC           2013h              float[2]
IN           2017h              float[2]
VA           201Bh              float[2]
VB           201Fh              float[2]
VC           2023h              float[2]
VS           2027h              float[2]
FREQ         202Bh              float[2]
VBAT         202Fh              float[2]
IAB(A)       2033h              float[2]
IBC(A)       2037h              float[2]
ICA(A)       203Bh              float[2]
VAB(V)       203Fh              float[2]
VBC(V)       2043h              float[2]
VCA(V)       2047h              float[2]
PA(MW)       204Bh              float
QA(MVAR)     204Dh              float
PB(MW)       204Fh              float
QB(MVAR)     2051h              float
PC(MW)       2053h              float
QC(MVAR)     2055h              float
P(MW)        2057h              float
Q(MVAR)      2059h              float
I0(A)        205Bh              float[2]
I1(A)        205Fh              float[2]
I2(A)        2063h              float[2]
V0(V)        2067h              float[2]
V1(V)        206Bh              float[2]
V2(V)        206Fh              float[2]

*>>
```

Figure 2.12 MAP 2:METER Command Verifies Metering Quantities

Notice in this case that all of the currents and voltages contain two floating-point numbers, one for magnitude, the other for phase angle. The magnitudes and phase angles are calculated from Fast Meter sample data.

d. Use the **MAP 2:TARGET BL** command to display a list of the data collected in the TARGET region (*Figure 2.13*). The BL option displays bit labels, the labels of the individual Relay Word bits collected and available.

```
*>>MAP2:TARGET BL <Enter>
Port 2,  Data Region TARGET  Map
Data Item    Starting Address   Type   Bit Labels
_YEAR        2800h              int
DAY_OF_YEAR  2801h              int
TIME(ms)     2802h              int[2]
TARGET       2804h              char[61]
             2804h              *      *      *      STSET *      *      *      *
             2805h              TLED11 TLED12 TLED13 TLED14 TLED15 TLED16 TLED17 TLED18
             2806h              TLED19 TLED20 TLED21 TLED22 TLED23 TLED24 TLED25 TLED26
             2807h              50A1   50B1   50C1   50A2   50B2   50C2   50A3   50B3
             2808h              50C3   50A4   50B4   50C4   50AB1  50BC1  50CA1  50AB2
             2809h              50BC2  50CA2  50AB3  50BC3  50CA3  50AB4  50BC4  50CA4
             280Ah              50A    50B    50C    51P1   51P1T  51P1R  51N1   51N1T
             280Bh              51N1R  51G1   51G1T  51G1R  51P2   51P2T  51P2R  51N2
             280Ch              51N2T  51N2R  51G2   51G2T  51G2R  51Q    51QT   51QR
             280Dh              50P1   50P2   50P3   50P4   50N1   50N2   50N3   50N4
             280Eh              67P1   67P2   67P3   67P4   67N1   67N2   67N3   67N4
             280Fh              67P1T  67P2T  67P3T  67P4T  67N1T  67N2T  67N3T  67N4T
             2810h              50G1   50G2   50G3   50G4   50Q1   50Q2   50Q3   50Q4
             2811h              67G1   67G2   67G3   67G4   67Q1   67Q2   67Q3   67Q4
             2812h              67G1T  67G2T  67G3T  67G4T  67Q1T  67Q2T  67Q3T  67Q4T
             2813h              50P5   50P6   50N5   50N6   50G5   50G6   50Q5   50Q6
             2814h              50QF   50QR   50GF   50GR   32VE   32QGE  32IE   32QE
             2815h              F32P   R32P   F32Q   R32Q   F32QG  R32QG  F32V   R32V
             2816h              F32I   R32I   32PF   32PR   32QF   32QR   32GF   32GR
             2817h              27A1   27B1   27C1   27A2   27B2   27C2   59A1   59B1
             2818h              59C1   59A2   59B2   59C2   27AB   27BC   27CA   59AB
             2819h              59BC   59CA   59N1   59N2   59Q    59V1   27S    59S1
             281Ah              59S2   59VP   59VS   SF     25A1   25A2   3P27   3P59
             281Bh              81D1   81D2   81D3   81D4   81D5   81D6   27B81  50L
             281Ch              81D1T  81D2T  81D3T  81D4T  81D5T  81D6T  VPOLV  LOP
             281Dh              *      *      IN106  IN105  IN104  IN103  IN102  IN101
             281Eh              LB1    LB2    LB3    LB4    LB5    LB6    LB7    LB8
             281Fh              LB9    LB10   LB11   LB12   LB13   LB14   LB15   LB16
             2820h              RB1    RB2    RB3    RB4    RB5    RB6    RB7    RB8
             2821h              RB9    RB10   RB11   RB12   RB13   RB14   RB15   RB16
             2822h              LT1    LT2    LT3    LT4    LT5    LT6    LT7    LT8
             2823h              LT9    LT10   LT11   LT12   LT13   LT14   LT15   LT16
             2824h              SV1    SV2    SV3    SV4    SV1T   SV2T   SV3T   SV4T
             2825h              SV5    SV6    SV7    SV8    SV5T   SV6T   SV7T   SV8T
             2826h              SV9    SV10   SV11   SV12   SV9T   SV10T  SV11T  SV12T
             2827h              SV13   SV14   SV15   SV16   SV13T  SV14T  SV15T  SV16T
             2828h              79RS   79CY   79LO   SH0    SH1    SH2    SH3    SH4
             2829h              CLOSE  CF     RCSF   OPTMN  RSTMN  FSA    FSB    FSC
             282Ah              LED9   50P32  LED10  59VA   TRGTR  52A    PB10   PB9
             282Bh              SG1    SG2    SG3    SG4    SG5    SG6    ZLOUT  ZLIN
             282Ch              ZLOAD  BCWA   BCWB   BCWC   COMMT  FAULT  SOTFT  BCW
             282Dh              ALARM  OUT107 OUT106 OUT105 OUT104 OUT103 OUT102 OUT101
             282Eh              3PO    SOTFE  Z3RB   KEY    EKEY   ECTT   WFC    PT
             282Fh              PTRX2  PTRX   PTRX1  UBB1   UBB2   UBB    Z3XT   DSTRT
             2830h              NSTRT  STOP   BTX    TRIP   OC     CC     DCHI   DCLO
             2831h              67P2S  67N2S  67G2S  67Q2S  PDEM   NDEM   GDEM   QDEM
             2832h              OUT201 OUT202 OUT203 OUT204 OUT205 OUT206 OUT207 OUT208
             2833h              OUT209 OUT210 OUT211 OUT212 *      *      *      *
             2834h              IN208  IN207  IN206  IN205  IN204  IN203  IN202  IN201
             2835h              *      *      *      *      *      *      *      *
             2836h              PB1    PB2    PB3    PB4    PB5    PB6    PB7    PB8
             2837h              LED1   LED2   LED3   LED4   LED5   LED6   LED7   LED8
             2838h              LED19  LED20  LED21  LED22  LED23  LED24  LED25  LED26
             2839h              RMB8A  RMB7A  RMB6A  RMB5A  RMB4A  RMB3A  RMB2A  RMB1A
             283Ah              TMB8A  TMB7A  TMB6A  TMB5A  TMB4A  TMB3A  TMB2A  TMB1A
             283Bh              RMB8B  RMB7B  RMB6B  RMB5B  RMB4B  RMB3B  RMB2B  RMB1B
             283Ch              TMB8B  TMB7B  TMB6B  TMB5B  TMB4B  TMB3B  TMB2B  TMB1B
             283Dh              LBOKB  CBADB  RBADB  ROKB   LBOKA  CBADA  RBADA  ROKA
             283Eh              PWRA1  PWRB1  PWRC1  PWRA2  PWRB2  PWRC2  INTC   INT3P
             283Fh              PWRA3  PWRB3  PWRC3  PWRA4  PWRB4  PWRC4  INTA   INTB
             2840h              SAGA   SAGB   SAGC   SAG3P  SWA    SWB    SWC    SW3P
*>>
```

Figure 2.13 MAP 2:TARGET Command Displays TARGET Region Data

e. View the data stored in the Port 2 METER region by issuing the command string **VIEW 2:METER**.

The SEL-2032 responds with a data “dump” showing the data stored in the region at the time of the request with the respective data item labels.

Note that all current and voltages are reported in primary system quantities.

f. View the data stored in the Port 2 TARGET region by issuing the command string **VIEW 2:TARGET BL**.

g. Check the communication and data retrieval performance by issuing the **STATUS** command.

The SEL-2032 responds with SEL-2032 general information, optional equipment information, and communication performance, including a listing of ports with their respective communication status, communication success rate, and database delays.

In *Figure 2.14*, the SEL-351S is connected to Port 2 of the SEL-2032, which is shown with Active status and 100 percent communication success rate. If the relay is disconnected or turned off, the status changes to Inactive.

```
*>>STATUS <Enter>
                                              Date: 11/19/01    Time: 15:13:55
FID=SEL-2032-R100-V0-Z000000-D20021222 FID=SLBT-2030-R103-V0-Z000000-D20010122

SELF-TESTS
RAM      SRAM     CODE     ARCH     EEPROM   P.S.  SET      BATTERY
512 kb   1024 kb  OK       1792 kb  OK       OK       OK       OK
IRIG-B Input: Absent
I/O Board: Absent
Port   Status           Success Rate   SET M     Database
1      Active               100%      None
2      Active               100%      None
3      Inactive                       None
4      Inactive                       None
5      Inactive                       None
6      Inactive                       None
7      Inactive                       None
8      Active                         None
9      Active                         None
10     Inactive                       None
11     Inactive                       None
12     Inactive                       None
13     Inactive                       None
14     Inactive                       None
15     Inactive                       None
16     Inactive                       None
17     Normal(0h)          NORM       None
F      Active              100%       None

*>>
```

Figure 2.14 STATUS Command Checks Communication and Data Retrieval

Section 3
Job Done Examples

Introduction

This section describes SEL-2032 Communications Processor operations and user interface with examples that include a variety of common applications.

Each example assumes you have successfully performed *Getting Started on page 2.14*, and that you have configured the SEL-2032 hardware by placing jumpers according to the instructions in *Jumper Settings on page 2.1*. The examples include an introduction to the problem or task, identification of the problem, overview or definition of the solution, and the step-by-step procedure you should follow to accomplish the solution with the SEL-2032.

Job Done® examples are also available for plug-in protocol card applications. See the instruction manual of each protocol card for examples of using the card-specific protocols and operations.

Example 1: Connect to the Front Port and Change Default Passwords

Introduction

This example demonstrates how to connect your PC or terminal to the front port (Port F), establish serial I/O communications, and change the factory-default password settings on the SEL-2032. You will need your SEL-2032, a PC or terminal with a serial port, and an SEL C234A cable to connect the PC or terminal to Port F on the front panel of the SEL-2032. If you are using a PC, you will also need a terminal emulation program.

Using Strong Passwords

It is important that you establish strong password protection to safeguard against unauthorized persons setting or resetting your SEL-2032 and the devices attached to it. Strong passwords consist of six or more characters (to a maximum of 12), with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks. Examples of valid, distinct strong passwords include:

Ot3579 A24.68 Ih2dcs 4u-Iwg Ic-4+

NOTE: Do not use characters that you have selected as LMD prefix characters. See LMD Distributed Port Switch Protocol on page 9.65 for a description of LMD prefixes.

Used properly, passwords provide good protection against unauthorized access. Make sure you choose strong passwords and record them in a secure location. If your passwords are forgotten or lost, you will need to install the main board password jumper in order to disable password protection long enough to view them with the **PAS** command.

The SEL-2032 ships with factory-default passwords for Access Levels 1, 2, and C. These passwords are shown in *Table 3.1*.

Table 3.1 Factory-Default Passwords for Access Levels 1, 2, and C

Access Level	Factory-Default Password
1	OTTER
2	TAIL
C	CLARKE

Set the Passwords, Step by Step

Step 1. Follow the SEL-2032 installation instructions listed in *Initial Checkout on page 2.14*.

Step 2. Connect one end of the SEL C234A cable to the serial port on your PC or terminal, and connect the other end to Port F on the front panel of the SEL-2032.

Step 3. The default factory settings for Port F are: 2400 baud, 8 data bits, 1 stop bit, and no parity. Set your PC or terminal communication parameters to the same settings and set your terminal emulation program to vt100 or vt52 emulation. Start a connection.

Step 4. Press a carriage return, **<Enter>**, and verify that a "*" prompt is returned. The "*" indicates that you are in Access Level 0.

Step 5. If you do not get an "*" with each carriage return, then something is wrong with your connection. Terminate your serial connection, check your cable connections and your communications parameters, and restart your serial I/O connection.

Step 6. When you receive the "*" prompt, you can type **HELP <Enter>** for a description of the commands available at Access Level 0. *Figure 3.1* shows a successful connection followed by the **HELP** and **ID** commands.

```
*HELP <Enter>
Commands available at current access level:
- ACCESS - Change access level to Access Level 1
- HELP - Provide information on available commands
- ID - Display SEL-2032 identification information
- QUIT - Change access level to Access Level 0
*ID
"FID=SEL-2032-R110-V0-D991222","FID=SLBT-2030-R101-V0-D980121","0DD5"
"COMMUNICATIONS PROCESSOR - S/N 98205023","0A73"

*
```

Figure 3.1 Commands Available

Step 7. To change passwords you need to move through Access Level 1 to Access Level 2. Type **ACC <Enter>** to go to Access Level 1. The SEL-2032 will respond with:

Password: ? ******

Step 8. The default factory password for Access Level 1 is OTTER, so type **OTTER <Enter>** and the SEL-2032 will respond with the Level 1 access notification and the "*****>" prompt indicating that you are in Access Level 1.

Step 9. Type **2AC <Enter>** to go to Access Level 2; the SEL-2032 responds with the same password prompt.

The default factory password for Access Level 2 is TAIL, so type **TAIL <Enter>** and the SEL-2032 responds with the Level 2 access notification and the “*****>>” prompt indicating that you are in Access Level 2.

Figure 3.2 demonstrates changing from Access Level 0 to Access Level 2.

```
*ACC <Enter>
Password: ? OTTER@
COMMUNICATIONS PROCESSOR - S/N 98205023     Date: 10/06/00    Time: 14:14:22
Level 1
*>2AC
Password: ? TAIL@@
COMMUNICATIONS PROCESSOR - S/N 98205023     Date: 10/06/00    Time: 14:14:45
Level 2
*>>
```

Figure 3.2 Changing Access Levels

Step 10. The **PAS** command is used to view and set passwords. Type **PAS <Enter>** to see the existing passwords settings.

Another form of the **PAS** command is used to set passwords. The command **PAS 1** is used to change the Level 1 password. For example, **PAS 1 <Enter>** starts the Access Level 1 password change sequence. Similarly, the command **PAS 2** starts the Access Level 2 password change sequence, and you can use **PAS C** to change the Access Level C password.

Step 11. After entering your new passwords, use the **PAS** command to view the new settings.

Figure 3.3 shows how to use the **PAS** command for viewing and setting passwords. When setting your passwords, be sure to choose “strong” passwords that cannot be guessed or broken with an automated password cracker.

```
*>>PAS <Enter>
1:OTTER
2:TAIL
*>>PAS 1 <Enter>
New level 1 password: ? ******
Verify new level 1 password: ? ******
Level 1 password changed
*>>PAS 2 <Enter>
New level 2 password: ? ******
Verify new level 2 password: ? ******
Level 2 password changed
*>>PAS <Enter>
1:Ot3579
2:Ta2468
*>>QUIT <Enter>
COMMUNICATIONS PROCESSOR - S/N 98205023     Date: 10/06/00    Time: 14:16:54

*
```

Figure 3.3 Using the PAS Command

Example 2: Using the SEL-2032 as a Port Switch

Introduction

This example assumes your substation has an SEL-2032, seven SEL-251 Relays, an IRIG-B source, and a telephone line. Also, you have SEL-C239 cables of the appropriate length to connect the SEL-2032 to each relay. You have a PC or terminal and an SEL C234A cable to communicate with the SEL-2032. You will connect all of these as shown in *Figure 3.4*.

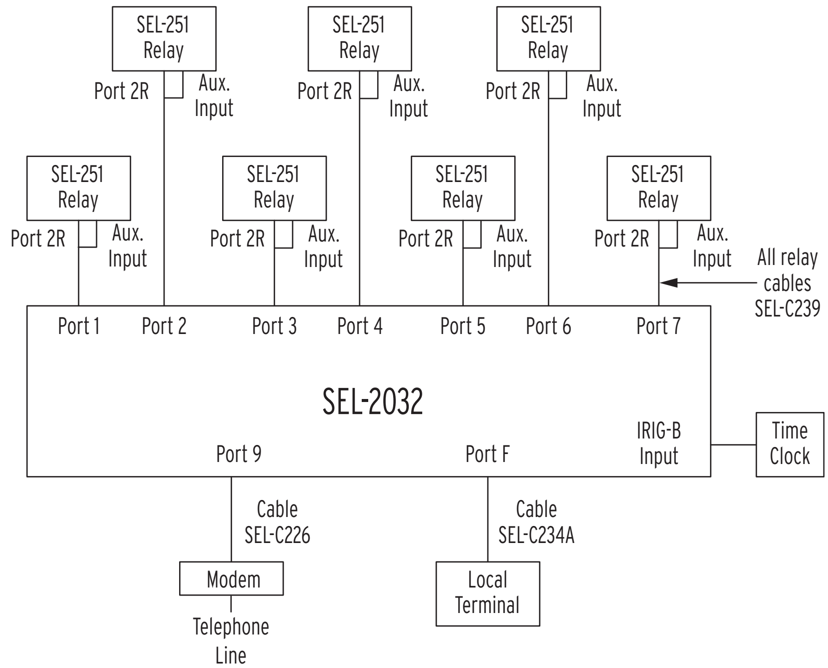


Figure 3.4 SEL-2032 Configured With SEL-251 Relays, External Modem, and IRIG-B Source

Identifying the Problem

Your objective in Example 2 is to accomplish the following tasks:

- ➤ You want the SEL-2032 to time synchronize all IEDs with the IRIG-B source.
- ➤ You want to send date messages to the relays even though they receive IRIG-B time code, so if power is cycled on a relay, the appropriate date (including year) is available as a reference.
- ➤ You want to access information in all the IEDs through the telephone port.

Defining the Solution

Complete Hardware Connections

Step 1. Connect each SEL-251 as follows:

a. On the relay, install cable SEL-C239 connectors to Port 2R and AUX INPUT.

b. Plug the other end of cable SEL-C239 into the desired SEL-2032 serial port.

Step 2. Connect the IRIG-B time source to the SEL-2032 IRIG-B input. (You need to know if the time source has a modulated or demodulated IRIG-B signal. Set IRIG setting accordingly.)

NOTE: You do not need to modify the baud rate of Port 2 at the relay; the SEL-2032 will match the baud rate during auto-configuration.

Step 3. Connect the modem to Port 9 using cable SEL-C226, and connect a telephone line to the phone line connector on the modem.

Step 4. Connect the serial port on your computer to Port F on the SEL-2032 with an SEL C234A cable.

Set the SEL-2032

Step 1. Issue the **ACCESS** and **2ACCESS** commands and associated passwords to go to Access Level 2.

Step 2. Use **SET P F** to set Port F parameters.

Step 3. Set Port 1 configuration communications options using the **SET P 1** command.

Step 4. Use **SET A 1** to define a timed trigger condition in the form of (Thh:mm:ss) to send a date message at a specific time once each day to the relay connected to Port 1.

Step 5. Use the **COPY 1 ALL** command to copy Port 1 settings to the other ports (2, 3, 4, 5, 6, and 7) with devices attached.

Step 6. Use **SET P 9** to set Port 9 as a modem port.

Verify and Test All Communication Paths

Step 1. Use the **STATUS** command to check that the IRIG-B signal is present and devices are connected to ports as expected.

Step 2. Check transparent communication with each port.

- ➢ Use the **PORT *n*** command to enter transparent communication with Port *n*, where *n* is any port number (1–16).
- ➢ Use **<Ctrl+D>** to end transparent communication.

Step 3. Check that all SEL relays are receiving the proper IRIG-B signal from the SEL-2032, that all relays have their Port 2 set to issue auto-messages, and that the relay Port 2 time-out is OFF.

- ➢ Enter Transparent Communication with each port, Access Level 1, and issue the **IRIG** command.
- ➢ Issue the **SHO** command to check the relay's AUTO and TIME settings.
- ➢ Exit transparent communication using the default disconnect sequence, **<Ctrl+D>**.

Step 4. Check that the SEL-2032 issues the correct date code to each relay. Change the relay date to the wrong year; use the **TOGGLE** command to issue the SEL-2032 date message.

Step 5. Check modem communication.

- ➢ Have someone call; the SEL-2032 modem should answer by the fourth ring.
- ➢ The remote caller can enter transparent communication, and you can watch the communication using front-panel LEDs and the **STATUS** command.

Set the SEL-2032, Step by Step

Step 1. Issue the **ACCESS** and **2ACCESS** commands and associated passwords to go to Access Level 2.

Step 2. Use **SET P F** to set Port F parameters to match those shown in *Table 3.2*.

Table 3.2 Example 2 Front Port Settings (SET P)

Setting Name	Setting Value	Comment
PORTID	"Service Port"	Enter a Port ID description.
MODEM	N	
BAUD	2400	
PARITY	N	
RTS_CTS	N	
XON_XOFF	Y	
TIMEOUT	OFF	
AUTO_HELP	Y	
TERTIME1	1	
TERSTRING	\004	Default TERSTRING="\004" is ASCII hexadecimal code for keystroke **<Ctrl+D>**. Use **<Ctrl+D>** to end or quit transparent communication with a port.
TERTIME2	OFF	

Step 3. Note that the STARTUP string in the following example reflects that you have not changed the relay passwords from the factory defaults.

If you change the passwords, you should modify the startup strings in the SEL-2032 to match the new passwords.

Step 4. Set Port 1 communications options using the **SET P** command to match the settings shown in *Table 3.3*. When prompted, initiate an auto-configuration of Port 1.

Table 3.3 Example 2 Relay Port Settings (SET P)

Setting Name	Setting Value	Comment
DEVICE	S	
PORTID	"Example 21.6 kV Line"	
BAUD	9600	
DATABIT	8	
STOPBIT	2	
PARITY	N	
RTS_CTS	N	
TIMEOUT	30	Set port time-out to 30 minutes to disconnect transparent communication automatically.

Step 5. Use **SET A** to define a timed trigger condition in the form of (Thh:mm:ss) to send a date message, at a specific time once each day, to the relay connected to Port 1. Skip Step 5 if you are using an SEL-500 series, SEL-300 series, or SEL-400 series relay with an IRIG-B input connected to the SEL-2032.

This setting sequence uses the **SET A** command to set a message trigger and a message in Port 1 of the SEL-2032. This example sets the SEL-2032 to issue the date command to the relay attached to Port 1 once each day. Even though you supply IRIG-B time to the relays, if a relay is powered down for any reason, it may need this date information to establish the current year because the year is not supplied by IRIG-B. The date is retrieved from the SEL-2032 Global region and formatted in a message string that the relay will recognize.

The SEL-2032 maintains date and time information in the Global region. You can access this information using the **VIEW** command. Use the labels displayed by the **VIEW** command when you define the date message sequence with the **SET A** command. For an interpretation of the labels shown in the **VIEW** screen and for a description of the Global region, see *Global Region on page 6.4*.

To see the Global data format, type **VIEW 1:GLOBAL <Enter>** to display Global database information. Your screen should look like the example in *Figure 3.5*.

```
*>>VIEW 1:GLOBAL <Enter>
Port 1,  Data Region GLOBAL   Data
FID = FID=SEL-2032-R100-V0-Z000000-D20021222
STATUS = 0100h  CONFIG = 0CA0h  __YEAR = 1997  DAY_OF_YEAR = 304 (10/01)
MONTH = 10  DATE = 31  TIME = 14:12:03.598
ELEMENTS = 04h,00h,00h,20h,FFh,FFh,00h
REMOTE_BIT_REG = 0000h  REMOTE_BITS = 00h  _YEARS = 97
_HOURS = 14  _MINS = 12  _SECS = 3
CARD1_FID = FID=SEL-2711-R100-V0-D971031
CARD1_SERVICES =       64  CARD1_STATUS = 0021h  CARD1_CONFIG = 0001h
  CARD1_STEST_ERR = 0082h
CARD2_FID =
CARD2_SERVICES =        0  CARD2_STATUS = 0000h  CARD2_CONFIG = 0000h
  CARD2_STEST_ERR = 0000h  PORT_STATUS = 0004h  ALT_PORT = 255
NUM_MESGS = 20  BAD_MESGS = 0

*>>
```

Figure 3.5 Global Data Region Contents

Now, type **SET A 1** to define a timed trigger condition and a message to send the date message to the relay connected to Port 1 at a specific time once each day. Enter the information and follow the prompts to set the SEL-2032 to match the settings shown in *Table 3.4*.

Table 3.4 Example 2 Port 1 Automatic Messaging Settings

Setting Name	Setting Value	Comment
AUTOBUF	Y	Permit the SEL-2032 to collect and store unsolicited messages from the relay, like summary event reports and group switch reports.
STARTUP	“ACC\nOTTER\n2AC\nTAIL\n”	
NOCONN	NA	
SEND_OPER	N	
REC_SER	N	
MSG_CNT	1	One outgoing message.
ISSUE1	T01:00:00.0	Trigger MESG1 at 1:00 a.m. every day.
MESG1	“DATE \RI ;01: GLOBAL:MONTH// \RI ;01: GLOBAL:DATE// \RI ;01: GLOBAL:_YEAR/\n”	Send the date command to the relay with the current date, i.e., DATE MM/DD/YYYY <CR>.
PARSE1	0	
DELAY1	ON	Leave DELAY1=ON so response to DATE message will not be interpreted as a response to a following message request.
ARCH_EN	N	
USER	0	

Step 6. Use the **COPY 1 ALL** command, as shown in *Figure 3.6*, to copy Port 1 settings to the other ports (2, 3, 4, 5, 6, and 7) with devices attached.

The above step results in the following screen. Port settings were not copied beyond Port 7. If you know that all SEL IEDs are identical, you may type **N <Enter>** when asked for auto-configuration and simply enter the Port ID for each port since auto-configuration information will be the same. Sometimes settings are lost during copying because of device incompatibilities. Therefore, whenever you use the **COPY** command you should check all settings using the **SHOWSET** command on each port (e.g., SHO 2).

```
*>>COPY 1 ALL <Enter>
Copy settings from Port 1 to Port 2 (Y/N) ? Y <Enter>
Perform auto-configuration on Port 2 (Y/N) ? Y <Enter>
Attempting auto-configuration...Done.
Port 2 Settings Changed
Copy settings from Port 1 to Port 3 (Y/N) ? Y <Enter>
Perform auto-configuration on Port 3 (Y/N) ? Y <Enter>
Attempting auto-configuration...Done.
Port 3 Settings Changed
Copy settings from Port 1 to Port 4 (Y/N) ? Y <Enter>
Perform auto-configuration on Port 4 (Y/N) ? Y <Enter>
Attempting auto-configuration...Done.
Port 4 Settings Changed
Copy settings from Port 1 to Port 5 (Y/N) ? Y <Enter>
Perform auto-configuration on Port 5 (Y/N) ? Y <Enter>
Attempting auto-configuration...Done.
Port 5 Settings Changed
Copy settings from Port 1 to Port 6 (Y/N) ? Y <Enter>
Perform auto-configuration on Port 6 (Y/N) ? Y <Enter>
Attempting auto-configuration...Done.
Port 6 Settings Changed
Copy settings from Port 1 to Port 7 (Y/N) ? Y <Enter>
Perform auto-configuration on Port 7 (Y/N) ? Y <Enter>
Attempting auto-configuration...Done.
Port 7 Settings Changed
Copy settings from Port 1 to Port 8 (Y/N) ? N <Enter>
Copy settings from Port 1 to Port 9 (Y/N) ? N <Enter>
Copy settings from Port 1 to Port 10 (Y/N) ? N <Enter>
Copy settings from Port 1 to Port 11 (Y/N) ? N <Enter>
Copy settings from Port 1 to Port 12 (Y/N) ? N <Enter>
Copy settings from Port 1 to Port 13 (Y/N) ? N <Enter>
Copy settings from Port 1 to Port 14 (Y/N) ? N <Enter>
Copy settings from Port 1 to Port 15 (Y/N) ? N <Enter>
Copy settings from Port 1 to Port 16 (Y/N) ? N <Enter>

*>>
```

Figure 3.6 Settings COPY Command Example

Step 7. Use **SET P** to set Port 9 as a modem port with the settings shown in *Table 3.5*.

Table 3.5 Example 2 Modem Port Settings (Sheet 1 of 2)

Setting Name	Setting Value	Comment
DEVICE	M	
PROTOCOL	S	
FAST_OP	N	
PORTID	“MODEM”	Enter “MODEM” or some other description to identify the port as a modem port.
MODEM	Y	
MSTR	“ATX0E0&D0S0=4”	Accept the default modem startup initialization string.
CD_CTS	N	
DCD_FLOW	Y	
BAUD	38400	The default baud rate for all rear ports is 9600. Set the baud rate to 38400 baud to take full advantage of the modem’s maximum baud rate. When you call the substation from a remote location, the modem on your PC and the SEL-2032 modem will negotiate the highest possible baud rate.
DATABIT	8	
STOPBIT	2	
PARITY	N	
RTS_CTS	N	

Table 3.5 Example 2 Modem Port Settings (Sheet 2 of 2)

Setting Name	Setting Value	Comment
XON_XOFF	Y	
TIMEOUT	30.0	
ECHO	Y	
AUTO_HELP	Y	
TERTIME1	1	
TERSTRING	"\004"	
TERTIME2	OFF	

Verify and Test All Communication Paths

The remainder of this example verifies proper communication with the SEL-251 Relays attached to each port of the SEL-2032.

Step 1. Issue the **STATUS** command to check that IRIG-B signal is present and devices are connected as expected. Your screen should look similar to *Figure 3.7*.

```
*>>STATUS <Enter>
COMMUNICATIONS PROCESSOR - S/N 95012004     Date: 01/25/01    Time: 13:46:43
FID=SEL-2032-R100-V0-Z000000-D20021222      FID=SLBT-2030-R103-V0-Z000000-D20010122
SELF-TESTS
RAM      SRAM     CODE     ARCH     EEPROM   P.S.     SET      BATTERY
512 kb   1024 kb  OK       1792 kb  OK       OK       OK       OK
IRIG-B Input: Absent
I/O Board: Absent
Port   Status           Success Rate   SET M     Database
1      Active                100%      None
2      Active                100%      None
3      Active                100%      None
4      Active                100%      None
5      Active                100%      None
6      Active                100%      None
7      Active                100%      None
8      Inactive                        None
9      Active                          None
10     Inactive                        None
11     Inactive                        None
12     Inactive                        None
13     Inactive                        None
14     Inactive                        None
15     Inactive                        None
16     Inactive                        None
17     Sole Node(100h)      NORM       None
F      Active               100%       None

*>>
```

Figure 3.7 STATUS Command Example

Step 2. Initiate transparent communications to the relay on Port 1 by typing **PORT 1 <Enter>**. Press **<Enter>** a second time to receive the relay system prompt, as shown in *Figure 3.8*.

```
*>>PORT 1 <Enter>
Transparent Communications to Port 1 established
<Enter>

=
```

Figure 3.8 Initiate Transparent Communications

You can now communicate with the relay attached to Port 1 as though your terminal were directly connected to the relay. The relay will be at Access Level 0, as indicated by the "=" prompt. If you do not see the "Transparent Communication

Established" message or the relay prompt, check the cable connection and the relay status. See *Section 10: Testing and Troubleshooting* for more detailed information.

Step 3. Use the **ACCESS** command and relay password to get to Access Level 1. At the "=>" relay prompt, issue the **IRIG** command. IRIG directs the relay to read the demodulated IRIG-B time-code input on the AUX input power panel port. If the relay reads the time code successfully, the relay updates the internal clock/calendar time and date and transmits a message with relay ID string, date, and time. If no IRIG-B signal is present, or the code cannot be read successfully, the relay sends the error message "IRIG B DATA ERROR." If you receive an error message, check the cable connection between the SEL-2032 and the relay AUX input port and consult *Section 10: Testing and Troubleshooting.*

Issue the **SHOWSET** command (**SHO** for short) to view the relay settings. You should see relay setting information similar to that shown in *Figure 3.9*.

```
=>SHO <Enter>
Settings for group 1
Example 21.6 kV Feeder - S/N 93245011
CTR  =120.00  PTR  =180.00
R1   =0.58    X1   =1.50    R0   =1.44    X0   =4.56
RS   =0.00    XS   =0.00    LL   =2.42
DATC =15      PDEM =12.00   QDEM =12.00   NDEM =0.99
79OI1=60      79OI2=600     79OI3=900     79OI4=0
79RST=1800    M79SH=00000
50C  =99.99   27L  =0.00    27H  =0.00    27C  =2       TCI  =0
50Q  =99.99   50QT =0
51QP =6.00    51QTD=15.00   51QC =3       51QRS=N
50NL =20.01   50NLT=2       50NH =99.99
51NP =1.50    51NTD=2.00    51NC =3       51NRS=N
50L  =99.99   50LT =0       50H  =39.99
51P  =6.00    51TD =6.00    51C  =3       51RS =N
52APU=1200    52ADO=0       TSPU =0       TSDO =0
TKPU =0       TKDO =0       TZPU =0       TZDO =0
PRESS RETURN ? <Enter>
SELogic Equations
S(123)  =
A(12)   =
B(12)   =50NLT
C(12)   =50NL
D(12)   =
E(34)   =79RS+79CY+52AT
F(34)   =IN6
G(34)   =
H(34)   =
J(1234) =
K(1234) =
L(1234) =
A1(1234)=TF
A2(1234)=NDEM
PRESS RETURN ? <Enter>
V(56)   =B*E*F
W(56)   =C*E*F
X(56)   =
Y(56)   =
Z(56)   =
A3(1346)=79CY
A4(2346)=
TR(1246)=50H+51T+51NT+V
RC(1246)=50H+TF
ER(1246)=51P+51QP+51NP+TF+W
SEQ(1)  =
ETC(1)  =
ITC(1)  =
Global settings
DEMR =Y       CFT  =60     TDUR =4      TFT  =30     TGR  =180 ITT  =5   TIME1=15
TIME2=0       AUTO =2      RINGS=3      IN1  =SS1    IN2  =DT  IN3  =RE  IN4  =
IN5  =52A     IN6  =

=>
```

Figure 3.9 Relay Group 1 Settings

While you have the relay global settings on the screen, verify that:

TIME2 = 0

AUTO = 2 or 3 (setting 2 is for Port 2 and setting 3 is for both Ports 1 and 2)

These settings allow the SEL-2032 to continue to receive automatic messages from the relay without the port timing out. If these two settings are not as shown above, go to Access Level 2 and use the relay **SET** command to change them.

Quit transparent communication using the default disconnect sequence or keystroke **<Ctrl+D>**.

NOTE: After transparent communications with the relay, the SEL-2032 will reissue the STARTUP string to the relay to return it to the access level needed for proper operation. If you change a relay password, modify the port's startup string to match. If you use an SEL-501 Relay and change one of the relay type settings, reconfigure afterwards so that the SEL-2032 maintains a correct target list.

You should see a termination message as shown in *Figure 3.10*.

```
=><Ctrl+D>
Transparent Communications to Port 1 terminated

*>>
```

Figure 3.10 Terminate Transparent Communications

Step 4. Use the **TOGGLE** command, as shown in *Figure 3.11*, to send the date message previously defined as MESG1 in the SEL-2032.

As shown here, you toggle the state of the D1 element to trigger the associated message MESG1. The SELOGIC® control equation in ISSUE1 normally does this, but the **TOGGLE** command lets you test the process without waiting for the SELOGIC control equation condition to become true.

```
*>>TOGGLE 1:D1 <Enter>
Bit toggled

*>>
```

Figure 3.11 TOGGLE Command Example

Reestablish transparent communications with the relay and verify that the date matches the date in the SEL-2032. Use the **DATE** command to change the date and year in the relay (DATE MM/DD/YY); exit transparent communication and issue the **TOGGLE** command again. Enter transparent communication and again verify that the date matches the date in the SEL-2032. If the date does not match, exit transparent communication and double-check the SEL-2032 MESG1 setting to make sure that the message string exactly matches the string in the **SET A** example shown earlier.

Step 5. Check modem communication.

Have someone call the phone number of the telephone line connected to the SEL-2032 modem. The modem should answer on the fourth ring. The caller's communication program should be set for an 8-bit word, no parity, and 2 stop bits. Any baud rate can be used, up to the maximum baud rate of the caller's and local modems.

The remote caller can enter transparent communication with any of the relays attached to the SEL-2032 using the **PORT** command, just as you did earlier. You can monitor the communication using the LEDs on the SEL-2032 front panel and using the **STATUS** command. The **STATUS** screen shows the ports that are in transparent communication and the port number they are in transparent communication with. For instance, if Port 9 is in transparent communication with Port 1, the status of Port 9 will show TRANS1, and the status of Port 1 will show TRANS9.

The remote caller should use the same procedure to quit transparent communication as he or she did earlier. If, for some reason, remote communication is cut off before the remote caller quits transparent communication, the TIMEOUT on the SEL-2032 modem port will disconnect transparent communication automatically in 30 minutes.

Example 3: Collect SEL Relay Status and Measurements

To demonstrate the power and simplicity of the SEL-2032, set the SEL-2032 to collect relay meter data from an SEL-351S Relay as follows:

Step 1. Connect the SEL-351S to an SEL-2032 port; this example uses Port 2.

Use the SEL C273A cable that handles both communication and IRIG-B.

- ➢ Connect the communication terminal at the Y end of the cable to Port 2 on the SEL-351S.
- ➢ Connect the single connector end of the cable to Port 2 on the SEL-2032.

Step 2. Enter Access Level 2 on the SEL-2032 and issue the command **SET P 2** to configure Port 2.

The SEL-2032 prompts for the type of device connected to the port.

- ➢ Enter **S** for SEL IED, **Y** to auto-configure the port, and press the **<Enter>** key to confirm the configuration prompts.

  The SEL-2032 establishes communication with the relay; determines the type of relay, relay ID, and communication baud rate; and determines if the relay is capable of Fast Meter.
- ➢ Enter **Y** to save port configuration changes at the final prompt.

Step 3. Issue the **AUTO 2** command to see what Fast Message features are supported by the SEL-351S. *Figure 3.12* shows an example output for the **AUTO** command.

```
*>>AUTO 2 <Enter>
FID:       FID=SEL-351S-7-R106-V0-Z003003-D20010110
DEVICE ID: FEEDER 1
BAUD RATE: 19200
OPERATE SUPPORT: Binary (1 Breakers, 16 Remote Bits S-C-P)
LEVEL 1 PASSWORD: OTTER
COMMANDS SUPPORTED:
  B 20METER
  B 20DEMAND
  B 20TARGET
  A 20HISTORY
  A 20STATUS
  A 20EVENT
  A 20EVENTS
  A 20EVENTL

*>>
```

Figure 3.12 Example AUTO Command Output

Step 4. Next, issue the command **SET A 2** to set an auto-message to collect relay meter and target data.

- ➢ Respond to prompts about saving unsolicited messages (AUTOBUF), the STARTUP string, operate command enable (**SENDOPER**), and receive SER enable (**RECSER**).
- ➢ Press **<Enter>** to confirm the defaults for all of these.
- ➢ Enter **2** when prompted for the message count.
- ➢ At the ISSUE1 prompt, enter **P00:00:01** to set the message to trigger once every second.
- ➢ At the MESG1 prompt, enter **20METER** to send the request for meter data to the SEL relay.
- ➢ At the ISSUE2 prompt, enter **P00:00:01** and at the MSG2 prompt enter **20TARGET** to collect relay target data.
- ➢ Enter **END** and press **<Enter>** to accept the default for remaining settings and enter **Y** to save changes.

As soon as the SEL-2032 accepts the setting change, the TXD and RXD Port 2 LEDs on the SEL-2032 will begin to flash as the SEL-2032 requests and receives meter data every second.

Step 5. Verify connection, configuration, and data transfer using SEL-2032 commands **WHO**, **MAP**, **VIEW**, and **STATUS**.

a. Verify that the relay is connected to the desired port and configured properly by issuing the **WHO** command.

   The SEL-2032 responds to this command with some basic information about the SEL-2032 and a list of the devices and device identification strings associated with each port. The example in *Figure 3.13* shows that an SEL-351S device is connected to Port 1.

```
*>>WHO <Enter>
                                              Date: 11/19/01    Time: 14:56:16
FID=SEL-2032-R100-V0-Z000000-D20021222 FID=SLBT-2030-R103-V0-Z000000-D20010122
Port#  Device    Protocol   Parameters  Identification
1      Master    SEL        9600,8,2,N
2      SEL-351S  SEL        19200,8,2,N FEEDER 1
3      SEL IED   SEL        9600,8,2,N
4      SEL IED   SEL        9600,8,2,N
5      SEL IED   SEL        9600,8,2,N
6      SEL IED   SEL        9600,8,2,N
7      SEL IED   SEL        9600,8,2,N
8      SEL IED   SEL        9600,8,2,N
9      SEL IED   SEL        9600,8,2,N
10     SEL IED   SEL        9600,8,2,N
11     SEL IED   SEL        9600,8,2,N
12     SEL IED   SEL        9600,8,2,N
13     SEL IED   SEL        9600,8,2,N
14     SEL IED   SEL        9600,8,2,N
15     SEL IED   SEL        9600,8,2,N
16     SEL IED   SEL        9600,8,2,N
17     SEL-2701  Ethernet   VTm:HS,CTl:HS,TIm:S,SBt:S
F*     Master    SEL        9600,8,2,N

*>>
```

Figure 3.13 WHO Command Example

b. Issue the command **MAP2**, as shown in *Figure 3.14*, to verify the location and type of data being collected on Port 2 of the SEL-2032.

The SEL-2032 responds with a database map of the Port 2 data regions. This map shows that meter data are being collected in Port 2 region D1, which is associated with Port 2 Message 1. The B METER indicates that the SEL-2032 is receiving binary, or Fast Meter, data from the SEL-351S. You can refer to the specific region by the region name, D1, or the data name, METER.

```
*>>MAP 2 <Enter>
Port 2 Database Assignments
  Region    Data Type   # Records
  GLOBAL    --
  LOCAL     --
  BUF       --
  D1      B METER
  D2      B TARGET
  D3        Unused
  D4        Unused
  D5        Unused
  D6        Unused
  D7        Unused
  D8        Unused
  A1        Unused
  A2        Unused
  A3        Unused
  USER      Unused

*>>
```

Figure 3.14 MAP Command Example

c. Verify the various metering quantities that are being collected and stored in the SEL-2032 by issuing the command **MAP 2:METER** or **MAP 2:D1**, as shown in *Figure 3.15*.

The SEL-2032 responds with a map of the specific region, including a listing of the data item names, the starting address for each data item, and the type of data stored at each address.

```
*>>MAP 2:METER
Port 2,  Data Region METER  Map
Data Item    Starting Address   Type
_YEAR        2000h              int
DAY_OF_YEAR  2001h              int
TIME(ms)     2002h              int[2]
MONTH        2004h              char
DATE         2005h              char
YEAR         2006h              char
HOUR         2007h              char
MIN          2008h              char
SECONDS      2009h              char
MSEC         200Ah              int
IA           200Bh              float[2]
IB           200Fh              float[2]
IC           2013h              float[2]
IN           2017h              float[2]
VA           201Bh              float[2]
VB           201Fh              float[2]
VC           2023h              float[2]
VS           2027h              float[2]
FREQ         202Bh              float[2]
VBAT         202Fh              float[2]
IAB(A)       2033h              float[2]
IBC(A)       2037h              float[2]
ICA(A)       203Bh              float[2]
VAB(V)       203Fh              float[2]
VBC(V)       2043h              float[2]
VCA(V)       2047h              float[2]
PA(MW)       204Bh              float
QA(MVAR)     204Dh              float
PB(MW)       204Fh              float
QB(MVAR)     2051h              float
PC(MW)       2053h              float
QC(MVAR)     2055h              float
P(MW)        2057h              float
Q(MVAR)      2059h              float
I0(A)        205Bh              float[2]
I1(A)        205Fh              float[2]
I2(A)        2063h              float[2]
V0(V)        2067h              float[2]
V1(V)        206Bh              float[2]
V2(V)        206Fh              float[2]

*>>
```

Figure 3.15 MAP 2:METER Command Example

Notice in this case that all of the currents and voltages contain two floating-point numbers, one for magnitude, the other for phase angle. The magnitudes and phase angles are calculated from Fast Meter sample data.

d. Use the **MAP 2:TARGET BL** command, as shown in *Figure 3.16*, to display a list of the data collected in the TARGET region. The BL option displays bit labels, the labels of the individual Relay Word bits collected and available.

```
*>>MAP 2:TARGET BL <Enter>
Port 2,  Data Region TARGET  Map
Data Item    Starting Address   Type   Bit Labels
_YEAR        2800h              int
DAY_OF_YEAR  2801h              int
TIME(ms)     2802h              int[2]
TARGET       2804h              char[61]
             2804h              *     *     *     STSET *     *     *     *
             2805h              TLED11 TLED12 TLED13 TLED14 TLED15 TLED16 TLED17 TLED18
             2806h              TLED19 TLED20 TLED21 TLED22 TLED23 TLED24 TLED25 TLED26
             2807h              50A1  50B1  50C1  50A2  50B2  50C2  50A3  50B3
             2808h              50C3  50A4  50B4  50C4  50AB1 50BC1 50CA1 50AB2
             2809h              50BC2 50CA2 50AB3 50BC3 50CA3 50AB4 50BC4 50CA4
             280Ah              50A   50B   50C   51P1  51P1T 51P1R 51N1  51N1T
             280Bh              51N1R 51G1  51G1T 51G1R 51P2  51P2T 51P2R 51N2
             280Ch              51N2T 51N2R 51G2  51G2T 51G2R 51Q   51QT  51QR
             280Dh              50P1  50P2  50P3  50P4  50N1  50N2  50N3  50N4
             280Eh              67P1  67P2  67P3  67P4  67N1  67N2  67N3  67N4
             280Fh              67P1T 67P2T 67P3T 67P4T 67N1T 67N2T 67N3T 67N4T
             2810h              50G1  50G2  50G3  50G4  50Q1  50Q2  50Q3  50Q4
             2811h              67G1  67G2  67G3  67G4  67Q1  67Q2  67Q3  67Q4
             2812h              67G1T 67G2T 67G3T 67G4T 67Q1T 67Q2T 67Q3T 67Q4T
             2813h              50P5  50P6  50N5  50N6  50G5  50G6  50Q5  50Q6
             2814h              50QF  50QR  50GF  50GR  32VE  32QGE 32IE  32QE
             2815h              F32P  R32P  F32Q  R32Q  F32QG R32QG F32V  R32V
             2816h              F32I  R32I  32PF  32PR  32QF  32QR  32GF  32GR
             2817h              27A1  27B1  27C1  27A2  27B2  27C2  59A1  59B1
             2818h              59C1  59A2  59B2  59C2  27AB  27BC  27CA  59AB
             2819h              59BC  59CA  59N1  59N2  59Q   59V1  27S   59S1
             281Ah              59S2  59VP  59VS  SF    25A1  25A2  3P27  3P59
             281Bh              81D1  81D2  81D3  81D4  81D5  81D6  27B81 50L
             281Ch              81D1T 81D2T 81D3T 81D4T 81D5T 81D6T VPOLV LOP
             281Dh              *     *     IN106 IN105 IN104 IN103 IN102 IN101
             281Eh              LB1   LB2   LB3   LB4   LB5   LB6   LB7   LB8
             281Fh              LB9   LB10  LB11  LB12  LB13  LB14  LB15  LB16
             2820h              RB1   RB2   RB3   RB4   RB5   RB6   RB7   RB8
             2821h              RB9   RB10  RB11  RB12  RB13  RB14  RB15  RB16
             2822h              LT1   LT2   LT3   LT4   LT5   LT6   LT7   LT8
             2823h              LT9   LT10  LT11  LT12  LT13  LT14  LT15  LT16
             2824h              SV1   SV2   SV3   SV4   SV1T  SV2T  SV3T  SV4T
             2825h              SV5   SV6   SV7   SV8   SV5T  SV6T  SV7T  SV8T
             2826h              SV9   SV10  SV11  SV12  SV9T  SV10T SV11T SV12T
             2827h              SV13  SV14  SV15  SV16  SV13T SV14T SV15T SV16T
             2828h              79RS  79CY  79LO  SH0   SH1   SH2   SH3   SH4
             2829h              CLOSE CF    RCSF  OPTMN RSTMN FSA   FSB   FSC
             282Ah              LED9  50P32 LED10 59VA  TRGTR 52A   PB10  PB9
             282Bh              SG1   SG2   SG3   SG4   SG5   SG6   ZLOUT ZLIN
             282Ch              ZLOAD BCWA  BCWB  BCWC  COMMT FAULT SOTFT BCW
             282Dh              ALARM OUT107 OUT106 OUT105 OUT104 OUT103 OUT102 OUT101
             282Eh              3PO   SOTFE Z3RB  KEY   EKEY  ECTT  WFC   PT
             282Fh              PTRX2 PTRX  PTRX1 UBB1  UBB2  UBB   Z3XT  DSTRT
             2830h              NSTRT STOP  BTX   TRIP  OC    CC    DCHI  DCLO
             2831h              67P2S 67N2S 67G2S 67Q2S PDEM  NDEM  GDEM  QDEM
             2832h              OUT201 OUT202 OUT203 OUT204 OUT205 OUT206 OUT207 OUT208
             2833h              OUT209 OUT210 OUT211 OUT212 * *     *     *
             2834h              IN208 IN207 IN206 IN205 IN204 IN203 IN202 IN201
             2835h              *     *     *     *     *     *     *     *
             2836h              PB1   PB2   PB3   PB4   PB5   PB6   PB7   PB8
             2837h              LED1  LED2  LED3  LED4  LED5  LED6  LED7  LED8
             2838h              LED19 LED20 LED21 LED22 LED23 LED24 LED25 LED26
             2839h              RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A
             283Ah              TMB8A TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A
             283Bh              RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B
             283Ch              TMB8B TMB7B TMB6B TMB5B TMB4B TMB3B TMB2B TMB1B
             283Dh              LBOKB CBADB RBADB ROKB  LBOKA CBADA RBADA ROKA
             283Eh              PWRA1 PWRB1 PWRC1 PWRA2 PWRB2 PWRC2 INTC  INT3P
             283Fh              PWRA3 PWRB3 PWRC3 PWRA4 PWRB4 PWRC4 INTA  INTB
             2840h              SAGA  SAGB  SAGC  SAG3P SWA   SWB   SWC   SW3P

*>>
```

Figure 3.16 Example MAP Command on the TARGET Region

e. View the data stored in the Port 2 METER region by issuing the command string **VIEW 2:METER**, as shown in *Figure 3.17*.

   The SEL-2032 responds with a data “dump” showing the data stored in the region at the time of the request with the respective data item labels.

   Note that all current and voltages are reported in primary system quantities.

f. Check the communication and data retrieval performance by issuing the SEL-2032 STATUS command.

The SEL-2032 responds with SEL-2032 general information, optional equipment information, and communication performance, including a listing of ports with their respective communication status, communication success rate, and database delays.

In this example, the SEL-351S is connected to Port 2 of the SEL-2032, which is shown with active status and 100 percent communication success rate. If the relay is disconnected or turned off, the status changes to inactive.

```
*>>STATUS <Enter>
                                                      Date: 11/19/01    Time: 15:13:55
FID=SEL-2032-R100-V0-Z000000-D20021222 FID=SLBT-2030-R103-V0-Z000000-D20010122
SELF-TESTS
RAM       SRAM     CODE      ARCH      EEPROM   P.S.  SET       BATTERY
512 kb   1024 kb  OK        1792 kb  OK        OK       OK        OK
IRIG-B Input: Absent
I/O Board: Absent
Port   Status           Success Rate   SET M     Database
1      Active                100%      None
2      Active                100%      None
3      Inactive                        None
4      Inactive                        None
5      Inactive                        None
6      Inactive                        None
7      Inactive                        None
8      Active                          None
9      Active                          None
10     Inactive                        None
11     Inactive                        None
12     Inactive                        None
13     Inactive                        None
14     Inactive                        None
15     Inactive                        None
16     Inactive                        None
17     Normal(0h)           NORM       None
F      Active               100%       None

*>>
```

Figure 3.17 STATUS Command Example

Example 4: Collect Unsolicited Write (Synchrophasor) Data

The SEL-2032 is capable of collecting synchrophasor data from SEL IEDs such as the SEL-311 series relays, most of the SEL-351 series relays, the SEL-421 and SEL-451, and metering devices such as the SEL-734 at user-defined discrete data rates. The SEL-2032 receives synchrophasor data as Unsolicited Write (UW) Messages within the SEL Fast Message protocol. This protocol is described in *Section 9: Protocols*.

Perform the following configuration steps to automatically collect synchrophasor data as fast as 60 messages per minute from an SEL-311C and make this data available to a DNP3 LAN/WAN master:

Step 1. Configure the SEL-311C Phasor Measurement Unit (PMU) settings.

➢ Enter Access Level 2 on the SEL-311C and issue the command **SET G EPMU** to edit Global settings.

➢ Configure the SEL-311C PMU settings as in *Table 3.6*. In this example, the SEL-311C is configured to transmit all available synchrophasors to the Port 3 USER region of the SEL-2032.

➢ Enter **Y** to save the global configuration changes at the final prompt.

Table 3.6 SEL-311C Global Settings for Synchrophasors

Global Setting Name	Description	Setting	Comment
EPMU	Enable Synchronized Phasor Measurement (Y, N)	Y	Set Global setting EPMU to Y to enable the remaining SEL-311C synchrophasor settings.
PMID	PMU Hardware ID	50395136	Decimal value of the hexadecimal 0300F800h, where the first two digits represent the SEL-2032 port number (3) and the last four represent the starting address of the USER region on the port (F800h)
PHDATAV	Phasor Data Set, Voltages (V1, ALL)	ALL	Transmit all voltage synchrophasors
VCOMP	Voltage Angle Compensation Factor (–179.99 to 180 degrees)	0.00	
PHDATAI	Phasor Data Set, Currents (ALL, NA)	ALL	Transmit all current synchrophasors
ICOMP	Current Angle Compensation Factor (–179.99 to 180 degrees)	0.00	
TS_TYPE	Time Source Type (IRIG, IEEE)	IRIG	

Step 2. Configure the SEL-311C serial port settings; this example uses port 2.

NOTE: Port 2 on the SEL-311C is the only serial port that accepts IRIG. If the SEL-2032 will be used to synchronize the SEL-311C to the IRIG signal, Port 2 of the SEL-311C must be used.

➢ Enter Access Level 2 on the SEL-311C and issue the command **SET P 2** to configure serial Port 2.

➢ Configure the SEL-311C serial port as in *Table 3.7*. Note that the maximum SPEED for an SEL IED (non-master) serial port connected to an SEL-2032 is 19200.

➢ Enter **Y** to save the port configuration changes at the final prompt.

Table 3.7 SEL-311C Serial Port Settings for Synchrophasors (Sheet 1 of 2)

Port Setting Name	Description	Setting
PROTO	Protocol (SEL, LMD, DNP, MBA, MBB, MB8A, MB8A, MBGA, MBGB)	SEL
SPEED	Baud Rate (300 to 38400)	19200
BITS	Data Bits (6, 7, 8)	8
PARITY	Parity (O, E, N)	N
T_OUT	Minutes to Port Time-out (0–30)	0

Table 3.7 SEL-311C Serial Port Settings for Synchrophasors (Sheet 2 of 2)

Port Setting Name	Description	Setting
DTA	DTA Meter Format (Y, N)	N
AUTO	Send Auto Messages to Port (Y, N)	N
STOP	Stop Bits (1, 2)	2
RTSCTS	Enable Hardware Handshaking (Y, N)	N
FASTOP	Fast Operate Enable (Y, N)	N

Step 3. Connect the SEL-311C to an SEL-2032 port; this example uses Port 3.

Use the SEL C273A cable that handles both communication and IRIG-B.

- ➢ Connect the end labeled SEL-300/500 series w/IRIG to Port 2 on the SEL-311C.
- ➢ Connect the other end of the cable to Port 3 on the SEL-2032.

Step 4. Enter Access Level 2 on the SEL-2032 and issue the command **SET P 3** to configure Port 3.

The SEL-2032 prompts for the type of device connected to the port.

- ➢ Enter **S** for SEL IED, **Y** to auto-configure the port, and press the **<Enter>** key to confirm the configuration prompts.

  The SEL-2032 establishes communication with the relay; determines the type of relay, relay ID, and communication baud rate; and determines if the relay is capable of Fast Meter, Fast Operate, and Fast Messages. This process can take a few minutes depending on the baud rate.

- ➢ Enter **Y** to save port configuration changes at the final prompt.

Step 5. After auto-configuration, use the **AUTO 3** command to determine the capability of the connected relay. *Figure 3.18* shows an example output for the **AUTO** command.

```
*>>AUTO 3 <Enter>
FID:       FID=SEL-311C-R111-V0-Z005004-D20060728
DEVICE ID: SEL-311C POTT
BAUD RATE: 19200
OPERATE SUPPORT: Binary (1 Breakers, 16 Remote Bits S-C-P)
SER SUPPORT: Binary Unsolicited
COMMANDS SUPPORTED:
  B 20METER
  B 20DEMAND
  B 20TARGET
  A 20HISTORY
  A 20STATUS
  A 20EVENT
  A 20EVENTS
  A 20EVENTL

*>>
```

Figure 3.18 Example AUTO Command Output

Not all synchrophasor-enabled SEL IEDs support the Fast Message protocol for collecting SER or synchrophasor data. If the relay supports the Fast Message protocol, you should see the line `SER Support: Binary Unsolicited` in the **AUTO** command response. Though the message indicates SER support, this line may imply (by the term `Unsolicited`) that the SEL IED also supports synchrophasor Unsolicited Write (UW) messages. When in doubt, refer to the appropriate SEL IED instruction manual to verify support for this functionality.

Step 6. Issue the command **SET A 3 SP_RATE** to configure the rate that the SEL-2032 will receive UW messages from the attached SEL-311C. This rate must match one of the supported transmission rates of the attached SEL IED. For this example, we will use 60 messages per minute, or one message per second. Also, to allocate sufficient memory space for storage of the synchrophasor data, set USER = 38 in the Port 3 USER data region of the SEL-2032.

- ➢ Set SP_RATE equal to 60.
- ➢ Set USER equal to 38.
- ➢ Enter **Y** to save changes at the final prompt.

```
AUTOBUF = Y
STARTUP ="ACC\n"
SEND_OPER= N
REC_SER = N
SP_RATE = 60
NOCONN  = NA

MSG_CNT = 0

ARCH_EN = N

USER    = 38
```

Figure 3.19 Example SET A 3 Settings

After the SEL-2032 accepts the setting change, the RXD Port 3 LED on the SEL-2032 will begin to flash as the SEL-2032 receives synchrophasor data 60 times per minute.

Step 7. Verify that synchrophasor data is being collected on Port 3 by issuing the **VIEW 3:USER** command. The SEL-2032 responds to the **VIEW** command with a data "dump" showing the contents of the USER region on Port 3 at the time of the request. In this example, the data are updated 60 times per minute, or once per second.

```
*>>VIEW 3:USER <Enter>
Port 3,  Data Region USER   Data

INTEGER = 0,-17344,8937,17007,-2388,17658,28494,-15725,16384,17658,
-31929,17190,24576,17659,9212,16953,-32768,17658,-19923,-15725,16384,
17525,29835,-15725,16384,17525,26584,17190,24576,17527,27377,16953,
-32768,17526,6086,-15725,16384,0


*>>
```

Figure 3.20 View 3:USER Output

Step 8. Move the synchrophasor data from the SEL-311C on Port 3 to Port 17 by using Math/Move equations. You may change the labels to suit your taste, i.e., `FREQ_PM` can be `FREQUENCY`. The VIEW 17:USER response below shows how the data may look once it has been "moved" to Port 17.

```
*>>SET M 17 <Enter>
0;I;SAMPLE = 3:F800h;1
1;L;SOC = 3:F801h;2
3;F;FREQ_PM = 3:F803h;2
5;F;VAM_PM = 3:F805h;2
7;F;VAA_PM = 3:F807h;2
9;F;VBM_PM = 3:F809h;2
11;F;VBA_PM = 3:F80Bh;2
13;F;VCM_PM = 3:F80Dh;2
15;F;VCA_PM = 3:F80Fh;2
17;F;V1M_PM = 3:F811h;2
19;F;V1A_PM = 3:F813h;2
21;F;IAM_PM = 3:F815h;2
23;F;IAA_PM = 3:F817h;2
25;F;IBM_PM = 3:F819h;2
27;F;IBA_PM = 3:F81Bh;2
29;F;ICM_PM = 3:F81Dh;2
31;F;ICA_PM = 3:F81Fh;2
33;F;I1M_PM = 3:F821h;2
35;F;I1A_PM = 3:F823h;2
37;B;STATUS = 3:F825h;1
*>>VIEW 17:USER <Enter>
Port 17,  Data Region USER   Data
SAMPLE = 0  SOC = -1136647445  FREQ_PM =     59.991
VAM_PM =   2002.535  VAA_PM =    -81.625  VBM_PM =   2000.767
VBA_PM =    158.500  VCM_PM =   2002.956  VCA_PM =     38.500
V1M_PM =   2002.086  V1A_PM =    -81.500  IAM_PM =    985.566
IAA_PM =    -81.500  IBM_PM =    984.642  IBA_PM =    158.500
ICM_PM =    992.321  ICA_PM =     38.500  I1M_PM =    987.510
I1A_PM =    -81.500  STATUS = 0000h


*>>
```

Figure 3.21 Math/Move Equations and 17:USER Contents

Step 9. Configure SEL-2032 Port 17 to make the synchrophasor data available to a DNP3 LAN/WAN master.

Table 3.8 SEL-2032 DNP LAN/WAN Settings

Port Setting	Setting	Description
ENDNP	Y	Enable DNP
IPADDR	192.168.0.101	IP Address of the DNP Client
SUBNETM	255.255.255.0	Subnet Mask for Network
DEFRTR	192.168.0.1	Default Router for the DNP Client
DNPADDR	0	DNP Address
DNPPNUM	20000	DNP Port Number on the DNP Master
DNPMAP	AUTO	DNP Map Mode, set to “AUTO” to use the Port 17 SET M settings
RPADR01	1	DNP Address for Master #1
DNPIP01	192.168.0.25	IP Address of the DNP Master
DNPTR01	UDP	Transport Protocol. UDP tends to be faster, but without the native error checking of TCP (user preference)
DNPUP01	REQ	UDP Response port number, leave at REQ
DNPMP01	1	DNP Map associate with DNP session #1, for use with Custom Mode
ECLASSA	2	Class for Analog Event Data (depends on Master settings)
ECLASSB	1	Class for Binary Event Data (depends on Master settings)
ECLASSC	3	Class for Counter Event Data (depends on Master settings)

Step 10. Configure the DNP3 LAN/WAN Master with a DNP3 data map that corresponds to the synchrophasor data points of the Math/Move equations in *Step 8*.

Example 5: Getting Data From a Non-SEL IED

Example 5 demonstrates the ability of the SEL-2032 to communicate with non-SEL IEDs using the nearly universal EIA-232 communications interface. The EIA-232 interface is a standard with specified electrical signal parameters that ensure compatibility between two devices. For devices that use this standard, you must know how to make the proper electrical connection between the two devices to permit communication. Additionally, each of these devices must recognize the “language” that the other “speaks;” therefore, you need the “dictionary,” or command set, that defines each language.

In this example, the SEL-2032 communicates with a DGH 1000 RTD Interface Module. This example assumes that you have connected the DGH 1000 to Port 12 on the SEL-2032, as shown in *Figure 3.22*, using the proper cable, and that you know the communication parameters (baud rate, data bits, parity, stop bits, and flow control) required by the DGH 1000. The example also assumes that you have the command set, or “dictionary” of terms, for each device. In this case you know that when you send the message string “$1RD” to the DGH 1000, the device returns the temperature as an ASCII floating-point number.

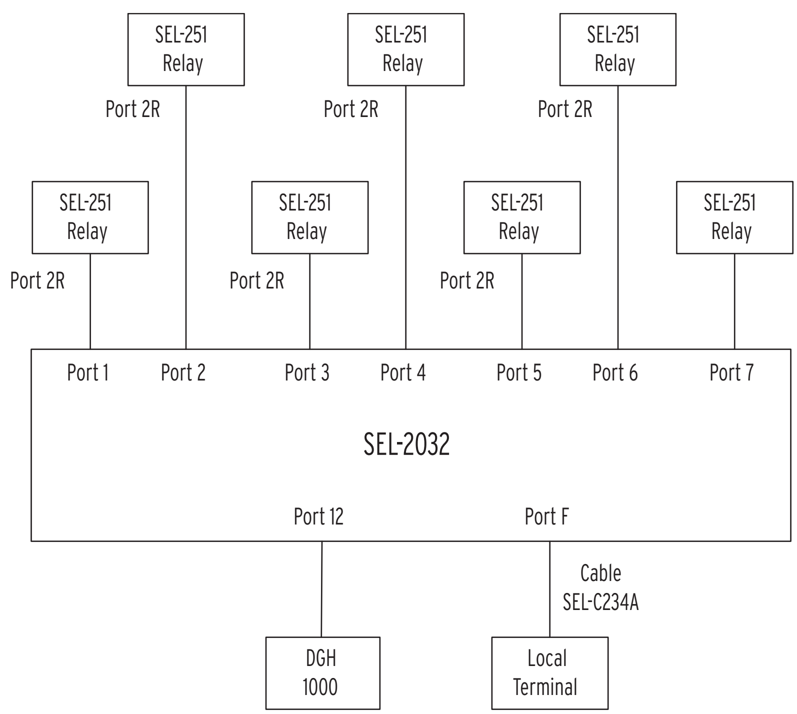


Figure 3.22 Non-SEL IED Attached to Port 12

Identifying the Problem

Your objective in this example is to use the SEL-2032 to retrieve temperature data from a remote thermal device (RTD) interface module called the DGH 1000. The DGH 1000 is connected to Port 12 of the SEL-2032 and you want to collect these data every 30 seconds.

Defining the Solution

Set the SEL-2032

Step 1. Use **SET P 12** to configure Port 12 as an "Other IED" port with the DGH 1000 communication parameters. Use the **SET A 12** command to make the following settings:

- ➢ Set AUTOBUF=N so Port 12 does not store unsolicited messages.
- ➢ Define message trigger ISSUE1 to send a message every 30 seconds.
- ➢ Create a message, $1RD\00D, that is sent to the DGH 1000 when triggered.
- ➢ Set PARSE and NUM to accept one floating-point number.

Step 2. Test the operation using the **TOGGLE** command to force data collection and the **VIEW** command to view the collected data.

Set the SEL-2032, Step by Step

Step 1. Use **SET P 12** to configure Port 12 as an "Other IED" port with the DGH 1000 communication parameters. Your settings should look like those in *Table 3.9*.

Table 3.9 Example 5 Port 12 Settings

Setting Name	Setting Value	Comment
DEVICE	O	Configure the port device type as "Other IED."
MODEM	N	
AUTO_BAUD	N	
PROTOCOL	A	Allow ASCII and binary communications.
PORTID	"DGH 1000"	Enter the name of the device for port identification.
BAUD	300	Enter communication parameters compatible with the DGH 1000.
DATABIT	8	
STOPBIT	1	
PARITY	N	
RTS_CTS	N	
XON_XOFF	N	
TIMEOUT	OFF	

Step 2. Set the SEL-2032 with the **SET A 12** command to collect data from the DGH 1000 every 30 seconds. Your settings should look like those in *Table 3.10*.

Table 3.10 Example 5 Port 12 Automatic Message Settings (Sheet 1 of 2)

Setting Name	Setting Value	Comment
AUTOBUF	N	
STARTUP	""	
NOCONN	NA	
MSG_CNT	1	Set MSG_CNT=1 to add a new message trigger and message.
ISSUE1	P00:00:30.0	Periodically trigger MESG1 every 30 seconds.

Table 3.10 Example 5 Port 12 Automatic Message Settings (Sheet 2 of 2)

Setting Name	Setting Value	Comment
MESG1	"$1RD\00D"	Send the command $1RD to request temperature data from the DGH 1000. The carriage return, \00D, is required to complete the command sequence.
PARSE1	2	Select the ASCII_FLOAT parsing method because you know the temperature is in floating-point format.
NUM1	1	Accept one item because you know only one number is returned from the DGH 1000.
DELAY1	ON	Since we know only one data item is coming in, we could set DELAY1 to OFF. If we wanted to collect data more often than every 5 seconds, we would need to set it OFF to avoid the idle time check. Since we are only collecting the data every 30 seconds, the value of the setting does not matter.
ARCH_EN	N	
USER	0	

Step 3. Use the **TOGGLE** command to assert the D1 bit on Port 12, as shown in *Figure 3.23*. The D1 message (MESG1) is sent when the D1 bit is asserted. This should result in one data collection operation.

Step 4. Use the **VIEW** command to view the data collected from the DGH 1000. The data are parsed and stored in the D1 Data region on Port 12 in floating-point format. The data are time-tagged at the time the SEL-2032 begins to receive the data.

```
*>>TOGGLE 12:D1 <Enter>
Bit toggled
*>>VIEW 12:D1 <Enter>
Port 12,  Data Region FLOAT   Data
_YEAR = 1995  DAY_OF_YEAR = 65 (03/06)  TIME = 18:53:18.857
FLOAT =      27.000

*>>
```

Figure 3.23 TOGGLE Command Asserts the D1 Bit on Port 12

Example 6: Modbus Job Done

Simple Meter Data Access

This example demonstrates the ability of the SEL-2032 to provide data to a Modbus master device. This example uses the SEL-2032, an SEL-321-1 Relay, and a Modbus Master set up as follows:

Step 1. Connect the SEL-321-1 to an SEL-2032 port (this example uses Port 2). Use the SEL-C239 (Y type) cable because it handles both communication and IRIG-B. Connect the communication terminal at the Y end of the cable to a port on the SEL-321-1. Connect the IRIG-B terminal at the Y end to the relay's AUX input port. Connect the single connector end of the cable to Port 2 on the SEL-2032.

Step 2. Connect a Modbus master device to an SEL-2032 Modbus port; this example uses Port 16.

Step 3. Change the SEL-2032 access level to Access Level 2 on the SEL-2032 and issue the command SET P 16 to configure Port 16, as shown in *Table 3.11*. The SEL-2032 will prompt for the type of device connected to the port. Enter M for Master, enter M a second time for Modbus protocol. Select the default floating-point map and set the start ID to 0. Assign an address to Port 2 and enter OFF for other port addresses.

Table 3.11 Example 6 Port 16 Port Configuration Settings

Setting Name	Setting Value	Comment
DEVICE	M	
PROTOCOL	M	
MAP_TYPE	F	
START_ID	0	
SETTLE1	0	
SETTLE2	0	
ADDRESS1	OFF	
ADDRESS2	6	
ADDRESS3	OFF	
ADDRESS4	OFF	
ADDRESS5	OFF	
ADDRESS6	OFF	
ADDRESS7	OFF	
ADDRESS8	OFF	
ADDRESS9	OFF	
ADDRESS10	OFF	
ADDRESS11	OFF	
ADDRESS12	OFF	
ADDRESS13	OFF	
ADDRESS14	OFF	
ADDRESS15	OFF	
ADDRESS16	OFF	
ADDRESS17	OFF	
ADDRESS18	OFF	
PORTID	“”	
BAUD	9600	
PARITY	N	

Step 4. Issue the command **SET P 2** to configure Port 2. The SEL-2032 will prompt for the type of device connected to the port. Enter **S** for SEL IED, enter **Y** to auto-configure the port, and press **<Enter>** to confirm the configuration prompts. The SEL-2032 will establish communication with the relay, relay ID, and communication baud rate and determine if the relay is capable of Fast Meter. Enter **Y** to save port configuration changes at the final prompt.

Step 5. Next, issue the command **SET A 2** to set an auto-message to collect relay meter data. Respond to prompts about saving unsolicited messages (AUTOBUF) and the STARTUP string. Press **<Enter>** to confirm the defaults for both prompts. Enter **1** when prompted for the message count. At the ISSUE1 prompt, enter **P00:00:01** to set the message to trigger once every second. At the MESG1 prompt, enter **20METER** to send the request for meter data to the SEL relay. Press **<Enter>** to accept the default for remaining settings and enter **Y** to save changes. As soon as the SEL-2032 accepts the setting change, the TXD and RXD Port 2 LEDs on the SEL-2032 will begin to flash as the SEL-2032 requests and receives meter data every second.

Step 6. Confirm that the meter data are collected in binary format by issuing a **MAP 2** command. The D1 region should show a "B" preceding the METER data type, indicating binary collection.

Step 7. View the data stored in the Port 2 METER data region by issuing the commands **VIEW 2:METER** or **VIEW 2:D1**. The SEL-2032 responds with a data "dump" showing the data stored in the region at the time of the request with the respective data item labels. In this example, the data are updated once each second.

Step 8. Cause the Modbus master to send a "read PORT 2 METER region" message. In the message, the slave address field is the Port 2 address set in Step 3. The Register Address field is METER (100). The Register Count is the meter data length for SEL-321-1. (use the **MODMAP** command to display the register map.) The returned METER data are the same as the data displayed by the **VIEW** command if the data have not been updated since issuing the **VIEW** command. The following shows a typical exchange:

06	to address 6
04	function code 4
00 64	starting register address 100
00 60	read 96 registers
xx xx	CRC-16 code

Figure 3.24 Received Message

06	from address 6
04	successful function code 4 response
C0	192 bytes of data following
00 05	first register
00 02	second register
. . .	
yy yy yy yy	last two registers (IEEE float)
xx xx	CRC-16 code

Figure 3.25 Response Message

Accessing Centralized Data

This example demonstrates the ability of the SEL-2032 to centralize data to reduce the number of Modbus accesses necessary to collect data. This example uses an SEL-121F and an SEL-501 on Ports 3 and 4 of an SEL-2032, respectively. The objective is to read the current and voltage magnitudes from the relays with a single Modbus access. Optional steps are shown to automatically move the data to a region accessible to a Modbus master that cannot use 6-digit addressing. The following procedure explains how to set the SEL-2032 and collect the data.

Step 1. Connect the two relays to Ports 3 and 4 of the SEL-2032. Establish basic communications settings to the first relay by auto-configuring using **SET P 3**. Use **SET A 3** to set meter data collection. Copy these settings to Port 4 using **COPY 3 4**. Auto-configure Port 4 while copying.

Step 2. Set Port 16 to be a Modbus port, as shown in *Table 3.12*.

Table 3.12 Example 6 Port 16 Port Configuration Settings (Sheet 1 of 2)

Setting Name	Setting Value	Comment
DEVICE	M	
PROTOCOL	M	
MAP_TYPE	F	
START_ID	0	
SETTLE1	0	
SETTLE2	0	
ADDRESS1	OFF	
ADDRESS2	OFF	
ADDRESS3	15	
ADDRESS4	16	
ADDRESS5	OFF	

Table 3.12 Example 6 Port 16 Port Configuration Settings (Sheet 2 of 2)

Setting Name	Setting Value	Comment
ADDRESS6	OFF	
ADDRESS7	OFF	
ADDRESS8	OFF	
ADDRESS9	OFF	
ADDRESS10	OFF	
ADDRESS11	OFF	
ADDRESS12	OFF	
ADDRESS13	OFF	
ADDRESS14	OFF	
ADDRESS15	OFF	
ADDRESS16	17	
ADDRESS17	OFF	
ADDRESS18	OFF	
PORTID	“Modbus Port”	
BAUD	9600	
PARITY	N	

Step 3. Determine where the data of interest is located using the commands **MAP 3:METER** and **MAP 4:METER**:

```
*>>MAP 3:METER <Enter>
Port 3,  Data Region METER  Map
Data Item    Starting Address   Type
_YEAR        2000h              int
DAY_OF_YEAR  2001h              int
TIME(ms)     2002h              int[2]
IA(A)        2004h              float[2]
IB(A)        2008h              float[2]
IC(A)        200Ch              float[2]
VA(V)        2010h              float[2]
VB(V)        2014h              float[2]
VC(V)        2018h              float[2]
VS(V)        201Ch              float[2]
IAB(A)       2020h              float[2]
IBC(A)       2024h              float[2]
ICA(A)       2028h              float[2]
VAB(V)       202Ch              float[2]
VBC(V)       2030h              float[2]
VCA(V)       2034h              float[2]
PA(MW)       2038h              float
QA(MVAR)     203Ah              float
PB(MW)       203Ch              float
QB(MVAR)     203Eh              float
PC(MW)       2040h              float
QC(MVAR)     2042h              float
P(MW)        2044h              float
Q(MVAR)      2046h              float
I0(A)        2048h              float[2]
I1(A)        204Ch              float[2]
I2(A)        2050h              float[2]
V0(V)        2054h              float[2]
V1(V)        2058h              float[2]
V2(V)        205Ch              float[2]

*>>
```

Figure 3.26 Port 3 Meter Region Data Map

```
*>>MAP 4:METER <Enter>
Port 4,  Data Region METER  Map
Data Item     Starting Address   Type
_YEAR         2000h              int
DAY_OF_YEAR   2001h              int
TIME(ms)      2002h              int[2]
IAX(A)        2004h              int
IBX(A)        2005h              int
ICX(A)        2006h              int
IAY(A)        2007h              int
IBY(A)        2008h              int
ICY(A)        2009h              int
3I2X(A)       200Ah              int
IRX(A)        200Bh              int
3I2Y(A)       200Ch              int
IRY(A)        200Dh              int

*>>
```

Figure 3.27 Port 4 Meter Region Data Map

Step 4. Set up the Port 16 user region to hold the currents and voltages of interest using the command **SET M 16**:

Table 3.13 Example 6 Port 16 Math/Data Movement Settings

Setting Name	Setting Value	Comment
1 000h	3:METER:IA(A)	
2 001h	3:METER:IB(A)	
3 002h	3:METER:IC(A)	
4 003h	3:METER:VA(V)	
5 004h	3:METER:VB(V)	
6 005h	3:METER:VC(V)	
7 006h	4:METER:IAX(A)	
8 007h	4:METER:IBX(A)	
9 008h	4:METER:ICX(A)	
10 009h	4:METER:IAY(A)	
11 00Ah	4:METER:IBY(A)	
12 00Bh	4:METER:ICY(A)	

Step 5. The SEL-2032 is now collecting meter data from the two relays. The items of interest are being copied to the Port 16 user region every half second. You can now access this data via Modbus. For this example, we will read the data using function code 03 from address F800h. (*Section 6: Database* shows that the User region starts at address F800h.) The data could also be read using function code 04 from address 2400 (0960h). To read the data, send the following message:

11	to address 17
03	function code 3
F8 00	starting register address F800h
00 0C	read 12 registers
xx xx	CRC-16 code

Figure 3.28 Received Message

11	from address 17
03	successful function code 3 response
18	24 bytes of data following
00 14	SEL-121F IA data
00 02	SEL-121F IB data
. . .	
xx xx	SEL-501 ICY data
xx xx	CRC-16 code

Figure 3.29 Response Message

Automatic Data Movement (Optional)

Some Modbus masters are unable to use 6-digit addressing for function code 03 and are unable to access the data as shown in *Step 5 on page 3.30*. This example will use a logic point to trigger the movement of user data to a memory region accessible to these masters. The objective of this step is to execute the transfer automatically and without additional latency relative to the computation of the user data region.

Step 1. With meter data now in the Port 16 user region, you can trigger a 20USER copy to populate its D1 region with the same data based on the MSET bit status. Use the command **SET A 16** with the following parameters:

➢ **ISSUE1=!MSET** (make sure to use the !)

➢ **MESG1=20USER**

The MSET bit is set during SET M equation execution. The above ISSUE will trigger the 20USER copy immediately following the SET M operations on Port 16.

Step 2. You can now access this data via Modbus with function code 03. The starting address in the D1 region is 2000h or 8192 decimal. The database will always have a date and timestamp in the first 4 registers, so the first accessible register with data is 2004h or 8196 decimal. To read the data, send the following message from the master:

11	to address 17
03	function code 3
20 04	starting register address 2004h
00 0C	read 12 registers
xx xx	CRC-16 code

Figure 3.30 Received Message

11	from address 17
03	successful function code 3 response
18	24 bytes of data following
00 14	SEL-121F IA data
00 02	SEL-121F IB data
. . .	
xx xx	SEL-501 ICY data
xx xx	CRC-16 code

Figure 3.31 Response Message

Section 4

SELOGIC Control Equations

Introduction

This section covers SELOGIC® control equation operation, inputs, syntax, and outputs. SELOGIC control equations are central to many of the functions of the SEL-2032 Relay. They are defined within the global (SET G), auto-message (SET A), plug-in card logic (SET O), and logic (SET L) settings described in *Section 7: Settings*.

Operation

SELOGIC control equations are at the heart of the more advanced functions of the SEL-2032. Use SELOGIC control equations to define when operations are to take place and control output contacts on the optional I/O board. Many conditions detected by the device are represented by Boolean values or bits that are used in these equations. You can assign the value of one bit to an output bit, which has some predefined use. You can also use Boolean equations to combine multiple input bits to drive a specified output. You will find examples of these equations later in this section. *Figure 4.1* illustrates the SELOGIC control equation data flow.

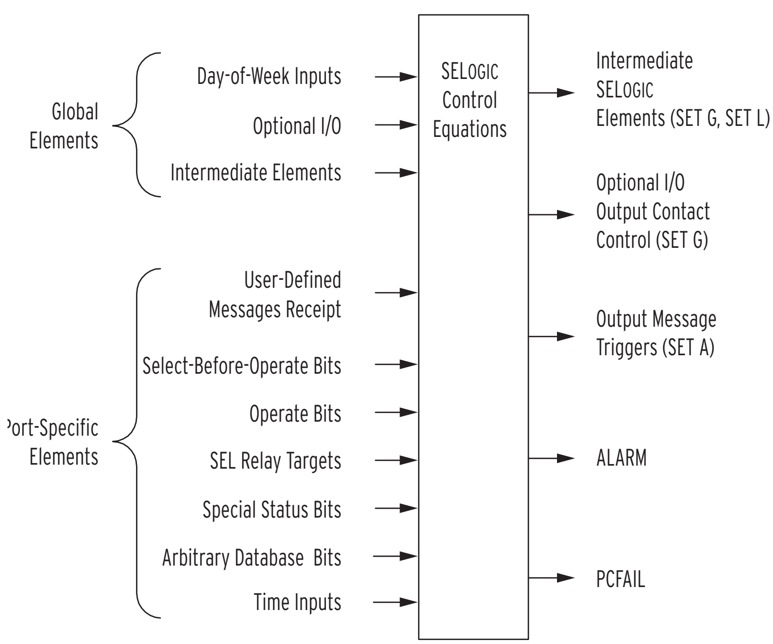


Figure 4.1 SELOGIC Control Equations Inputs and Outputs

SELOGIC control equation inputs include the current time, global elements (as seen by executing the **TAR G** command), local elements (as seen by executing the **TAR *n*** command), and arbitrary database bits.

Messages are triggered by the rising edge (or assertion) of the trigger condition bit. You can use output messages for the following tasks:

- Request data from an IED.
- Send a command to an IED (to change setting groups, for example).
- Send data you want stored to a printer or master device.

In addition to inputs and outputs, there are five global intermediate logic variables and the 96 port-specific logic variables. You can use these variables to write equations, the results of which may be used in output equations. Three intermediate elements have pickup and dropout delay timers associated with them.

Inputs

As shown in *Figure 4.1*, there are a number of different types of SELOGIC control equation inputs. These include global elements, local elements, relay elements, relay status information, arbitrary database bits, and timed conditions.

Global Elements

Global elements exist within the Global data region that is common to all port databases. Items within this region include the day of the week, remote bits, intermediate SELOGIC control equation terms, and I/O board inputs and outputs. These elements are defined in *Section 6: Database*. Global elements are referenced in SELOGIC control equations by their element names. For example, you would enter the Sunday day-of-week element in a SELOGIC control equation as SUN.

Local Elements

Local elements exist within the Local data region of each port's database. Some of these elements are asserted by user-defined command receipt, some by select-before-operate registers, some by SELOGIC control equations, and others by data collection operation. These elements are defined in *Section 6: Database*. To use a local element in a logic equation, you must give both its port number and label. For example, to access element D1 on Port 3, the element label to use is 3:D1. If the SELOGIC control equation you are writing is port-specific, the port for elements on that port need not be specified.

Relay Elements

SEL relay elements are available on any SEL relay port that is collecting element data (uses 20TARGET data collection). Each element may be specified by its element label, preceded by the port number. For example, to access relay element 52A on Port 4, you use 4:52A. If the element name matches a local or global element, you must specify the region to identify the proper element (e.g., 4:TARGET:IN1). If you write a port-specific equation, the port for the desired relay element is in the local port, and the relay element label is unique from any local and global elements, then you do not need to specify the port number. You can view the relay element labels by using the **TAR *n* ALL**, **MAP *n* TARGET BL**, or **VIEW *n* TARGET BL** commands.

Status Information

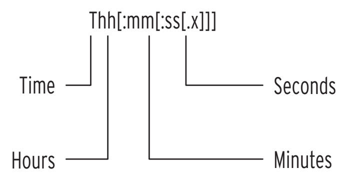
Along with their meter information, some SEL relays provide status information, which includes bits for self-test failures and new events. These bits are stored in the SEL-2032 as part of the relay element data. Use the **TARGET** command once a port is configured to see what SEL relay special elements are available. These items are selected the same way as SEL relay elements.

Database Bits as Elements

Arbitrary database bit references allow any bit of any register within any database region to be referenced as a SELOGIC control equation term. To specify an element of this type, you must select the port number, register number, and bit number. For example, to access bit 11 of register 800Fh on Port 12, use the element label: 12:800Fh:Bh. If the register does not exist when you select it, you will be warned, but the term will be accepted. If it does not exist when SELOGIC control equations run, it will be treated as false (logical 0).

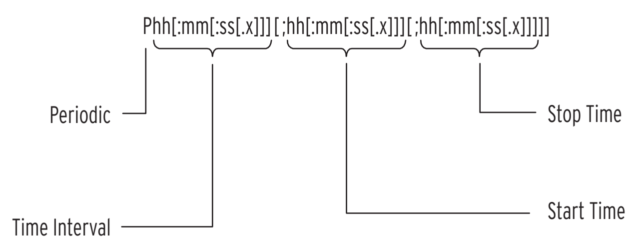
Timed Conditions

For controlling operations that must occur at specified times or periodically, you may use time-of-day or periodic items. Time-of-day equation entries have the following syntax:



This portion of an equation is true when the specified time-of-day occurs. The minutes, seconds, and tenths-of-seconds fields are optional, as indicated by the square brackets. To make something occur periodically, use a periodic item:

NOTE: Because the SEL-2032 can only sample relay elements, you should only use elements you are confident will be asserted when a sample occurs. Elements that are only asserted momentarily will probably not be seen by the SEL-2032 in their asserted state. To use them, you need to use the capabilities of the SEL relay to extend the element assertion time so it can be seen by the SEL-2032.



This item specifies the interval, optional start time, and optional stop time. The minutes, seconds, and tenths-of-seconds fields for all three time fields are optional, as indicated by the square brackets. For all three time fields the interval specifies how often to perform an operation. The start time specifies the time-of-day to start the interval. If the start time is not included, it defaults to 00:00:00.0. The stop time specifies the time-of-day to stop the periodic samples. It defaults to 24:00:00.0. Both of these timed conditions will be true for approximately 100 milliseconds. If a start time is specified with a smaller time increment than the periodic time interval, the start time acts as an offset. This may be useful to prevent simultaneous operation of multiple messages that could result in database delays.

Equation Syntax

You create SELOGIC control equations by combining terms (inputs described above) in logical equations. This section describes the syntax of these equations. The simplest equation consists of directly entering a single element. More complex equations require the use of logical operators.

Operators

You can create SELOGIC control equations that use multiple SEL-2032 elements with logical AND (*), OR (+), and inversion (!) operators in a single equation. The following list defines the use of these operators.

*	AND	Requires that elements on both sides of the * symbol be asserted before the logic condition is true. For example, in the equation OUT1=IN1*IN2 the terms IN1 and IN2 must both be true for OUT1 to be true.
+	OR	Requires that one element on either side of the + symbol be asserted before the logical condition is true. The equation OUT1=IN1+IN2 requires either IN1 or IN2 to be true for OUT1 to be true.
!	Invert	Inverts the value of the element immediately following the ! symbol. For example, the equation OUT1=IN1*!IN2 requires IN1 to be true and IN2 to be false for OUT1 to be true.

Insert a backslash (\) symbol at the end of the line of a SELOGIC control equation (just before pressing **<Enter>**) to continue the same equation on a subsequent line. Otherwise, the equation may only be one line. There is a 200-characters-per-equation limit for a single equation and a 50-term (element names and time functions) limit per equation.

Operator Precedence

When the SEL-2032 processes the SELOGIC control equations, the ! is applied first, followed by AND (*) functions, and finally by OR (+) functions. The *, +, and ! functions may be used in any combination. For example, consider the equation:

$$OUT4 = X * Y + Z * V \quad \textbf{Equation 4.1}$$

This logic says that the AND function (*) is performed on assigned values for intermediate elements X and Y, Z and V before they are ORed (+) to determine the state of output 4 (OUT4=(X*Y)+(Z*V)). This is typically referred to as a sum-of-products equation.

Equation Disabling

Programming an equation to NA disables that function, i.e., OUT4 = NA.

Limitations

Table 4.1 lists unacceptable combinations of SELOGIC control equation operators:

Table 4.1 Unacceptable SELOGIC Control Equation Operator Combinations

*+	**	!*	!+
+*	++	!!	

Outputs

You use SELOGIC control equations to control output contacts, intermediate logic, and auto-message triggers.

Contact Outputs

Four output contacts on the optional I/O board are controlled by SELOGIC control equations. The output contact equations are processed every 3.9 milliseconds. An output contact will be asserted (closed for a type A contact) when its corresponding SELOGIC control equation is true; it will be deasserted when its corresponding SELOGIC control equation is false. Contact output SELOGIC control equations are established in the global settings.

In the SEL-2032, there is an additional output contact equation, ALARM. This equation is for controlling the alarm contact. The alarm contact closes for self-test failures, regardless of this setting. With this setting, you can control what additional conditions the alarm contact is closed for. This equation will be processed every 3.9 milliseconds, like the other outputs.

Global Intermediate Logic

Five intermediate logic elements (V, W, X, Y, Z) may be used to hold intermediate results. These elements also have associated pickup/dropout timers which the SEL-2032 may use for various timing functions. These elements are processed every 15.6 milliseconds.

The timers operate as standard pickup/dropout timers. For a timer output (VT, WT, XT, YT, or ZT) to assert, the corresponding input must be true for the pickup time. Similarly, for a timer output to deassert once it has asserted, the corresponding input must be false for the dropout time. Pickup and dropout times can be set to zero to disable them.

Intermediate logic SELOGIC control equations and timer values are established in the global settings.

In the SEL-2032, there is also an equation for PCFAIL. This is an element which appears in the global elements to indicate protocol card failure. You can modify this equation to suit your particular definition of a card failure. You can then use this result to indicate card failure to your system.

Local Intermediate Logic

There are 96 intermediate logic elements associated with each port. These elements operate together to form 32 S-R latches where 32 elements are set elements, 32 are clear elements, and 32 are the latch outputs. The set and clear elements are driven by SELOGIC control equations (SET L), by master port Fast Operate commands, and by Modbus®, and DNP3 operations. See *Section 9: Protocols* for information on using Fast Operate commands, Modbus control, and DNP3 control. *Figure 4.2* illustrates the relationship of these control methods.

NOTE: If the set and clear elements are asserted at the same instant (for example, by assigning both of them to the same input bit), the corresponding latch output will also assert. However, even if the auto-message setting SEND_OPER = Y, the SEL-2032 will not send an operate command along with assertion of the latch output.

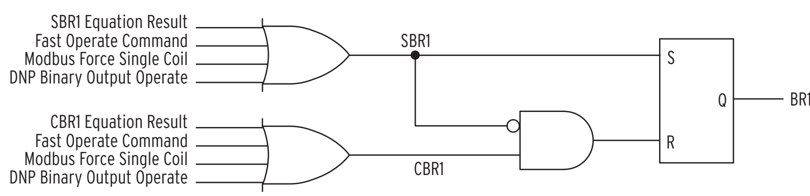


Figure 4.2 Example of Latch Operation

Message Triggers

On all used ports, you can set the port to send a message based on a trigger condition. These trigger conditions, which are defined using SELogic control equations, are processed every 15.6 milliseconds.

Whenever the SEL-2032 detects a rising edge (_⌐) of a trigger condition (ISSUE*x* setting), it sets the corresponding D*x* or ARCH*x* element. Once the message has been issued and any corresponding data collection is completed, the D*x* or ARCH*x* is cleared. If a rising edge of a trigger condition is detected but the corresponding D*x* or ARCH*x* element is already set, then the corresponding DLY*x* or DLYA*x* bit is set to indicate that an auto-message operation has been missed. You can clear DLY*x* and DLYA*x* bits by executing a **STATUS** command. *Figure 4.3* illustrates this logic.

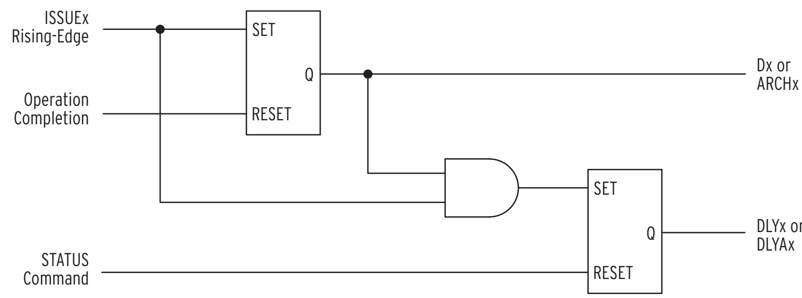


Figure 4.3 Message Triggering Logic

A typical trigger sequence starts with a trigger condition being satisfied. For example, consider the SELogic control equation ISSUE1 = P00:00:10.0. This trigger condition will have a rising edge every 10 seconds. *Figure 4.4* illustrates the relative timing of this issue condition and its corresponding message element (D1).

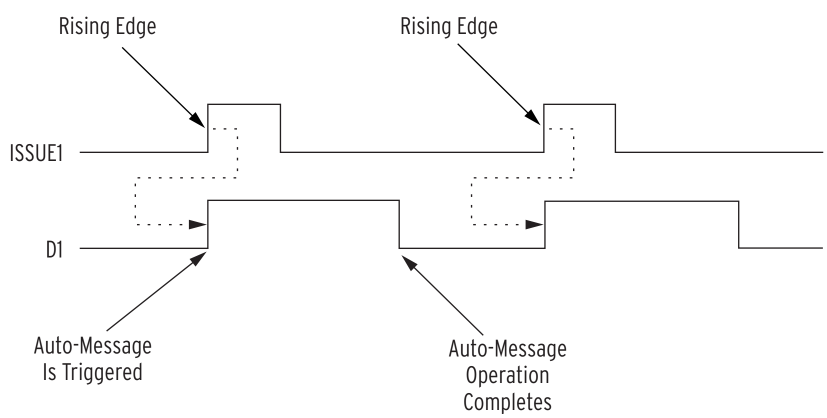


Figure 4.4 Normal Auto-Message Trigger

If the auto-message is not completely processed before the next trigger occurs (for this example, longer than 10 seconds), then the DLY*x* bit is set, as shown in *Figure 4.5*.

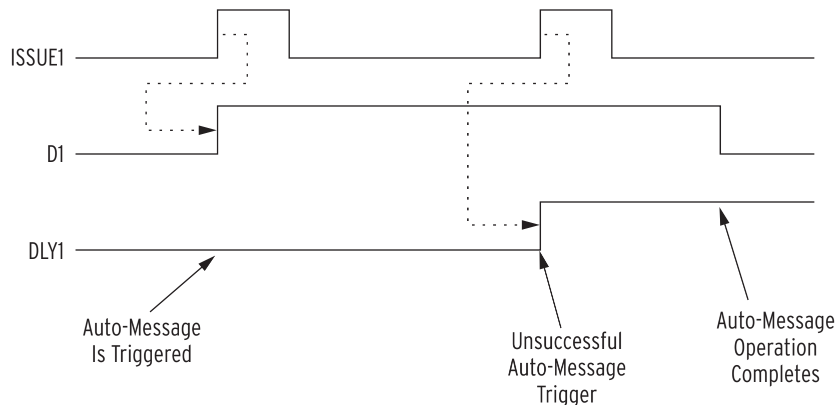


Figure 4.5 Unsuccessful Auto-Message Trigger

The database delay region of the **STATUS** command response indicates which auto-messages are unsuccessful. You may need to increase the ISSUE period to eliminate repeated unsuccessful auto-message triggers.

Another interesting case to consider is when SELOGIC control equations contain elements that are cleared by the triggered auto-message. If such an element is set again before the auto-message processing is complete, further triggering may be disabled. For example, consider the following trigger and message settings:

ISSUE2 = 1:UMB+2:UMB **Equation 4.2**

MESG2 = \DAC1/\DAC2/ **Equation 4.3**

These settings are meant to output any unsolicited messages received on Ports 1 and 2. However, 1:UMB can become set while \DAC2/ is being processed, leaving the trigger condition in a set state and precluding any further rising edges; the trigger condition has become disabled. *Figure 4.6* illustrates this problem.

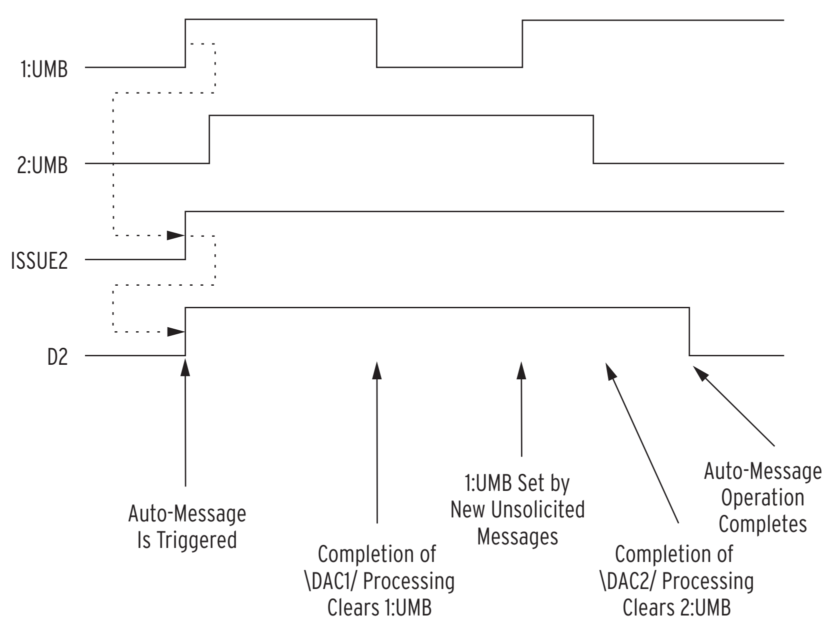


Figure 4.6 Trigger Lock-Out Problem

You can prevent this problem by writing a SELOGIC control equation that forces the trigger condition to reset itself immediately.

The following SELOGIC control equation adds !D2 to the previous equation:

ISSUE2 = 1:UMB*!D2+2:UMB*!D2 **Equation 4.4**

Now, as shown by *Figure 4.7*, the trigger condition is only true momentarily; then it retriggers upon completion of the message processing.

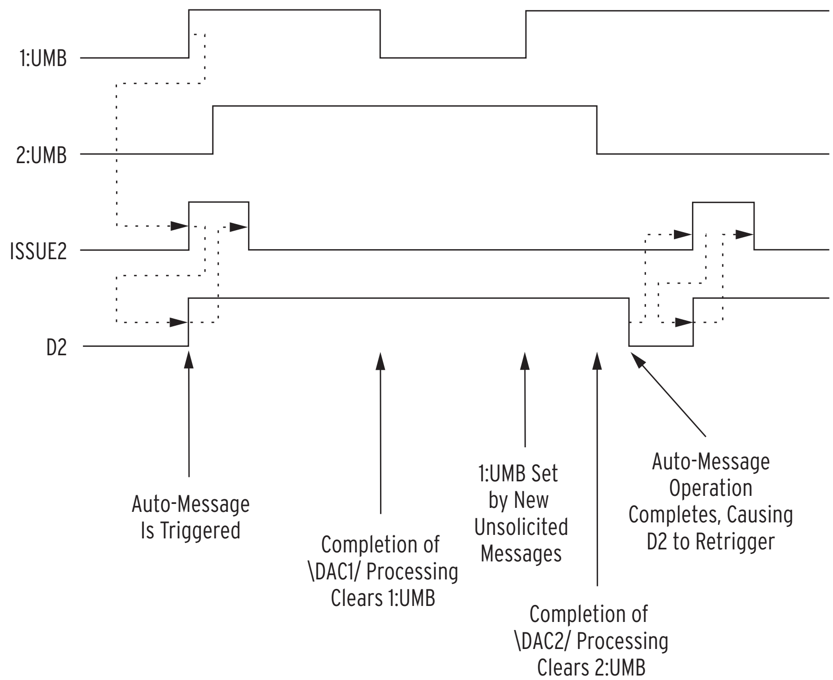


Figure 4.7 Forcing Retriggering Avoids Trigger Lock-Out

Processing Sequence

You may need to consider the order in which SELOGIC control equations are processed to fully understand their operation and thereby ensure the desired result. When a SELOGIC control equation contains, as one of its terms, the result of another SELOGIC control equation, the order in which the equations are processed may affect the result. For example, consider three SELOGIC control equations, A, B, and C, that are processed in alphabetic order. It takes 1 µs to process each equation, and the group is processed every 31 ms in the SEL-2032. If SELOGIC control equation B contains the results of equation A, the results of B will be current (within 1 µs) because A was processed as part of the current process cycle. However, if equation B contains the results of equation C, the results of B will not be current because the results of C are from the previous process cycle, which is now one processing interval old.

The SEL-2032 processes SELOGIC control equations in the order and frequency shown in *Table 4.2*. *Figure 4.8* illustrates this processing sequence.

Table 4.2 SELOGIC Control Equation Execution Order

Symbol	Period	Description	Execution Order
DI, DO	7.8 ms	Output SELOGIC control equations	OUT1–OUT4, ALARM
I	31.2 ms	Intermediate Logic	V,VT,W,WT,X,XT,Y,YT,Z,ZT, PCFAIL
1–18	31.2 ms	Port Logic (e.g., 3 = Port 3 Logic)	SBR1–SBR16, CBR1–CBR16, SRB1–SRB16, CRB1–CRB16, ISSUE1–ISSUE12, ISSUE1A–ISSUE3A, BR1–BR16, RB1–RB16
CC	7.8 ms	Card Output Logic	17:CCOUT1–17:CCOUT64 18:CCOUT1–18:CCOUT64

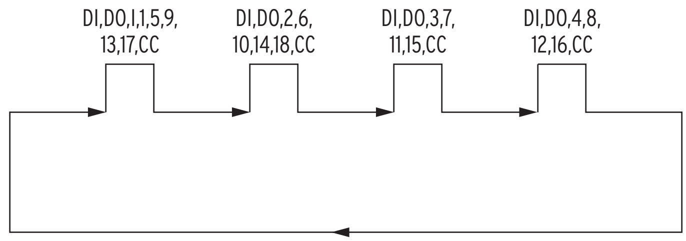


Figure 4.8 Processing Sequence Illustration

To illustrate the effects of the processing sequence, consider the following equations:

$$W = V \qquad \textbf{Equation 4.5}$$

$$V = W \qquad \textbf{Equation 4.6}$$

$$ISSUE1 = 1UMB*!D1 \qquad \textbf{Equation 4.7}$$

In *Equation 4.5*, V is processed before W, so W always exactly matches V in value. However, in *Equation 4.6*, V always lags W by one processing interval because V is processed before W; V is assigned the value W was set to during the last processing interval. In *Equation 4.7*, the issue condition is true for one processing interval, because D1 is found based on the ISSUE1 value; so the D1 used in the equation is the result of the previous processing interval's computations.

Processing of Local Intermediate Logic

The processing of the Local Intermediate Logic elements (SBR1, CBR1,…, CRB16) has some unique properties that the user should be aware of. These properties have changed, so the discussion below is based on the firmware version of your SEL-2032. This discussion applies only to the Local Intermediate Logic elements. These are the elements whose SELOGIC control equation are defined via the **SET L** command.

Communications and Triggered Messages

Whenever the SEL-2032 transmits a triggered message to an IED on one of its ports, it increments the LOCAL:NUM_MESG message counter in the database. If the SEL-2032 does not receive a response to the triggered message, it will set the port status to Inactive (bit 5 of LOCAL:PORT_STATUS and LOCAL:INAC) and increment the LOCAL:BAD_MESG message counter in the database. If, while the port status is Inactive, the SEL-2032 transmits ten consecutive messages without receiving a response, it will also set port status to Port Communication FAIL (bit 10 of LOCAL:PORT_STATUS). If PARSE*x* = IGNORE and the SEL-2032 does not receive a response to a transmitted message, it will not set port status to Inactive, nor increment the LOCAL:BAD_MESG message counter in the database.

If the port device type, DEVICE = OTHER or SEL, the SEL-2032 will transmit every triggered message regardless of the port status. In general, the SEL-2032 will only retransmit a message if it has been retriggered. However, if the triggered message is a Binary 20message, e.g., Binary 20METER, or SEL Fast Message Read (such as 20ENERGY), and port status is Inactive, the SEL-2032 will retransmit the message until it reestablishes communication with the IED. Furthermore, if the device type is DEVICE = SEL and port status is Inactive, for each triggered user-defined message or ASCII 20message, (e.g., ASCII 20METER) message, the SEL-2032 will also transmit a CR/LF (Carriage Return with Linefeed).

For DEVICE = SEL IED, if an ASCII Operate or a Fast (Binary) Operate is triggered while the port status is Inactive, the Operate is issued and the trigger is cleared. The SEL-2032 will retransmit the Operate only if it has been retriggered.

The SEL-2032 will clear the Port Inactive and Communication FAIL statuses if any of the following occurs:

If the port DEVICE = OTHER IED,

- The SEL-2032 receives a response of at least one character, PARSE*x* is not set to IGNORE, and it can successfully parse the response from the IED.
- The SEL-2032 receives a response of at least one character and the PARSE*x* is set to IGNORE. Conversely, if the PARSE*x* is set to IGNORE and the IED does not respond with at least one character, the port Inactive and Communication FAIL statuses will *not* be cleared.
- The SEL-2032 receives an unsolicited response of at least one character.

If the port DEVICE = SEL IED,

- The SEL-2032 successfully performs a binary data collection such as a 20METER or 20DEMAND.

  Note: If the SEL-2032 issues an Enable/Disable Unsolicited SER message and does not receive a response, the port status will remain unchanged.
- The SEL-2032 receives an unsolicited response of at least one character.

Whenever the port Inactive status is cleared, the SEL-2032 will transmit the contents of the STARTUP string.

Section 5
Message Strings

Introduction

This section provides information about the characters, special sequences of characters, and predefined strings that you can use in a number of SEL-2032 settings. A blue pull-out card at the end of the book contains a summary list of special characters and predefined strings.

Overview

A string is a sequence of characters that make up part, or all, of a message command or identifier label. Each character may be an ASCII printable character or any 8-bit code that represents a nonprintable character. You use these strings in the following ways:

- ➤ Device and Port IDs, termination strings, and modem startup strings in Port configuration using the **SET P** command.
- ➤ Startup sequence for an IED and message strings in auto-messages using the **SET A** command.
- ➤ User-defined commands and responses using the **SET U** command.

NOTE: You should avoid using LMD prefix characters in Master port user-defined commands. For an explanation of LMD and a list of LMD prefix characters see Section 9: Protocols.

Message strings consist of literal characters, special sequences, and predefined strings. Literal characters include both ASCII printable and nonprintable characters. Special sequences are strings that are interpreted to have a special meaning when they are used, such as dial a particular phone number, or output a specified set of database data. Predefined strings are used with SEL IEDs to represent certain predefined operations, such as 20METER means collect meter data in best method available for attached device. The following sections further describe these types of message sequences.

Literal Characters

Message strings typically contain some literal characters. These consist of both ASCII printable characters and nonprintable characters. Printable characters (except ‘\’) are entered into a string by directly entering the character (depressing the key for that character on your keyboard). You can also enter any character based on its 8-bit code. To enter a nonprintable character (or special sequence strings) using printable characters, you must use a special sequence to indicate that you are entering something other than a printable character. These sequences always begin with a backslash (‘\’). *Table 5.1* shows the format of the various special character sequences available.

The following are examples of simple strings:

“Another device” A literal string for “Another device”

“TRIG\nY\n” String for **TRIG<Enter>Y<Enter>**

“\002HI\\BOB\003” String for **<STX>HI\BOB<ETX>**

You can use the quote character to define the beginning and end of a string. If you do not, the SEL-2032 will put the string in quotes anyway. The only exception is for predefined strings discussed later in this section.

Table 5.1 Special Characters for Use in Strings

Character	Comments
\”	The SEL-2032 interprets this as a quote character in a string, as distinguished from quotes at the beginning and end of a string.
\\	The SEL-2032 interprets this as a backslash character in a string.
\n	**<Enter>** sequence (CR/LF combination, just CR on SEL IED ports).
\0xx	The SEL-2032 interprets this as an 8-bit character, where xx = an ASCII character value in hexadecimal; (e.g., \004 is ASCII End-of-Text, EOT, character). See *Appendix E: ASCII Reference Table* for a conversion table.
\ **<Enter>**	Use to continue a string to the next line.

Special Sequences

The SEL-2032 is preprogrammed to interpret special sequences of characters for special purposes. You can use these special character sequences in auto-messages or user-defined commands to control the data that are referenced by the message and to control the response initiated by the message. These special sequences are particularly well suited for use with non-SEL IEDs and devices.

Message Sequences

You may use the special character sequences listed in *Table 5.2* in automatic messages, configured with SET A, and special-purpose user-defined command responses, configured with SET U.

Table 5.2 Special Message Sequences for Strings (Sheet 1 of 3)

Character	Comments
\CS*x*/	Begin checksum calculation. *x* specifies checksum type. c = CRC-16. Based on the polynomial $X^{16} + X^{15} + X^2 + 1$ b = 8-bit checksum. Sum all bytes and take least significant byte. w = 16-bit checksum. Sum all bytes and take two-byte result.
\CE/	Stop checksum calculation.

Table 5.2 Special Message Sequences for Strings (Sheet 2 of 3)

Character	Comments
\CO*yz*/	Output checksum. *y* specifies format. a = ASCII-hexadecimal. b = binary. x = binary with XON/XOFF encoding *z* specifies byte order. h = high byte first. l = low byte first.
\DA[*C*][*P*]*n*/	Output unsolicited message queue data for Port *n*. *C* = if included, clear the queue after the read. *P* = if included, only read characters that have been added to the unsolicited message queue since the last time the message queue was read. *P* and *C* options are mutually exclusive. Valid for use with Ports 17 and 18.
\D*t*/	Data item output for READACK setting (SET U). *t* specifies the data format. b = binary word (2 bytes). h = ASCII-hexadecimal word (4 digits). c = binary bytes (1 byte). g = ASCII-hexadecimal byte (2 digits).
\F*p*:*r*[;*C*[*A*]]/	Output formatted region data. *p* = the port number. *r* = the data region. *;C* = clear archive item after it is read. *;CA* = read the entire queue of records from an Archive data region and clear them as they are read.[a] Valid for use with Ports 17 and 18.
\I*dstr*[:*h*]/	Initiate a phone call using the given dial string. Only applies to modem ports. *dstr* = a dial string of up to 40 characters. Typically consists of ATDT and phone number. See your modem user's manual for more information on dial strings. *h* = hang up flag. Set to Y to automatically hang up modem at end of string. Set to N to leave modem connected. You will need to send a separate message later to disconnect the modem (i.e., "\MATH"). (If not included, the default is Y.)
\M	Modem Escape String. Sends modem escape sequence to force a modem into command mode. (The modem escape sequence is a 2-second pause, issuance of the string "+++," and another 2-second pause.) Only available on modem ports. Literal characters in a string after this sequence will be output, even if the carrier detect input is low.

Table 5.2 Special Message Sequences for Strings (Sheet 3 of 3)

Character	Comments
\R*t*;saddr[;*n*]/	Output register contents. *t* specifies the data format. b = binary word (2 bytes). c = binary byte (1 byte). d = binary default (size according to data type). g = ASCII-hexadecimal byte (2 digits). h = ASCII-hexadecimal word (4 digits). f = float in ASCII. i = integer in ASCII. u = unsigned integer in ASCII. x = binary byte with XON/XOFF encoding. y = binary word with XON/XOFF encoding saddr = register address, using any valid register access method. (See *Section 6: Database*.) *n* = specifies how many registers to read. Data items are delimited by spaces for all except b, c, and d formats. One (1) is assumed if you do not specify. Valid for use with Ports 17 and 18.
\SP/	Suppress prompt (on Master port). Do not display new prompt after message contents. Valid for use with Ports 17 and 18.
\T*d*/	Time delay; use this code to place a delay within string output. *d* = time in seconds and may be specified as decimal fraction. (This time delay will be rounded to the nearest 1\32 of a second.) Time must be in the range of 0.03–2047. Valid for use with Ports 17 and 18.
\W;saddr;*n*,daddr/	Unsolicited database write. Applies only to ports where DEVICE=MASTER or SEL, and PROTOCOL=SEL. Unsolicited Write messages are binary format and interleaved within ASCII message exchanges. While you may include up to eight \W…/ sequences within the same Automatic Message Setting (MESG*n*), no other characters or special message sequences are allowed before, after, or in between the Unsolicited Write strings. saddr = Source register starting address, using any valid register access method. The source address range may be any database region other than the Archive data regions (A1–A3). (See *Section 6: Database*.) *n* = Specifies how many registers to write. Number of registers must not exceed 115. daddr = Destination SEL-2020/2030 User region address, using any valid User region address (F800h–FFFFh). (See *Section 6: Database*.) [b]

[a] See the discussion in Archive Data Regions on page 6.21.
[b] Since the destination starting address refers to allocated memory within a separate SEL-2032, there is no verification that the destination User region memory exists. Use the SET A command to adjust the User region memory size of a destination SEL-2032. (See Section 7: Settings.)

EXAMPLE 5.1 Message Strings

The following are examples of using special message sequences in strings:

MESG1="\F1:METER/"

Output the formatted meter data from Port 1. The following screen shows a sample response to this message.

```
Port 1,  Data Region METER   Data
_YEAR = 1995  DAY_OF_YEAR = 1 (01/01)  TIME = 01:59:37.859
IA(A) =   2374.623,   102.078  IB(A) =   2353.747,   -17.810
IC(A) =   2369.258,  -137.949  VA(V) =  11278.516,   103.606
VB(V) =  11289.020,   -16.545  VC(V) =  11270.235,  -136.424
IAB(A) =   4092.593,   131.987  IBC(A) =   4093.101,    12.229
ICA(A) =   4107.771,  -107.898  VAB(V) =  19558.934,   133.546
VBC(V) =  19524.914,    13.488  VCA(V) =  19524.873,  -106.397
PA(MW) =     26.773  QA(MVAR) =      0.714  PB(MW) =     26.565
QB(MVAR) =      0.587  PC(MW) =     26.693  QC(MVAR) =      0.711
P(MW) =     80.030  Q(MVAR) =      2.012  I0(A) =      7.170,   135.000
  I1(A) =   2365.875,   102.106  I2(A) =      5.750,    40.418
V0(V) =      7.299,   -80.537  V1(V) =  11279.251,   103.546
V2(V) =     13.106,   163.608
```

MESG2="DATE \Ri;1:GLOBAL:MONTH//\\Ri;1:GLOBAL:DATE//\Ri;1:GLOBAL:_YEAR/\n"

Output SEL IED date command, with date being read from global region of Port 1's database. An example output from this is shown below:

```
DATE 5/2/1995<CR><LF>.
```

MESG3="\IATDT15093321890/\T5/\DAC7/"

Initiate a phone call by issuing embedded dial string and waiting for connect indication from modem, wait 5 seconds after connection, output unsolicited message data from Port 7, and clear the Port 7 unsolicited message buffer. The phone call will be placed, even if there is no data to send (the unsolicited message buffer is empty). The connection will be dropped once the transfer is complete.

MESG4="\CSC/\002\RH;12:USER:0;100/\003\CE/,\C0ah/\n"

Output <STX> followed by Port 12 User Region data and <ETX>, followed by comma and CRC-16 checksum displayed in ASCII hexadecimal format and then <CR><LF>. The \CSc/ and \CE/ strings indicate that the CRC-16 checksum is calculated on all of the data output from the <STX> through the <ETX>.

Parsing Sequences

You use the **SET U** command to create basic and complex user-defined message strings that the SEL-2032 will recognize. Basic user-defined commands have a fixed character sequence. The SEL-2032 will recognize a basic message from an attached device only if that message matches the user-defined message character sequence exactly, in both form and content.

For more advanced applications, you can use parsing sequence characters to develop a user-defined message that permits the message sent from the attached device to vary in content, provided it matches the message format exactly. You can also use parsing sequences to construct a single user-defined message string. This string format can recognize messages having a partially fixed character sequence with a “wildcard” format. Refer to *Table 5.3* for parsing sequence characters you can use with the SEL-2032.

Table 5.3 Special Parsing Sequences for Strings

Character	Comments
\A*t*/	Register address. For READ and WRITE settings only. *t* specifies the address format. b = binary (2 bytes). a = ASCII-hexadecimal (4 digits).
\D*t*/	Data item. For WRITE setting only. *t* specifies the data format. b = binary word (2 bytes). h = ASCII-hexadecimal word (4 digits). c = binary bytes (1 byte). g = ASCII-hexadecimal byte (2 digits).
\P*t*/	Port number. For TRANS, READ, and WRITE settings only. *t* specifies the Port number format. b = binary (1 byte). a = ASCII-hexadecimal (2 digits).
\X[X]/	Ignore character. \X/ indicates ignore one character. \XX/ indicates ignore all characters following until the next defined character is encountered.

EXAMPLE 5.2 Parsing Sequences

The following are examples of using special parsing sequences in strings:

CMD1="In the\XX/"

The CMD1 bit will assert whenever a string that begins with "In the" is received at the SEL-2032 Port set with this user-defined message.

WRITE="W\Pa/@\Aa/=\Dh/"

Creates a write command that the SEL-2032 uses to recognize data in a special format. In this example, the string containing the data must begin with a W, followed by a Port number, an @ symbol, a database address, an = character, and finally the data. For instance, to write 0 (zero) to Port 8, address F800h, you would have to send the string "W08@F800=0000" to the SEL-2032.

Predefined Strings

When working with SEL relays, the SEL-2032 includes some predefined strings you can use in SET A auto-messages to collect data. The SEL-2032 also includes four predefined strings you can enter as **SET U** user-defined commands to recognize automatic messages sent from an SEL relay. *Table 5.4* lists the predefined strings you can use on auto-configured SEL IED ports for data collection (SET A MESG*x* settings). *Table 5.5* lists other predefined strings that are available regardless of the port type.

Table 5.6 lists predefined strings you can use on SEL IED ports to watch for unsolicited messages (relay auto-messages).

Table 5.4 Predefined Strings for Auto-Messages with Auto-Configured SEL IEDs

String	Comment
20METER	Send ASCII meter or Fast Meter command, as appropriate.
20DEMAND	Send ASCII demand meter or fast demand meter command, as appropriate.
20TARGET	Send ASCII target command sequence or Fast Meter, as appropriate.[a]
20HISTORY	Send ASCII history command.
20STATUS	Send ASCII status command.
20BREAKER	Send ASCII breaker command.
20EVENT	Send ASCII request for standard (4 sample/cycle) event report. Stored in a parsed format. (Refer to the following subsection for some additional features.)
20EVENTS	Send ASCII request for standard (4 sample/cycle) event report. Stored in a literal format. (Refer to the following subsection for some additional features.)
20EVENTL	Send ASCII request for long (16 sample/cycle) event report. Stored in a literal format. (Refer to the following subsection for some additional features.)

[a] When the SEL-2032 collects target data from relays that do not have Fast Meter capability, the **TARGET** commands sent by the SEL-2032 may momentarily modify the front-panel targets on the relays—just as if you were sending the **TARGET** command to the relay without the SEL-2032.

Table 5.5 Other Predefined Strings for Auto-Messages

String	Comment
20USER	No message is sent, but data from User Region is copied to this region.

Table 5.6 Predefined Strings for General-Purpose User-Defined Commands

String	Comment
20EVENT	Recognize summary event reports received from SEL relays and trigger with delay. Will continue to retrigger until all reports are collected.
20EVENTQ	Recognize summary event reports received from SEL relays and trigger immediately.
20STATUS	Recognize status messages received from SEL relays.
20GROUP	Recognize group switch messages from SEL relays.

20EVENT Features

Because SEL relays may trigger multiple event reports in rapid succession, the SEL-2032 has special features based on these triggers to facilitate collecting event reports. To take advantage of these special features, you must set **20EVENT** as a user-defined command with **SET U**. The SEL-2032 then keeps track of the number of summary event reports received from the SEL relay on that port. You must then set MESG3 or MESG3A to 20EVENT, 20EVENTS, or 20EVENTL. The SEL-2032 will then collect the oldest unread event report from the SEL relay. The CMD*x* bit corresponding to the **20EVENT** command continues to retrigger every 5 minutes as long as there are uncollected event reports. (To have the CMD*x* bit trigger immediately on each unsolicited summary event report, use the user-defined command **20EVENTQ**.) The number of reports left to read is visible in the Local region of the port database.

These features can be used to collect and process event reports in a number of ways. The following example illustrates collecting event reports and calling them out when you do not have archive memory installed.

EXAMPLE 5.3 Collecting and Calling Out Event Reports

Consider a relay on Port 1 and modem on Port 8 with the following settings:

```
SET U 1
  CMD1=20EVENT
SET A 1
  ISSUE3=CMD1*!8:D1
  MESG3=20EVENT
SET A 8
  ISSUE1=!1:D3
  MESG1="\IATDT15093321890/\F1:D3/"
```

Consider what happens when the relay triggers three event reports in rapid succession. The 1:CMD1 bit triggers collection of an event report. Because the SEL-2032 received three summary event reports, the SEL-2032 collects the third event report. After the SEL-2032 finishes collecting this event report, the modem initiates a phone call and uploads the event report. Every 5 minutes, the SEL-2032 retriggers the 1:CMD1 causing the next event report to be collected and transferred via modem, until all three event reports have been collected and transferred.

If the modem port is unsuccessful at initiating a phone call when the next 1:CMD1 trigger occurs, the !8:D1 term in the event report collection trigger equation prevents a new event report from being read until the event report has been successfully transferred. The 1:CMD1 bit continues to retrigger every 5 minutes until all unread event reports are collected.

Modem Dial-Out Process

The SEL-2032 can dial out to a remote PC, terminal, or IED through an attached modem. This feature is useful to transfer data automatically from the SEL-2032 database to a remote location or to acquire data from a remote device. With the **SET A** command, set an ISSUE*n* message trigger to define the condition that initiates the dial-out process, and set a MESG*n* to define the message content and data.

The ISSUE*n* trigger condition can be based on time and/or day-of-week, or any logic condition using global and local elements in the SEL-2032 database collected from attached devices. The MESG*n* message string must begin with a \I.../ special string sequence, followed by the data (or data request) and/or data output strings, \R.../ or \F.../, that define the message to be sent.

The \I special string sequence initiates the dial-out process through the modem using the provided dial string. For example \IATDT15093321890/ would dial the SEL factory. The SEL-2032 will wait up to 60 seconds for a carrier signal from the remote modem, which indicates the call has been completed. If a carrier signal is not detected in 60 seconds, the SEL-2032 will hang-up and wait 2 minutes before initiating a subsequent dial-out attempt. (Only two attempts are made before the SEL-2032 gives up on the message.) You must, therefore, set the remote modem to answer a call in less than 60 seconds. The SEL-2032 data are transferred when a successful connection is made.

Section 6
Database

Introduction

The SEL-2032 Communications Processor database contains status information and data collected from devices attached to the 16 rear communication ports. There is also information associated with the plug-in protocol card slots Port 17 and 18. This section describes the structure of the database and the various ways data within the database can be accessed.

Database Structure

The SEL-2032 data area includes a database of 16-bit registers for each of the 16 rear communication ports and a database for each of the two plug-in protocol cards. Each port database consists of up to 15 regions, including Global (GLOBAL), Local (LOCAL), Unsolicited Message Buffer (BUF), eight Data regions (D1–D8), three Archive data regions (A1–A3), and a User region (USER). Global, Local, and User regions are available on all used ports. The Unsolicited Message Buffer (BUF) and Data regions are available on ports with SEL IED and other IED device types. The Archive data regions are available on IED ports. The first Data region (D1) and Archive data region (A1) are available on Master ports for use with the 20USER setting. See *Section 5: Message Strings* for more information. *Figure 6.1* illustrates the overall database structure.

Table 6.1 provides detailed information about each port's database. More detailed information about each region is located in *Region Descriptions on page 6.4*.

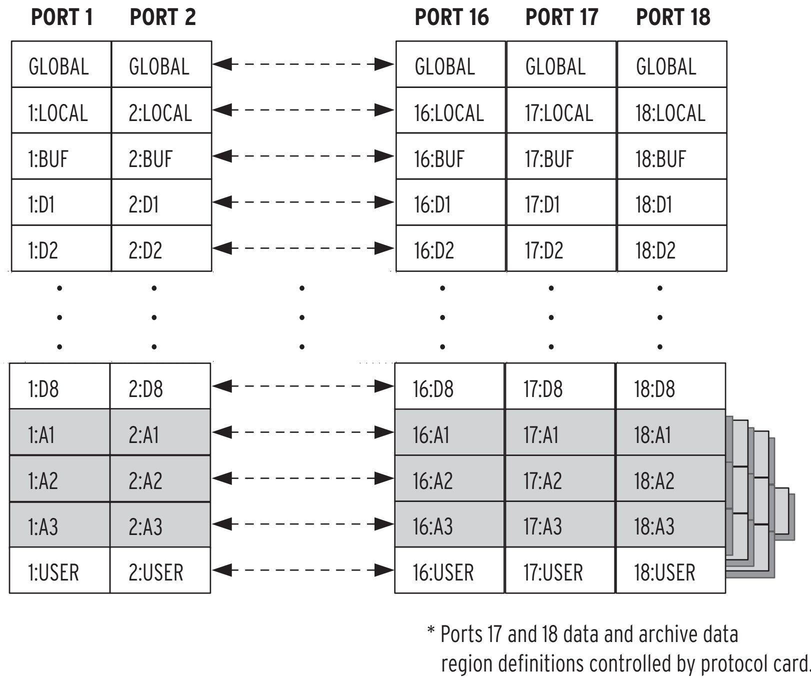


Figure 6.1 Overall Database Structure

The region sizes shown in *Table 6.1* indicate the maximum amount of data that can be stored in each region. The actual data stored in each region of each port depends on the settings you apply using the **SET A** command.

Table 6.1 Database Regions for a Single Port

Region	Address From	Address To	Size (Registers)
Global Region	0000h	07FFh	2k
Local Region	0800h	0FFFh	2k
BUF (Unsolicited Message Buffer)	1000h	1FFFh	4k
Data Region 1	2000h	27FFh	2k
Data Region 2	2800h	2FFFh	2k
Data Region 3	3000h	47FFh	6k
Data Region 4	4800h	4FFFh	2k
Data Region 5	5000h	57FFh	2k
Data Region 6	5800h	5FFFh	2k
Data Region 7	6000h	67FFh	2k
Data Region 8	6800h	6FFFh	2k
Archive Data Region 1	7000h	77FFh	2k
Archive Data Region 2	7800h	7FFFh	2k
Archive Data Region 3	8000h	F7FFh	30k
User Region	F800h	FFFFh	2k

If you set AUTOBUF=Y on a port, unsolicited messages are stored in the BUF region until the region is cleared or until the region is completely filled. When the BUF region is filled, the newest data will overwrite the oldest data as they are received.

The Data regions D1–D8 and the Archive data regions A1–A3 store data solicited by messages you create with the automatic message (SET A) settings. The data you solicit using “20” messages are parsed automatically in the associated data region. All of the “20” message responses will fit in any of the Data regions, except the response to the 20EVENT, 20EVENTS, and 20EVENTL messages. These messages elicit an event report from an SEL relay. Only the D3 and A3 data regions are large enough to hold an entire 20EVENT or 20EVENTS event report response and only the A3 data region is large enough to hold a 20EVENTL event report response. Check the event size of newer relays to determine if they will fit in the available regions.

⚠DANGER
Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

You control the size of the data solicited with non-“20” messages based on the parsing method you choose and the size of the message response you define with the NUM*x* setting. If you specify a size larger than the region size, the SEL-2032 will respond immediately with an “Out of Range” message.

The Data and Archive data regions of Ports 17 and 18 are controlled by the installed protocol card. Refer to your protocol card instruction manual to determine if, and how, these regions are used by the protocol card.

You can only reference those portions of regions that have data assigned. If you reference an address that is not assigned, the SEL-2032 will respond with a message that the data address does not exist.

You can allocate all, or a portion, of the User region with the **SET A** command, or the **SET M** command will automatically allocate the User region. You must use the **STORE** command, user-defined write command, or Modbus® write function code to put the data into this area. You may also use **SET M** to establish automatic storage of data into the User region.

Archive data regions are structured differently from other regions. Where all other regions contain only a single record, the Archive data regions contain a queue of records. From a data access point of view, the Archive data regions appear to only contain the oldest record. However, as soon as it is cleared, the next oldest record appears. The number of archive records that can be stored is only limited by the amount of nonvolatile Flash memory. See *Archive Data Regions on page 6.21* for more information.

The nonvolatile nature of these data regions, combined with the unique capability to contain multiple records, make them ideally suited to long-term data collection and storage. You can use the **VIEW** command to view the data associated with any record in the Archive data region queue; all other commands read only the oldest record. See the memory calculation procedure in *Appendix D: System Planning Sheet* for more information.

The SEL-2032 assigns Data and Archive data regions alternate labels or names based on the data they store. For instance, if you use the 20METER message to collect and store SEL relay meter data in Data region D1, that region is assigned the alternate label “METER.” Use the **MAP** command to view a list of regions on a port and any alternate labels associated with some of the regions.

You can also use the **MAP** command to show the detailed structure of any region.

Data Storage Formats

Data are contained within the SEL-2032 database in various formats. Character items and strings are stored with each character requiring one register but only using the lower byte of the register; the high byte is always zero. Any unused characters in a string are set to a value of zero. Integer items require a complete register. Real numbers are stored in IEEE single-precision floating-point format in two registers with the most-significant word stored in the lower-addressed register of the two. See *Figure 6.2* for an illustration of how these data types map into the registers. You can use the **VIEW** and **MAP** commands to identify the data storage format and see the stored data. You can use message strings in an auto-message to transfer the data from the SEL-2032 to another device in virtually any format. See *Section 5: Message Strings* for more detailed information.

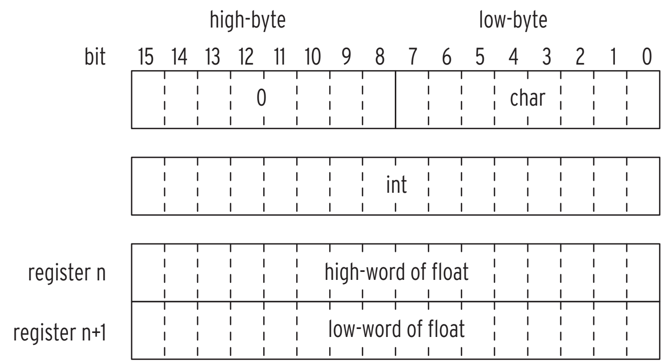


Figure 6.2 Register Usage for Different Data Types

Region Descriptions

Global Region

The Global region (GLOBAL) includes the following data that are common to all ports: SEL-2032 FID string, status and configuration information, date and time, global element bits, plug-in card status within an SEL-2032, and Port F status (see *Table 6.2*, *Table 6.3*, and *Table 6.4*). Each port database contains the same information in this region (e.g., 1:GLOBAL is the same as 2:GLOBAL).

Table 6.2 Global Region (Sheet 1 of 3)

Starting Address	Data Item Label	Data Type	Notes
0000h	FID	char[40]	Read-only
0028h	STATUS	int	Bit for each type of failure; read-only. For a complete discussion of failure types, see *STATUS on page 8.21*. The Status register is detailed in *Figure 6.3*.
0029h	CONFIG	int	Indicates SEL-2032 hardware configuration; read-only, see *Figure 6.4* for details of the Configuration register.
002Ah	_YEAR	int	i.e., 1994
002Bh	DAY_OF_YEAR	int	1–365
002Ch	MONTH	int	1–12
002Dh	DATE	int	1–31
002Eh	TIME(ms)	int[2]	Append two registers to get 32-bit time; register 2Eh has high-word, 2Fh has low-word; 0–86399999.
0030h	ELEMENTS	char[7]	8-bit character for each row. The Global Elements are detailed in *Global Elements on page 6.8*.

Table 6.2 Global Region (Sheet 2 of 3)

Starting Address	Data Item Label	Data Type	Notes
0037h	REMOTE_BIT_REG	int	For details on the Remote Bit Control register (see *Figure 6.5*)
0038h	REMOTE_BITS	int	Directly operate all 8 remote bits. Lower byte corresponds to bits: bit 0 is R8, bit 1 is R7, … bit 7 is R1. The upper byte must be the complement of the lower byte for command to be accepted.
0039h	_YEARS	int	Years in the century. 0–99
003Ah	_HOURS	int	Hours in the day. 0–23
003Bh	_MINS	int	Minutes in the hour. 0–59
003Ch	_SECS	int	Seconds in the minute. 0–59
0100h	PC1_FID	char[40]	Firmware identification string of the plug-in protocol card in Port 17
0128h	PC1_SERVICES	int[2]	Indicates what services are supported by both the SEL-2032 and the protocol card in Port 17. The first register is always 0. The second register uses the following bits: Bit 0: Card-initiated Virtual Terminal Bit 1: SEL-2032-initiated Virtual Terminal Bit 2: Card-initiated File Transfers Bit 3: SEL-2032-initiated File Transfers Bit 4: Card-initiated Control Operations Bit 5: SEL-2032-initiated Control Operations Bit 6: SEL-2032 can force card into SELBOOT mode Bit 7: Card-initiated Time Sync. Bit 8: SEL-2032-initiated Time Sync. Bit 9: Card can force SEL-2032 into SELBOOT mode
012Ah	PC1_STATUS	int	Bit-mapped integer that indicates protocol card status: Bit 0: Card alive and initialized Bit 1: Card self-test failure Bit 2: Card network port failure Bit 3: Settings error Bit 4: Card running in SELBOOT mode Bit 7: Card is in low resource condition (e.g., low memory) Bit 15: Card is no longer accessing shared-memory; card has probably failed
012Bh	PC1_CONFIG	int	Set to 0 if no protocol card is recognized in Port 17; set to 1 if protocol card is recognized.
012Ch	PC1_STEST_ERR	int	Contains self-test error code from protocol card. See the protocol card instruction manual for interpretation.
0200h	PC2_FID	char[40]	Firmware identification string of the protocol card in Port 18.

Table 6.2 Global Region (Sheet 3 of 3)

Starting Address	Data Item Label	Data Type	Notes
0228h	PC2_SERVICES	int[2]	Indicates what services are supported by both the SEL-2032 and the protocol card in Port 18. The first register is always 0. The second register uses the following bits: Bit 0: Card-initiated Virtual Terminal Bit 1: SEL-2032-initiated Virtual Terminal Bit 2: Card-initiated File Transfers Bit 3: SEL-2032-initiated File Transfers Bit 4: Card-initiated Control Operations Bit 5: SEL-2032-initiated Control Operations Bit 6: SEL-2032 can force card into SELBOOT mode Bit 7: Card-initiated Time Sync. Bit 8: SEL-2032-initiated Time Sync. Bit 9: Card can force SEL-2032 into SELBOOT mode
022Ah	PC2_STATUS	int	Bit-mapped integer that indicates protocol card status: Bit 0: Card alive and initialized Bit 1: Card self-test failure Bit 2: Card network port failure Bit 3: Settings error Bit 4: Card running in SELBOOT mode Bit 7: Card is in low resource condition (e.g., low memory) Bit 15: Card is no longer accessing shared-memory; card has probably failed
022Bh	PC2_CONFIG	int	Set to 0 if no card is recognized in Port 18; set to 1 if card is recognized.
022Ch	PC2_STEST_ERR	int	Contains self-test error code from protocol card. See the protocol card instruction manual for interpretation.
0400h	PORT_STATUS	int	Read-only. The Port F Status Register is detailed in *Figure 6.6*.
0401h	ALT_PORT	int	Port number Port F is in transparent communications with; 255 if not transparently connected; read-only.
0402h	NUM_MESGS	Int	PORT F #Messages Received. Reset when port reset, or count exceeds 32767; read-only.
0403h	BAD_MESGS	Int	PORT F #Bad Messages Received. Reset when previous field reset; read-only.
0404h	Unused		

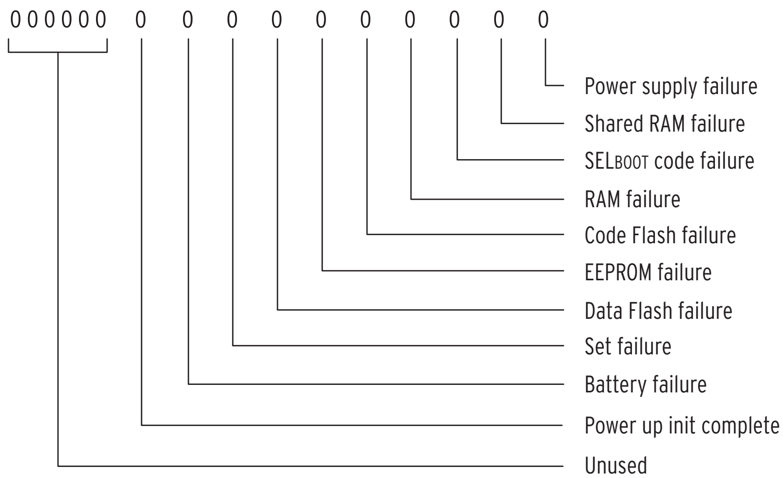


Figure 6.3 Global Status Register

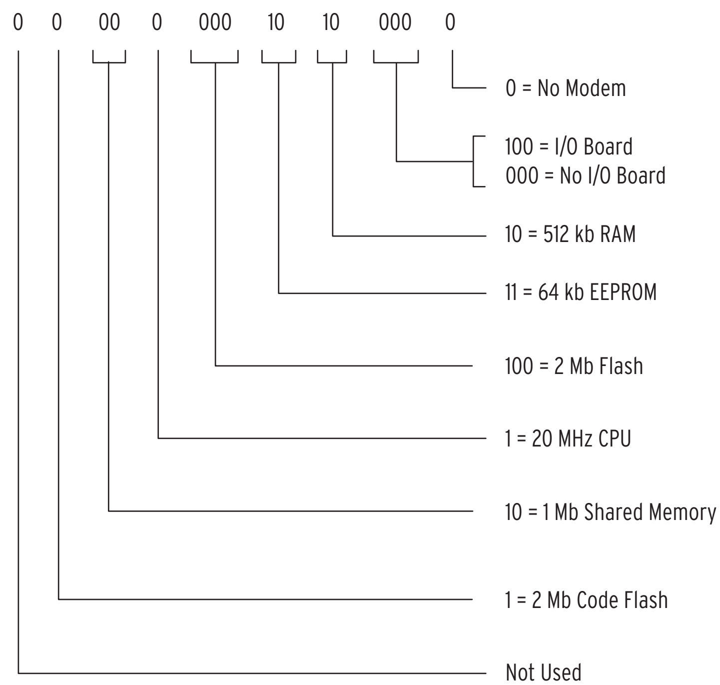


Figure 6.4 Configuration Register

The Remote Bit Control register is detailed in *Figure 6.5*. Use this register to control remote bits. For example, write 007Bh (0000000001111011 binary) to the Remote Bit Control register (address 0037h) to pulse remote bit R3 for 3 seconds.

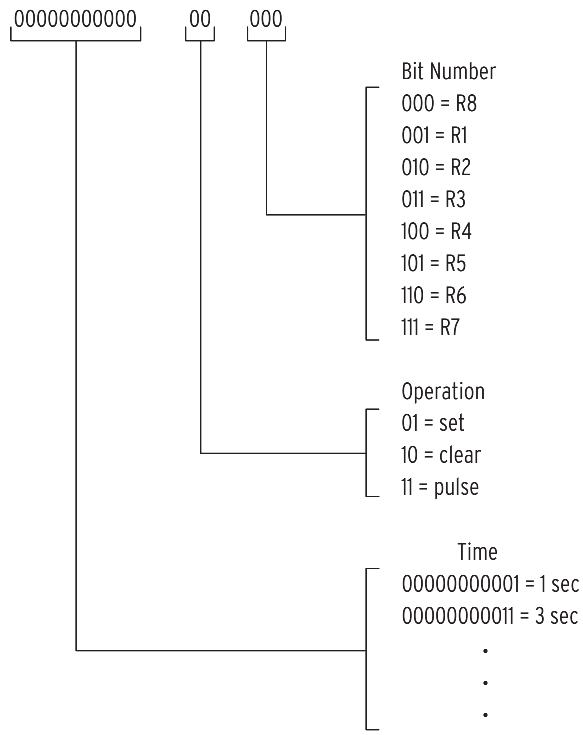


Figure 6.5 Remote Bit Control Register

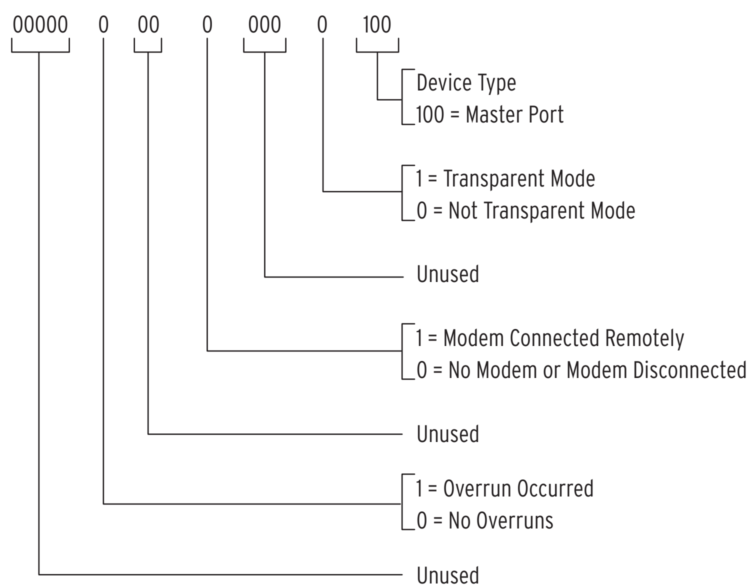


Figure 6.6 Port F Status Register

Global Elements

Table 6.3 shows global elements. *Table 6.4* lists definitions for global elements.

Table 6.3 Global Elements

Row	Global Elements						
0	SUN	MON	TUE	WED	THU	FRI	SAT	IRIG
1	V	W	X	XT	Y	YT	Z	ZT
2	R1	R2	R3	R4	R5	R6	R7	R8
3	PINAC	PCF	INAC	SDLY	*	PCFAIL	ALARM	SALARM
4	IN8	IN7	IN6	IN5	IN4	IN3	IN2	IN1
5	IN16	IN15	IN14	IN13	IN12	IN11	IN10	IN9
6	OUT1	OUT2	OUT3	OUT4	*	*	VT	WT

Row 0. Day-of-Week elements, SUN–SAT; one is asserted each day of the week; and the external IRIG-B status element (IRIG) is asserted when the SEL-2032 detects the external IRIG-B signal.

Row 1. Intermediate Variable elements, V, W, X, Y, and Z, are asserted when the corresponding intermediate logic equation is true; and associated timer bits, XT, YT, and ZT, are asserted when the pickup timer times out until the dropout timer times out.

Row 2. Remote elements, R1–R8, are set, cleared, or pulsed by the **CONTROL** command.

Row 3. SEL-2032 Status elements indicate a port is inactive pending auto-configuration (PINAC); a port has failed power-up auto-configuration (PCF); at least one port is inactive because it is not responding or not responding correctly (INAC); and there has been at least one data collection missed since the last **STATUS** command (SDLY). The PCFAIL bit indicates if a plug-in protocol card has failed and is based on a SET G setting. The ALARM bit indicates if an alarm condition has occurred, based on a SET G setting. (If a self-test failure caused the alarm contact to close, this will not be indicated by this bit; only user-configured alarms will be indicated.) The SALARM bit asserts for one second whenever there is a settings change, Access Level 2 is gained, a password is entered incorrectly on three successive attempts, or a password is changed.

Row 4. External Input elements, IN1–IN8, are asserted when the associated external input is asserted (only available with optional I/O board).

Row 5. External Input elements, IN9–IN16, are asserted when the associated external input is asserted (only available with optional I/O board).

Row 6. External Output elements, OUT1–OUT4, are asserted when the associated external output contact operates (only available with optional I/O board). Timer bits, VT and WT, assert when the pickup timer times out until the dropout timer times out.

All bit positions with an * are reserved for future use.

Table 6.4 Global Element Definitions (Sheet 1 of 2)

Row	Element	Definition
0	SUN	Sunday Flag
	MON	Monday Flag
	TUE	Tuesday Flag
	WED	Wednesday Flag
	THU	Thursday Flag
	FRI	Friday Flag
	SAT	Saturday Flag
	IRIG	IRIG-B Input Present Flag is set when IRIG-B input is sensed.
1	V	Intermediate Element V
	W	Intermediate Element W
	X	Intermediate Element Y
	ST	X Element Timer Output
	Y	Intermediate Element Y
	YT	Y Element Timer Output
	Z	Intermediate Element Z
	ZT	Z Element Timer Output
2	RI	Remote Bit 1
	R2	Remote Bit 2
	•	•
	•	•
	•	•
	R8	Remote Bit 8
3	PINAC	A port is in a Power-Up Inactive State
	PCF	A port is in a Power-Up Configuration Failure State
	INAC	A port is in an Inactive State
	SKLY	A SELOGIC® control equation automatic message operation has been missed on a port.
	*	Unused
	PCFAIL	A protocol card has failed; result of PCFAIL SELOGIC control equation setting
	ALARM	An alarm condition has occurred; result of ALARM SELOGIC control equation setting
	SALARM	Settings Change Alarm
4	IN8[a]	Input Eight Element
	IN7	Input Seven Element
	•	•
	•	•
	•	•
	IN1	Input One Element
5	IN16[a]	Input Sixteen Element
	IN15	Input Fifteen Element
	•	•
	•	•
	•	•
	IN9	Input Nine Element

Table 6.4 Global Element Definitions (Sheet 2 of 2)

Row	Element	Definition
6	OUT1[a]	Output One Element
	OUT2	Output Two Element
	OUT3	Output Three Element
	OUT4	Output Four Element
	*	Unused
	*	Unused
	VT	V Element Timer Output
	WT	W Element Timer Output

[a] Elements IN1–IN16 and OUT1–OUT4 are available with optional I/O board only.

Local Region

The Local region (LOCAL) contains information specific to the local port. This information includes port status, local elements (intermediate logic, general command receipt, select-before-operate flags), database status, select-before-operate registers, archive queue counters, device FID (for auto-configured SEL IED ports), and port ID setting. See *Table 6.5–Table 6.7* for detailed information.

The Local region also contains the most recent fault location and type. These registers are only used if **20EVENT** or **20EVENTQ** is set as a user-defined command so that the SEL-2032 is watching for unsolicited summary event reports. Once the fault location and type are updated, the SEL-2032 will not update them again until 30 seconds elapse during which no unsolicited event reports are received. This allows the database to maintain the type and location of the initial fault.

The UW_FAIL register represents the total number of message failures. Additional detail is reported when the UW_FAIL register is read using the default SEL-2032 **VIEW** command (**VIEW *n* LOCAL**, where *n* represents the port number). Failure counts are itemized and reported based on the following categories:

- CRC Fail
- Address Fail
- Insufficient Memory
- Busy
- General Data Error

Table 6.5 Local Region (Sheet 1 of 3)

Starting Address	Data Item Label	Data Type	Notes
0800h	PORT_STATUS	int	Read-only (see *Port Status Register on page 6.14*)
0801h	ALT_PORT	int	Port number this port is in transparent communications with; 255 if not transparently connected; read-only.
0802h	NUM_MESGS	int	#Messages Received. Reset when port reset, port inactive, or count exceeds 32767; read-only.
0803h	BAD_MESGS	int	#Bad Messages Received. Reset when previous item reset; read-only.
0804h	ARCHIVE_CNTRS	int[3]	Number of records in each Archive data region; read-only.

Table 6.5 Local Region (Sheet 2 of 3)

Starting Address	Data Item Label	Data Type	Notes
0807h	ELEMENTS	char[18]	Read-only (see *Local Elements on page 6.15*)
0819h	SBO_REGS	char[4]	Must write AAh then 55h to this register within 1 second to pulse SELOGIC control equations bit (SB01–SB04).
081Dh	COMMAND_REG	char	Number (1–8) of command bit (CMDx) to set; write-only.
081Eh	CLR_ARCH_REG[a]	int	Write FE01h, FD02h, or FC03h to clear record in Archive data regions A1–A3, respectively.
081Fh	FID	char[80]	FID string of attached SEL IED
086Fh	PORTID	char[41]	Port ID setting
0898h	EVENT_COUNT	char	Number of unread event report (see *20EVENT Features on page 5.7*)
0899h	FAULT_LOC	float	Most recent fault location.
089Bh	FAULT_TYPE	char[10]	ASCII string describing most recent fault type.
08A5h	UNSOL_WRT	int	Number of Unsolicited Write messages received since last reset. Resets when count exceeds 6535, port reset, **STATUS C** or **STATUS R** command execution or UW_TIME reset; read only.
08A6h	UW_FAIL	int	Number of failed Unsolicited Write messages received since last reset. Resets when UNSOL_WRT or UW_TIME resets; read only.
08A7h	UW_TIME(ms)	int[2]	Time period since last Unsolicited Write statistics reset. Use this value to calculate message success/failure rates. Append two registers to get 32-bit time; register 08A7h is high-word, 08A8h is low-word. Resets when count exceeds 4294967296 (about 50 days) or UNSOL_WRT reset; read only.
08A9h	UW_MAXTIME(ms)	int[2]	Maximum time between received Unsolicited Write messages. Append two registers to get 32-bit time; register 08A9h is high-word, 08AAh is low-word. Resets when UNSOL_WRT or UW_TIME resets.
08Abh	BIN_STATUS	int	Binary Communications Status. Bit 0 = SER receipt enabled Bit 1 = SER transmit enabled Bit 2 = Unread SER data available Bit 3 = SER Data lost (from this port point of view) Bit 4–8 = Unused Bit 3 cleared by **STATUS C** or **STATUS R** command.

Table 6.5 Local Region (Sheet 3 of 3)

Starting Address	Data Item Label	Data Type	Notes
08ACh	BIN_MSG_LOST	int	Number of Binary Messages Dropped due to buffer overflow or invalid header. Cleared by **STATUS C** or **STATUS R** command.
08ADh	UNSOL_SER_RX	int	Number of Unsolicited Binary SER Messages Received. Cleared by **STATUS C** or **STATUS R** command.
08AEh	SER_RX_NOACK	int	Number of Unsolicited Binary SER Messages Received but not Acknowledged. Cleared by **STATUS C** or **STATUS R** command.
08AFh	UNSOL_SER_TX	int	Binary SER Messages Transmitted. Cleared by **STATUS C** or **STATUS R** command.
08B0h	SER_TX_NOACK	int	Binary SER Messages Transmitted but not Acknowledged. Cleared by **STATUS C** or **STATUS R** command.

[a] See Archive Data Regions on page 6.21 for important information about archive memory clear operation frequency.

Port Status Register

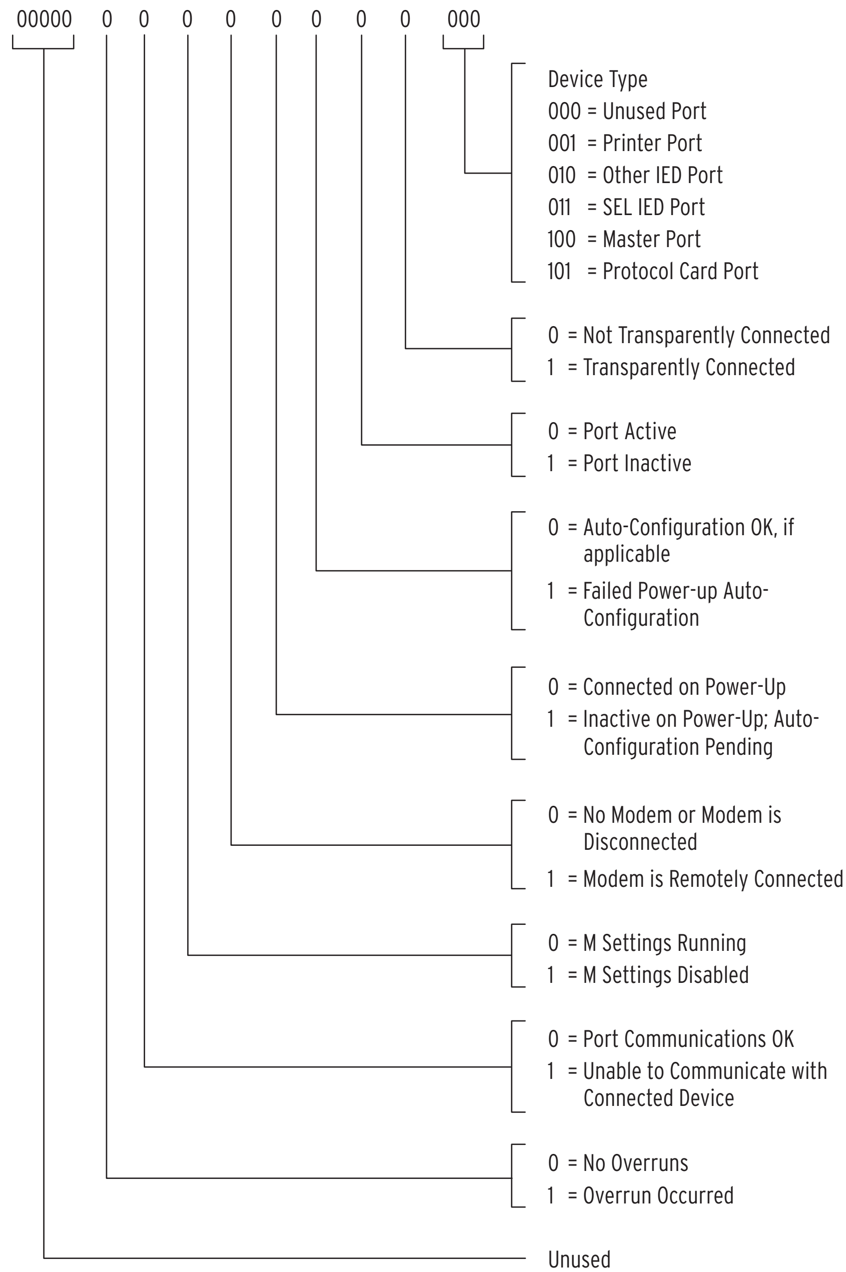


Figure 6.7 Port Status Register

The “Port Inactive” bit indicates a communications problem. Once the SEL-2032 has completed its power-up initialization, this bit sets whenever the connected device fails to respond correctly to an automatic message (**SET A**). The bit is cleared as soon as the SEL-2032 communicates successfully again with the device. The “Port Inactive” bit may be set and cleared regularly if the communications link is noisy. The “Port Inactive” bit does not apply to ports with Device Type set to Master. This bit will always be cleared (Port Active) for Master ports (including DNP3 and Modbus ports).

The “Unable to Communicate with Connected Device” bit is set only when the SEL-2032 fails on 10 consecutive attempts to communicate with the connected device. The bit is cleared as soon as the SEL-2032 communicates successfully with the device. This bit generally indicates a major communications problem, as opposed to an intermittent problem. This bit does not apply to ports with Device Type set to Master. The bit will always be cleared (Port Communications OK) for Master ports.

See the **STATUS** command description for a more complete discussion of the various port status possibilities.

Local Elements

Table 6.6 shows local elements. *Table 6.7* lists the definitions for all port-specific elements.

Table 6.6 Local Elements

Row	Local Elements							
0	CMD1	CMD2	CMD3	CMD4	CMD5	CMD6	CMD7	CMD8
1	SBO1	SBO2	SBO3	SBO4	CTS	XOFF	INAC	UMB
2	D1	D2	D3	D4	D5	D6	D7	D8
3	D9	D10	D11	D12	ARCH1	ARCH2	ARCH3	MSET
4	DLY1	DLY2	DLY3	DLY4	DLY5	DLY6	DLY7	DLY8
5	DLY9	DLY10	DLY11	DLY12	DLYA1	DLYA2	DLYA3	DLY
6	BR1	BR2	BR3	BR4	BR5	BR6	BR7	BR8
7	BR9	BR10	BR11	BR12	BR13	BR14	BR15	BR16
8	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
9	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16
10	SBR1	SBR2	SBR3	SBR4	SBR5	SBR6	SBR7	SBR8
11	SBR9	SBR10	SBR11	SBR12	SBR13	SBR14	SBR15	SBR16
12	SRB1	SRB2	SRB3	SRB4	SRB5	SRB6	SRB7	SRB8
13	SRB9	SRB10	SRB11	SRB12	SRB13	SRB14	SRB15	SRB16
14	CBR1	CBR2	CBR3	CBR4	CBR5	CBR6	CBR7	CBR8
15	CBR9	CBR10	CBR11	CBR12	CBR13	CBR14	CBR15	CBR16
16	CRB1	CRB2	CRB3	CRB4	CRB5	CRB6	CRB7	CRB8
17	CRB9	CRB10	CRB11	CRB12	CRB13	CRB14	CRB15	CRB16
18	*	*	*	*	*	*	*	NOCONN
19	*	*	*	*	*	*	*	*

Row 0. Command elements, CMD1–CMD8, are each associated with one of the eight user-defined commands. The associated CMD bit is asserted when the SEL-2032 receives the user-defined command.

Row 1. Select-Before-Operate elements, SBO1–SBO4, assert when two specific messages are sent in proper time sequence. Clear-To-Send element, CTS, is asserted when the CTS line is “up”; Transmit-OFF element, XOFF, is asserted when the SEL-2032 receives an XOFF signal from the attached device; the inactive element, INAC, is set when the port is inactive; and the Unsolicited-Message-Buffer element, UMB, asserts when a message is stored in the port BUF region.

Row 2. Message trigger elements, D1–D8, set when the associated trigger operation is pending or in progress.

Row 3. Message trigger elements, D9–D12, and Archive data region trigger elements, ARCH1 to ARCH3, set when the associated trigger operation is pending or in progress. M settings element, MSET, is asserted while the Math/Move equations for the port are executing.

Row 4. Message trigger delay elements, DLY1–DLY8, assert when the associated message trigger element, D1–D8, does not reset before the next trigger condition occurs, indicating a possible data collection delay or message error.

Row 5. Message trigger delay elements, DLY9–DLY12 and DLYA1–DLYA3, assert when the associated message trigger element, D9–D12 or ARCH1–ARCH3, does not reset before the next trigger condition occurs, indicating a possible data collection delay or message error.

Rows 6-7. Breaker bits (BR1–BR16) may be associated with issuing breaker operate commands (OPEN/CLOSE) or may be used as latches for intermediate SELOGIC control equations. These bits are set by the SBR1–SBR16 elements and cleared by the CBR1–CBR16 elements.

Rows 8-9. Remote bits (RB1–RB16) may be associated with issuing remote bit commands (CONTROL) or may be used as latches for intermediate SELOGIC control equations. These bits are set by the SRB1–SRB16 elements and cleared by the CRB1–CRB16 elements.

Rows 10-13. Set breaker (SBR1–SBR16) and set remote bit (SRB1–SRB16) set the corresponding breaker and remote bit elements, but may also be used as intermediate terms for SELOGIC control equations. These bits are controlled by logic equations (SET L) and by receipt of master port Fast Operate commands.

Rows 14-17. Clear breaker (CBR1–CBR16) and clear remote bit (CRB1–CRB16) clear the corresponding breaker and remote bit elements, but may also be used as intermediate terms for SELOGIC control equations. These bits are controlled by SELOGIC control equations (SET L) and by receipt of master port Fast Operate commands.

Rows 18-19. Asterisks indicate elements for future use. When NOCONN is set, no transparent communications are allowed to or through the port (see *Restricting Port Access with NOCONN on page 7.25*). Row 19 does not show in the **VIEW** command.

You can use the **VIEW** or **TARGET** command to show local element status. The SEL-2032 **TARGET** command response will also display the status of relay elements received from an attached SEL relay in rows 20 and up, as if they were appended to the local elements.

The **TARGET** command for Ports 17 and 18 will display the status of the CCIN and CCOUT bits in rows 20 and up, as if they were appended to the local elements.

Table 6.7 Local Element Definitions (Sheet 1 of 2)

Row	Element	Description
0	CMD1	User-defined command number 1 received flag.
	CMD2	User-defined command number 2 received flag.
	•	•
	•	•
	•	•
	CMD8	User-defined command number 8 received flag.
1	SBO1	Select-before-operate register 1 flag. Pulsed by writing AAh then 55h to register 0819h within 1.0 second of each other.
	SBO2	Select-before-operate register 2 flag. Controlled by register 081Ah.
	SBO3	Select-before-operate register 3 flag. Controlled by register 081Bh.
	SBO4	Select-before-operate register 4 flag. Controlled by register 081Ch.
	CTS	Follows the state of CTS input.
	XOFF	Set when port has been disabled by remote device using XOFF character.
	INAC	Set when port is inactive.
	UMB	Data present in unsolicited message buffer flag.
2–3	D1	Auto-message 1 trigger.
	D2	Auto-message 2 trigger.
	•	•
	•	•
	•	•
	D12	Auto-message 12 trigger.
	ARCH1	Archive 1 auto-message trigger.
	ARCH2	Archive 2 auto-message trigger.
	ARCH3	Archive 3 auto-message trigger.
	MSET	Set while Math/Move equations executing.
4–5	DLY1	Auto-message 1 trigger overrun flag.
	DLY2	Auto-message 2 trigger overrun flag.
	•	•
	•	•
	•	•
	DLY12	Auto-message 12 trigger overrun flag.
	DLYA1	Archive 1 auto-message trigger overrun flag.
	DLYA2	Archive 2 auto-message trigger overrun flag.
	DLYA3	Archive 3 trigger overrun flag.
	DLY	Logical OR of DLY1–12 and DLYA1–3.
6–7	BR1	Local latch result which may be associated with Breaker 1.
	BR2	Local latch result which may be associated with Breaker 2.
	•	•
	•	•
	•	•
	BR16	Local latch result which may be associated with Breaker 16.
8–9	RB1	Local latch result which may be associated with Remote Bit 1.
	RB2	Local latch result which may be associated with Remote Bit 2.
	•	•
	•	•
	•	•
	RB16	Local latch result which may be associated with Remote Bit 16.

Table 6.7 Local Element Definitions (Sheet 2 of 2)

Row	Element	Description
10–11	SBR1 SBR2 • • • SBR16	Intermediate result which sets element BR1. Intermediate result which sets element BR2. • • • Intermediate result which sets element BR16.
12–13	SRB1 SRB2 • • • SRB16	Intermediate result which sets element RB1. Intermediate result which sets element RB2. • • • Intermediate result which sets element RB16.
14–15	CBR1 CBR2 • • • CBR16	Intermediate result which clears element BR1. Intermediate result which clears element BR2. • • • Intermediate result which clears element BR16.
16–17	CRB1 CRB2 • • • CRB16	Intermediate result which clears element RB1. Intermediate result which clears element RB2. • • • Intermediate result which clears element RB16.

Table 6.8 lists additional elements that are appended to the local elements for Ports 17 and 18, as viewed by the **TARGET** command and accessed by SELOGIC control equations. They are in the interface memory for the card slots rather than in the local database so are not included in the **VIEW** command.

Table 6.8 Ports 17 and 18 Control Input and Output Elements (Sheet 1 of 2)

Row	Control Elements							
20	CCIN1	CCIN2	CCIN3	CCIN4	CCIN5	CCIN6	CCIN7	CCIN8
21	CCIN9	CCIN10	CCIN11	CCIN12	CCIN13	CCIN14	CCIN15	CCIN16
22	CCIN17	CCIN18	CCIN19	CCIN20	CCIN21	CCIN22	CCIN23	CCIN24
23	CCIN25	CCIN26	CCIN27	CCIN28	CCIN29	CCIN30	CCIN31	CCIN32
24	CCIN33	CCIN34	CCIN35	CCIN36	CCIN37	CCIN38	CCIN39	CCIN40
25	CCIN41	CCIN42	CCIN43	CCIN44	CCIN45	CCIN46	CCIN47	CCIN48
26	CCIN49	CCIN50	CCIN51	CCIN52	CCIN53	CCIN54	CCIN55	CCIN56
27	CCIN57	CCIN58	CCIN59	CCIN60	CCIN61	CCIN62	CCIN63	CCIN64
28	CCOUT1	CCOUT2	CCOUT3	CCOUT4	CCOUT5	CCOUT6	CCOUT7	CCOUT8
29	CCOUT9	CCOUT10	CCOUT11	CCOUT12	CCOUT13	CCOUT14	CCOUT15	CCOUT16
30	CCOUT17	CCOUT18	CCOUT19	CCOUT20	CCOUT21	CCOUT22	CCOUT23	CCOUT24
31	CCOUT25	CCOUT26	CCOUT27	CCOUT28	CCOUT29	CCOUT30	CCOUT31	CCOUT32

Table 6.8 Ports 17 and 18 Control Input and Output Elements (Sheet 2 of 2)

Row	Control Elements							
32	CCOUT33	CCOUT34	CCOUT35	CCOUT36	CCOUT37	CCOUT38	CCOUT39	CCOUT40
33	CCOUT41	CCOUT42	CCOUT43	CCOUT44	CCOUT45	CCOUT46	CCOUT47	CCOUT48
34	CCOUT49	CCOUT50	CCOUT51	CCOUT52	CCOUT53	CCOUT54	CCOUT55	CCOUT56
35	CCOUT57	CCOUT58	CCOUT59	CCOUT60	CCOUT61	CCOUT62	CCOUT63	CCOUT64

Rows 20–27. CCIN1–CCIN64 are input bits, set by the card installed in the slot.

Rows 28–35. CCOUT1–CCOUT64 are output bits, set by using SELOGIC control equations specified with the **SET O** command.

You can use the **CARD** or **TARGET** command to view the status of the CCIN and CCOUT bits.

Unsolicited Message Buffer

The Unsolicited Message Buffer (BUF) contains all unsolicited messages received from an IED. You must set AUTOBUF=Y with the **SET A** command for unsolicited messages to be stored here. Use the **CLEAR m:BUF** or **VIEW m:BUF C** commands periodically to clear the message queue so data are not overwritten. Alternatively, a \DACn/ string can clear these buffers.

At the top of the Unsolicited Message Buffer region are two registers, Start Index and End Index (see *Table 6.9*), that contain register offsets. The Start and End Indices reference the beginning address of the circular buffer (1002h) to determine the address of the start and end of data. The first offset points to the address of the beginning of unread data. The second offset points to the address just beyond the last unread data. The SEL-2032 maintains the second offset. If you reference these data by region with VIEW, CLEAR, or \DAC string, the SEL-2032 maintains the first index for you. If you are directly reading the data (using VIEW by address, or user-defined **READ** command) you must maintain the first offset as data are read.

The remainder of the region acts as a circular character buffer beginning at address 1002h. Each register in the circular buffer contains one character. When the end of the buffer is reached, it wraps around to the beginning of the circular buffer (address 1002h) and continues. If the buffer gets full (end index catches up to start index), the oldest data will be overwritten.

When the SEL-2032 is connected to an SEL IED, the SEL-2032 removes all passwords that are echoed from the SEL IED that would otherwise go into the Unsolicited Message Buffer. This typically occurs in response to issuing the STARTUP string to the SEL IED. This is to prevent unauthorized users from gaining access to the SEL IED passwords by examining the unsolicited message buffer.

Table 6.9 BUF (Unsolicited Message Queue) Organization

Starting Address	Data Item Label	Data Type	Notes
1000h	START_OFFSET	int	Offset from 1002h to first active character in buffer (0–4093).
1001h	END_OFFSET	int	Offset from 1002h to next available character location in buffer (0–4093); read-only.
1002h	BUFFER	char[4094]	Circular buffer of characters; Start and End indices indicate where nonerased information exists; read-only.

Data Regions

The Data regions D1–D8 hold data collected by the SEL-2032. The first four registers of each Data region hold the date and time that the data were collected. The remainder of the Data region is for the collected data. Using the **SET A** command, you specify a parsing method for data. There are parsing methods defined specifically for SEL relays for the following types of data:

- Demand meter
- Meter
- History
- Status
- Elements
- Breaker
- Event
- SER

The following parsing options are valid for any IED data:

- Extract and store integers.
- Extract and store floating points.
- Store response as character string.
- Store response as integer string.
- Store response as integer string while decoding XON/XOFF encodings.
- Extract and store response using FLEX parsing.
- Ignore response.

The format of the data stored in a Data region depends on the parsing method and the type of device connected. Once you have set a Data region to collect a specific type of data, use the **MAP** command to determine how the data are organized and formatted. Refer to *Data Parsing Options on page 7.14* for more detailed information about parsing options.

STATE Data Region

The SEL-2032 creates the STATE data region when you connect an SEL device to the SEL-2032 and enable Fast SER with the Automatic Messaging setting, REC_SER (only available if the connected device supports Fast SER). The STATE region includes both a present value and time-stamped event buffer. You can use the STATE region to send relay SER time-stamped data to a DNP3 master connected to the SEL-2032. The STATE region supports both directly connected SEL devices and lower-tier SEL-2032 Communications Processors.

The SEL-2032 receives SER data from a connected SEL relay and saves the data directly as database elements of the STATE region. The SEL-2032 does not perform logic operations on SER data in the STATE region. In order to perform logic operations on SER data from a connected SEL relay, you must execute them in the originating relay prior to assigning the data to the SER settings. For example, you might be monitoring a breaker 52a auxiliary stack contact using an input (IN101) wired to an SEL-351 relay on Port 3. The relay only monitors the 52a element, but you want to bring back a normally closed contact (52b) to SCADA. You can, by using the SELOGIC settings in the relay, do this very easily as follows:

```
SV3 = !IN101
```

Then you would map the SV3 element in your SER setting to the relay. Finally you would monitor SV3 from the STATE region in the SEL-2032:

```
0:0;B = 3:STATE:SV3
```

You will then be monitoring the inverted state of the 52a at the DNP master.

See specific protocol sections for more information on using the STATE region area.

The connected SEL device collects and transmits data for the STATE region using the SER function. This means that available data and data organization within the SEL-2032 are affected by the SER settings in the device. If you change SER settings in the connected device (for example, an SEL relay), you must also modify references to the STATE region within the SEL-2032 to reflect the changes.

Archive Data Regions

The Archive data regions (A1–A3) are very similar to the Data regions. However, in the Archive data regions, data are stored in nonvolatile Flash memory. Each data region acts as a queue, buffering multiple responses. Each record can be as large as the data region. The only limit on the number of records you can store in an Archive data region is the amount of available nonvolatile Flash memory.

NOTE: If you completely clear an Archive data region that contains a large number of records (thousands of records), it may take a few minutes for the clearing to complete. During this time, most SEL-2032 automatic data collection will be suspended.

In the Local region of the database, counters are maintained for each Archive data region indicating the number of records currently queued up. You can view the archived data records with the **VIEW** command, or you can read the archived data records with an auto-message using the \F.../ formatted read message string. You can remove archived data records using the **CLEAR** or **VIEW C** commands, you can include the ;C or ;CA modifiers in a \F.../ string, or you can use the Clear Archive Register in the Local region.

NOTE: Frequent archive record clearing may exceed EEPROM capabilities. Refer to the following paragraphs.

Carefully consider the method used for archive record clearing to ensure the SEL-2032 archive memory EEPROM does not experience premature failure. Every time an archive record(s) is cleared, a register corresponding to that port and region is updated. The archive memory EEPROM is guaranteed to support 100000 writes; therefore, select a clearing method that will not clear any specific region more than 100000 times.

The best way to minimize clearing operations is to use the **CLEAR A** command or the \F...; CA/ string to clear archive records on a periodic basis. These methods only cause one EEPROM update, while clearing a potentially large number of records. Use *Appendix D: System Planning Sheet* to determine memory usage and necessary clearing frequency.

If the archive memory becomes full, the SEL-2032 will not store any new records until enough archive memory is freed up. Use the **MEMORY** command to check how full the memory is.

User Region

You can use the User region (USER) for whatever purpose you desire. When using DNP3 communications you read the data from this region (see *Section 9: Protocols* for more information). Data can be put in this region by writing from a master device using either the **STORE** command or the user-defined data **WRITE** command. Data can also be stored in this region automatically using the **SET M** command. Any port may then use these data in constructing messages. Use **SET A** to enable this region. **SET M** will also enable this region if it was not previously set using **SET A**.

The User region includes 10 registers of nonvolatile storage. If the SEL-2032 loses power, these registers are reloaded automatically with the stored value when the SEL-2032 regains power. Values in the nonvolatile storage are updated from the volatile version (visible in the User region and updated every 0.5 seconds) once a day at 23:30 (11:30 pm) and any time you change settings on the port where nonvolatile registers are being used. You can manually initialize nonvolatile registers using the **STORE** command. See *Math/Data Movement (SET M) Settings on page 7.31* for more information on configuring and using nonvolatile storage.

Access Methods

You can access data contained within the database by function, region, register, or bit.

Access by Function

You can access much of the data within the database based on its function; you do not need to know where it is in the database to reference it. The following commands access database information by function:

CONTROL Affects Global elements in Global region.

DATE Accesses date information in Global region.

ID Reads FID string from Global or Local regions.

STATUS Reads various Global and Local region items.

TARGET Reads Global, Local, and Relay elements contained in Global, Local, and D*x* regions.

TIME Accesses time within Global region.

Access by Region

Access data by region when working with groups of associated data. To access by region, specify a port number and a region label. The region label may be the generic label or the data type, as given by the **MAP** command.

Table 6.10 Data Access by Region Labels (Sheet 1 of 2)

Generic Labels	Example Data Type Labels
GLOBAL	METER
LOCAL	DEMAND
BUF	TARGET

Table 6.10 Data Access by Region Labels (Sheet 2 of 2)

Generic Labels	Example Data Type Labels
D1–D8	STATUS
A1–A3	FLOAT
USER	CHAR

The **CLEAR**, **MAP**, and **VIEW** commands use region access methods. The special message string \F.../ also uses region access. Some examples of accessing data by region are:

VIEW 2:METER Displays meter data from the Port 2 database.

MESG1="\F8:DEMAND/" Defines the contents of MESG1 as formatted demand data from the Port 8 database.

CLEAR 7:A1 Clear the oldest record from region A1 of the Port 7 database.

Access by Register

When you view a port database by register you are viewing a contiguous space of 64k registers. You reference a register in one of three ways:

Port Number:Address

Port Number:Region Label:Address Offset

Port Number:Region Label:Data Item Label

The **STORE** and **VIEW** commands support address accesses, as does the \R.../ special message string.

Consider accessing the year within the Global region. It can be referenced any of the following ways (the port number is arbitrary when you are accessing the Global region):

1:002Ah

1:GLOBAL:2Ah

1:GLOBAL:_YEAR

Some other examples are:

VIEW 5:1234h An SEL-2032 command typed from the command line that displays the contents of Port 5, hexadecimal address 1234.

MESG1="\Rb;5:1234h/" The same register and port number as above in a message string that defines the contents of Message 1 as register data found in that address in binary format.

MESG1="\Rf;5:METER:IA/" Defines the contents of Message 1 as the IA data item of the meter data found in the Port 5 database in floating-point format.

STORE 8:USER:0 "Data" Stores the string “Data” starting at first address of User region on Port 8.

Often, you will wish to access multiple adjacent registers at once. The **STORE** command allows this by letting you store a set of data, starting at the specified address. Add the parameters NR and a count after the address in a **VIEW** command to display multiple registers. Add a semicolon and a count after the address within a \R.../ special message string to read multiple registers. The following examples illustrate multiple register access:

STORE 8:USER:0 5,7,9,11 Store integers 5, 7, 9, and 11 in first four registers of the User region.

VIEW 5:LOCAL:ELEMENTS NR 6 View 6 registers, starting with first element register in Port 5’s Local region.

MESG2= "\Rf;5:METER:IA;6/" Read 6 registers (3 floats), starting with the IA register in the meter region of Port 5.

Access by Bit

Individual bits within the database can also be accessed. Five-bit access methods are available:

Bit Label

Port Number:Bit Label

Port Number:Region Label:Bit Label

Port Number:Address:Bit Number

Port Number:Region Label:Address Offset:Bit Number

The first two access methods are shorthand notations for the third method. When only a bit label is specified, the SEL-2032 searches the Global, then Local, and then TARGET regions for the bit. When only a port number and bit label are specified, the SEL-2032 searches the Local then TARGET regions on the specified port for the bit.

The last two access methods use bit numbers. Bit numbers must be in the range 0 to 15 where 0 is the least-significant bit and 15 is the most-significant bit.

Bit access is primarily used within SELOGIC control equations but can also be used within **SET M** equations and by the **VIEW** and **TOGGLE** commands. Bits within Archive data regions may not be used in SELOGIC control equations nor by the **TOGGLE** command. They can still be examined using the **VIEW** command. You can view the bit labels using the **TAR**, **MAP region BL**, and **VIEW region BL** commands.

Consider accessing the local element CMD4 on Port 5 from the Port 5 settings. This bit can be referenced the following ways:

CMD4 Bit Label

5:CMD4 Port Number : Bit Label

5:LOCAL:CMD4 Port Number : Region Label : Bit Label

5:0807h:4 Port Number : Address : Bit Number

5:LOCAL:7:4 Port Number : Region Label : Address Offset : Bit Number

Some other examples are:

ISSUE1=IN1 References Global IN1 element if the I/O board is installed; otherwise references IN1 bit in TARGET region, if it exists.

VIEW 1:27L or VIEW 1:TARGET:27L View status of 27L bit on Port 1 within the TARGET region (27L does not exist in Local region).

OUT2=5:TARGET:LOP Causes OUT2 to follow the state of the LOP element in Port 5's TARGET region.

OUT3=7:1234h:7 Causes OUT3 to follow the state of bit 7 (high bit of low byte) of register 1234h within the Port 7 database.

X=9:D2:13h:Ah Causes X to follow the state of bit 10 within the 19th register of the Port 9 D2 region.

Within a SELOGIC control equation setting, if you reference a bit by an address that does not exist, the SEL-2032 responds with a warning message and will not accept the setting.

Section 7
Settings

Introduction

This section provides detailed information about the commands used to configure and control the SEL-2032 Communications Processor and explains how you should respond to the SEL-2032 settings prompts. You can also use this section as a reference to SEL-2032 settings when using the SEL-5020 Settings Assistant software. At the end of this section is a set of tables that list all settings in the SEL-2032.

SET Commands

Use the **SET** command variations to configure the SEL-2032. These commands correspond to the different classes of settings shown in *Figure 7.1*. *Figure 7.1* also shows how the **SET** commands relate to specific ports.

The SEL-2032 checks each entry to ensure that it is a valid choice. If it is not, an "Out of Range" message is generated, and the SEL-2032 prompts for the same setting again.

When you finish a setting, it is not necessary to scroll through the remaining settings. Type **Y <Enter>** to approve the new settings or **N <Enter>** to abort setting changes. If you type **Y <Enter>** and have a setting violation, an error message is displayed, and the settings prompt moves to the first setting that affects the failure. If settings are acceptable, the SEL-2032 saves them. While the active settings are updated, the SEL-2032 port being modified is disabled and the SALARM bit asserts for one second. In an SEL-2032, SALARM is assigned to ALARM by default, so the alarm contact will close for one second unless the ALARM setting has been modified.

When the settings change on a port, that port is reset. If you change the settings on the current port, the settings become effective after being accepted. If you change the baud rate, you will have to change the baud rate on your terminal to match in order to resume communicating with the SEL-2032. You may not change the settings on a port that is currently communicating transparently with another port. Also, only one setting session is permitted at one time; you will receive a message that the **SET** command is not available if someone else is using one of the **SET** commands at the time you send a **SET** command.

Use the **COPY** or **SWAP** commands to copy and move settings between ports. Always use the **SHOWSET** command on ports you copied or swapped settings on to verify that all port references and messages are correct.

SET Function	Port 1	. . .	Port 16	Port 17	Port 18	Port F
Port Configuration	SET P 1	. . .	SET P 16	SET P 17	SET P 18	SET P F
Automatic Messages	SET A 1	. . .	SET A 16	SET A 17	SET A 18	------
User-Defined Commands	SET U 1[a]	. . .	SET U 16[a]	SET U 17[a]	SET U 18[a]	------
Data Movement Equations	SET M 1	. . .	SET M 16	SET M 17	SET M 18	------
Output Logic for Protocol Cards	SET L 1	. . .	SET L 16	SET L 17	SET L 18	------
Global Settings	------	. . .	------	SET O 17	SET O 18	------

Global Settings	SET G[b]
SER Settings	SET R[b]
Calibration Settings	SET C[b]

[a] not printer ports
[b] not port-specific

Figure 7.1 SET Commands as They Apply to SEL-2032 Ports

Port Configuration (SET P) and Communication Settings

Use the **SET P** command to:

- Configure each port you connect to a new device.
- Reconfigure a port you connect to a different device.
- Reconfigure a port connected to a device that has upgraded firmware.

Port Configuration Settings

When you issue the **SET P** command, the SEL-2032 prompts you for configuration and communication parameters. A description of each prompt and a discussion about the appropriate responses to each prompt follows. When you use the **SET P** command for Port 17 or 18, the settings are provided by the plug-in protocol card. For information on DNP3 settings for an Ethernet connection via an SEL-2701, see *Distributed Network Protocol 3.0 (DNP3) LAN/WAN on page 9.43*. Otherwise, see the instruction manual for the plugin protocol card to see what settings are available.

Table 7.1 includes detailed information about the SET P settings.

Table 7.1 Port Configuration (SET P) Settings Information (Sheet 1 of 5)

Setting	Comment	Description
DEVICE	Device Type (Unused, SEL IED, Other IED, Printer, Master).	You select the device type attached to this port: **U**nused if no device is connected. **S**EL IED if an SEL device is connected. **O**ther IED if another vendor's IED is connected. **P**rinter if a serial printer is connected. **M**aster if an RTU, PC, PLC, NIM or ASCII terminal is connected.
CONFIG	Auto-configure port (Y/N).	If you say yes, the SEL-2032 determines relay type, model number, metering capability, port ID, baud rate, passwords, relay elements, and other information necessary for the SEL-2032 to communicate automatically with SEL relays. The SEL-2032 reports the results of the auto-configuration once it successfully completes. This process may take two minutes or longer.
AUTO_BAUD	Attempt to detect port baud rate (Y/N).	The SEL-2032 depends on the IED returning a <CR> or <LF> character in response to a <CR><LF> for baud rate determination to work.
PROTOCOL	Communications Type (SEL/LMD/Modbus/DNP for Master, or ASCII/BINARY for Other IED).	This setting identifies special port communication parameters. For Other IEDs you may choose between ASCII and BINARY; selecting ASCII allows the normal ASCII and binary communication; selecting BINARY automatically disables XON/XOFF handshaking. If Port 16 DEVICE is set to master, the choices are SEL, LMD, Modbus®, and DNP. If Port 12 or 14 DEVICE is master, then the choices are SEL, LMD, and Modbus. For any other port with DEVICE set to master, the choices are SEL and LMD. Selecting SEL allows the normal ASCII and binary communications, selecting LMD adds the SEL LMD Protocol, selecting Modbus disables normal communications and enables Modbus communications on the selected port, and selecting DNP disables normal communications and enables DNP3 communications on the selected port. If you choose LMD, you must select an address and prefix character and set the settle time. If you choose Modbus, you must select the address for each port with Modbus data. If you choose DNP, there are a number of additional settings to configure the DNP3 operation. See *Section 9: Protocols* for reference information on LMD, Modbus, and DNP3 protocols.
ADDRESS	First LMD Port Address (1–81).	You supply a port address only if you selected LMD as the PROTOCOL. The LMD address is the first of 17 used by the SEL-2032; the defined address is for SEL-2032 communications and the next 16 are for transparent communications to the respective ports. See *Section 9: Protocols* for an explanation of LMD Distributed Port Switch Protocol.
PREFIX	LMD Address Prefix Character (@#$%&).	You supply LMD prefix character only if LMD was selected as the PROTOCOL. The prefix setting is the character the SEL-2032 watches for when using LMD protocol. See *Section 9: Protocols* for an explanation of LMD Distributed Port Switch Protocol.
SETTLE	LMD Port Settle Time (0–30 seconds).	You supply an LMD port settle time only if LMD was selected as the PROTOCOL. See *Section 9: Protocols* for an explanation of LMD Distributed Port Switch Protocol.
MAP_TYPE	Modbus Map Type (F=Float, I=Integer).	Selection for Modbus map style. See *Section 9: Protocols* for an explanation of the two map styles.
START_ID	Starting Code for ID List (0–255).	Used to offset Modbus device ID list. See *Section 9: Protocols* for reference information on Modbus.
SETTLE1	Transmission delay from RTS assertion (0–30000 ms).	Delay between RTS assertion and start of transmission for Modbus and DNP3 protocols. See *Section 9: Protocols* for reference information on Modbus and DNP3 protocols.

Table 7.1 Port Configuration (SET P) Settings Information (Sheet 2 of 5)

Setting	Comment	Description
SETTLE2	Posttransmit RTS deassertion delay (0–30000 ms).	Delay between end of transmission and RTS deassertion for Modbus and DNP3 protocols. See *Section 9: Protocols* for reference information on Modbus and DNP3 protocols.
BUSY_DIS	Disable transmission of Modbus Busy (Y/N)	Disable Modbus ports from sending a busy response. This may be used with masters that do not tolerate a busy response from a slave device.
ADDRESS1	Address of Port 1 (1–247).	Modbus device address 1–247, or OFF if no Modbus access desired. Similarly for ADDRESS2–16. See *Section 9: Protocols* for reference information on Modbus.
ADDRESS	DNP Address (0–65534 or 0000h–FFFEh).	Address of the SEL-2032. It must be unique from all other DNP3 addresses on the connection. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
CLASS	Class for event data (0 for no event data, 1, 2, 3).	Enter the DNP3 class, 1–3, to reference SEL-2032 event data under. Enter 0 if you do not want any event data. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
16BIT	Use 16- or 32-bit default variations for analog inputs (16/32).	DNP3 analog input objects can use default variations 16 or 32-bits in size. Set this to 16 or 32-bit, based on which default you prefer. Generally 32-bit is preferable, because you get a better range, but if your master does not support 32-bit analog inputs, you must use 16-bit. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
SO_TIMEOUT	Select/Operate time-out interval, seconds (0.0–30).	Enter the maximum allowable time between DNP3 function codes for Select and Operate. If an Operate command follows the Select command by more than this time-out, the operation will not occur. Set based on worst-case timing of your master. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
DL_CONFIRM	Number of data-link retries (0 for no confirmation, 1–15).	Set to 0 to disable DNP3 data-link confirmation. Otherwise, set to the number of retries you want the DNP3 data-link to use. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
DL_TIMEOUT	Data Link Time-out (0–5000 milliseconds).	Set to the worst-case DNP3 data-link acknowledge time of your master. When using DNP3 data-link confirmation, this is the time the SEL-2032 waits before assuming there is no confirmation and resending the message. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
MIN_DELAY	Minimum Delay from DCD to transmission (0–1000 msec).	This is the minimum delay the SEL-2032 waits from DCD going away or from the last character being received before initiating data transmission. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
MAX_DELAY	Maximum Delay from DCD to transmission (0–1000 msec).	This is the maximum delay the SEL-2032 waits from DCD going away or from the last character being received before initiating data transmission, if there is a transmission pending. Set this to something bigger than MIN_DELAY to cause some randomness in the time at which it attempts to transmit again. In a system with unsolicited messaging, this helps reduce the likelihood of repeated collisions. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
REPORT_ON	Percent of Full-Scale Change to Report on (0–100%).	This setting determines at what point counter and analog input events are declared. Set this to the percent of the full-scale that you want events reported on. With the default size set to 16-bit, full scale is +/-32767. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
UNSOL_REP	Allow Unsolicited Reporting (Y/N).	Set to Yes to enable unsolicited DNP3 event reporting or No to disable such reporting. See *Section 9: Protocols* for an explanation of the DNP3 protocol.

Table 7.1 Port Configuration (SET P) Settings Information (Sheet 3 of 5)

Setting	Comment	Description
UNSOL_POW	Enable unsolicited messages on power-up (Y/N).	Set based on whether or not you want DNP3 unsolicited reporting enabled on power-up. If your master supports the unsolicited message enable function code, set this to No and let your master enable it to reduce bus contention on power-up. Otherwise, set it to Yes. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
REP_ADDR	Address of master to Report to (0–65534 or 0000h–FFFEh).	Set this to the address of the master on your DNP3 network. This is the address the SEL-2032 sends unsolicited responses to. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
NUM_EVENT	Number of events to transmit on (1–200).	Set this to the number of events you want to have accumulate before the SEL-2032 sends the data in a DNP3 unsolicited response. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
AGE_TX	Age of oldest event to force transmit on (1.0–60.0 sec).	Set this to the maximum age you want your event data to get to before sending it in a DNP3 unsolicited response, even if the minimum number of events have not yet accumulated. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
CONFIRM_TO	Time-out for Acknowledge of Event Data (50–50000 msec)	Set this to the maximum time it should take your master to issue a DNP3 application layer to confirm an unsolicited or event data response. When sending DNP3 unsolicited responses or event data, this is the delay time the SEL-2032 waits before considering the data transmission unsuccessful. See *Section 9: Protocols* for an explanation of the DNP3 protocol.
DNP_PAIR	Enable use of DNP Trip/Close pairs (Y/N).	Use this setting to force all control points bits to be available as a single DNP3 index to allow “TRIP/CLOSE” operations on a single point.
CLSO_VIEW	Make control points visible in Class 0 poll (Y/N).	Make all enabled CMD, SBO, BR and RB control points available in a class 0 poll.
DNP_CMDNUM	Number of CMD bits available per port (0–8).	Number of CMD bits available to DNP3 for each port.
DNP_SBONUM	Number of Set Before Operate bits available per port (0–4).	Number of SBO bits available to DNP3 for each port.
DNP_BRNUM	Number of breaker bits available per port (0–16).	Number of breaker bits available to DNP3 for each port.
DNP_RBNUM	Number of remote bit pairs available per port (0–8).	Number of remote bit pairs available to DNP3 for each port.
FAST_OP	Enable Fast Operate commands on this port (Y/N).	Use this setting to enable (Y) or disable (N) fast operate support on this master port. Fast Operate commands can be used to rapidly change the various set and clear logic bits. See *Section 9: Protocols* for more information on Fast Operate commands.
PORTID	Port Identification String.	Provides a convenient means to label or identify the connected device. Auto-configuration automatically sets the Port ID to the relay ID on SEL IED ports. Used by the **WHO** command to identify the port. Maximum 40 characters.
MODEM	Modem Control (Y/N).	You set to Y (Yes) if using an external dial-up modem. This setting is only available for master and other IED ports.

Table 7.1 Port Configuration (SET P) Settings Information (Sheet 4 of 5)

Setting	Comment	Description
MSTR	Modem Startup String.	If you use a modem, you must enter a modem startup string to initialize the modem. The default string sets the modem to answer on four rings. You may set this number to match the needs of your modem and application, but, to match SEL-2032 expectations, there are a few modem settings that should not be modified: The escape character must be “+” The modem must be in verbal mode The echo must be disabled The X0 code set should be selected The escape code guard time should be one second See your modem instruction manual for details on your modem.
CD_CTS	Modem Carrier Detect connected to CTS input (Y/N).	If you are using an external modem which has its Data Carrier Detect (DCD) output connected to the SEL-2032 CTS input (such as with SEL-C222 cable), set this to Y. Otherwise, set it to N.
DCD_FLOW	Use DCD control line for flow control (Y/N).	If you are using an external modem on Ports 1 or 9 of the SEL-2032 and connect the Data Carrier Detect (DCD) output of the modem to the DCD input (pin 1) of the SEL-2032, set this to Y. Otherwise, set it to N.
BAUD	Baud Rate (300; 600; 1200; 2400; 4800; 9600; 19200; 38400).	You enter the baud rate at which this port communicates. Port F limits are 300–9600 bps. Only ports that are designated as masters may use 38400 baud. Automatically set if auto-configured.
DATABIT	Number data bits (7, 8).	You enter the number of data bits this port requires for communication. Port F is fixed at 8 data bits with no parity or 7 bits with parity. *Figure 7.2* illustrates how this setting influences the EIA-232 character format.
STOPBIT	Stop bits (1, 2).	You enter the stop bits this port requires for communication. Port F is fixed at 1 stop bit. *Figure 7.2* illustrates how this setting influences the EIA-232 character format.
PARITY	Parity (N, O, E, 1, 0).	You enter the parity this port uses in communicating. Port F is limited to parity options N (No), O (Odd), and E (Even). *Figure 7.2* illustrates how this setting influences the EIA-232 character format.
RTS_CTS	Enable RTS/CTS handshaking (Y/N).	You set to Y (Yes) to enable RTS/CTS handshaking. If LMD Protocol, Modbus, or DNP3 is used, RTS/CTS control is not available. Instead, RTS is driven to control any external transceiver. For a definition of RTS/CTS, see *Data Flow Control on page 7.10*. With Modem set to Y (Yes) and CD_CTS set to Y (Yes), RTS_CTS control is not available.
SENDTIME	Send Date/Time synchronization to Protocol Card (Y/N).	If the installed protocol card supports host-initiated time synchronization, the Port settings include a SENDTIME setting. This setting allows you to enable/disable host-initiated time synchronization of the connected protocol card. The only values accepted for this setting are “Y” and “N.” If the connected protocol card does not support the receipt of time synchronization commands, then the SENDTIME setting is hidden for the port.
XON_XOFF	Enable XON/XOFF flow control (Y/N).	You set to Y (Yes) to enable XON/XOFF flow control. If PROTOCOL is set to binary, XON/XOFF flow control is forced to N (No). For a definition of XON/XOFF, see *Data Flow Control on page 7.10*.

Table 7.1 Port Configuration (SET P) Settings Information (Sheet 5 of 5)

Setting	Comment	Description
TIMEOUT	Port Time-out in minutes (0–120).	The time-out setting is used for two different functions. After a set amount of idle time expires with the port in transparent mode, transparent mode is automatically terminated. On Master ports, if this time expires with the port idling, any in-process command is terminated and the access level is reduced to Level 0. The time-out action also disconnects LMD communications and hangs up the modem if it is connected. A value of 0 disables time-out. **Note:** Use a non-zero time-out value for modem ports. If the modem connection is unintentionally interrupted, you can call and successfully reconnect TIMEOUT minutes later.
ECHO	Echo received characters (Y/N).	Master Port only. The echo option allows you to decide whether or not you wish the SEL-2032 to provide character echo to a master device (only printable characters are echoed). ECHO is always Y (Yes) for Port F.
AUTO_HELP	Automatic help messages enabled (Y/N).	Default setting is AUTO_HELP=Y. You can disable Auto-Help on a port by setting AUTO_HELP=N. Auto-Help provides correct commands and command syntax messages when you enter an incorrect command or command syntax. If you disable Auto-Help on a Master port, you can still request help with the **HELP** command.
TERTIME1	First delay time (0–600 seconds).	You enter a time that a port must be idle before checking for the termination string. For a description of transparent communications, see *Transparent Communications on page 7.8*.
TERSTRING	**Prompt**. Termination string.	You enter a string that terminates transparent communications. The default is \004, the code for **<Ctrl+D>**. For a description of transparent communications, see *Transparent Communications*.
TERTIME2	Second delay time (0–600 seconds).	You enter a time the port must be idle, after receiving the termination string, before terminating transparent communications. For a description of transparent communications, see *Transparent Communications*.

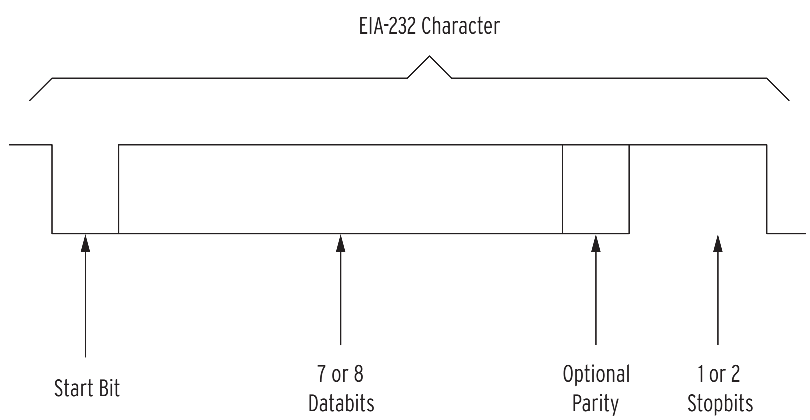


Figure 7.2 EIA-232 Character Format

Auto-Configuration

Auto-configuration, or automatic configuration, is the process of collecting information from the connected SEL device that describes available communications capabilities. This information includes the firmware ID, device type, and available remote bits, breaker bits, and “20” messages. You can use the **AUTO** command at any time to display a summary of collected information.

When you connect an SEL device to the SEL-2032, use 9600 or 19200 bps when performing the auto-configuration. If your application requires communications at lower data rates, connect the devices before installation and perform the auto-configuration at 9600 bps. After auto-configuration is complete, install the SEL-2032 and devices and set to a lower data rate.

If auto-configuration fails, it may indicate that the connected device is not recognized, that there is a communication problem between the devices, or that the connected device was slow to respond. Check for any obvious problems with the connection, then reattempt auto-configuration. If auto-configuration still fails, attempt to gain transparent communications with the device using PORT *n*. If this does not succeed, there is a communication problem. If you can connect transparently, but auto-configuration still fails, there probably is an incompatibility between the connected device and the SEL-2032. If this happens, contact the factory for further assistance.

When auto-configuration is complete, the SEL-2032 displays a summary of the collected information. It is important to examine this summary and verify that it is as expected. Communications problems could cause the auto-configuration to be incomplete without causing an auto-configuration error.

On power up, the SEL-2032 uses the firmware ID (FID) collected for each port to verify that the connected device has not been replaced with a different device. If the device has changed (or had newer firmware installed), the SEL-2032 flags the port as “CONFIG FAIL” status and stops communicating with the device. You can prevent unexpected communications loss on power up by following the procedure in *Relay Firmware Upgrades on page 10.6*.

Transparent Communications

Transparent communications allow a master device to communicate directly with an IED or printer through the SEL-2032. You enter the transparent communications mode using the **PORT** command from the SEL-2032 command set or using a special user-defined command string you set with the TRANS setting (see **SET U** subsection in this section).

Broadcast communications are similar to transparent communications, except that a master port communicates with multiple IEDs simultaneously. Broadcast communications can only be entered using the **BROADCAST** command.

When you connect to an SEL IED, the SEL-2032 automatically issues a **QUIT** command to the SEL IED before completing the connection. This way, initial access to the SEL IED will be at Level 0, requiring the user to know the relay password(s) in order to access it. When the transparent connection is terminated, the SEL-2032 reissues the STARTUP string to restore the SEL IED to the necessary access level for data collection and control.

While you are transparently communicating through the SEL-2032, Fast Meter and Fast Message binary data continue to be collected and Fast Operate control operations continue to be sent. If you attempt a Fast Meter or Fast Operate request via the transparent connection, your request and the automatic request may collide, leading to neither taking place. If you plan to use Fast Meter or Fast Operate commands while transparently connected, you should disable any automatic Fast Meter collection and Fast Operate control to avoid these collisions.

The SEL-2032 requires a three-step procedure to terminate transparent communications. This three-step procedure helps ensure that transparent mode is not accidentally terminated by normal data communications. The three-step process includes an initial channel idle time (set with TERTIME1), a termination character sequence (set with TERSTRING), and a second channel idle time (set with TERTIME2). All of these items are user definable and can be set such that they are not used when less security is required. The SEL-2032 default termination sequence has the first time delay set to one second, the termination character set to <EOT> (end of transmission character, ASCII character 4, **<Ctrl+D>** on most keyboards), and the second time delay set to zero.

Direct Transparent Mode

The SEL-2032 normally uses data buffering when transferring data through transparently connected ports. Some non-SEL IED protocols are intolerant of this data buffering since the buffering introduces random inter-character time delays into the data stream. The SEL-2032 includes a Direct Transparent mode that eliminates these inter-character delays while maintaining the buffering effectiveness. The Direct Transparent mode inter-character delay is typically less than one millisecond and never exceeds two milliseconds. The Direct Transparent mode is available on any rear-panel Master port, however is not available on the front Master port.

To select the Direct Transparent mode, add the D parameter to the **PORT** command (**PORT *n* D**, where *n* selects the port number). The SEL-2032 passes characters through rapidly, without significant buffering delays. Therefore, no handshaking is required if the Master and Slave port baud rates match. Hardware handshaking may be required if the Master and Slave port baud rates do not match. Software handshaking (XON/XOFF) is not supported by the SEL-2032 in Direct Transparent mode, regardless of the XON_XOFF port setting. However, XON/XOFF characters pass through the transparent port connection, allowing the connected devices to use software handshaking independent of the SEL-2032.

The Direct Transparent mode (D parameter) typically should not be used when transparently connecting to SEL devices. SEL interleaved binary messages (binary 20METER, 20TARGET, etc.) are not supported during Direct Transparent mode connections.

Virtual Terminal Communications

The SEL-2032 supports virtual terminal (VT) communications when a VT-enabled card is installed in Port 17 or Port 18. VT support allows a user to communicate using ASCII commands through a network, similar to directly communicating via an ASCII terminal.

The SEL-2032 can function as a VT server. For example, with an SEL-2701 Ethernet Processor installed in an SEL-2032, a user located at a PC connected to the Ethernet network can communicate with the SEL-2032. The virtual terminal mechanism for Ethernet is Telnet. At the PC, using Telnet client software, the user specifies the information to establish a connection with the SEL-2032. At this point, the keyboard and Telnet window on the PC emulate a direct ASCII terminal link to the SEL-2032.

The SEL-2032 can also function as a VT client. This is a special case of the transparent communications, initiated by a **PORT** command from a terminal connected to an SEL-2032 master port. The user specifies a network port with VT capability and a network destination address. For example, with a laptop PC connected to the front port of an SEL-2032, a user can establish a Telnet connection through an SEL-2701 and Ethernet to a relay located in another station. For example, use the command **PORT 17 10.200.0.53** to connect to the device with IP address 10.200.0.53.

The VT communications also support automated data collection functionality. The **DCF** command allows automated data collection on ports 17 and 18 (see *DCF on page 8.7* for details). Use the user-defined commands (CMD1–CMD8) and message trigger (D1–D12) to collect IED data as you would with serial ports. See the **SET A** and **SET U** commands in *Table 8.4*.

Data Flow Control

All SEL devices, including the SEL-2032, support XON/XOFF software data flow control. The SEL-2032 also supports RTS/CTS hardware data flow control. If the device connected to an SEL-2032 port has XON/XOFF software data flow control capability, you should enable this flow control method on both the SEL-2032 and the connected device. You should use RTS/CTS hardware data flow control only if the connected device has RTS/CTS capability and does not have XON/XOFF capability. In either case, both the SEL-2032 and the connected device must have the same data flow control method enabled.

You can enable XON/XOFF data flow control on an SEL-2032 port with the **SET P** command by setting XON_XOFF = Y. With XON/XOFF data flow control enabled, the SEL-2032 monitors the volume of data in its received data buffer on that port and transmits an XON (hexadecimal code 11) character when that port's buffer drops below one-quarter (25 percent) full. The SEL-2032 transmits an XOFF (hexadecimal code 13) character when that port's buffer is over three-fourths (75 percent) full. A device connected to the SEL-2032 port with XON/XOFF software data flow control enabled should terminate message transmission at the end of the message in progress when an XOFF character is received from the SEL-2032 and should resume transmission when an XON character is received.

Likewise, you can use XON/XOFF to control the SEL-2032 message and data transmission. When the SEL-2032 receives an XOFF character when it is transmitting a message, the SEL-2032 pauses transmission until it receives an XON character. If the SEL-2032 is not sending a message or data when it receives XOFF, the SEL-2032 does not send any new transmission until it receives an XON character from the other device.

Set RTS_CTS = N for any SEL-2032 to SEL relay connection. If RTS_CTS = N, the SEL-2032 RTS output will always be asserted, and the CTS input status will have no effect on communication.

Consult the instruction manual or contact the device vendor to determine the proper flow control technique for each non-SEL device. If you select RTS/CTS hardware data flow control, make sure that the cable you are using to connect the device to the SEL-2032 is wired for RTS/CTS.

When RTS/CTS hardware flow control is required, use **SET P** to set RTS_CTS = Y. Automatic communication sources with RTS/CTS hardware data flow control enabled must stop message transmission immediately when the SEL-2032 deasserts RTS so they do not overwrite the SEL-2032 buffer on that port. Likewise, if RTS_CTS = Y, the SEL-2032 does not send message or data characters until the CTS input is asserted.

Modem Operation

There are a number of issues to consider if you are using a modem. In particular, flow control and disconnect sequences need to be considered.

When a modem connection is made, it is possible for the phone line connection to be at a lower baud rate than the modem-to-SEL-2032 connection. This can lead to a loss of characters during large data transfers, because the SEL-2032 can overrun the modem. This can be prevented by setting the SEL-2032 to the lowest likely connection rate, typically 2400 baud. Alternatively, you can enable RTS/CTS or XON/XOFF flow control between the SEL-2032 and the modem.

To use hardware flow control, set RTS_CTS = Y on the modem port. Only use this setting if the RTS and CTS control lines are wired between the SEL-2032 and the modem. The modem should default to use hardware flow control.

Alternatively, to use software flow control, set XON_XOFF=Y on the modem port and modify the MSTR setting to enable XON/XOFF handshaking within the modem. Refer to your modem data sheet to determine the appropriate code for your modem.

Many external modems do not behave well if they receive non-modem messages while they are not connected. For this reason, you should connect the Data Carrier Detect output of the modem to the SEL-2032 so transmissions to the modem can be prevented. If you have the modem connected to Port 1 or 9 of an SEL-2032, you can connect DCD and RTS/CTS flow control signals to the SEL-2032. If you are connected to any other port of a SEL-2032, connect the modem DCD output to the CTS input of the SEL-2032 and set CD_CTS to Yes. Of course, with this connection you will not be able to use RTS/CTS flow control.

Another thing to consider when using modems is how to terminate the connection. If you simply hang up, the SEL-2032 is left in whatever state you were in. This could be a state to which you cannot call back. To avoid this, you should do two things:

- When a modem is on a Master port, always exit transparent connections and issue the **QUIT** command to terminate the connection. This way, you always leave the SEL-2032 in a known state.
- Set the port TIMEOUT setting to something other than 0. If you do leave the SEL-2032 in an undesired state, it will return to a basic Access Level 0 state after the TIMEOUT time, as if a **QUIT** command had been issued.

Automatic Message (SET A) Settings

Use the **SET A** command to set the SEL-2032 to:

- Automatically buffer unsolicited messages the SEL-2032 receives.
- Automatically print those unsolicited messages, and clear the buffer after printing if you desire.
- Automatically issue operate messages based on operating elements.
- Automatically collect Sequential Events Recorder (SER) data.
- Automatically collect synchrophasor data from SEL IEDs.
- Define startup strings for connected devices so the SEL-2032 can communicate automatically with those devices.
- Create messages to send to other devices and define conditions that trigger those messages (messages are commands, data, or both).

- ➤ Define data parsing methods you want used on responses received.
- ➤ Define conditions where data are archived in optional nonvolatile memory.

You can create up to 12 automatic messages per port with the standard SEL-2032 configuration. Eight of these message functions have an associated data area to store responses, and the other four are for messages only. There are three additional message functions associated with the nonvolatile Flash memory, for a total of 15 possible message functions per port.

Automatic Message Operation

The messaging process is diagrammed in *Figure 7.3*.

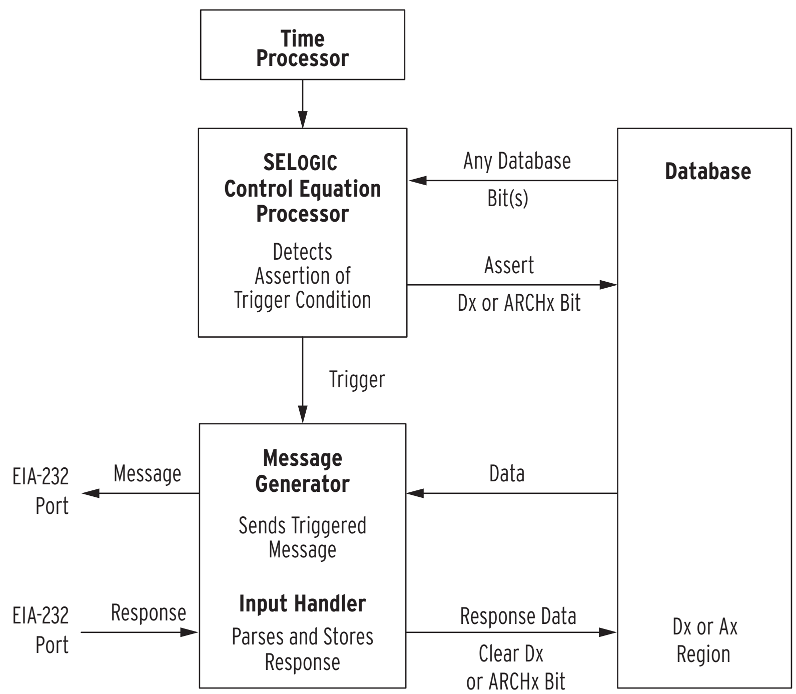


Figure 7.3 Automatic Message Operation Functional Block Diagram

The SELOGIC control equation processor (*Figure 7.3*) detects the true or false status of the trigger condition as defined in a SELOGIC control equation (using the ISSUEx setting). When the condition becomes true, SELOGIC control equation processor sets the Dx or ARCHx bit (depending on whether it is a Data or Archive data region of the database involved) and causes the Message Generator to issue the message that you have defined with the auto-message setting. See *Section 4: SELOGIC Control Equations* for more details about triggering.

The message issued may elicit a response. With the settings, you tell the SEL-2032 what data to expect (including meter, ASCII floating point, and integer) and how to parse, validate, and store the data. The data are then stored in the appropriate region of the database and the Dx or ARCHx bit is cleared. If a response is not expected, the Dx or ARCHx bit is cleared upon issue of the triggered message. See *Section 5: Message Strings* for details on strings.

Data Collection Periods

You can set the SEL-2032 to collect data from attached devices on an exception basis, i.e., only when an event occurs, and you can set the SEL-2032 to collect data on a regular, periodic basis. Each SEL-2032 port collects data independently, based on your settings, and you can set each port to collect data in different ways using separate message trigger conditions and data request messages. Likewise, each SEL-2032 port responds to requests for data independently, based on your settings. In either case, the SEL-2032 will not issue or respond to another request for data on the same port until the previous request has been satisfied. If the data response has not been completed before the same message trigger condition occurs again, the second trigger will be missed completely. The SEL-2032 acknowledges this missed trigger by setting a delay bit in the port register, which is reported in the SEL-2032 status report.

Although both exception and periodic data collection can encounter this type of delay, you can control the periodic collection period, and thereby minimize the possibility of collection delays and missed triggers. First, you should consider if the attached device is capable of transferring data in binary format, or only in ASCII character format, and second, the type of data you plan to request, i.e., meter, target, demand, or another type.

Table 7.2 presents some general guidelines regarding minimum data collection periods you should use to collect various types of data from SEL relays in binary or ASCII format. The guidelines in this table assume the relay is using a baud rate of 2400 or above and is not busy processing events or communicating on more than one port. As this table shows, there is a dramatic difference between the minimum collection period for a relay that has Fast Meter (binary data transfer) capability and one that can transfer data only in ASCII format.

Table 7.2 SEL-2032 Minimum Data Collection Period (in Seconds)

Command	Binary Data Format (Fast Meter)	ASCII Data Format (no Fast Meter)
20METER	1	10
20DEMAND	1	10
20TARGET	1	20[a]
20STATUS	N/A	10
20BREAKER	N/A	10
20HISTORY	N/A	20[b]
20EVENT	N/A	120
20EVENTS	N/A	120
20EVENTL[c]	N/A	300

[a] SEL-321 Relay requires one minute.
[b] SEL-321 Relay requires 30 seconds. The SEL-BFR and SEL-2BFR Relays require 40 seconds.
[c] Only supported on SEL relays that support 16 sample/cycle event reports.

When connecting to SEL-100 and SEL-200 series relays that have Fast Meter binary data capability, always connect to Port 2 on the relay. Binary data transfer is not supported on Port 1 of these relays.

Collection periods for non-“20” message-based collections are dependent on the device response speed and the value of the DELAY setting. As a minimum, the collection period always contains the time required to send a request and receive the response. If DELAY is set to ON, there is an additional delay while the SEL-2032 waits for the port to be idle for 15 seconds on SEL IED ports and 5 seconds on all other ports.

Data Parsing Options

The SEL-2032 database stores data that are parsed, or separated, into the smallest useful element or bit size. Parsing data in the SEL-2032 reduces the communication and processing burden for other devices or systems that use these data by permitting them to request and transfer only the specific data they need.

The SEL-2032 automatically parses data that are recognized from SEL relays. You request these data using the "20" message format. The type of response depends on the SEL relay's capability. If the relay has Fast Meter capability, the response to the 20METER message is in a binary format. Some relays also respond to 20TARGET and 20DEMAND messages with a binary data format. Binary data are transferred faster than ASCII data and allow simultaneous ASCII dialogue, making Fast Meter binary data transfer the preferred choice whenever possible.

The SEL-2032 also automatically calculates additional metering parameters from the binary data. For example, ASCII meter data provide current and voltage magnitude, but the binary meter data results include magnitude and angle. Binary meter data also include calculated voltage and current sequence quantities, calculated per-phase watts and vars, and three-phase watts and vars.

You can parse message responses that are not recognized SEL data in several ways. You can set the SEL-2032 to ignore the data by setting PARSE*x* = 0. Or you can set the SEL-2032 to accept the data and parse it according to one of the six techniques listed below. If DEVICE is set to SEL and the connected device echoes the request message, parsing begins after the echoed request is received.

ASCII Integer (Parse = 1)

This technique parses numbers only; every number separated by a space, comma, decimal, or any other nonnumeric character is stored as a separate item. For example, if you selected the ASCII Integer option, and set the number of responses (NUM*x*) to 7, the following message is parsed as shown below:

> Message: "This is a 2030 message with numbers 10, -6.2, and 2,459.884"
>
> Parsed result: "2030, 10, -6, 2, 2, 459, 884"

If you set the number of responses less than 7, the parsed result is truncated; if you set the number of responses greater than 7, the result includes trailing zeroes, i.e., "..., 884, 0, 0, 0."

ASCII Float (Parse = 2)

This technique also parses numbers only, but retains decimals as part of each number. All other nonnumeric characters are parsing characters. For example, if you selected the ASCII Float option and set the number of responses (NUM*x*) to 5, the following message is parsed as shown below:

> Message: "This is a 2030 message with numbers 10, -6.2, and 2,459.884"
>
> Parsed result: "2030, 10, -6.2, 2, 459.884"

If you set the number of responses less than 5, the parsed result set is truncated; if you set the number of responses greater than 5, the result includes trailing zeroes, i.e., "..., 459.884, 0, 0, 0."

Character String (Parse = 3)

This technique retains all numbers and characters in a character string. For example, if you selected the Character String option and set the number of responses (NUM*x*) to 60, the example message is parsed as follows:

Message: “This is a 2030 message with numbers 10, -6.2, and 2,459.884”

Parsed response: “This is a 2030 message with numbers 10, -6.2, and 2,459.884”

For this parsing method, the SEL-2032 always appends a NULL character (00h) to the end of the parsed response before storing it to the database. This means that the NUM*x* setting must be set to a value one greater than the expected number of response items. The above string is actually 59 characters in length, yet the NUM*x* setting was set to 60.

If you set the number of responses less than 60, the parsed result is truncated; if you set the number of responses greater than 60, the result includes extra trailing nulls. These are nonprinting characters, so you will not see any difference when using default data viewing methods, i.e., “...d 2,459.884.”

Integer String (Parse = 4)

This technique stores each pair of received bytes in a register, most-significant-byte first. The Integer String option is primarily useful for capturing data from devices that send data in binary words. Because this parsing option uses both upper and lower bytes of each register, it stores data in fewer registers (less space) than the Character String option. You can retrieve data from these registers using the special strings designed to work with a data word. See *Section 9: Protocols* for more detailed information.

Integer String With XON/XOFF Encoding (Parse = 5)

This technique works just like Integer String, except each pair of received bytes is compared to a set of special codes that are used to encode the XON (11h) and XOFF (13h) characters. If one of the special codes is encountered, the appropriate 11h or 13h character is stored. The encodings used are as follows: a 99h followed by a 01h represents XON (11h), a 99h followed by a 02h represents a XOFF (13h), a 99h followed by a 03h represents a 99h. Since 99h is always encoded, any 99h that is received and is not followed by 01h, 02h, or 03h is ignored. For example, if you set the parse option to Integer String with XON/XOFF encoding and set the number of items (NUM*n*) to 4, the following message is parsed as shown below (all data shown as hexadecimal character codes):

Message: 0199021099903249915FF9934C80B

Parsed result: 011310992415FF34

Notice that the NUM*n* setting applies to the number of “parsed” items, not to the number of received items. This parsing method is useful when binary data are being received while XON/XOFF flow control is enabled.

Flexible Parsing (Parse = 6)

This technique parses received characters according to a user-defined Decode Equation. The Decode Equation identifies data types and search strings expected in the received characters. Text strings that match the Decode Equation are stored into the Data region.

Decode Equations

A Decode Equation consists of one or more Decode Expressions as shown in *Equation 7.1*.

$$\mathrm{DEq} = \mathrm{DExp}_1,\ \mathrm{DExp}_2,\ \ldots\ \mathrm{DExp}_n \qquad \textbf{Equation 7.1}$$

Use braces, { }, to enclose a group of expressions together. This is especially useful when parsing tabular data. The following string is an example of a Decode Equation.

4{(I, S5, I, F)& '\00D'}

In this example, the SEL-2032 expects four rows of data with each row containing an integer, string of 5 characters, an integer, and a floating-point value. At the end of each row is a carriage return.

A Decode Expression consists of one or more Decode Elements or a Search String as shown below.

DExp = DElem

D Exp = (DElem$_1$, DElem$_2$, …, DElem$_n$)

D Exp = Search String

Use parentheses, ( ), to enclose a logical group of Decode Elements, and commas to separate the Decode Elements within a logical group. The following string shows an example Decode Expression with three Decode Elements.

I, 3F, S20

This example specifies one integer, an array of three floating-point numbers, and a string of 20 characters.

Decode Elements. A Decode Element consists of a Data Type (Type) and optional parameters as shown below.

DElem = [*r*]Type[*n*][@|;label]

These optional parameters are shown below in brackets but the brackets are not actually entered. The Data Type and optional parameters are defined in *Table 7.3*.

An example of a Decode Element is: 2F5;My_Float. This example shows an array of two floating-point numbers, each with a maximum of 5 ASCII characters. The data are stored in the SEL-2032 database with the My_Float label.

Decode Elements also have user-defined reset values. It may be desirable to have user-defined reset values for failed parsing conditions. Specify the numerical reset values in the Decode Equation. After defining a reset value, any subsequent data items that fail to parse are reset to the new reset value. The Decode Equation shown in *Equation 7.2*, resets the database with the following reset values if the SEL-2032 fails to parse the incoming data.

F = 78F0 0000h (default reset value defined in table 3.6)

H = 8000h (default reset value defined in table 3.6)

I = 8000h (default reset value defined in table 3.6)

F = 3.55 (reset value defined with RF3.55)

H = 3Ah (reset value defined with RH3A)

I = 222 (reset value defined with RI222)

DECODE = "F, H, I, RF3.55, RH3A, RI222, F, H, I"

Equation 7.2

Table 7.3 Decode Element Definitions

Element	Definition
r	**Repeat Count**. Optional number of times to repeat the data type in the expanded Decode Equation. Range is 1–2048. Repeat count data items are stored as an array.
Type	**Data Type**. The parser ignores all leading white space (space or tab characters) for all data types except C. See *Table 7.4* for specific data types and definitions.
Reset Values	If parsing fails, the SEL-2032 stores the data type reset value into the database. See *Table 7.4* for data type reset values. Also see User-Defined Reset Values.
n	**Length**. Optional maximum expected size of the ASCII string for the data type. Range is 1–32767. If *n* is not specified, the value of *n* is based on the data type specified. See *Table 7.4* for the default length of *n*. Once a valid character is found, all valid characters are read and stored until the specified length of characters is read or an invalid character is found.
@	**Non-Storage Element**. The @ sign causes the data item to be parsed according to the data type, but not stored in the database. In the example, I, F@, the @ sign reserves space for an integer, but not for the floating-point. The @ sign cannot be specified with the label option.
label	**Optional Label**. This optional label is applied to the data type. Only one label is allowed per data type. Data elements with a repeat count share the same label. Labels are limited to 10 characters, and characters must be (a–z, A–Z, 0–9 or the underscore character). A label cannot be specified with the @ sign option. The labels MONTH, DAY, YEAR, HOUR, MIN, SECONDS, SEC, and MSEC are reserved by the SEL-2032. You may, however, use these labels if they are not in uppercase. For example, Min is an acceptable label.

Table 7.4 Data Type Characteristics (Sheet 1 of 2)

Data Types	Definitions	Reset Values	Default Length (if n not specified)
I	Integer (0–9 and leading + or –)	8000h	5 valid characters plus sign
F	Floating Point (0–9, + or –, and scientific notation)	7F800000h	10 valid characters
C	ASCII String (all ASCII characters including leading white space)	‘’ (empty string)	1 character

Table 7.4 Data Type Characteristics (Sheet 2 of 2)

Data Types	Definitions	Reset Values	Default Length (if n not specified)
S	ASCII String (all ASCII characters excluding leading white space)	‘’ (empty string)	1 character
H	ASCII Hexadecimal Number (0–9, A–F, a–f)	8000h	4 valid characters
RI*v*	User-defined reset value for I Data Type, where *v* is the reset value. Format the same as I Data Type.		
RF*v*	User-defined reset value for F Data Type, where *v* is the reset value. Format the same as F Data Type.		
RH*v*	User-defined reset value for H Data Type, where *v* is the reset value. Format the same as H Data Type. *V* is specified in hexadecimal.		

Search Strings. A Search String in the Decode Expression instructs the SEL-2032 to search the incoming message for an exact match or until the message acquisition times out. Use any keyboard character in a string. A Search String may be specified with either a preceding ampersand (&) or a comma as shown below.

SExp = ‘str’

SExp = & ‘str’

SExp = , ‘str’

A preceding ampersand causes the SEL-2032 to search the incoming string for an exact match to the Search String. If the Search String is found, the previous Decode Expression is evaluated. If the Decode Expression is successfully parsed before the Search String is found, the Search String is treated as a Search String with a preceding comma. When using the ampersand, the Search String has precedence over the preceding Decode Expressions.

A preceding comma causes the SEL-2032 to evaluate all expressions in the specified order. If an expression before the search string fails, and then the Search String is found, the parser continues parsing after finding the Search String.

The Search String allows characters in hexadecimal format using \0*xx* (where *xx* is a hexadecimal number represented by ASCII characters). Null characters (\000) and single quotes are not allowed within Search Strings. The following string is an example of a Search String. See *Table 7.3* for reserved labels.

‘Text’, I, F& ‘str’

In this example, the parser searches for the ‘Text’ string, then it parses the next integer and floating-point value. While evaluating the floating-point value, the parser is also searching for the ‘str’ Search String. If ‘str’ is found before the floating-point, the floating-point value is reset. See *Table 7.4* for the data type reset values.

Database Storage and Parsing Rules

After successful setting creation, the database storage is reserved. After receipt and parsing of the first response, the database region is valid regardless of the success or failure of the data parsing. This allows you to view the database region and aids in troubleshooting the Decode Equation.

An element is parsed successfully if the first character evaluated is within the ranges specified in *Table 7.4* for each data type. Once a valid character is found, all valid characters are read and stored until the maximum number of characters is read or an invalid character is found.

If an invalid character is read before any valid characters, then the parse rule fails and the data element is reset.

If an invalid character is found after at least one valid character, the current Decode Element is valid and evaluation of the next element starts.

If all the Decode Elements within a Decode Expression fail, or the message collection times-out, then all the remaining data elements referenced in the Decode Equation are reset to the values listed in *Table 7.4*.

Parsing Precedence

Parsing is evaluated from left to right according to the Decode Equation. However, special rules apply to Search Strings using a preceding ampersand. This type of Search String is referred to as an ampersand Search String in the text below.

If a Search String is the first expression in the Decode Equation, then the parser searches for the Search String in the message. Once the Search String is found, evaluation of the Decode Equation proceeds.

The ampersand Search String has the highest precedence. If a Decode Equation contains a Search String, and the Search String is found before the completion of the previous Decode Expression, the Decode Expression has failed and all remaining elements in the Decode Expression are reset (see the reset values in *Table 7.4*).

If the incoming string contains data that is both valid for the specified data type, and matches the ampersand Search String, the Search String has precedence. If the incoming data only contains the Search String, then the previous Decode Expression is reset.

The ampersand Search String is evaluated with the preceding Decode Expression. A Search String with a preceding comma is evaluated in the order it appears in the Decode Expression.

EXAMPLE 7.1 Parsing Precedence Examples

I, F, H& 'str' The parser watches for 'str' while evaluating for the H element. If 'str' is found before the H element, then H is reset.

I, (F, H)& 'str' The parser watches for 'str' while evaluating for both the F and H elements. If 'str' is found while evaluating F, both F and H are reset.

2{I, (F, H)}& 'str' In this case, because the 'str' is outside the brace, the 'str' is only searched for on the very last element of the array. To evaluate 'str' for each row of the array, move 'str' inside the brace.

I, H, 'str', F The parser evaluates the incoming data for Integer and Hex and then parses the data until 'str' is found. After 'str' is found, the parser evaluates the next floating point. If H is not found and 'str' is found, processing continues for F.

EXAMPLE 7.2 Flex Parsing Example

Parse the maximum and minimum values from an SEL-351R min/max meter report.

Enter the following SET A settings.

ISSUE1 = T10:00:00

MESG1 = "MET M \n"

PARSE1 = 6

DECODE1 = " 'Min', '\00D', 11{S6, (F, 5I, F, F, 5I, F)& '\00D'}"

These settings cause the SEL-2032 to request a min/max meter report from the SEL-351R at 10:00 am and parse the response according to the decode string, DECODE1. Shown below is an example SEL-351R min/max meter report.

```
==>>MET M <Enter>
RECLOSER R1                        Date: 03/28/01    Time: 10:39:02.389
FEEDER XYZ
           Max    Date      Time             Min    Date      Time
IA(A)      200.0  03/28/01  10:38:56.774     198.0  03/28/01  10:38:57.291
IB(A)      202.1  03/28/01  10:38:56.774     199.0  03/28/01  10:38:58.069
IC(A)      202.2  03/28/01  10:38:57.091     197.0  03/28/01  10:38:56.774
IN(A)    RESET                             RESET
IG(A)    RESET                             RESET
VA(kV)   RESET                             RESET
VB(kV)   RESET                             RESET
VC(kV)   RESET                             RESET
VS(kV)   RESET                             RESET
MW3P     RESET                             RESET
MVAR3P   RESET                             RESET
LAST RESET 03/28/01 10:38:56.773
```

Figure 7.4 SEL-351R Min/Max Report

In this example, the parser inspects 11 rows of data after finding the 'Min' string and a carriage return. If a row contains min and max data, the database stores the following data for the Max string and repeats the process for the Min string:

First Label IA(A)

Max Value as a Floating-Point Value 200.0

Date and Time as Integers (up to the seconds field) 03 28 01 10 38

Seconds as a Floating-Point Value 56.774

If the row contains the RESET string, the decode elements are not evaluated and are set to the reset value.

Parsing Delays

When you use any of the above "generic" parsing methods, (Parse = 1, 2, 3, 4, 5), the SEL-2032 uses the NUM*x* setting to determine when to stop collecting data items. For flex parsing (Parse = 6), the SEL-2032 uses DECODE*x* to determine when to stop collecting data items. If the SEL-2032 has not received the specified number of items, it continues to wait for them until a predetermined amount of time has passed without receipt of a new item. This time delay is 5 seconds for ports with DEVICE set to Other-IED and 15 seconds for ports with DEVICE set to SEL-IED. Once this amount of time passes, the SEL-2032 takes the data items that it has received and continues to the next step in the parsing process, either performing checksum validation or simply storing the data to the database.

If the SEL-2032 receives the number of items specified by the NUM*x* or DECODE*x* setting, the next task is determined by the DELAY*x* setting. If the DELAY*x* setting is set to "ON," then the SEL-2032 executes the same type of delay as described above, ignoring any received items until no more items are received for a fixed time interval. It then moves on to the next step in the parsing process. If the DELAY*x* setting is set to "OFF," then the SEL-2032 immediately moves on to the next step in the parsing process. Any characters received beyond the number of expected data items may end up in the Unsolicited Message Buffer or may even be captured by a subsequent data collection process. Setting the DELAY*x* setting to "ON" helps to ensure that excess characters in a device response will not be treated as part of a subsequent request-response sequence. This introduces time delays in the parsing process, preventing rapid successive data collections. When it is known that the responding device sends a fixed number of items without any excess trailing characters, setting DELAY*x* to "OFF" may be preferable because this enables the parsing process to complete quickly, allowing for rapid successive data collections.

Checksum Validation

If you choose a parse type of Character String (PARSE*n*=3), Integer String (PARSE*n*=4), or Integer String with XON/XOFF encoding (PARSE*n*=5), you can set the SEL-2032 to perform checksum validation on the parsed response. The CHECK*n* setting specifies the type of checksum being used (CRC-16, 8-bit checksum, or 16-bit checksum) and the format of the checksum (ASCII hexadecimal or binary). The ORDER*n* setting specifies the byte ordering of the checksum for CRC-16 and 16-bit checksums. The START*n*, STOP*n*, and CHKPOS*n* settings specify the locations of the data to be validated and the checksum in the received data stream. Three methods are available for specifying these position settings:

- ➤ specify a byte index in the received data stream, where byte index 1 is the first position
- ➤ specify a character or character code, where a trailing 'i' can be appended to indicate that the character itself is included
- ➤ specify the number of bytes that follow the item being specified

To specify a byte index, you enter a positive integer. To specify a character you can enter the character or, if the character is nonprintable, the ASCII character code. Add the trailing 'i' to specify inclusion of the character itself. You must quote any numeric character so that it is not treated as a byte index (e.g., enter '9' or "9" to indicate the character 9 as opposed to byte 9). The examples in *Table 7.5* demonstrate the use of each method.

Table 7.5 Example Position Settings (Sheet 1 of 2)

Example Setting	Meaning
START1 = 1	Start calculating checksum at first received byte.
START1 = #	Start calculating checksum at the first byte following the character '#'.
START1 = #i	Start calculating checksum at the '#' character ('#' is included in checksum).
START1 = E10	Start calculating checksum 10 bytes before the end of the message.
STOP1 = 20	Stop checksum calculation at 20th byte (byte 20 is the last byte of data).
STOP1 = \003	Stop checksum calculation at ETX character (03 character code) (ETX character is not included in checksum).

Table 7.5 Example Position Settings (Sheet 2 of 2)

Example Setting	Meaning
STOP1 = \003i	Stop checksum calculation after ETX (ETX character is included in checksum).
STOP1 = E4	Stop calculating checksum 4 bytes before the end of the message.
CHKPOS1 = 40	The checksum starts at the 40th byte of the received data.
CHKPOS1 = \001	The checksum starts after the SOH character (01 character code).
CHKPOS1 = E2	The checksum is located 2 bytes from the end of the message.

Suppose the string below is sent to the SEL-2032 and you wish to verify that there are no transmission errors. Assume that the checksum is calculated on the data within the quotes. In this case the checksum is a 16-bit checksum in ASCII hexadecimal format with the high byte first. There are many different ways that you could specify the locations of the data and checksum. Four examples are given.

received data: “This is data”, 044E

settings:

CHECK = 16A,

ORDER = H,

method 1: START = 2,	STOP = 13,	CHKPOS = 16
method 2: START = E18,	STOP = E6,	CHKPOS = E4
method 3: START = “,	STOP = ”,	CHKPOS = ‘,’
method 4: START = 2,	STOP = ”,	CHKPOS = E4

The method you choose for each of the position settings depends on the format of the received data. These position settings apply only to the data to be stored. This means that the NUM*n* setting must be large enough to contain all of the data and the checksum. Otherwise, the checksum verification will consistently fail. The position settings must be sequential in the received data: the START*n* position must be on or before the STOP*n* position and the STOP*n* position must precede the CHKPOS*n* position.

The ACK*n* and NACK*n* settings allow you to set strings to be sent following successful or failed checksum validation, respectively. The content of these strings is limited to characters and character codes. None of the special SEL-2032 strings are allowed.

When the SEL-2032 is set to do checksum verification, data are only stored to the database when the checksum verification is successful. If the checksum verification fails, the SEL-2032 rerequests the data by sending the NACK*n* string if one is set. If no NACK*n* string is set, the MESG*n* string is sent again. The SEL-2032 then parses the data and attempts checksum verification again. If this verification fails again, one final attempt (for a total of three) is made. If the NACK*n* string was sent previously and resulted in no response at all, the final rerequest is made using the MESG*n* string. If the checksum verification is successful, the data are stored to the database (including the checksum) and the ACK*n* string is sent to the connected device.

SET A Settings

When you send the **SET A** command to a specific port, the SEL-2032 prompts you for responses based on the type of device connected to that port.

Table 7.6 Automatic Message (SET A) Settings Information (Sheet 1 of 3)

Setting	Comment	Description
AUTOBUF	Save unsolicited messages (Y/N).	You enter Y (Yes) to save unsolicited messages received by the SEL-2032. Ports configured for IEDs can buffer unsolicited messages. User-defined commands work regardless of this setting. Not available for Master or Printer.
STARTUP	Prompt. Port startup string.	You enter a startup string for the device attached to this port. The startup string supports devices that need some initialization on power-up. When the SEL-2032 is powered-up, these startup messages are transmitted. Typically, this string is used on SEL relays that need to be at Access Level 1 or Access Level 2 for automatic data collection by the SEL-2032. Not available for Master ports. The SEL-2032 does not show this setting to a Level 1 user of the SEL-2032. This is to prevent an unauthorized user from getting access to passwords that may be embedded in the startup string. The startup string is sent: When you accept setting changes after the **SWAP** or **COPY** commands. At power up. When an inactive port becomes active. When you accept SET A setting changes. When leaving transparent communications with a device.
SEND_OPER	Send operate command on logic bit transition (Y/N/YP).	Use this setting to enable automated control of the attached SEL device. The YP selection indicates that remote bits should always be pulsed (see *Automated Control on page 7.25*).
REC_SER	Enable Automatic Sequential Events Recorder Collection (Y/N).	Set to Y (Yes) to enable automatic SER data collection from an SEL IED. Not all SEL IEDs support this feature. **Note**: If REC_SER = Y, data region 8 (D8) stores the relay SER data. You can still send messages using MESG8, but you will not be allowed to parse a response.
SP_RATE	Synchrophasor messages per minute (N = NONE, 1, 2, 3, 4, 6, 10, 12, 15, 20, 30, 60)	Set to a numeric value to enable automatic synchrophasor data collection from the attached SEL IED. Set to "N" to disable data collection. Not all SEL IEDs support this feature at all data rates.
NOCONN	Block external connections to this port.	Set to NA to enable modem, transparent and virtual terminal connections to this port. Set to SELOGIC control equation that equals 1 when you want connections to be disabled (see *Restricting Port Access with NOCONN*).
MSG_CNT	How many auto-message sequences (0–12).	You enter the number of the auto-message(s) you wish to use. Messages 1–8 have an associated data area to store responses, messages 9–12 are for messages only.
PRINT_ALL	Print all unsolicited messages (Y/N).	You set to Y (Yes) to print all unsolicited messages received by the SEL-2032 to a Printer port. Only those messages received on ports that have AUTOBUF = Y are printed. The PRINT_ALL prompt only appears on ports with a DEVICE = P for printer. This setting occupies the Message 1 position. You can create more selective printing functions using SELOGIC control equations and message strings on other message functions.
CLEAR_BUF	Clear unsolicited message buffer after print (Y/N).	You set to Y (Yes) to clear the unsolicited message buffer after printing. Only applies to Printer ports. **Note:** Up to 12 auto-messages may be defined using the ISSUE*x* and MESG*x* settings. The first 8 may have their responses parsed using the PARSE*x* setting.

Table 7.6 Automatic Message (SET A) Settings Information (Sheet 2 of 3)

Setting	Comment	Description
ISSUE1–12 ISSUE1A–3A[a]	Item 1–12 trigger.	You enter the trigger condition as a SELOGIC control equation that riggers the associated message. ISSUE1 triggers MESG1, ISSUE2 triggers MESG2, etc. See the *Section 4: SELOGIC Control Equations* for instructions on developing these trigger conditions. There is a 200-character per equation limit for a single equation and a 50-term (element names and time functions) limit per equation.
MESG1–12 MESG1A–3A[a]	Item 1–12 message.	You enter the message string to be sent when the associated ISSUE condition is met. Each message is limited to 1000 characters. Use the \ symbol at the end of a line and press **<Enter>** to continue on the next line. See *Section 5: Message Strings* for information on the special strings that can be entered here.
PARSE1–8 PARSE1A–3A[a]	Item 1–8 response parsing method (0=IGNORE, 1=ASCII_INT, 2=ASCII_FLOAT, 3=CHAR_STRING, 4=INT_STRING, 5=INT_STRX, 6=FLEX).	You select the parsing option to be used for the message response. For Master and Printer ports, the parsing option is always forced to IGNORE. Parsing is automatically set for SEL relays if the message string is a recognized “20” command.
DECODE1–8 DECODE1A–3A[a]	Flexible Parsing Decode Equation.	Enter a Decode Equation to parse a response. The string is limited to 1000 characters (see *Flexible Parsing (Parse = 6) on page 7.16*).
NUM1–8 NUM1A–3A[a]	Item 1–8 number of data items.	You enter the maximum number of items the SEL-2032 may store from the response. The limit is determined by the type of data and the size of the associated region. See *Section 6: Database* for more information on region sizes.
DELAY1–12 DELAY1A–3A[a]	Item 1–12 time delay to allow response to complete (OFF, ON).	If you know you are collecting the entire response, use the OFF setting to avoid unnecessary delays. Otherwise, use the ON setting so the response does not confuse subsequent data collections. When on, the SEL-2032 waits for the port to go idle for 15 seconds on an SEL IED port or 5 seconds on an Other IED port before considering the response complete.
CHECK1–8 CHECK1A–3A[a]	Checksum verification (N=NONE, 8A=8BIT ASCII, 8B=8BIT Binary, 16A=16BIT ASCII, 16B=16BIT Binary, CA=CRC16 ASCII, CB=CRC16 Binary).	You select the verification method you wish to use to confirm that the data was accurately transmitted over the data channel. The data must contain a validation code of this same type and format. Otherwise, select NONE.
ORDER1–8 ORDER1A–3A[a]	Checksum byte order (H=High byte first, L=Low byte first)	You enter the ordering of the bytes in the received validation code. Does not apply to 8-bit (single-byte) checksums.
START1–8 START1A–3A[a]	Position or character where verification starts.	You enter the position in the received data where the checksum validation should begin. This position can be an index from the start, an index from the end, or a specific character. Refer to *Checksum Validation on page 7.21*, for more information on using this setting.
STOP1–8 STOP1A–3A[a]	Position or character where verification stops.	You enter the position in the received data where the checksum validation should end. This position can be an index from the start, an index from the end, or a specific character. Refer to *Checksum Validation*, for more information on using this setting.
CHKPOS1–8 CHKPOS1A–3A[a]	Position or character where checksum is located.	You enter the position in the received data where the validation code will be located. This position can be an index from the start, an index from the end, or a specific character. Refer to *Checksum Validation*, for more information on using this setting.
ACK1–8 ACK1A–3A[a]	Acknowledge string.	You define the string to send to the connected device when the data received from it passes the checksum verification. This string is limited to 10 characters. Refer to *Checksum Validation*, for more information on using this setting.
NACK1–8 NACK1A–3A[a]	Negative Acknowledge string.	You define the string to send to the connected device when the data received from it does not pass the checksum verification. This string is limited to 10 characters. Refer to *Checksum Validation*, for more information on using this setting.

Table 7.6 Automatic Message (SET A) Settings Information (Sheet 3 of 3)

Setting	Comment	Description
ARCH_EN[a]	Enable use of archive data items (Y/N).	You enter Y (Yes) to enable use of nonvolatile memory. ARCH_EN is forced to N (No) if nonvolatile Flash memory is not installed. Not available for printer ports.
USER	Size of user-defined data space in registers.	You enter the number of registers you need to use for data storage in the User region of memory. This may be automatically increased during SET M operations.

[a] Set ARCH_EN=Y, to enable the archive AUTO settings.

Automated Control

You can associate SELOGIC control equation elements with specific SEL IED operations by enabling the SEND_OPER setting. Changes in these elements can then cause the SEL-2032 to directly issue operate commands to the attached SEL IED.

To find out what is associated, use the **AUTO *n*** command to determine the number of supported breakers and remote bits for operate control. For every breaker supported, one BR*n* bit is associated with an SEL IED breaker. For every remote bit supported, one RB*n* bit is associated with an SEL IED remote bit. Setting and clearing of BR*n* bits corresponds to issuing **OPEN** and **CLOSE** commands, respectively. When SEND_OPER=Y, setting and clearing of RB*n* bits correspond to issuing remote bit set and clear commands, respectively. When SEND_OPER=YP, setting RB*n* bits corresponds to issuing remote bit pulse commands and clearing RB*n* bits has no direct effect.

If the attached SEL IED is an SEL-2032, the 16 breakers correspond to the BR1 bits on each port. Similarly, the 16 remote bits correspond to the RB1 bits on each port. For example, if you set BR5 in the local SEL-2032 on a port auto-configured with an SEL-2032 attached, the command to set Port 5 BR1 is issued to the attached SEL-2032.

The SEL-2032 can issue these commands in one of two ways: ASCII or binary. The **AUTO** command tells you which is supported. When ASCII commands are used, the SEL-2032 has to wait for any ASCII communications in process to complete before issuing the command. If binary commands are used, the SEL-2032 issues the command to the attached SEL IED within 100 milliseconds.

The operate commands are issued on the rising edge of the set and clear bits, unless they both rise simultaneously. Consequently, the breaker and remote bits track the value of the last operation performed by the SEL-2032. The relay may operate breakers or have its remote bits changed independent of the SEL-2032, so you cannot depend on the state of the breaker and remote bits to indicate the state of the relay.

If you wish to block the operation of one of these bits, assign both the set and clear equations to a blocking element. For instance, if you use X to block breaker one operations, you would set the equations to:

SBR1 = X CBR1 = X

With both the set and clear elements asserted, there can be no rising edges to trigger operate commands.

Restricting Port Access with NOCONN

You can use the NOCONN setting to terminate any active Modem, Transparent, and Virtual Terminal connections and disable access to a port. The SELOGIC equation you enter for the NOCONN setting controls the value of the NOCONN bit for that port. When the NOCONN bit asserts on a port with any of the aforementioned connections, transmissions in progress are aborted, reception of characters are terminated, and the connections are dropped. The termination will appear as a port timeout.

When a Modem, Transparent, or Virtual Terminal connection exists on a port or SEL Master port, the SEL-2032 checks the state of the port's NOCONN bit at least once per second.

When the NOCONN bit asserts, the reception and transmission of data will be restricted as defined below.

Modem Ports

The SEL-2032 checks the NOCONN bit before answering a call from a modem. If the bit is asserted (1), then the SEL-2032 will not answer.

When the NOCONN bit is asserted, the SEL-2032 will abort an automatic message when the \I…/ string is read. This includes an automatic dial-out message string. If you prefer to not have automatic dial-out blocked, you can adjust the NOCONN logic so the NOCONN bit is always deasserted (0) when dial-out is triggered.

If you connect via modem to a Master port to create a transparent (or Virtual Terminal) connection to a Slave port or protocol card, assertion of the NOCONN bit on the Master port will terminate both the modem connection and the connection to the Slave port or card.

Master SEL Ports

When the NOCONN bit is asserted on a Master SEL port, the SEL-2032 limits data reception to Fast Operate commands, clears the XOFF status (to enable transmission of characters once NOCONN is deasserted) and restricts access to the port. The SEL-2032 will only process Fast Operate commands while the NOCONN bit is asserted. All other commands, messages and characters will be ignored. If you also require Fast Operate commands to be ignored, you must set the FAST_OP setting to 'N'. While the NOCONN bit is asserted, the SEL-2032 will not output a command prompt in response to any commands or messages.

While the NOCONN bit is asserted, the SEL-2032 will continue to transmit any message triggered by the ISSUE*x* setting. The NUM_MESG counter will be incremented whenever a message is triggered (Master ports do not support parsing or storing responses from a triggered message, so you will not be able to detect communication failures or bad messages). You may override the transmission of messages while NOCONN is asserted by including **!(<port number>:NOCONN)** in the ISSUE*x* setting.

If Unsolicited SER reporting is enabled and the NOCONN bit is asserted, the SEL-2032 shall temporarily disable Unsolicited SER reporting. Once the NOCONN bit is deasserted, Unsolicited SER reporting will resume. It is not necessary for the Fast Message client to re-enable SER reporting if it was enabled before NOCONN was deasserted. If an Unsolicited SER message is unacknowledged when the NOCONN bit asserted, it shall be regenerated with the exact same data content except for the status byte (which will contain the current system state) once the NOCONN bit is deasserted. It is recommended that you configure the Fast Message client to periodically issue Enable Unsolicited SER requests to an IED to restart the reporting of unsolicited SER in case of loss of communications to the IED.

Transparent Connections

Before making a transparent connection, the SEL-2032 checks the NOCONN bit on the Slave port. If the bit is asserted, the attempted transparent connection is immediately aborted. In addition, the NOCONN bit blocks transparent connections on every mechanism: **PORT** command, user-defined transparent connect string (TRANS in **SET U**), and Distributed Port Switch Protocol (LMD). If the PORT command is attempted, the following error message is displayed:

```
Unable to connect, Port x blocked by NOCONN bit.
```

Virtual Terminal Connections

The SEL-2032 shall check the NOCONN bit before allowing any Virtual Terminal connection.

When the VT connection is initiated by a SEL-2032 user via the **PORT** command, the SEL-2032 shall function exactly as described above for transparent connections.

When the protocol card initiates a VT connection, the SEL-2032 shall reject the connection as long as the NOCONN bit is asserted.

User-Defined (SET U) Commands

Use the **SET U** command to:

- Create user-defined commands that the SEL-2032 recognizes and obeys.
- Enable handling of a recognized, but unsolicited, SEL relay auto-message.
- Control the SEL-2032 command set.

User-defined commands allow the SEL-2032 to recognize unsolicited inputs. You can create up to 11 user-defined commands for any Master port, including 8 general-purpose and 3 special-purpose commands. You can create up to 4 general-purpose user-defined commands on SEL IED and other IED ports.

The SEL-2032 has a predefined command set (e.g., **SHOW**, **VIEW**, **SET**) that allows you to control, interrogate, and set the SEL-2032 functions from your computer. If a port is connected to an unattended device (e.g., an RTU or substation computer), the SEL-2032 predefined command set may be supplemented or replaced by user-defined commands that are appropriate for the device and function. They are called user defined because you define the command string and the action performed by the SEL-2032 when the command is received by the SEL-2032. These commands are available at all access levels.

On IED ports, the SEL-2032 recognizes unsolicited messages from the IED based on user-defined message strings you define with the **SET U** command (e.g., a summary event report from an SEL relay).

On a Master port, commands are normally terminated with a carriage return (<**CR**>). The carriage return typically is sent from a terminal or PC by depressing the **<Enter>** key. User-defined commands on a Master port are similarly recognized upon receipt of a **<CR>**. If you disable the SEL-2032 command set to use only user-defined commands on that port (using the CMD_EN setting), you may select an alternate command termination character (using the CMD_CH setting).

General-Purpose Commands

You can set the SEL-2032 so that receipt of a command you defined sets an SEL-2032 database bit. You can then use that bit in a SELOGIC control equation to trigger a control action or message response.

When the SEL-2032 receives a general-purpose user-defined command, it pulses the associated local element command (CMD*x*) bit. You may create up to eight general-purpose commands per port to control the local elements CMD1–CMD8.

For SEL relays, there are predefined auto-messages that you can set the SEL-2032 to recognize, such as status, summary event reports, and group switch reports. For example, if you define the first general-purpose command on an SEL IED port to be **20EVENT**, the SEL-2032 element CMD1 on that port pulses when the SEL-2032 receives a summary event report. You use the CMD1 bit within a SELOGIC control equation to trigger a message or a control action in response.

Similarly, on a Master port, you could define “XYZ” to be a user-defined command (CMD1=“XYZ”). When the SEL-2032 receives “XYZ” on the Master port, it pulses the CMD1 bit as shown in *Figure 7.5*, which you may use to trigger a response. See *Section 5: Message Strings* for definitions of valid message strings.

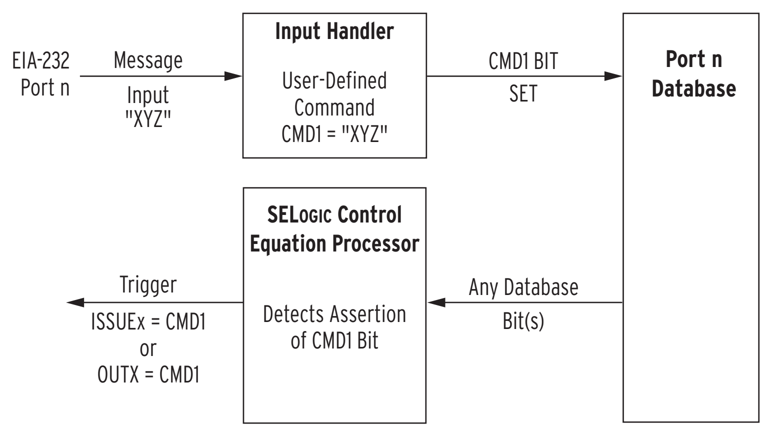


Figure 7.5 SET U Example CMD1 Message Detection

Special-Purpose Commands

There are three commands whose syntax and response messages you may define using the settings READ, WRITE, and TRANS (transparent connect). These commands read data items, write data items, and enter transparent communications. These commands are similar to the **VIEW**, **STORE**, and **PORT** commands available in the SEL-2032 command set. The **READ**, **WRITE,** and **TRANS** special purpose commands may be useful with master devices that you can program to communicate automatically with the SEL-2032.

To build these commands, you must specify the position and format of the port number, address, and data, as applicable, within the message. You then specify how the SEL-2032 should respond to each of these commands for both successful and unsuccessful operations.

For example, assume you have made the following settings. See *Section 5: Message Strings* for an explanation of the special characters used in these settings.

TRANS = "TR\Pa/" TRANSACK = "\006" TRANSNACK = "\015" To enter transparent mode with another SEL-2032 port, use the message format you defined with the **TRANS** command. For example, to enter transparent mode with Port 5 with these settings, issue the command **TR05 <Enter>**. If the transparent connection is successful, the SEL-2032 responds with 06h (ASCII ACK) and you will be transparently connected. To terminate the transparent connection, use the transparent disconnect sequence you set using SET P. If the transparent connection could not be established, the SEL-2032 responds with 15h (ASCII NACK).

READ = "RD\Pa/@\Aa/" READACK = "RP\Dh/" READNACK = "" To read data from the SEL-2032 database, use the message format you defined with the **READ** command. To read from Port 7's database at address 1001h with these settings, send the command **RD07@1001 <Enter>**. The SEL-2032 will respond with the data if the read is successful (e.g., RP0013). If the read cannot be performed, the SEL-2032 will not respond, because there is no response defined for a failed read (READNACK) in these settings.

WRITE = "WR\Pa/@\Aa/=\Dh/" WRITEACK = "OK" WRITENACK = "FAIL" To write data to the SEL-2032 database, use the message format you have defined with the **WRITE** command. To write 0036h to Port 11's database at address D007h with these settings, send the message **WR0B@D007=0036 <Enter>** to the SEL-2032. The SEL-2032 responds “OK” if successful, or “FAIL” if the write could not be performed.

This example uses ASCII commands, but these commands could also have been built as binary commands.

SET U Settings

The **SET U** command prompts you for user-defined strings and the command you want to use to trigger a response on Master, SEL IED, and other IED ports. **SET U** is not applicable to printer ports. You can also use the **SET U** command to disable the SEL-2032 command set on Master ports. *Table 7.7* includes detailed information about the **SET U** settings.

Table 7.7 User-Defined (SET U) Settings (Sheet 1 of 2)

Setting	Comment	Description
CMD_EN[a]	Enable SEL-2032 Commands (Y/N).	You enter N (No) to disable the SEL-2032 command set. This setting is only available for Master ports.
CMD_CH[a]	Command termination character.	You may define the command termination character with this entry. This setting is only available if CMD_EN is set to N (No); it is forced to <CR> otherwise. Changing this character from <CR> disables prompting on this port. Setting range is any single character or control character.
CMD_CNT[a, b, c]	Number of general-purpose commands (0–8).	You enter a number (0–8) to enable command strings (CMD1–CMD8). (0–4) on SEL IED and other IED ports.
CMD1–8[a] or CMD1–4	Command String 1-8 (Master ports) or Command String 1–4 (SEL, Other ports).	You enter the string that the SEL-2032 watches for to control the associated CMD bit. Each string is limited to 39 characters.

Table 7.7 User-Defined (SET U) Settings (Sheet 2 of 2)

Setting	Comment	Description
STR_EN	Enable use of special-purpose commands (Y/N).	You set to Y (Yes) to enable use of the special-purpose user-defined commands. For Master ports only.
TRANS	Initiate transparent mode sequence.	You define a character sequence that the SEL-2032 watches for to initiate transparent communications. This setting is only available if STR_EN is set to Y (Yes). Must include \P.../ port number string. This string is limited to 39 characters.
TRANSACK	Transparent mode acknowledge.	You define the response string the SEL-2032 uses if an entry into transparent mode is successful. This setting is only available if STR_EN is set to Y (Yes). This response string is limited to 1000 characters.
TRANSNACK	Transparent mode denial.	You define the response string the SEL-2032 uses if an entry into transparent mode is unsuccessful. This setting is only available if STR_EN is set to Y (Yes). This response string is limited to 1000 characters.
READ	Read data.	You define the character sequence the SEL-2032 watches for to perform a data read operation. You must include \P../ and \A../ strings. This setting is only available if STR_EN is set to Y (Yes). This string is limited to 39 characters.
READACK	Read data normal response.	You define the response string the SEL-2032 uses if a read operation is successful. Must include \D.../ string. This setting is only available if STR_EN is set to Y (Yes). This response string is limited to 1000 characters.
READNACK	Read data error response.	You define the response string the SEL-2032 uses if a read operation is not successful. This setting is only available if STR_EN is set to Y (Yes). This response string is limited to 1000 characters.
WRITE	Write data.	You define the character sequence the SEL-2032 watches for to perform a data write operation. Must include \P.../, \A.../ and \D.../ strings. This setting is only available if STR_EN is set to Y (Yes). This string is limited to 39 characters.
WRITEACK	Write data success response.	You define the response the SEL-2032 uses if a write operation is successful. This setting is only available if STR_EN is set to Y (Yes). This response string is limited to 1000 characters.
WRITENACK	Write data error response.	You define the response the SEL-2032 uses if a write operation is unsuccessful. This setting is only available if STR_EN is set to Y (Yes). This response string is limited to 1000 characters.

[a] Valid for use with Ports 17 and 18, depending on installed card.
[b] You may define up to eight command strings: CMD1—CMD8.
[c] If CMD_CH is set to <CR>, the SEL-2032 will ignore nonprinting characters entered on the port. Therefore, you should not use nonprinting characters in user-defined commands unless you change the termination character.

Logic (SET L) Settings

Use the **SET L** command to establish the SELOGIC control equations that control the intermediate breaker and remote bit logic. There are a total of 64 bits that can be directly controlled by these equations. These elements act as inputs to 32 S-R latches, whose outputs are also available for use in SELOGIC control equations. On SEL IED ports, these bits can be associated with IED breaker and remote bit operation, as discussed earlier in this section. The operation of these latches is more fully described in *Section 4: SELOGIC Control Equations*.

Table 7.8 fully describes these settings.

Table 7.8 Logic (SET L) Settings

Setting	Comment	Description
SBR1–SBR16	SBR*n*=	You enter a SELOGIC control equation definition for this set breaker logic element.
CBR1–CBR16	CBR*n*=	You enter a SELOGIC control equation definition for this clear breaker logic element.
SRB1–SRB16	SRB*n*=	You enter a SELOGIC control equation definition for this set remote bit logic element.
CRB1–CRB16	CRB*n*=	You enter a SELOGIC control equation definition for this clear remote bit logic element.

Math/Data Movement (SET M) Settings

You use the **SET M *n*** command to create a macro that automatically copies specific data from any designated SEL-2032 port database to the SEL-2032 port "*n*" database User region. This permits you to concentrate selected data from one or more port databases into a single port database User region for quick and easy data retrieval. You can also scale each selected data item by multiplying or dividing by a scaling constant. The **SET M *n*** command permits you to create up to 600 lines of equations and operations for each of the 18 SEL-2032 port databases.

This settings class is unique from all others. There are no settings labels and prompts. Instead, you enter equations and operations as lines within the settings. Because of this, the edit control keys and commands are slightly different. *Table 7.9* lists the available editing keys and commands.

Table 7.9 Editing Keys and Commands for SET M and SET R

Command	Function
<Enter>	Go to next line; if on empty line at end of settings, exit settings.
END <Enter>	Exit settings.
<Ctrl+X>	Abort settings (lose all changes).
^<Enter>	Go back to previous line.
<<Enter>	Go back to first line.
><Enter>	Go to blank line following the last line.
***n* <Enter>**	Go to line *n*.
DELETE [*n*] <Enter>	Delete the current line. If *n* is included, delete *n* lines, starting with the current line.
INSERT <Enter>	Insert a blank line at the current location; current line and all following lines shift down one line.

Each line within the **SET M** entry may contain an equation, operation, or a comment.

Equations define how to move data into the port User region. They have the following syntax, where brackets [ ] indicate optional items, and a vertical bar | is used to separate mutually exclusive options. See *Table 7.10* for an explanation of the **SET M** equation parameters.

> *dest*[,*type*][;[*atype*][;*label*]][+|-|*|/]=
> *source*[,*type*][*scaling*][;*repeat_count*]

or

> *dest*[,*type*] [;[*atype*][;*label*]][+|-|*|/]=*constant*[;*repeat_count*]

or

> *dest*:*bit*[;[*atype*][;*label*]][+|*]=[!]*source_bit*

or

> *dest*:*bit*[;[*atype*][;*label*]][+|*]=*bit_const*

or

> *dest;;NVOL_MEM=nvol_const*

Table 7.10 Math/Data Movement Equation Parameters (Sheet 1 of 2)

Equation Parameter	Explanation
type	Data type for the location
F	Float (IEEE single-precision)
I	Signed integer (16-bit two's complement)
P	Pack character data LSB first (available on left side only)
C	Pack character data MSB first (available on left side only)
H1L	Read low byte as ASCII-hex value (available on right side only)
H1H	Read high byte as ASCII-hex value (available on right side only)
dest	Default to integer
source	Defaults to location data type
constant	Defaults to float if a decimal point is present, to integer otherwise
atype	Access type
B	Treat as 16 binary items (default if type is P or equation is a bit assignment)
I	Treat as 16-bit signed integer (default if type is I)
L	Treat as 32-bit signed integer
F	Treat as floating point number (default if type is F)
C	Treat as 16-bit counter
S	Treat as packed ASCII string (default if type is C)
label	ASCII text label of up to 19 characters; characters must be alphanumeric (a–z, A–Z, 0–9) or underscore (_)
[+|–|*|/]	Specifies (for register operations) mathematical operator, add, subtract, multiply, divide
source	Source address using any valid register addressing method. A special source method may also be used for SER data from a lower-tier SEL-2032. This method allows data points to be referenced by SER index. For example, the string 3:SER:2.58, references the SER region on Port 3, and the 58th bit from Port 2 of the lower-tier SEL-2032.
scaling	Scaling for positive values using either a /*constant* or **constant*

Table 7.10 Math/Data Movement Equation Parameters (Sheet 2 of 2)

Equation Parameter	Explanation
dest	Destination address as an offset into the User region in decimal or hexadecimal
repeat_count	Number of subsequent addresses to copy
constant	Numeric, decimal (integer or floating-point) constant
bit	Bit number from 0–15
+	Used (in bit operations) in front of = to form "+=" indicating that the source bit is ORed into the destination bit
*	Used (in bit operations) in front of = to form "*=" indicating that the source bit is ANDed into the destination bit
!	Indicates that the source bit value should be inverted (complemented)
source_bit	Bit from an SEL-2032 database; see *Section 6: Database* for more information on bit access methods
bit_const	Constant 0 or 1, indicating the state of a bit
nvol_const	Constant 1–10 indicating how many of the following registers will be used for nonvolatile storage.

Item Labels

The labels that you enter are limited to alphanumeric characters (a–z, A–Z, 0–9) and the underscore character (_). If you enter any other items within a **SET M** label, you will either receive an error message from the SEL-2032 or the equation that you entered will not function as expected. For example, the equation below could be entered with the intention of assigning the label "QA+" to the item in the first User region register.

0;;QA+=2:METER:QA This equation is actually interpreted as the following:

0;;QA += 2:METER:IA Add the value of 2:METER:IA to the first User region register and give this register the "QA" label.

Examples

0 = 1:METER:IA Store the Port 1 IA value to the first location in the User region; if the value is stored as a floating-point value, it will be converted to an integer.

1 = 1:METER:VA/100 Divide the Port 1 VA value by 100 and store it to the second location in the User region; if the value is stored as a floating-point value, it will be converted to an integer after the division. The value scaled must be positive.

2,f = 2:2800h,f;6 Starting from the Port 2 address 2800h, copy 6 values to the User region, starting at the third register; treat both the source and destination values as floating-point values, so each copy will move two registers.

14 = 123H Store the value 123h (291) in the 15th register of the User region.

15,C = 1:GLOBAL:0;40 Copy FID string into a packed character format.

55;C;DEAD_COUNTER=5 Store a 5 in the 56th register of the User region and treat it as a counter with the label "DEAD_COUNTER."

60:0 = X Store the value of Global Element X to bit 0 of the 61st register in the User region.

60:0;;GLOBALS += Y Perform a Logical OR of Global bit Y with the current value of bit 0 in the 61st User region register. Store the result to bit 0 in the 61st User region register and give that register the label "GLOBALS."

122:14 = 1 Set bit 14 of the 123rd register in the User region to 1.

97:4;I;TAR_WRD = !3:52A Store the inverted value of the Port 3 relay 52A element to bit 4 of the 98th User region register and treat it as a 16-bit signed integer with the label “TAR_WRD”.

1 += 1:METER:VB Add the Port 1 VB value to the value in the second register of the User region and store the result in the second register of the User region.

1:0;B=2:STATE:1.5 Move 6 SER points (references start with 0 for the first point) statuses from Port 2 to User region and make time-stamped SER data available to protocol (for example, DNP3).

1:0;B=2:STATE:52A Move status of 52A from Port 2 to User region and make time-stamped SER data available to protocol (for example, DNP3).

100h;;NVOL_MEM = 10 Configure 10 contiguous registers for nonvolatile register storage. The contents of registers 101h–10Ah will be stored in nonvolatile memory at 23:30 (11:30 pm) each day or when you change settings on the port where you have configured the nonvolatile storage. The User region registers 101h–10Ah are automatically reloaded with the values stored in nonvolatile memory during SEL-2032 power up. This equation can be used once per port.

ASCII Hexadecimal Data Conversion Example

Assume that region D1 on Port 1 contains the string “A5F0” in registers 4 and 5. A **VIEW** command displays the data shown in *Figure 7.6*.

```
*>VIEW 1:D1:4 NR 2 <Enter>
4135h    4630h
*>
```

Figure 7.6 Example VIEW Command

The objective is to convert to the integer value A5F0 (42,480). Use the SET M functions described above to convert as illustrated in *Figure 7.7*:

```
0 = 1:D1:5,H1L       # convert and store first half of low byte
0 += 1:D1:5,H1H*16   # convert, shift, and add second half of low byte
0 += 1:D1:4,H1L*256  # convert, shift, add low 4 bits of upper byte
0 += 1:D1:4,H1H*4096 # convert, shift, and add upper 4 bits
```

Figure 7.7 Example Math/Data Movement Settings

If the data were parsed using Character String parsing (parse type 3), the **VIEW** command display appears as shown in *Figure 7.8*:

```
*>VIEW 1:D1:4 NR 4 <Enter>
0041h    0035h    0046h    0030h
*>
```

Figure 7.8 Character String Parsed Data

The objective is to convert to the integer value A5F0 (42,480). Use the SET M functions to convert as illustrated in *Figure 7.9*.

```
0 = 1:D1:7,H1L       # convert and store first half of low byte
0 += 1:D1:6,H1L*16   # convert, shift, and add second half of low byte
0 += 1:D1:5,H1L*256  # convert, shift, add low 4 bits of upper byte
0 += 1:D1:4,H1L*4096 # convert, shift, and add upper 4 bits
```

Figure 7.9 Data Conversion Settings

Flow Control (IF-ELSE Syntax)

The IF/ELSE/ENDIF statements allow the user to modify the execution of SET M based on database values.

The SET M branching uses IF, ELSE, and ENDIF to define the expression and bound statements that are executed based on the results of the expression. The syntax of the IF/ELSE/ENDIF expressions follows:

IF *Expression*

Statements Then

ELSE

Statements Else

ENDIF

The ELSE portion of the IF/ELSE/ENDIF expression is optional. When the *Expression* is evaluated as TRUE (non-zero), then the $Statements_{Then}$ are executed; otherwise, the $Statements_{Else}$ are executed, if defined.

EXAMPLE 7.3 IF/ELSE/ENDIF Expression

```
IF 3:TARGET : 52A
    5 = 3:METER:IA
ELSE
    5 = 4:METER:IA
ENDIF
```

The Expression of the IF/ELSE/ENDIF is composed of a single bit reference or the complement of a single bit reference if “!” precedes the expression. The following types of bit references are allowed:

- Bit Label
- Port Number:Bit Label
- Port Number:Region Label:Bit Label
- Port Number:Address:Bit Number
- Port Number:Region Label:Address Offset:Bit Number

The SEL-2032 is capable of supporting three nesting levels of IF/ELSE/ENDIF statements.

Data Type Considerations

You may need to give special consideration to data types within your equations. When working with analog quantities, the meaning of integer and floating-point quantities is straightforward. However, when accessing other types of data (e.g., status, strings, targets) you will want to be more careful. These types of items are stored as character or integer data. Generally, you will simply want to copy them using default data types with no scaling. This results in no change in their representation.

When multiple equations are used to manipulate the same register, the access type and label from the last reference to that register is used to define its final access type and label.

Another thing to consider is reasonable limits to the repeat count. Generally, you should only copy one type of data with a single equation. This is because the SEL-2032 performs its type determinations based on the first item only. Thus, if your repeat count tries to copy data of multiple types, the data of types that differ from the initial type will be misinterpreted.

Two types of operations are allowed:

FREEZE *n*

RELEASE *n*

where *n* is a region reference (port number:region label) in the SEL-2032. The FREEZE operation prevents the specified database area from changing until the corresponding RELEASE operation has been performed. Use these operations to maintain data coherency while moving multiple data items from a specific port database. If you do not use these, it is possible that data may be updated in the midst of copying a block of data. For every FREEZE operation, a corresponding RELEASE operation is required. Only one port database may be frozen at a time.

You may also add comments. Comments start with a '#' character and continue to the end of the line. Comments may exist as stand-alone lines or following equations or operations.

On any type of entry, comment, equation, or operation you may continue the entry to a second line by placing a backslash (\) as the last character on the line. Whether you make an entry all on one line, or use multiple lines, the total length of the entry may not exceed 80 characters.

When you exit settings, the SEL-2032 prompts you for settings acceptance, just like in all other settings classes. If the User region allocation (USER settings in SET A) is insufficient for the given SET M settings, the SEL-2032 automatically increases it as necessary. If there is insufficient memory for the increased User region, you will be warned and the **STATUS** command will show the SET M status on the port to be disabled.

Once these settings have been accepted, the SEL-2032 processes them every half second, on the half second.

Global (SET G) Settings

Use the **SET G** command to:

- ➤ Create a device identification string.
- ➤ Select a time synchronization source.
- ➤ Select between modulated and demodulated IRIG-B input.
- ➤ Define intermediate logic using SELOGIC control equations.
- ➤ Define SELOGIC control equations that control optional I/O board output contacts.

Global settings include primarily the intermediate logic and optional output contact logic available in the SEL-2032. *Table 7.11* lists all Global settings and their description strings. You should use **SET G** to modify and **SHO G** to view these settings.

Each of the five intermediate logic variables (V, W, X, Y, and Z) described in *Table 7.11* has corresponding generic pickup/dropout timers. For the output of a timer to be asserted, its input must first be asserted for the pickup time. Once a timer is asserted, for its output to be deasserted, its input must be deasserted for the dropout time. If an I/O board is installed, you may define conditions that assert outputs on the board.

You define the logic elements using SELOGIC control equations and set their timers using the **SET G** command. For a complete discussion of these equations, see *Section 4: SELOGIC Control Equations***.**

Table 7.11 includes a complete description of the **SET G** settings.

Table 7.11 Global (SET G) Settings and Definitions (Sheet 1 of 2)

Setting	Comment	Description
ID	Device Identification.	Any string of up to 40 characters that you wish to use to identify this device.
TIME_SRC	SEL-2032 Time Synchronization source (IRIG, DNP, OFF, PC1, PC2).	Select the source used by the SEL-2032 to time-synchronize itself.
IRIG_SIG	Type of IRIG Source (Modulated/Demodulated)	Use this setting to select the type of IRIG-B input you are expecting. If you are using the port 15 IRIG-B input, this setting must be demodulated. If you are not using any IRIG-B input, we recommend that you set it to demodulated.
PCFAIL	PCFAIL=	Enter a SELOGIC control equation to control the PCFAIL global status element. The default equation causes the PCFAIL bit to assert if a card is present, but not alive and initialized.
LOG_EN	Enable use of intermediate logic (Y/N).	There are five intermediate logic variables, three of which have associated timers. You set this setting to Y (Yes) to enable their use, or set it to N (No) if you do not plan to use them.
V	V=	You enter a SELOGIC control equation definition for the intermediate logic element V.
W	W=	You enter a SELOGIC control equation definition for the intermediate logic element W.
X	X=	You enter a SELOGIC control equation definition for the intermediate logic element X.
Y	Y=	You enter a SELOGIC control equation definition for the intermediate logic element Y.
Z	Z=	You enter a SELOGIC control equation definition for the intermediate logic element Z.
VPICKUP	V Timer Pickup time (seconds).	The range is 0.0–86400.0 seconds in 0.1-second increments.
VDROPOUT	V Timer Dropout time (seconds).	The range is 0.0–86400.0 seconds in 0.1-second increments.
WPICKUP	W Timer Pickup time (seconds).	The range is 0.0–86400.0 seconds in 0.1-second increments.
WDROPOUT	W Timer Dropout time (seconds).	The range is 0.0–86400.0 seconds in 0.1-second increments.
XPICKUP	X Timer Pickup time (seconds).	The range is 0.0–86400.0 seconds in 0.1-second increments.
XDROPOUT	X Timer Dropout time (seconds).	The range is 0.0–86400.0 seconds in 0.1-second increments.
YPICKUP	Y Timer Pickup time (seconds).	The range is 0.0–86400.0 seconds in 0.1-second increments.
YDROPOUT	Y Timer Dropout time (seconds).	The range is 0.0–86400.0 seconds in 0.1-second increments.
ZPICKUP	Z Timer Pickup time (seconds).	The range is 0.0–86400.0 seconds in 0.1-second increments.
ZDROPOUT	Z Timer Dropout time (seconds).	The range is 0.0–86400.0 seconds in 0.1-second increments.
ALARM	ALARM=	Enter a SELOGIC control equation to control the alarm contact. Independent of this equation, the alarm contact asserts (closes) for self-test failures. Use this setting to control under what other conditions you want the alarm contact to close. The default setting causes the alarm contact to pulse on access level change to Access Level 2, successive password failures, and settings changes.
DEBOUNCE	Input debounce time: (0 = OFF, 1 = 8 ms, 2 = 16 ms, 3 = 24 ms, 4 = 32 ms)	Use this setting to enable a software debounce on the SEL-2032 inputs. This setting is only available if the optional I/O board is installed.

Table 7.11 Global (SET G) Settings and Definitions (Sheet 2 of 2)

Setting	Comment	Description
OUT1	Output contact 1 assignment.	You enter a SELOGIC control equation definition for contact OUT1. This setting is available only if the optional I/O board is installed.
OUT2	Output contact 2 assignment.	You enter a SELOGIC control equation definition for contact OUT2. This setting is available only if the optional I/O board is installed.
OUT3	Output contact 3 assignment.	You enter a SELOGIC control equation definition for contact OUT3. This setting is available only if the optional I/O board is installed.
OUT4	Output contact 4 assignment.	You enter a SELOGIC control equation definition for contact OUT4. This setting is available only if the optional I/O board is installed.

SER (SET R) Settings

Use the **SET R** command to define which bits are monitored for Sequential Events Recorder (SER) data.

This settings class has no labels or prompts. You enter the names of those SEL-2032 elements that you wish to monitor for SER tracking. The only elements that are allowed are the Digital Input elements IN1–IN16. You may monitor one or all of these elements. Because the Digital Inputs are available only with the optional IO Board installed, the **SET R** command has no effect when the IO Board is not installed.

The various editing keys and commands are listed in *Table 7.9*. You may enter only a single element name on each line. To complete the settings process you may either type END followed by **<Enter>** or simply hit **<Enter>** at a blank line.

In order to use the SER data that is generated as a result of these settings, you must enable the SEL-2032 to transmit the data via a binary protocol (see *Logic (SET O) Settings*).

Logic (SET O) Settings

Use the **SET O** command to establish the SELOGIC control equations that control the CCOUT bits. There are a total of 64 bits for each of Ports 17 and 18 that can be directly controlled by these equations. The card installed in the slot must support the CCOUT bits to access these settings. These elements act as inputs to each card installed in a card slot. *Table 7.12* gives a description of these settings. For more information on the operation of these settings see *Section 4: SELOGIC Control Equations*.

Table 7.12 Logic (SET O) Settings and Definition

Setting	Comment	Description
CCOUT1–CCOUT64	CCOUT*n*=	You enter a SELOGIC control equation definition to control the state of the element bit.

Settings Sheets

Using the Settings Sheets

The following settings sheets show the settings available within each setting class. Additionally, the settings sheets show the settings available for specific device configurations.

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Worksheet SET G

Device Identification = ____________________

SEL-2032 Time Synchronization Source (IRIG, DNP, OFF) = ____________________

Type of IRIG Source (Modulated/Demodulated) =____________________

PCFail = ____________________

Enable use of intermediate logic (Y/N) = ____________________

V = ____________________

W = ____________________

X = ____________________

Y = ____________________

Z = ____________________

V Timer Pickup time (seconds) = ____________________

V Timer Dropout time (seconds) = ____________________

W Timer Pickup time (seconds) = ____________________

W Timer Dropout time (seconds) = ____________________

X Timer Pickup time (seconds) = ____________________

X Timer Dropout time (seconds) = ____________________

Y Timer Pickup time (seconds) = ____________________

Y Timer Dropout time (seconds) = ____________________

Z Timer Pickup time (seconds) = ____________________

Z Timer Dropout time (seconds) = ____________________

ALARM = ____________________

OUT1 = ____________________

OUT2 = ____________________

OUT3 = ____________________

OUT4 = ____________________

Date: ______________________________
Approved by: ______________________
SEL-2032 S/N: _____________________

SEL IED, SET P, and SET A

Port ( )		
SET P		
DEVICE	(U=Unused, S=SEL IED, O=Other IED, P=Printer, M=Master)	____________________
CONFIG	Auto-configure port (Y/N)	____________________
PORTID[a]	Port Identification String	____________________
BAUD[a]	(300; 600; 1,200; 2,400; 4,800; 9,600; 19,200)	____________________
DATABIT	Number data bits (7, 8)	____________________
STOPBIT	Stop bits (1, 2)	____________________
PARITY	(N, O, E, 1, 0)	____________________
RTS_CTS	Enable RTS_CTS handshaking (Y/N)	____________________
TIMEOUT	Port timeout (0.0–30.0 minutes)	____________________
SET A		
AUTOBUF	Save Unsolicited Messages (Y/N)	____________________
STARTUP[a]	Port Startup String	____________________
SEND_OPER	Send operate command automatically (Y/N/YP)	____________________
REC_SER	Enable automatic SER collection when applicable (Y/N)	____________________
SP_RATE	Synchrophasor messages per minute (N = NONE, 1, 2, 3, 4, 6, 10, 12, 15, 20, 30, 60) WARNING: Ensure IED supports chosen message rate	____________________
NOCONN	Block external connections to this port	____________________
MSG_CNT	How many auto-message sequences (0–12)	____________________
		____________________
ISSUE1–12	Items 1–12 triggers D1–D12	See Worksheet SET A
MESG1–12	Items 1–12 messages	See Worksheet SET A
PARSE1–8	Items 1–8 response parsing methods	See Worksheet SET A
DECODE1–8	Items 1–8 FLEX parse decode string	See Worksheet SET A
NUM1–8	Items 1–8 number of data items	See Worksheet SET A
DELAY1–12	Items 1–12 time delay to allow response to complete (OFF,ON)	See Worksheet SET A
CHECK1–8	Items 1–8 message validation	See Worksheet SET A
ORDER1–8	Items 1–8 validation byte order	See Worksheet SET A
START1–8	Items 1–8 validation start	See Worksheet SET A
STOP1–8	Items 1–8 validation stop	See Worksheet SET A
CHKPOS1–8	Items 1–8 validation position	See Worksheet SET A
ACK1–8	Items 1–8 acknowledge string	See Worksheet SET A
NACK1–8	Items 1–8 negative acknowledge string	See Worksheet SET A
Archive Settings		
ARCH_EN	Enable use of archive data items (Y/N)	____________________
ISSUE1A–3A	Archive 1–3 triggers A1–A3	See Worksheet SET A
MESG1A–3A	Archive 1–3 messages	See Worksheet SET A
PARSE1A–3A	Archive 1–3 response parsing methods	See Worksheet SET A

Port ( )		
DECODE1A–3A	Archive 1–3 FLEX parse decode string	See Worksheet SET A
NUM1A–3A	Archive 1–3 number of data items	See Worksheet SET A
DELAY1A–3A	Archive 1–3 time delay to allow response to complete (OFF,ON)	See Worksheet SET A
CHECK1A–3A	Archive 1–3 message validation	See Worksheet SET A
ORDER1A–3A	Archive 1–3 validation byte order	See Worksheet SET A
START1A–3A	Archive 1–3 validation start	See Worksheet SET A
STOP1A–3A	Archive 1–3 validation stop	See Worksheet SET A
CHKPOS1A–3A	Archive 1–3 validation position	See Worksheet SET A
ACK1A–3A	Archive 1–3 acknowledge string	See Worksheet SET A
NACK1A–3A	Archive 1–3 negative acknowledge string	See Worksheet SET A
USER	Size of user-defined data space in registers	____________________
SET U		See Worksheet SET U

[a] Set automatically if auto-configuration is performed.

Date: ______________________
Approved by: ______________________
SEL-2032 S/N: ______________________

Other IED, SET P, and SET A

Port ( )		
SET P		
DEVICE	U=Unused, S=SEL IED, O=Other IED, P=Printer, M=Master)	______________
MODEM	Modem control (Y/N)	______________
MSTR	Startup string (only if MODEM is Y)	______________
CD_CTS	Modem CD connected to CTS input (Y/N) (only if MODEM is Y)	______________
DCD_FLOW[a]	Use DCD control line for flow control (Y/N)	______________
AUTO_BAUD	(Y/N)	______________
PROTOCOL	(A=ASCII, B=BINARY)	______________
PORTID	Port Identification String	______________
BAUD[b]	(300; 600; 1,200; 2,400; 4,800; 9,600; 19,200)	______________
DATABIT	Number data bits (7, 8)	______________
STOPBIT	Stop bits (1, 2)	______________
PARITY	(N, O, E, 1, 0)	______________
RTS_CTS	Enable RTS_CTS handshaking (Y/N)	______________
XON_XOFF	Enable XON_XOFF flow control (Y/N)	______________
TIMEOUT	Port timeout (0.0–30.0 minutes)	______________
SET A		
AUTOBUF	Save Unsolicited Messages (Y/N)	______________
STARTUP	Port Startup String	______________
NOCONN	Block external connections to this port	______________
MSG_CNT	How many auto-message sequences (0–12)	______________
ISSUE1–12	Items 1–12 triggers D1–D12	See Worksheet SET A
MESG1–12	Items 1–12 message	See Worksheet SET A
PARSE1–8	Items 1–8 response parsing methods	See Worksheet SET A
DECODE1–8	Items 1–8 FLEX parse decode string	See Worksheet SET A
NUM1–8	Items 1–8 number of data items	See Worksheet SET A
DELAY1–12	Items 1–12 time delay to allow response to complete (OFF,ON)	See Worksheet SET A
CHECK1–8	Items 1–8 message validation	See Worksheet SET A
ORDER1–8	Items 1–8 validation byte order	See Worksheet SET A
START1–8	Items 1–8 validation start	See Worksheet SET A
STOP1–8	Items 1–8 validation stop	See Worksheet SET A
CHKPOS1–8	Items 1–8 validation position	See Worksheet SET A
ACK1–8	Items 1–8 acknowledge string	See Worksheet SET A
NACK1–8	Items 1–8 negative acknowledge string	See Worksheet SET A
ARCH_EN	Enable use of archive data items (Y/N)	______________
ISSUE1A–3A	Archive 1–3 trigger A1–A3	See Worksheet SET A

Port ( )		
MESG1A–3A	Archive 1–3 messages	See Worksheet SET A
PARSE1A–3A	Archive 1–3 response parsing methods	See Worksheet SET A
DECODE1A–3A	Items 1–3 FLEX parse decode string	See Worksheet SET A
NUM1A–3A	Archive 1–3 number of data items	See Worksheet SET A
DELAY1A–3A	Archive 1–3 time delay to allow response to complete (OFF,ON)	See Worksheet SET A
CHECK1A–3A	Archive 1–3 message validation	See Worksheet SET A
ORDER1A–3A	Archive 1–3 validation byte order	See Worksheet SET A
START1A–3A	Archive 1–3 validation start	See Worksheet SET A
STOP1A–3A	Archive 1–3 validation stop	See Worksheet SET A
CHKPOS1A–3A	Archive 1–3 validation position	See Worksheet SET A
ACK1A–3A	Archive 1–3 acknowledge string	See Worksheet SET A
NACK1A–3A	Archive 1–3 negative acknowledge string	See Worksheet SET A
USER	Size of user-defined data space in registers	____________________
SET U		See Worksheet SET U

[a] Only available if MODEM=Y and CD_CTS=N.
[b] Set automatically if auto-baud is performed.

Date: ______________________________

Approved by: ______________________

SEL-2032 S/N: ______________________

Master Port (SEL or LMD Protocol), SET P, and SET A

Port ( )		
SET P		
DEVICE	(U=Unused, S=SEL IED, O=Other IED, P=Printer, M=Master)	____________________
PROTOCOL[a]	(S=SEL, L=LMD, M=Modbus, D=DNP)	____________________
ADDRESS[b]	First LMD port address (1–8)	____________________
PREFIX[b]	LMD address prefix character (@, #, $, %, &)	____________________
SETTLE[b]	LMD port settle time (0–30 seconds)	____________________
FAST_OP[c]	Enable *Fast Operate* commands (Y/N)	____________________
PORTID	Port Identification String	____________________
MODEM	Modem control (Automatically Y if modem installed, automatically N if LMD protocol is selected) (Y/N)	____________________
MSTR	Startup string (only if MODEM is Y)	____________________
CD_CTS	Modem CD connected to CTS input (Y/N) (only if MODEM is Y)	____________________
DCD_FLOW[d]	Use DCD control line for flow control (Y/N)	____________________
BAUD[a]	(300; 600; 1,200; 2,400; 4,800; 9,600; 19,200; 38,400)	____________________
DATABIT[a]	Number data bits (7, 8)	____________________
STOPBIT[a]	Stop bits (1, 2)	____________________
PARITY[a]	(N, O, E, 1, 0)	____________________
RTS_CTS	Enable RTS_CTS handshaking (Y/N)	____________________
XON_XOFF	Enable XON_XOFF flow control (Y/N)	____________________
TIMEOUT	Port timeout (0.0–30.0 minutes)	____________________
ECHO[a]	Echo received characters (Y/N)	____________________
AUTOHELP	Automatic help messages enabled (Y/N)	____________________
TERTIME1	First delay time (0–600 seconds)	____________________
TERSTRING1	Termination string	____________________
TERTIME2	Second delay time (0–600 seconds)	____________________
SET A		
NOCONN	Block external connections to this port	____________________
MSG_CNT	How many auto-message sequences (0–12)	____________________
ISSUE1–12	Items 1–12 triggers D1–D12	See Worksheet SET A
MESG1–12	Items 1–12 messages	See Worksheet SET A
ARCH_EN	Enable use of archive data items (Y/N)	____________________
ISSUE1A–3A	Item 1A–3A trigger ARCH1–ARCH3	____________________
MESG1A–3A	Item 1A–3A message	____________________
USER	Size of user-defined data space in registers	____________________
SET U		See Worksheet SET U

[a] Port F limited to 300–9,600 baud, 8 data bits (including parity), 1 stop bit, SEL protocol, echo enabled, and parity options N, O, and E.
[b] Applies if PROTOCOL set to LMD.
[c] Applies if Protocol set to SEL.
[d] Only available if MODEM=Y and CD_CTS=N.

Master Modbus Port, SET P, and SET A

Port ( )		
SET P		
DEVICE	(U=Unused, S=SEL IED, O=Other IED, P=Printer, M=Master)	____________________
PROTOCOL	(S=SEL, L=LMD, M=Modbus, D=DNP)	____________________
MAP_TYPE	(F=Float, I=Integer)	____________________
START_ID	Starting Code for ID list (0–255)	____________________
SETTLE1	Transmission delay from RTS assertion, ms	____________________
SETTLE2	Post-transmit RTS deassertion delay, ms	____________________
BUSY_DIS	Disable transmission of Busy response	____________________
ADDRESS1	Address of Port 1 (1–247)	____________________
ADDRESS2	Address of Port 2 (1–247)	____________________
ADDRESS3	Address of Port 3 (1–247)	____________________
ADDRESS4	Address of Port 4 (1–247)	____________________
ADDRESS5	Address of Port 5 (1–247)	____________________
ADDRESS6	Address of Port 6 (1–247)	____________________
ADDRESS7	Address of Port 7 (1–247)	____________________
ADDRESS8	Address of Port 8 (1–247)	____________________
ADDRESS9	Address of Port 9 (1–247)	____________________
ADDRESS10	Address of Port 10 (1–247)	____________________
ADDRESS11	Address of Port 11 (1–247)	____________________
ADDRESS12	Address of Port 12 (1–247)	____________________
ADDRESS13	Address of Port 13 (1–247)	____________________
ADDRESS14	Address of Port 14 (1–247)	____________________
ADDRESS15	Address of Port 15 (1–247)	____________________
ADDRESS16	Address of Port 16 (1–247)	____________________
PORT ID	Port Identification String	____________________
BAUD	(300; 600; 1,200; 2,400; 4,800; 9,600; 19,200; 38,400)	____________________
PARITY	(N,O,E)	____________________
SET A		
MSG_CNT	How many auto-message sequences (0–1)	____________________
ISSUE1	Item 1 trigger D1	____________________
MESG1	Item 1 message	____________________
ARCH_EN	Enable use of archive data items (Y/N)	____________________
ISSUE1A	Item 1A trigger ARCH1	____________________
MESG1A	Item 1A message	____________________
USER	Size of user-defined data space in registers	____________________
SET U		Not available.

Date: ____________________
Approved by: ____________________
SEL-2032 S/N: ____________________

Master DNP3 Port, SET P, and SET A

Port ( )		
SET P		
DEVICE	(U=Unused, S=SEL IED, O=Other IED, P=Printer, M=Master)	____________
PROTOCOL	(S=SEL, L=LMD, M=Modbus, D=DNP)	____________
ADDRESS	DNP Address (0–65534 or 0000h–FFFEh)	____________
CLASS	Class for event data (0 for no event, 1–3)	____________
16BIT	Use 16- or 32-bit default variations for analog inputs	____________
SO_TIMEOUT	Select/Operate time-out interval, seconds (0.0–30.0)	____________
DL_CONFIRM	Number of data-link retries (0 for no confirm, 1–15)	____________
DL_TIMEOUT	Data Link Time-out interval, seconds (0.0–30.0)	____________
MIN_DELAY	Minimum Delay from DCD to transmission, ms	____________
MAX_DELAY	Maximum Delay from DCD to transmission, ms	____________
SETTLE1	Transmission delay from RTS assertion, ms	____________
SETTLE2	Post-transmit RTS deassertion delay, ms	____________
REPORT_ON	Percent of Full-Scale Change to Report on (0–100%)	____________
UNSOL_REP	Allow Unsolicited Reporting (Y/N)	____________
UNSOL_POW	Enable unsolicited messages on power up (Y/N)	____________
REP_ADDR	Address of master to Report to (0–65534 or 0000h–FFFEh)	____________
NUM_EVENT	Number of events to transmit on (1–200)	____________
AGE_TX	Age of oldest event to force transmit on, sec (1.0–60.0)	____________
CONFIRM_TO	Time-out for confirmation of unsolicited message, ms	____________
DNP_PAIR	Enable use of DNP Trip/Close pairs (Y/N)	____________
CLS0_VIEW	Make control points visible in Class 0 polls (Y/N)	____________
DNP_CMDNUM	Number of CMD bits available per port (0–8)	____________
DNP_SBONUM	Number of SBO bits available per port (0–4)	____________
DNP_BRNUM	Number of Breaker bits available per port (0–16)	____________
DNP_RBNUM	Number of Remote bits available per port (0–16)	____________
PORT ID	Port Identification String	____________
BAUD	(300; 600; 1,200; 2,400; 4,800; 9,600; 19,200; 38,400)	____________
SET A		
MSG_CNT	How many auto-message sequences (0–1)	____________
ISSUE1	Item 1 trigger, D1	____________
MESG1	Item 1 message	____________
ARCH_EN	Enable use of archive data items (Y/N)	____________
ISSUE1A	Item 1A trigger, ARCH1	____________
MESG1A	Item 1A message	____________
USER	Size of user-defined data space	____________
SET U		Not available.

Printer, SET P, and SET A

Port ( )		
SET P		
DEVICE	(U=Unused, S=SEL IED, O=Other IED, P=Printer, M=Master)	____________________
PORTID	Port Identification String	____________________
BAUD	(300; 600; 1,200; 2,400; 4,800; 9,600; 19,200)	____________________
DATABIT	Number data bits (7, 8)	____________________
STOPBIT	Stop bits (1, 2)	____________________
PARITY	(N, O, E, 1, 0)	____________________
RTS_CTS	Enable RTS_CTS handshaking (Y/N)	____________________
XON_XOFF	Enable XON_XOFF flow control (Y/N)	____________________
TIMEOUT	Port timeout (0.0–30.0 minutes)	____________________
SET A		
STARTUP	Port Startup String	____________________
MSG_CNT	How many auto-message sequences (0–12)	____________________
PRINT_ALL	Print all buffered unsolicited messages (Y/N)	____________________
CLEAR_BUF	Clear unsolicited message buffer after print (Y/N)	____________________
ISSUE2–12	Items 2–12 trigger D2–D12	See Worksheet SET A
MESG2–12	Items 2–12 messages	See Worksheet SET A
USER	Size of user-defined data space in registers	____________________
SET U		Not available.

Date: ______________________________
Approved by: _______________________
SEL-2032 S/N: ______________________

SEL-2701, SET P, and SET A

Port (17 / 18)		
SET P		
SENDTIME	Send Date/Time synchronization to Protocol Card (Y/N)	____________________
XON_XOFF	Enable XON/XOFF flow control (Y/N	____________________
TIMEOUT	Port Timeout in minutes (0.0–120.0)	____________________
TERTIME1	First delay time (0–600 seconds)	____________________
TERSTRING	Termination string	____________________
TERTIME2	Second delay time (0–600 seconds)	____________________
IPADDR	IP address (www[h].xxx[h].yyy[h].zzz[h])	____________________
SUBNETM	Subnet mask (www[h].xxx[h].yyy[h].zzz[h])	____________________
DEFRTR	Default router (www[h].xxx[h].yyy[h].zzz[h])	____________________
NETPORT	Primary network port (A=Port A, B=Port B, D=Disabled)	____________________
FAILOVR	Enable fail over mode (Y/N)	____________________
FTIME	Network port fail over time (0–65535 msec)	____________________
NETASPD	Network speed, Port A (A=Auto, 10=Mbs, 100=100Mbs)	____________________
NETBSPD	Network speed, Port B (A=Auto, 10=Mbs, 100=100Mbs)	____________________
FTPSERV	Enable FTP server (Y/N)	____________________
FTPCBAN	FTP connect banner	____________________
FTPIDLE	FTP idle time-out (5–255 minutes)	____________________
FTPANMS	Enable anonymous FTP login (Y/N)	____________________
FTPAUSR	Associate anonymous user access rights with user	____________________
T1CBAN	Telnet connect banner for host	____________________
T1INIT	Allow Telnet sessions to be initiated by the host (Y/N)	____________________
T1RECV	Allow Telnet sessions to be received by the host (Y/N)	____________________
T1PNUM	Telnet port number for host (port_num = 23 or >= 1024)	____________________
T2CBAN	Telnet connect banner for card	____________________
T2RECV	Allow Telnet sessions to be received by the card (Y/N)	____________________
T2PNUM	Telnet port number for card (port_num >= 1024)	____________________
TIDLE	Telnet idle time-out (0–255 minutes)	____________________
HOST1	Alias for host #1	____________________
IPADR1	IP address for host #1 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST2	Alias for host #2	____________________
IPADR2	IP address for host #2 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST3	Alias for host #3	____________________
IPADR3	IP address for host #3 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST4	Alias for host #4	____________________
IPADR4	IP address for host #4 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST5	Alias for host #5	____________________
IPADR5	IP address for host #5 (www[h].xxx[h].yyy[h].zzz[h])	____________________

Port (17 / 18)		
HOST6	Alias for host #6	____________________
IPADR6	IP address for host #6 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST7	Alias for host #7	____________________
IPADR7	IP address for host #7 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST8	Alias for host #8	____________________
IPADR8	IP address for host #8 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST9	Alias for host #9	____________________
IPADR9	IP address for host #9 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST10	Alias for host #10	____________________
IPADR10	IP address for host #10 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST11	Alias for host #11	____________________
IPADR11	IP address for host #11 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST12	Alias for host #12	____________________
IPADR12	IP address for host #12 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST13	Alias for host #13	____________________
IPADR13	IP address for host #13 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST14	Alias for host #14	____________________
IPADR14	IP address for host #14 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST15	Alias for host #15	____________________
IPADR15	IP address for host #15 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST16	Alias for host #16	____________________
IPADR16	IP address for host #16 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST17	Alias for host #17	____________________
IPADR17	IP address for host #17 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST18	Alias for host #18	____________________
IPADR18	IP address for host #18 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST19	Alias for host #19	____________________
IPADR19	IP address for host #19 (www[h].xxx[h].yyy[h].zzz[h])	____________________
HOST20	Alias for host #20	____________________
IPADR20	IP address for host #20 (www[h].xxx[h].yyy[h].zzz[h])	____________________
ENUCA	Enable UCA protocol (Y/N)	____________________
NSAP	Network Service Access Point (xxxx.yyyy.zzzz)	____________________
ENTXGOS	Enable transmission of the GOOSE (Y/N)	____________________
TRMULGR	GOOSE sending multicast group address (uu-vv-ww-xx-yy-zz)	____________________
GOSIED	GOOSE sending IED name	____________________
GOSRPTC	GOOSE sending repeat timing coefficient (1.0<=coeff<2.0)	____________________
GOSIED1	GOOSE sending IED for monitor1	____________________
GOSIED2	GOOSE sending IED for monitor2	____________________
GOSIED3	GOOSE sending IED for monitor3	____________________
GOSIED4	GOOSE sending IED for monitor4	____________________
GOSIED5	GOOSE sending IED for monitor5	____________________

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Port (17 / 18)		
GOSIED6	GOOSE sending IED for monitor6	____________________
GOSIED7	GOOSE sending IED for monitor7	____________________
GOSIED8	GOOSE sending IED for monitor8	____________________
CTRLB1	Control bit 1 assignment (msg=1–8:bit=0–160)	____________________
CTRLB2	Control bit 2 assignment (msg=1–8:bit=0–160)	____________________
CTRLB3	Control bit 3 assignment (msg=1–8:bit=0–160)	____________________
CTRLB4	Control bit 4 assignment (msg=1–8:bit=0–160)	____________________
CTRLB5	Control bit 5 assignment (msg=1–8:bit=0–160)	____________________
CTRLB6	Control bit 6 assignment (msg=1–8:bit=0–160)	____________________
CTRLB7	Control bit 7 assignment (msg=1–8:bit=0–160)	____________________
CTRLB8	Control bit 8 assignment (msg=1–8:bit=0–160)	____________________
CTRLB9	Control bit 9 assignment (msg=1–8:bit=0–160)	____________________
CTRLB10	Control bit 10 assignment (msg=1–8:bit=0–160)	____________________
CTRLB11	Control bit 11 assignment (msg=1–8:bit=0–160)	____________________
CTRLB12	Control bit 12 assignment (msg=1–8:bit=0–160)	____________________
CTRLB13	Control bit 13 assignment (msg=1–8:bit=0–160)	____________________
CTRLB14	Control bit 14 assignment (msg=1–8:bit=0–160)	____________________
CTRLB15	Control bit 15 assignment (msg=1–8:bit=0–160)	____________________
CTRLB16	Control bit 16 assignment (msg=1–8:bit=0–160)	____________________
CTRLB17	Control bit 17 assignment (msg=1–8:bit=0–160)	____________________
CTRLB18	Control bit 18 assignment (msg=1–8:bit=0–160)	____________________
CTRLB19	Control bit 19 assignment (msg=1–8:bit=0–160)	____________________
CTRLB20	Control bit 20 assignment (msg=1–8:bit=0–160)	____________________
CTRLB21	Control bit 21 assignment (msg=1–8:bit=0–160)	____________________
CTRLB22	Control bit 22 assignment (msg=1–8:bit=0–160)	____________________
CTRLB23	Control bit 23 assignment (msg=1–8:bit=0–160)	____________________
CTRLB24	Control bit 24 assignment (msg=1–8:bit=0–160)	____________________
CTRLB25	Control bit 25 assignment (msg=1–8:bit=0–160)	____________________
CTRLB26	Control bit 26 assignment (msg=1–8:bit=0–160)	____________________
CTRLB27	Control bit 27 assignment (msg=1–8:bit=0–160)	____________________
CTRLB28	Control bit 28 assignment (msg=1–8:bit=0–160)	____________________
CTRLB29	Control bit 29 assignment (msg=1–8:bit=0–160)	____________________
CTRLB30	Control bit 30 assignment (msg=1–8:bit=0–160)	____________________
CTRLB31	Control bit 31 assignment (msg=1–8:bit=0–160)	____________________
CTRLB32	Control bit 32 assignment (msg=1–8:bit=0–160)	____________________
CTRLB33	Control bit 33 assignment (msg=1–8:bit=0–160)	____________________
CTRLB34	Control bit 34 assignment (msg=1–8:bit=0–160)	____________________
CTRLB35	Control bit 35 assignment (msg=1–8:bit=0–160)	____________________
CTRLB36	Control bit 36 assignment (msg=1–8:bit=0–160)	____________________
CTRLB37	Control bit 37 assignment (msg=1–8:bit=0–160)	____________________
CTRLB38	Control bit 38 assignment (msg=1–8:bit=0–160)	____________________

Port (17 / 18)		
CTRLB39	Control bit 39 assignment (msg=1–8:bit=0–160)	____________________
CTRLB40	Control bit 40 assignment (msg=1–8:bit=0–160)	____________________
CTRLB41	Control bit 41 assignment (msg=1–8:bit=0–160)	____________________
CTRLB42	Control bit 42 assignment (msg=1–8:bit=0–160)	____________________
CTRLB43	Control bit 43 assignment (msg=1–8:bit=0–160)	____________________
CTRLB44	Control bit 44 assignment (msg=1–8:bit=0–160)	____________________
CTRLB45	Control bit 45 assignment (msg=1–8:bit=0–160)	____________________
CTRLB46	Control bit 46 assignment (msg=1–8:bit=0–160)	____________________
CTRLB47	Control bit 47 assignment (msg=1–8:bit=0–160)	____________________
CTRLB48	Control bit 48 assignment (msg=1–8:bit=0–160)	____________________
CTRLB49	Control bit 49 assignment (msg=1–8:bit=0–160)	____________________
CTRLB50	Control bit 50 assignment (msg=1–8:bit=0–160)	____________________
CTRLB51	Control bit 51 assignment (msg=1–8:bit=0–160)	____________________
CTRLB52	Control bit 52 assignment (msg=1–8:bit=0–160)	____________________
CTRLB53	Control bit 53 assignment (msg=1–8:bit=0–160)	____________________
CTRLB54	Control bit 54 assignment (msg=1–8:bit=0–160)	____________________
CTRLB55	Control bit 55 assignment (msg=1–8:bit=0–160)	____________________
CTRLB56	Control bit 56 assignment (msg=1–8:bit=0–160)	____________________
CTRLB57	Control bit 57 assignment (msg=1–8:bit=0–160)	____________________
CTRLB58	Control bit 58 assignment (msg=1–8:bit=0–160)	____________________
CTRLB59	Control bit 59 assignment (msg=1–8:bit=0–160)	____________________
CTRLB60	Control bit 60 assignment (msg=1–8:bit=0–160)	____________________
CTRLB61	Control bit 61 assignment (msg=1–8:bit=0–160)	____________________
CTRLB62	Control bit 62 assignment (msg=1–8:bit=0–160)	____________________
CTRLB63	Control bit 63 assignment (msg=1–8:bit=0–160)	____________________
CTRLB64	Control bit 64 assignment (msg=1–8:bit=0–160)	____________________
ENDNP	Enable DNP3 (Y,N)	____________________
DNPADR	DNP3 Address (0–65519)	____________________
DNPPNUM	DNP3 Port Number for TCP and UDP (1–65534)	____________________
DNPMAP	DNP3 map Mode (AUTO, CUSTOM)	____________________
RPADR01	DNP3 Address for Master 1 (0–65519)	____________________
DNPIP01	IP Address for Master 1 (www.xxx.yyy.zzz)	____________________
DNPTR01	Transport Protocol for Master 1 (UDP, TCP)	____________________
DNPUP01	UDP Response Port Number for Master 1 (1–65534, REQ)	____________________
UNSL01	Enable Unsolicited Reporting for Master 1 (Y,N)	____________________
PUNSL01	Enable Unsolicited Reporting at Power up for Master 1 (Y,N)	____________________
DNPMP01	CUSTOM Mode: DNP3 map associated with Master 1 (1–5)	____________________
DNPCL01	Enable Controls for Master 1 (Y,N)	____________________
RPADR02	DNP3 Address for Master 2 (0–65519)	____________________
DNPIP02	IP Address for Master 2 (www.xxx.yyy.zzz)	____________________
DNPTR02	Transport Protocol for Master 2 (UDP, TCP)	____________________

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Port (17 / 18)		
DNPUP02	UDP Response Port Number for Master 2 (1–65534, REQ)	____________
UNSL02	Enable Unsolicited Reporting for Master 2 (Y,N)	____________
PUNSL02	Enable Unsolicited Reporting at Power up for Master 2 (Y,N)	____________
DNPMP02	CUSTOM Mode: DNP3 map associated with Master 2 (1–5)	____________
DNPCL02	Enable Controls for Master 2 (Y,N)	____________
RPADR03	DNP3 Address for Master 3 (0–65519)	____________
DNPIP03	IP Address for Master 3 (www.xxx.yyy.zzz)	____________
DNPTR03	Transport Protocol for Master 3 (UDP, TCP)	____________
DNPUP03	UDP Response Port Number for Master 3 (1–65534, REQ)	____________
UNSL03	Enable Unsolicited Reporting for Master 3 (Y,N)	____________
PUNSL03	Enable Unsolicited Reporting at Power up for Master 3 (Y,N)	____________
DNPMP03	CUSTOM Mode: DNP3 map associated with Master 3 (1–5)	____________
DNPCL03	Enable Controls for Master 3 (Y,N)	____________
RPADR04	DNP3 Address for Master 4 (0–65519)	____________
DNPIP04	IP Address for Master 4 (www.xxx.yyy.zzz)	____________
DNPTR04	Transport Protocol for Master 4 (UDP, TCP)	____________
DNPUP04	UDP Response Port Number for Master 4 (1–65534, REQ)	____________
UNSL04	Enable Unsolicited Reporting for Master 4 (Y,N)	____________
PUNSL04	Enable Unsolicited Reporting at Power up for Master 4 (Y,N)	____________
DNPMP04	CUSTOM Mode: DNP3 map associated with Master 4 (1–5)	____________
DNPCL04	Enable Controls for Master 4 (Y,N)	____________
RPADR05	DNP3 Address for Master 5 (0–65519)	____________
DNPIP05	IP Address for Master 5 (www.xxx.yyy.zzz)	____________
DNPTR05	Transport Protocol for Master 5 (UDP, TCP)	____________
DNPUP05	UDP Response Port Number for Master 5 (1–65534, REQ)	____________
UNSL05	Enable Unsolicited Reporting for Master 5 (Y,N)	____________
PUNSL05	Enable Unsolicited Reporting at Power up for Master 5 (Y,N)	____________
DNPMP05	CUSTOM Mode: DNP3 map associated with Master 5 (1–5)	____________
DNPCL05	Enable Controls for Master 5 (Y,N)	____________
RPADR06	DNP3 Address for Master 6 (0–65519)	____________
DNPIP06	IP Address for Master 6 (www.xxx.yyy.zzz)	____________
DNPTR06	Transport Protocol for Master 6 (UDP, TCP)	____________
DNPUP06	UDP Response Port Number for Master 6 (1–65534, REQ)	____________
UNSL06	Enable Unsolicited Reporting for Master 6 (Y,N)	____________
PUNSL06	Enable Unsolicited Reporting at Power up for Master 6 (Y,N)	____________
DNPCL06	Enable Controls for Master 4 (Y,N)	____________
RPADR07	DNP3 Address for Master 7 (0–65519)	____________
DNPIP07	IP Address for Master 7 (www.xxx.yyy.zzz)	____________
DNPTR07	Transport Protocol for Master 7 (UDP, TCP)	____________
DNPUP07	UDP Response Port Number for Master 7 (1–65534, REQ)	____________
UNSL07	Enable Unsolicited Reporting for Master 7 (Y,N)	____________

Port (17 / 18)		
PUNSL07	Enable Unsolicited Reporting at Power up for Master 7 (Y,N)	____________
DNPMP07	CUSTOM Mode: DNP3 map associated with Master 7 (1–5)	____________
DNPCL07	Enable Controls for Master 7 (Y,N)	____________
RPADR08	DNP3 Address for Master 8 (0–65519)	____________
DNPIP08	IP Address for Master 8 (www.xxx.yyy.zzz)	____________
DNPTR08	Transport Protocol for Master 8 (UDP, TCP)	____________
DNPUP08	UDP Response Port Number for Master 8 (1–65534, REQ)	____________
UNSL08	Enable Unsolicited Reporting for Master 8 (Y,N)	____________
PUNSL08	Enable Unsolicited Reporting at Power up for Master 8 (Y,N)	____________
DNPMP08	CUSTOM Mode: DNP3 map associated with Master 8 (1–5)	____________
DNPCL08	Enable Controls for Master 8 (Y,N)	____________
RPADR09	DNP3 Address for Master 9 (0 - 65519)	____________
DNPIP09	IP Address for Master 9 (www.xxx.yyy.zzz)	____________
DNPTR09	Transport Protocol for Master 9 (UDP, TCP)	____________
DNPUP09	UDP Response Port Number for Master 9 (1–65534, REQ)	____________
UNSL09	Enable Unsolicited Reporting for Master 9 (Y,N)	____________
PUNSL09	Enable Unsolicited Reporting at Power up for Master 9 (Y,N)	____________
DNPMP09	CUSTOM Mode: DNP3 map associated with Master 9 (1–5)	____________
DNPCL09	Enable Controls for Master 9 (Y,N)	____________
RPADR10	DNP3 Address for Master 10 (0–65519)	____________
DNPIP10	IP Address for Master 10 (www.xxx.yyy.zzz)	____________
DNPTR10	Transport Protocol for Master 10 (UDP, TCP)	____________
DNPUP10	UDP Response Port Number for Master 10 (1–65534, REQ)	____________
UNSL10	Enable Unsolicited Reporting for Master 10 (Y,N)	____________
PUNSL10	Enable Unsolicited Reporting at Power up for Master 10 (Y,N)	____________
DNPMP10	CUSTOM Mode: DNP3 map associated with Master 10 (1–5)	____________
DNPCL10	Enable Controls for Master 10 (Y,N)	____________
ECLASSA	Class for Analog Event Data (0–3)	____________
ECLASSB	Class for Binary Event Data (0–3)	____________
ECLASSC	Class for Counter Event Data (0–3)	____________
DECPL	Data Scaling Decimal Places (0–3)	____________
ANADB	Data Reporting Dead Band Counts (0–32767)	____________
STIMEO	Seconds to Select/Operate Time-out (0.0–30.0)	____________
DNPPAIR	AUTO Mode: Enable Use of DNP3 Trip Close Pairs (Y,N)	____________
DNPINA	Seconds to send Inactive Heartbeat (0=Off, 1–7200)	____________
NUMEVE	Number of Events to Transmit On (1–200)	____________
AGEEVE	Age of Oldest Event to Transmit On (0–100000 sec)	____________
ETIMEO	Event Message Confirm Timeout (1–50 sec)	____________
URETRY	Unsolicited Message Max Retry Attempts (2–10)	____________
UTIMEO	Unsolicited Message Offline Timeout (1–5000 sec)	____________

Date: ______________________
Approved by: ______________________
SEL-2032 S/N: ______________________

Port (17 / 18)		
SET A		
NOCONN	Block external connections to this port	____________________
MSG_CNT	How many auto-message sequences (0–12)	____________________
ISSUE1–12	Items 1–12 trigger D1–12	See Worksheet SET A
MESG1–12	Items 1–12 messages	See Worksheet SET A
USER	Size of user-defined data space in registers	____________________
SET U		
CMD_EN	Enable SEL-2032 commands (Y/N)	____________________
CMD_CH	Command termination character	____________________
CMD_CNT	Number of general-purpose commands (0–8)	____________________
CMD1–8	Command strings 1–8	See Worksheet SETU

SEL-2711, SET P

Port (17 / 18)		
SET P		
ADDRESS	Modbus Plus node Address (1–64)	___________________
MAP_IR	Map Input Registers to Holding Registers (Y/N)	___________________
PATH_1	Control Point 1 routing path (Address range 1–247, 0=OFF)	___________________
COIL_1	Control Point 1 Modbus coil number	___________________
PATH_2	Control Point 2 routing path (Address range 1–247, 0=OFF)	___________________
COIL_2	Control Point 2 Modbus coil number	___________________
PATH_3	Control Point 3 routing path (Address range 1–247, 0=OFF)	___________________
COIL_3	Control Point 3 Modbus coil number	___________________
PATH_4	Control Point 4 routing path (Address range 1–247, 0=OFF)	___________________
COIL_4	Control Point 4 Modbus coil number	___________________
PATH_5	Control Point 5 routing path (Address range 1–247, 0=OFF)	___________________
COIL_5	Control Point 5 Modbus coil number	___________________
PATH_6	Control Point 6 routing path (Address range 1–247, 0=OFF)	___________________
COIL_6	Control Point 6 Modbus coil number	___________________
PATH_7	Control Point 7 routing path (Address range 1–247, 0=OFF)	___________________
COIL_7	Control Point 7 Modbus coil number	___________________
PATH_8	Control Point 8 routing path (Address range 1–247, 0=OFF)	___________________
COIL_8	Control Point 8 Modbus coil number	___________________
PATH_9	Control Point 9 routing path (Address range 1–247, 0=OFF)	___________________
COIL_9	Control Point 9 Modbus coil number	___________________
PATH_10	Control Point 10 routing path (Address range 1–247, 0=OFF)	___________________
COIL_10	Control Point 10 Modbus coil number	___________________
PATH_11	Control Point 11 routing path (Address range 1–247, 0=OFF)	___________________
COIL_11	Control Point 11 Modbus coil number	___________________
PATH_12	Control Point 12 routing path (Address range 1–247, 0=OFF)	___________________
COIL_12	Control Point 12 Modbus coil number	___________________
PATH_13	Control Point 13 routing path (Address range 1–247, 0=OFF)	___________________
COIL_13	Control Point 13 Modbus coil number	___________________
PATH_14	Control Point 14 routing path (Address range 1–247, 0=OFF)	___________________
COIL_14	Control Point 14 Modbus coil number	___________________
PATH_15	Control Point 15 routing path (Address range 1–247, 0=OFF)	___________________
COIL_15	Control Point 15 Modbus coil number	___________________
PATH_16	Control Point 16 routing path (Address range 1–247, 0=OFF)	___________________
COIL_16	Control Point 16 Modbus coil number	___________________
SET A		Not available.
SET U		Not available.

Date: ____________________________
Approved by: ______________________
SEL-2032 S/N: _____________________

Worksheet SET A

D1

ISSUE1: ____

MESG1: ____

____

PARSE1: ____________ NUM1:____________ DELAY1:____________

DECODE1: ____

CHECK1:________ ORDER1:________ START1: ________ STOP1:________ CKPOS1: ________

ACK1: ______________________ NACK1: ______________________

D2

ISSUE2: ____

MESG2: ____

____

PARSE2: ____________ NUM2:____________ DELAY2:____________

DECODE2: ____

CHECK2:________ ORDER2:________ START2: ________ STOP2:________ CKPOS2: ________

ACK2: ______________________ NACK2: ______________________

D3

ISSUE3: ____

MESG3: ____

____

PARSE3: ____________ NUM3:____________ DELAY3:____________

DECODE3: ____

CHECK3:________ ORDER3:________ START3: ________ STOP3:________ CKPOS3: ________

ACK3: ______________________ NACK3: ______________________

D4

ISSUE4: ____

MESG4: ____

____

PARSE4: ____________ NUM4:____________ DELAY4:____________

DECODE4: ____

CHECK4:________ ORDER4:________ START4: ________ STOP4:________ CKPOS4: ________

ACK4: ______________________ NACK4: ______________________

D5

ISSUE5: ____

MESG5: ____

____

PARSE5: ____________________ NUM5: ____________________ DELAY5: ____________________

DECODE5: ____

CHECK5: ________ ORDER5: ________ START5: ________ STOP5: ________ CKPOS5: ________

ACK5: ______________________________ NACK5: ______________________________

D6

ISSUE6: ____

MESG6: ____

____

PARSE6: ____________________ NUM6: ____________________ DELAY6: ____________________

DECODE6: ____

CHECK6: ________ ORDER6: ________ START6: ________ STOP6: ________ CKPOS6: ________

ACK6: ______________________________ NACK6: ______________________________

D7

ISSUE7: ____

MESG7: ____

____

PARSE7: ____________________ NUM7: ____________________ DELAY7: ____________________

DECODE7: ____

CHECK7: ________ ORDER7: ________ START7: ________ STOP7: ________ CKPOS7: ________

ACK7: ______________________________ NACK7: ______________________________

D8

ISSUE8: ____

MESG8: ____

____

PARSE8: ____________________ NUM8: ____________________ DELAY8: ____________________

DECODE8: ____

CHECK8: ________ ORDER8: ________ START8: ________ STOP8: ________ CKPOS8: ________

ACK8: ______________________________ NACK8: ______________________________

Date: ____________________
Approved by: ____________________
SEL-2032 S/N: ____________________

D9

ISSUE9: ____________________

MESG9: ____________________

____

DELAY9: ____________________

D10

ISSUE10: ____________________

MESG10: ____________________

____

DELAY10: ____________________

D11

ISSUE11: ____________________

MESG11: ____________________

____

DELAY11: ____________________

D12

ISSUE12: ____________________

MESG12: ____________________

____

DELAY12: ____________________

A1

ISSUE1A: ____

MESG1A: ____

____

PARSE1A: ____________ NUM1A: ____________ DELAY1A: ____________

DECODE1A: ____

CHECK1A: ______ ORDER1A: ______ START1A: _______ STOP1A: ________ CKPOS1A: ________

ACK1A: ______________________ NACK1A: ______________________

A2

ISSUE2A: ____

MESG2A: ____

____

PARSE2A: ____________ NUM2A: ____________ DELAY2A: ____________

DECODE2A: ____

CHECK2A: ______ ORDER2A: ______ START2A: _______ STOP2A: ________ CKPOS2A: ________

ACK2A: ______________________ NACK2A: ______________________

A3

ISSUE3A: ____

MESG3A: ____

____

PARSE3A: ____________ NUM3A: ____________ DELAY3A: ____________

DECODE3A: ____

CHECK3A: ______ ORDER3A: ______ START3A: _______ STOP3A: ________ CKPOS3A: ________

ACK3A: ______________________ NACK3A: ______________________

Date: ______________________
Approved by: ______________________
SEL-2032 S/N: ______________________

Worksheet SET U

CMD_EN[1]	Enable SEL-2032 commands (Y/N)	______
CMD_CH[1]	Command termination character	______
CMD_CNT	Number of general-purpose commands (0–8)	______
CMD1	Command String 1 =	______
CMD2	Command String 2 =	______
CMD3	Command String 3 =	______
CMD4	Command String 4 =	______
CMD5[1]	Command String 5 =	______
CMD6[1]	Command String 6 =	______
CMD7[1]	Command String 7 =	______
CMD8[1]	Command String 8 =	______
STR_EN[1]	Enable use of special-purpose commands (Y/N)	______
TRANS[1]	Initiate transparent mode sequence	______
TRANSACK[1]	Transparent mode acknowledge	______
TRANSNACK[1]	Transparent mode denial	______
READ[1]	Read data	______
READACK[1]	Read data normal response	______
READNACK[1]	Read data error response	______
WRITE[1]	Write data	______
WRITEACK[1]	Write data success response	______
WRITENACK[1]	Write data error response	______

[1] Only available on Master ports

Worksheet SET L

Port #_____

SBR1 = ____

SBR2 = ____

SBR3 = ____

SBR4 = ____

SBR5 = ____

SBR6 = ____

SBR7 = ____

SBR8 = ____

SBR9 = ____

SBR10 = ____

SBR11 = ____

SBR12 = ____

SBR13 = ____

SBR14 = ____

SBR15 = ____

SBR16 = ____

CBR1 = ____

CBR2 = ____

CBR3 = ____

CBR4 = ____

CBR5 = ____

CBR6 = ____

CBR7 = ____

CBR8 = ____

CBR9 = ____

CBR10 = ____

CBR11 = ____

CBR12 = ____

CBR13 = ____

CBR14 = ____

CBR15 = ____

CBR16 = ____

SRB1 = ____

SRB2 = ____

SRB3 = ____

Date: ______________________

Approved by: ______________________

SEL-2032 S/N: ______________________

SRB4 = ______________________

SRB5 = ______________________

SRB6 = ______________________

SRB7 = ______________________

SRB8 = ______________________

SRB9 = ______________________

SRB10 = ______________________

SRB11 = ______________________

SRB12 = ______________________

SRB13 = ______________________

SRB14 = ______________________

SRB15 = ______________________

SRB16 = ______________________

CRB1 = ______________________

CRB2 = ______________________

CRB3 = ______________________

CRB4 = ______________________

CRB5 = ______________________

CRB6 = ______________________

CRB7 = ______________________

CRB8 = ______________________

CRB9 = ______________________

CRB10 = ______________________

CRB11 = ______________________

CRB12 = ______________________

CRB13 = ______________________

CRB14 = ______________________

CRB15 = ______________________

CRB16 = ______________________

Date: ______________________________

Approved by: ________________________

SEL-2032 S/N: ______________________

Worksheet SET M

Data Destination				Equation	Comments
Register or Bit Reference	Type	Access Type	Label		

Date: ______________________________
Approved by: ________________________
SEL-2032 S/N: _______________________

Worksheet SET O

Port # ___________

CCOUT1 = ____

CCOUT2 = ____

CCOUT3 = ____

CCOUT4 = ____

CCOUT5 = ____

CCOUT6 = ____

CCOUT7 = ____

CCOUT8 = ____

CCOUT9 = ____

CCOUT10 = ____

CCOUT11 = ____

CCOUT12 = ____

CCOUT13 = ____

CCOUT14 = ____

CCOUT15 = ____

CCOUT16 = ____

CCOUT17 = ____

CCOUT18 = ____

CCOUT19 = ____

CCOUT20 = ____

CCOUT21 = ____

CCOUT22 = ____

CCOUT23 = ____

CCOUT24 = ____

CCOUT25 = ____

CCOUT26 = ____

CCOUT27 = ____

CCOUT28 = ____

CCOUT29 = ____

CCOUT30 = ____

CCOUT31 = ____

CCOUT32 = ____

CCOUT33 = ____

CCOUT34 = ____

CCOUT35 = ____

CCOUT36 = ____________________

CCOUT37 = ____________________

CCOUT38 = ____________________

CCOUT39 = ____________________

CCOUT40 = ____________________

CCOUT41 = ____________________

CCOUT42 = ____________________

CCOUT43 = ____________________

CCOUT44 = ____________________

CCOUT45 = ____________________

CCOUT46 = ____________________

CCOUT47 = ____________________

CCOUT48 = ____________________

CCOUT49 = ____________________

CCOUT50 = ____________________

CCOUT51 = ____________________

CCOUT52 = ____________________

CCOUT53 = ____________________

CCOUT54 = ____________________

CCOUT55 = ____________________

CCOUT56 = ____________________

CCOUT57 = ____________________

CCOUT58 = ____________________

CCOUT59 = ____________________

CCOUT60 = ____________________

CCOUT61 = ____________________

CCOUT62= ____________________

CCOUT63 = ____________________

CCOUT64 = ____________________

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Section 8

Serial Port Communications and Commands

Introduction

You can control, monitor, operate, and set the SEL-2032 Communications Processor with the command set described in this section. You can use this command set by connecting to the SEL-2032 front port or any rear port set to the SEL protocol. This section is a reference for using SEL-2032 commands. For examples of how to accomplish specific tasks with these commands, see *Section 1: Introduction and Specifications,* and *Section 3: Job Done Examples*. A list summarizing the commands appears on a blue pullout card at the back of the book.

Command Operation

Command/response protocol refers to the command structure and syntax that you must use to communicate with the SEL-2032. Access levels determine the levels at which you can interrogate the SEL-2032. Higher levels of access are required to set and operate the device.

Command/Response Protocol

The built-in SEL-2032 command set operates according to the following command/response protocol:

- All commands accepted by the SEL-2032 must be of the form:

  <command><CR> or <command><CR><LF>

- The SEL-2032 recognizes both full commands or commands abbreviated to the first three characters: **SHOWSET 1** is equivalent to **SHO 1**.
- You may use upper- and lowercase characters without distinction, except in passwords.
- Arguments are separated from commands by spaces, commas, semicolons, colons, or slashes.
- The SEL-2032 transmits all noninteractive messages shown in *Figure 8.1*.

NOTE: The ENTER key on most keyboards is configured to send the ASCII character 13 (^M) for a carriage return. This manual instructs you to press the **<Enter>** key after commands, which should send the proper ASCII code to the SEL-2032.

```
<STX><MESSAGE LINE 1><CR><LF>
 <MESSAGE LINE 2><CR><LF>
 .
 .
 .
<LAST MESSAGE LINE><CR><LF>
<ETX><STX> <PROMPT><ETX>
```

Figure 8.1 Noninteractive Message Format

Each message begins with the start-of-transmission character STX (ASCII character 02) and ends with the end-of-transmission character ETX (ASCII character 03). Each line of the message ends with a carriage return and line feed.

- The CAN character (ASCII character 24) aborts a pending transmission. This capability is useful in terminating an unwanted transmission.
- You can send control characters from most keyboards with the following keystrokes:
  XON: **<CTRL+Q>** (hold down the Control key and press Q)
  XOFF: **<CTRL+S>** (hold down the Control key and press S)
  CAN: **<CTRL+X>** (hold down the Control key and press X)

Command Access Levels

A multilevel password system with three access levels provides security against unauthorized access. This system allows you to give personnel access only to those functions they require. The password system is disabled when the password jumper is inserted on the main board of the SEL-2032. See *Jumper Settings on page 2.1* for information on using this jumper. Passwords can be set or disabled on an access level basis using the **PASSWORD** command, described in *PASSWORD on page 8.15*.

Each level has an associated screen prompt that indicates the active level. *Table 8.1* shows the access levels of the prompts as well as the commands available from each access level.

⚠WARNING
This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

Table 8.1 Access Level Characteristics (Sheet 1 of 2)

Access Level	0	1	2
Prompt	*	*>	*>>
Available Commands	ACCESS	2ACCESS ACCESS AUTO BROADCAST CLEAR DATE DCF[a] DNPMAP FILE	2ACCESS ACCESS AUTO BROADCAST CAL CARD CLEAR CONTROL COPY DATE DEFRAG DCF DNPMAP FILE

Table 8.1 Access Level Characteristics (Sheet 2 of 2)

Access Level	0	1	2
Prompt	*	*>	*>>
	HELP ID QUIT	HELP ID IRIG MAP MEM MODMAP PORT QUIT SER SHOWSET STATUS TARGET TIME VIEW WHO	HELP ID IRIG L_D[b] MAP MEM MODMAP PASSWORD PORT QUIT SER SET SHOWSET STATUS STORE SWAP TARGET TIME TOGGLE VIEW WHO

[a] The DCF command is only available on virtual terminal connections.
[b] The L_D command is only available on Port F of the SEL-2032.

Changing Access Levels

The SEL-2032 always reverts to Access Level 0 at power-up, after time-out, and when you issue the **QUIT** command at the end of a communication session. To access Level 1, you must type **ACCESS <Enter>** at the “*” prompt and then enter the password. To enter Access Level 2 from Access Level 1, use the **2ACCESS** command and the Access Level 2 password. If the password disable jumper is installed on the main board, a password is not required to change access levels. See *Jumper Settings on page 2.1* for information on installing jumpers.)

To return to Access Level 0, use the **QUIT** command. The port automatically returns to Access Level 0 after no activity has occurred on the port for the specified time-out interval.

See the following paragraphs for the details of using the **ACCESS**, **2ACCESS**, and **QUIT** commands.

Command Set

This section describes all SEL-2032 commands in alphabetical order. The minimum access level for each command is indicated in parentheses after the command name. See *Table 8.1* for a complete summary of command access levels.

2ACCESS

Use the **2ACCESS** command (Access Level 1) to enter Access Level 2. You need a password unless the password disable jumper is installed (J17B in the SEL-2032). Use the **PASSWORD** command at Level 2 to change passwords.

The display in *Figure 8.2* shows successful access.

```
*>2ACCESS <Enter>
Password: ? ****** <Enter>
COMMUNICATIONS PROCESSOR - S/N 95012004   Date: 03/07/95  Time: 08:38:10
Level 2

*>>
```

Figure 8.2 2ACCESS Command

You may use any command from the "*>>" prompt. The SALARM bit will go to 1 for one second for a successful Level 2 access and for three successive bad passwords. In the SEL-2032, you can use SALARM in the ALARM SELOGIC® control equation.

ACCESS

Use the **ACCESS** command (Access Level 0) to enter Access Level 1. You need a password unless the password disable jumper is installed (J17B in the SEL-2032). From Access Level 2, you can use the **PASSWORD** command to change this password.

The display in *Figure 8.3* shows successful access.

```
*ACCESS <Enter>
Password: ? ****** <Enter>
COMMUNICATIONS PROCESSOR - S/N 95012004   Date: 03/07/95  Time: 08:45:43
Level 1
*>
```

Figure 8.3 ACCESS Command

If you enter wrong passwords for three consecutive attempts, the SEL-2032 pulses the SALARM bit for one second and displays the message shown in *Figure 8.4*.

```
Access Denied
WARNING: Access by unauthorized persons strictly prohibited.
```

Figure 8.4 Access Denied Message

In the SEL-2032, you can use SALARM in the ALARM SELOGIC control equation.

AUTO n

The **AUTO** command (Access Level 1) displays the results of auto-configuration on a port. The response message shows the device FID string, the device ID string, the baud rate, the supported operate commands, and a list of supported "20" commands. The operate command support indicates whether ASCII or binary operate messages are supported, the number of breakers and remote bits supported, and the type of remote bit operations supported (set, clear, pulse). Each "20" command is preceded by an A to indicate that data will be collected using an ASCII format or B to indicate binary Fast Meter format. *Figure 8.5* shows an example of a typical **AUTO** command response.

```
*>>AUTO 1 <Enter>
FID:       FID=SEL-151-R412-V656rp1rqys-D940901-E2
DEVICE ID: Example 21.6 kV Line
BAUD RATE: 9600
OPERATE SUPPORT:ASCII (1 Breakers, 0 Remote Bits)
COMMANDS SUPPORTED:
 B 20METER
 A 20DEMAND
 B 20TARGET
 A 20HISTORY
 A 20STATUS
 A 20BREAKER
 A 20EVENT
 A 20EVENTS

*>>
```

Figure 8.5 AUTO Command

BROADCAST

The **BROADCAST** command (Access Level 1) allows you to communicate from one master port to all IED ports simultaneously. When you issue the **BROADCAST** command, the SEL-2032 will indicate the connected ports. From then on, anything you enter will be sent to all connected ports.

Any messages from any of the connected IED ports will be sent to the single master port, as long as they are framed with the <STX>/<ETX> characters. To transfer binary messages, add an AAh byte after the <STX> character and then a message length as the next byte. The SEL-2032 will use the message length to determine the end of the message, instead of checking for an <ETX> character.

Use the **BROADCAST** command with an R parameter to enter broadcast communications in a receive-only mode. In this mode, master port messages are used for connection termination only.

Exit broadcast mode by entering the transparent termination sequence defined in the SEL-2032 master port settings. See *Transparent Communications on page 7.8* for additional discussion on termination sequences. You will need to allow an extra second for TERTIME1 due to some additional **BROADCAST** command delays. Note that the **BROADCAST** command is not supported for virtual terminal master ports.

CAL

Use the **CAL** command (Access Level 2) to enter Access Level C. You need a password unless the password disable jumper is installed (J17B in the SEL-2032). Use the **PASSWORD** command at Level C to change passwords.

Figure 8.6 shows successful access.

```
*>>CAL <Enter>
Password: ? ******
COMMUNICATIONS PROCESSOR-S/N 2007087055     Date: 01/20/12    Time: 11:52:44
WARNING:  CALIBRATION level is for SEL authorized use only.  Commands at this
    level may disrupt device operation and cause the device to become
    inoperable until returned to the factory for repair.  SEL shall not be
    responsible for any damage or liability resulting from unauthorized
    access.  Use the 2AC command to return to normal operation.
Level C
**>>
```

Figure 8.6 CAL Command

The CAL access level is the calibration level and is intended for use by the SEL factory, and for use by SEL field service personnel to help diagnose troublesome installations. A list of commands available at the CAL level is available from SEL upon request.

Do not enter the CAL access level except as directed by SEL.

CARD n

NOTE: Frequent archive record clearing may exceed EEPROM capabilities. See the discussion in Archive Data Regions on page 6.21. If you completely clear an Archive data region that contains a large number of records (thousands of records), it may take a few minutes for the clearing to complete. During this time, most SEL-2032 automatic data collection will be suspended.

The **CARD** command (Access Level 1) displays the value of the Control Input and Control Output elements for the protocol card ports as shown in *Figure 8.7*. Parameter *n* specifies the port (17 or 18).

```
*>CARD 17 <Enter>
Protocol Card Input Logic Elements =
0000 0000 0000 0000
Protocol Card Output Logic Elements =
0000 0000 0000 0000

*>
```

Figure 8.7 CARD Command

Append the Bit Label flag BL to display the control bit labels.

CLEAR m:n

The **CLEAR** command (Access Level 1) clears data from the unsolicited message queue or from the Archive data region of an intelligent electronic device (IED) port. Parameter *m* specifies which port (1–18). Parameter *n* may be BUF for the unsolicited message queue or A1, A2, or A3 for the appropriate archive. Alternatively, for the Archive data regions, you may use the data label for the region (see **MAP** command). Clearing the unsolicited message queue clears all received messages from the buffer. Clearing an archive entry removes the oldest item from that archive queue; subsequent entries will remain. To completely clear an archive queue, add the parameter A. For example, use: **CLEAR 4:A2 A** to clear Port 4, Archive 2, all entries.

CONTROL m

The **CONTROL** command (Access Level 2) sets (asserts), clears (deasserts), and pulses (asserts and deasserts) global element bits R1–R8. These bits exist in the Global region of the SEL-2032 database. In the example below, executing the **CONTROL** command controls the global element bit R5. When you enter the **CONTROL** command with parameter *m* to identify the bit number to control, the SEL-2032 prompts for an operation; enter one of the following operation codes:

- SRB to set the specified bit
- CRB to clear the specified bit
- PRB to pulse the specified bit.

These are the only acceptable operations. You must again specify the bit to control (1–8) following the operation. If you intend to pulse the bit, you can supply a time parameter or a one-second time is the default. The example in *Figure 8.8* pulses R5 for 3 seconds.

```
*>>CONTROL 5 <Enter>
Control RB5: PRB 5 3 <Enter>

*>>
```

Figure 8.8 CONTROL Command

COPY m n

The **COPY** command (Access Level 2) copies all port-specific settings including port (P), automatic message (A), data movement (M), user-defined command (U), protocol card control (O), and logic (L) settings from Port *m* to Port *n* (*m* and *n* equal any combination of 1–16). You can also copy between Ports 17 and 18. Type **COPY 1 ALL <ENTER>** to copy Port 1 settings to all other rear-panel ports.

Use **SET** to modify copied settings. Settings cannot be copied to any port that is actively involved in transparent communications.

The SEL-2032 makes confirmations as shown in *Figure 8.9* for each port to which settings are copied.

```
*>>COPY 1 5 <Enter>
Copy settings from Port 1 to Port 5 (Y/N) ? Y <Enter>
Perform auto-configuration on Port 5 (Y/N) ? N <Enter>
Port 5 Settings Changed

*>>
```

Figure 8.9 COPY Command

If you copy to multiple ports using the ALL parameter, the confirmation is repeated for each port.

If you copy settings having CONFIG=Y, the SEL-2032 asks if you want to auto-configure the destination port. If you answer **N** (No), the SEL-2032 assumes the devices connected to the two ports are identical. If you answer **Y** (Yes), you may lose some auto-message settings on the destination port if the connected device is not the same type as the device connected to the source port.

When you use the **COPY** command, the SEL-2032 will make changes to port numbers used in strings and in SELogic control equations within the copied settings based on the following rules: for the command format “**COPY *n m***”, any reference to Port *n* will change to *m*, and any reference to a port other than *n* will remain unchanged. Always use the **SHOWSET** command to verify settings following a copy. Use the **SET** command to make required adjustments to settings.

The SALARM bit asserts for one second after a successful copy to indicate that the settings have changed. In the SEL-2032, SALARM is assigned to ALARM by default, so the alarm contact will close for one second unless this setting has been changed.

If you copy settings to the current port, change your terminal’s communication parameters to match once you accept the changes.

DATE

The **DATE** command (Access Level 1), without parameters, displays the date stored by the internal calendar/clock. Use the **DATE** command with a date parameter to change the date: **DATE mm/dd/yy**. For example, set the date to March 20, 1994, as shown in *Figure 8.10*.

```
*>>DATE 03/20/94 <Enter>
03/20/94
*>>
```

Figure 8.10 DATE Command

If you use IRIG-B, the day of the year determined from IRIG-B overrides the date settings.

DCF

The **DCF** command (Access Level 1) enables or disables virtual terminal (VT) data collection. This feature allows you to perform data collection through the SEL-2701 Ethernet Processor in a similar manner that you would through an SEL-2032 serial port. Use the **DCF ON** command to enable VT data collection and **DCF OFF** command to disable VT data collection (see

Figure 8.11). The **DCF** command must be entered via the VT connection from which you want to collect data. Only one DCF session can be enabled on port 17 or 18.

```
*>>DCF ON <Enter>
Data collection features enabled

*>>
```

Figure 8.11 DCF Command

The **DCF** command also supports a NOECHO parameter. When the NOECHO parameter is set, the virtual terminal does not echo characters as long as DCF is enabled.

```
*>>DCF ON NOECHO <Enter>
Data collection features enabled

*>>
```

Figure 8.12 DCF Command With NOECHO Parameter

DEFRAGMENT

The **DEFRAGMENT** command (Access Level 2) defragments EEPROM. The SEL-2032 settings are stored in EEPROM. After multiple settings changes, the available portion of EEPROM may become fragmented (available bytes exist as several small blocks as opposed to a single larger block). The **DEFRAGMENT** command, as shown in *Figure 8.13*, may be necessary in order to allow further settings changes to be successfully saved.

```
*>>DEFRAGMENT <Enter>
Performing EEPROM defragmentation will suspend most SEL-2032 activities.
Perform EEPROM defragmentation (Y/N)? Y <Enter>
Defragmenting ... complete.

*>>
```

Figure 8.13 DEFRAGMENT Command

Executing the **DEFRAGMENT** command will momentarily suspend many of the SEL-2032 database and communications activities while the SEL-2032 concentrates the available EEPROM into a single block. Use the **MEM** command to check EEPROM fragmentation.

DNPMAP

The **DNPMAP** command (Access Level 1), shown in *Figure 8.14*, displays a map of the data available to DNP3 on Port 16, including object type, index, and default variation. When issued at the command line, this map will be based on the port and math settings on Port 16. Event objects will not be displayed; event objects will have the same indices as their corresponding static object.

```
*>>DNPMAP <Enter>
                                            Date: 07/03/01    Time: 11:49:27
DNP Address:  0000h
Object Type     Index      Default Variation      Label
     01          0-15           02              1:TARGET:TARGET
     30          0              03              1:METER:IA(A)
     30          1              03              1:METER:IB(A)
     30          2              03              1:METER:IC(A)
Control Points (also available in Class 0 poll)
Object Type     Index      Item
  10, 12         0-7       Global Remote Elements
  10, 12         8-9       Port 1 Breaker Bits
  10, 12        10-17      Port 1 Remote Bits
  10, 12        18-19      Port 2 Breaker Bits
  10, 12        20-27      Port 2 Remote Bits
  10, 12        28-29      Port 3 Breaker Bits
  10, 12        30-37      Port 3 Remote Bits
  10, 12        38-39      Port 4 Breaker Bits
  10, 12        40-47      Port 4 Remote Bits
  10, 12        48-49      Port 5 Breaker Bits
  10, 12        50-57      Port 5 Remote Bits
  10, 12        58-59      Port 6 Breaker Bits
  10, 12        60-67      Port 6 Remote Bits
  10, 12        68-69      Port 7 Breaker Bits
  10, 12        70-77      Port 7 Remote Bits
  10, 12        78-79      Port 8 Breaker Bits
  10, 12        80-87      Port 8 Remote Bits
  10, 12        88-89      Port 9 Breaker Bits
  10, 12        90-97      Port 9 Remote Bits
  10, 12        98-99      Port 10 Breaker Bits
  10, 12       100-107     Port 10 Remote Bits
  10, 12       108-109     Port 11 Breaker Bits
  10, 12       110-117     Port 11 Remote Bits
  10, 12       118-119     Port 12 Breaker Bits
  10, 12       120-127     Port 12 Remote Bits
  10, 12       128-129     Port 13 Breaker Bits
  10, 12       130-137     Port 13 Remote Bits
  10, 12       138-139     Port 14 Breaker Bits
  10, 12       140-147     Port 14 Remote Bits
  10, 12       148-149     Port 15 Breaker Bits
  10, 12       150-157     Port 15 Remote Bits
  10, 12       158-159     Port 16 Breaker Bits
  10, 12       160-167     Port 16 Remote Bits
  10, 12       168-169     Port 17 Breaker Bits
  10, 12       170-177     Port 17 Remote Bits
  10, 12       178-179     Port 18 Breaker Bits
  10, 12       180-187     Port 18 Remote Bits

*>>
```

Figure 8.14 DNPMAP Command

The **DNPMAP** command can also be used to display data available to DNP3 communication sessions on the SEL-2701 Ethernet ports. First, establish a virtual terminal connection to the SEL-2701 console by using PORT 17 or PORT 18. Then issue the **DNPMAP** command. The SEL-2701 will respond with the contents of the DNPMAP.TXT file, which is a summary file containing the session number, DNP3 and IP addresses of each master, transport protocol (TCP or UDP), and DNP3 map associated with each configured session. If issued with the optional parameter *n*, where *n* is the session map number from 1 to 5, the response to the **DNPMAP *n*** command will be the contents of the DNPMAP*nn*.TXT file, where *nn* is the 2-digit session map number (01–05). The DNPMAP*nn*.TXT file contains the detailed DNP3 map data, with line-by-line information on each data point for session *nn* (see *Section 9: Protocols*).

Table 8.2 Variations on the FILE Command

Command	Action	Format	Applications
FILE DIR	Perform directory operations.Wildcards (* ?) are supported.	FILE DIR [*directory1* [*directory2*]]	Returns a list of filenames in specified directory (*directory1*) and subdirectory (*directory2*). If neither parameter is specified, then the list of files and directories in the root directory is returned.
FILE READ	Read a file from the SEL-2032.	FILE READ [*directory1* [*directory2*]] *filename*	Initiates a file transfer of the file *filename* (in the folder *directory1*, subdirectory *directory2*) from the SEL-2032 to external support software. The *filename* parameter is required.
FILE WRITE	Write a file to the SEL-2032.	FILE WRITE [*directory1* [*directory2*]] [*filename*]	Initiates a file transfer of the file *filename* (in the folder *directory1*, subdirectory *directory2*) from external support software to the SEL-2032. If the *filename* parameter is not specified, the file name must be given in the Ymodem header.

FILE

Use the **FILE** command (Access Level 1 and 2) to perform file operations on the SEL-2032 file system. See *Table 8.2*. for variations of the **FILE** command.

All text enclosed in [brackets] indicate optional command line parameters. The **FILE** command allows access to second level subdirectories as the optional *directory2* parameter.

The SETTINGS directory is the only file directory in the SEL-2032. For **FILE READ** operations, specify the *directory1* (and *directory2*) parameters as needed. The **FILE WRITE** command is available only for the second-level subdirectories of the SETTINGS directory. Parameter *filename* is optional for **FILE WRITE** operations. If *filename* is not specified, the file name must be given in the Ymodem header. When using the **FILE WRITE** command, you should use only file names that already exist in the relay.

HELP

The **HELP** command (Access Level 0), as shown in *Figure 8.15*, lists all commands available at the current access level with a one-line description of each, as shown in the display below. Use the **HELP** command with another command as its parameter and it will provide the syntax and a brief description of the command. If you use the **HELP** command with an invalid command parameter, the SEL-2032 responds with an error message.

```
*HELP <Enter>
Commands available at current access level:
- ACCESS - Change access level to Access Level 1
- HELP - Provide information on available commands
- ID - Display SEL-2032 identification information
- QUIT - Change access level to Access Level 0

*
```

Figure 8.15 HELP Command

ID

The SEL-2032 responds to the **ID** command (Access Level 0) with identification information, including the following:

FID	SEL-2032 firmware identification string
BFID	SELBOOT firmware identification string
CID	SEL-2032 firmware checksum
DEVID	ID as set in the global settings
DEVCODE	Device Code

PARTNO	Part Number: Reserved for future use
CONFIG	Configuration: Reserved for future use
SPECIAL	Reserved for future use

An example command response is shown in *Figure 8.16*.

```
*ID <Enter>
"FID=SEL-2032-R100-V0-Z000000-D20021222","08D6"
"BFID=SLBT-2030-R103-V0-Z000000-D20001226","095C"
"CID=507D","025D"
"DEVID="COMMUNICATIONS PROCESSOR - S/N 97312004","0A70"
"DEVCODE=52","030E"
"PARTNO=","0281"
"CONFIG=000000","0383"
"SPECIAL=","02AE"
*
```

Figure 8.16 ID Command

The four digits at the end of each line are the 16-bit checksum in ASCII-hexadecimal for the preceding string. This checksum is calculated by summing the character codes starting with the first quotation mark and going through the comma separating the string and checksum.

You can also use the **WHO** or **STATUS** command to determine **ID** information. The **ID** command provides consistency between the SEL-2032 and the new standard **ID** command format for SEL relays.

Add a port number to the **ID** command (**ID *p***, where *p* is any valid port number 1–16) to obtain the FID, BFID, and DEVID of the device connected to that port of the SEL-2032. Use a port number of 17 or 18 to determine the FID and device name of an installed protocol card, as shown in *Figure 8.17*.

```
*ID 17 <Enter>
"SEL-2701-R113-V0-Z000000-D20010102","07BA"
"BFID=SLBT-2701-R103-V0-Z000000-D20001228","0967"
"DEVID=Ethernet","0558""
*
```

Figure 8.17 ID Command for Installed Protocol Cards

IRIG

The **IRIG** command (Access Level 1), as shown in *Figure 8.18*, directs the SEL-2032 to read the IRIG-B time-code input at the IRIG-B port on the back panel.

If it reads the time code successfully, it updates the internal clock/calendar time and date. The SEL-2032 then sends its ID, date, and time to the terminal.

```
*>IRIG <Enter>
COMMUNICATIONS PROCESSOR - S/N 95012004   Date: 03/07/95  Time: 09:06:33

*>
```

Figure 8.18 IRIG Command

If the IRIG-B signal is not present or cannot be read, the SEL-2032 sends the error message “IRIG-B DATA ERROR.” If the signal is present but the global TIMESYNC setting is not set to IRIG, the SEL-2032 will display the error message, “IRIG SIGNAL PRESENT BUT NOT PROCESSED DUE TO TIMESYNC SETTING.”

Normally, using this command is unnecessary because the SEL-2032 automatically synchronizes every few minutes; however, you can use the **IRIG** command to avoid waiting for automatic synchronization during testing and installation checkout.

L_D

The **L_D** command (Access Level 2) causes the SEL-2032 to exit normal execution mode and enter SELBOOT mode. This command is only available from the front port. This command should only be used when you are going to load new firmware into the SEL-2032 or into a plug-in card using the SEL-2032. All normal operation will cease while in SELBOOT mode.

MAP m

The **MAP** command (Access Level 1) displays the organization of data stored in a port database. Parameter *m* specifies the port number. Data are listed by association with each region if only the port number parameter is given. If you add a region parameter, text and numeric references are shown for data stored in the region, e.g., **MAP 2:TARGET**. See Access Methods in *Section 6: Database* for a complete description of database access methods.

To observe the use of the Port 1 database, type **MAP 1 <Enter>**. You will see a screen with the format shown in *Figure 8.19*.

```
*>>MAP 1 <Enter>
Port 1 Database Assignments
  Region  Data Type  # Records
  GLOBAL  --
  LOCAL   --
  BUF     --
  D1      Unused
  D2    B METER
  D3      Unused
  D4    B TARGET
  D5    A STATUS
  D6      Unused
  D7      Unused
  D8      Unused
  A1      Unused
  A2      Unused
  A3    A EVENT     0
  USER    Unused

*>>
```

Figure 8.19 Port MAP Command

In the above example, every region in the database is listed by its label. GLOBAL, LOCAL and BUF contain data pertinent to the SEL-2032, and the other regions contain data collected for Port 1. The type of data stored in each region is listed. The letter just to the left of the data name in the Data Type column indicates the data transfer format: A for ASCII, B for Binary. The # Records column lists records queued in the A1–A3 archive data regions.

Use the **MAP** command with a region specifier to see the labels, addresses, and types of data stored in that region, as shown in *Figure 8.20*.

```
>>MAP 1:D2 <Enter>
Port 1, Data Region METER Map
Data Item   Starting Address   Type
_YEAR       2800h              int
DAY_OF_YEAR 2801h              int
TIME(ms)    2802h              int[2]
IA(A)       2804h              float[2]
IB(A)       2808h              float[2]
IC(A)       280Ch              float[2]
VA(V)       2810h              float[2]
VB(V)       2814h              float[2]
VC(V)       2818h              float[2]
IAB(A)      281Ch              float[2]
IBC(A)      2820h              float[2]
ICA(A)      2824h              float[2]
VAB(V)      2828h              float[2]
VBC(V)      282Ch              float[2]
VCA(V)      2830h              float[2]
PA(MW)      2834h              float
QA(MVAR)    2836h              float
PB(MW)      2838h              float
QB(MVAR)    283Ah              float
PC(MW)      283Ch              float
QC(MVAR)    283Eh              float
P(MW)       2840h              float
Q(MVAR)     2842h              float
I0(A)       2844h              float[2]
I1(A)       2848h              float[2]
I2(A)       284Ch              float[2]
V0(V)       2850h              float[2]
V1(V)       2854h              float[2]
V2(V)       2858h              float[2]

*>>
```

Figure 8.20 Data Region MAP Command

Each item within a region has a label, a numeric address (given in hexadecimal), and a type. The types are “char” for character data, “int” for integer data, and “float” for floating point data. If an item consists of an array of these entries, the number of items is indicated in brackets after the type specifier, e.g., int[2] means there are two integers stored. For vector quantities, the first float contains the magnitude and the second float contains the angle. In the example above, IA(A) magnitude is at address 2804h and IA(A) angle is at address 2806h.

Add the BL parameter to the **MAP** command to receive bit label information if it is available. The example in *Figure 8.21* illustrates the BL parameter.

```
*>>MAP 2:TARGET BL <Enter>
Port 2, Data Region TARGET Map
Data Item   Starting Address  Type   Bit Labels
_YEAR       4800h             int
DAY_OF_YEAR 4801h             int
TIME(ms)    4802h             int[2]
TARGET      4804h             char[9]
            4804h             INST  A     B     C     Q    N    RS    LO
            4805h             51P   50L   50H   51QP  50Q  51NP 50NL  50NH
            4806h             51T   50LT  50C   51QT  50QT 51NT 50NLT 27
            4807h             79RS  79CY  79LO  79SH  52AT 52BT IN6   IN5
            4808h             PDEM  QDEM  NDEM  TF    CF   TCMA  ST   TRIP
            4809h             A     B     C     D     E    F     G    H
            480Ah             J     KT    L     V     W    X     Y    ZT
            480Bh             *     *     IN6   IN5   IN4  IN3   IN2  IN1
            480Ch             *     TRIP  CLOSE A1    A2   A3    A4   ALRM

*>>
```

Figure 8.21 MAP Command With BL Option

The bit labels are listed in most-significant to least-significant bit order, the same as in SEL relays. Bit labels are available in the GLOBAL, LOCAL, and TARGET (if not in archive) regions.

MEMORY

The **MEMORY** command (Access Level 1) displays the status of all dynamically allocated memory. This includes RAM, which is used for temporary data storage; EEPROM, where string and SELOGIC control equation settings are stored; nonvolatile Flash, where archive data are stored; and Shared RAM, where the database is stored. The report indicates the number of bytes of dynamic memory, the number of free (unused) bytes, the number of free blocks (contiguous segments of unused memory), and the size of the largest free block. The screen in *Figure 8.22* shows a typical **MEM** report.

```
*>>MEM <Enter>
Memory        Total      Bytes    Blocks  Largest block
type          bytes      free     free      available
RAM           275536     196678        2      176980
EEPROM         34820      34656        2       34624
ARCHIVE      1835008    1000000        1     1000000
DATA
SET M         128000     100000        1      100000
SETTINGS
SRAM         1046524     789420        1      789420

*>>
```

Figure 8.22 MEM Command

You can use the free bytes and largest available block to determine if you are running out of memory. The number of free blocks indicates how badly the memory is fragmented. The more free blocks there are, the less efficiently the SEL-2032 can use the available free memory.

MODMAP

The **MODMAP** command (Access Level 1) displays the Modbus® Read Input Register map of a specific region. The MODMAP display format is similar to the example Modbus data map tables in *Section 9: Protocols*.

The command syntax is:

MOD port number:region_name map_type

where:

- port numbers are 1–18
- region_names are BREAKER, DEMAND, HISTORY, METER, TARGET, and USER
- map_type is either F or I, corresponding to floating map and integer map.

Figure 8.23 is an example of the MODMAP display for Port 2 Meter region using an integer map.

```
*>>MODMAP 2:METER I <Enter>
Reg.#(Dec)  Description   Type    Unit and Scale
100         Month         int
101         Day           int
102         Year          int
103         Hours         int
104         Minutes       int
105         Seconds       int
106         Milliseconds  int
107         Day of Week (Sunday-0, Monday-1, ...)int
108         IA            int     A
109         IA            int     Degrees*10
110         IB            int     A
111         IB            int     Degrees*10
112         IC            int     A
113         IC            int     Degrees*10
114         IN            int     A
115         IN            int     Degrees*10
116         VA            int     kV*10
117         VA            int     Degrees*10
118         VB            int     kV*10
119         VB            int     Degrees*10
120         VC            int     kV*10
121         VC            int     Degrees*10
122         VS            int     kV*10
123         VS            int     Degrees*10
124         FREQ          int     Hz*10
125         FREQ          int     N/A
126         VBAT          int     V*10
127         VBAT          int     N/A
128         IAB(A)        int     A
129         IAB(A)        int     Degrees*10
130         IBC(A)        int     A
131         IBC(A)        int     Degrees*10
132         ICA(A)        int     A
133         ICA(A)        int     Degrees*10
134         VAB(V)        int     kV*10
135         VAB(V)        int     Degrees*10
136         VBC(V)        int     kV*10
137         VBC(V)        int     Degrees*10
138         VCA(V)        int     kV*10
139         VCA(V)        int     Degrees*10
140         PA(MW)        int     MW*10
141         QA(MVAR)      int     MVAR*10
142         PB(MW)        int     MW*10
143         QB(MVAR)      int     MVAR*10
144         PC(MW)        int     MW*10
145         QC(MVAR)      int     MVAR*10
146         P(MW)         int     MW*10
147         Q(MVAR)       int     MVAR*10
148         I0(A)         int     A
149         I0(A)         int     Degrees*10
150         I1(A)         int     A
151         I1(A)         int     Degrees*10
152         I2(A)         int     A
153         I2(A)         int     Degrees*10
154         V0(V)         int     kV*10
155         V0(V)         int     Degrees*10
156         V1(V)         int     kV*10
157         V1(V)         int     Degrees*10
158         V2(V)         int     kV*10
159         V2(V)         int     Degrees*10
*>>
```

Figure 8.23 MODMAP Command

PASSWORD

Use the **PASSWORD** command (Access Level 2) to change the existing passwords of the SEL-2032. Issuing the **PAS 1** command starts the Level 1 password change sequence. Similarly, issuing the **PAS 2** command starts the Level 2 password change sequence. *Figure 8.24* shows an example of how to use the **PAS** command for setting passwords.

```
*>>PAS 1 <Enter>
New level 1 password: ? ******
Verify new level 1 password: ? ******
Level 1 password changed
*>>PAS 2 <Enter>
New level 2 password: ? ******
Verify new level 2 password: ? ******
Level 2 password changed
*>>
```

Figure 8.24 PASSWORD Change Sequence

When setting your passwords, be sure to choose strong passwords that cannot be guessed or broken easily with automated password cracking software. If you are certain that your physical control of all access to the SEL-2032 is sufficient to prevent unauthorized access, or if the devices connected between the SEL-2032 and any other access points provide sufficient protection from unauthorized access, then you may disable password protection. To disable passwords at a specific level, enter the keyword **DISABLE** when prompted to enter a new password for the desired level.

When the SEL-2032 saves the password, it asserts the SALARM global element for approximately one second. SALARM is assigned to ALARM by default; the alarm contact will close for one second unless the ALARM setting has been modified.

If the passwords are lost or you wish to operate the SEL-2032 without password protection, install the Password Jumper on position **J17 B** on the main board (see *Jumper Settings on page 2.1* for jumper location). When password protection is disabled, you and others can gain access to the SEL-2032 without knowing the passwords, which includes the ability to view or change active passwords and settings.

Managing Passwords for Connected IEDs

The **PASSWORD** command is also used to inspect and change the passwords used to access connected IEDs (the **PASSWORD** command does not modify the passwords on the connected IED). To inspect the password for a given port, type **PAS PORT *n*** (where *n* is the port number).

```
*>>PAS PORT 3

1: A1Hyw8
2: Wa71Opq
*>>
```

Figure 8.25 PAS PORT n Command

To generate a report of all passwords used by the SEL-2032 to access connected IEDs, type **PAS PORT ALL**.

Similar to changing the passwords for the SEL-2032, the command **PAS PORT *n* 1** starts the Level 1 password change sequence for the port number specified by *n*, and **PAS PORT *n* 2** starts the Level 2 password change sequence for the port number specified by *n*. When the connected IED's password is saved, the port's STARTUP setting is modified to reflect the new password and the SALARM global element is pulsed.

If the password at a specific access level in a connected IED has been disabled, enter the keyword **DISABLE** instead of a password when setting the password.

Using Strong Passwords

It is important that you establish strong password protection to safeguard against unauthorized persons setting or controlling your SEL-2032 and the devices attached to it. Strong passwords consist of six or more characters (to a maximum of 12), with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks. Examples of valid, distinct strong passwords include:

Ot3579 A24.68 Ih2dcs 4u-Iwg Ic-4+

NOTE: Do not use characters that you have selected as LMD prefix characters. See Section 9: Protocols, for a description of LMD prefixes.

Used properly, passwords provide good protection against unauthorized access. Make sure you choose strong passwords and record them in a secure location. If your passwords are forgotten and lost, you will need to install the main board password jumper in order to disable password protection long enough to view them with the **PAS** command.

PORT n

The **PORT** command (Access Level 1) connects the master port issuing the command to the designated port, permitting transparent communication between the two ports. To terminate transparent communications and return to SEL-2032 command operation, use the disconnect sequence set for your port. You cannot connect to a port that is already communicating transparently.

The example in *Figure 8.26* illustrates using the **PORT** command to enter and exit transparent communications:

```
*>>PORT 9 <Enter>
Transparent Communications to Port 9 established
ID <Enter>
"FID=SEL-2032-R100-V0-Z000000-D20021222","08D6"
"BFID=SLBT-2030-R103-V0-Z000000-D20001226","095C"
"CID=507D","025D"
"DEVID="COMMUNICATIONS PROCESSOR - S/N 97312004","0A70"
"DEVCODE=52","030E"
"PARTNO=","0281"
"CONFIG=000000","0383"
"SPECIAL=","02AE"
<Ctrl+D>
Transparent Communications to Port 9 terminated

*>>
```

Figure 8.26 PORT Command

This example uses the default termination character <Ctrl+D> to exit transparent communications. You can set the termination string on the master port using the TERSTRING setting within the **SET P** command.

When connecting to a printer port, you may add an E parameter to enable echoing from the SEL-2032 (e.g., **PORT 5 E**). Using this parameter, you can see what you are sending to the printer, but you will not see any messages sent to you by the printer.

To select the Direct Transparent mode, add the D parameter to the **PORT** command (**PORT *n* D**, where *n* selects the port number). The Direct Transparent mode passes characters through rapidly, without significant buffering delays and disables RTS/CTS handshaking regardless of the RTS_CTS setting for the port. Direct Transparent mode also suspends processing of all logic settings, automatic messages, and math/movement settings.

If you have a card that supports virtual terminal features installed in Ports 17 or 18, use the **PORT** command to establish communications with other devices on the network. Refer to your protocol card instruction manual for more information.

See *Transparent Communications on page 7.8* for a more complete discussion of transparent communications.

If the NOCONN bit is set, a transparent connection will not be established and an error message will be sent (see *Restricting Port Access with NOCONN on page 7.25*).

QUIT

The **QUIT** command (Access Level 0) causes the SEL-2032 to return control to Access Level 0 from Level 1 or Level 2. The command displays the SEL-2032 ID, date, and time of **QUIT** command execution.

Use this command when you finish communicating with the SEL-2032 to prevent unauthorized access. Control returns to Access Level 0 automatically after a settable interval with no activity (see the TIMEOUT setting in *Table 7.1*). If the port you are communicating with is using LMD Distributed Port Switch Protocol, the connection is dropped when you issue the **QUIT** command. If you are connected to the port through a dial-up modem, the SEL-2032 will hang up the modem when it receives a **QUIT** command.

SER

The SER command (Access Level 1) displays SER region data. The command has the following format:

SER *x* [BL] | [*m*] [*n*] | [C | CA | R]

where:

- *x* is either a port number, GLOBAL or ALL.
- BL displays the labels of the SER points for the specified port
- *m* is the number of most recent records to display–default is the last 20
- *n*, if supplied with *m*, defines a range of records to display
- C or R clears the SER records for the selected port
- CA clears all of the SER records in the SEL-2032. When CA is selected, no port number may be specified.

Variations of the SER command are detailed in *Table 8.3*.

Table 8.3 Variations of the SER Command

Command	Action	Format	Application
SER	Display the SER records currently in the SEL-2032.	SER 1 SER GLOBAL SER 1 5 11	Display the SER records in the port 1 SER region. Display the GLOBAL region SER data. Display records 5–11 from port 1 SER region.
SER *n* BL	Display the SER data points and their index.	SER 1 BL	Display the SER points collected from the attached IED and their relative index in the SER region.
SER *n* C	Clear SER records.	SER 1 C or SER 1 R SER CA	Clear port 1 SER records. Clear all SEL-2032 SER records.

Examples of the **SER** command are shown in *Figure 8.27*.

```
*>>SER 2 <Enter>
<STX>
Port 2,  SER Data
#      DATE        TIME           ELEMENT             STATE
9    07/23/1996  08:15:32.123     52A               Deasserted
8    07/23/1996  08:15:31.123     52A               Asserted
7    07/23/1996  08:15:30.123     52A               Deasserted
6    07/23/1996  08:15:29.123     52A               Asserted
5    07/23/1996  08:15:28.123     52A               Deasserted
4    07/23/1996  08:15:27.123     52A               Asserted
3    07/23/1996  08:15:26.123     52A               Deasserted
2    07/23/1996  08:15:25.123     52A               Asserted
1    07/23/1996  08:15:24.123     52A               Deasserted
<ETX>
*>>
```

Figure 8.27 SER Command

The example in *Figure 8.28* uses the BL parameter with the **SER** command.

```
*>>SER 2 BL <Enter>
<STX>
SER Data Points from attached device
Port    ELEMENT              FAST SER INDEX
2       52A                  0
2       CLOSE                1
2       ALARM                2
2       IN101                3
<ETX>
*>>
```

Figure 8.28 SER Command With BL Option

SET

Use the **SET** command variations (Access Level 2) to configure the SEL-2032. These **SET** command variations are listed in *Table 8.4* with their parameters, formats, and uses. *Table 8.5* lists the editing keys used with all **SET** commands. **SET M** has some additional editing features, which are described in *Math/Data Movement (SET M) Settings on page 7.31*.

The **SET** command always requires a class parameter (P, A, U, M, L, O, G, or R). If the setting is port specific, the class is P, A, M, L, O, or U and you must supply the port position (1–16 or F). Classes P, A, M, L, O, or U may also be used with port numbers 17 and 18. You can give these parameters in any order, for example, **SET 1 A** or **SET A 1**. The default **SET** command starts with the first setting for the setting class. You may override the default and specify the first setting displayed for editing by entering it as a **SET** parameter. For example, type **SET 1 A ISSUE1** to jump directly to the ISSUE1 setting for Port 1.

Basic, but intelligent, port configurations are established with **SET P** commands. You apply the advanced communication, control, and database features of the SEL-2032 with the **SET A**, **SET U**, **SET M**, **SET L**, **SET O**, **SET R**, and **SET G** commands. On Ports 17 and 18 of the SEL-2032, **SET P**, **SET A**, and **SET U** are used to modify the settings of a plug-in card. The settings that are presented in response to these commands are a function of the installed card. See the plug-in card instruction manual to learn about its settings.

Use the commands *COPY m n on page 8.6* or *SWAP n m on page 8.24* to move settings between ports.

Refer to *Section 7: Settings* for an explanation of all the settings, including their applicability to various connected device types.

Table 8.4 Examples of Variations on the SET Command

Command	Action	Format	Application
SET P *n*	Enter Port ID. Set all port configuration and communication parameters.[a,b]	SET P SET P 1 SET P 2 PARITY	Set current port Set Port 1 Set Port 2 starting at entry PARITY
SET A *n*	Define automatic message and trigger sequences.[b,c] Determine response handling for messages. Set data parsing conditions.	SET A SET A 4 SET A 3 ISSUE1A	Set current port Set Port 4 Set Port 3 starting with ISSUE1A
SET U *n*	Configure SEL-2032 command set.[b,c,d] Create user-defined commands.	SET U SET U 4 SET U 12 READ	Set current port Set Port 4 Set Port 12 starting with READ setting
SET L *n*	Define logic equations.[b,c]	SET L SEL L 6 SET L 12 CBR2	Set current port Set Port 6 Set Port 12 starting with CBR2 setting
SET M *n*	Set data scaling and movement equations.[b,c]	SET M SET M 7	Set current port Set Port 7
SET G	Enter SEL-2032 ID. Set intermediate SELOGIC® control equations. Output contact functions.	SET G SET G ID	Set global settings Set global settings starting at ID
SET R	Set Sequential Events Recorder (SER) elements.	SET R	Set SER elements
SET O *n*	Define logic equations for CCOUT elements.[b]	SET O 17 SET O 18 CCOUT6	Set Port 17 Set Port 18 starting with the CCOUT6 setting

[a] If you use **SET P** to change settings on a modem port and there is an active connection, the connection will hang up when you accept the settings.
[b] Available for Ports 17 and 18 if a plug-in protocol card is installed in the appropriate slot.
[c] Not available on the front-panel port (Port F).
[d] Not available when port device type is set to Printer. (Select port device type using **SET P**.)

Table 8.5 Editing Keys for SET Commands

Press Key(s)	Results
∧ <Enter>	Moves to previous entry in a setting category until you get to the first entry in the category and then it moves to previous category.
< <Enter>	Moves to the first entry prompt in the previous settings category.
> <Enter>	Moves to the first entry prompt in the next settings category.
<Enter>	Accepts setting, then moves to next entry prompt.
End <Enter>	Exits editing session and displays all settings. Prompts: "Accept settings (Y/N)?". Type **Y <Enter>** to save changes and exit, **N <Enter>** to exit without saving. Also accepts lowercase letters (end, y, n).
<Ctrl+X>	Aborts editing session without saving changes.
OFF <Enter>	Flags a setting as not applicable. Also accepts lowercase letters (off).

SHOWSET t

Use the **SHOWSET** command (Access Level 1) to display settings. **SHOWSET** works with all settings classes: P, A, M, U, L, O, G, R, and C. The P, A, U, M, and L classes require a port number parameter (1–16 or F). In the SEL-2032, classes P, A, M, L, O, and U are also available for Ports 17 and 18. For example, enter the command **SHOWSET P F** to examine the front-panel port settings or enter the command **SHOWSET G** to examine the global settings. You can display P, A, M, U, L, and O settings for a port by giving the port number as the only parameter to **SHOWSET**. (For example, use **SHOWSET 5** to view all Port 5 settings.) Enter parameters following the **SHOWSET** command in any order.

You cannot enter or modify settings with this command. Change settings with the **SET** command.

STATUS

Use the **STATUS** command (Access Level 1) to inspect self-test status, the configuration of this unit, and the status of each port. The SEL-2032 automatically sends the **STATUS** command response message to Port F whenever the self-test software enters a warning or failure state. Add a repeat count parameter to cause the **STATUS** command to repeat a given number of times. For example, type **STATUS 4** to view the status information four times.

The SEL-2032 **STATUS** report format appears as shown in *Figure 8.29* and *Figure 8.30*.

```
*>>STATUS <Enter>
COMMUNICATIONS PROCESSOR - S/N XXXXXXXX   Date: 2/16/04  Time: 00:01:17
FID=SEL-2032-R103-V0-Z001000-D20050418    FID=SLBT-2030-R103-V0-Z000000-D20010122
SELF-TESTS
RAM     SRAM     CODE  ARCH     EEPROM  P.S.   SET    BATTERY   SETM
512 kb  1024 kb  OK    1792 kb OK       OK     OK     OK        OK
IRIG-B Input: Absent
I/O Board: Installed
Port  Status           Success Rate  SET M     Data
1     Active(overrun)                None
2     Active                         None
3     Active                         None
4     Active                         None
5     Active                         None
6     Inactive                       None
7     Inactive                       None
8     Inactive                       None
9     Inactive                       None
10    Inactive                       None
11    Inactive                       None
12    Inactive                       None
13    Inactive                       None
14    Inactive                       None
15    Inactive                       None
16    Active              100%       None
17    NORMAL(0h)          NORM       None
18    NORMAL(0h)          NORM       None
F     Active                         None
Last Status Reset: 02/15/04 18:36:21
*>>
```

Figure 8.29 Active State for (Overrun)

```
*>>STATUS <Enter>
COMMUNICATIONS PROCESSOR - S/N XXXXXXXX   Date: 2/16/04  Time: 00:01:17
FID=SEL-2032-R103-V0-Z001000-D20050418    FID=SLBT-2030-R103-V0-Z000000-D20010122
SELF-TESTS
RAM     SRAM     CODE  ARCH    EEPROM  P.S.   SET    BATTERY   SETM
512 kb  1024 kb  OK    1792 kb OK      OK     OK     OK        OK
IRIG-B Input: Absent
I/O Board: Installed
Port  Status         Success Rate  SET M     Data
1     Active                       None
2     Active                       None
3     Active                       None
4     Active                       None
5     Active                       None
6     Inactive                     None
7     Inactive                     None
8     Inactive                     None
9     Inactive                     None
10    Inactive                     None
11    Inactive                     None
12    Inactive                     None
13    Inactive                     None
14    Inactive                     None
15    Inactive                     None
16    Active            100%       None
17    NORMAL(0h)        NORM       None
18    NORMAL(0h)        NORM       None
F     Active                       None
17    Active VT1(data)  100%
Last Status Reset: 02/15/04 18:36:21
*>>
```

Figure 8.30 Active State for (Data)

Table 8.6 describes the **STATUS** report self-test and configuration fields.

The configuration information (RAM size, nonvolatile Flash memory size, IRIG-B input, and I/O board presence) reported in the status message is determined at system power-up. A configuration item not reported as expected may indicate a problem in accessing that item. If a failure occurs, the SEL-2032 will attempt to continue operating, but invalid data may be reported.

Table 8.6 Status Report Description (Sheet 1 of 2)

Parameter	Status Displayed	Explanation
RAM	xxxx kb	Installed RAM size; self-test OK.
	Uxx	Self-test failure in specified RAM device.
SRAM	xxxx kb	Installed Shared-RAM size; self-test OK.
	Uxx	Self-test failure in specified RAM device.
CODE	OK	Code Flash self-test successful.
	Uxx	Self-test failure in specific device.
ARCH	xxxx kb	Installed nonvolatile Flash memory size; self-test successful.
	FAIL	Self-test failure.
EEPROM	OK	EEPROM self-test successful.
	FAIL	Self-test failure.
P.S.	OK	Power supply voltages are acceptable.
	FAIL	A power supply voltage is out-of-tolerance.
SET	OK	Settings are OK.
	FAIL	Settings are not valid.
BATTERY	OK	Battery-backed clock battery was OK on last power-up.
	FAIL	Bad date or time reported by battery-backed clock on last power-up. This is probably due to a low battery.

Table 8.6 Status Report Description (Sheet 2 of 2)

Parameter	Status Displayed	Explanation
IRIG-B Input	Absent	No IRIG-B input signal is detected.
	Present	IRIG-B input signal is present.
I/O Board	Absent	No I/O board is installed.
	Installed	I/O board is installed.

The SEL-2032 settings become invalid when the SEL-2032 copies ROM default settings into EEPROM. This problem occurs when new code is installed in the SEL-2032. You use the **SET C** command to change the settings to VALID. For any unexpected self-test failure, you should contact the factory immediately to get the unit repaired.

Port Status Information

Status. The Port Status Column of the report indicates, for each port, whether the port is Unused, Active (in a normal active state), Inactive (not responding), pInactive (in an inactive state with a power-up auto-configuration pending), ConfigFail (in a power-up auto-configuration failure state), Trans *n* (communicating transparently with some other port, e.g., Trans 7), Trans C *yyyy* (communicating transparently with card C to network device *yyyy*), or Broadcast (communicating to all IED ports simultaneously).

A “dropped character” diagnostic appended to the port Status indicates that the serial port has been unable to process characters. This condition could occur if a transparent connect between two ports is created with different baud rates and flow control is disabled. In this case, the faster port could theoretically transfer more data than the slower baud rate port could process. When this occurs “(overrun)” will be appended to the slower baud rate port. Overrun will remain appended to the port status until STATUS Clear is issued, loss of power occurs, or the SEL-2032 is re-initialized.

Plug-in card status and status code are reported for Ports 17 and 18. See the instruction manual for the plug-in card for information about these indications. For cards that support virtual terminal connections, an additional line is appended for active virtual terminal connections; the status can include Master VTn (virtual terminal master session) or Trans PVtn (virtual terminal transparent connection to Port P).

Success Rate. The Success Rate column indicates the percentage of error-free messages received; errors could be due to checksum failure or unexpected data items. The Success Rate is reset when you issue a **STATUS CLEAR** or **STATUS RESET** command, or you issue a **SET P** command for a port.

In the SEL-2032, additional plug-in card status is provided in this column. The value will be NORM if everything is working as expected. The value will be FAIL if the card quits responding to the SEL-2032.

SET M. The SET M column indicates the state of SET M settings. ‘None’ indicates that there are not SET M settings on the port or that the SEL-2032 is still doing power-up initialization and the settings have not yet compiled. ‘Running’ indicates that SET M settings exist and are running on the designated port. ‘Disabled’ indicates that SET M settings exist but are not running on the designated port; this is typically due to insufficient RAM. See *Section 7: Settings* for a complete discussion of SET M settings.

Database Delays. The Database Delays column indicates in which database regions (e.g., D1 A1) data have not been collected at the desired rate since the last **STATUS** command was issued. Any entry in this column indicates a request for data with a previous request pending. These delays will occur: a) in transparent mode because the SEL-2032 cannot perform its data collection operation, b) if the data collection rate is set too high for the IED response time, or c) if the SEL-2032 is so busy that it cannot process data requests at the set rates.

Ram Allocation Failure Information. The Ram Allocation Failure indicator provides diagnostic information about unavailability of memory when requested. There are two separate unavailable memory counters, one is for the SEL-2032 memory and the other is for the shared memory between the SEL-2032 and installed protocol cards. The counters increment when the SEL-2032 attempts to reserve memory and is unable to. You can use these counters to determine if the SEL-2032 RAM requirements are exceeding the physical RAM installed in the SEL-2032. The Ram Allocation Failure counters are nonvolatile. Loss of power or re-initialization will clear the counters. The **STATUS CLEAR** command will also clear the counters. If both counters are zero, the Ram Allocation Failure will not be displayed in the Status Report.

STORE m:n d

Use the **STORE** command (Access Level 2) to store data directly into a database. Parameter *m* specifies the port number (1–18 in the SEL-2032); parameter *n* specifies the starting database address; and parameter *d* is a data stream with each item consisting of data as characters, decimal integers, hexadecimal integers, or single-precision floating-point numbers. You identify the data as character data by placing the character(s) in single quotes (i.e., ‘F’), null-terminated string data by placing the character(s) in double quotes (i.e., “G”). Decimal integer data are the default. Hexadecimal integer data are indicated when the last character is an “h.” Floating-point data are indicated by the presence of a decimal point (.) within the number.

Use the **STORE** command to force data into the database for test purposes. The database address being accessed must be a valid database address for writing. You cannot write to read-only addresses in the Global and Local Data Regions. You can write to any allocated User Data Region. You set up the User Data Region for each port as a portion of the auto-message settings (SET A). Use the **VIEW** command to confirm that data are stored as you expected.

The example in *Figure 8.31* illustrates how you use the **STORE** command to store various types of data and how you use the **VIEW** command to see the stored response:

```
*>>STORE 3:F800h 'F' 123 123h 123. <Enter>
*>>VIEW 3:F800h NR 5 <Enter>
3:F800h
0046h 007Bh 0123h 42F6h 0000h

*>>
```

Figure 8.31 STORE Command

SWAP n m

The **SWAP** command (Access Level 2), as shown in *Figure 8.32*, switches all port-specific settings (P, A, M, U, O, and L settings) between two ports. The SEL-2032 requests confirmation, as for the **COPY** command. This command can only be performed if neither of the two ports is currently communicating transparently. Before performing the **SWAP**, the SEL-2032 requests confirmation. If you answer yes, the alarm contact is pulsed and the involved ports are reset. Neither of the selected ports may be the current port or Port F. In the SEL-2032, Ports 17 and 18 can be used only to swap with each other only if identical cards are installed in both slots.

```
*>>SWAP 4 6 <Enter>
Swap Port 6 settings with Port 4 settings (Y/N) ? Y <Enter>
Port 6 Settings Changed
Port 4 Settings Changed

*>>
```

Figure 8.32 SWAP Command

When you use the **SWAP** command, the SEL-2032 makes changes to port numbers used in strings and in SELOGIC control equations within the settings on all ports, based on the following rules: for the command format "**SWAP *n* *m***," any reference to Port *n* will change to *m*, and any reference to Port *m* will change to *n*; any reference to a port other than *n* or *m* will remain unchanged. You should always use **SHOWSET** after a swap to make sure all settings and port references are as desired.

TARGET n m

The **TARGET** command (Access Level 1) displays global or port-specific element information. You enter G for parameter *n* to display global elements or 1–18 for port-specific elements (Port F has no elements). Port-specific elements include elements from the Local region and from the TARGET region (if it exists as a data region). For parameter *m*, enter the element row number you want displayed or enter ALL to show all of the elements. You may add a repeat count as a third parameter to repeat the displayed response the specified number of times. You can always abort the display using the <CAN> character (**<Ctrl+X>**).

Because many of the SEL-2032 elements will assert (logical 1) for only a few milliseconds, the SEL-2032 elements displayed by the **TARGET** command are the logical OR of each element's status during the last one-second period. If an element is asserted at any point within the last second, the element status is displayed as asserted. When displaying repeatedly, each update will be one second apart, so each will show the element status since the previous row's display. The **TARGET** display of the SEL IED elements will simply show the result of the most recent sample from the device. See *Section 4: SELOGIC Control Equations* for a description of all local and global elements.

TIME

The **TIME** command (Access Level 1) displays and sets the internal clock. To set the clock, type **TIME** and the desired setting, then press **<Enter>**. To set the clock to 23:30:00, make the entry shown in *Figure 8.33*.

```
*>TIME 23:30:00 <Enter>
23:30:00
*>
```

Figure 8.33 TIME Command

A quartz crystal oscillator provides the time base for the internal clock. You can also set the time clock automatically through the SEL-2032 time-code input using a source of modulated or demodulated IRIG-B time code. The SEL-2032 contains a battery-backed real-time clock, so the time and date will be maintained through a loss of power.

TOGGLE m

The **TOGGLE** command (Access Level 2) toggles the specified element (parameter *m*) for test purposes. You may specify global elements simply by giving their name. Local elements must have the port number preceding the element label (e.g., 4:D2). Toggle the Control Input and Output bits by specifying the port and element label (e.g., 17:CCIN12). If that element can trigger an operation, then that operation will occur. Use this command to test your data collection and data access functions without having to force some external condition.

When you use the **TOGGLE** command with the CCOUT*n* bits, internal logic in the SEL-2032 executes normally. However, to reduce the likelihood of misoperation due to testing in a network environment, the CCOUT*n* toggle changes are not sent to the plug-in cards.

Normally, the toggled element will automatically toggle back as a result of subsequent SELOGIC control equation calculations. However, if the specified bit has an unused SELOGIC control equation, it will remain in the new state until you use the **TOGGLE** command to return it to the original state. The **TOGGLE** command is intended for test purposes only; you should use the **CONTROL** command for operational control.

VIEW

Use the **VIEW** command (Access Level 1) to display data stored in a port's database. The data are displayed as formatted data if accessed by data region, as hexadecimal words if accessed by address, or as binary value if accessed by bit. Supply the parameters listed in *Table 8.7* after the **VIEW** command in the order listed.

NOTE: You cannot use the clear parameter C with /n, i.e., you can only clear the oldest record.

Table 8.7 VIEW Command Parameters

Parameter	Explanation
data reference	Use any valid data region (port number, region label, or data type label), register address, or bit access method to specify the data to be viewed. See *Section 6: Database* for a description of valid access methods. Examples: **VIEW 1:D1** (port #:region label) **VIEW 1:METER** (port #:data type label) **VIEW 1_0807h** (port #:register address **VIEW 1:0807h:4** (port #:register address:bit number)
C	Add the clear flag after a BUF or Archive data region reference to clear that region as you view it. Example:**VIEW 1:BUF C**
BL	Add the bit label flag after a region reference to see any elements in that region displayed as bits with their labels. Such elements exist in the GLOBAL, LOCAL, and TARGET (if not in archive) regions. Example: **VIEW 1:A3/4**
/*n*	Add a number "*n*" after an Archive data region reference to see that record number within the archive record queue. Number 1 is the oldest record, higher numbers reference newer records. Example: **VIEW 1:A3/4**
NR *n*	Add an NR followed by a count parameter "*n*" after a register reference to see "*n*" registers of data. Example: **VIEW 1:0807h NR 4**

WHO

Use the **WHO** command (Access Level 1) to obtain a list of devices connected to the SEL-2032, including installed plug-in protocol cards. The SEL-2032 responds with a table showing device type, protocol, baud rate, data bits, stop bits, parity, and a device identification string for the device on each port. The screen shown in *Figure 8.34* is a sample response.

```
*>WHO <Enter>
                     Date: 11/29/00  Time: 11:06:56
FID=SEL-2032-R100-V0-Z000000-D20021222    FID=SLBT-2030-R103-V0-Z000000-D20010122
Port# Device    Protocol  Parameters  Identification
1     SEL-151   SEL       9600,8,2,N  Example 21.6 kV Line
2     SEL-151   SEL       9600,8,2,N  Example 21.6 kV Line
3     SEL-151   SEL       9600,8,2,N  Example 21.6 kV Line
4     SEL-151   SEL       9600,8,2,N  Example 21.6 kV Line
5     SEL-151   SEL       9600,8,2,N  Example 21.6 kV Line
6     SEL-151   SEL       9600,8,2,N  Example 21.6 kV Line
7     SEL-151   SEL       9600,8,2,N  Example 21.6 kV Line
8     Master    SEL       38400,8,2,N MODEM
9     Printer   ASCII     9600,8,2,N  Line Printer
10    SEL IED   SEL       9600,8,2,N
11    Master    SEL       9600,8,2,N  RTU
12    Other IED ASCII     300,8,1,N   DGH1000
13    SEL IED   SEL       9600,8,2,N
14    SEL IED   SEL       9600,8,2,N
15    SEL IED   SEL       9600,8,2,N
16    Master    DNP       9600,8,2,N
17    SEL-2701  Ethernet  VTm:HS,CTl:HS,TIm:S,SBt:S
18    SEL-2701  Ethernet  VTm:HS,CTl:HS,TIm:S,SBt:S
F*    Master    SEL       9600,8,2,N

*>
```

Figure 8.34 WHO Command

When a plug-in protocol card is installed, Port 17 or 18 will identify it. The Parameters column indicates the capabilities of the card. The possible features are:

FTx	File transfer
VTm	Virtual terminal
CTl	Control operations
SBt	SELBOOT
TIm	Time synchronization

For each of these, there is an indication if the SEL-2032 can accept these operations (H) and if the plug-in card can accept these operations (S).

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Section 9
Protocols

Introduction

This section provides a detailed description of the protocols supported by the SEL-2032 Communications Processor. The native command/response handling is described in *Section 8: Serial Port Communications and Commands*. This section describes the LMD Distributed Port Switch Protocol, Fast Operate Configuration and Commands, Modbus® RTU Protocol, and DNP3 Protocol (Serial and Ethernet). All of these protocols apply to master ports only; the SEL-2032 acts as a slave to these protocols.

SEL Fast Message Protocol

Overview

The SEL Fast Message protocol is a collection of SEL protocols including Fast Meter, Fast Operate, Fast SER, and unsolicited tier-to-tier data transfer. Configuration and operation of these protocols is completely automatic between SEL devices. See SEL Application Guide AG95-10 *Configuration and Fast Meter Messages* for more information on Fast Messages. SEL offers PC software that uses the SEL Fast Message protocol to communicate with the SEL-2032. You can also obtain the details of the Fast Message protocol from SEL and write software or configure devices to communicate with the SEL-2032.

The Fast Message protocol is a binary protocol that the SEL-2032 can interleave with an ASCII conversation. This means that when you connect a single cable between the SEL-2032 and another SEL device, that cable carries both an ASCII engineering or configuration conversation simultaneously with a binary Fast Message conversation. This means that SCADA data collection and control, for example, continue uninterrupted even when an engineer dials into the substation to collect event data from one of the relays. This is an important and powerful feature of the SEL-2032 and the Fast Message protocol.

SEL IEDs and the SEL-2032

When you connect SEL IEDs including SEL relays to the SEL-2032, you can collect data from these devices without understanding the details of the Fast Message protocol. When you configure the SEL-2032 port, you initiate a process called auto-configuration. When the SEL-2032 performs an auto-configuration, it automatically collects all of the information necessary to support Fast Message communications with the attached device.

After you have performed an auto-configuration and completed SEL-2032 port configuration, perform an **AUTO** command on the SEL-2032 to determine what Fast Message capabilities of the device are available. *Figure 9.1* shows an example of the **AUTO** command for a connected SEL-387E Relay.

NOTE: Some SEL IEDs support configurable Fast Message Read (FMR) messages. You may need to force the SEL-2032 to auto-configure if you change any FMR settings. See individual relay manuals for details on FMR settings.

```
 *> AUTO 8 <Enter>
FID:       FID=SEL-387E-R102-V0-Z001001-D20001116
DEVICE ID: SEL-387E
BAUD RATE: 19200
OPERATE SUPPORT: Binary (3 Breakers, 16 Remote Bits S-C-P)
SER SUPPORT: Binary Unsolicited
COMMANDS SUPPORTED:
  B 20METER
  B 20DEMAND
  B 20TARGET
  A 20HISTORY
  A 20STATUS
  A 20BREAKER
  A 20EVENT
  A 20EVENTS
  A 20EVENTL
 *>
```

Figure 9.1 Example AUTO Command Operation

The **AUTO** command example in *Figure 9.1* shows that the relay supports control from 3 circuit breakers and 16 remote bits through the SEL Fast Operate protocol. You can access these by programming SELOGIC control equations for Port 8 BR1–BR3 and RB1–RB16. You must enable Fast Operate support in the relay port settings as well as the automatic message settings of the SEL-2032. The SEL Fast Operate protocol does not require any additional message settings to send Fast Operate messages to the relay. The SEL-2032 automatically composes and sends Fast Operate messages when the breaker bits and remote bits change state within the SEL-2032.

Follow these steps to enable Fast Operate messages that set or clear remote bits or breaker bits.

Step 1. Set the **FASTOP** setting equal to **Y** in the relay port settings for the port connected to the SEL-2032. The relay breaker jumper must be in the proper position to enable serial port commands. Refer to the relay instruction manual for this setting.

Step 2. Enable Fast Operate messages in the SEL-2032 by setting the auto-message setting **SEND_OPER** equal to **Y**.

Step 3. Toggle the corresponding Set and Clear elements SRB1–16, CRB1–16, SBR1–4, and CBR1–4.

In the example above, control of breaker bit one, BR1, will send Fast Operate **OPEN** or **CLOSE** commands for breaker one in the SEL-387E. Control of breaker bit two, BR2, will send Fast Operate **OPEN** or **CLOSE** commands for breaker two in the SEL-387E. In addition, control of breaker bit three, BR3, will send Fast Operate **OPEN** or **CLOSE** commands for breaker three in the SEL-387E. You should consult the SEL-387E instruction manual to verify that, in the relay logic settings, the breaker control bits are assigned to control appropriate outputs which in turn are used to energize the open or close control circuits to the associated circuit breaker. Similarly, verify that, in the SEL-2032 logic settings, remote bits are assigned to perform desired controls.

Some relays, such as the SEL-421, do not have internal breaker bits, though they can still control circuit breakers. When you set BR1 on a port connected to an SEL-421, the SEL-2032 sends a message to the SEL-421 that asserts the manual **OPEN** command bit OC1 for one processing interval. If you clear

BR1, the SEL-2032 sends a message to the SEL-421 that asserts the **CLOSE** command bit CC1 for one processing interval. If you are using the default settings, OC1 will open circuit breaker one and CC1 will close circuit breaker one. You can control and condition the effect of OC1 and CC1 by changing the manual trip and close settings (BK1MTR, BK2MTR, BK1MCL, BK2MCL) in the SEL-421. Operation for circuit breaker two with BR2, OC2, and CC2 is similar.

The example **AUTO** command also shows that SER support for binary unsolicited or Fast SER messages is available. This means that messages are automatically generated by the relay SER (sequential events recorder) that send the new status of selected Relay Word bits and the timestamp associated with the change of state. If you enable Fast SER, you can collect the station SER information from an SEL-2032 port using SEL protocol and the SEL PC driver software or from DNP3 messages from the SEL-2032.

The supported commands that are listed describe what data you can collect from the relay using “20” messages rather than writing individual data collection messages and configuring the SEL-2032 to parse the data. For example, you can collect instantaneous metering data by setting the SEL-2032 to send a 20METER message in the automatic messaging settings (SET A). When you enter 20METER as the outgoing message, you will not be prompted for any further configuration because the SEL-2032 has already collected the necessary information to send the message and parse the results during the auto-configuration process.

Sequential Events Recorder (SER) Data

The SEL-2032 is capable of collecting Sequential Events Recorder (SER) data from SEL relays, generating SER data based on its 16 digital inputs, and automatically forwarding all SER data to another SEL-2032 or other programmable data gathering device. SER data collection from connected devices requires that REC_SER=Y and a TARGET data region is set up on each port that will receive the data. All SER data is collected and transmitted with the SEL Fast Message protocol.

If you have a Master device, capable of capturing and translating data, you must follow these steps to perform SER data collection:

NOTE: SER data are also available to other processes within the SEL-2032. When a port is enabled to receive SER information from the relay, the SEL-2032 uses Data region 8 (D8) as the SER region (see Data Regions on page 6.20).

Step 1. Use **SET P *n*** to auto-configure all relay ports.

Step 2. After auto-configuration, use the **AUTO *n*** command to determine the capability of the connected relay.

Not all SEL relays support the Fast Message protocol for collecting SER data. If the relay supports the Fast Message protocol, you should see the line `SER Support: Binary Unsolicited` in the **AUTO** command response. If this line is not present, then the REC_SER setting has no affect and the SEL-2032 cannot perform automatic SER collection from the relay.

You may wish to connect one or more relay digital outputs to the digital inputs of the SEL-2032 and monitor the SEL-2032 input elements as SER data.

Step 3. Use **SET A *n*** to enable gathering of SER data and set up a TARGET data region on all ports *n*. For each port *n*, set REC_SER = Y and add a “20TARGET” auto-message with any real or “dummy” trigger. If you do not actually want to collect TARGET data, you may use a dummy trigger for the auto-message as shown below.

```
*>>SET A 11 MSG_CNT

Automatic message settings for Port 11


How many auto-message sequences (0-12)       MSG_CNT = 0     ? 1

Item 1 trigger D1
ISSUE1  = NA
 ? R1

Item 1 message
MESG1   = ""
 ? 20TARGET
```

These settings cause the SEL-2032 to enable automatic SER data transmission from the connected relay. Once set in this manner, the relay will send all SER data to the SEL-2032 as they are generated. The **SER** command will also be capable of displaying SER data by port number as well as global SER data. If the port TARGET region is not present, the **SER** command cannot be used to display SER data for that port number.

Step 4. Use **SET A *n*** to set REC_SER = Y on all ports (*n*) from which you wish to gather SER data.

This setting causes the SEL-2032 to enable automatic SER data transmission within the connected relay. The relay will now send all SER data to the SEL-2032 as the data are generated.

Step 5. Use the **SET R** command to define SEL-2032 SER elements.

If all the data of interest are within the relays, you may not wish to define any SEL-2032 SER elements. Alternately, if you have relays that do not support automatic SER collection, you may need to monitor the SEL-2032 digital inputs in order to get SER data that represent the data within those relays.

Step 6. Connect your intelligent Master to a rear-panel Master port on the SEL-2032.

Your Master must send a binary “Enable SER” message to the SEL-2032 to enable the SEL-2032 port to transmit the SER data. The SEL-2032 then transmits the SER data in an unsolicited fashion as the data are received and/or generated. Your Master must send an “SER Acknowledge” message to the SEL-2032 to indicate successful receipt of the data. Only then will the SEL-2032 proceed to the next block of data. Until it receives the Acknowledge message, the SEL-2032 retransmits the same data repeatedly every 500 milliseconds.

Your Master may disable the SER data transmission at any time by sending the binary “Disable SER” message.

SEL Fast Message Synchrophasor Protocol

Synchrophasor measurement refers to the concept of providing measurements taken on a synchronized schedule at precise moments in time. A high-accuracy clock, commonly using a Global Positioning System (GPS) receiver such as the SEL-2407 Satellite-Synchronized Clock, makes synchrophasor measurement possible.

The availability of an accurate time reference over a large geographic area allows multiple devices to synchronize the gathering of power system data. The high-accuracy clock allows precise event report analysis and other off-line analysis functions. The SEL-2032 communications processor or a dedicated synchrophasor processor can collect synchrophasor data from various Phasor Measurement Units (PMUs). The SEL-2032 uses SEL Fast Message Unsolicited Write (UW) messages to collect synchrophasor data from SEL devices such as the SEL-311 series relays, most of the SEL-351 series relays, the SEL-421 and SEL-451, and metering devices such as the SEL-734.

Unsolicited Write (Synchrophasor) Messages

SEL Fast Message UW messages are general Fast Messages that transport measured synchrophasor information. The rate that an SEL IED can send UW messages to an attached SEL-2032 depends on the length of message data and port BAUD setting. The SEL-421-2, for example, can send either positive-sequence voltage (single synchrophasor), three-phase and positive-sequence voltages (four synchrophasors), or three phases of voltage and current along with positive-sequence voltage and current (eight synchrophasors maximum). Message packet size starts at 40 bytes for the single-synchrophasor message and increases to 64 and 96 bytes for the four- and eight-synchrophasor options, respectively. *Table 9.1* lists the supported SEL-2032 UW message periods, available port BAUD settings, and the maximum message size that can fit within the port bandwidth. Blank entries indicate bandwidths of less than 40 bytes.

Table 9.1 SEL-2032 Serial Port Bandwidth for Synchrophasors (in Bytes)

Requested Message Period	Equivalent Message Rate		Port Setting BAUD						
(ms)	Msg per second	Msg per minute	300	600	1200	2400	4800	9600	19200
1000	1.0000	60		43	86	173	347	695	1391
2000	0.5000	30	43	86	173	347	695	1391	2782
3000	0.3333	20	65	130	260	521	1043	2086	4173
4000	0.2500	15	86	173	347	695	1391	2782	5565
5000	0.2000	12	108	217	434	869	1739	3478	6956
6000	0.1667	10	130	260	521	1043	2086	4173	8347
10000	0.1000	6	217	434	869	1739	3478	6956	13913
15000	0.0667	4	326	652	1304	2608	5217	10434	20869
20000	0.0500	3	434	869	1739	3478	6956	13913	27826
30000	0.0333	2	652	1304	2608	5217	10434	20869	41739
60000	0.0167	1	1304	2608	5217	10434	20869	41739	83478

The formula used to calculate message size nn is:

$$nn = bps/(1.15 \cdot L \cdot f)$$

where:

bps	=	port BAUD
L	=	length of message byte (1 start bit, 8 data bits, 2 stop bits, 1 parity = 12)
f	=	frequency of messages in seconds
1.15	=	factor to account for system delays

Note that no IED can support the transmission of all messages at all data speeds. If the selected data rate is not sufficient for the given message length, the IED will respond with an error message (see *Fast Message Synchrophasor Settings*).

Some observations from *Table 9.1*:

- ➤ A serial port set to 2400 baud or higher can handle any size message at any supported data rate.
- ➤ A serial port set to 1200 baud can handle any size message at any data rate, up to 30 messages a minute
- ➤ A serial port set to 300 baud can handle a single-synchrophasor message at 30 messages a minute, a four-synchrophasor message at 20 messages a minute, and any size message at 12 messages per minute or less.
- ➤ A rate of 60 messages per minute requires 600 baud for single-synchrophasor messages, 1200 baud for four-synchrophasor messages, or 2400 baud for any size message.
- ➤ A serial port set to any baud can handle any size message up to 12 messages a minute.

Because it is a member of the SEL family of interleaved protocols, the SEL Fast Message Synchrophasor protocol is able to share the same physical port with separate data streams (see *SEL Protocol on page 1.7*).

Fast Message Synchrophasor Settings

In the SEL Fast Message format, the SEL-2032 communications processor must request a particular data message period, which it embeds in its automatic enable message. If the requested message period is supported, the SEL IED will acknowledge the request and begin transmitting synchrophasors. If the requested message period is not permitted, the SEL IED will respond with an `Invalid data` error message and will not transmit any synchrophasor data.

The synchrophasor automatic message setting SP_RATE allows the SEL-2032 to automatically Enable or Disable Unsolicited Data Transfer Messages to attached SEL IEDs over serial connections. The Enable Message contains the SP_RATE value instructing the attached SEL IED to begin sending “Unsolicited Write” (UW) Messages (synchrophasor data) back to the SEL-2032. See *Automatic Message (SET A) Settings on page 7.11* for a short description and valid settings for SP_RATE.

The SP_RATE setting will only be available if the attached device is an SEL IED, as indicated by the port DEVICE setting. It is available whether the attached SEL IED supports this functionality or not. If the SP_RATE is “N”, the SEL-2032 will not enable or disable UW messages.

If SP_RATE is anything other than "N", the SEL-2032 will attempt to enable UW message transmission only if during autoconfiguration the IED indicates support for transmitting UW messages in its Fast Message Configuration response or the attached IED is one of the following:

- SEL-311A/B (R107 or higher)
- SEL-311C (R110 or higher)
- SEL-311L-1/-7 (R207 or higher)
- SEL-311L-0/-6 (R156 or higher)

The SEL-2032 will automatically send the "Enable Unsolicited Data Transfer" message (function code 0x20) to the attached SEL IED along with the rate value. This message instructs the SEL IED to begin sending UW Messages (synchrophasor data) to the SEL-2032 at the specified rate. If the attached IED does not support UW message transmission or the specified message rate, the setting will fail to enable synchrophasor data transmission. Note that the SEL-421, SEL-451, and SEL-734 devices only support an SP_RATE of 60 when transmitting synchrophasor data to the SEL-2032. The SEL-311 series relays and most SEL-351 series relays support all valid message rates. It is the responsibility of the user to choose a valid UW message rate (selected by SP_RATE) supported by the attached SEL IED. Refer to the appropriate SEL IED instruction manual for supported data rates.

Fast Message Synchrophasor Processing

When UW message collection is enabled and the IED supports UW message transmission, the SEL-2032 will periodically attempt to enable UW message transmission every five minutes. This ensures that if the connected SEL IED ever stops sending UW messages (for example, in the event of a power failure), the SEL-2032 will re-enable them after a maximum interval of five minutes.

In order to disable UW Message collection, the user must set SP_RATE to "N" (None). The SEL-2032 will automatically send a "Disable Unsolicited Data Transfer" message to the attached SEL IED.

When necessary, the SEL-2032 will send a "Disable Unsolicited Data Transfer" message to the attached SEL IED, disabling UW messages. This includes during port settings changes, initiation of transparent communications, reconfiguration, etc. Once the SEL-2032 is able to receive UW messages, the SEL-2032 will automatically send an "Enable Unsolicited Data Transfer" message (along with the rate value) to reenable data collection.

The IED must respond to every Enable or Disable message the SEL-2032 sends within 1/2 second. If it does not receive a response, the SEL-2032 will send the message up to three times more (for a total of four attempts). After making the fourth attempt, the SEL-2032 will return to processing normal communications traffic.

Note that the SEL-2032 will process all UW messages from a lower-tier device whether or not UW messages are enabled or disabled via this new automatic setting.

Multitiered SEL-2032 Applications

If you have more than 16 IEDs in your substation, you can collect data with a multitiered SEL-2032 architecture similar to that shown in *Figure 9.2*. With this architecture, the connection between the SEL-2032 and the relays uses the Fast Message protocol to convey measurements, control messages, and collect SER information. As with connections to other SEL IEDs, the message and communication configuration is mostly automated by the auto-configuration process. You can pass data between the SEL-2032 and the relays (in either direction) using the “\W” automatic message described in *Section 7: Settings*.

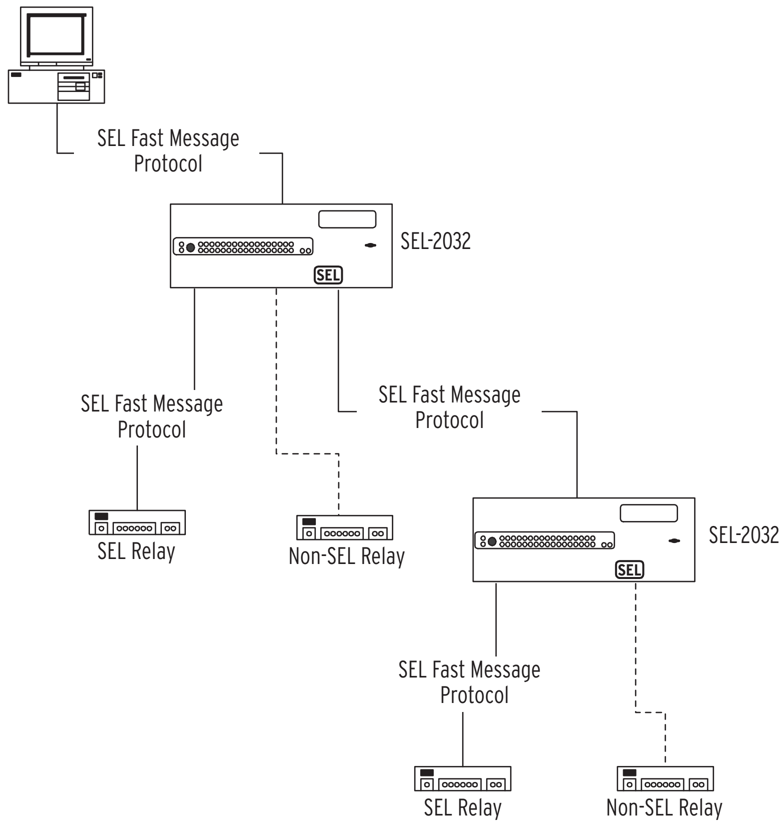

Figure 9.2 SEL-2032 Multitiered Application Example

Modbus RTU Protocol

Overview

The SEL-2032 supports the Modbus RTU protocol on Ports 12, 14, and 16 for access to data from any SEL-2032 port database. The SEL-2032 is a Modbus slave, not a master. Modbus can access any information within the SEL-2032 database, and can also perform basic control functions.

As shown in *Figure 9.3*, the SEL-2032 acts as a virtual Modbus network of 18 Modbus slaves. Port 12 acts as an access point to a multidrop network of 18 Modbus devices, each with a unique Modbus slave address. The reason for this is that each port database contains almost the maximum amount of data for a Modbus slave. By providing multiple independent Modbus slaves, the SEL-2032 allows access to every register in every database.

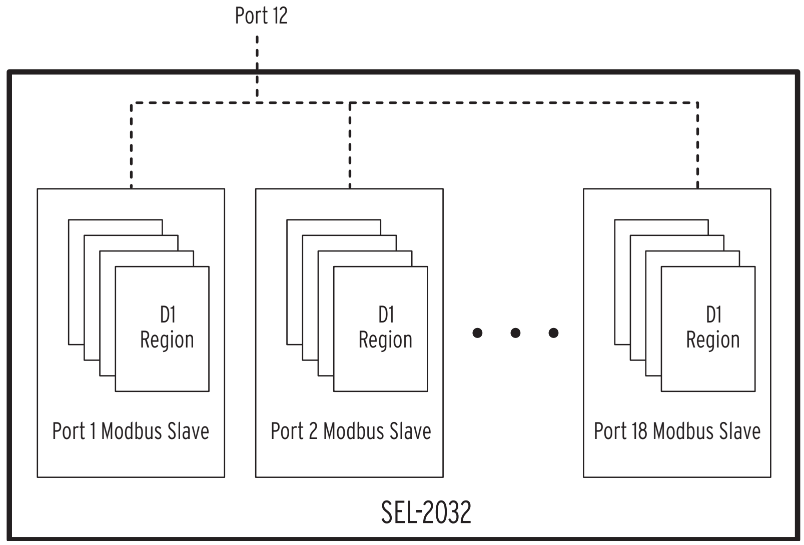

Figure 9.3 SEL-2032 Virtual Modbus Network

In addition to direct database access, the SEL-2032 provides access to data from individual ports with SEL relays mapped as input (3X) registers. If you have configured the SEL-2032 to collect data from an SEL relay, the relay data are automatically mapped into registers providing a virtual environment of Modbus slaves corresponding to the connected SEL relays.

Modbus Basics

Modbus is a protocol developed to allow master devices to collect data from Modicon PLCs. Modbus is much less complex than protocols like DNP3 and UCA2, but does not contain features like time-stamped data or file transfer. To overcome the lack of features, some manufacturers have designed and implemented proprietary extensions to Modbus that are only compatible with other devices from that manufacturer. The SEL-2032 Modbus implementation avoids proprietary extensions and therefore provides several basic functions for reading data, writing data, and diagnostics. You can get more information on the Modbus protocol at the Modicon web site www.modicon.com.

The key to implementing Modbus in a device that is not a Modicon PLC is to map data within the device to data types available in a PLC and provide mapping information to allow Modbus masters to manipulate the data and perform control operations. The basic Modbus data types are shown in *Table 9.2*.

Table 9.2 Modbus Data Types

Modbus Data Type	Type	Examples	Modicon PLC Data Type	SEL Data Type
Coil	0X	00001, 0099, 01023	Internal binary storage, binary outputs	Remote bits, breaker bits, bits within database registers
Input	1X	10001, 1099, 11023	Discrete inputs	Remote bits, breaker bits, bits within database registers
Input Register	3X	30001, 3099, 31023	16-bit analog input values	16-bit SEL-2032 database registers (use 2 consecutive registers for floating point numbers)
Holding Register	4X	40001, 4099, 41023	16-bit internal storage, 16-bit analog output values	16-bit SEL-2032 database registers (use 2 consecutive registers for floating point numbers)

Table 9.3 contains a summary of Modbus mapping for the SEL-2032. The summary also contains a brief list of the capabilities of the SEL-2032 that are available with each data type. You must use the correct register references and Modbus function codes for the Modbus master you are using to access the data.

Table 9.3 SEL Modbus Map Summary

Modbus Data Type	SEL Mapping	Use
Coil (0X)	See *Table 9.5*	Read status of global elements, local elements, Relay Word bits, and bits within User region registers Control remote bits and breaker bits.
Input (1X)	See *Table 9.5*	Read status of global elements, local elements, Relay Word bits, and bits within User region registers.
Input Register (3X)	Automatic	Read automatic Modbus map data. Use the **MODMAP** command; see *Table 9.8* to *Table 9.13* for examples.
Holding Register (4X)	SEL-2032 database address plus 1	Read any register within the SEL-2032 on any port Write data to SEL-2032 User region on any port.

Sophisticated Modbus masters utilize standard Modbus register references and automatically create Modbus messages using Modbus function codes. For example, HMI drivers such as Wonderware® InTouch® require that you enter reference that includes the Modbus register reference. You can use the Modbus mapping listed in *Table 9.3* to create the correct Modbus reference. For example, the first register of the User region is F800h. If you wish to access this register as a holding register, convert to decimal (63488) and add 1 and place the type identifier (4) before the number for a reference of 463489. There are additional examples and information about Modbus references in *Function Codes on page 9.12*.

Modbus protocol compatibility facilitates connection to many Remote Terminal Units (RTU), and to most Programmable Logic Controllers (PLC) and PLC Networks.

Settings

From Port F or another master port, use the **SET P 12**, **SET P 14**, or **SET P 16** command to set the device type to MASTER and the protocol to MODBUS. The SEL-2032 will prompt for the map style, device ID offset, and Modbus slave address for each of 18 ports. With the map type setting, you select between the default map which contains floating-point data and the integer-only map. With the device ID offset setting, you can select an offset for the device ID table, which is discussed later in this section. You must also provide the slave device address(es) for Modbus access to data from the desired port(s).

For each SEL-2032 port connected to an IED with data you want to access by Modbus, you must use the following **SET** commands (refer to *Section 7: Settings*):

- ➤ Use the **SET P** command to set and auto-configure the SEL IED port.
- ➤ For function code 04 access, use the **SET A** command to specify 20METER, 20DEMAND, 20HISTORY, 20TARGET, and 20BREAKER data retrieval as desired. The region selected

for the data collection does not matter; Modbus will access the first data region of that type on the port. Scaling and conversions are handled automatically with function code 04. You can also access user region data using this function code. Because of the amount of internal processing performed on these reads, system performance may be affected (see *Read Input Register (Function Code 04h) on page 9.16*).

- For function code 03 access, set the collections as desired and use the **MAP** command to determine the data addresses. Function code 03 direct database reads may require scaling or conversion by using **SET M** commands. See below and *Read Holding Register (Function Code 03h) on page 9.15* for more information.
- For custom data access, use **SET M** to organize and scale data as desired. This is the most efficient method and provides the best update performance to the Modbus master.

Hardware Connections and RTS Line Usage

An EIA-232 connection is the most common connection between an SEL-2032 and an RTU. When Modbus is used in a dedicated link, the RTU should ignore the Request-To-Send (RTS) output from the SEL-2032. To accomplish this, you may need to connect the Clear-To-Send (CTS) pin to +12 Vdc in the cable connector at the RTU.

If you use the SEL-2032 as a slave in a multidrop Modbus configuration, use the RTS output as your push-to-talk signal to key on the slave transmitter. Devices that typically utilize RTS keying include EIA-232 to 4-wire EIA-485 converters and modems bridged to a shared audio line. The SEL-2032 asserts the RTS line prior to transmitting, executes the delay established by the SETTLE1 setting, transmits a message, executes the delay established by the SETTLE2 setting, and deasserts the RTS line. While the SETTLE2 (post transmit) delay is executing, the RTS line remains asserted. So, a transmission that occurs during the SETTLE2 delay will be sent without executing the SETTLE1 (pretransmit) delay.

Data Access Considerations

When you program the Modbus master device to read data, you may access all data in one read message, or you may access selected data with separate read messages. If you read all data, the data you read will all correspond to a single data sample from the attached relay. However, if you read the data in pieces, subsequent reads will not necessarily be from the same data sample. You can avoid this by using the 05 function code to freeze a copy of the data for reading.

Data can be stored in either an Archive data region or a normal database region. If the data are stored in a normal database region, the data retrieved through Modbus protocol are the newest collected data from the relays. If the data are stored in an Archive data region, the data retrieved through Modbus protocol are the oldest collected data from the relays.

To clear the oldest collected data in an Archive data region, send the clear message (using function code 05h). After the oldest record is cleared, the next record can be read. The clear only works for data in an Archive data region. If the data are not stored in an Archive data region, the SEL-2032 will respond to the clear with an exception message containing error code “Illegal Data Address (02h).”

Floating-point data requires 32-bits or two 16-bit Modbus registers. The SEL-2032 presents floating-point data as two consecutive floating-point registers. For example, if you move the current from Port 3 to the Port 16 User region with the **SET M** line 000h,F = 3:METER:IA then you would read the data from register F800h and F801h. The register addresses converted to Modbus references are 46389 and 46390. The SEL-2032 stores floating-point data in SEL standard format of MSW (Most Significant Word) in the first register and LSW (Least Significant Word) in the second register. Modicon PLCs store LSW in the first register and the MSW in the second register, so Modbus drivers configured to work with floating-point data from Modicon PLCs are not compatible with floating-point data from the SEL-2032.

Timing

The SEL-2032 should generally respond within 1 second of receiving a Modbus request. In the rare case that database access is unavailable, the SEL-2032 will respond with a Modbus busy signal. For Modbus function 03h read requests, the SEL-2032 should respond within 1 second of receiving a request, and typically within 0.5 seconds. Depending on processor and communications loads, you may experience delays in response times for Modbus function 04h read requests. See *Read Holding Register (Function Code 03h) on page 9.15* and *Read Input Register (Function Code 04h) on page 9.16* for more information.

The Modbus protocol requires a 3.5-character silence to denote the beginning or end of a message. The SEL-2032 monitors the elapsed time between receipt of characters. If 3.5-character times elapse without a new character, then the SEL-2032 ends the message and starts listening for a new transmission. All messages received by the SEL-2032 must be separated by at least 3.5-character times plus 2.0 ms to ensure there is no confusion between messages (3.5-character times is 4.0 ms at 9600 baud).

Function Codes

Message Framing

All Modbus data requests consist of an address, a function code, some data, and a checksum. For the SEL-2032 to respond, the address must match one of those established in the settings, and the checksum must be valid. This frame format can be viewed as follows:

1 byte. Slave Address (must match an ADDRESS*n* setting)

1 byte. Function Code (see below for supported function codes)

n bytes. Information specific to function code

2 bytes. CRC–16 code for message

For successful operations, the response message will have the same format as the request message. For error responses, the message format will be as follows:

1 byte. Slave Address (echo of received)

1 byte. Exception Function Code (function code with high-bit set)

1 byte. Exception Code (see below)

2 bytes. CRC–16 code for message

Whenever multiple-byte values are sent over Modbus, they are sent most significant byte first.

The function codes supported by the SEL-2032 are listed in *Table 9.4*.

Table 9.4 Supported Function Codes

Function Code	Description
01h	Read Coil Status
02h	Read Input Status
03h	Read Holding Register
04h	Read Input Register
05h	Force Single Coil
06h	Preset Single Register
10h	Preset Multiple Registers
11h	Report Slave ID

Read Coil Status (Function Code 01h)

The SEL-2032 uses function code 01h to read the status of various bits. You may read up to 1000 bits at once.

The master request must have the following format:

1 byte. Slave Address
1 byte. Function Code (01h)
2 bytes. Starting Bit Address
2 bytes. Number of Bits to Read
2 bytes. CRC–16 for Message

A successful SEL-2032 response will have the following format:

1 byte. Slave Address
1 byte. Function Code (01h)
1 byte. Byte Count
n bytes. Data
2 bytes. CRC–16 for Message

The data response contains 8 bits per data byte, with the LSB of the first byte corresponding to the addressed bit.

Table 9.5 summarizes the supported bit addresses. Control points are detailed in *Table 9.6*.

Table 9.5 Supported Bit Addresses (Sheet 1 of 2)

Bit Addresses	Coil (0x) Reference[a]	Input (1x) Reference[a]	Corresponding Database Register
1000h–100Fh	04097–04112	14097–14112	Global Status Register
1010h–101Fh	04113–04128	14113–14128	Global Configuration Register
1020h–1057h	04129–04184	14129–14184	7 Global Element Registers (low byte only)
1058h–105Fh	04185–04192	14185–14192	Reserved–Always 0
1060h–106Fh	04193–04208	14193–14208	Local Status Register
1070h–10FFh	04209–04352	14209–14352	18 Local Element Registers (low byte only)

Table 9.5 Supported Bit Addresses (Sheet 2 of 2)

Bit Addresses	Coil (0x) Reference[a]	Input (1x) Reference[a]	Corresponding Database Register
1100h–15FFh	04353–05632	14353–15632	Target Region Targets (low bytes only)
1600h–	05633–	15633–	User Region Registers, see *Table 9.6*

[a] Four-digit addressing.

Table 9.6 Control Point Addresses

Control Point	Bit Address	0x Reference[a]	1x Reference[a]
RB1	10B7	04279	14279
RB2	10B6	04278	14278
RB3	10B5	04277	14277
RB4	10B4	04276	14276
RB5	10B3	04275	14275
RB6	10B2	04274	14274
RB7	10B1	04273	14273
RB8	10B0	04272	14272
RB9	10BF	04287	14287
RB10	10BE	04286	14286
RB11	10BD	04285	14285
RB12	10BC	04284	14284
RB13	10BB	04283	14283
RB14	10BA	04282	14282
RB15	10B9	04281	14281
RB16	10B8	04280	14280
BR1	10A7	04263	14263
BR2	10A6	04262	14262
BR3	10A5	04261	14261
BR4	10A4	04260	14260
BR5	10A3	04259	14259
BR6	10A2	04258	14258
BR7	10A1	04257	14257
BR8	10A0	04256	14256
BR9	10AF	04271	14271
BR10	10AE	04270	14270
BR11	10AD	04269	14269
BR12	10AC	04268	14268
BR13	10AB	04267	14267
BR14	10AA	04266	14266
BR15	10A9	04265	14265
BR16	10A8	04264	14264

[a] Four-digit address style.

In all cases, bit numbering starts with the LSB of each register. See *Section 6: Database* for a description of these registers. To access relay target data, you must set a region to collect the target data. Then, using the **MAP *n* TARGET BL** command, you can determine how many bytes of target data exist and what each bit is. The first target element is accessible at 1100h.

When referencing the data from most masters, you will need to set the coil number one greater than the listed bit address (0X references).

Read Input Status (Function Code 02h)

Function code 02h is used in a manner identical to function code 01h, as discussed above. Most masters use 1X references with this function code. To find the 1X reference with 5-digit addressing, add 10001 to the bit address specified above.

Read Holding Register (Function Code 03h)

The SEL-2032 uses function code 03h to read from the database directly. Refer to *Section 6: Database* for a description of the database. Use the **MAP** command to determine the details of the register maps based on your settings. You can read a maximum of 125 registers at once with function code 03.

Most masters use 4X references with this function code. Under certain circumstances, you may need to use 5- or 6-digit addressing to access these registers. To find the 4X reference with 5-digit addressing, add 40001 to the database addresses. For addresses above 9999 (270Fh), the SEL-2032 requires the master to use 6-digit addressing to avoid corrupting the type identifier digit 4. To find the 4X reference with 5-digit addressing, add 40001 to the database addresses. For example, the first register in the user region is at address F800h, which is converted to 463489 for 6-digit addressing. To read the user region with 5-digit addressing, you can access the registers as 3X using function code 04h, but you may suffer a performance hit (see *Read Input Register (Function Code 04h) on page 9.16*).

If your Modbus master cannot access data in the user region, you can use the **20USER** command to copy data to a more accessible address range (see *Example 6: Modbus Job Done on page 3.25*).

The master request must have the following format:

1 byte. Slave Address

1 byte. Function code (03h)

2 bytes. Starting database address

2 bytes. Number of registers to read

2 bytes. CRC–16 for message

A successful SEL-2032 response will have the format:

1 byte. Slave Address

1 byte. Function code (03h)

1 byte. Byte count (should be twice number of registers read)

n bytes. Byte Count Bytes of Data

2 bytes. CRC–16 for Message

Read Input Register (Function Code 04h)

The SEL-2032 uses function code 04h to read specific data from a Modbus map. This map contains various types of data at discrete addresses depending on relay type, but independent of settings. You must first collect relay meter data with the **20METER** command in order for it to be visible in the register map. You can then use the **MAP_TYPE** setting to select whether the SEL-2032 uses the default map, which includes floating-point data, or an integer-only map. You may read a maximum of 125 registers at once with function code 04h.

Function code 04h provides a method for a Modbus master to read various relay data values directly and receive scaled values without the requirement of math/movement settings. Conversions are done internally based on the type of data being read. Essentially, the Modbus master can do direct reads of magnitudes, angles, timestamps, etc., and get automatically scaled values that retain most of the resolution of the original floating point numbers.

The master request must have the following format:

1 byte. Slave Address

1 byte. Function Code (04h)

2 bytes. Starting database address

2 bytes. Number of registers to read

2 bytes. CRC–16 for message

A successful SEL-2032 response will have the format:

1 byte. Slave Address

1 byte. Function Code (04h)

1 byte. Byte Count (should be twice number of registers read)

n bytes. Byte count bytes of data

2 bytes. CRC–16 for message

Table 9.8 to *Table 9.14* show examples for integer type data from various SEL relays for 04h accesses. You can use the **MODMAP** command to identify the registers that contain the data you want to collect through the Modbus port. Most masters use 3X references when accessing input registers. To use this reference method with 5-digit addressing, simply add 30001 to the address in the **MODMAP** command response. The User Region begins at address 32401. Ensure your master can accept floating-point data transferred with the most significant word first before configuring the SEL-2032 to use them.

NOTE: Response times will increase when using function code 04h to access a large amount of Modbus specific map data. Whenever possible, concentrate required data items close to the beginning of the USER region for efficient data reads and quicker response times.

While accessing relay data using function code 04h does not require processor-intensive math/movement settings, you should consider overall system performance before using this data access method. For example, if you connect 10 SEL relays to your SEL-2032 and a Modbus master on Port 14, you could use function code 04h to read data from the relay register maps. Your Modbus master will require many read messages to access the data in this setup—at least one message per relay. On top of this, the floating-point processing required to convert each data item can cause response times to increase to 2.5 seconds or longer. However, if you move all data to a single User Region on an SEL-2032 port, your Modbus master may be able to read all required data with a single Modbus read, allowing data update rates as fast as one second. See *Example 6: Modbus Job Done on page 3.25* for an example of accessing centralized data in the SEL-2032.

Force Single Coil (Function Code 05h)

The SEL-2032 uses this function code for a variety of data control purposes. Specifically, you can use it to clear archive records, hold copies of data records, release copies of data records, and operate breaker and remote bit elements.

The master request must have the following format:

1 byte. Slave Address

1 byte. Function Code (05h)

2 bytes. Coil Reference

2 bytes. Operation Code

2 bytes. CRC–16 for Message

A successful SEL-2032 response is an echo of the request message.

There are six special purpose coil references:

0000h. Clear archive record using function code 04h addressing

0003h. Copy a region using function code 04h addressing

0004h. Release a region copy using function code 04h addressing

0010h. Clear archive record using function code 03h addressing

0013h. Copy a region using function code 03h addressing

0014h. Release a region copy using function code 03h addressing

Coil references 0000h and 0010h are for clearing archive records. The operation code must be the starting address of the record to clear. Once you clear an archive record, subsequent reads from that region will return data from the next record stored in that region.

NOTE: Frequent archive record clearing may exceed EEPROM capabilities. See the discussion in Archive Data Regions on page 6.21.

Coil references 0003h and 0013h cause a copy of the specified region to be made. Subsequent reads from this region will read from your copy. This allows you to read data regions that are larger than 125 registers without the data changing between accesses. Specify the region to copy by giving its starting address as the operation address. Use coil references 0004h and 0014h to release the region copy once you are done with it. If there is insufficient memory to make the requested copy, the SEL-2032 will respond with a BUSY exception code.

For coil references 0000h, 0003h, and 0004h, the operation code must correspond to a modified map address (map function code 04h uses). For operation codes 0010h, 0013h, and 0014h, this starting address must correspond to a true database address.

Coil references 10AOh–10BFh correspond to the port breaker and remote bit elements. See *Table 9.6* for a list of coil references for these elements.

Send a coil ON (operation code FF00h) to set the bit and OFF (operation code 0000h) to clear the bit.

Preset Single Register (Function Code 06h)

The SEL-2032 uses this function to allow a Modbus master to write directly to a database register. *Section 6: Database* shows which registers are writable and defines their operation. If you are accustomed to 4X references with this function code, for 6-digit addressing simply add 400001 to the standard database addresses.

The master request must have the following format:

1 byte. Slave Address

1 byte. Function Code (06h)

2 bytes. Register Address

2 bytes. Data

2 bytes. CRC–16 for message

A successful SEL-2032 response is an echo of the request message.

Preset Multiple Registers (Function Code 10h)

This function code works much like code 06h, except you can write multiple registers at once, up to 120 per operation. Normally, this function code will only be used in the User region. If you are accustomed to 4X references with the function code, for 6-digit addressing simply add 400001 to the standard database addresses. The master request must have the following format:

1 byte. Slave Address

1 byte. Function Code (10h)

2 bytes. Starting Address

2 bytes. Number of registers to write

1 byte. Byte count (should be twice number of registers)

n bytes. Byte count bytes of data

2 bytes. CRC–16 for Message

A successful response has the format:

1 byte. Slave Address

1 byte. Function Code (10h)

2 bytes. Starting Address

2 bytes. Number of Registers

2 bytes. CRC–16 for Message

Report Slave ID (Function Code 11h)

The SEL-2032 identifies the port device type when it receives this request. It also provides information on how data is being collected from an SEL relay so the specific map to use can be determined.

The master request must have the following format:

1 byte. Slave Address

1 byte. Function Code (11h)

2 bytes. CRC–16 for Message

A successful SEL-2032 response has the following format:

1 byte. Slave Address

1 byte. Function Code (11h)

1 byte. Byte Count (7)

1 byte. Slave ID (see following table)

1 byte. Run Status

1 byte. Fast Meter Status

4 bytes. Reserved (always 0)

2 bytes. CRC–16 for Message

The reported slave ID is simply the sum (modulo-256) of the START_ID setting and the device ID from *Table 9.7*.

Table 9.7 Device ID (Sheet 1 of 2)

Slave ID	Description
00	Unused[a]
01	Printer[a]
02	Other IED[a]
03	Unknown SEL IED[a]
04	Master Port[a]
05	SEL-49
06	SEL-121
07	SEL-121-10
08	SEL-121B/221B
09	SEL-121C/221C
10	SEL-121D/221D
11	SEL-121F/221F
12	SEL-121G/221G
13	SEL-121H/221H
14	SEL-121S/221S
15	SEL-151/251
16	SEL-151C/251C
17	SEL-151CD/251CD
18	SEL-151D/251D
19	SEL-167/267
20	SEL-167D/267D
21	SEL-187V/287V
22	SEL-279
23	SEL-279H
24	SEL-321
25	SEL-501
26	SEL-BFR/2BFR
27	SEL-PG10/2PG10
28	SEL-587
29	SEL-551
30	SEL-351
31	SEL-352
32	SEL-387/387A
33	SEL-300G
34	SEL-351R

Table 9.7 Device ID (Sheet 2 of 2)

Slave ID	Description
35	SEL-701
36	Reserved
37–38	Reserved
39	SEL-421
40–44	Reserved
45	SEL-2100
46	SEL-311A
47	SEL-311B
48	SEL-311C
49	SEL-351S
50	SEL-311L
51	SEL-351A
52	SEL-2032
53	SEL-587Z
54	SEL-387E

[a] These items apply specifically to the SEL-2032.

You would normally only offset this table, using START_ID, if you need the values to be unique from the IDs of other devices on your Modbus network. The reported run status will be FFh if the port is Active, 00h otherwise. The Fast Meter status indicates what data is being collected using binary data collection. Possible values are listed below:

0. No Fast Meter
1. Meter data only
3. Meter and Target data
7. Meter, Target, and Demand data

Error Handling

There are a number of errors that an SEL-2032 Modbus port can detect and handle. Framing errors (message did not have a correct slave address or length) and CRC mismatches will prevent an SEL-2032 response to the message. If a legitimate message is received, but cannot be processed, the SEL-2032 will respond with an error response, as indicated in the Message Framing subsection above. The following is a list of possible exception codes:

01-ILLEGAL FUNCTION. The received function code is not supported.

02-ILLEGAL DATA ADDRESS. Some portion of requested registers is undefined or invalid. For data writes, this may mean that the address is read-only. For force single coil operations, the address is not the beginning of a valid region.

03-ILLEGAL DATA VALUE. The referenced data value in a force single coil operation is not valid for the given coil.

04-FAILURE IN ASSOCIATED DEVICE. The port accessed is not currently collecting the desired data because of improper settings or because the port is inactive or read from an empty region.

06–BUSY, REJECTED MESSAGE. The SEL-2032 is unable to respond in a timely fashion due to internal data access conflicts. Also, used to indicate insufficient memory for requested operation.

Master Device Configuration Considerations

Modbus masters are capable of block requesting registers. Block requests of data can be a problem, as described in the following example.

EXAMPLE 9.1 Block Requests

You want 5 registers starting at address 105, and another 5 registers starting at address 205, and your Modbus master can request up to 125 registers. It will request 105 registers starting at address 105. The SEL-2032 may not have data defined for all addresses between 100 and 200, and will declare the request invalid. To get these 10 registers, you must alter the maximum registers that your Modbus master can request, or move the registers to a contiguous area of a User region (using the SET M procedure) and request them at this new address.

Register Maps for Meter Data, Integer Type

The example in *Table 9.8* shows meter data mapped as 16-bit signed integers. If a measured or calculated value exceeds the maximum value shown, the register will contain the maximum value shown.

Table 9.8 Example Register Map for Meter Data, Integer Type (Sheet 1 of 3)

Reg.#	Description	Units	Range
I. Data from Relays with ASCII Meter Format.			
SEL-121D/221D:			
100(R)	Meter Date stamp	Month	1–12
101(R)	Meter Date stamp	Day of the Month	1–31
102(R)	Meter Date stamp	Year	0–99
103(R)	Meter Time stamp	Hours	0–23
104(R)	Meter Time stamp	Minutes	0–59
105(R)	Meter Time stamp	Seconds	0–59
106(R)	Meter Time stamp	Milliseconds	0–999
107(R)	Meter Date stamp	Day of the week (Sunday–0 • • • Saturday–6)	0–6
108(R)	Phase Current IA	A, primary	0–32767 A, pri
109(R)	Phase Current IB	A, primary	0–32767 A, pri
110(R)	Phase Current IC	A, primary	0–32767 A, pri
111(R)	Difference Voltage VAB	kV/10, primary	0.0–3276.7 kV, pri
112(R)	Difference Voltage VBC	kV/10, primary	0.0–3276.7 kV, pri
113(R)	Difference Voltage VCA	kV/10, primary	0.0–3276.7 kV, pri
114(R)	Real Power P	MW/10, primary	±3276.7 MW, pri
115(R)	Reactive Power Q	MVAR/10, primary	±3276.7 MVAR, pri

Table 9.8 Example Register Map for Meter Data, Integer Type (Sheet 2 of 3)

Reg.#	Description	Units	Range
II. Data from Relays with Binary Fast Meter Format			
SEL-351; SEL-351R Binary Fast Meter Format:			
100(R)	Meter Date stamp	Month	1–12
101(R)	Meter Date stamp	Day of the Month	1–31
102(R)	Meter Date stamp	Year	0–99
103(R)	Meter Time stamp	Hours	0–23
104(R)	Meter Time stamp	Minutes	0–59
105(R)	Meter Time stamp	Seconds	0–59
106(R)	Meter Time stamp	Milliseconds	0–999
107(R)	Meter Date stamp	Day of the week (Sunday–0 • • • Saturday–6)	0–6
108(R)	Phase Current Magnitude IA	Amps, primary	0–32767 A, pri
109(R)	Phase Current Angle	Degrees/10	±180.0°
110(R)	Phase Current Magnitude IB	Amps, primary	0–32767 A, pri
111(R)	Phase Current Angle	Degrees/10	±180.0°
112(R)	Phase Current Magnitude IC	Amps, primary	0–32767 A, pri
113(R)	Phase Current Angle	Degrees/10	±180.0°
114(R)	Neutral Current Magnitude IN	A, primary	0–32767 A, pri
115(R)	Neutral Current Angle	Degrees/10	±180.0°
116(R)	Phase Voltage Magnitude VA	kV/10, primary	0–3276.7 kV, pri
117(R)	Phase Voltage Angle	Degrees/10	±180.0°
118(R)	Phase Voltage Magnitude VB	kV/10, primary	0–3276.7 kV, pri
119(R)	Phase Voltage Angle	Degrees/10	±180.0°
120(R)	Phase Voltage Magnitude VC	kV/10, primary	0–3276.7 kV, pri
121(R)	Phase Voltage Angle	Degrees/10	±180.0°
122(R)	Synchronizing Voltage Magnitude VS	kV/10, primary	0–3276.7 kV, pri
123(R)	Synchronizing Voltage Angle	Degrees/10	±180.0°
124(R)	Frequency Magnitude	Hertz/10	0–3276.7 Hz
125(R)	Frequency Angle	Degrees	±180.0° (0.0)
126(R)	Battery Voltage Magnitude VBAT	kV/10, primary	0–3276.7 kV, pri
127(R)	Battery Voltage Angle	Degrees/10	±180.0° (0.0)
128(R)	Line Current Magnitude IAB	Amps, primary	0–32767 A, pri
129(R)	Line Current Angle	Degrees/10	±180.0°
130(R)	Line Current Magnitude IBC	Amps, primary	0–32767 A, pri
131(R)	Line Current Angle	Degrees/10	±180.0°
132(R)	Line Current Magnitude ICA	Amps, primary	0–32767 A, pri
133(R)	Line Current Angle	Degrees/10	±180.0°
134(R)	Line Voltage Magnitude VAB	kV/10, primary	0–3276.7 kV, pri

Table 9.8 Example Register Map for Meter Data, Integer Type (Sheet 3 of 3)

Reg.#	Description	Units	Range
135(R)	Line Voltage Angle	Degrees/10	±180.0°
136(R)	Line Voltage Magnitude VBC	kV/10, primary	0–3276.7 kV, pri
137(R)	Line Voltage Angle	Degrees/10	±180.0°
138(R)	Line Voltage Magnitude VCA	kV/10, primary	0–3276.7 kV, pri
139(R)	Line Voltage Angle	Degrees/10	±180.0°
140(R)	Phase Real Power PA	MW/10, primary	±3276.7 MW
141(R)	Phase Reactive Power QA	MVAR/10, primary	±3276.7 MVAR
142(R)	Phase Real Power PB	MW/10, primary	±3276.7 MW
143(R)	Phase Reactive Power QB	MVAR/10, primary	±3276.7 MVAR
144(R)	Phase Real Power PC	MW/10, primary	±3276.7 MW
145(R)	Phase Reactive Power QC	MVAR/10, primary	±3276.7 MVAR
146(R)	Three Phase Real Power PMW	MW/10, primary	±3276.7 MW
147(R)	Three Phase Reactive Power QMVAR	MVAR/10, primary	±3276.7 MVAR
148(R)	Zero-Sequence Current Magnitude I0	A, primary	0–32767 A, pri
149(R)	Zero-Sequence Current Angle	Degrees/10	±180.0°
150(R)	Positive-Sequence Current Magnitude I1	A, primary	0–32767 A, pri
151(R)	Positive-Sequence Current Angle	Degrees/10	±180.0°
152(R)	Negative-Sequence Current Magnitude I2	A, primary	0–32767 A, pri
153(R)	Negative-Sequence Current Angle	Degrees/10	±180.0°
154(R)	Zero-Sequence Voltage Magnitude V0	kV/10, primary	0–3276.7 kV, pri
155(R)	Zero-Sequence Voltage Angle	Degrees/10	±180.0°
156(R)	Positive-Sequence Voltage Magnitude V1	kV/10, primary	0–3276.7 kV, pri
157(R)	Positive-Sequence Voltage Angle	Degrees/10	±180.0°
158(R)	Negative-Sequence Voltage Magnitude V2	kV/10, primary	0–3276.7 kV, pri
159(R)	Negative-Sequence Voltage Angle	Degrees/10	±180.0°

Register Maps for Demand Meter Data, Integer Type

The first eight registers of Modbus demand meter data are the collection date and time stamp. This is the time the SEL-2032 received the demand data.

Table 9.9 Example Map for Demand Meter Data, Integer Type (Sheet 1 of 2)

Reg.#	Description	Units	Range
For SEL-151/251,-1,-2,-3; SEL-151C/251C,-1,-2,-3; SEL-151CD/251CD,-1,-3; SEL-151D/251D,-1,-3:			
2300(R)	Demand Date stamp	Month	1–12
2301(R)	Demand Date stamp	Day of the Month	1–31
2302(R)	Demand Date stamp	Year	0–99
2303(R)	Demand Time stamp	Hours	0–23
2304(R)	Demand Time stamp	Minutes	0–59

Table 9.9 Example Map for Demand Meter Data, Integer Type (Sheet 2 of 2)

Reg.#	Description	Units	Range
2305(R)	Demand Time stamp	Seconds	0–59
2306(R)	Demand Time stamp	Milliseconds	0–999
2307(R)	Demand Date stamp	Day of the week (Sunday–0 • • • Saturday–6)	0–6
2308(R)	Phase Current IA	A, primary	Integer
2309(R)	Phase Current IB	A, primary	Integer
2310(R)	Phase Current IC	A, primary	Integer
2311(R)	Residual Current IR	A, primary	Integer
2312(R)	Negative Sequence 3I2	A, primary	Integer
2313(R)	Real Power P	MW/10, primary	±3276.7 MW, pri
2314(R)	Reactive Power Q	MVAR/10, primary	±3276.7 MVAR, pri
2315(R)	Peak Demand Phase Current IA	A, primary	Integer
2316(R)	Peak Demand Phase Current IB	A, primary	Integer
2317(R)	Peak Demand Phase Current IC	A, primary	Integer
2318(R)	Peak Demand Residual Current IR	A, primary	Integer
2319(R)	Peak Demand Negative Sequence 3I2	A, primary	Integer
2320(R)	Peak Demand Real Power P	MW/10, primary	±3276.7 MW, pri
2321(R)	Peak Demand Reactive Power Q	MVAR/10, primary	±3276.7 MVAR, pri

Register Maps for History Data, Integer Type

The first eight registers of the Modbus history data are the collection date and time stamp. This is the time the SEL-2032 received the history data. The data following the collection date and time stamp are a series of history records, from most recent to oldest. The number of history records for each relay is also indicated.

Table 9.10 Example Register Map for History Data, Integer Type (Sheet 1 of 2)

Reg.#	Description	Units	Range
History Map for SEL-121/221,-1,-2,-2A,-3,-4,-5,-6,-8,-10,-16,-17; SEL-121D/221D; SEL-121F/221F,-1,-2, -3,-8; SEL-121G/221G,-3,-4,-5,-6,-7,-8,-9; SEL-121H/221H; SEL-121S/221S; SEL-PG10/2PG10,-7,-8 (Total history records are 12):			
200(R)	History Date stamp	Month	1–12
201(R)	History Date stamp	Day of the Month	1–31
202(R)	History Date stamp	Year	0–99
203(R)	History Time stamp	Hours	0–23
204(R)	History Time stamp	Minutes	0–59
205(R)	History Time stamp	Seconds	0–59
206(R)	History Time stamp	Milliseconds	0–999

Table 9.10 Example Register Map for History Data, Integer Type (Sheet 2 of 2)

Reg.#	Description	Units	Range
207(R)	History Date stamp	Day of the week (Sunday–0 • • • Saturday–6)	0–6
208(R)	1st History Record Number	None	1–12
209(R)	1st History Date Stamp	Month	1–12
210(R)	1st History Date Stamp	Day	1–31
211(R)	1st History Date Stamp	Year	0–99
212(R)	1st History Time Stamp	Hours	0–23
213(R)	1st History Time Stamp	Minutes	0–59
214(R)	1st History Time Stamp	Seconds	0–59
215(R)	1st History Time Stamp	Milliseconds	0–999
216–218(R)	1st Fault Type	None	6 Char
219(R)	1st Fault Location	Miles/10 or Kilometers/10	±3276.7
220(R)	1st Fault Duration	Cycles/10	0.0–3276.7 Cycles
221(R)	1st Fault Current	A, primary	Integer
222(R)	2nd History Record Number	None	1–12
•	•	•	•
•	•	•	•
•	•	•	•
375(R)	12th Fault Current	A	Integer

Register Maps for Relay Target Data, Both Types

The first eight registers of Modbus target data are the collection date and time stamp. Following the date and time stamp is the target string. The bit labels for the target string are also shown in MSB to LSB order. You can obtain these bit labels by typing **MAP *n* BL,** where ***n*** is the port number.

These maps apply to both the floating-point and integer only map types.

Table 9.11 Example Register Map for Relay Target Data, Both Types (Sheet 1 of 2)

Reg.#	Description	Units	Range
SEL-121/221,-1,-2,-2A,-3,-5,-6:			
2100(R)	Target Date stamp	Month	1–12
2101(R)	Target Date stamp	Day of the Month	1–31
2102(R)	Target Date stamp	Year	0–99
2103(R)	Target Time stamp	Hours	0–23
2104(R)	Target Time stamp	Minutes	0–59
2105(R)	Target Time stamp	Seconds	0–59
2106(R)	Target Time stamp	Milliseconds	0–999

Table 9.11 Example Register Map for Relay Target Data, Both Types (Sheet 2 of 2)

Reg.#	Description	Units	Range
2107(R)	Target Date stamp	Day of the week (Sunday–0 • • • Saturday–6)	0–6
2108–2112(R)	Target[a]	None	

[a] See Table 9.12 for details.

Table 9.12 Target Data

Reg#	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
2108	EN	A	B	C	G	1	2	3	*	*	CA1	BC1	AB1	C1	B1	A1
2109	*	*	CA2	BC2	AB2	C2	B2	A2	*	*	CA3	BC3	AB3	C3	B3	A3
2110	*	46P	46PH	47P	46Q	47Q	47QH	32Q	*	TRIP	CLOSE	TTI	A	B	C	ALARM
2111	*	*	ET	52A	DC	BT	TT	DT	Z3FT	Z3F	Z2FT	Z2F	Z1F	BPF	GS	GD
2112	ABC	*	21P3	21G3	21P2	21G2	21P1	21G1	*	*	*	*	*	*	*	*

Register Maps for Breaker Data, Integer Type

The first eight registers of Modbus breaker data are the collection date and time stamp.

Table 9.13 Register Map for Breaker Data, Integer Type (Sheet 1 of 2)

Reg.#	Description	Units	Range
For SEL-151/251,-1,-2,-3; SEL-151C/251C,-1,-2,-3; SEL-151CD/251CD,-1,-3; SEL-151D/251D,-1,-3:			
2200(R)	Breaker Date stamp	Month	1–12
2201(R)	Breaker Date stamp	Day of the Month	1–31
2202(R)	Breaker Date stamp	Year	0–99
2203(R)	Breaker Time stamp	Hours	0–23
2204(R)	Breaker Time stamp	Minutes	0–59
2205(R)	Breaker Time stamp	Seconds	0–59
2206(R)	Breaker Time stamp	Milliseconds	0–999
2207(R)	Breaker Date stamp	Day of the week (Sunday–0 • • • Saturday–6)	0–6
2208(R)	Relay Trips	None	Integer
2209(R)	Breaker Last reset Date stamp	Month	1–12
2210(R)	Breaker Last reset Date stamp	Day of the Month	1–31
2211(R)	Breaker Last reset Date stamp	Year	0–99
2212(R)	Breaker Last reset Time stamp	Hours	0–23
2213(R)	Breaker Last reset Time stamp	Minutes	0–59

Table 9.13 Register Map for Breaker Data, Integer Type (Sheet 2 of 2)

Reg.#	Description	Units	Range
2214(R)	Breaker Last reset Time stamp	Seconds	0–59
2215(R)	IA	kA/10, primary	0.00–3276.7 kA, pri
2216(R)	IB	kA/10, primary	0.00–3276.7 kA, pri
2217(R)	IC	kA/10, primary	0.00–3276.7 kA, pri
2218(R)	Ext Trips	None	Integer
2219(R)	Breaker Last reset Date stamp	Month	1–12
2220(R)	Breaker Last reset Date stamp	Day of the Month	1–31
2221(R)	Breaker Last reset Date stamp	Year	0–99
2222(R)	Breaker Last reset Time stamp	Hours	0–23
2223(R)	Breaker Last reset Time stamp	Minutes	0–59
2224(R)	Breaker Last reset Time stamp	Seconds	0–59
2225(R)	IA	kA/10, primary	0.00–3276.7 kA, pri
2226(R)	IB	kA/10, primary	0.00–3276.7 kA, pri
2227(R)	IC	kA/10, primary	0.00–3276.7 kA, pri

Register Map for User Data

Table 9.14 Example Register Map for User Data[a]

Reg.#	Description	Units	Range
2400(R)	First User Register	—	—
•	•	•	•
•	•	•	•
•	•	•	•
4446(R)	Last User Register	—	—

[a] The actual number of User region registers available depends on the SET A USER setting on the port.

Serial Distributed Network Protocol (Serial DNP3)

Overview

The SEL-2032 supports DNP 3.0 Level 2 Slave protocol serially on Port 16. It can be used for data access and for control. For a complete description of this protocol, refer to the *DNP Basic Four Documentation Set* and the *DNP V3.00 Subset Definition*, both of which are available from the DNP User's Group at www.dnp.org.

For information on DNP3 over an Ethernet connection, see *Distributed Network Protocol 3.0 (DNP3) LAN/WAN on page 9.43*.

Installation

If you are using the SEL-2032 in a point-to-point DNP3 connection, simply connect Port 16 to your DNP3 master. If you are using the SEL-2032 in a multidrop configuration, you will need to connect a transceiver to Port 16. If the transceiver has a Carrier Detect (CD) signal, connect it to the Port 16 CTS input. Otherwise, connect RTS to CTS at Port 16. If the transceiver requires a signal to enable its transmitter, you can use the RTS output on Port 16 for that function.

Configuration

Section 7: Settings lists all of the DNP3-related settings and their functions. In order to best configure the SEL-2032 for optimal DNP3 operation, you will need to understand the basics of DNP3 and the capabilities of your DNP3 master.

Data-Link Operation

There are two important decisions you need to make about your data-link layer operation. One is how you want to handle data-link confirmation. The other is how you want to handle data-link access.

The DNP User's Group recommends that you disable data-link confirmation altogether, which significantly reduces communications overhead. If you enable data-link confirmation, you must set the data-link time-out long enough to allow for the worst-case response of your master plus transmission time.

When the SEL-2032 decides to transmit on the DNP3 link, it has to wait if the physical connection is in use. The SEL-2032 monitors physical connections by using both its CTS input (treated as a carrier detect) and by monitoring for incoming characters. Once the physical link is idle, as indicated by CTS being deasserted and no characters being received, the SEL-2032 waits a configurable amount of time before beginning a transmission. This hold-off time will be a random time between the MIN_DELAY and MAX_DELAY setting values. This hold-off is random so multiple devices waiting to communicate on the network will not continually collide.

Data Access Method

Based on the capabilities of your system, you will need to determine how you want to retrieve data on your DNP3 connection. *Table 9.15* summarizes the main options, from least to most efficient, and indicates the key related settings.

Table 9.15 Data Access Methods

Data Retrieval Method	Description	Relevant SEL-2032 Settings
Polled Static	The master polls for static (Class 0) data only.	Set CLASS = 0, Set UNSOL_REP = N.
Polled Report-by-Exception	The master polls frequently for event data and occasionally for static data.	Set CLASS to a non-zero value, Set UNSOL_REP = N.
Unsolicited Report-by-Exception	The slave devices send unsolicited event data to the master and the master occasionally sends integrity polls for static data.	Set CLASS to a non-zero value, Set UNSOL_REP = Y, Set NUM_EVENT and AGE_TX according to how often you want messages sent.
Quiescent	The master never polls and relies on unsolicited reports only.	Set CLASS to a non-zero value, Set UNSOL_REP = Y, Set NUM_EVENT and AGE_TX according to how often you want messages sent.

For point-to-point connections, we recommend that you use Unsolicited Report-by-Exception as it provides the greatest communications efficiency and data update performance. If, however, your master does not support unsolicited data or you are using a multidrop system where other devices do not have adequate DNP Link Busy Monitoring, use Polled Report-by-Exception. If you wish to collect time-stamped event information, you must use either Polled Report-by-Exception or Unsolicited Report-by-Exception to collect Object Type 2 data (time-stamped binary events).

Device Profile Document

As required by the *DNP V3.00 Subset Definitions* document, below is the device profile.

Table 9.16 SEL-2032 DNP3 Device Profile (Sheet 1 of 2)

Parameter	Value
Vendor name	Schweitzer Engineering Laboratories
Device name	SEL-2032 Communications Processor
Highest DNP3 request level	Level 2
Highest DNP3 response level	Level 2
Device function	Slave
Notable objects, functions, and/or qualifiers supported	Supports enabling/disabling of unsolicited reports on a class basis
Maximum data link frame size transmitted/received (octets)	292
Maximum data link retries	Configurable, range 0–15
Requires data link layer confirmation	Configurable by setting
Maximum application fragment size transmitted/received (octets)	2048
Maximum application layer retries	None
Requires application layer confirmation	When reporting Event Data
Data link confirm time-out	Configurable
Complete application fragment time-out	None
Application confirm time-out	Configurable
Complete Application response time-out	None
Executes control WRITE binary outputs	Always
Executes control SELECT/OPERATE	Always
Executes control DIRECT OPERATE	Always
Executes control DIRECT OPERATE–NO ACK	Always
Executes control count greater than 1	Never
Executes control Pulse On	Always
Executes control Pulse Off	Always
Executes control Latch Off	Always
Executes control Latch Off	Always
Executes control Queue	Never
Executes control Clear Queue	Never
Reports binary input change events when no specific variation requested	Only time-tagged
Reports time-tagged binary input change events when no specific variation requested	Binary Input change with time

Table 9.16 SEL-2032 DNP3 Device Profile (Sheet 2 of 2)

Parameter	Value
Sends unsolicited responses	Configurable with unsolicited message enable settings
Sends static data in unsolicited responses	Never
Default counter object/variation	Object 20, Variation 6
Counter roll-over	16 bits
Sends multifragment responses	No

Where an item in the device profile is indicated to be configurable, it is controlled by the SEL-2032 settings (see *Section 7: Settings*).

Object List

Table 9.17 lists the objects and variations with supported function codes and qualifier codes available in the SEL-2032. The list of supported objects conforms to the format laid out in the DNP3 specifications and includes both supported and unsupported objects. Those that are supported include the function and qualifier codes. The objects that are not supported are shown without any corresponding function and qualifier codes.

Table 9.17 SEL-2032 DNP3 Object List (Sheet 1 of 5)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
1	0	Binary Input–All Variations	1	0, 1, 6, 7, 8		
1	1	Binary Input	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
1	2[e]	Binary Input With Status	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
2	0	Binary Input Change–All Variations	1	6, 7, 8		
2	1[e]	Binary Input Change Without Time	1	6, 7, 8	129, 130	17, 28
2	2	Binary Input Change With Time	1	6, 7, 8	129	17, 28
2	3	Binary Input Change With Relative Time	1	6, 7, 8	129	17, 28
10	0	Binary Output–All Variations	1	0, 1, 6, 7, 8		
10	1	Binary Output				
10	2[e]	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1
12	0	Control Block–All Variations				
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block				
12	3	Pattern Mask				
20	0	Binary Counter–All Variations	1	0, 1, 6, 7, 8		
20	1	32-Bit Binary Counter				
20	2	16-Bit Binary Counter				

Table 9.17 SEL-2032 DNP3 Object List (Sheet 2 of 5)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter Without Flag	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
20	6[e]	16-Bit Binary Counter Without Flag	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
20	7	32-Bit Delta Counter Without Flag				
20	8	16-Bit Delta Counter Without Flag				
21	0	Frozen Counter–All Variations				
21	1	32-Bit Frozen Counter				
21	2	16-Bit Frozen Counter				
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter With Time of Freeze				
21	6	16-Bit Frozen Counter With Time of Freeze				
21	7	32-Bit Frozen Delta Counter With Time of Freeze				
21	8	16-Bit Frozen Delta Counter With Time of Freeze				
21	9	32-Bit Frozen Counter Without Flag				
21	10	16-Bit Frozen Counter Without Flag				
21	11	32-Bit Frozen Delta Counter Without Flag				
21	12	16-Bit Frozen Delta Counter Without Flag				
22	0	Counter Change Event–All Variations	1	6, 7, 8		
22	1	32-Bit Counter Change Event Without Time	1	6, 7, 8	129	17, 28
22	2[e]	16-Bit Counter Change Event Without Time	1	6, 7, 8	129, 130	17, 28
22	3	32-Bit Delta Counter Change Event Without Time				

Table 9.17 SEL-2032 DNP3 Object List (Sheet 3 of 5)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
22	4	16-Bit Delta Counter Change Event Without Time				
22	5	32-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	6	16-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	7	32-Bit Delta Counter Change Event With Time				
22	8	16-Bit Delta Counter Change Event With Time				
23	0	Frozen Counter Event–All Variations				
23	1	32-Bit Frozen Counter Event Without Time				
23	2	16-Bit Frozen Counter Event Without Time				
23	3	32-Bit Frozen Delta Counter Event Without Time				
23	4	16-Bit Frozen Delta Counter Event Without Time				
23	5	32-Bit Frozen Counter Event With Time				
23	6	16-Bit Frozen Counter Event With Time				
23	7	32-Bit Frozen Delta Counter Event With Time				
23	8	16-Bit Frozen Delta Counter Event With Time				
30	0	Analog Input–All Variations	1	0, 1, 6, 7, 8		
30	1	32-Bit Analog Input	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
30	2	16-Bit Analog Input	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
30	3	32-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
30	4[e]	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
31	0	Frozen Analog Input–All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input With Time of Freeze				

Table 9.17 SEL-2032 DNP3 Object List (Sheet 4 of 5)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
31	4	16-Bit Frozen Analog Input With Time of Freeze				
31	5	32-Bit Frozen Analog Input Without Flag				
31	6	16-Bit Frozen Analog Input Without Flag				
32	0	Analog Change Event–All Variations	1	6, 7, 8		
32	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129	17, 28
32	2[e]	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
33	0	Frozen Analog Event–All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
40	0	Analog Output Status–All Variations	1	0, 1, 6, 7, 8		
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
40	2[e]	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 7, 8
41	0	Analog Output Block–All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date–All Variations				
50	1	Time and Date	1, 2	7, 8 index=0	129	07, quantity=1
50	2	Time and Date With Interval				
51	0	Time and Date CTO–All Variations				

Table 9.17 SEL-2032 DNP3 Object List (Sheet 5 of 5)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO	07, quantity=1			
52	0	Time Delay–All Variations				
52	1	Time Delay, Coarse				
52	2	Time Delay, Fine	129	07, quantity=1		
60	0	All Classes of Data	1, 20, 21	6		
60	1	Class 0 Data	1	6		
60	2	Class 1 Data	1, 20, 21	6, 7, 8		
60	3	Class 2 Data	1, 20, 21	6, 7, 8		
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
70	1	File Identifier				
80	1	Internal Indications	2	0, 1 index=7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary–Coded Decimal				
101	2	Medium Packed Binary–Coded Decimal				
101	3	Large Packed Binary–Coded Decimal				
N/A		No object required for the following function codes: 13 cold start 14 warm start 23 delay measurement	13, 14, 23			

[a] Supported in requests from master.
[b] May generate in response to master.
[c] Decimal.
[d] Hexadecimal.
[e] Default variation.

Object Definitions

Input Objects

Binary input, counter, and analog input objects are fully configurable by the user. To make data visible to DNP3, it must be moved to the User region on Port 16 using the **SET M** process to establish what data are moved and how they are to be treated. See *Section 7: Settings* for more information on using **SET M**. To determine the DNP3 map once these settings are in place, use the **DNPMAP** command See *Section 8: Serial Port Communications and Commands* for more information on this command.

Output Objects: DNP_PAIR = N

There are 1452 binary output points supported. The first 84 are readable with an Object 60 (Class 0) poll. All of the binary output points may be read using an Object 10 poll. Within the control relay output block used to control the binary outputs, only the code field within the control code byte is used; all other fields are ignored. The Latch On/Off and Pulse On/Off codes can be used with each binary output object, however their meaning is specific to the item, as shown in *Table 9.18*. For more information on these bits, see *Section 6: Database*. The first 8 bits are in the Global region and the remaining ones are in the Local region. The DNP Trip and Close operations have no effect on any control bit when DNP_PAIR is equal to N.

Table 9.18 Binary Object Operations (DNP_PAIR = N)

Bit Label	Operation Code			
	Latch On	Latch Off	Pulse On	Pulse Off
R1–R8	Set	Clear	Set	Clear
CMD1–CMD8	Set	Do nothing	Set	Do nothing
SBO1–SBO4	Set	Do nothing	Set	Do nothing
SBR1–SBR16	Set	Do nothing	Set	Do nothing
SRB1–SRB16	Set	Do nothing	Set	Do nothing
CBR1–CBR16	Set	Do nothing	Set	Do nothing
CRB1–CRB16	Set	Do nothing	Set	Do nothing

Table 9.20 lists the complete output object references. Use the relative indices from *Table 9.19* to determine specific bit locations within the *Table 9.20* port-specific control point index ranges (8–83, 84–159, etc.). For example, to determine the index of the SRB10 bit on Port 3, first find the Port 3 Index Range in *Table 9.20* (236–311). Then, get the Relative Indices of SRB1–SRB16 from *Table 9.19* (28–43). Now you can calculate that Port 3 SRB10 has the relative index of 37 (28 + 10 - 1), and its absolute index is 273 (236 + 37). Objects 8–83 are unique from other objects because the actual port being mapped to is determined by the analog output object. This yields two ways in which binary output objects can be operated: directly using indexes 0–7 and 84–1451 or by reference by writing to analog output object 0 and binary output object 8–83 at the same time. For the example above, you can either write the desired output value to index 273, or simultaneously write a 3 to analog output object 0 and the output value to binary output object 37. The bits can only be read by first setting the analog output object to select the port data to read.

Table 9.19 Relative Indices

Relative Index	Covered Bits
0–7	CMD1–CMD8
8–11	SB01–SB04
12–27	SBR1–SBR16
28–43	SRB1–SRB16
44–59	CBR1–CBR16
60–75	CRB1–CRB16

Table 9.20 Binary Output Objects (DNP_PAIR = N)

Index Range	Applicable Port	Covered Bits
0–7	N/A	R1–R8
8–83	Selected by Analog Object Index 0	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16[a]
84–159	Port 1	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
160–235	Port 2	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
236–311	Port 3	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
312–387	Port 4	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
388–463	Port 5	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
464–539	Port 6	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
540–615	Port 7	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
616–691	Port 8	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
692–767	Port 9	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
768–843	Port 10	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
844–919	Port 11	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
920–995	Port 12	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
996–1071	Port 13	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
1072–1147	Port 14	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
1148–1223	Port 15	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
1224–1299	Port 16	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
1300–1375	Port 17	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16
1376–1451	Port 18	CMD1–CMD8, SBO1–SBO4, SBR1–SBR16, SRB1–SRB16, CBR1–CBR16, CRB1–CRB16

[a] See Table 9.18.

Output Objects: DNP_PAIR = Y

When you set DNP_PAIR to Y, you must also consider the quantity and type of control points that you will use for each port. With DNP_PAIR set to Y, you will also be prompted for the settings listed in *Table 9.21*.

Table 9.21 Settings Enabled When DNP_PAIR = Y

Setting	Range	Description
CLS0_VIEW	Y/N	If set to Y, then all Control Points are visible in a Class 0 poll as Object Type 10. If set to N, then no Object 10 points will be available in a Class 0 poll of the SEL-2032.
DNP_CMDNUM	0–8	Quantity of command points that you wish to make available as DNP Control Points (Object Type 12).
DNP_SBONUM	0–4	Quantity of SEL-2032 SBO points for each port that you wish to make available as DNP Control Points (Object Type 12).
DNP_BRNUM	0–16	Quantity of SEL-2032 Breaker Bits for each port that you wish to make available as DNP Control Points (Object Type 12).
DNP_RBNUM	0–8	Quantity of DNP Remote Bit pairs for each port that you wish to make available as DNP Control Points (Object Type 12).

See *Section 6: Database* for a description of each type of SEL-2032 Control Point that you can make available through DNP3, including Command Bits (CMD*n*), Select Before Operate Bits (SBO*n*), Breaker Bits (BR*n*), and Remote Bits (RB*n*). Note that the Select Before Operate Bits are those within the SEL-2032 and that DNP3 select-before-execute operations are valid for all available control points.

Use the settings that describe the quantity of bits that you want to be available for the DNP3 master for each SEL-2032 port. For example, for a single port, if you set DNP_CMDNUM = 8, DNP_SBONUM = 4, DNP_BRNUM = 16, and DNP_RBNUM = 8, the Object 12 indices shown in *Table 9.22* would be available for Port 1. Indices 0–7 are reserved for Global Remote Bits.

Table 9.22 Example Control Points

DNP3 Object 12 Indices	SEL-2032 Control Points	DNP3 Object 12 Control Operation Code					
		Latch On	Latch Off	Pulse On	Pulse Off	CLOSE	TRIP
8–15	CMD1–CMD8	Set	NA[a]	Set	NA[a]	Set	NA[a]
16–19	SBO1–SBO4	Set	NA[a]	Set	NA[a]	Set	NA[a]
20–35	BR1–BR16	Pulse SBRn	Pulse CBRn	Pulse SBRn	Pulse CBRn	Pulse CBRn	Pulse SBRn
36	RB1–RB2	Pulse SRB2	Pulse SRB1	Pulse SRB2	Pulse SRB1	Pulse SRB2	Pulse SRB1
37	RB3–RB4	Pulse SRB4	Pulse SRB3	Pulse SRB4	Pulse SRB3	Pulse SRB4	Pulse SRB3
38	RB5–RB6	Pulse SRB6	Pulse SRB5	Pulse SRB6	Pulse SRB5	Pulse SRB6	Pulse SRB5
39	RB7–RB8	Pulse SRB8	Pulse SRB7	Pulse SRB8	Pulse SRB7	Pulse SRB8	Pulse SRB7
40	RB9–RB10	Pulse SRB10	Pulse SRB9	Pulse SRB10	Pulse SRB9	Pulse SRB10	Pulse SRB9
41	RB11–RB12	Pulse SRB12	Pulse SRB11	Pulse SRB12	Pulse SRB11	Pulse SRB12	Pulse SRB11
42	RB13–RB14	Pulse SRB14	Pulse SRB13	Pulse SRB14	Pulse SRB13	Pulse SRB14	Pulse SRB13
43	RB15–RB16	Pulse SRB16	Pulse SRB15	Pulse SRB16	Pulse SRB15	Pulse SRB16	Pulse SRB15

[a] SEL-2032 internal logic automatically clears these bits.

In *Table 9.22*, the indices for Port 2 begin at 44 and proceed to 79. The indices continue to the maximum index of 655. If your DNP3 master does not support high control point index numbers, you can reduce the available points. The example indices in *Table 9.23* correspond to DNP_CMDNUM = 0, DNP_SBONUM = 0, DNPBRNUM = 1, and DNPRBNUM = 4.

Table 9.23 Example Control Points

DNP3 Object 12 Index	SEL-2032 Control Points	DNP3 Object 12 Control Operation Code					
		Latch On	Latch Off	Pulse On	Pulse Off	CLOSE	TRIP
8	1:BR1	Pulse 1:SBR1	Pulse 1:CBR1	Pulse 1:SBR1	1:Pulse CBR1	1:Pulse CBR1	1:Pulse SBR1
9	1:RB1–RB2	Pulse 1:SRB2	Pulse 1:SRB1	Pulse 1:SRB2	1:Pulse SRB1	1:Pulse SRB2	1:Pulse SRB1
10	1:RB3–RB4	Pulse 1:SRB4	Pulse 1:SRB3	Pulse 1:SRB4	1:Pulse SRB3	1:Pulse SRB4	1:Pulse SRB3
11	1:RB5–RB6	Pulse 1:SRB6	Pulse 1:SRB5	Pulse 1:SRB6	1:Pulse SRB5	1:Pulse SRB6	1:Pulse SRB5
12	1:RB7–RB8	Pulse 1:SRB8	Pulse 1:SRB7	Pulse 1:SRB8	1:Pulse SRB7	1:Pulse SRB8	1:Pulse SRB7
13	2:BR1	Pulse 2:SBR1	Pulse 2:CBR1	Pulse 2:SBR1	2:Pulse CBR1	2:Pulse CBR1	2:Pulse SBR1
14	2:RB1–RB2	Pulse 2:SRB2	Pulse 2:SRB1	Pulse 2:SRB2	2:Pulse SRB1	2:Pulse SRB2	2:Pulse SRB1
15	2:RB3–RB4	Pulse 2:SRB4	Pulse 2:SRB3	Pulse 2:SRB4	2:Pulse SRB3	2:Pulse SRB4	2:Pulse SRB3
16	2:RB5–RB6	Pulse 2:SRB6	Pulse 2:SRB5	Pulse 2:SRB6	2:Pulse SRB5	2:Pulse SRB6	2:Pulse SRB5
17	2:RB7–RB8	Pulse 2:SRB8	Pulse 2:SRB7	Pulse 2:SRB8	2:Pulse SRB7	2:Pulse SRB8	2:Pulse SRB7
18	3:BR1	Pulse 3:SBR1	Pulse 3:CBR1	Pulse 3:SBR1	3:Pulse CBR1	3:Pulse CBR1	3:Pulse SBR1
19	3:RB1–RB2	Pulse 3:SRB2	Pulse 3:SRB1	Pulse 3:SRB2	3:Pulse SRB1	3:Pulse SRB2	3:Pulse SRB1
20	3:RB3–RB4	Pulse 3:SRB4	Pulse 3:SRB3	Pulse 3:SRB4	3:Pulse SRB3	3:Pulse SRB4	3:Pulse SRB3
21	3:RB5–RB6	Pulse 3:SRB6	Pulse 3:SRB5	Pulse 3:SRB6	3:Pulse SRB5	3:Pulse SRB6	3:Pulse SRB5
22	3:RB7–RB8	Pulse 3:SRB8	Pulse 3:SRB7	Pulse 3:SRB8	3:Pulse SRB7	3:Pulse SRB8	3:Pulse SRB7
Port 4-17 Not Shown							
93	18:BR1	Pulse 18:SBR1	Pulse 18:CBR1	Pulse 18:SBR1	18:Pulse CBR1	18:Pulse CBR1	18:Pulse SBR1
94	18:RB1–RB2	Pulse 18:SRB2	Pulse 18:SRB1	Pulse 18:SRB2	18:Pulse SRB1	18:Pulse SRB2	18:Pulse SRB1
95	18:RB3–RB4	Pulse 18:SRB4	Pulse 18:SRB3	Pulse 18:SRB4	18:Pulse SRB3	18:Pulse SRB4	18:Pulse SRB3
96	18:RB5–RB6	Pulse 18:SRB6	Pulse 18:SRB5	Pulse 18:SRB6	18:Pulse SRB5	18:Pulse SRB6	18:Pulse SRB5
97	18:RB7–RB8	Pulse 18:SRB8	Pulse 18:SRB7	Pulse 18:SRB8	18:Pulse SRB7	18:Pulse SRB8	18:Pulse SRB7

Internal Indication Object

Within the Internal Indications (IIN) object, the bits are used as specified within the DNP3 standard. When TIME_SRC is equal to DNP3 within the Global settings, the SEL-2032 requests time synchronization every 15 minutes. Bit 4 within the IIN object will be set and remain set until the SEL-2032 receives a time synchronization. If the SEL-2032 receives a time synchronization, it will clear the bit and then set it again 15 minutes later. The SEL-2032 does not have local/remote states, so the local/remote bit indicates whether or not SELOGIC control equations are running. If SELOGIC control equations are not running, the status is indicated as local since the DNP3 data will not be updated by **SET M** while SELOGIC control equations are not running.

Timing

Maximum data-link response time (without confirmation): 150 ms.

Maximum class 0 request response time (without confirmation): 300 ms.

Maximum data-link confirm time: 150 ms.

Maximum application confirm time (without data-link confirmation): 50 ms.

Time Synchronization

When TIME_SRC is equal to DNP3 within the Global settings, you can perform Time Synchronization via DNP3 by executing a write to the Date/ Time object (object 50). The DNP3 protocol assumes that the time value sent by the master device is the time at which the first bit of the first byte of the write request is received by the slave (SEL-2032). It is the responsibility of the master to account for transmission delay between sending the request and the SEL-2032 receipt of the request. In many systems this transmission delay will be 0. For example, in a simple point-to-point connection, the moment the first bit is transmitted by the master, it is received by the slave device. In configurations where the communication link may introduce delays, the master may perform a delay measurement command and then calculate the transmission delay based on the result of the delay measurement. The master can then add this calculated transmission delay time to the time value that it sends to the SEL-2032 when it writes the time. When time synchronization is performed, the SEL-2032 will synchronize itself to within 5 ms (+3/–2) of the given time. When the delay measurement command is performed, the value reported by the SEL-2032 is accurate to 10 ms (+5/–5). So, disregarding errors external to the SEL-2032, a time synchronization that uses a Delay Measurement calculation is accurate to within 15 ms (+8/-7).

Event Data

The SEL-2032 generates DNP3 event data in one of two ways. For devices that support the SEL Fast SER protocol, the SEL-2032 processes incoming SER data to provide DNP3 events (Object 2 data) with time stamps generated in the connected device. For example, an SEL-421 Relay provides SER data with a –0/+2 ms accuracy and 1 ms time-stamp resolution and that data becomes DNP3 events in the SEL-2032. This system also supports two-tier SEL-2032 applications. *Figure 9.4* illustrates the flow of SER data.

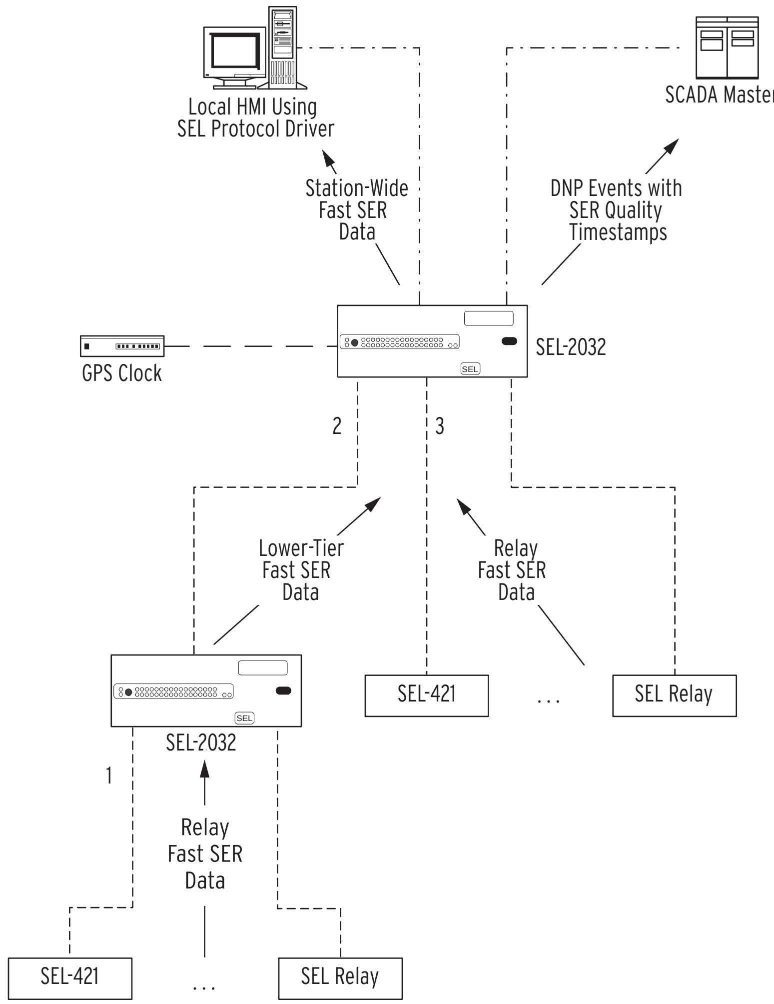

Figure 9.4 SER Data Flow

For devices and data that do not support the SEL Fast SER protocol including SEL equipment without an internal SER function, non-SEL equipment, and analog data from any device, the SEL-2032 generates DNP3 event objects (Object 2 and 32) by scanning the Port 16 User Region. This results in an average time-stamp accuracy of approximately (–0/+0.25 seconds plus one-half of the device polling time) for an overall approximate accuracy of –0/+1 second.

To determine if your SEL device supports the Fast SER protocol, consult the Instruction Manual or connect the SEL device, perform an autoconfiguration on the SEL-2032 port connected to the device, and issue the **AUTO** command. For equipment that supports the Fast SER protocol, you will see Binary Unsolicited listed under SER Support as shown in *Figure 9.5*.

```
**>AUTO 3
FID:      FID=SEL-421-R100-V0-Z001001-D20010703
DEVICE ID: Relay 1
BAUD RATE: 9600
OPERATE SUPPORT: Binary (2 Breakers, 32 Remote Bits S-C-P)
SER SUPPORT: Binary Unsolicited
COMMANDS SUPPORTED:
  B 20METER
  B 20DEMAND
  B 20TARGET
  A 20STATUS
  A 20BREAKER
  A 20EVENTL
```

Figure 9.5 Example AUTO Command Response for Device That Supports Fast SER

Proceed with the following steps to use Fast SER to provide SER quality DNP3 event time stamps for the circuit breaker position contact (52a) from an SEL-421 Relay connected to Port 3:

Step 1. Connect the SEL-421 Relay to the SEL-2032 with a cable that provides both data and IRIG connections (C273A) or a data cable (C272A) and a directly connected IRIG source.

Step 2. Configure Port 3 of the SEL-2032 to communicate with an SEL IED and select Yes when prompted to start an autoconfiguration.

Step 3. Perform an **AUTO 3** command on the SEL-2032 and you will see a response similar to that in *Figure 9.5* indicating that Fast SER data is available.

Step 4. Configure the SEL-421 SER function to monitor the circuit breaker position contact called 52AA1 inside the relay.

Step 5. Configure automatic messaging for the SEL-2032 Port 3 to collect 20TARGET data.

This data will act as present state data during SEL-2032 initialization.

Step 6. Configure the SEL-2032 Port 16 for DNP3 using the appropriate parameters for your DNP3 master device.

You must enable event data by setting the Event Class setting CLASS to 1, 2, or 3.

Step 7. Enter the following math/movement statement on Port 16:

0:0 = 3:STATE:52AA1

Step 8. Collect event data with the DNP3 master.

If a trip-reclose-trip event occurs with the circuit breaker connected to the SEL-421, the DNP3 master will receive three time-stamped events, one for each circuit breaker trip and close.

To collect the same data from the SEL-421 shown on Port 1 of the lower tier in *Figure 9.4*, follow the additional steps below:

Step 9. Connect the SEL-421 to the lower-tier SEL-2032 with a cable that provides both data and IRIG connections (C273A) or a data cable (C272A) and a directly connected IRIG source.

Step 10. Configure Port 1 of the lower-tier SEL-2032 to communicate with an SEL IED and select Yes when prompted to start an autoconfiguration.

Step 11. Perform an **AUTO 1** command on the SEL-2032 and you will see a response similar to that in *Figure 9.5* indicating that Fast SER data is available.

Step 12. Configure the SEL-421 SER function to monitor the circuit breaker position contact called 52AA1 inside the relay as SER point 1.

Step 13. Configure automatic messaging for the lower-tier SEL-2032 Port 3 to collect 20TARGET data.

This data will act as present state data during SEL-2032 initialization.

Step 14. On the upper-tier SEL-2032, enter the following math/movement statement on Port 16 (52AA1 is set as SER point 1 in the SEL-421 Relay):

0:1 = 2:STATE:1.0

Step 15. Collect event data with the DNP3 master.

If a trip-reclose-trip event occurs with the circuit breaker connected to the SEL-421 on the lower-tier SEL-2032, the DNP3 master will receive three time-stamped events, one for each circuit breaker trip and close.

The syntax used for the two-tier system is described generically:

a.b = x:STATE:y.z

where the variables have the uses listed in *Table 9.24*.

Table 9.24 Two-Tier Fast SER Math/Movement Statement Parameters

Parameter	Definition
a	User Region destination register
b	User Region destination bit of destination register
x	Port connected to lower-tier SEL-2032
y	Port on lower-tier SEL-2032 where Fast SER device is connected
z	SER point number in device (see following discussion)

When configuring a two-tier system, you will need SER point numbers from the device connected to the lower-tier SEL-2032. To obtain these, print or display the SER settings for the device. The point number is the number of the input point, starting with the first point assigned to the SER. For example, in an SEL-300 series relay, the first point assigned in the SER1 setting (that contains several SER assignments) is point 1. For an SEL-421, each SER point is configured in a separate setting line. To find the point number, count from the first point starting with one to the point that you are going to configure.

It is very important to note that the operation of this system depends on settings in the SEL-2032 as well as SER settings in the connected devices. It is, therefore, very important that you coordinate communications processor settings and relay settings carefully and ensure that when changes are made to the relay, that appropriate changes are made within the SEL-2032.

Distributed Network Protocol 3.0 (DNP3) LAN/WAN

Overview

The optional SEL-2701 Ethernet Processor with DNP3 allows the SEL-2032 to support the DNP 3.0 Level 2 Slave protocol over an Ethernet connection. It can be used for data access and for control. For a complete description of this protocol, refer to the DNP Basic Four Documentation Set and the DNP V3.00 Subset Definition, both of which are available from the DNP User's Group at www.dnp.org.

For information on DNP3 over a serial connection, see *Serial Distributed Network Protocol (Serial DNP3) on page 9.27*.

Configuration

The DNP3 protocol settings that become available for DNP3 on the SEL-2701 Ethernet port are shown in *Table 9.25*. The DNP3 protocol settings are for the port assigned to the SEL-2701: Port 17 or 18. Keep in mind that any settings for the SEL-2701 DNP3 Ethernet port will not affect any DNP3 serial port configuration or operation and vice versa.

It may be useful to note a few parameters that are unique to configuring DNP3 over Ethernet:

- The ENDNP setting allows the user to enable or disable all DNP3 sessions on the Ethernet interface.
- The DNPMAP setting enables the usage of custom DNP3 maps to define the data/control maps for the DNP3 sessions. The DNPMAP setting can have one of two values—AUTO or CUSTOM.
- DECPL indicates an exponential scaling factor, 10^{DECPL}, to multiply by the raw value to calculate engineering units. Thus the default value of DECPL, 0, will still result in the raw value being multiplied by 1 (10^0).

Up to 10 sets of unique master station parameters can be configured for implementation when the SEL-2032 communicates with a specified DNP3 host. These parameters include: DNPIP*xx*, DNPTR*xx*, DNPUP*xx*, UNSL*xx*, PUNSL*xx*, DNPMP*xx*, and DNPCL*xx*, where *xx* is a master station number from 01–10. These allow you to specify, for all communication sessions with a particular master, whether or not to:

- enable or disable unsolicited reporting at power up,
- enable or disable unsolicited reporting for normal operation,
- indicate which custom DNP3 map is associated with it, and
- enable or disable controls.

Note that although 10 masters are supported by the SEL-2701, only five unique configuration files are available. These mapping files follow the naming convention SET_DNP*xyy*.TXT, where *x* indicates the DNP3 map from 1 to 5, and *yy* indicates the port number of the installed SEL-2701. These files reside in the SEL-2701 settings subdirectory and are associated with the DNPMP*nn* setting of DNP3 Master *nn*, where *nn* is the master's identification number from 01 to 10. The DNPMP*nn* setting determines which configuration is used for communication sessions with master *nn*. For example, if DNPMP01 is set to 3, DNP3 Ethernet sessions between the SEL-2032 through its SEL-2701 on Port 17, and DNP Master 01 will employ the custom mapping file named SET_DNP317.TXT. Mapping files may be used for one or several sessions, or not at all.

See *Custom Data Mapping on page 9.56* for a discussion of how to configure custom DNP3 maps.

Table 9.25 SEL-2032 Ethernet Port DNP3 Protocol Settings (Sheet 1 of 3)

Name	Description	Range	Default
ENDNP	Enable DNP3 (Y, N)	Y, N	N
DNPADR	DNP3 Address (0–65519)	0–65519	0
DNPPNUM	DNP3 Port Number for TCP and UDP (1–65534)	1–65534	20000
DNPMAP	DNP3 map Mode (AUTO, CUSTOM)	AUTO, CUSTOM	AUTO
RPADR01	DNP3 Address for Master 1 (0–65519)	0–65519	1
DNPIP01	IP Address for Master 1 (www.xxx.yyy.zzz)	20 Char String	""
DNPTR01	Transport Protocol for Master 1 (UDP, TCP)	TCP, UDP	TCP
DNPUP01	UDP Response Port Number for Master 1 (1–65534, REQ)	REQ, 1–65534	20000
UNSL01	Enable Unsolicited Reporting for Master 1 (Y, N)	Y, N	N
PUNSL01	Enable Unsolicited Reporting at Power up for Master 1 (Y, N)	Y, N	N
DNPMP01	CUSTOM Mode: DNP3 map associated with Master 1 (1–5)	1–5	“1”
DNPCL01	Enable Controls for Master 1 (Y, N)	Y, N	N
RPADR02	DNP3 Address for Master 2 (0–65519)	0–65519	1
DNPIP02	IP Address for Master 2 (www.xxx.yyy.zzz)	20 Char String	“”
• • •			
DNPCL02	Enable Controls for Master 2 (Y, N)	Y, N	N
RPADR03	DNP3 Address for Master 3 (0–65519)	0–65519	1
DNPIP03	IP Address for Master 3 (www.xxx.yyy.zzz)	20 Char String	“”
• • •			
DNPCL03	Enable Controls for Master 3 (Y, N)	Y, N	N
RPADR04	DNP3 Address for Master 4 (0–65519)	0–65519	1
DNPIP04	IP Address for Master 4 (www.xxx.yyy.zzz)	20 Char String	“”
• • •			
DNPCL04	Enable Controls for Master 4 (Y, N)	Y, N	N
RPADR05	DNP3 Address for Master 5 (0–65519)	0–65519	1

Table 9.25 SEL-2032 Ethernet Port DNP3 Protocol Settings (Sheet 2 of 3)

Name	Description	Range	Default
DNPIP05	IP Address for Master 5 (www.xxx.yyy.zzz)	20 Char String	“”
•			
•			
•			
DNPCL05	Enable Controls for Master 5 (Y, N)	Y, N	N
RPADR06	DNP3 Address for Master 6 (0–65519)	0–65519	1
DNPIP06	IP Address for Master 6 (www.xxx.yyy.zzz)	20 Char String	“”
•			
•			
•			
DNPCL06	Enable Controls for Master 4 (Y, N)	Y, N	N
RPADR07	DNP3 Address for Master 7 (0–65519)	0–65519	1
DNPIP07	IP Address for Master 7 (www.xxx.yyy.zzz)	20 Char String	""
•			
•			
•			
DNPCL07	Enable Controls for Master 7 (Y, N)	Y, N	N
RPADR08	DNP3 Address for Master 8 (0–65519)	0–65519	1
DNPIP08	IP Address for Master 8 (www.xxx.yyy.zzz)	20 Char String	“”
•			
•			
•			
DNPCL08	Enable Controls for Master 8 (Y, N)	Y, N	N
RPADR09	DNP3 Address for Master 9 (0–65519)	0–65519	1
DNPIP09	IP Address for Master 9 (www.xxx.yyy.zzz)	20 Char String	“”
•			
•			
•			
DNPCL09	Enable Controls for Master 9 (Y, N)	Y, N	N
RPADR10	DNP3 Address for Master 10 (0–65519)	0–65519	1
DNPIP10	IP Address for Master 10 (www.xxx.yyy.zzz)	20 Char String	“”
•			
•			
•			
DNPCL10	Enable Controls for Master 10 (Y, N)	Y, N	N
ECLASSA	Class for Analog Event Data (0–3)	0–3	2

Table 9.25 SEL-2032 Ethernet Port DNP3 Protocol Settings (Sheet 3 of 3)

Name	Description	Range	Default
ECLASSB	Class for Binary Event Data (0–3)	0–3	1
ECLASSC	Class for Counter Event Data (0–3)	0–3	0
DECPL	Data Scaling Decimal Places (0–3)	0–3	0
ANADB	Data Reporting Dead Band Counts (0–32767)	0–32767	100
STIMEO	Seconds to Select/Operate Time-out (0.0–30.0)	0.0–30.0	1.0
DNPPAIR	AUTO Mode: Enable Use of DNP3 Trip Close Pairs (Y, N)	Y, N	N
DNPINA	Seconds to send Inactive Heartbeat (0=Off, 1–7200)	0–7200	120
NUMEVE	Number of Events to Transmit On (1–200)	1–200	10
AGEEVE	Age of Oldest Event to Transmit On (0–100000 sec)	0–100000	2
ETIMEO	Event Message Confirm Timeout (1–50 sec)	1–50	2
URETRY	Unsolicited Message Max Retry Attempts (2–10)	2–10	3
UTIMEO	Unsolicited Message Offline Timeout (1–5000 sec)	1–5000	60

Data Access

The DNP3 master session must be configured for one of the data access methods below.

Table 9.26 DNP3 Over Ethernet Access Methods

Access Method	Master Polling	SEL-2032/SEL-2701 Settings
Polled static	The master polls for static (Class 0) data only.	Set ECLASSB, ECLASSC, ECLASSA to Off, UNSL*nn* to No (where *nn* is the session number from 01–10).
Polled report-by-exception	The master polls frequently for event data and occasionally sends integrity polls for static data.	Set ECLASSB, ECLASSC, ECLASSA to the desired non-zero event class, UNSL*nn* to No.
Unsolicited report-by-exception	The slave devices send unsolicited event data to the master and the master occasionally sends integrity polls for static data.	Set ECLASSB, ECLASSC, ECLASSA to the desired non-zero event class, set UNSL*nn* to Yes and PUNSL*nn* to Yes or No.
Quiescent	The master never polls and relies on unsolicited reports only.	Set ECLASSB, ECLASSC, ECLASSA to the desired non-zero event class, set UNSL*nn* and PUNSL*nn* to Yes.

As with Serial DNP3, in both the unsolicited report-by-exception and quiescent polling methods shown in *Table 9.26*, you must make a selection for the session's PUNSL*nn* setting. This setting enables or disables unsolicited data reporting at power up for this session. If your master can send the DNP3 message to enable unsolicited reporting from the SEL-2032, you should set the session's PUNSL*nn* to No.

Device Profile Document

Table 9.27 contains the standard DNP3 over Ethernet device profile information. Rather than checkboxes in the example Device Profile in the DNP3 Subset Definitions, only the relevant selections are shown.

Table 9.27 SEL-2032 DNP3 Over Ethernet Device Profile (Sheet 1 of 2)

Parameter	Value
Vendor name	Schweitzer Engineering Laboratories
Device name	SEL-2032 Communications Processor with SEL-2701 Ethernet Processor
Highest DNP3 request level	Level 2
Highest DNP3 response level	Level 2
Device function	Slave
Notable objects, functions, and/or qualifiers supported	None
Maximum data link frame size transmitted/received (octets)	292
Maximum data link retries	0
Requires data link layer confirmation	Never
Maximum application fragment size transmitted/received (octets)	2048
Maximum application layer retries	None
Requires application layer confirmation	When reporting Event Data
Data link confirm time-out	Configurable
Complete application fragment time-out	None
Application confirm time-out	Configurable
Complete Application response time-out	None
Executes control WRITE binary outputs	Always
Executes control SELECT/OPERATE	Always
Executes control DIRECT OPERATE	Always
Executes control DIRECT OPERATE-NO ACK	Always
Executes control count greater than 1	Never
Executes control Pulse On	Always
Executes control Pulse Off	Always
Executes control Latch On	Always
Executes control Latch Off	Always
Executes control Queue	Never
Executes control Clear Queue	Never
Reports binary input change events when no specific variation requested	Only time-tagged
Reports time-tagged binary input change events when no specific variation requested	Binary input change with time
Sends unsolicited responses	Configurable with unsolicited message enable settings

Table 9.27 SEL-2032 DNP3 Over Ethernet Device Profile (Sheet 2 of 2)

Parameter	Value
Sends static data in unsolicited responses	Never
Default counter object/variation	Object 20, Variation 6
Counter roll-over	N/A
Sends multifragment responses	Yes

Object List

The list of DNP3 objects given in *Table 9.28* lists the additions and exceptions to the list of supported serial DNP3 objects in *Table 9.17*. Note the added support of object 34, and removed support of objects 112 and 113.

Table 9.28 SEL-2032 DNP3 LAN/WAN Object List (Sheet 1 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
1	0	Binary Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
1	1	Binary Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
1	2[e]	Binary Input With Status	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
2	0	Binary Input Change—All Variations	1	6, 7, 8		
2	1	Binary Input Change Without Time	1	6, 7, 8	129	17, 28
2	2[e]	Binary Input Change With Time	1	6, 7, 8	129, 130	17, 28
2	3	Binary Input Change With Relative Time	1	6, 7, 8	129	17, 28
10	0	Binary Output—All Variations	1	0, 1, 6, 7, 8		
10	1	Binary Output				
10	2[e]	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1
12	0	Control Block—All Variations				
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block				
12	3	Pattern Mask				
20	0	Binary Counter—All Variations	1	0, 1, 6, 7, 8, 17, 28		
20	1	32-Bit Binary Counter				
20	2	16-Bit Binary Counter				
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28

Table 9.28 SEL-2032 DNP3 LAN/WAN Object List (Sheet 2 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
20	6[e]	16-Bit Binary Counter Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	7	32-Bit Delta Counter Without Flag				
20	8	16-Bit Delta Counter Without Flag				
21	0	Frozen Counter—All Variations				
21	1	32-Bit Frozen Counter				
21	2	16-Bit Frozen Counter				
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter With Time of Freeze				
21	6	16-Bit Frozen Counter With Time of Freeze				
21	7	32-Bit Frozen Delta Counter With Time of Freeze				
21	8	16-Bit Frozen Delta Counter With Time of Freeze				
21	9	32-Bit Frozen Counter Without Flag				
21	10	16-Bit Frozen Counter Without Flag				
21	11	32-Bit Frozen Delta Counter Without Flag				
21	12	16-Bit Frozen Delta Counter Without Flag				
22	0	Counter Change Event—All Variations	1	6, 7, 8		
22	1	32-Bit Counter Change Event Without Time	1	6, 7, 8	129	17, 28
22	2[e]	16-Bit Counter Change Event Without Time	1	6, 7, 8	129, 130	17, 28
22	3	32-Bit Delta Counter Change Event Without Time				
22	4	16-Bit Delta Counter Change Event Without Time				
22	5	32-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	6	16-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28

Table 9.28 SEL-2032 DNP3 LAN/WAN Object List (Sheet 3 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
22	7	32-Bit Delta Counter Change Event With Time				
22	8	16-Bit Delta Counter Change Event With Time				
23	0	Frozen Counter Event—All Variations				
23	1	32-Bit Frozen Counter Event Without Time				
23	2	16-Bit Frozen Counter Event Without Time				
23	3	32-Bit Frozen Delta Counter Event Without Time				
23	4	16-Bit Frozen Delta Counter Event Without Time				
23	5	32-Bit Frozen Counter Event With Time				
23	6	16-Bit Frozen Counter Event With Time				
23	7	32-Bit Frozen Delta Counter Event With Time				
23	8	16-Bit Frozen Delta Counter Event With Time				
30	0	Analog Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
30	1	32-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30	2	16-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30	3	32-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30	4[e]	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30	5	Short Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30	6	Long Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
31	0	Frozen Analog Input—All Variations				
31	1	32-Bit Frozen Analog Input				

Table 9.28 SEL-2032 DNP3 LAN/WAN Object List (Sheet 4 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input With Time of Freeze				
31	4	16-Bit Frozen Analog Input With Time of Freeze				
31	5	32-Bit Frozen Analog Input Without Flag				
31	6	16-Bit Frozen Analog Input Without Flag				
32	0	Analog Change Event—All Variations	1	6, 7, 8		
32	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129	17, 28
32	2[e]	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32	5	Short Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32	6	Long Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
33	0	Frozen Analog Event—All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
34	0	Analog Input Reporting Dead-Band Setting—All Variations	1	1, 6, 7, 8, 17, 28	129	1, 17, 28
34	0	Analog Input Reporting Dead-Band Setting—All Variations	2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	1[e]	16-Bit Analog Input Reporting Dead-Band Setting	1	1, 6, 7, 8, 17, 28	129	1, 17, 28
34	1[e]	16-Bit Analog Input Reporting Dead-Band Setting	2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28

Table 9.28 SEL-2032 DNP3 LAN/WAN Object List (Sheet 5 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
34	2	32-Bit Analog Input Reporting Dead-Band Setting	1	1, 6, 7, 8, 17, 28	129	1, 17, 28
34	2	32-Bit Analog Input Reporting Dead-Band Setting	2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	3	Floating Point Analog Input Reporting Dead-Band Setting	1	1, 6, 7, 8, 17, 28	129	1, 17, 28
34	3	Floating Point Analog Input Reporting Dead-Band Setting	2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
40	0	Analog Output Status—All Variations	1	0, 1, 6, 7, 8	139	
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	2[e]	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
41	0	Analog Output Block—All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date—All Variations				
50	1	Time and Date			129	07, quantity=1
50	2	Time and Date With Interval				
50	3	Time and Date at Last Recorded Time	1	7, 8 index=0	129	07, quantity=1
51	0	Time and Date CTO—All Variations				
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO	07, quantity=1			
52	0	Time Delay—All Variations				
52	1	Time Delay, Coarse				
52	2	Time Delay, Fine			129	07, quantity=1
60	0	All Classes of Data	1, 20, 21	6		
60	1	Class 0 Data	1	6	129	0, 1
60	2	Class 1 Data	1, 20, 21	6, 7, 8	129	17, 28
60	3	Class 2 Data	1, 20, 21	6, 7, 8	129	17, 28
60	4	Class 3 Data	1, 20, 21	6, 7, 8	129	17, 28

Table 9.28 SEL-2032 DNP3 LAN/WAN Object List (Sheet 6 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
70	1	File Identifier				
80	1	Internal Indications	2	0, 1 index=7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary—Coded Decimal				
101	2	Medium Packed Binary—Coded Decimal				
101	3	Large Packed Binary—Coded Decimal				
112	all	Virtual Terminal Output Block				
113	all	Virtual Terminal Event Data				
N/A		No object required for the following function codes: 13 cold start 14 warm start 24 record current time	13, 14, 24			

[a] Supported in requests from master.
[b] May generate in response to master.
[c] Decimal.
[d] Hexadecimal.
[e] Default variation.

Object Definitions

Data in the SEL-2032 can mapped to DNP3 automatically by the SEL-2701 or with custom map files. Both methods allow a certain degree of customization, but the more customized the maps are, the more configuration is required. The DNP3 settings DNPMAP and DNPPAIR control the degree of customization and configuration needed with either method.

Automatic Data Mapping

NOTE: Each time the SEL-2032 executes the **SET M** command to populate its DNP port User data region, it uses the time of execution as the time stamp for all of the data moved. Therefore, individual event timestamps are ignored when DNPMAP = AUTO. In order to preserve SER timestamps for all input points from an attached IED all the way through to the DNP Master, you must set DNPMAP = CUSTOM (see Custom Data Mapping on page 9.56).

When DNPMAP = AUTO the SEL-2701 maps (to DNP3) input points—binary, analog, and/or counter—that have already been moved to the Host's associated User data region. Similarly, the SEL-2701 maps up to 255 Analog Outputs in the Host's associated D1 data region, but it automatically creates and populates this region. Binary Outputs are mapped to DNP3 based on the DNPPAIR setting, discussed below.

Input Objects

Binary input, counter, and analog input objects are fully configurable by the user. To make data visible to DNP3 when DNPMAP = AUTO, it must be moved to the User data region on the SEL-2701 port (Port 17 or 18) using the **SET M** process to establish what data are mapped and how they are to be treated. See *Section 7: Settings* for more information on using **SET M**. To determine the DNP3 data map once these settings are in place, establish a virtual terminal session to the SEL-2701 with the **PORT** command and use the **DNPMAP** command. See the SEL-2701 *Instruction Manual* for more information on this command.

Output Objects: DNPPAIR = N

There are 607 binary output points mapped to DNP3 when DNPPAIR = N. Each port (serial and Ethernet) on the SEL-2032 has 16 controllable remote bits for a total of 288. Each serial port on the SEL-2032 has 16 circuit breaker bits, totaling 256 points. These points are mapped to DNP3 sequentially by port and bit number, as seen in *Table 9.29*.

If the SEL-2032 receives a command through the SEL-2701 from a recognized master, it will pulse, set, or clear the appropriate control bit in the communications processor. The communications processor will then proceed to perform the commanded operation on the end device. For breaker and remote bit (BR and RB) operations, control bits are pulsed, and do not need to be reset or cleared after a successful operation, nor before the next one.

Table 9.29 SEL-2032 DNP3 Over Ethernet Object 12 Control Point Operation, DNPMAP = AUTO, DNPPAIR = N (Sheet 1 of 2)

DNP3 Indices (Control Pt. IDs)	Control Points	Trip / Close Pairs		Code Selection Operation			
		Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0–63	CCIN1–CCIN64	SET	CLEAR	SET	CLEAR	SET	CLEAR
64	1:RB1	Pulse 1:SRB1	Pulse 1:CRB1	Pulse 1:SRB1	Pulse 1:CRB1	Pulse 1:SRB1	Pulse 1:CRB1
65	1:RB2	Pulse 1:SRB2	Pulse 1:CRB2	Pulse 1:SRB2	Pulse 1:CRB2	Pulse 1:SRB2	Pulse 1:CRB2
66	1:RB3	Pulse 1:SRB3	Pulse 1:CRB3	Pulse 1:SRB3	Pulse 1:CRB3	Pulse 1:SRB3	Pulse 1:CRB3
• • •							
79	1:RB16	Pulse 1:SRB16	Pulse 1:CRB16	Pulse 1:SRB16	Pulse 1:CRB16	Pulse 1:SRB16	Pulse 1:CRB16
80	2:RB01	Pulse 2:SRB1	Pulse 2:CRB1	Pulse 2:SRB1	Pulse 2:CRB1	Pulse 2:SRB1	Pulse 2:CRB1

Table 9.29 SEL-2032 DNP3 Over Ethernet Object 12 Control Point Operation, DNPMAP = AUTO, DNPPAIR = N (Sheet 2 of 2)

DNP3 Indices (Control Pt. IDs)	Control Points	Trip / Close Pairs		Code Selection Operation			
		Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
•							
•							
•							
351	18:RB16	Pulse 18:SRB16	Pulse 18:CRB16	Pulse 18:SRB16	Pulse 18:CRB16	Pulse 18:SRB16	Pulse 18:CRB16
352	1:BR1	Pulse 1:CBR1	Pulse 1:SBR1	Pulse 1:SBR1	Pulse 1:CBR1	Pulse 1:SBR1	Pulse 1:CBR1
353	1: BR2	Pulse 1:CBR2	Pulse 1:SBR2	Pulse 1:SBR1	Pulse 1:CBR2	Pulse 1:SBR1	Pulse 1:CBR2
354	1: BR3	Pulse 1:CBR3	Pulse 1:SBR3	Pulse 1:SBR1	Pulse 1:CBR3	Pulse 1:SBR1	Pulse 1:CBR3
•							
•							
•							
367	1:BR16	Pulse 1:CBR16	Pulse 1:SBR16	Pulse 1:SBR16	Pulse 1:CBR16	Pulse 1:SBR16	Pulse 1:CBR16
368	2:BR1	Pulse 2:CBR1	Pulse 2:SBR1	Pulse 2:SBR1	Pulse 2:CBR1	Pulse 2:SBR1	Pulse 2:CBR1
•							
•							
•							
607	16:BR16	Pulse 16:CBR16	Pulse 16:SBR16	Pulse 16:SBR16	Pulse 16:CBR16	Pulse 16:SBR16	Pulse 16:CBR16

Output Objects: DNPPAIR = Y

When you set DNPPAIR = Y, there are 463 binary output points mapped to DNP3. Each port (serial and Ethernet) on the SEL-2032 has 16 controllable remote bit pairs for a total of 144. Each serial port on the SEL-2032 has 16 circuit breaker bits, totaling 256 points. These points are mapped to DNP3 sequentially by port and bit number, as seen in *Table 9.30*. As with DNPPAIR = N above, RB and BR control bits are pulsed and do not need to be reset or cleared after a successful operation, nor before the next one.

Table 9.30 SEL-2032 DNP3 Over Ethernet Object 12 Control Point Operation, DNPMAP = AUTO, DNPPAIR = Y (Sheet 1 of 2)

DNP3 Indices (Control Pt. IDs)	Control Points	Trip / Close Pairs		Code Selection Operation			
		Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0–63	CCIN1–CCIN64	SET	CLEAR	SET	CLEAR	SET	CLEAR
64	1:RB02/RB01	Pulse 1:SRB02	Pulse 1:SRB01	Pulse 1:SRB02	Pulse 1:SRB01	Pulse 1:SRB02	Pulse 1:SRB01
65	1:RB04/RB03	Pulse 1:SRB04	Pulse 1:SRB03	Pulse 1:SRB04	Pulse 1:SRB03	Pulse 1:SRB04	Pulse 1:SRB03
66	1:RB06/RB05	Pulse 1:SRB06	Pulse 1:SRB05	Pulse 1:SRB06	Pulse 1:SRB05	Pulse 1:SRB06	Pulse 1:SRB05
•							
•							
•							
71	1:RB16/RB15	Pulse 1:SRB16	Pulse 1:SRB15	Pulse 1:SRB16	Pulse 1:SRB15	Pulse 1:SRB16	Pulse 1:SRB15
72	2:RB02/RB01	Pulse 2:SRB02	Pulse 2:SRB01	Pulse 2:SRB02	Pulse 2:SRB01	Pulse 2:SRB02	Pulse 2:SRB01
•							
•							
•							

Table 9.30 SEL-2032 DNP3 Over Ethernet Object 12 Control Point Operation, DNPMAP = AUTO, DNPPAIR = Y (Sheet 2 of 2)

DNP3 Indices (Control Pt. IDs)	Control Points	Trip / Close Pairs		Code Selection Operation			
		Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
207	18:RB16/RB15	Pulse 18:SRB16	Pulse 18:SRB15	Pulse 18:SRB16	Pulse 18:SRB15	Pulse 18:SRB16	Pulse 18:SRB15
208	1:BR1	Pulse 1:CBR1	Pulse 1:SBR1	Pulse 1:SBR1	Pulse 1:CBR1	Pulse 1:SBR1	Pulse 1:CBR1
209	1:BR2	Pulse 1:CBR2	Pulse 1:SBR2	Pulse 1:SBR2	Pulse 1:CBR2	Pulse 1:SBR2	Pulse 1:CBR2
210	1:BR3	Pulse 1:CBR3	Pulse 1:SBR3	Pulse 1:SBR3	Pulse 1:CBR3	Pulse 1:SBR3	Pulse 1:CBR3
•							
•							
•							
223	1:BR16	Pulse 1:CBR16	Pulse 1:SBR16	Pulse 1:SBR16	Pulse 1:CBR16	Pulse 1:SBR16	Pulse 1:CBR16
224	2:BR1	Pulse 2:CBR1	Pulse 2:SBR1	Pulse 2:SBR1	Pulse 2:CBR1	Pulse 2:SBR1	Pulse 2:CBR1
•							
•							
•							
463	16:BR16	Pulse 16:CBR16	Pulse 16:SBR16	Pulse 16:SBR16	Pulse 16:CBR16	Pulse 16:SBR16	Pulse 16:CBR16

Custom Data Mapping

NOTE: When DNPMAP = CUSTOM, the SEL-2032 stores the most recent value of all DNP points in its STATE region. Like the User region, the STATE region has one time stamp, which indicates the time at which the collective data was last updated. However, the STATE region also has an SER queue. It is the SER queue that provides a per point history of time-stamped changes within the region. For this reason, you must set DNPMAP = CUSTOM if you want to preserve SER time stamps from an attached IED all the way through to the DNP Master.

By setting the DNPMAP parameter to CUSTOM, you have the ability to specify the DNP3 data points available for up to 10 unique master sessions using any of 5 distinct data maps. The most efficient way to set the DNP3 Map mode and assign data maps to DNP3 masters is to use the SEL-5020 Settings Assistant.

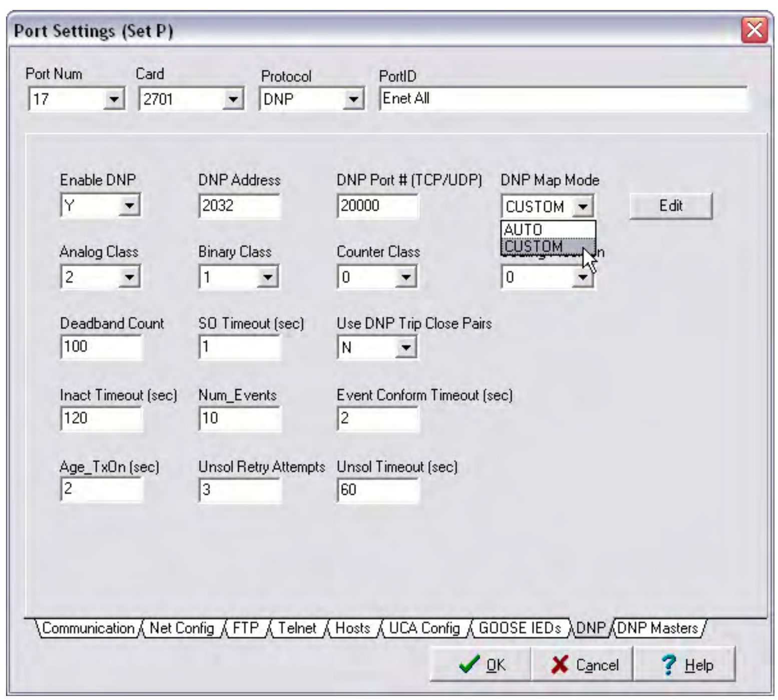

Figure 9.6 SEL-5020: Set DNP Map Mode to CUSTOM

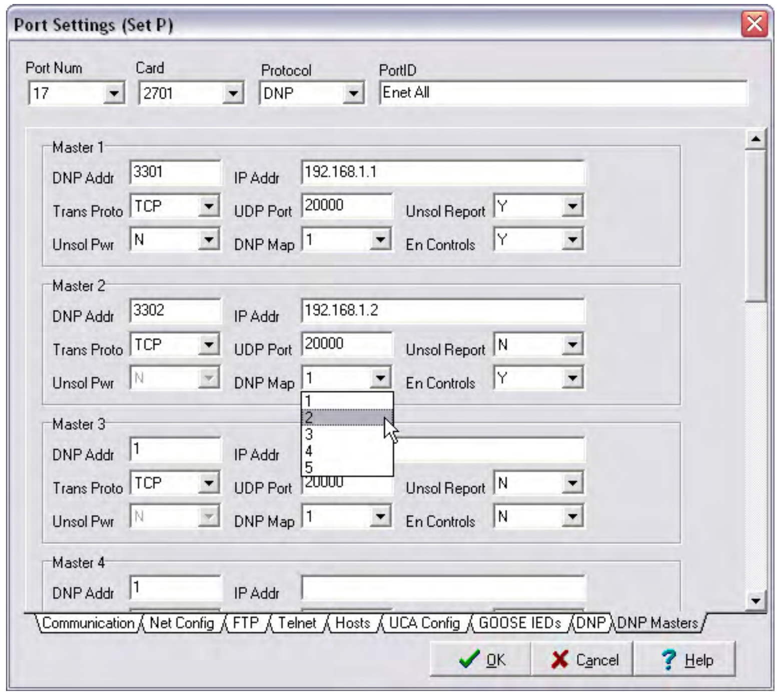

Figure 9.7 SEL-5020: Assign Custom DNP3 Map to Master

When the Ethernet port has been configured to use custom DNP3 maps, the SEL-2701 will obtain these maps from the Communications Processor Settings subdirectory. Custom maps saved in a communications processor have filenames of the form SET_DNP*xyy*.TXT, where *x* is the map number (1–5), and *yy* is the port number (17 or 18).

The settings described in *Table 9.31* are used to define the custom DNP3 maps. Note that these settings are only accessible as files in the SETTINGS subdirectory or by using the SEL-5020 Settings Assistant. The latter is recommended for creation and modification of DNP3 maps within the communications processor. You can use either absolute addresses or data labels to specify input points in custom DNP3 maps.

Table 9.31 SEL-2032 DNP3 Over Ethernet Map Settings (Sheet 1 of 2)

Name	Type	Range	Default	Description
BIM0000–BIM1023	Point	String of form “p:addr:bit”, or “p:<region:item:bit>”, or “p<region:item>:bit#”, where: p must be in range 1–number-of-virtual-devices addr must be in range 0–65534 bit must be in range 0-15 <region:item:bit> is a valid colon-separated database region-item-bit label reference. <region:item> is a valid colon-separated database region-item label reference.	“”	These settings correlate specific database bits with binary input indices or labels. Maximum label widths are: Region: 9 Item: 16 Bit: 14 Labels may not contain spaces, colons, or commas.
BIC0000–BIC1023	Event Class	DFLT, 0–3	DFLT	These settings specify the event class for that index. A value of DFLT indicates to use the ECLASSB setting, 0 indicates to not generate events, and 1–3 provide the specific class to place the point events into.

Table 9.31 SEL-2032 DNP3 Over Ethernet Map Settings (Sheet 2 of 2)

Name	Type	Range	Default	Description
BOM0000–BOM0511	Point	OFF, 0–(MAX as defined by *Table 9.32*)	OFF	These settings correlate specific control operations from *Table 9.32* to binary output indices. A value of OFF indicates no object at that index.
CIM0000–CIM0127	Point	String of form “p:addr” or “p:<region:item>” where: p must be in range 1–number-of-virtual-devices addr must be in range 0–65534 <region:item> is a valid colon-separated database region-item label reference.	“”	These settings correlate specific database registers with counter indices. Maximum label widths are: Region: 9 Item: 16 Labels may not contain spaces, colons, or commas.
CIC0000–CIC0127	Event Class	DFLT, 0–3	DFLT	These settings specify the event class for that index. A value of DFLT indicates to use the ECLASSC setting, 0 indicates to not generate events, and 1–3 provide the specific class to place the point events into.
AIM0000–AIM0511	Point	String of form “p:addr[,t]” or “p:<region:item>[,t]” where: p must be in range 1–number-of-virtual-devices addr must be in range 0–65534 t must be i, u, il, ul, or f. <region:item> is a valid colon-separated database region-item label reference.	“”	These settings correlate specific database registers with analog input indexes. The optional “treat-as” qualifier (t) is used to indicate that the data at the referenced database address is to be treated as if is of this type, rather than the type indicated in the database. Maximum label widths are: Region:9 Item:16 Labels may not contain spaces, colons, or commas.
AIC0000–AIC0511	Event Class	DFLT, 0–3	DFLT	These settings specify the event class for that index. A value of DFLT indicates to use the ECLASSA setting, 0 indicates to not generate events, and 1–3 provide the specific class to place the point events into.
AIS0000–AIS0511	Scaling Factor	DFLT, 0.000001–1000000.0	DFLT	A value of DFLT indicates to use the DECPL setting for determining the scaling of a point. The given point will be multiplied by this value before being reported through DNP3.
AID0000–AID0511	Dead Band	DFLT, 0–32767	DFLT	This is the dead band to use for the point at the given index. A value of DFLT indicates to use the scaling on the ANADB setting.
AOM0000–AOM0063	Point	OFF, 0–255	OFF	These settings correlate addresses within the card-controlled D1 region to analog output indexes. A value of OFF indicates no object at that index.

When DNPMAP = CUSTOM, the contents of the custom DNP3 map files define the points that are included in the DNP3 map. The database capacity for each point type per map and system-wide is discussed below:

➤ The total number of Binary Input points allowed per map is 1024. The total system capacity (all custom DNP3 maps) is 2048 Digital Input points with unique references.

- ➤ The total number of Analog Input points allowed per map is 512. The total system capacity is 2048 Analog Inputs with unique references.
- ➤ The total number of Binary Output control points allowed per map is 512.
- ➤ The total number of Analog Output control points allowed per map is 64. The total system capacity, for all the custom DNP3 maps, is 256 Analog Output points with unique references.

The DNP3 index for any data point within a custom DNP3 map is assigned based on the associated setting name (i.e., BIM*xxxx* for a Binary Input, where *xxxx* is the DNP3 index).

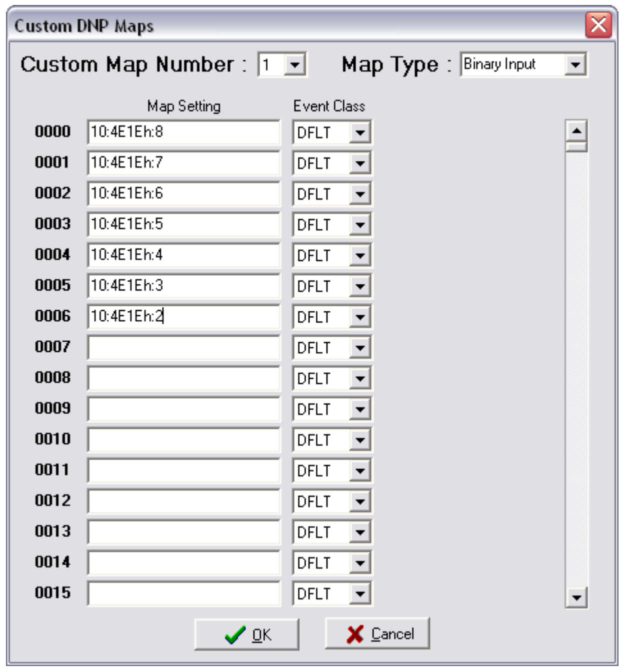

Figure 9.8 SEL-5020: Sample Custom Binary Input DNP3 Map

Analog dead bands and scaling factors may be set for each individual point. Use the AID*xxxx* setting to impose a dead band of 0–32767. This may be used in conjunction with a scaling factor of 0.000001–1000000.0 entered in AIS*xxxx*.

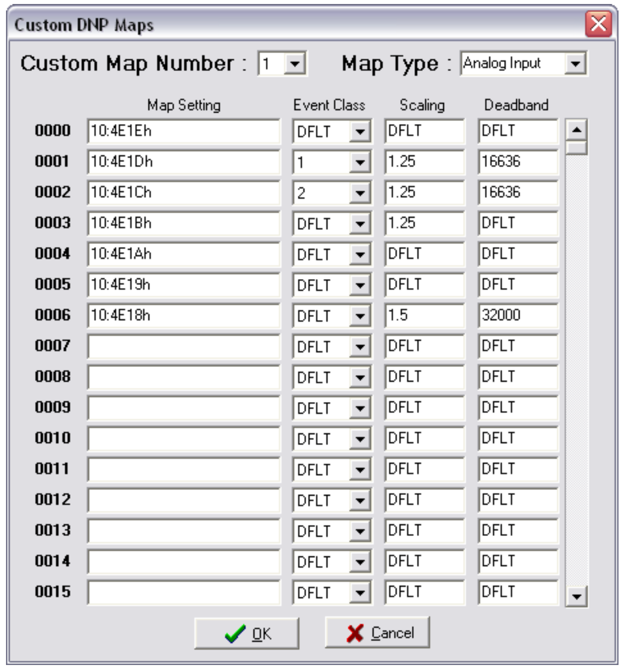

Figure 9.9 SEL-5020: Sample Custom Analog Input DNP3 Map

When DNPMAP = CUSTOM, the DNPPAIR setting is ignored. Instead of referring to the DNPPAIR setting for paired or non-paired points, the control point is associated to the Binary Output by a Control Point Identifier (CPId). The CPId represents either a single control point (non-paired) or two control points (paired), and the operation selects the control point. A custom DNP3 map may contain any combination of paired and non-paired Binary Output control points.

The SEL-2032 DNP3 LAN/WAN interface also maps incoming control points either to remote bits or to internal command bits that cause circuit breaker operations. See *Table 9.32* for a list of control points and control methods available in the SEL-2032.

Table 9.32 SEL-2032 DNP3 LAN/WAN Object 12 Control Point, DNPMAP = CUSTOM (Sheet 1 of 2)

DNP3 Indices (Control Pt. IDs)	Control Points	Trip / Close Pairs		Code Selection Operation			
		Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0–63	CCIN01–CCIN64	SET CCIN*xx*	CLEAR CCIN*xx*	SET CCIN*xx*	CLEAR CCIN*xx*	SET CCIN*xx*	CLEAR CCIN*xx*
64	1:RB1	Pulse 1:SRB1	Pulse 1:CRB1	Pulse 1:SRB1	Pulse 1:CRB1	Pulse 1:SRB1	Pulse 1:CRB1
65	1:RB2	Pulse 1:SRB2	Pulse 1:CRB2	Pulse 1:SRB2	Pulse 1:CRB2	Pulse 1:SRB2	Pulse 1:CRB2
66	1:RB3	Pulse 1:SRB3	Pulse 1:CRB3	Pulse 1:SRB3	Pulse 1:CRB3	Pulse 1:SRB3	Pulse 1:CRB3
•							
•							
•							
80	1:RB16	Pulse 1:SRB16	Pulse 1:CRB16	Pulse 1:SRB16	Pulse 1:CRB16	Pulse 1:SRB16	Pulse 1:CRB16
80	2:RB1	Pulse 2:SRB1	Pulse 2:CRB1	Pulse 2:SRB1	Pulse 2:CRB1	Pulse 2:SRB1	Pulse 2:CRB1
•							
•							
•							

Table 9.32 SEL-2032 DNP3 LAN/WAN Object 12 Control Point, DNPMAP = CUSTOM (Sheet 2 of 2)

DNP3 Indices (Control Pt. IDs)	Control Points	Trip / Close Pairs		Code Selection Operation			
		Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
351	18:RB16	Pulse 18:SRB16	Pulse 18:CRB16	Pulse 18:SRB16	Pulse 18:CRB16	Pulse 18:SRB16	Pulse 18:CRB16
352	1:RB02/RB01	Pulse 1:SRB02	Pulse 1:SRB01	Pulse 1:SRB02	Pulse 1:SRB01	Pulse 1:SRB02	Pulse 1:SRB01
353	1:RB04/RB03	Pulse 1:SRB04	Pulse 1:SRB03	Pulse 1:SRB04	Pulse 1:SRB03	Pulse 1:SRB04	Pulse 1:SRB03
354	1:RB06/RB05	Pulse 1:SRB06	Pulse 1:SRB05	Pulse 1:SRB06	Pulse 1:SRB05	Pulse 1:SRB06	Pulse 1:SRB05
•							
•							
•							
359	1:RB16/RB15	Pulse 1:SRB16	Pulse 1:SRB15	Pulse 1:SRB16	Pulse 1:SRB15	Pulse 1:SRB16	Pulse 1:SRB15
360	2:RB02/RB01	Pulse 2:SRB02	Pulse 2:SRB01	Pulse 2:SRB02	Pulse 2:SRB01	Pulse 2:SRB02	Pulse 2:SRB01
•							
•							
•							
495	18:RB16/RB15	Pulse 18:SRB16	Pulse 18:SRB15	Pulse 18:SRB16	Pulse 18:SRB15	Pulse 18:SRB16	Pulse 18:SRB15

In the SEL-2032, the control points correspond to all remote bits plus the CCIN*x* and CCOUT*x* bits. CPIds for the SEL-2032 with 64 CCIN*x* points, 288 Remote Bits, and 144 RB pairs, are given in *Table 9.32*. You can use the CPIds to assign Binary Output points to custom DNP3 maps.

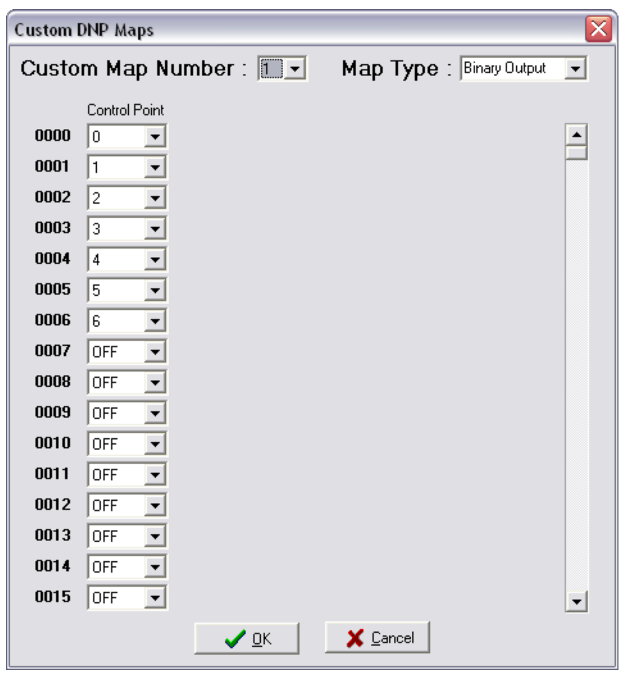

Figure 9.10 SEL-5020: Sample Binary Output Custom DNP3 Map

Any of the 256 Analog Output Quantities in the D1 Region can be included in a custom data map. Up to 64 Analog Outputs can be assigned to a custom map. These are selected using their relative position within the region: 0 to 255. Note that you must add 1 to the index to find the corresponding Analog Quantity number. For example, if you use index 63, that will correspond to RA064.

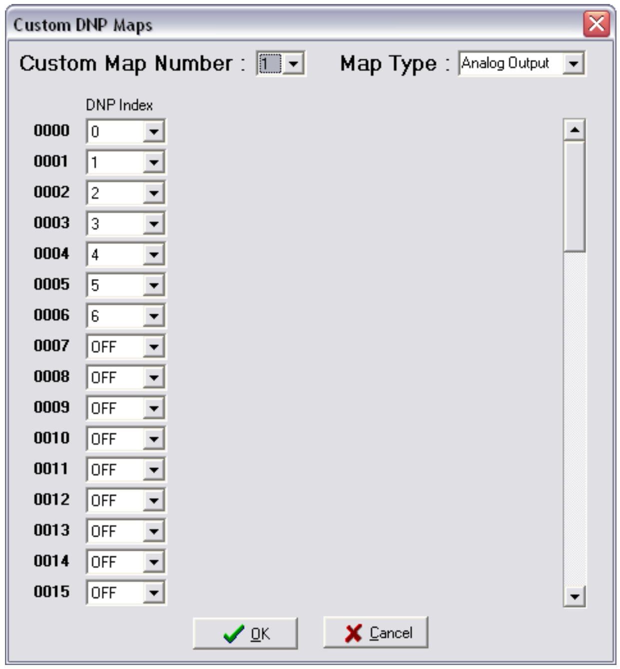

Figure 9.11 SEL-5020: Sample Analog Output Custom DNP3 Map

See *Figure 9.12* for the custom DNP3 Custom Map file generated by the SEL-5020 software for an SEL-2701 installed in a communications processor.

```
[INFO]
RELAYTYPE=SEL-2701
FID=SEL-2701-X169-V2-Z002001-D20050922
BFID=SLBT-2701-X046-V0-Z000000-D20050824
PARTNO=27011H4X
[D1]
AIM0000,"3:200Bh,F"
AIC0000,"DFLT"
AIS0000,"DFLT"
AID0000,"DFLT"
AIM0001,"3:200Fh,F"
AIC0001,"DFTL"
AIS0001,"DFTL"
AID0001,"DFTL"
AIM0002,"3:2013h,F"
AIC0002,"DFTL"
AIS0002,"DFTL"
AID0002,"DFTL"
AIM0003,"3:2017h,F"
AIC0003,"DFLT"
AIS0003,"DFTL"
AID0003,"DFLT"
AIM0004,"3:201Bh,F"
AIC0004,"DFLT"
AIS0004,"DFLT"
AID0004,"DFLT"
AIM0005,"3:201Fh,F"
AIC0005,"DFLT"
AIS0005,"DFLT"
AID0005,"DFLT"
AIM0006,"3:2032h,F"
AIC0006,"DFLT"
AIS0006,"DFTL"
AID0006,"DFTL"
AIM0007,"3:2027h,F"
AIC0007,"DFLT"
AIS0007,"DFLT"
AID0007,"DFLT"
AIM0008,""
AIC0008,"DFLT"
AIS0008,"DFLT"
AID0008,"DFLT"
…
AIM0511,""
AIC0511,"DFLT"
AIS0511,"DFLT"
AID0511,"DFLT"
BIM0000,"3:281Dh:0"
BIC0000,"DFLT"
BIM0001,"3:281Dh:1"
BIC0001,"DFLT"
BIM0002,"3:281Dh:2"
BIC0002,"DFLT"
BIM0003,"3:281Dh:3"
BIC0003,"DFLT"
BIM0004,"3:281Dh:4"
BIC0004,"DFLT"
BIM0005,"3:281Dh:5"
BIC0005,"DFLT"
BIM0006,""
BIC0006,"DFLT"
…
BIM1023,""
BIC1023,"DFLT"
CIM0000,""
CIC0000,"DFLT"
CIM0001,""
CIC0001,"DFLT"
…
CIM0127,""
CIC0127,"DFLT"
AOM0000,"OFF"
AOM0001,"OFF"
…
AOM0063,"OFF"
BOM0000,"0"
BOM0001,"1"
BOM0002,"2"
BOM0003,"3"
BOM0004,"OFF"
…
BOM0511,"OFF"
```

Figure 9.12 Sample SET_DNP1.txt File

Use the **DNPMAP** command in a virtual terminal to the SEL-2701 to display the data points (object types, indices, default variation, and source) and controls (object type, indices, and destination) that are accessible via DNP3. The output of the **DNPMAP** command documents the DNP3 data map(s) in the SEL-2701 to help with the configuration of the DNP3 master.

Note that if you issue a **DNPMAP** command at the command line, you will get the (serial) DNP3 data map of the host device, if it exists. However, if you issue a **PORT** command (**PORT 5** on an SEL-400 series relays, **PORT 17** or **PORT 18** on an SEL communications processor) to open a transparent session to the SEL-2701 console, then a **DNPMAP [*x*]**, you will get the DNPMAP output from the SEL-2701. The **PORT** command redirects all input from a serial port away from the command parser for the device and sends the stream of data to the SEL-2701. Also, any data that comes from the SEL-2701 is redirected out the serial port.

Specify the desired custom map using an integer parameter corresponding to a DNPMAP number (1–5). For example, the command **DNPMAP 2** would be used to view the custom data map for DNP3 Session 2. If a DNPMAP number is not specified, a summary of DNP3 map settings for all configured sessions will be displayed.

Summary and detailed map configurations are also available in the DNPMAP.TXT and DNPMAP*nn*.TXT files from the SEL-2701 FTP interface. The individual file names associated with the detailed custom map settings follow the DNPMAP*nn*.TXT naming convention.

Event Data

The same serial DNP3 event data objects are available for DNP3 over an Ethernet network. However, configuration is slightly different. You can still configure the SEL-2032 to either report the data without a polling request from the master (unsolicited data) or hold the data until the master requests it with an event poll message.

NOTE: Most RTUs that act as substation DNP3 masters perform an event poll that collects event data of all classes simultaneously. Confirm that the polling configuration of your master allows independent polling for each class before implementing separate classes in the SEL-2032.

With the event class settings ECLASSB, ECLASSC, and ECLASSA, you can set the event class for binary, counter, and analog information. Virtual terminal information is not supported for DNP3 over Ethernet since Telnet is available to provide this capability. As with serial DNP3, you can also use the classes as a simple priority system for collecting event data.

For event data collection, you must also consider and enter appropriate settings for dead band and scaling operations on analog points shown in *Table 7.2*. You can set and use either default dead band and scaling according to data type or use a custom data map to select dead bands on a point-by-point basis. See *Custom Data Mapping on page 9.56* for a discussion of how to set scaling and dead-band operations on a point-by-point basis.

The setting ANADB defines default dead-band operation for analog events. A DNP3 master may also impose its own default dead band that it will use for event data for a specific channel that override the SEL-2032 ANADB setting. Because the default variations of DNP3 Objects 30 and 32 use integer data, you must use scaling to send digits after the decimal point and avoid rounding to a simple integer value. Scaling on the Ethernet DNP3 connection is subject to the same limitations of the serial interface. The master should also be configured to perform the appropriate arithmetic conversion on the incoming value to display it in proper engineering units.

Set the default analog value scaling with the DECPL setting. Application of event reporting dead bands occurs after scaling the incoming value with 10^{DECPL}. For example, if you set DECPL to 2 and ANADB to 10, a measured current of 10.14 amps would be scaled to the value 1014 (10.14 • 10^2) and would have to increase to more than 1024 or decrease to less than 1004 (a dead band of 0.2 amps) for the SEL-2032 to report a new event value.

As with the DNP3 serial connection, the NUMEVE and AGEEVE settings are used to decide when to send unsolicited data to the master. The SEL-2032 sends an unsolicited report when the total number of events accumulated in the event buffer reaches NUMEVE.

The SEL-2032 also sends an unsolicited report if the age of the oldest event in the buffer exceeds AGEEVE. The SEL-2032 uses the same buffer capacities with DNP3 over Ethernet as through the serial connection, listed in *Table 6.5*.

Time Synchronization

Time synchronization is not supported for DNP3 over the Ethernet port. However, SEL-2032 will accept messages that contain a Record Current Time (Function Code 24) request and return a Null Response.

LMD Distributed Port Switch Protocol

This protocol permits multiple SEL devices to share a common communications channel. It is appropriate for low-cost, low-speed port switching applications where updating a real-time database is not a requirement.

Settings

Use the **SET P** command to activate the multidrop protocol. Change the PROTOCOL port setting from the default SEL to LMD to reveal the following settings:

ADDRESS Two-character ASCII address. The range is “01” to “81.” The default is “01.” This address represents the first of 17 addresses that the SEL-2032 will use. The first address will connect you to the SEL-2032 in command/response mode. The subsequent 16 addresses will connect you directly to the respective port.

PREFIX One character to precede the address. This should be a character which does not occur in the course of other communications with the relay. Valid choices are one of the following: “@” “#” “$” “%” “&.” The default is “@.”

SETTLE TIME Time in seconds that transmission is delayed after the request to send (RTS line) asserts. This delay accommodates transmitters with a slow rise time.

Operation

1. The device ignores all input from this port until it detects the prefix character and the two-byte address.
2. The device then asserts the RTS line, which you can use to key a serial data transmitter. The port enables echo and message transmission. If the port has received an XOFF character, the device performs as if it received an XON.
3. Wait until you receive a prompt before entering commands to avoid losing echoed characters while the external transmitter is warming up.
4. Until the device connection terminates, you can use the standard commands that are available when PROTOCOL is set to SEL.

NOTE: You can use the **SET P** command to change the port settings to return to SEL protocol.

5. The **QUIT** command terminates the connection. If no data are sent to the device before the port time-out period, it automatically terminates the connection.
6. Enter the sequence **Ctrl+X QUIT <CR>** before entering the prefix character if all devices in the multidrop network do not have the same prefix setting.

Section 10
Testing and Troubleshooting

Introduction

This section contains important information for owning and operating the SEL-2032 Communications Processor and also contains information about the Alarm conditions for the SEL-2032 and its self-tests. Troubleshooting with corrective actions and initial checkout procedures are also discussed.

Alarm Conditions

The SEL-2032 asserts the ALARM contact for a variety of conditions automatically, and it also asserts based on the ALARM SELOGIC® control equation. The ALARM equation is assigned to SALARM. *Table 10.1* lists the various conditions that cause ALARM contact and SALARM operations.

Table 10.1 Alarm Conditions

Command or Condition	Asserts ALARM Contact	Asserts SALARM Bit	Comment
2ACCESS		Yes	One-second pulse when entering Access Level 2 or if password is entered incorrectly on three successive attempts.
ACCESS		Yes	One-second pulse if password is entered incorrectly on three successive attempts.
PASSWORD		Yes	One-second pulse when password is changed.
SET		Yes	One-second pulse on settings change.
COPY		Yes	One-second pulse on settings change.
SWAP		Yes	One-second pulse on settings change.
Self-Test Failure	Yes	No	Latches if SEL-2032 fails a self-test (contact the factory).
Invalid Settings	Yes	No	SEL-2032 has detected invalid settings; contact SEL for assistance.

Self-Tests

The SEL-2032 continually runs the following self-tests. Any test failure causes an alarm to be latched and the status report to be issued on Port F.

RAM. The SEL-2032 continually performs read-write test of RAM, both local and shared.

Code Flash. The SEL-2032 continually computes and checks a checksum of ROM.

EEPROM/Archive Flash. The SEL-2032 continually validates data blocks using checksums.

Power Supply. Threshold comparators (+/– 15 V) are continually checked for tolerance.

Troubleshooting

Power System Problems

Table 10.2 describes typical SEL-2032 power system problems and solutions.

Table 10.2 Power System Problems

Symptom	Probable Cause	Corrective Action
All front-panel LEDs remain dark when LED TEST button is pressed.	No power to rear-panel power terminals.	Supply power to rear-panel power terminals.
	Internal power supply defective.	Remove power and contact the factory.
+5 Vdc not supplied to pin 1 of rear-panel communication port(s).	Jumper(s) not installed on main board.	See *Jumper Settings on page 2.1*.

Communications Problems

Refer to *Table 10.3* for troubleshooting some basic communications problems.

Table 10.3 Communications Problems (Sheet 1 of 2)

Symptom	SEL-2032 does not communicate with PC.
Probable Cause	Serial cable damaged or wrong cable connected.
Corrective Action	Inspect the cabling for damage and proper connection.
Symptom	SEL-2032 does not communicate with PC.
Probable Cause	SEL-2032 baud rate default jumper installed.
Corrective Action	1. Set the PC terminal to 2400 baud to communicate with the SEL-2032. 2. Using the **SET** command, set the SEL-2032 baud rate. 3. Access the main board. Refer to *Jumper Settings on page 2.1*. 4. Remove jumper J17 A. Place the jumper on one pin of the connector for safekeeping. 5. Set the baud rate of the PC terminal to match the SEL-2032. 6. Cycle SEL-2032 power and reconnect.

Table 10.3 Communications Problems (Sheet 2 of 2)

Symptom	SEL-2032 does not communicate with connected IED.
Probable Cause	Port and baud rate settings of PC may be incorrect.
Corrective Action	Set the port and baud rate settings of the PC terminal to match the SEL-2032. If you do not know what the settings are, install the baud rate jumper and then make the settings.
Symptom	SEL-2032 does not communicate with connected IED.
Probable Cause	Serial cable damaged or wrong cable connected.
Corrective Action	Inspect the cabling for damage and proper connection. Make sure appropriate cable is connected (see *Table 2.4*).
Symptom	SEL-2032 does not communicate with connected IED.
Probable Cause	Port settings do not match the IED settings.
Corrective Action	Using the **SET** command, set the port settings to match those of the IED connected to the port.
Symptom	SEL-2032 does not communicate with connected IED.
Probable Cause	Port may be locked up due to hardware handshaking
Corrective Action	Reset IED and/or reset port settings using **SET P** and accepting settings.
Symptom	SEL-2032 does not communicate with connected IED.
Probable Cause	Component failure. Port F LED(s) illuminates but others do not illuminate when port is addressed.
Corrective Action	Remove power and contact the factory.
Symptom	No prompt.
Probable Cause	Incorrect baud rate.
Corrective Action	Verify baud rate in communication software. Default baud rate for the SEL-2032 is 2400.
Symptom	SEL-2032 not accepting **REC** command
Probable Cause	Not in the SELBOOT mode
Corrective Action	Enter **L_D** to get into the SELBOOT mode. When in SELBOOT mode, the prompt is an exclamation point.
Symptom	Protocol card not accepting **REC *n*** command
Probable Cause	SEL-2032 and protocol card are not in the SELBOOT mode
Corrective Action	Enter **L_D** to get into the SELBOOT mode. When in SELBOOT mode, the prompt is an exclamation point. Also see next problem to force SELBOOT mode.
Symptom	Unknown communication problem
Probable Cause	1. Incompatible firmware in SEL-2032 and protocol card. 2. Device not in SELBOOT mode.
Corrective Action	Force SEL-2032 into SELBOOT mode using the following procedure: Cycle Power on the SEL-2032 while depressing the LED TEST button on the SEL-2032.[a]

[a] The SEL-2032 will enable with the default baud rate of 2400.

Initial Checkout

Perform the following steps:

Step 1. Visually inspect the SEL-2032 for loose or damaged parts.

Step 2. Connect and apply power to the SEL-2032; see the PWR SUP field on the rear-panel nameplate for power requirements.

If you do not have the proper voltage source available, use a power supply, like the SEL-LPS, to power the unit.

Step 3. Press and hold the LED TEST button and confirm that all LEDs illuminate.

Step 4. Connect a terminal (or computer equipped with terminal emulation software) to the front-panel connector Port F of the SEL-2032 using an SEL C234A cable or equivalent.

Step 5. Set the computer terminal or emulation software to operate at the following settings:

- 2400 baud
- 8 data bits
- 1 stop bit
- no parity

Step 6. Press **<Enter>** and verify that an asterisk (*) prompt is returned.

Step 7. Type **ACCESS <Enter>** to change to Access Level 1.

If you have not yet changed the password, enter the factory-set password. You will see a screen similar to *Figure 10.1*, with the password shown instead of ******.

```
*ACCESS <Enter>
Password: ? ****** <Enter>

EXAMPLE 2030 - S/N 94153001              Date: 10/31/97    Time: 13:45:03
Level 1

*>
```

Figure 10.1 ACCESS Command Screen

Step 8. Type **STATUS <Enter>** and verify that a status report similar to the one in *Figure 10.2* appears on your terminal.

Verify the following from the report:

- RAM memory size should be 512 kb.
- Shared-RAM size should be 1024 kb.
- Flash should be 1792 kb.
- IRIG-B input and I/O board should match your configuration.
- Any plug-in protocol cards should show up as expected in Port 17 or 18.

Refer to the **STATUS** command explanation in *Section 8: Serial Port Communications and Commands* for more detailed information.

```
*>>STATUS <Enter>
COMMUNICATIONS PROCESSOR - S/N 95012004     Date: 10/31/01    Time: 13:46:43
FID=SEL-2032-R100-V0-Z000000-D20021222 FID=SLBT-2030-R103-V0-Z000000-D20010122
SELF-TESTS
RAM      SRAM     CODE     ARCH     EEPROM   P.S. SET      BATTERY
512 kb   1024 kb  OK       1792 kb  OK       OK       OK       OK
IRIG-B Input: Absent
I/O Board: Absent
Port   Status          Success Rate   SET M     Database
1      Active               100%      None
2      Inactive                       None
3      Inactive                       None
4      Inactive                       None
5      Inactive                       None
6      Inactive                       None
7      Inactive                       None
8      Active                         None
9      Active                         None
10     Inactive                       None
11     Inactive                       None
12     Inactive                       None
13     Inactive                       None
14     Inactive                       None
15     Inactive                       None
16     Inactive                       None
17     Sole Node(100h)     NORM       None
F      Active              100%       None

*>>
```

Figure 10.2 STATUS Command Screen

Calibration

Schweitzer Engineering Laboratories (SEL) performs a calibration of the SEL-2032 clock at the factory. You do not need to periodically calibrate the clock.

Battery Replacement

A battery maintains the clock (date and time) if the external DC source is lost or removed. The battery is a 3 V lithium coin cell. At room temperature (25°C), the battery will operate nominally for 10 years at rated load.

The battery experiences a low self-discharge rate when the SEL-2032 is powered from an external source. If the source is lost or disconnected, the battery discharges to keep the internal clock going. The battery cannot be recharged.

⚠CAUTION
There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac® no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.

Perform the battery replacement procedure if the SEL-2032 reports a battery failure. You will also notice that the time and date are incorrect. To change the battery, perform the following steps:

Step 1. Remove power from the SEL-2032.

Step 2. Remove any cables connected to Port F of the SEL-2032.

Step 3. Remove the front-panel screws and front panel.

Step 4. Locate the battery on the front left-hand side of the main board.

Step 5. Remove the battery from beneath the clip and install a new one; the positive side (+) of the battery faces up.

⚠CAUTION
Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

Step 6. Replace the front panel and front-panel screws and tighten securely.

Step 7. Replace any cables removed from the SEL-2032.

Step 8. Apply power to the SEL-2032, and set the date and time again.

A battery failure will be reported the first time you power-up with a new battery because the date and time reported by the battery-backed clock will not be valid.

The SEL-2032 monitors the clock registers on power-up. If the clock registers are invalid, the battery is presumed to be discharged and a battery failure is reported.

Relay Firmware Upgrades

When you upgrade the firmware for an SEL relay attached to the SEL-2032, perform the following steps:

Step 1. Take the relay out of service.

The SEL-2032 will show the relay's port status as Inactive and will no longer collect data.

Step 2. Upgrade the relay firmware according to its upgrade instructions.

Step 3. Apply power to the relay and reset its settings, as necessary.

Step 4. Perform any relay testing that your practices require.

Step 5. Reconnect the relay to the SEL-2032, if necessary.

Step 6. Connect a computer terminal to the SEL-2032 and go to Access Level 2.

Step 7. Make a backup copy of your SEL-2032 settings before continuing with the next steps.

The backup settings may be needed if the SEL-2032 has auto configuration problems with the upgraded relay causing settings to be lost.

Step 8. Execute a **SET P** command on the relay's port and auto-configure the port; save these settings.

Step 9. Confirm that the SEL-2032 is now communicating as before.

Place the relay back in service.

Appendix A
Firmware and Manual Versions

Firmware

Determining the Firmware Version

To determine the firmware version, view the status report by using the serial port **STATUS** command. The status report displays the Firmware Identification (FID) label.

The firmware version will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device firmware identification (FID) string.

Existing firmware:

FID=SEL-2032-**R100**-V0-Z003000-Dxxxxxx

Standard release firmware:

FID=SEL-2032-**R101**-V0-Z003000-Dxxxxxx

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-2032-R100-**V0**-Z000001-Dxxxxxx

Point release firmware:

FID=SEL-2032-R100-**V1**-Z000001-Dxxxxxx

Table A.1 lists the firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Table A.1 Firmware Revision History (Sheet 1 of 3)

Firmware Identification (FID) Number	Description of Changes	Manual Date Code
SEL-2032-R115-V1-Z003001-D20151028	Includes all the functions of SEL-2032-R115-V0-Z003001-D20150512 with the following addition: ➤ Modified **PAS** command to only display the relay's password if the password is contained in the STARTUP string. ➤ Modified the **PAS** command to not automatically append access command and password to the STARTUP string.	20151028
SEL-2032-R115-V0-Z003001-D20150512	➤ Modified **PASSWORD** command to provide display and modification of passwords used for connected IEDs. ➤ Modified **PASSWORD** command to no longer display local passwords.	20150512

Table A.1 Firmware Revision History (Sheet 2 of 3)

Firmware Identification (FID) Number	Description of Changes	Manual Date Code
SEL-2032-R114-V0-Z003001-D20110701	➤ Manual update only (see *Table A.2*).	20120126
SEL-2032-R114-V0-Z003001-D20110701	➤ Changed to allow settings change on ports with RTS_CTS enabled, but CTS deasserted. ➤ Resolved issue with collecting large ASCII reports from the SEL-2032. ➤ Resolved issue with using multiple virtual terminal sessions.	20110701
SEL-2032-R113-V0-Z003001-D20091201	➤ Added support for more than 127 rows of target data from a relay. ➤ Fixed issue with IRIG signal reporting hour 24 instead of hour 0 at midnight. ➤ Modified functionality to no longer restrict Fast Messages to static messages only.	20091201
SEL-2032-R112-V0-Z003001-D20090812	➤ Corrected issue that could cause the SEL-2032 to fail to auto-configure with an SEL-400 series relay.	20090812
SEL-2032-R111-V0-Z003001-D20090212	➤ Corrected an issue where SEL-2030/2032 port database information may become temporarily unavailable when certain connected IEDs, such as the SEL-352, are restarted.	20090212
SEL-2032-R110-V0-Z003001-D20080110	➤ Manual update only (see *Table A.2*).	20080620
SEL-2032-R110-V0-Z003001-D20080110	➤ Enhanced Direct Transparent functionality to allow ACSELERATOR QuickSet QuickSet® SEL-5030 Software connections via the front port or SEL-2701 Ethernet Processor to a downstream-connected relay. ➤ Allowed SET M equations to continue to execute during an active Direct Transparent connection on the port. ➤ Fixed issue where Null characters may be dropped during Transparent connections. ➤ Auto-disabled Xon/Xoff handshaking during SEL-5020 YMODEM file transfers. ➤ Improved storage capacity for relay configuration information. ➤ Corrected power miscalculation for older connected relays.	20080110
SEL-2032-R109-V0-Z003001-D20070629	➤ Enhanced security by adding NOCONN functionality for SEL Master ports.	20070629
SEL-2032-R108-V0-Z003001-D20070208	Note: This firmware version was not production released. See R109 above. ➤ Added SP_RATE setting for support of SEL Fast Messaging for synchrophasors.	20070208
SEL-2032-R107-V0-Z002001-D20061122	➤ ASCII Automatic Messages and ASCII Operate commands issued while a port's status is inactive will no longer be queued and sent once that port's status returns to an active state.	20061122
SEL-2032-R106-V0-Z002001-D20060214	➤ Improved efficiency of Modbus® function code 03 and 04 reads. ➤ Extended duration of MSET bit assertion to insure that the bit is available for SELOGIC® equations.	20060214
SEL-2032-R105-V0-Z002001-D20051107	➤ Switching a port protocol from Modbus to SEL Master with unsolicited write (\W) commands does not cause a lockup. ➤ Added precision time-tagging from FAST SER messages and local data into the data transferred from the host to the SEL-2701. ➤ Added the capability to configure and use up to five custom DNP3 maps.	20051107
SEL-2032-R104-V0-Z002001-D20050801	➤ Added DCF command and diagnostic functions	20050801
SEL-2032-R103-V0-Z000000-D20041222	➤ Corrected SEL Binary SER mapping to DNP3 event message function.	20041222

Table A.1 Firmware Revision History (Sheet 3 of 3)

Firmware Identification (FID) Number	Description of Changes	Manual Date Code
SEL-2032-R102-V0-Z000000-D20030605	➤ Increased available message processing RAM.	20030605
SEL-2032-R101-V0-Z000000-D20030312	➤ Enabled \W messaging for both Master and SEL ports. ➤ Improved performance of serial port buffering and unsolicited message handling.	20030312
SEL-2032-R100-V0-Z000000-D20030115	➤ Initial version.	20030115

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date.

Table A.2 lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.2 Instruction Manual Revision History (Sheet 1 of 3)

Revision Date	Summary of Revisions
20151028	Appendix A ➤ Updated for firmware version R115-V1. ➤ Updated to include information on point releases. Appendix B ➤ Updated to include information on point releases.
20150512	Section 1 ➤ Updated *Network Interfaces* to note that the SEL-2711 is no longer available for purchase. Section 3 ➤ Updated *Using Strong Passwords* to indicate a maximum password length of 12 characters. Section 8 ➤ Updated *PASSWORD*. ➤ Updated *Using Strong Passwords* to indicate a maximum password length of 12 characters. Appendix A ➤ Updated for firmware version R115.
20120126	Section 1 ➤ Updated *Specifications*. Section 3 ➤ Added *Table 3.1: Factory-Default Passwords for Access Levels 1, 2, and C*. ➤ Added PAS C to *Step 10* in *Set the Passwords, Step by Step*. Section 8 ➤ Updated *Table 8.1: Access Level Characteristics*. ➤ Added CAL command information in *Command Set*. Command Summary ➤ Added CAL command.
20110701	Appendix A ➤ Updated for firmware version R114.

Table A.2 Instruction Manual Revision History (Sheet 2 of 3)

Revision Date	Summary of Revisions
20091201	**Section 9** ➤ Added note to force auto-configure if IED FMR settings have changed. **Appendix A** ➤ Updated for firmware version R113.
20090812	**Appendix A** ➤ Updated for firmware version R112.
20090212	**Appendix A** ➤ Updated for firmware version R111.
20080620	**Section 9** ➤ Updated *Automatic Data Mapping*. ➤ Updated *Custom Data Mapping*. **Appendix C** ➤ Updated *Table C.1: SEL-2032 Compatibility Matrix*.
20080110	**Section 4** ➤ Updated *Local Intermediate Logic*. **Appendix A** ➤ Updated for firmware version R110.
20070629	**Section 7** ➤ Added *Restricting Port Access with NOCONN*. **Section 9** ➤ Updated *Fast Message Synchrophasor Settings* and *Fast Message Synchrophasor Processing*. **Appendix A** ➤ Updated for firmware version R109.
20070208	**Section 3** ➤ Added *Example 4: Collect Unsolicited Write (Synchrophasor) Data*. **Section 7** ➤ Added fifth bullet to *Automatic Message (SET A) Settings*. ➤ Added SP_RATE information in *Table 7.6*. **Settings Sheets** ➤ Added SP_RATE setting to *Settings Sheet—SEL IED, SET P and SET A*. **Section 9** ➤ Updated *SEL IEDs and the* SEL-2032. ➤ Moved *Sequential Events Recorder (SER) Data* from *Section 7* to *Section 9*. ➤ Updated first paragraph and *Step 3* in *Sequential Events Recorder (SER) Data*. ➤ Added *SEL Fast Message Synchrophasor Protocol* in *SEL Fast Message Protocol*. ➤ Updated *Output Objects: DNP_PAIR = N*. **Appendix A** ➤ Updated for firmware version R108. **Appendix B** ➤ Deleted *Using Compressed File Formats*. ➤ Added *Step 4* to *Prepare for Firmware Upgrade*.
20061122	**Section 4** ➤ Added *Communications and Triggered Messages*. **Appendix A** ➤ Updated for firmware version R107.
20060214	**Section 3** ➤ Added 20USER memory copy example to *Modbus Job Done*. **Section 9** ➤ Revised *Timing* in *Modbus RTU Protocol*. ➤ Expanded descriptions of function codes 03h and 04h in *Function Codes*.

Table A.2 Instruction Manual Revision History (Sheet 3 of 3)

Revision Date	Summary of Revisions
20051107	➤ Reissued entire manual to include DNP3 for LAN/WAN support. Appendix A ➤ Updated Firmware and Manual Version tables.
20050801	Section 5 ➤ Added data format "d=binary default" for "\Rt;saddr[;n]/" in *Table 5.2*. Section 6 ➤ Added the overrun bit to *Figure 6.6* and *Figure 6.7*. Section 7 ➤ Added DCF command to *Virtual Terminal Communications* and modified SET commands in *Figure 7.1*. Section 8 ➤ Added DCF command to *Table 8.1* and describe DCF. ➤ Added overrun statistics, last reset, and Ram Allocation Failure indications to STATUS command. Appendix A ➤ Updated Firmware and Manual Version tables.
20041222	Appendix A ➤ Updated Firmware and Manual Version tables.
20030605	Section 5 ➤ Added \W message limit to *Table 5.2*. Section 9 ➤ Added breaker bit usage description to **AUTO** command example. ➤ Corrected virtual terminal support in DNP3 Device Profile Document in *Table 9.17*. Appendix A ➤ Updated Firmware and Manual Version tables.
20030312	Appendix A ➤ Updated Firmware and Manual Version tables. Appendix D ➤ Added Calculate Memory Usage information and tables.
20030115	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Overview

This instruction guides you through the process of upgrading firmware in the device. The firmware upgrade will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device firmware identification (FID) string.

Existing firmware:

FID=SEL-2032-**R100**-V0-Z003000-Dxxxxxx

Standard release firmware:

FID=SEL-2032-**R101**-V0-Z003000-Dxxxxxx

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-2032-R100-**V0**-Z000001-Dxxxxxx

Point release firmware:

FID=SEL-2032-R100-**V1**-Z000001-Dxxxxxx

The release date is after the D. For example, the following is firmware revision number 100, release date December 10, 2003.

FID=SEL-2032-R100-V0-Z001001-**D20031210**

New versions of SEL-2032 or SEL-2030 (SEL-203*x*) firmware may contain new settings and enhanced features. The SEL-203*x* dynamically allocates several resources, including operating memory and settings storage, and new features may require more resources. This means that if you upgrade an SEL-203*x* from a previous version and you have extensive **SET M** programming, your settings may not fit into the remaining resources after installing the new version of firmware. If you have difficulties installing settings or with the firmware upgrade process, contact SEL for assistance.

NOTE: Use caution when installing new firmware to verify that your previous settings operate as expected after installation. A procedure for verification of your settings is included in the firmware upgrade instructions.

There may be new features and capabilities that require you to provide additional settings beyond those in your present firmware. To determine potential effects of new settings on your application, carefully review the firmware upgrade descriptions in the SEL-203*x* Instruction Manual released with the new firmware.

Your firmware upgrade may require an upgrade to firmware in the communications cards installed in your SEL-203*x*. Contact SEL for assistance with firmware version compatibility with your SEL-203*x*.

Firmware Files

The programs (firmware) that run in the SEL-203*x* and SEL-2700 family of cards reside in Flash memory. To load new firmware versions, follow the instructions below. The SEL-203*x* has two programs that you may need to upgrade: the regular, or "executable" program, and the SELBOOT program.

Throughout these instructions, the plug-in cards are referred to as SEL-27xx, where xx in 27xx is the placeholder for a complete card number. For example, if you are loading firmware for an SEL-2701 Ethernet Processor card, substitute SEL-2701 for all references to SEL-27xx.

Table B.1 Firmware Upgrade Files

Product	File Name	File Type
SEL-203*x*	rvvv2032.S19	SEL-203*x* firmware[a] (can be downloaded to SEL-203*x*).
SEL-2030 SELBOOT	rvvvS030.S19	SEL-2030 SELBOOT firmware[a] (can be downloaded to SEL-2030).
SEL-27xx	rvvv27xx.S19	SEL-27xx firmware[a] (can be downloaded to SEL-27xx).
SEL-27xx SELBOOT	Svvv27xx.S19	SEL-27xx SELBOOT firmware[a] (can be downloaded to SEL-27xx).
Compressed File	SEL2032.EXE	Self-Extracting Compressed[b] file containing the .S19 files noted in this table (canNOT be downloaded to SEL-2032 or SEL-27xx).

[a] Where vvv is the firmware revision number.
[b] File must be uncompressed before using, follow the steps in Upgrade Procedure to uncompress your file.

Upgrade Procedure

A Prepare for Firmware Upgrade

Follow the steps listed below to prepare for a firmware upgrade:

Step 1. Capture your settings using the SEL-5020 Settings Assistant Software or otherwise document them so that you can reinstall them.

Some circumstances may require that you reinstall settings to complete the firmware upgrade process. For example, if you are upgrading many revisions (R101 to R115) or if the upgrade is interrupted by a power loss, you will need to reinstall settings.

Step 2. Review the firmware upgrade considerations listed above. If you have extensive **SET M** programming or want to reinstall the present firmware version, contact SEL for copies of your present firmware version on digital media.

Step 3. Disconnect communications cables from the SEL-203*x* to attached relays if those relays are presently in service and can operate power system equipment.

Step 4. Prepare to load the firmware.

➢ Insert the disk containing the new firmware into the appropriate disk drive on the computer.

For a faster upload (and less potential for file corruption), copy the new firmware to the local hard drive and upload the new firmware from the hard drive.

➢ Some firmware is in self-extracting compressed files (files with .exe extensions). For firmware in such files, from Windows Explorer double-click on the file and select the directory on the hard drive where you want to access the uncompressed files. Verify that these uncompressed files have an .s19 extension.

Firmware Upgrade Command Summary

Table B.2 Firmware Upgrade Command Summary

Command	Description	Example
L_D	Put the SEL-203*x* and any installed protocol cards into SELBOOT mode.	**L_D** and **Yes** at the verification prompt. The **L_D** command is only available from Access Level 2. Once in SELBOOT mode, the prompt is an exclamation point (**!**).
HELP	List of commands available within SELBOOT mode.	**HELP** displays a list of available commands.
BAUD	Change baud rate for the SEL-203*x* port.	**BAUD 38400** sets the SEL-203*x* baud rate to 38400. This is the highest available baud rate and is recommended.
REC	Set the SEL-203*x* in the “ready to receive executable file” mode.	**REC** and **Yes** at the verification prompt. Now the SEL-203*x* is ready to receive an S-Record file via the Xmodem protocol.
REC *n*	Set the protocol card in the “ready to receive executable file” mode.	**REC 17** and **Yes** at the verification prompt. Now the SEL-203*x* is ready to receive an S-Record file via the Xmodem protocol for the protocol card on Port 17.
REC boot	Set the SEL-203*x* in the “ready to receive SELBOOT executable file” mode.	**REC boot** and **Yes** at the verification prompt. Now the SEL-203*x* is ready to receive a new SELBOOT S-Record file via the Xmodem protocol.
REC boot *n*	Set the protocol card in the “ready to receive SELBOOT executable file” mode.	**REC boot 17** and **Yes** at the verification prompt. Now the protocol card is ready to receive a new SELBOOT S-Record file via the Xmodem protocol.
EXIT	Exit SELBOOT mode	**EXIT** to exit SELBOOT mode and return the SEL-203*x* to normal operation.

B Upgrade Firmware

Step 1. Prepare to upgrade the SEL-203*x* using the instructions in *Prepare for Firmware Upgrade on page B.2*.

Step 2. Cycle power on the SEL-203*x* while holding the **LED TEST** button.

This places the SEL-203*x* in SELBOOT mode, where it can receive new program code for itself or a connected protocol card. While in SELBOOT mode, you can enter the **HELP** command to receive a description of the available commands.

Step 3. Establish a serial connection with the front-panel port on the SEL-203*x*. Use the following communications parameters: 2400 bps, no parity, 8 data bits, 1 stop bit.

Make sure your communications software is capable of performing Xmodem file transfers.

Step 4. Use the **BAUD** command to set the port baud rate.

- ➢ Set the port at 38400 bits per second by entering **BAUD 38400**.
- ➢ Change the baud rate parameter in your communications software to match and then reestablish communications.

Step 5. Complete the appropriate set of steps below:

SEL-203x

a. Type the **REC** command.

b. Respond by entering **Y** at the confirmation prompt.

c. When the SEL-203*x* is ready to receive the new code, it prompts you to press any key to initiate the firmware download.

d. The SEL-203*x* expects the file transfer to start within approximately 10 seconds; otherwise the transfer will fail.

e. Press a key and then use an Xmodem file transfer to send the new SEL-203*x* code.

SEL-27xx

a. Type the **REC *n*** command, where ***n*** is the protocol card port (e.g., if the card is on Port 17, then enter **REC 17**).

b. Respond by entering **Y** to the confirmation prompt.

c. When the SEL-203*x* is ready to receive the new code, it prompts you to press any key to initiate the firmware download.

d. Press a key and then use an Xmodem file transfer to send the new protocol card code.

SEL-27xx SELBOOT code

a. Type the **REC boot *n*** command, where ***n*** is the protocol card port (e.g., if the card is on Port 17, then enter **REC boot 17**).

b. Respond by entering **Y** at the confirmation prompt.

c. When the SEL-203*x* is ready to receive the new code, it prompts you to press any key to initiate the firmware download.

d. The SEL-203*x* expects the file transfer to start within approximately 10 seconds; otherwise the transfer will fail.

e. Press a key and then use an Xmodem file transfer to send the new SEL-203*x* SELBOOT code.

SEL-203x SELBOOT code

a. Type the **REC boot** command.

b. Respond by entering **Y** at the confirmation prompt.

c. When the SEL-203*x* is ready to receive the new code, it prompts you to press any key to initiate the firmware download.

d. The SEL-203*x* expects the file transfer to start within approximately 10 seconds; otherwise the transfer will fail.

e. Press a key and then use an Xmodem file transfer to send the new SEL-203*x* SELBOOT code.

Step 6. When the transfer is complete, the SEL-203*x* and SEL-27xx indicate whether they received the new code successfully.

- ➢ If the transfer was not successful, repeat *Step 5*.
- ➢ When the transfer succeeds, repeat *Step 5* if you are upgrading multiple programs and/or multiple protocol cards.
- ➢ Once all upgrades are complete, enter the **EXIT** command to return the SEL-203*x* and associated protocol cards to normal operation.

Step 7. To communicate with the SEL-203*x*, use the baud rate you used in *Step 1* to establish communications.

Step 8. Study the documentation that came with the upgrade to determine if you need to make any settings changes.

New firmware versions may contain new functions and new settings. It may be necessary to modify settings to achieve operation that is the equivalent of operation before the upgrade.

Step 9. Check the settings and operation of your SEL-203*x* by executing the **STATUS** command and examining the results. If the status is not as you expect, contact SEL for assistance.

Step 10. Because the SEL-203*x* dynamically allocates resources, you must perform a test to verify that the settings and operation of the SEL-203*x* are correct. Remove and reapply power to the SEL-203*x* and observe the startup sequence of the SEL-203*x*. After the startup is complete, connect to the SEL-203*x* and execute the **STATUS** command to verify proper operation. If the status is not as you expect, contact SEL for assistance.

Upgrade Warning

SEL-2701 firmware releases prior to R108 are not compatible with SELBOOT version R102. A “SLBT FAIL” (Hex 0x0004) message may appear if a **STA**tus command is issued when SELBOOT R102 is used with firmware releases R100–R105.

Factory Assistance

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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Appendix C
SEL IED Compatibility

The SEL-2032 is designed to work with and was tested with SEL intelligent electronic devices (IED) listed in the table below, plus all SEL IEDs released after December 1994. Each SEL-2032 should work with most older IED firmware versions, but some firmware will not be compatible. If you have an old version of IED firmware and experience difficulties using it with the SEL-2032, you should upgrade the IED firmware to the current version. The date code is a part of the FID string found at the top of each long event report.

Table C.1 SEL-2032 Compatibility Matrix (Sheet 1 of 2)

SEL IEDs	Date Codes
49	881007
49E[a]	881007
121, -1, -2, -2A, -3, -4, -6, -8	920522
121-10, -16, -17	930420
121B/221B, -1	940722
121C-1/221C, -1	930708
121D/221D	931102
121F/221F, -1, -2, -3, -8	930420
121G/221G, -3, -4, -5, -6, -7, -8, -9	941021
121H/221H, -3	940126
121S/221S	921102
151/251, -1, -2, -3	940901
151C/251C, -1, -2, -3	940901
251CD, -1, -3	940901
151D/251D, -1, -3	940901
167/267, -2, -4, -5	931026
167D/267D, -3	940830
187V/287V, -1	940820
279	941110
279H, -1, -2	941107
BFR/2BFR, -1	940125
PG10/2PG10, -7, -8	930830
300G	All
311 family	All
321	940927
321-1	941114
321-5	960807
321-3	All

Table C.1 SEL-2032 Compatibility Matrix (Sheet 2 of 2)

SEL IEDs	Date Codes
351 family	All
351A	All
351R	All
352 family	All
387 family	All
421 family	All
451 family	All
487B	All
501,-2	941108
547	All
551 family	All
551C	All
587Z	All
651R	All
701 family	All
710	All
734	All
749M	All
751A	All
2410	All
2411 family	All
2414	All
2431	All
2505 family	All
2506	All
2515	All
2516	All
2522	All
2523	All
2600 family	All
3021 family	All

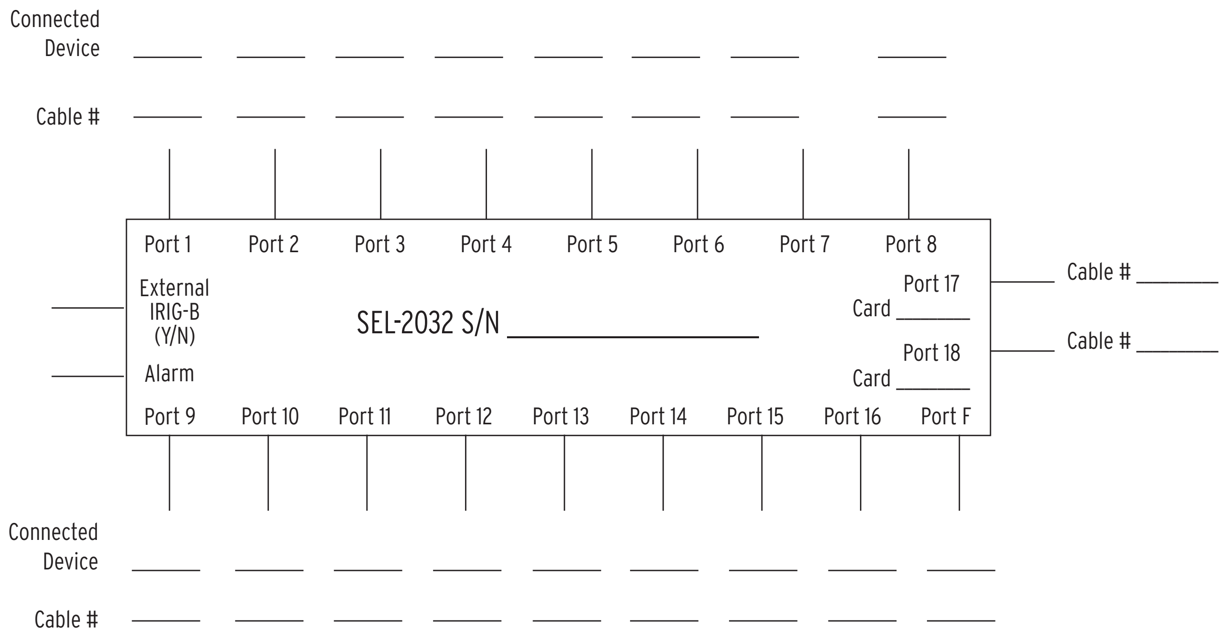
[a] Only works at speeds of 2400 bps or below.

Appendix D
System Planning Sheet

Date ______________________

Approved by ______________________

SEL-2032 Location ______________________



Optional I/O

Description			Description
OUT1		IN7	
OUT2		IN8	
OUT3		IN9	
OUT4		IN10	
IN1		IN11	
IN2		IN12	
IN3		1N13	
IN4		IN14	
IN5		IN15	
IN6		IN16	

Figure D.1 SEL-2032 Device Connection Plan

Calculate Memory Usage

Nonvolatile Flash Memory Usage Estimation

The total nonvolatile Flash memory available for archive storage is 7,168 blocks. (A block is 256 bytes.) *Table D.1* shows the memory requirements for various types of data. Each item requires one to five blocks of overhead, plus 1/7 to 240 blocks per record stored, as indicated in the table.

Table D.1 "20" Message Archive Requirements in Blocks

Relay	Meter	Fast Meter	Demand	Target	Status	Breaker	History	EVENT	EVENTS	EVENTL
49	*n*/3+2	–	–	–	2*n*+1	–	*n*+2	11*n*+3	25*n*+1	–
121	*n*/3+2	–	–	*n*/6+1	2*n*+1	–	2*n*+2	11*n*+3	25*n*+1	–
121-10	*n*/3+2	*n*+4	–	*n*/7+1	2*n*+1	–	2*n*+2	11*n*+3	25*n*+1	–
121B	*n*/3+2	*n*+4	–	*n*/7+1	2*n*+1	–	2*n*+2	11*n*+3	25*n*+1	–
121C	*n*/3+2	*n*+4	–	*n*/7+1	2*n*+1	–	2*n*+2	11*n*+3	25*n*+1	–
121D	*n*/4+2	–	–	*n*/7+1	2*n*+1	–	2*n*+2	11*n*+3	25*n*+1	–
121F	*n*/3+3	*n*+4	–	*n*/7+1	2*n*+1	–	2*n*+2	11*n*+3	25*n*+1	–
121G	*n*/3+2	*n*+4	–	*n*/7+1	2*n*+1	–	2*n*+2	11*n*+3	25*n*+1	–
121H	*n*/3+2	*n*+4	–	*n*/7+1	2*n*+1	–	2*n*+2	11*n*+3	25*n*+1	–
121S	*n*/3+2	*n*+4	–	*n*/7+1	2*n*+1	–	2*n*+2	11*n*+3	25*n*+1	–
151	*n*/3+3	*n*+4	*n*/3+2	*n*/6+1	2*n*+1	*n*/2+3	3*n*+2	11*n*+3	25*n*+1	–
151C	*n*/3+3	*n*+4	*n*/3+2	*n*/6+1	2*n*+1	*n*/2+3	3*n*+2	11*n*+3	25*n*+1	–
151CD	*n*/4+2	*n*+3	*n*/3+2	*n*/6+1	2*n*+1	*n*/2+3	3*n*+2	11*n*+3	25*n*+1	–
151D	*n*/4+2	*n*+3	*n*/3+2	*n*/6+1	2*n*+1	*n*/2+3	3*n*+2	11*n*+3	25*n*+1	–
167	*n*/3+3	–	*n*/3+3	*n*/7+1	2*n*+1	–	3*n*+2	11*n*+3	25*n*+1	–
167D	*n*/3+2	*n*+3	*n*/3+2	*n*/7+1	2*n*+1	–	3*n*+2	11*n*+3	25*n*+1	–
187V	*n*/3+2	–	–	*n*/6+1	2*n*+1	–	3*n*+2	12*n*+3	25*n*+1	–
279	*n*/3+2	–	–	*n*/7+1	2*n*+1	*n*/4+2	–	–	–	–
279H	*n*/3+2	–	–	*n*/6+1	2*n*+1	–	3*n*+2	13*n*+3	25*n*+1	–
BFR	*n*/3+2	–	–	*n*/7+1	2*n*+1	–	14*n*+2	16*n*+3	48*n*+1	–
300G	–	*n*+5	*n*/2+4	*n*/4+1	2*n*+4	–	11*n*+1	31*n*+4	48*n*+1	240*n*+1
PG10	*n*/3+2	*n*+4	–	*n*/7+1	2*n*+1	–	2*n*+2	11*n*+3	25*n*+1	–
321	*n*/3+2	*n*+5	–	*n*/3+1	2*n*+1	–	10*n*+2	11*n*+3	48*n*+1	240*n*+1
321-1[a]	–	*n*+3	–	*n*/3+1	*n*+3	–	12*n*+2	9*n*+2	48*n*+1	240*n*+1
351	–	*n*+6	*n*+5	*n*/3+1	2*n*+4	–	5*n*+4	31*n*+5	48*n*+1	240*n*+1
351R	–	*n*+5	*n*/2+4	*n*/3+1	2*n*+5	–	7*n*+3	36*n*+5	48*n*+1	240*n*+1
352	–	2*n*+6	–	*n*/2+1	2*n*+4	2*n*+3	5*n*+3	16*n*+4	48*n*+1	240*n*+1
387	–	*n*+4	*n*+3	*n*/4+1	2*n*+5	*n*/2+4	32*n*+3	22*n*+4	48*n*+1	240*n*+1
501	*n*/5+2	*n*+3[b]	*n*/5+2	*n*/6+1	2*n*+1	*n*/3+3	4*n*+2	14*n*+3	48*n*+1	–
551	–	*n*/3+2	–	*n*/7+1	*n*+3	–	5*n*+2	17*n*+3	48*n*+1	–
587	–	*n*+4	*n*/3+2	*n*/6+1	*n*+4[c]	–	4*n*+2[c]	23*n*+5[c]	48*n*+1[c]	–

[a] Only applies to SEL-321-1 Relays with a date code later than 950907. Older SEL-321-1 Relays have same sizes as SEL-321 Relays.
[b] Only applies to SEL-501 Relays with a date code later than 960101.
[c] Only available in SEL-587 Relays with a date code later than 950907.

Determine the Flash Memory Required

Perform the following steps, using *Table D.2* as a planning sheet:

Step 1. Estimate the desired maximum number of records (n) of each type on each port

Step 2. Determine the memory requirements per region

1. For “20” message archive regions, use the records estimated as *n* in *Table D.1*.
2. For regions in which you use generic parsing, proceed with the following:
   a. Calculate the number of bytes required for each record.

      For CHAR_STRING parsing, each record will require $S = 28 + \text{NUM}$ bytes where NUM is your size setting for the region.

      For INT_STRING or ASCII_INT parsing, each record will require $S = 28 + 2 \cdot \text{NUM}$ bytes.

      For ASCII_FLOAT parsing, each record will require $S = 28 + 4 \cdot \text{NUM}$.

   b. Calculate the number of blocks required per record.

      If the size determined in bytes is greater than 254, the number of blocks required per record is the record size in bytes plus 2 divided by 256 and rounded up:

$$A = \left\lceil \frac{S + 2}{256} \right\rceil$$

      If the size determined in bytes is less than 128, the number of records that will fit in a block is 254 divided by the record size and rounded down:

$$A = \frac{1}{\left\lfloor \frac{254}{S} \right\rfloor}$$

      If the size determined is greater than 128 bytes and less than 254, you will get one record per block:

$$A = 1$$

      The archive memory requirements are:

$$An + 1$$

Step 3. Calculate the blocks required per region

1. Round all fractions up to the nearest integer.
2. Enter the number of blocks in *Table D.2*.

Step 4. Sum to determine total requirement

If the total requirement exceeds 7,168 blocks, you must use more than one SEL-2032 or reduce the amount of data you archive.

Table D.2 Archive Memory Usage Estimation

Port	Archive 1			Archive 2			Archive 3		
	No. of Records	Record Size	Number of Blocks	No. of Records	Record Size	Number of Blocks	No. of Records	Record Size	Number of Blocks
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Total A1 Blocks ________ Total A2 Blocks ________ Total A3 Blocks ________

A1 Blocks + A2 Blocks + A3 Blocks = ________

Maximum available: = 7,168

For example, consider the case where you want to collect demand meter data from an SEL-151 Relay every 15 minutes and want the SEL-2032 to store up to 10 days worth of this data. This yields a total desired number of records of 960. From *Table D.1*, the memory requirement for 151 demand meter data is $n/3 + 2$. Thus, the total number of blocks is $(960/3) + 2 = 322$.

RAM Usage Estimation

In the SEL-2032, 1 MB of shared RAM is available. Of this, all but 4 KB is available to the database. To determine the memory used by your planned functions, sum the memory used for all database regions, including archive regions.

User Region Memory

Memory requirements for the User region are 30 bytes + twice the USER setting you enter with the **SET A** command. (Be aware that the USER setting may automatically increase when you use the **SET M** command.) If you are using **SET M**, there will be an additional memory requirement of 30 bytes per line in your **SET M** settings.

Data Region Usage

To estimate Data Region (D1–D8 and A1–A3) memory usage for “20” data collection, use the record sizes directly from *Table D.3*. For non-20 data collection, you determine the record sizes from the PARSE and NUM settings:

S = 128 + NUM	if PARSE = CHAR_STRING
S = 128 + 2 • NUM	if PARSE = INT_STRING or PARSE = ASCII_INT
S = 128 + 4 • NUM	if PARSE = ASCII_FLOAT

Table D.3 Data Record Sizes (Bytes) by Relay and Record Type

SEL Relay	Record Type								
	Fast Meter	Meter	Demand	Target	Status	Breaker	History	EVENT	EVENTS
49		52			408		138	2682	6148
121		52		427	408		392	2682	6148
121-10	1054	52		361	408		392	2672	6148
121B	1054	52		328	408		428	2770	6148
121C	1054	52		361	408		416	2770	6148
121D		34		361	408		392	2770	6148
121F	1092	58		361	408		392	2770	6148
121G	1054	52		361	408		392	2770	6148
121H	1054	52		361	408		392	2770	6148
121S	1054	52		361	408		392	2772	6148
151	1054	58	44	427	408	60	632	2672	6148
151C	1054	58	44	427	408	60	560	2668	6148
151CD	850	38	44	427	408	60	560	2668	6148
151D	850	38	44	427	408	60	632	2672	6148
167		64	64	361	408		656	2770	6148
167D	850	46	46	361	408		656	2770	6148
187V		44		427	408		512	2864	6148
279		44		394	408	36			
279H		52		427	408		512	3120	6148
BFR		52		394	408		3408	3868	12400
PG1O	1054	52		262	408		392	2770	6148
300G	1472		980	1794	1360		3248	8728	12288
321[a]	1282	52		1902	488/906		2328/3296	2672/2764	12400
351	1514		1242	1884	1206		1946	8738	12400
351R	1368		980	2638	1548		2310	10172	12288
352	1582			3186	1310	948	1720	4720	12400
387	1010		778	2014	1428	1008	8638	6506	12400
501	782[b]	28	28/438[b]	460	488	64	888	3414	12400
551	364			694	962		1498	4612	12400
587	1100		438	660	1082[c]		1390[c]	6838[c]	12400**

[a] For columns with two numbers, the first number applies to the SEL-321 and to SEL-321-1 Relays with a date code earlier than 950907. The second number applies to newer SEL-321-1 Relays.
[b] Only applies to SEL-501 Relays with a date code later than 960101.
[c] Only available in SEL-587 Relays with a date code later than 950907.

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Appendix E

ASCII Reference Table

Table E.1 ASCII Reference Table

Decimal	Hexadecimal	Character	Keystroke
0	00	NUL	
1	01	SOH	Ctrl+A
2	02	STX	Ctrl+B
3	03	ETX	Ctrl+C
4	04	EOT	Ctrl+D
5	05	ENQ	Ctrl+E
6	06	ACK	Ctrl+F
7	07	BEL	Ctrl+G
8	08	BS	Ctrl+H
9	09	HT	Ctrl+I
10	0A	LF	Ctrl+J
11	0B	VT	Ctrl+K
12	0C	FF	Ctrl+L
13	0D	CR	Ctrl+M
14	0E	SO	Ctrl+N
15	0F	SI	Ctrl+O
16	10	DLE	Ctrl+P
17	11	DC1 (XON)	Ctrl+Q
18	12	DC2	Ctrl+R
19	13	DC3 (XOFF)	Ctrl+S
20	14	DC4	Ctrl+T
21	15	NAK	Ctrl+U
22	16	SYN	Ctrl+V
23	17	ETB	Ctrl+W
24	18	CAN	Ctrl+X
25	19	EM	Ctrl+Y
26	1A	SUB	Ctrl+Z
27	1B	ESC	ESC
28	1C	FS	
29	1D	GS	
30	1E	RS	
31	1F	US	
32	20	SP	SPACE
33	21	!	!
34	22	"	"
35	23	#	#
36	24	$	$
37	25	%	%
38	26	&	&
39	27	'	'
40	28	(	(
41	29	)	)
42	2A	*	*
43	2B	+	+
44	2C	,	,
45	2D	-	-
46	2E	.	.
47	2F	/	/
48	30	0	0
49	31	1	1
50	32	2	2
51	33	3	3
52	34	4	4
53	35	5	5
54	36	6	6
55	37	7	7
56	38	8	8
57	39	9	9
58	3A	:	:
59	3B	;	;
60	3C	<	<
61	3D	=	=
62	3E	>	>
63	3F	?	?
64	40	@	@
65	41	A	A
66	42	B	B
67	43	C	C
68	44	D	D
69	45	E	E
70	46	F	F
71	47	G	G
72	48	H	H
73	49	I	I
74	4A	J	J
75	4B	K	K
76	4C	L	L
77	4D	M	M
78	4E	N	N
79	4F	O	O
80	50	P	P
81	51	Q	Q
82	52	R	R
83	53	S	S
84	54	T	T
85	55	U	U
86	56	V	V
87	57	W	W
88	58	X	X
89	59	Y	Y
90	5A	Z	Z
91	5B	[	[
92	5C	\	\
93	5D	]	]
94	5E	^	^
95	5F	_	_
96	60	`	`
97	61	a	a
98	62	b	b
99	63	c	c
100	64	d	d
101	65	e	e
102	66	f	f
103	67	g	g
104	68	h	h
105	69	i	i
106	6A	j	j
107	6B	k	k
108	6C	l	l
109	6D	m	m
110	6E	n	n
111	6F	o	o
112	70	p	p
113	71	q	q
114	72	r	r
115	73	s	s
116	74	t	t
117	75	u	u
118	76	v	v
119	77	w	w
120	78	x	x
121	79	y	y
122	7A	z	z
123	7B	{	{
124	7C	|	|
125	7D	}	}
126	7E	~	~
127	7F	DEL	DEL

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Glossary

ASCII	American National Standard Code for Information Interchange
CPU	Central Processor Unit
CTS	Clear-To-Send
DCD	Data-Carrier-Detect
DNP3	Distributed Network Protocol
EEPROM	Electronically Erasable Programmable Read-Only Memory
EIA	Electronic Industries Association
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FID	Firmware Identification
Flash Memory	Nonvolatile memory (retains data when power is removed)
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
HMI	Human-Machine Interface
IED	Intelligent Electronic Device
IRIG-B	Inter-Range Instrumentation Group (U.S. Government)
LMD	SEL Distributed Port Switch Protocol
LPS	Linear Power Supply
LSB	Least Significant Bit
MOV	Metal Oxide Varistor
MSB	Most Significant Bit
Parse	To separate a string into its component parts and decide which parts to keep
PS	Power Supply
RFI	Radio Frequency Interference
RTS	Request-To-Send
RTU	Remote Terminal Unit
RXD	Receive Data

SCADA Supervisory Control and Data Acquisition

TTL Transistor-Transistor Logic (0 Vdc to +5 Vdc)

TXD Transmit Data

VT Virtual Terminal: A method to emulate a direct serial communications link through a network

XON Transmit ON character

XOFF Transmit OFF character

Index

Page numbers appearing in bold mark the location of the topic's primary discussion.

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SEL-2032 Command Summary

Command	Description
2ACCESS	Use to enter Access Level 2 to change SEL-2032 settings.
ACCESS	Use this command to enter Access Level 1 for interrogate, read-only capability.
AUTO *n*	Displays the results of auto-configuration on selected port.
BROADCAST	Establish direct communications with all IED ports simultaneously. To terminate communications and return to command operation, use the termination sequence set for your port. (**<Ctrl+D>** is the default termination sequence.)
CAL	Enter Access Level C. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CARD	Displays the value of the Control Input and Control Output elements for the protocol card ports (Ports 17 and 18).
CLEAR *m*:*n*	Clears data from the unsolicited message queue or from the archive data regions of an intelligent electronic device (IED) port. Parameter *m* specifies which port (1–16). Parameter *n* may be BUF for the unsolicited message queue or A1, A2, or A3 for the Archive data regions.
CONTROL *m*	Parameter *m* specifies the global elements, R1–R8, you will operate. You are then prompted to enter one of three control operations: **SRB** sets a specified bit; **CRB** clears a specified bit; and **PRB** pulses a specified bit. To pulse, supply a time as a second parameter or a one-second time is the default.
COPY *m n*	Copies port-specific settings (classes P, A, M, U, and L) from Port *m* to Port *n* (*m* and *n* equal any combination of 1–18). Type **COPY *m* ALL <Enter>** if you wish to copy the Port *m* settings to all other ports.
DATE	Displays the date stored by the internal calendar/clock. Use a date parameter to change the date: **DATE *mm*/*dd*/*yy***.
DCF	Enable data collection features on a virtual terminal session.
DEFRAGMENT	Defragment EEPROM.
DNPMAP	Displays map of data available on DNP 3.00 port.
FILE	Performs file transfer operations on the SEL-2032 file system.
HELP	Lists all commands available at the current access level. Use with a command as its parameter and it will provide the syntax and a brief description of the command.
ID	Displays SEL-2032 current ID, as set in the global settings, and the firmware identification string (FID string). See also **WHO** and **STATUS** commands.
IRIG	Directs the SEL-2032 to read IRIG-B time-code input at the IRIG-B port. It updates the internal clock/calendar time and date to the time code.
LD	Causes SEL-2032 to enter SELBOOT mode. This is used when you want to load new code into the SEL-2032.
MAP *m*:*n*	Displays the data structure and format for data stored in a port database. Parameter *m* = port number (1–18). Parameter *n* = data region (GLOBAL, LOCAL, BUF, D1–D8, or A1–A3).
MEMORY	Displays the status of memory usage.
MODMAP *m*:*n t*	Displays the Modbus® 3x register (Input Register) map for the selected port. Parameter *m* is the port number. Parameter *n* specifies the data region to view. Parameter *t* specifies the map type (I for integer map and F for floating point).
PASSWORD	Shows or sets passwords.
PORT *n i*	Establishes transparent communication between the master port issuing the command and the designated port *n*. With Ports 17 and 18, use parameter *i* to specify a network address.
QUIT	Causes the SEL-2032 to return control to Access Level 0 from Level 1 or 2. The command displays the SEL-2032 ID, date, and time of **QUIT** command execution.

Command	Description
SER	Displays the SER data for a selected port with the following options and format: SER *x* [BL] | [*m*] [*n*] | [C | CA | R] Parameter *x* is either a port number or GLOBAL. BL displays the SER labels for the specified port. Parameter *m* is the number of the most recent records to display—default is the last 20. Parameter *n*, if supplied with *m*, defines a range of records to display. C or R clears the SER records for the selected port.[b] CA clears all of the SER records in the SEL-2032. When CA is selected, no port number may be specified.[b]
SET *n*	See SET/SHOW Command Options table.
SHOWSET *n*	See SET/SHOW Command Options table.
STATUS	Shows SEL-2032 self-test status and the configuration, communication, and data performance of each port.
STORE *m*:*n* *d*	Stores data directly into a database. Parameter *m* specifies the port number (Port F is not a valid option); parameter *n* specifies the starting database address; and parameter *d* is a data stream with each item consisting of data as characters, strings, decimal integers, hexadecimal integers, or single-precision floating-point numbers.
SWAP *n m*	Switches all port-specific settings (P, A, M, U, and L settings) between two ports.
TARGET *n m*	Displays global element or port-specific element information. Enter **G** for parameter *n* to display global elements or enter **1–18** to display port-specific elements (the front-panel port has no elements). For parameter *m*, enter the element row number you want displayed or enter **ALL** to show all of the elements.
TIME	Displays or sets time for the internal clock.
TOGGLE *m*	Toggles a specified element bit, *m* (e.g., 4:GRB1).
VIEW *m*:*n*	Shows data stored in a port's database. Parameter *m* specifies which port (1–18). Parameter *n* specifies what data to view: an address range in decimal or hex; a specific region of the database; **GLOBAL**, **LOCAL**, **BUF**, **D1–D8**, or **A1–A3**.
WHO	Shows what is connected to each port.

SET/SHOW Command Options

Option	Setting Type	Description
G	Global	Settings that affect overall SEL-2032 operation
A n[a]	Automatic Messaging	Outgoing messages and response parsing for specified port
U n[b]	User-Defined Messages	Custom commands added to the SEL command set for the specified port
P n[c]	Port Configuration	Communications parameters and protocol selection for the specified port
M n[a]	Math/Data Movement	Data concentration, scaling, and movement settings for the specified port
L n[d]	Logic	Internal SEL-2032 control bit logic for specified port
O n[e]	Communications Card Logic	Control bit logic for specified communications card
R	Sequential Events Recorder	SER point monitor assignments

[a] 1–16 plus 17 or 18 if protocol cards installed
[b] 1–16
[c] 1–16 or F plus 17 or 18 if protocol cards installed
[d] 1–18
[e] 17 or 18 if protocol cards installed

SEL-2032 Message Strings

Special Characters for Use in Strings (Sheet 1 of 2)

Character	Use[a]	Comment
\"	A	Quote character. Use to insert a quote character in a string.
\\	A	Backslash character. Insert a backslash character in a string.
\n	A	New line character (CR/LF combination, just CR on SEL IED ports).
\0xx	A	Insert any 8-bit character. xx = A character value in hex; (e.g., \004 is ASCII EOT character. See *Appendix E: ASCII Reference Table* for ASCII conversion table.)
\<Enter>	A	Use this sequence to continue a string to the next line
\At/	I[b]	Register address. t = specifies the address format: b = binary (2 bytes) a = ASCII-hex (4 digits)
\Csx/	O	Begin checksum calculation x specifies checksum type: c = CRC-16 b = 8-bit checksum w = 16=bit checksum
\CE/	O	Stop checksum calculation
\COyz	O	Output checksum. y specifies format: a = ASCII-hexadecimal b = binary x = binary with XON/XOFF encoding z specifies byte order: h = high byte first l = low byte first
\DA[C][P]*n*/	O	DA = output unsolicited message queue data for Port *n*; C = if included, clear the queue after the read; the data are handled as set of characters. P = only output characters not previously output; mutually exclusive with C parameter.
\Dt/	I[b] or REA-DACK	D = data item. t = specifies the data format: b = binary word (2 bytes) c = binary bytes (1 byte) h = ASCII-hex word (4 digits) g = ASCII-hex byte (2 digits)
\Fp:r[;C[A]]/	O	F = Output formatted region data. p = port number r = the data region ;C = clear archive item after it is read CA = read the entire queue of records from an archive region and clear them as they are read.
\Idstr[:h]/	O	Initiate a phone call using the given dial string. Only applies to modem ports. dstr = a dial string of up to 40 characters. Typically consists of ATDT and phone number. h = hang-up flag. Y to hang up at end of message N to stay on line

Special Characters for Use in Strings (Sheet 2 of 2)

Character	Use[a]	Comment
\M	O	Issue modem escape sequence. Only applies to modem ports.
\Pt/	I[b]	P = Port number t = specifies the port number format: b = binary (1 byte) a = ASCII=hex (2 digits
\Rt;saddr[;*n*]/	O	R = Output register contents t = specifies the data format: b = binary word (2 bytes) c = binary byte (1 byte) d = binary default g = ASCII-hex byte (2 digits) h = ASCII-hex word (4 digits) f = float in ASCII i = integer in ASCII u = unsigned integer in ASCII x = binary byte with XON/XOFF encoding y = binary word with XON/XOFF encoding saddr = register address, using any valid register access method. *n* = specifies how many items to read. Data items are delimited by spaces for all except b, c, and d formats. One (1) is assumed if you do not specify.
\SP/	O	Suppress prompt (on Master port). Do not display new prompt after message contents.
\Td/	O	Time delay; use this code to place a delay within string output; d = time in seconds and may be specified as decimal fraction. Time must be in the range of 0.03–2047
\W;saddr;n,daddr/	O	Unsolicited database write. Applies only to ports where DEVICE=MASTER or SEL, and PROTOCOL=SEL. saddr = Source register starting address, using any valid register access method. The source address range may be any database region other than the Archive regions (A1–A3). n = Specifies how many registers to write. Number of registers must not exceed 115. daddr = Destination SEL-2032 User region address, using any valid User region address (F800h–FFFFh).
\X[X]/	I	X = Ignore character. \X/ indicates ignore one character. \xx/ indicates ignore all characters following until the next defined character is encountered.

[a] Use code: A = All messages; I = Input messages; O = Output messages.
[b] Only usable in special-purpose, user-defined commands.

Predefined Strings for Auto-Messages With Auto-Configured SEL Relays

String	Comment
20METER	Send ASCII or Fast Meter[a] command, as appropriate.
20DEMAND	Send ASCII demand meter or Fast Demand meter command, as appropriate.
20TARGET	Send ASCII target command sequence or Fast Meter[a], as appropriate.
20HISTORY	Send ASCII history command.
20STATUS	Send ASCII status command
20BREAKER	Send ASCII breaker command.
20EVENT	Send ASCII event command. Store in parsed format.
20EVENTS	Send ASCII event command. Store in literal format.
20EVENTL	Send ASCII long event command. Store in literal format.

[a] When the SEL-2032 collects target data from relays that do not have Fast Meter capability, the **TARGET** commands sent by the SEL-2032 may modify the front-panel targets on the relays--just as if you were sending the **TARGET** command to the relay without the SEL-2032.

Predefined Strings for Auto-Messages

String	Comment
20USER	Copy user region data to this region.

Predefined Strings for General-Purpose, User-Defined Commands With SEL IEDs

String	Comment
20EVENT	Recognize summary event reports received from SEL IEDs (delay between triggers).
20EVENTQ	Recognize summary event reports received from SEL IEDs (trigger immediately).
20STATUS	Recognize status messages received from SEL IEDs.
20GROUP	Recognize group switch commands from SEL IEDs.

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SEL-2032 Command Summary

Command	Description
2ACCESS	Use to enter Access Level 2 to change SEL-2032 settings.
ACCESS	Use this command to enter Access Level 1 for interrogate, read-only capability.
AUTO *n*	Displays the results of auto-configuration on selected port.
BROADCAST	Establish direct communications with all IED ports simultaneously. To terminate communications and return to command operation, use the termination sequence set for your port. (**<Ctrl+D>** is the default termination sequence.)
CAL	Enter Access Level C. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CARD	Displays the value of the Control Input and Control Output elements for the protocol card ports (Ports 17 and 18).
CLEAR *m*:*n*	Clears data from the unsolicited message queue or from the archive data regions of an intelligent electronic device (IED) port. Parameter *m* specifies which port (1–16). Parameter *n* may be BUF for the unsolicited message queue or A1, A2, or A3 for the Archive data regions.
CONTROL *m*	Parameter *m* specifies the global elements, R1–R8, you will operate. You are then prompted to enter one of three control operations: **SRB** sets a specified bit; **CRB** clears a specified bit; and **PRB** pulses a specified bit. To pulse, supply a time as a second parameter or a one-second time is the default.
COPY *m n*	Copies port-specific settings (classes P, A, M, U, and L) from Port *m* to Port *n* (*m* and *n* equal any combination of 1–18). Type **COPY *m* ALL <Enter>** if you wish to copy the Port *m* settings to all other ports.
DATE	Displays the date stored by the internal calendar/clock. Use a date parameter to change the date: **DATE *mm*/*dd*/*yy***.
DCF	Enable data collection features on a virtual terminal session.
DEFRAGMENT	Defragment EEPROM.
DNPMAP	Displays map of data available on DNP 3.00 port.
FILE	Performs file transfer operations on the SEL-2032 file system.
HELP	Lists all commands available at the current access level. Use with a command as its parameter and it will provide the syntax and a brief description of the command.
ID	Displays SEL-2032 current ID, as set in the global settings, and the firmware identification string (FID string). See also **WHO** and **STATUS** commands.
IRIG	Directs the SEL-2032 to read IRIG-B time-code input at the IRIG-B port. It updates the internal clock/calendar time and date to the time code.
LD	Causes SEL-2032 to enter SELBOOT mode. This is used when you want to load new code into the SEL-2032.
MAP *m*:*n*	Displays the data structure and format for data stored in a port database. Parameter *m* = port number (1–18). Parameter *n* = data region (GLOBAL, LOCAL, BUF, D1–D8, or A1–A3).
MEMORY	Displays the status of memory usage.
MODMAP *m*:*n t*	Displays the Modbus® 3x register (Input Register) map for the selected port. Parameter *m* is the port number. Parameter *n* specifies the data region to view. Parameter *t* specifies the map type (I for integer map and F for floating point).
PASSWORD	Shows or sets passwords.
PORT *n i*	Establishes transparent communication between the master port issuing the command and the designated port *n*. With Ports 17 and 18, use parameter *i* to specify a network address.
QUIT	Causes the SEL-2032 to return control to Access Level 0 from Level 1 or 2. The command displays the SEL-2032 ID, date, and time of **QUIT** command execution.

Command	Description
SER	Displays the SER data for a selected port with the following options and format: SER *x* [BL] | [*m*] [*n*] | [C | CA | R] Parameter *x* is either a port number or GLOBAL. BL displays the SER labels for the specified port. Parameter *m* is the number of the most recent records to display—default is the last 20. Parameter *n*, if supplied with *m*, defines a range of records to display. C or R clears the SER records for the selected port.[b] CA clears all of the SER records in the SEL-2032. When CA is selected, no port number may be specified.[b]
SET *n*	See SET/SHOW Command Options table.
SHOWSET *n*	See SET/SHOW Command Options table.
STATUS	Shows SEL-2032 self-test status and the configuration, communication, and data performance of each port.
STORE *m*:*n* *d*	Stores data directly into a database. Parameter *m* specifies the port number (Port F is not a valid option); parameter *n* specifies the starting database address; and parameter *d* is a data stream with each item consisting of data as characters, strings, decimal integers, hexadecimal integers, or single-precision floating-point numbers.
SWAP *n m*	Switches all port-specific settings (P, A, M, U, and L settings) between two ports.
TARGET *n m*	Displays global element or port-specific element information. Enter **G** for parameter *n* to display global elements or enter **1–18** to display port-specific elements (the front-panel port has no elements). For parameter *m*, enter the element row number you want displayed or enter **ALL** to show all of the elements.
TIME	Displays or sets time for the internal clock.
TOGGLE *m*	Toggles a specified element bit, *m* (e.g., 4:GRB1).
VIEW *m*:*n*	Shows data stored in a port's database. Parameter *m* specifies which port (1–18). Parameter *n* specifies what data to view: an address range in decimal or hex; a specific region of the database; **GLOBAL**, **LOCAL**, **BUF**, **D1–D8**, or **A1–A3**.
WHO	Shows what is connected to each port.

SET/SHOW Command Options

Option	Setting Type	Description
G	Global	Settings that affect overall SEL-2032 operation
A n[a]	Automatic Messaging	Outgoing messages and response parsing for specified port
U n[b]	User-Defined Messages	Custom commands added to the SEL command set for the specified port
P n[c]	Port Configuration	Communications parameters and protocol selection for the specified port
M n[a]	Math/Data Movement	Data concentration, scaling, and movement settings for the specified port
L n[d]	Logic	Internal SEL-2032 control bit logic for specified port
O n[e]	Communications Card Logic	Control bit logic for specified communications card
R	Sequential Events Recorder	SER point monitor assignments

[a] 1–16 plus 17 or 18 if protocol cards installed
[b] 1–16
[c] 1–16 or F plus 17 or 18 if protocol cards installed
[d] 1–18
[e] 17 or 18 if protocol cards installed

SEL-2032 Message Strings

Special Characters for Use in Strings (Sheet 1 of 2)

Character	**Use**[a]	**Comment**
\"	A	Quote character. Use to insert a quote character in a string.
\\	A	Backslash character. Insert a backslash character in a string.
\n	A	New line character (CR/LF combination, just CR on SEL IED ports).
\0xx	A	Insert any 8-bit character. xx = A character value in hex; (e.g., \004 is ASCII EOT character. See *Appendix E: ASCII Reference Table* for ASCII conversion table.)
\<Enter>	A	Use this sequence to continue a string to the next line
\At/	I[b]	Register address. t = specifies the address format: b = binary (2 bytes) a = ASCII-hex (4 digits)
\Csx/	O	Begin checksum calculation x specifies checksum type: c = CRC-16 b = 8-bit checksum w = 16=bit checksum
\CE/	O	Stop checksum calculation
\COyz	O	Output checksum. y specifies format: a = ASCII-hexadecimal b = binary x = binary with XON/XOFF encoding z specifies byte order: h = high byte first l = low byte first
\DA[C][P]*n*/	O	DA = output unsolicited message queue data for Port *n*; C = if included, clear the queue after the read; the data are handled as set of characters. P = only output characters not previously output; mutually exclusive with C parameter.
\Dt/	I[b] or REA-DACK	D = data item. t = specifies the data format: b = binary word (2 bytes) c = binary bytes (1 byte) h = ASCII-hex word (4 digits) g = ASCII-hex byte (2 digits)
\Fp:r[;C[A]]/	O	F = Output formatted region data. p = port number r = the data region ;C = clear archive item after it is read CA = read the entire queue of records from an archive region and clear them as they are read.
\Idstr[:h]/	O	Initiate a phone call using the given dial string. Only applies to modem ports. dstr = a dial string of up to 40 characters. Typically consists of ATDT and phone number. h = hang-up flag. Y to hang up at end of message N to stay on line

Special Characters for Use in Strings (Sheet 2 of 2)

Character	Use[a]	Comment
\M	O	Issue modem escape sequence. Only applies to modem ports.
\Pt/	I[b]	P = Port number t = specifies the port number format: b = binary (1 byte) a = ASCII=hex (2 digits
\Rt;saddr[;*n*]/	O	R = Output register contents t = specifies the data format: b = binary word (2 bytes) c = binary byte (1 byte) d = binary default g = ASCII-hex byte (2 digits) h = ASCII-hex word (4 digits) f = float in ASCII i = integer in ASCII u = unsigned integer in ASCII x = binary byte with XON/XOFF encoding y = binary word with XON/XOFF encoding saddr = register address, using any valid register access method. *n* = specifies how many items to read. Data items are delimited by spaces for all except b, c, and d formats. One (1) is assumed if you do not specify.
\SP/	O	Suppress prompt (on Master port). Do not display new prompt after message contents.
\Td/	O	Time delay; use this code to place a delay within string output; d = time in seconds and may be specified as decimal fraction. Time must be in the range of 0.03–2047
\W;saddr;n,daddr/	O	Unsolicited database write. Applies only to ports where DEVICE=MASTER or SEL, and PROTOCOL=SEL. saddr = Source register starting address, using any valid register access method. The source address range may be any database region other than the Archive regions (A1–A3). n = Specifies how many registers to write. Number of registers must not exceed 115. daddr = Destination SEL-2032 User region address, using any valid User region address (F800h–FFFFh).
\X[X]/	I	X = Ignore character. \X/ indicates ignore one character. \xx/ indicates ignore all characters following until the next defined character is encountered.

[a] Use code: A = All messages; I = Input messages; O = Output messages.
[b] Only usable in special-purpose, user-defined commands.

Predefined Strings for Auto-Messages With Auto-Configured SEL Relays

String	Comment
20METER	Send ASCII or Fast Meter[a] command, as appropriate.
20DEMAND	Send ASCII demand meter or Fast Demand meter command, as appropriate.
20TARGET	Send ASCII target command sequence or Fast Meter[a], as appropriate.
20HISTORY	Send ASCII history command.
20STATUS	Send ASCII status command
20BREAKER	Send ASCII breaker command.
20EVENT	Send ASCII event command. Store in parsed format.
20EVENTS	Send ASCII event command. Store in literal format.
20EVENTL	Send ASCII long event command. Store in literal format.

[a] When the SEL-2032 collects target data from relays that do not have Fast Meter capability, the **TARGET** commands sent by the SEL-2032 may modify the front-panel targets on the relays--just as if you were sending the **TARGET** command to the relay without the SEL-2032.

Predefined Strings for Auto-Messages

String	Comment
20USER	Copy user region data to this region.

Predefined Strings for General-Purpose, User-Defined Commands With SEL IEDs

String	Comment
20EVENT	Recognize summary event reports received from SEL IEDs (delay between triggers).
20EVENTQ	Recognize summary event reports received from SEL IEDs (trigger immediately).
20STATUS	Recognize status messages received from SEL IEDs.
20GROUP	Recognize group switch commands from SEL IEDs.

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