SEL-2100
Logic Processor

Instruction Manual

20250127

SCHWEITZER ENGINEERING LABORATORIES

CAUTION: The SEL-2100 contains devices sensitive to electrostatic discharge (ESD). When working on the relay with front or top cover removed, work surfaces and personnel must be properly grounded or equipment damage may result.

ATTENTION: Le SEL-2100 contient des pièces sensibles aux décharges électrostatiques (DES). Quand on travaille sur le relais avec le panneau avant ou du dessus enlevé, les surfaces de travail et le personnel doivent être mis à la terre convenablement pour éviter les dommages à l'équipement.

CAUTION: This procedure requires that you handle components sensitive to Electrostatic Discharge (ESD). If your facility is not equipped to work with these components, we recommend that you return the relay to SEL for firmware installation.

ATTENTION: Cette procédure requiert que vous manipuliez des composants sensibles aux décharges électrostatiques (DES). Si vous n'êtes pas équipés pour travailler avec ce type de composants, nous vous recommandons de les retourner à SEL pour leur installation.

CAUTION: Verify proper orientation of any replaced Integrated Circuit(s) (ICs) before reassembling the SEL-2100. Energizing the SEL-2100 with an IC reversed irrecoverably damages the IC. If you mistakenly re-energize the relay with an IC reversed, do not place the SEL-2100 in service using that IC, even if you correct the orientation.

ATTENTION: Vérifier l'orientation d’un circuit intégré (CI) que vous remplacez avant de l’ installer sur le SEL-2100. La mise sous-tension du SEL-2100 avec un CI inversé endommagera de façon irréversible celui-ci. Si vous remettez le relais sous tension par mégarde, ne pas laisser le SEL-2100 en service avec ce CI, même si l'orientation a été corrigée.

CAUTION: Never work on the SEL-2100 with the front or top cover removed, when the SEL-2100 is energized.

ATTENTION: Ne jamais travailler sur le SEL-2100 avec le panneau avant ou du dessus enlevé, quand le SEL-2100 est sous-tension.

WARNING: Do not rely upon pins 5 and 9 for safety grounding, because their current-carrying capacity is less than control power short circuit and protection levels.

AVERTISSEMENT: Ne pas se fier aux broches 5 et 9 pour une mise à la terre sécuritaire: leur limite de support en courant est inférieure au niveau de court-circuit assuré par la protection.

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. Dispose of used batteries according to the manufacturer’s instructions.

ATTENTION: Il y a un danger d’explosion si la pile électrique n’est pas correctement remplacée. Utiliser exclusivement Ray-O-Vac® No. BR2335 ou un équivalent recommandé par le fabricant. Se débarrasser des piles usagées suivant les instructions du fabricant.

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 équipement 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 accès non-autorisé à l'équipement pourrait être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accès non-autorisé.

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PM2100-01

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SECTION 1: INTRODUCTION

INTRODUCTION

The SEL-2100 Logic Processor retrieves remote system information and device status using MIRRORED BITS® communications, combines that information with local contact inputs using SELOGIC® control equations, and issues commands via MIRRORED BITS communications and local outputs. Use the SEL-2100 to implement advanced protection and control schemes like those depicted below.

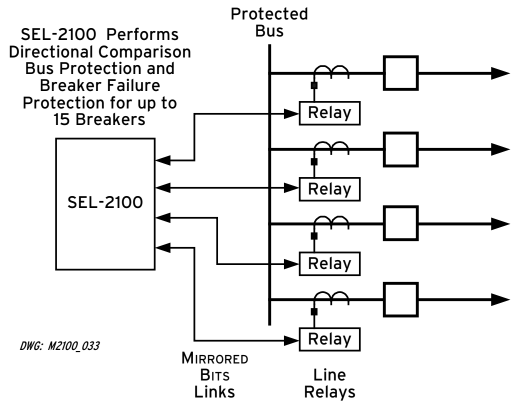

Figure 1.1: Bus and Breaker Failure Protection

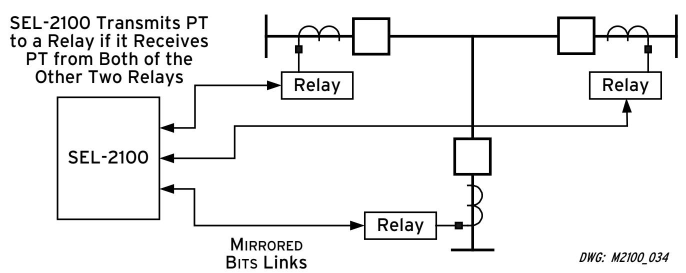

Figure 1.2: Multiterminal Line Protection

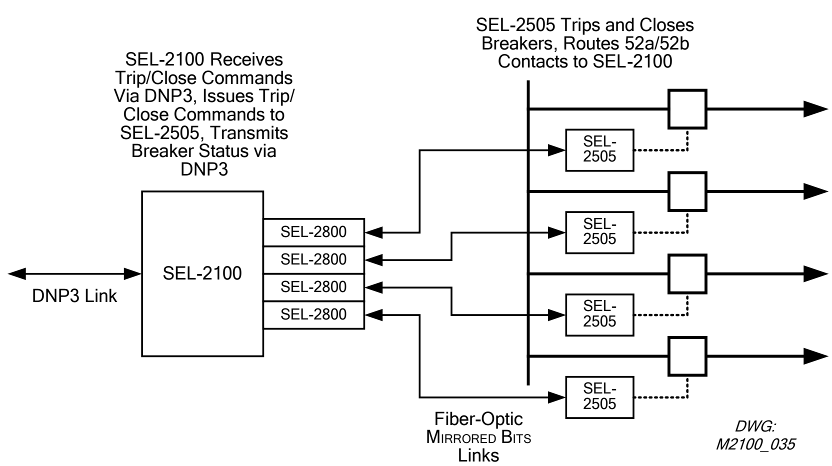

Figure 1.3: Centralized Breaker Control with Fiber-Optic Interface to Circuit Breakers

To implement the solutions mentioned above, the SEL-2100 exchanges information with protective relays and other MIRRORED BITS compatible devices, and makes decisions based on that information.

For example, in Figure 1.1, the SEL-2100 receives the status of directional overcurrent or distance elements from each line relay. The SEL-2100 compares the status of the directional or distance elements to determine if the protected bus is faulted. It then uses MIRRORED BITS to transmit trip commands to each line relay during bus faults.

In Figure 1.2, the SEL-2100 receives permissive trip signals from line relays at all three terminals using MIRRORED BITS. The SEL-2100 transmits a permissive trip signal to a relay if it receives a permissive trip signal from both of the other relays.

The SEL-2100 in Figure 1.3 receives remote trip and close commands via DNP3, and distributes those commands to circuit breakers via SEL-2505 Remote I/O Modules using MIRRORED BITS communications. Each SEL-2505 returns breaker status to the SEL-2100, where it is delivered to the control system via DNP3.

The SEL-2100 is ideal for many other applications. See ***Section 3: Application Examples*** for more applications ideas, and for more information on the applications depicted in Figure 1.1 and Figure 1.2.

MIRRORED BITS Communications

In all the applications mentioned, the SEL-2100 communicates with other devices via MIRRORED BITS communications, and processes information using SELOGIC control equations. MIRRORED BITS devices exchange the status of eight logic points, with the speed, security, and dependability suitable for power system protection, using a simple EIA-232 communications channel. For example, MIRRORED BITS devices typically exchange the status of eight logic points in four milliseconds. If one of the data exchanges is corrupted by noise, signal degradation, or some other problem, the receiving device detects that the data are corrupted with greater than 99.999993% certainty, and discards it. In other words, the receiving device on average detects all but one in more than 16 million disturbances. This exceeds the performance recommended by IEC Standard 834 for teleprotection devices.

MIRRORED BITS uses simple EIA-232 channels. Use almost any communications equipment for MIRRORED BITS communications. MIRRORED BITS is presently in operation on

- Dedicated fiber optics
- Multiplexed fiber optics
- Analog microwave
- Digital microwave
- Multiplexed digital radio
- Spread spectrum radio

as well as many other types of channels.

See ***Section 8: MIRRORED BITS Communications*** for more information about MIRRORED BITS communications.

SELOGIC Control Equations

The logic points exchanged by MIRRORED BITS might represent the status of protective elements, control switches, breaker status, alarm status, or any other piece of information represented as on or off, 1 or 0, yes or no, picked up or dropped out, open or closed, etc. MIRRORED BITS is so flexible because the function of each logic point, or bit, is determined by a SELOGIC control equation. SELOGIC control equations are simple Boolean equations written by the user. For example, the SEL-2100 SELOGIC control equation setting

T4P1 = IN101 + IN102

transmits the logical OR of control inputs IN101 and IN102 as Transmit MIRRORED BIT 4 on Port 1 (T4P1), i.e., T4P1 asserts if either contact input IN101 OR IN102 assert. See ***Section 5: SELOGIC Control Equations and the Relay Word*** for more information about SELOGIC control equations.

Advanced Application Logic

The SEL-2100 supports Advanced Application Logic modules that perform specific functions. You can specify Advanced Application Logic when you order an SEL-2100, or purchase this logic as a firmware upgrade.

When installed, an application logic module consumes a portion of available SELOGIC control equation elements and edges. To preserve the maximum amount of programming capability, SEL recommends ordering or specifying an application logic module only when the function is required for a specific application, not for general-purpose use.

Appendix K contains instructions for loading and unloading Advanced Application Logic modules. Descriptions of the available application logic modules will be added in separate appendices when SEL releases new modules.

Other Features

The SEL-2100 also contains a Sequential Events Records with over 32,000 records stored in non-volatile memory. The Sequential Events Recorder (SER) clock synchronizes to an optional external modulated or demodulated IRIG-B time code source. See ***Section 7: Sequential Events Recorder*** for more information about the SER.

The user configures and controls the SEL-2100 by entering commands through use of a terminal or terminal emulator. To enter those commands, connect a serial communications cable to the SEL-2100 front serial port, configure the terminal or terminal emulation software, and obtain security access by entering the proper password. The following initial checkout procedure describes these steps in more detail. After the initial checkout procedure, the user is encouraged to explore the commands and settings of the SEL-2100.

INITIAL CHECKOUT PROCEDURE

Perform the following steps to verify that the SEL-2100 is operational:

Step 1. Apply power to the SEL-2100. (The power and safety ground connections are clearly labeled on the rear panel.)

Step 2. Press and hold the LED TEST button and confirm that all LEDs illuminate.

Step 3. Connect a terminal (or computer equipped with terminal emulation software) to the front-panel connector Port F of the SEL-2100 through an SEL-C234A cable.

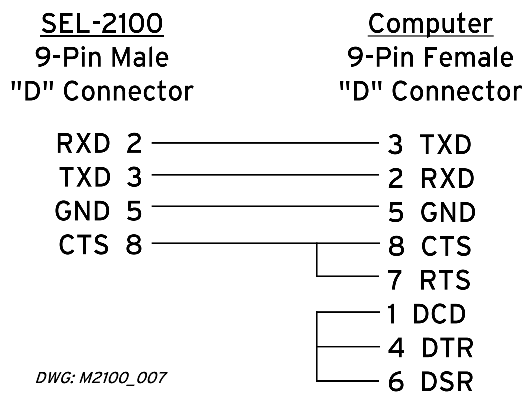

Figure 1.4: SEL-C234A Cable Diagram

Step 4. Set the computer terminal or emulation software to operate at:

Bits per Second	2400
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

Step 5. Press **<Enter>** and verify that a " = " prompt is returned.

Step 6. Type **ACC <Enter>** to enter Access Level 1. The SEL-2100 is shipped with the factory-default passwords shown in the table under ***PAS Command*** in ***Section 4: Serial Port Communications and Commands***. Enter the factory-set password at the password prompt.

```
=ACC <Enter>
Password: ? ***** <Enter>

SEL-2100                          Date: 02/21/2005    Time: 08:10:47.032
STATION A
Level 1

=>
```

Step 7. Type **STA <Enter>** and verify that a status report similar to the one below appears on your terminal. Confirm that IRIG-B input and I/O board configurations are as expected. The status and communications statistics are shown for the 16 rear-panel ports and the front-panel port. Refer to the **STATUS** command explanation in ***Section 4: Serial Port Communications and Commands*** for more detailed information.

```
=>STA <Enter>

SEL-2100                        Date: 02/21/2005    Time: 08:15:10.718
STATION A

FID=SEL-2100-RXXX-V0-ZXXXXXX-DXXXXXXXX       CID=XXXX

SELF TESTS

RAM       ROM       CR_RAM    EEPROM    +15V_PS   -15V_PS
OK        OK        OK        OK        OK        OK

IRIG-B Input: ABSENT
I/O Board: OK
Processing Interval: 4 ms

Port   Port Type        Status
1      SEL-ASCII        NA
2      SEL-ASCII        NA
3      SEL-ASCII        NA
4      SEL-ASCII        NA
5      SEL-ASCII        NA
6      SEL-ASCII        NA
7      SEL-ASCII        NA
8      SEL-ASCII        NA
9      SEL-ASCII        NA
10     SEL-ASCII        NA
11     SEL-ASCII        NA
12     SEL-ASCII        NA
13     SEL-ASCII        NA
14     SEL-ASCII        NA
15     SEL-ASCII        NA
16     SEL-ASCII        NA
F      SEL-ASCII        NA

SEL-2100 Enabled

=>
```

If you wish to test every serial port, repeat steps 6 and 7 on rear Ports 1 through 16.

Continued Exploration

Continue to explore several of the more commonly used commands and settings. For more information about these and other commands, see ***Section 4: Serial Port Communications and Commands***.

In the next few steps, you will learn how to display and change settings for a serial port, set a serial port for MIRRORED BITS protocol, verify that the MIRRORED BITS ports are properly exchanging data, program a Transmit MIRRORED BIT, use a Receive MIRRORED BIT to trigger an SER entry, and control (set or clear) a Remote Bit.

Serial Port Settings

The SEL-2100 settings are divided into several sections. Serial port settings configure each of the 17 serial ports. Type **SHOW P F <Enter>** to display the settings for Port F (the front serial port on the SEL-2100).

```
=>SHOW P F <Enter>
Port F

PROTO = SEL
SPEED = 2400     PARITY= N
T_OUT = 15       TLINES= 20       AUTO  = N
RTSCTS= N        FASTOP= N

=>
```

Port F is presently set for SEL protocol at 2400 bps with no parity check. The port connection will disconnect automatically after 15 minutes without activity. When displaying long reports, the SEL-2100 will pause every 20 lines. Automatic messages (status reports, etc.) are not sent to this port. These and other serial port settings are discussed in ***Appendix H: Settings Sheets***.

The **SHOW** command, and all other SEL-2100 commands, may be shortened to the first three letters of the command. In fact, the commands used earlier in the initial checkout procedure, **ACC** and **STA**, are the first three letters of the **ACCESS** and **STATUS** commands. The SEL-2100 only checks the first three letters of each command. The **SHOW** command above may be shortened to **SHO P F <Enter>**.

Attempt to change the settings of Port F by typing **SET P F <Enter>**.

```
=>SET P F <Enter>
Invalid Access Level
=>
```

Notice that the SEL-2100 indicates the **SET** command requires access to a more secure level. The prompt ("=", or "=>", or "=>>") indicates the present security Access Level (0, 1, or 2, respectively). Notice that the present prompt is "=>" which is the Access Level 1 prompt. At Access Level 1, the user can primarily view settings, reports, etc. The user is not allowed to change settings, control outputs, etc. That is why the relay responded "Invalid Access Level" above.

To gain access to security Access Level 2, use the **2ACCESS** command, abbreviated to 2AC. Type **2AC <Enter>**. The relay responds by prompting for the level 2 password. The factory-default level 2 password is shown in the table under ***PAS Command*** in ***Section 4: Serial Port Communications and Commands***.

```
=>2AC <Enter>
Password: ? **** <Enter>

SEL-2100                          Date: XX/XX/XXXX    Time: 09:33:27.989
STATION A


Level 2
=>>
```

The following commands change the baud rate of the front serial port on the SEL-2100. Make sure you know how to change the baud rate on your terminal emulation software before continuing. To exit the settings process at any time and abandon any settings changes, type **<Ctrl+X>**.

The relay asserts the ALARM Relay Word bit for one second after a successful Access Level 2 or Access Level C access. If access is denied, the ALARM Relay Word bit asserts for one second.

Enter the command **SET P F <Enter>**. Because the present access level is 2, the SEL-2100 responds by prompting for new Port F settings.

```
=>>SET P F <Enter>
Port F
Protocol(SEL,LMD)                         PROTO = SEL       ?
```

The first setting choice is the serial port protocol, PROTO. The choices are shown in parenthesis. The present PROTO setting is SEL. The front-panel serial port only allows protocols SEL and LMD. The other serial ports allow other protocols. The SEL protocol allows configuration and control of the SEL-2100. The SEL protocol allows commands such as **ACC**, **2AC**, **SET**, **SHO**, etc. See ***Section 4: Serial Port Communications and Commands*** for more information on the SEL protocol.

Press **<Enter>** to accept the present setting and move on to the next setting.

```
=>>SET P F <Enter>
Port F
Protocol(SEL,LMD)                                  PROTO = SEL       ? <Enter>
Baud Rate(300-9600)                                SPEED = 2400      ?
```

The next setting controls the serial port baud rate. Change the baud rate setting SPEED to 9600. The front serial port supports a maximum baud rate of 9600. The other serial ports allow baud rates as fast as 38,400. The new speed setting will not take effect until all serial port settings are entered and the SEL-2100 has saved the new settings.

```
=>>SET P F <Enter>
Port F
Protocol(SEL,LMD)                                  PROTO = SEL       ? <Enter>
Baud Rate(300-9600)                                SPEED = 2400      ? 9600 <Enter>
Parity(O,E,N)                                      PARITY= N         ?
```

There are other serial port settings available. See the settings sheets in ***Appendix H: Settings Sheets*** for all the possible serial port settings. We do not change any of the other settings for Port F at this time. To get to the end of the settings, you could press **<Enter>** at each setting prompt, until all serial ports settings have been displayed. Alternatively, type **END <Enter>**, which terminates the settings process.

```
=>>SET P F <Enter>
Port F
Protocol(SEL,LMD)                                  PROTO = SEL      ? <Enter>
Baud Rate(300-9600)                                SPEED = 2400     ? 9600 <Enter>
Parity(O,E,N)                                      PARITY= N        ? END <Enter>

PROTO = SEL
SPEED = 9600     PARITY= N
T_OUT = 15       TLINES= 20       AUTO  = N
RTSCTS= N        FASTOP= N

Save Changes(Y/N)?
```

After the settings process is complete, the SEL-2100 displays the settings that it is about to save, and asks if they should be saved or abandoned. After reviewing the settings for accuracy, answer **Y <Enter>** to save the settings, or **N <Enter>** to abandon the settings.

```
=>>SET P F <Enter>
Port F
Protocol(SEL,LMD)                                  PROTO = SEL      ? <Enter>
Baud Rate(300-9600)                                SPEED = 2400     ? 9600 <Enter>
Parity(O,E,N)                                      PARITY= N        ? END <Enter>

PROTO = SEL
SPEED = 9600     PARITY= N
T_OUT = 15       TLINES= 20       AUTO  = N
RTSCTS= N        FASTOP= N

Save Changes(Y/N)? Y <Enter>
Settings saved
```

The SEL-2100 has now changed the baud rate setting on the active port. The terminal or terminal emulation package is still set for the old baud rate, so the terminal or emulator cannot communicate with the SEL-2100. Change the baud rate on the terminal or terminal emulation software to 9600 baud. If you are using HyperTerminal, remember to click the disconnect and then connect button so the new baud rate setting can take effect.

Press **<Enter>** to test the new baud rate settings. The SEL-2100 should respond with the Access Level 2 prompt "=>>". If it does not, ensure the terminal emulation settings are correct, especially the baud rate setting.

Type **SHO P <Enter>** to display the new serial port settings. Notice that when the port specifier F, or some other port specifier 1 through 16 is not supplied to the **SHO P** command, the SEL-2100 displays settings for the presently active port, or Port F in this case. The same rule applies to the **SET P** command.

```
=>>SHO P <Enter>
Port F

PROTO = SEL
SPEED = 9600     PARITY= N
T_OUT = 15       TLINES= 20       AUTO  = N
RTSCTS= N        FASTOP= N

=>>
```

MIRRORED BITS Settings

The next few steps establish a MIRRORED BITS link between Port 1 and Port 2 on the SEL-2100. Normally, a MIRRORED BITS port is established between two different devices (e.g., an SEL-2100 and an SEL-311C Relay). For the purposes of this tutorial, and often when designing and testing actual protection and control schemes, it is convenient to use the SEL-2100 to emulate the remote MIRRORED BITS device.

Set Port 1 to MIRRORED BITS protocol at 38,400 baud with the other settings default using the **SET P 1** command. For more information about MIRRORED BITS settings, see ***Section 8: MIRRORED BITS Communications***.

```
=>>SET P 1 <Enter>
Port 1
Protocol(SEL,LMD,DNP,MB,MB8)                       PROTO = SEL       ? MB <Enter>
MBT9600(Y,N)                                       MBT   = N         ? <Enter>
Baud Rate(300-38400)                               SPEED = 2400      ? 38400 <Enter>
Seconds to Mirrored Bits Rx Bad Pickup(1-10000)    RBADPU= 60        ? END <Enter>

PROTO = MB
MBT   = N        SPEED = 38400    RBADPU= 60       CBADPU= 1000
RXID  = 1        TXID  = 2        RXDFLT=XXXXXXXX
R1PU  = 1        R1DO  = 1        R2PU  = 1        R2DO  = 1
R3PU  = 1        R3DO  = 1        R4PU  = 1        R4DO  = 1
R5PU  = 1        R5DO  = 1        R6PU  = 1        R6DO  = 1
R7PU  = 1        R7DO  = 1        R8PU  = 1        R8DO  = 1

Save Changes(Y/N)? Y <Enter>
Settings saved
=>>
```

Port 1 is now set for MIRRORED BITS protocol, and the green transmit LED for Port 1 on the SEL-2100 front panel should be illuminated, because Port 1 is now transmitting MIRRORED BITS data. Set Port 2 for MIRRORED BITS at 38,400 baud also, but reverse the RXID and TXID settings.

```
=>>SET P 2 <Enter>
Port 2
Protocol(SEL,LMD,DNP,MB,MB8)                         PROTO = SEL      ? MB <Enter>
MBT9600(Y,N)                                         MBT   = N        ? <Enter>
Baud Rate(300-38400)                                 SPEED = 2400     ? 38400 <Enter>
Seconds to Mirrored Bits Rx Bad Pickup(1-10000)      RBADPU= 60       ? <Enter>
PPM Mirrored Bits Channel Bad Pickup(1-30000)        CBADPU= 1000     ? <Enter>
Mirrored Bits Receive Identifier(1-4)                RXID  = 1        ? 2 <Enter>
Mirrored Bits Transmit Identifier(1-4)               TXID  = 2        ? 1 <Enter>
Mirrored Bits Receive Default State(string of 1s, 0s or Xs)
       87654321
RXDFLT=XXXXXXXX
     ? END <Enter>

PROTO = MB
MBT   = N        SPEED = 38400    RBADPU= 60       CBADPU= 1000
RXID  = 2        TXID  = 1        RXDFLT=XXXXXXXX
R1PU  = 1        R1DO  = 1        R2PU  = 1        R2DO  = 1
R3PU  = 1        R3DO  = 1        R4PU  = 1        R4DO  = 1
R5PU  = 1        R5DO  = 1        R6PU  = 1        R6DO  = 1
R7PU  = 1        R7DO  = 1        R8PU  = 1        R8DO  = 1

Save Changes(Y/N)? Y <Enter>
Settings saved
=>>
```

Connect Port 1 to Port 2 with SEL cable SEL-C273A or SEL-C272A or using SEL-2800 fiber-optic modems. The green and red transmit and receive LEDs for both Port 1 and Port 2 should now be illuminated because both ports are transmitting and receiving MIRRORED BITS data continuously. Type **TAR ROK1 <Enter>** to view the Receive OK bit for Port 1. The Receive OK bit for Port 2 through Port 8 are also displayed.

```
=>>TAR ROK1 <Enter>

ROK8   ROK7   ROK6   ROK5   ROK4   ROK3   ROK2   ROK1
0      0      0      0      0      0      1      1

=>>
```

The “1” below ROK1 and ROK2 indicates that those ports are receiving valid MIRRORED BITS data. The **TAR** command allows the user to view the contents of the Relay Word, a collection of about 500 logic points or bits stored in the SEL-2100. See ***Section 5: SELOGIC Control Equations and the Relay Word*** for more information about the Relay Word.

SELOGIC Control Equations Settings

Next, program Transmit MIRRORED BIT 5 on Port 1 to assert when Remote Bit 1 asserts. This gives a convenient way to assert the Transmit MIRRORED BIT by asserting the Remote Bit. Use the **SET L T5P1 TERSE** command to program the Transmit MIRRORED BIT. The **TERSE** option tells the SEL-2100 not to display all the settings at the end of the settings process.

```
=>>SET L T5P1 TERSE <Enter>
SELogic group 1

Mirrored Bits Transmit Equations For Port 1:

T5P1  =0

     ? RB1 <Enter>
T6P1  =0

     ? END <Enter>
Save Changes(Y/N)? Y <Enter>

330 Elements and 100 Edges remain available.

Settings saved
=>>
```

SET L tells the SEL-2100 to change settings for the SELOGIC control equations. **SET L T5P1** tells the SEL-2100 to start the settings change process with setting T5P1. See ***Section 4: Serial Port Communications and Commands*** for more information about the **SET L** command.

Sequential Events Recorder and Remote Bit Operation

Transmit MIRRORED BIT 5 on Port 1 (T5P1) now asserts when Remote Bit RB1 asserts. Since Port 1 is exchanging MIRRORED BITS information with Port 2, bits transmitted by Port 1 are received by Port 2, and vice versa. When T5P1 asserts, Receive MIRRORED BIT 5 on Port 2 (R5P2) also asserts. Use the **SET R** command to set the SER to trigger a new entry when T5P1, R5P2, and RB1 change state. See ***Section 7: Sequential Events Recorder*** for more information regarding SER trigger settings.

```
=>>SET R <Enter>


Sequential Events Recorder trigger lists:
24 elements max.(enter NA to null)
SER1  =0
     ? T5P1 R5P2 RB1 <Enter>
24 elements max.(enter NA to null)
SER2  =0
     ? END <Enter>
Sequential Events Recorder trigger lists:
SER1  =T5P1 R5P2 RB1
SER2  =0
SER3  =0
SER4  =0

SER5  =0
SER6  =0

Save Changes(Y/N)? Y <Enter>
Settings saved
=>>
```

Clear the SER report with the **SER C** command. If this is the first time the SER has been used on the SEL-2100, skip this step.

```
=>>SER C <Enter>
Clear the SER
Are you sure (Y/N) ? Y <Enter>
Clearing Complete

=>>
```

Assert, deassert, then pulse Remote Bit RB1 using the **CON** command. See ***Section 7: Sequential Events Recorder*** for more information about Remote Bits.

```
=>>CON 1 <Enter>
CONTROL RB1: SRB 1 <Enter>
=>>CON 1 <Enter>
CONTROL RB1: CRB 1 <Enter>
=>>CON 1 <Enter>
CONTROL RB1: PRB 1 <Enter>
=>>
```

When RB1 asserts, T5P1 asserts. Because Port 1 and Port 2 are exchanging MIRRORED BITS data, when T5P1 asserts, R5P2 asserts. Both T5P1 and R5P2 trigger new SER entries, so we can use the SER report to calculate how long it takes to transmit and receive a MIRRORED BIT. View the SER report with the **SER** command.

```
=>>SER <Enter>

SEL-2100                           Date: 01/16/2000    Time: 10:04:43.276
STATION A

FID=SEL-2100-X108-V0-Z001001-D19991210       CID=A8B4

#      DATE        TIME           ELEMENT         STATE

   12  01/16/2000  10:02:27.787   RB1             Asserted
   11  01/16/2000  10:02:27.787   T5P1            Asserted
   10  01/16/2000  10:02:27.795   R5P2            Asserted
    9  01/16/2000  10:02:33.239   RB1             Deasserted
    8  01/16/2000  10:02:33.239   T5P1            Deasserted
    7  01/16/2000  10:02:33.247   R5P2            Deasserted
    6  01/16/2000  10:02:36.399   RB1             Asserted
    5  01/16/2000  10:02:36.399   T5P1            Asserted
    4  01/16/2000  10:02:36.403   RB1             Deasserted
    3  01/16/2000  10:02:36.403   T5P1            Deasserted
    2  01/16/2000  10:02:36.407   R5P2            Asserted
    1  01/16/2000  10:02:36.411   R5P2            Deasserted

=>>
```

The SER report shows that RB1 asserted and deasserted twice. RB1 asserted when you set RB1 with the **SRB 1** command above. RB1 deasserted when you cleared RB1 with the CRB 1 command. RB1 asserted, then deasserted, when you pulsed RB1 with the **PRB 1** command.

Notice that each time RB1 changed state, T5P1 simultaneously changed state because of the SELOGIC control equation T5P1 = RB1. Eight milliseconds after T5P1 changes state, R5P2 also changes state. In that eight milliseconds, the SEL-2100 constructed a MIRRORED BITS message and transmitted it on Port 1, received a MIRRORED BITS message on Port 2, decoded the message and checked it for errors, and copied the received data to Relay Word Bits R1P2 through R8P2.

HARDWARE OVERVIEW

The SEL-2100 Logic Processor has 16 rear-mounted, nine-pin, EIA-232 ports configured for SEL-ASCII, DNP, or MIRRORED BITS communications. An optional input/output module adds as many as 16 control inputs and 4 contact outputs. Connect the SEL-2505 Remote I/O Module to any SEL-2100 MIRRORED BITS port to add eight more contact inputs and outputs.

FUNCTIONAL OVERVIEW

Figure 1.5 shows a functional block diagram of the SEL-2100.

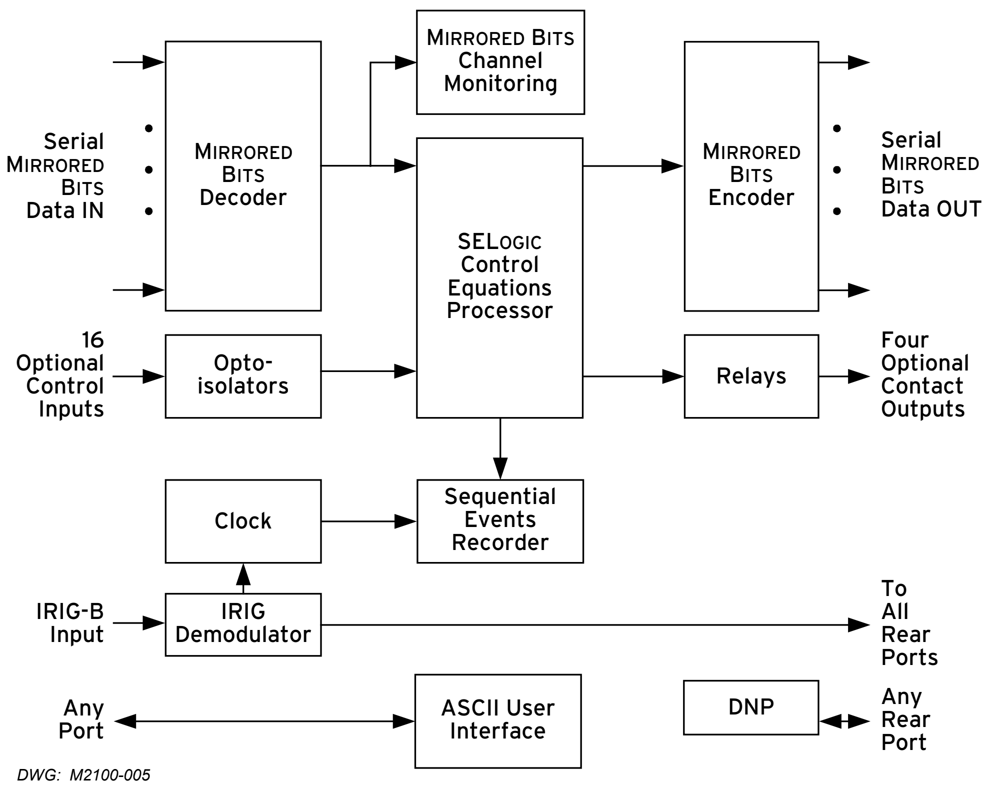

Figure 1.5: SEL-2100 Functional Block Diagram

The SEL-2100 receives and transmits MIRRORED BITS data on as many as 15 of the 16 rear-panel EIA-232 ports. MIRRORED BITS communications exchanges eight bits of information between devices at minimal expense and provides speed and security suitable for protection.

The SEL-2100 decodes received MIRRORED BITS data and checks for errors in the received data. The decoded MIRRORED BITs data are passed to the SELOGIC control equations processor, which combines those data with optional optoisolated contact inputs using user-defined Boolean equations. The outputs of the Boolean equations set the value of Transmit MIRRORED BITS and control optional contact outputs.

The MIRRORED BITS encoder creates an information packet from eight Transmit MIRRORED BITS per port, and transmits the encoded data out the MIRRORED BITS ports.

The SEL-2100 monitors each MIRRORED BITS channel. Each time the MIRRORED BITS decoder detects an error the channel monitor generates a new record. The channel monitor summarizes all disturbances in a report, and creates instantaneous and filtered alarm points for short-term and long-term channel problems. Use the channel monitor to detect when a fiber or cable is cut, disconnected, or degraded, or even when a remote device is unreliable.

An SER tracks changes in as many as 144 user-selected Relay Word bits inside the SEL-2100. The SER can record every time a breaker or switch opens or closes via contact input or Receive MIRRORED BIT, each time the SEL-2100 issues a trip command via contact output or Transmit MIRRORED BIT, every time a relay is taken out of service, etc.

The SEL-2100 receives an IRIG-B time code, which synchronizes time stamps in SER reports. The SEL-2100 also distributes the received time code to any device connected to a rear-panel serial port.

The front-panel EIA-232 serial port allows a local or remote user to change settings, view the SER report or MIRRORED BITS channel monitor report.

Connect the SEL-2100 to your existing SCADA system using DNP3 Level 2. The SEL-2100 supports DNP on any rear-panel serial port. Use DNP to select any of the six settings groups, get change-of-state information via the SER, read any Relay Word bit, or control the 64 remote control bits.

Table 1.1 summarizes the capabilities of each of the 17 EIA-232 ports.

Table 1.1: Protocol Settings

	SEL ASCII and LMD	**DNP***	**MIRRORED BITS**
Front Port	≤ 9600 baud†	No	No
Rear Port 16	Yes	Yes	No
Rear Ports 1–15	Yes	Yes	Yes

* DNP available on one port at a time.

† When more than two rear ports are used for MIRRORED BITS, it may be necessary to reduce the front-panel baud rate to 4800, 2400, or 1200 baud.

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SECTION 2: INSTALLATION

INTRODUCTION

Design your installation using the mounting and connection information in this section. Options include rack or panel mounting with terminal block wiring. This section also includes information on configuring the relay for your application.

MOUNTING

Rack Mount

We offer the SEL-2100 in a rack-mount version that bolts easily into a standard 19-inch rack. See Figure 2.1. From the front of the relay, insert four rack screws (two on each side) through the holes on the relay mounting flanges.

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

Panel Mount

We also offer the SEL-2100 in a panel-mount version for a clean look. Panel-mount relays have sculpted front-panel molding that covers all installation holes (see Figure 2.1). Cut your panel and drill mounting holes according to the dimensions in Figure 2.1. Insert the relay into the cutout, aligning four relay mounting studs on the rear of the relay front panel with the drilled holes in your panel, and use nuts to secure the relay to your panel.

The projection panel-mount option covers all installation holes and maintains the sculpted look of the panel-mount option; the relay projects 2.75 inches (69.9 mm) from the front of your panel. This ordering option increases space at the rear of the relay for applications where the relay would ordinarily be too deep to fit your cabinet.

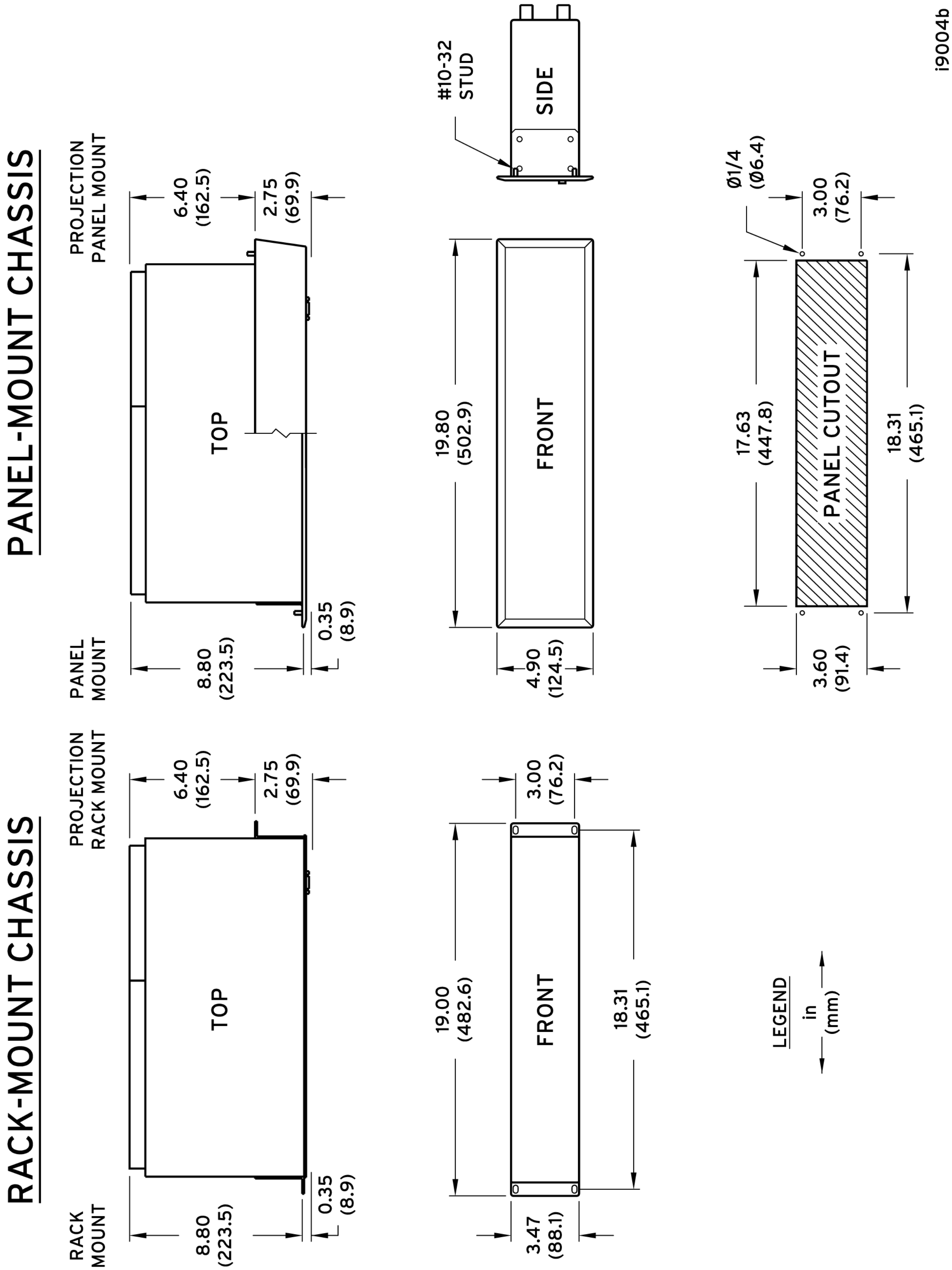


Figure 2.1: SEL-2100 Dimensions and Panel-Mount Cutout

Frame Ground Connection

Connect the grounding terminal “Z05” labeled “GND” on the rear panel of the SEL-2100 to a proper station ground. This connection is vital for safety and performance.

Power Connections

Connect the terminals labeled “PWR” on the rear panel to a power source that matches the power supply characteristics specified on the rear panel of your SEL-2100. Connect the source with the proper polarity as indicated by the “+” label on Terminal Z03 and the “–” label on Terminal Z04. The SEL-2100 consumes about 12 watts and the internal power supply has a wide input voltage range. See ***Appendix G: Specifications*** for more information.

Alarm Contact Connection

The SEL-2100 includes an Alarm contact connected to rear-panel terminals Z01 and Z02 labeled “ALARM”. 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 power is removed from the SEL-2100. See ***Jumper Settings*** later in this section for instructions to change the Alarm contact to a form A contact.

IRIG-B Input Connection

Connect either a modulated or demodulated IRIG-B time-code signal to the rear-panel BNC connector labeled “MODULATED/DEMODULATED IRIG-B IN”. At the factory, the IRIG-B input is configured for a demodulated signal. See ***Jumper Settings*** later in this section for instructions to configure the SEL-2100 for modulated IRIG-B input.

IRIG-B Output Connection

When a modulated or demodulated IRIG-B time-code signal is connected to the IRIG input, the SEL-2100 distributes demodulated IRIB-B time-code through Pin 4 of all rear-panel serial ports. Unlike the SEL-2020, the SEL-2100 cannot generate an IRIG signal unless an IRIG signal is connected to the IRIG input.

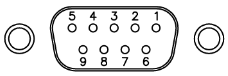
Communication Circuit Connections

The SEL-2100 is equipped with sixteen rear-panel serial communications ports, labeled “PORT 1” through “PORT 16”, and one front-panel serial communications port, labeled “PORT F”. The data connection for each SEL-2100 serial communications port uses EIA-232 standard signal levels in a nine-pin, subminiature "D" connector, or DB-9 (see Figure 2.2 and Table 2.1). The communication circuits are protected internally by surge suppression networks.

Keep the communication cables as short as possible to minimize communication circuit interference, and also to minimize hazardous ground potential differences that can develop during abnormal power system conditions.

Connect EIA-232 cables as far as 50 feet (15 meters). For longer connections, use the SEL-2800, SEL-2810, or SEL-2815 Fiber-Optic Modems. These modems connect directly to the SEL-2100 and SEL relay communications ports and are powered by the ports.

Table 4.7 lists standard SEL communication cables available for use with the SEL-2100. Please call the SEL factory or local field office with questions about cables and cable connections.



(Female chassis connector, viewed from outside panel.)

Figure 2.2: Nine-Pin Connector

Table 2.1: Serial Port Connector Pin Definitions

Pin	Ports 1–16	Port F
1	+5 Vdc*	N/C
2	RXD	RXD
3	TXD	TXD
4	+IRIG-B	N/C
5,9	GND	GND
6	GND (-IRIG-B)**	N/C
7	RTS	RTS
8	CTS	CTS

* When internal jumper is installed.

** Pin 6 is grounded internally to the SEL-2100 and is used as the reference for the +IRIG-B signal on pin 4.

WARNING

Do not rely upon pins 5 and 9 for safety grounding, because their current-carrying capacity is less than control power short circuit and protection levels.

Jumper Settings

Jumpers on the main processor circuit board configure the SEL-2100 for modulated or demodulated IRIG-B input, form A or form B Alarm contact output, and passwords enabled or disabled. Circuit board jumpers also connect +5 V to Pin 1 on all the rear-panel serial ports. Use this connection to power external devices, such as the Pulsar MBT9600 MIRRORED BITS® Modem.

Jumpers on the optional I/O circuit board configure the contact outputs as form A or form B.

Verify the circuit board jumpers are set as required before placing the SEL-2100 in service. At the factory, the circuit board jumpers are configured as follows:

- Demodulated IRIG-B time-code input
- Form B Alarm contact output
- +5 V <u>not</u> connected to Pin 1 of the rear-panel serial ports
- Password protection enabled
- Form A optional contact outputs

Follow the instructions below to change circuit board jumpers on the main processor circuit board and on the optional I/O circuit board.

Step 1: Open the SEL-2100

1. De-energize the SEL-2100.

⚠ CAUTION	Never work on the SEL-2100 with the front or top cover removed, when the SEL-2100 is energized.

2. Remove the screws attaching the front panel and top cover and remove the front panel and top cover.

⚠ CAUTION	The SEL-2100 contains devices sensitive to electrostatic discharge (ESD). When working on the relay with front or top cover removed, work surfaces and personnel must be properly grounded or equipment damage may result.

3. If the optional I/O board is installed, disconnect any cables joining the I/O board to the main board.
4. Remove the I/O board temporarily by sliding it forward and out.

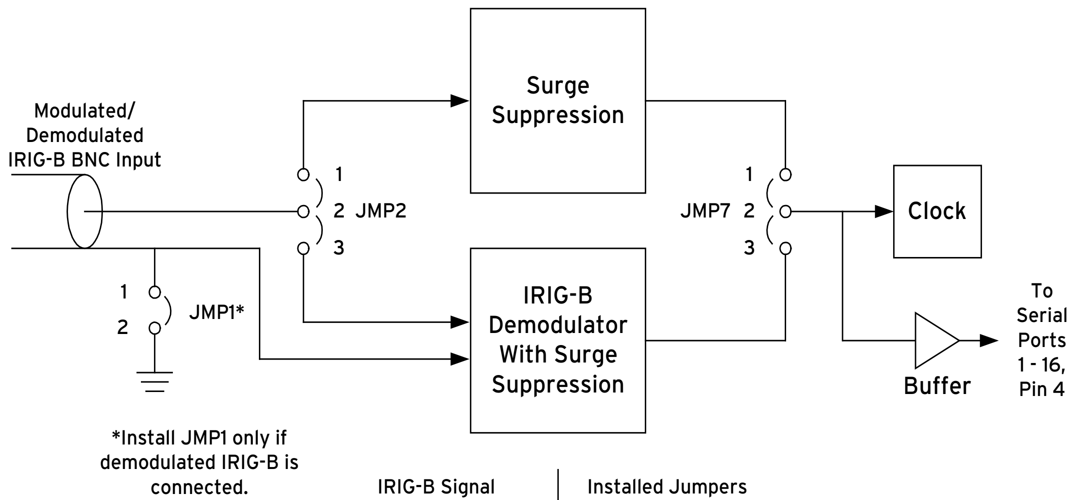
Step 2: Set the Circuit Board Jumpers

Password Jumper

Install jumper JMP9B on the main processor circuit board to disable password protection for user interface Access Level 1 and Access Level 2. Remove jumper JMP9B to enable password protection for those access levels. See Figure 2.5 for the exact location of JMP9 on the main processor circuit board.

IRIG Jumpers

Jumpers JMP1, JMP2, and JMP7 configure the main processor circuit board to receive modulated or demodulated IRIG-B time-code input. Set the jumpers as indicated in Figure 2.3 for either modulated or demodulated IRIG-B time-code input. See Figure 2.5 for exact jumper locations on the main processor circuit board.



IRIG-B Signal	Installed Jumpers
Demodulated (Factory Default)	JMP2, Pins 1, 2 JMP7, Pins 1, 2 JMP1, Pins 1, 2
Modulated	JMP2, Pins 2, 3 JMP7, Pins 2, 3

DWG: M2100_037

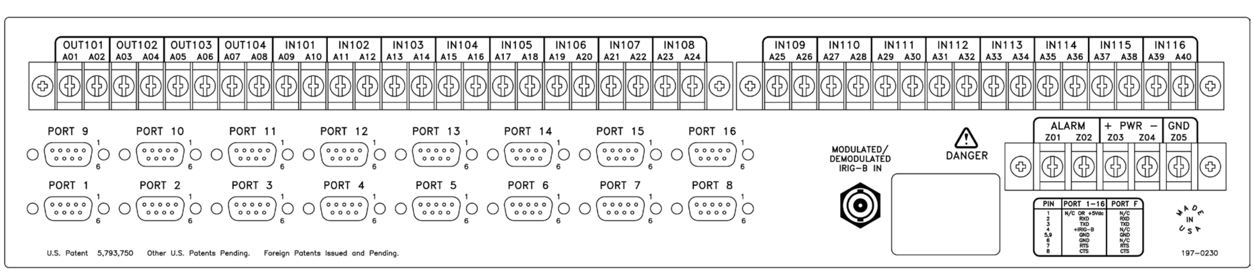
Figure 2.3: Main Board IRIG Jumpers

Alarm Contact Jumper

JMP8 on the main processor circuit board selects the form of the Alarm contact. See Figure 2.5 for the exact location of JMP8. JMP8 is soldered into the main processor circuit board. To change the form B Alarm contact to form A, desolder the jumper wire and solder it between the A terminal and the common terminal of JMP8.

Serial Port +5 V Power Jumpers

JMP3, JMP4, JMP5, and JMP6 connect +5 V power to Pin 1 on each of the rear-panel serial ports. Use this connection to power external devices such as the Pulsar MBT9600 MIRRORED BITS Modem. See Figure 2.5 for the exact location of these jumpers. See Table 2.2 for jumper assignment. The current drawn from all the serial port power connections must not exceed 0.5 amperes, so a maximum of four MBT9600 modems can be attached.



i3100a

Figure 2.4: SEL-2100 Rear Panel–with Optional I/O Board

Table 2.2: +5 V Power Jumpers for Rear-Panel Serial Ports

Serial Port	+5 V Jumper
Port 1	JMP6, Position A
Port 2	JMP6, Position C
Port 3	JMP5, Position A
Port 4	JMP5, Position C
Port 5	JMP4, Position A
Port 6	JMP4, Position C
Port 7	JMP3, Position B
Port 8	JMP3, Position C
Port 9	JMP6, Position B
Port 10	JMP6, Position D
Port 11	JMP5, Position B
Port 12	JMP5, Position D
Port 13	JMP4, Position B
Port 14	JMP4, Position D
Port 15	JMP3, Position A
Port 16	JMP3, Position D

Optional Contact Output Jumpers

JMP33, JMP34, JMP35, and JMP36 on the optional I/O circuit board configure each of the four contact outputs as either form A or form B. See Figure 2.6 for the exact location of those jumpers. Those jumpers are soldered into the circuit board. To change any form A contact output to form B, desolder the jumper wire from the circuit board and solder it between the B terminal and the common terminal.

Step 3: Reassemble the SEL-2100

After configuring jumpers, reassemble the SEL-2100 as follows:

1. If you removed an optional I/O board, replace it.
2. Reconnect any cables that were disconnected between the I/O board and the main board.
3. Replace the top cover and top-cover screws and tighten them securely.
4. Replace the front panel and front-panel screws and tighten them securely.

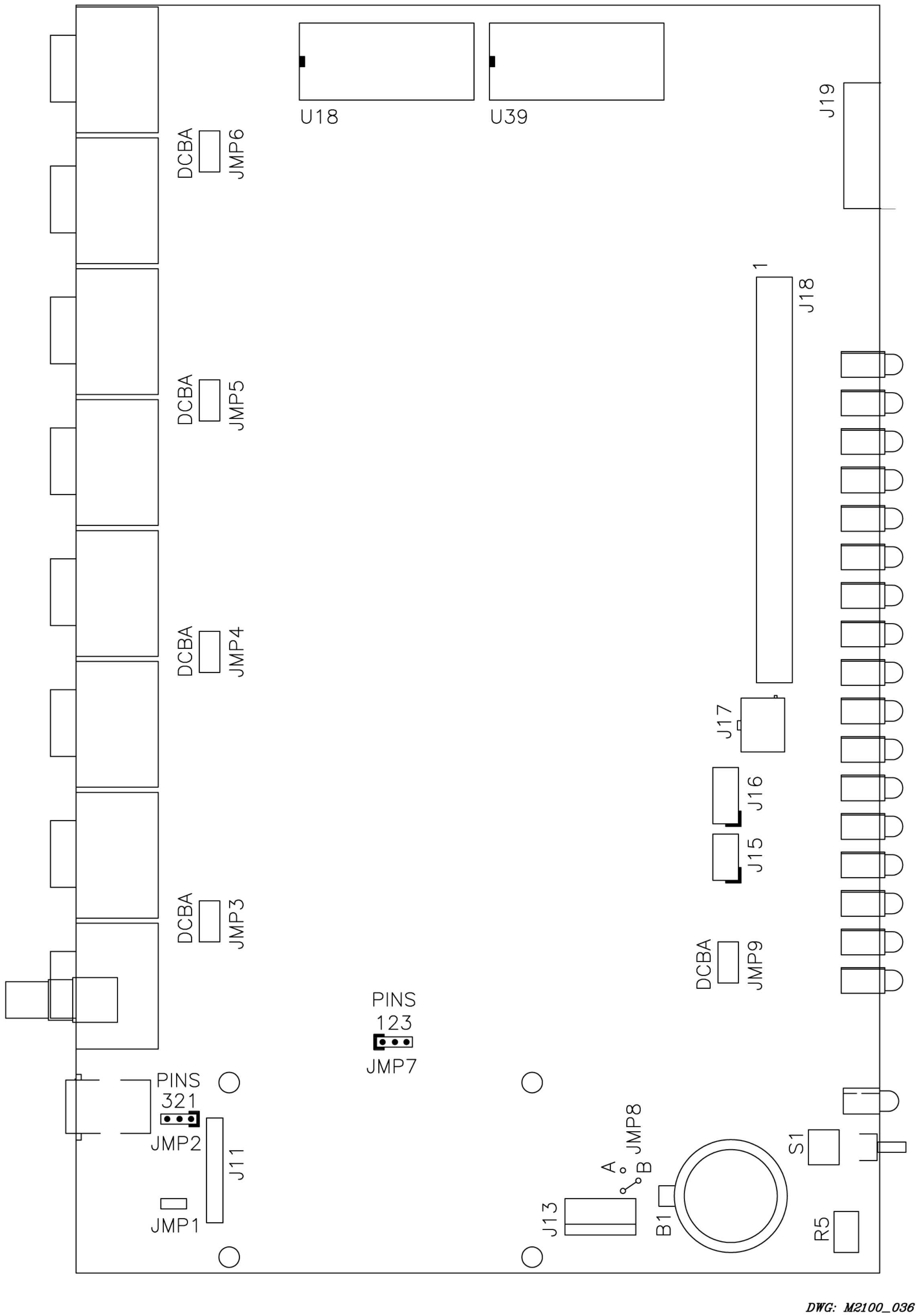


Figure 2.5: SEL-2100 Main Board Jumper Location

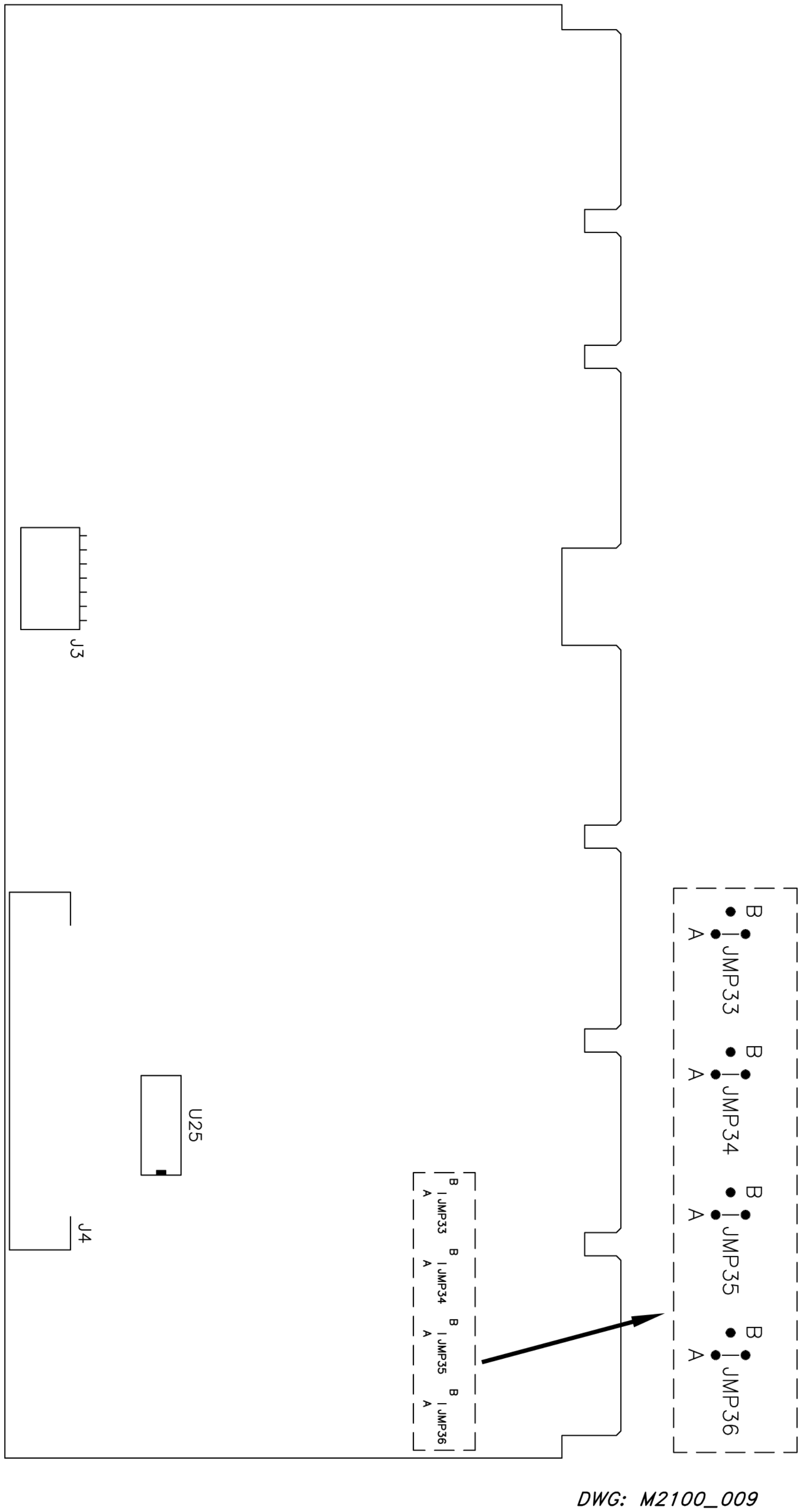


Figure 2.6: SEL-2100 Optional I/O Board Jumper Location

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SECTION 3: APPLICATION EXAMPLES

MULTISTATION DIRECT TRANSFER TRIPPING (DTT)

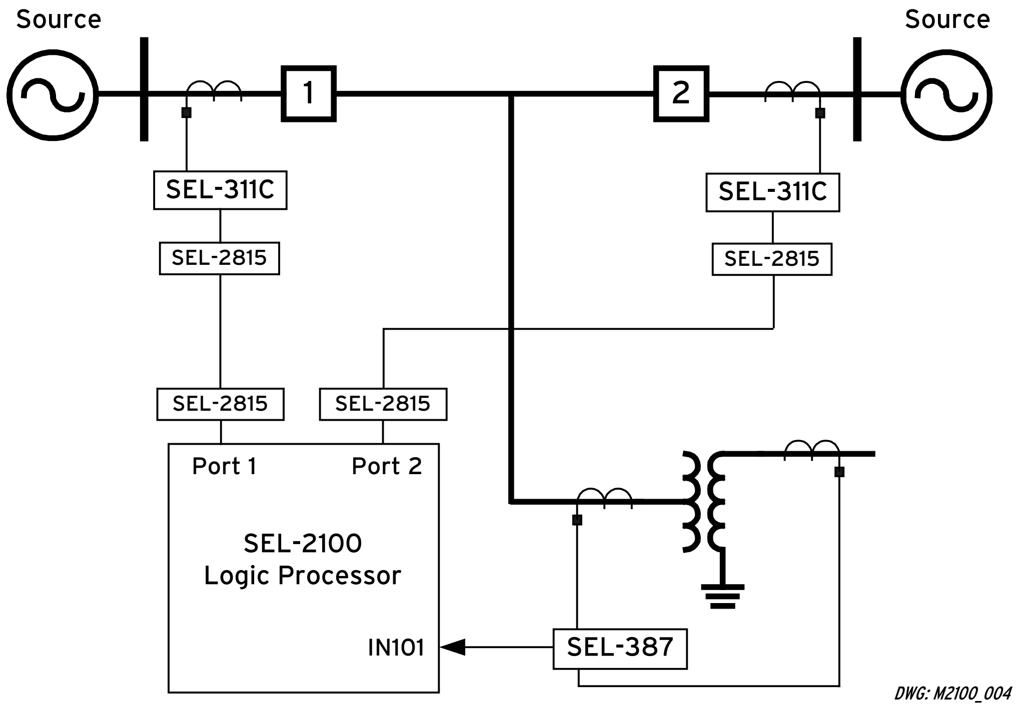

Figure 3.1: SEL-2100 and SEL-387 Protect Transformer Connected Directly to a Line Tap

Figure 3.1 shows a transformer connected directly to the protected line without a high-side breaker. Both circuit breakers 1 and 2 must trip for transformer faults. In this application, the relays at Terminals 1 and 2 connect to an SEL-2100 at the tap location using fiber-optic cables. The SEL-2100 sends trip signals to the SEL-311C Relays at Terminals 1 and 2 when the SEL-387 Relay at Terminal 3 detects a transformer fault.

The SEL-2100 also transfers permissive-trip (PT) signals between the relays at Terminals 1 and 2 and indicates to Relay 1 when Relay 2 experiences a communications problem, and vice versa.

SELOGIC Control Equations and Settings

SEL-2100 Settings

When the SEL-387 Relay detects a transformer fault, it asserts contact input IN101 in the SEL-2100. The following SELOGIC® control equations in the SEL-2100 send a transfer-trip signal to the relays at Terminals 1 and 2 when the SEL-387 detects a transformer fault.

T1P1 = IN101

T1P2 = IN101

Transfer the PT signal from Relay 2 to Relay 1, and vice versa, by routing the received PT signal through the SEL-2100 using SELOGIC control equations.

T2P1 = R2P2

T2P2 = R2P1

Also send the communications ALARM bit from Relay 1 to Relay 2, and vice versa:

T3P1 = !ROK2

T3P2 = !ROK1

SEL-311C Relay Settings

Include Receive MIRRORED BIT® 1 in the Direct Transfer Trip (DTT) SELOGIC control equation in each SEL-311C in Figure 3.1.

DTT = … + RMB1A + …

Assign the received permissive-trip signal to Receive MIRRORED BIT 2, and transmit the permissive trip keying signal on Transmit MIRRORED BIT 1.

PT = RMB2A

TMB1A = KEY

Use Receive MIRRORED BIT 3 in each SEL-311C Relay to alarm until communications are restored.

Setting the SEL-2100

Follow these steps to set the SEL-2100 for the application shown in Figure 3.1.

Step 1. Set Ports 1 and 2 for MIRRORED BITS communications. Here we will assume that the SEL-311C Relays are both set for 38,400 baud, Relay 1 is set for RXID = 1, TXID = 2, and Relay 2 is set for RXID = 3, TXID = 4. Set the RXID and TXID settings in the SEL-2100 to mirror the settings in the relays.

The communications channels in this example are both dedicated fiber, so set the RBADPU and CBADPU alarm thresholds restrictively at 1 second and 100 parts per million unavailability, respectively.

Set all default receive values (RXDFLT) to zero. This deasserts the received permissive trip signals (and all other Receive MIRRORED BITS) when the associated MIRRORED BITS channel fails. Note that when MIRRORED BITS serial port settings are changed, the received MIRRORED BITS reset to zero regardless of the RXDFLT setting.

See ***Section 8: MIRRORED BITS Communications*** for more information regarding MIRRORED BITS settings.

```
=>>SET P 1 <Enter>
Port 1
Protocol(SEL,LMD,DNP,MB,MB8)                        PROTO = SEL       ? MB <Enter>
MBT9600(Y,N)                                        MBT   = N         ? <Enter>
Baud Rate(300-38400)                                SPEED = 2400      ? 38400 <Enter>
Seconds to Mirrored Bits Rx Bad Pickup(1-10000)     RBADPU= 60        ? 1 <Enter>
PPM Mirrored Bits Channel Bad Pickup(1-30000)       CBADPU= 1000      ? 100 <Enter>
Mirrored Bits Receive Identifier(1-4)               RXID  = 1         ? 2 <Enter>
Mirrored Bits Transmit Identifier(1-4)              TXID  = 2         ? 1 <Enter>
Mirrored Bits Receive Default State(string of 1s, 0s or Xs)
       87654321
RXDFLT=XXXXXXXX
     ? 00000000 <Enter>
Mirrored Bits R1 Pickup Debounce msgs(1-8)          R1PU  = 1         ? END <Enter>

PROTO = MB
MBT   = N        SPEED = 38400    RBADPU= 1        CBADPU= 100
RXID  = 2        TXID  = 1        RXDFLT=00000000
R1PU  = 1        R1DO  = 1        R2PU  = 1        R2DO  = 1
R3PU  = 1        R3DO  = 1        R4PU  = 1        R4DO  = 1
R5PU  = 1        R5DO  = 1        R6PU  = 1        R6DO  = 1
R7PU  = 1        R7DO  = 1        R8PU  = 1        R8DO  = 1

Save Changes(Y/N)? Y <Enter>
Settings saved


=>>SET P 2 <Enter>
Port 2
Protocol(SEL,LMD,DNP,MB,MB8)                        PROTO = SEL       ? MB <Enter>
MBT9600(Y,N)                                        MBT   = N         ? <Enter>
Baud Rate(300-38400)                                SPEED = 2400      ? 38400 <Enter>
Seconds to Mirrored Bits Rx Bad Pickup(1-10000)     RBADPU= 60        ? 1 <Enter>
PPM Mirrored Bits Channel Bad Pickup(1-30000)       CBADPU= 1000      ? 100 <Enter>
Mirrored Bits Receive Identifier(1-4)               RXID  = 1         ? 4 <Enter>
Mirrored Bits Transmit Identifier(1-4)              TXID  = 2         ? 3 <Enter>
Mirrored Bits Receive Default State(string of 1s, 0s or Xs)
       87654321
RXDFLT=XXXXXXXX
     ? 00000000 <Enter>
Mirrored Bits R1 Pickup Debounce msgs(1-8)          R1PU  = 1         ? END <Enter>

PROTO = MB
MBT   = N        SPEED = 38400    RBADPU= 1        CBADPU= 100
RXID  = 4        TXID  = 3        RXDFLT=00000000
R1PU  = 1        R1DO  = 1        R2PU  = 1        R2DO  = 1
R3PU  = 1        R3DO  = 1        R4PU  = 1        R4DO  = 1
R5PU  = 1        R5DO  = 1        R6PU  = 1        R6DO  = 1
R7PU  = 1        R7DO  = 1        R8PU  = 1        R8DO  = 1

Save Changes(Y/N)? Y <Enter>
Settings saved
=>>
```

Step 2. View the ROK1 and ROK2 Relay Word bits in the SEL-2100 to verify the MIRRORED BITS links are operational. A "1" under ROK2 and ROK1 indicates that the MIRRORED BITS links to both relays are operational.

```
=>>TAR ROK1 <Enter>

ROK8   ROK7   ROK6   ROK5   ROK4   ROK3   ROK2   ROK1
0      0      0      0      0      0      1      1

=>>
```

If the MIRRORED BITS links are not operational, check port connections and port settings in the both the SEL-2100 and SEL-311C Relays.

See ***Section 4: Serial Port Communications and Commands*** for more information regarding the **TAR** command.

Step 3. Configure the Transmit MIRRORED BITS for each port using the **SET L** command. Notice the TERSE option on the **SET L** command. It prevents the settings being displayed at the end of the setting process. Also notice that entering ">" during the setting process (at setting T4P1 below) skips to the next settings section.

```
=>>SET L T1P1 TERSE <Enter>
SELogic group 1

Mirrored Bits Transmit Equations For Port 1:

T1P1  =0

     ? IN101 <Enter>
T2P1  =0

     ? R2P2 <Enter>
T3P1  =0

     ? !ROK2 <Enter>
T4P1  =0

     ? > <Enter>

Mirrored Bits Transmit Equations For Port 2:

T1P2  =0

     ? IN101 <Enter>
T2P2  =0

     ? R2P1 <Enter>
T3P2  =0

     ? !ROK1 <Enter>
T4P2  =0

     ? END <Enter>
Save Changes(Y/N)? Y <Enter>

330 Elements and 100 Edges remain available.

Settings saved

=>>
```

See ***Section 4: Serial Port Communications and Commands*** and ***Section 5: SELOGIC Control Equations and the Relay Word*** for more information regarding the **SET L** command.

Step 4. Setup the Sequential Events Recorder to record activity on the Transmit and Receive MIRRORED BITS used by the scheme, and also to record activity on contact input IN101. In the next step, we will use Receive MIRRORED BIT 1 on each port to measure round trip delay of the MIRRORED BITS link, so add Receive MIRRORED BIT 1 to the SER trigger list also. The order in which the Relay Word bits appear in the SER trigger settings SER1 through SER6 has no effect on SER operation.

```
=>>SET R <Enter>


Sequential Events Recorder trigger lists:
24 elements max.(enter NA to null)
SER1  =0
     ? IN101 T1P1 T2P1 T3P1 R1P1 <Enter>
24 elements max.(enter NA to null)
SER2  =0
     ? T1P2 T2P2 T3P2 R1P2 <Enter>
24 elements max.(enter NA to null)
SER3  =0
     ? END <Enter>

Sequential Events Recorder trigger lists:
SER1  =IN101 T1P1 T2P1 T3P1 R1P1
SER2  =T1P2 T2P2 T3P2 R1P2
SER3  =0
SER4  =0
SER5  =0
SER6  =0

Save Changes(Y/N)? Y <Enter>
Settings saved
=>>
```

See ***Section 7: Sequential Events Recorder*** for more information regarding the SER trigger settings.

Step 5. Verify the scheme logic works as expected and measure the round trip delay of the MIRRORED BITS links using the SER. To measure the round trip delay, set each SEL-311C to reflect its Receive MIRRORED BIT 1 to its Transmit MIRRORED BIT 1 (TMB1A = RMB1A). Then clear the SEL-2100 SER with the **SER C** command.

```
=>>SER C <Enter>
Clear the SER
Are you sure (Y/N) ? Y <Enter>
Clearing Complete

=>>
```

Finally, assert SEL-2100 contact input IN101, and inspect the SEL-2100 to measure the round trip MIRRORED BITS delay.

```
=>>SER <Enter>

SEL-2100                         Date: 12/16/2000    Time: 21:53:31.906
STATION A

FID=SEL-2100-R100-V0-Z001001-D19991221       CID=ECB6

#      DATE        TIME           ELEMENT         STATE

    5  12/16/2000  21:53:29.656   IN101           Asserted
    4  12/16/2000  21:53:29.656   T1P2            Asserted
    3  12/16/2000  21:53:29.656   T1P1            Asserted
    2  12/16/2000  21:53:29.672   R1P2            Asserted
    1  12/16/2000  21:53:29.672   R1P1            Asserted

=>>
```

The SER report indicates that IN101, T1P2, and T1P1 all asserted simultaneously at 21:53:29.656. Receive MIRRORED BITS R1P1 and R1P2 return (assert) 16 ms later, indicating that the round trip MIRRORED BITS delay, including processing in the SEL-311C, is about one cycle for both links.

See ***Section 4: Serial Port Communications and Commands*** and ***Section 7: Sequential Events Recorder*** for more information regarding the **SER** command.

THREE-TERMINAL PERMISSIVE OVERREACHING TRANSFER TRIPPING (POTT)

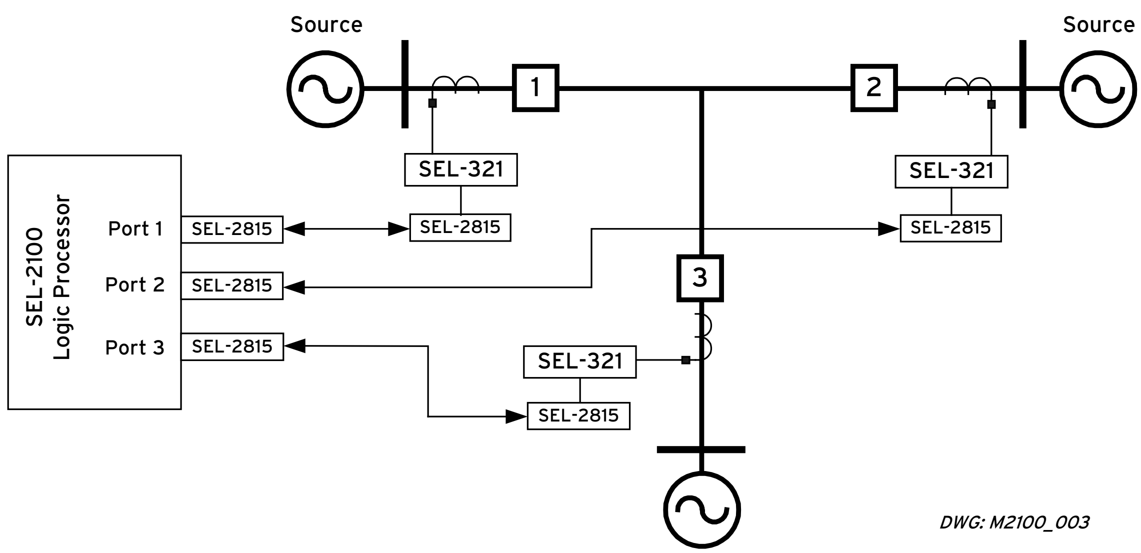

Figure 3.2: SEL-2100 Protects a Three-Terminal Line

POTT Description

Three-terminal lines with power sources on all terminals are difficult to protect. Pilot communication channels are required to achieve fast tripping at all terminals for faults on the protected line. The SEL-321 Relay includes predefined logic for Permissive Overreaching Transfer Tripping (POTT). Refer to ***SEL Application Guide AG95-29: Applying the SEL-321 Relay to Permissive Overreaching Transfer Trip (POTT) Schemes*** for more details.

In Figure 3.2, SEL-2815 Fiber-Optic Modems connect the SEL-2100 to three SEL-321 Relays via MIRRORED BITS communications. In a POTT scheme, each relay trips when it receives a permissive-trip signal from both remote terminals, and it sees either a fault in the forward direction, or it senses a weak-infeed fault condition. The SEL-2100 in Figure 3.2 keys permissive trip to a relay if it receives permissive trip from both other relays.

SELOGIC Control Equations and Settings

The following SEL-321 Relay logic settings configure the SEL-321 for POTT using MIRRORED BITS communications. In this example, Transmit MIRRORED BIT 1 (TMB1) is used to transmit permissive-trip (KEY), and Receive MIRRORED BIT 1 (RMB1) is used as the received permissive trip (PT) signal.

TMB1 = KEY
RMB1 = PT

Notice in the SEL-321 Relay that Receive MIRRORED BITS are assigned functions by placing the Receive MIRRORED BIT name on the left side of the equal sign in a SELOGIC control equation. The SEL-321 Relay is unique in this regard among SEL relays with SELOGIC control equations. All other SEL relays, and the SEL-2100, use Receive MIRRORED BITS on the right side of an equal sign in SELOGIC control equations.

In this example, the SEL-2100 sends a permissive-trip signal to the relay at Terminal 1 if it receives permissive-trip signals from the relays at Terminal 2 AND Terminal 3.

The SEL-2100 SELOGIC control equation for this is:

T1P1 = R1P2 * R1P3

This logic setting transmits MIRRORED BIT 1 on Port 1 when MIRRORED BIT 1 is received on Port 2 AND Port 3.

Similar logic is applied to Ports 2 and 3, as shown in Figure 3.3.

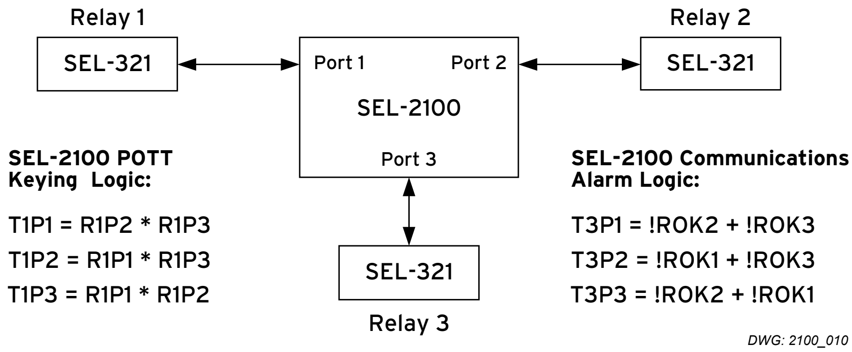

Figure 3.3: SEL-2100 SELOGIC Control Equations for the Example Shown in Figure 3.2

The SEL-2100 coordinates permissive transfer-trip signals between the relays at the three line ends, so all that is required in the SEL-321 Relay is the existing POTT and weak-infeed logic. The SEL-2100 also provides one convenient location to monitor and report on all communications channels.

A new consideration for this application is enhanced communications alarm logic. Because each relay communicates with the SEL-2100 directly, the relay at Terminal 1 can now detect a communications problem between the SEL-2100 and the relays at Terminals 2 or 3. A similar situation exists for the other two relays.

Use the SEL-2100 to send a channel alarm to each relay. For example, the SELOGIC control equation:

T3P1 = !ROK2 + !ROK3

sends Transmit MIRRORED BIT 3 to the relay at Terminal 1 if either of the other two relays experience a communications problem. Use Receive MIRRORED BIT 3 (RMB3) in each SEL-321 Relay to alarm until communications are restored to all relays.

DISTRIBUTION BUS PROTECTION WITH RADIAL FEEDERS

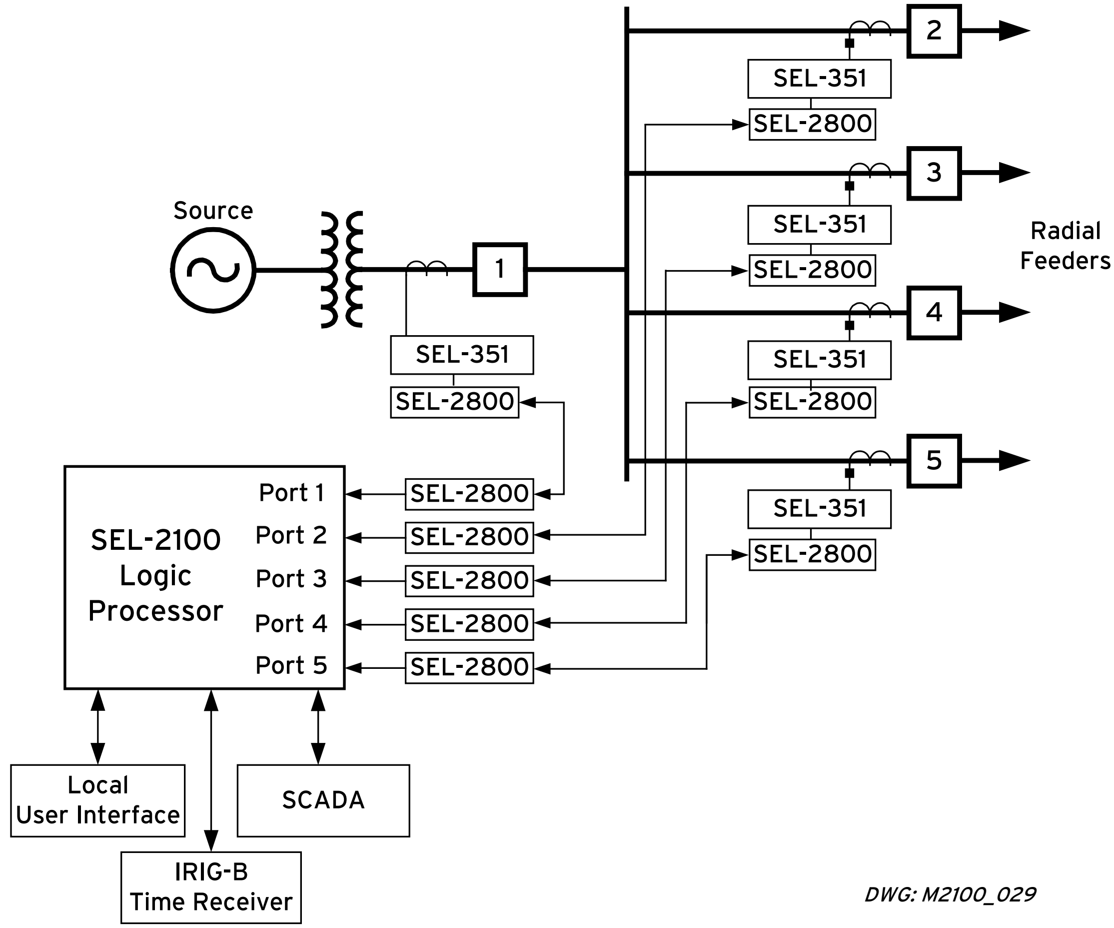

Figure 3.4: SEL-2100 and SEL-351 Protect a Distribution Bus with Radial Feeders

Description

The SEL-2100 setup shown in Figure 3.4 provides bus protection for a radial system. If the transformer low-side relay senses a fault, and no feeder relay senses a fault, the fault must be located on the bus. Unlike conventional schemes, there is no control wiring between the feeder relays and the transformer low-side relay. Replacing wire with fiber increases scheme security and dependability (because the SEL-2100 monitors communications) and reduces the number of possible dc grounds.

SELOGIC Control Equations and Settings

Feeder Relay Settings

The feeder relays transmit a blocking signal to the SEL-2100 on MIRRORED BIT 1 when they detect a feeder fault.

TMB1A = … + 67N1 + 67Q1 + 67P1 …

where 67N1, 67Q1, and 67P1 may be replaced with other appropriate feeder relay fault detectors.

SEL-2100 Settings

The SEL-2100 combines all the blocking signals from the feeder relays and transmits one blocking signal (T1P1) to the transformer low-side relay at Terminal 1.

T1P1 = R1P2 + R1P3 + R1P4 + R1P5

Transformer Low-Side Relay Settings

The transformer low-side relay at Terminal 1 uses built-in Directional Comparison Blocking (DCB) logic to block tripping when it receives the block signal from the SEL-2100.

BT = RMB1A

Set the DCB carrier coordination delay timer to allow the feeder relays time to detect a feeder fault and transmit that fault detection through the SEL-2100. With all MIRRORED BITS links operating at 19,200 baud or faster, a carrier coordination timer of 2.5 cycles is sufficient.

SECTIONALIZED BUS PROTECTION WITH LOOPED FEEDERS

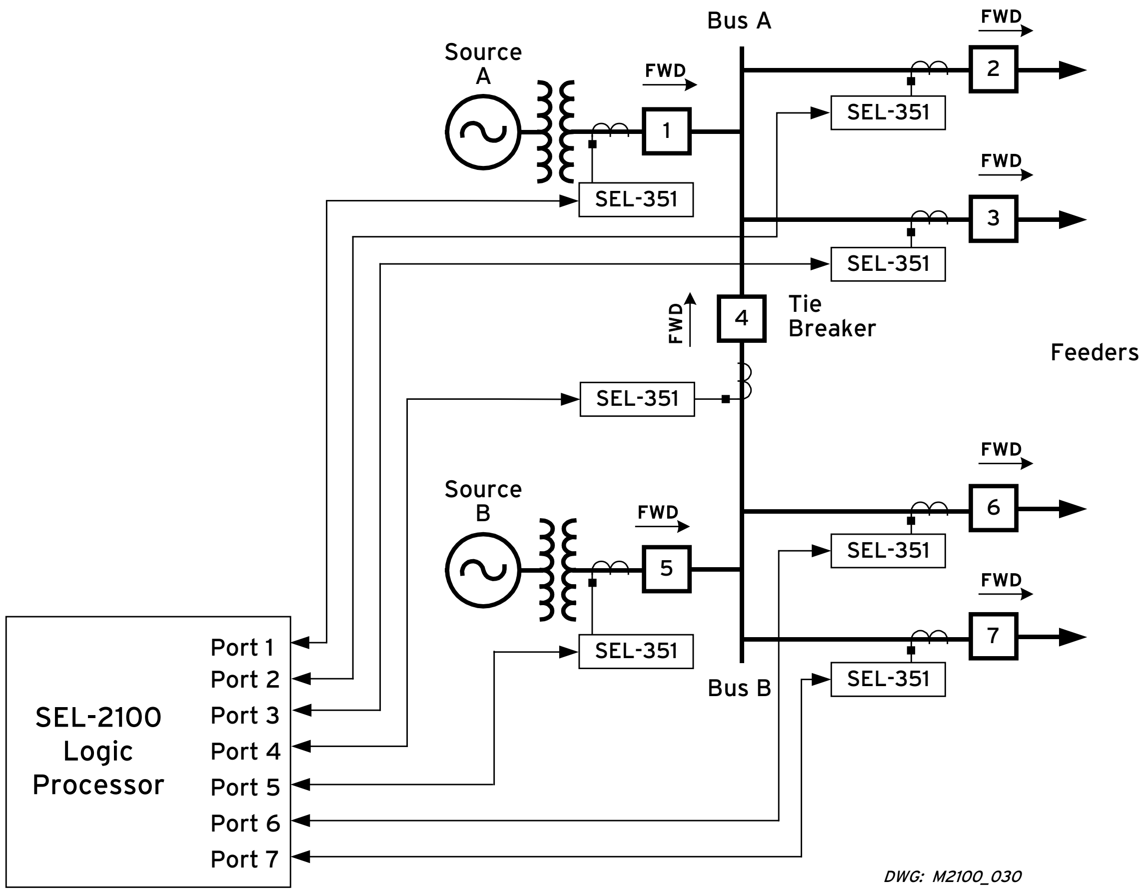

Figure 3.5: Protection for Sectionalized Bus and Looped Feeders Using the SEL-2100

Bus Protection Scheme Description

Figure 3.5 shows an installation with two local sources, a bus tie breaker, and four feeders that may or may not have remote sources connected.

The SEL-2100 setup shown in Figure 3.5 provides bus protection for each bus section. Each relay includes directional overcurrent elements that detect bus and line faults. This scheme recognizes that remote breakers may be open or a line may be radial, eliminating any directional decision during bus faults for the relay on the associated line.

The directional decisions from all of the relays are combined using SELOGIC control equations in the SEL-2100. When a bus fault occurs, the SEL-2100 issues trip commands via MIRRORED BITS to all relays connected to the faulted bus section.

SEL-2100 Logic Description

Each relay has both forward- and reverse-sensing directional elements. These elements are not necessarily part of the feeder protection trip logic, but they are sent to the SEL-2100 via MIRRORED BITS communications for bus protection.

The SEL-2100 determines if a trip condition exists for each bus (A or B) and issues the trip signal to the appropriate relays when a bus fault occurs.

For Bus A, if any of the Relays 1, 2, 3, or 4 detect a fault in the direction of Bus A, and none of the Relays 1, 2, 3, or 4 detect a fault in the direction away from Bus A, and this condition lasts for longer than 12 ms, then there must be a fault on Bus A, and the SEL-2100 issues a trip command to Relays 1, 2, 3, and 4 via MIRRORED BITS. The 12 ms timer filters any differences in the individual relay directional element pickup and transmit times to prevent an erroneous trip decision.

The logic for protection of Bus B is similar.

Figure 3.6 shows the bus fault is cleared within three cycles plus the interrupting time of the slowest circuit breaker, assuming each MIRRORED BITS communications link operates at 19,200 baud or faster.

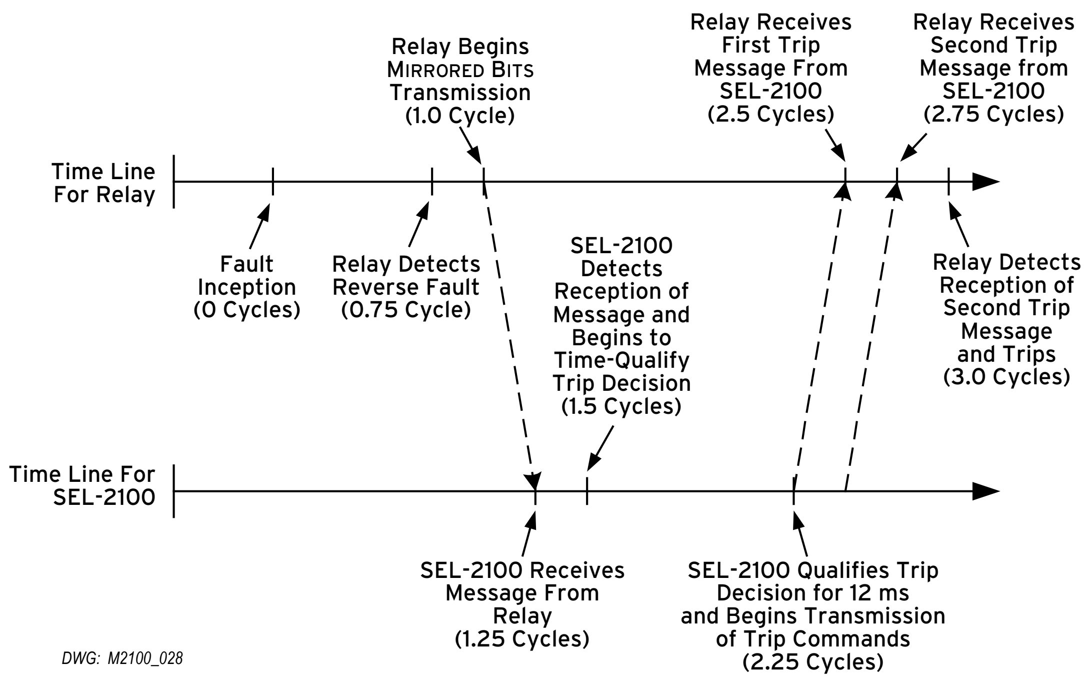

Figure 3.6: Looped Feeder Bus Protection Time Line

Relay Settings Description

In each relay, the fault detectors with direction toward the bus must be less sensitive than the fault detectors with direction away from the bus. This ensures that any line fault detected by adjacent relays is also detected by the relay on the faulted line. Therefore, each relay uses a high-set fault detector in the direction of the bus, and a medium-set fault detector in the direction away from the bus. Both fault detectors from each relay are transmitted to the SEL-2100 via MIRRORED BITS.

Relay 4 is a special case. It has medium- and high-set fault detectors in both directions. All four directional decisions are transmitted to the SEL-2100 via MIRRORED BITS.

Other Features

The scheme allows for any relay to be taken out of service with the associated breaker open without disabling bus protection. The scheme automatically disables bus protection if a loss-of-potential condition occurs for any relay on the bus. During a loss-of-potential condition, or when a relay or communications channel fails without the relay being taken out of service, backup protection is provided by torque controlled time-overcurrent elements in each relay. The SEL-2100 also provides breaker failure protection for all of the breakers shown.

MIRRORED BITS, Relay Word Bits, and SELOGIC Control Equation Assignments

Table 3.1: MIRRORED BITS Assignment and Function for Bus Protection Scheme of Figure 3.5

SEL-2100 MIRRORED BIT	Functional Description
R1P*n*, where *n* = 1 to 7, except 4	High-set fault detector in direction of bus received from Relay *n*.
R2P*n*, where *n* = 1 to 7, except 4	Medium-set fault detector in direction away from bus received from Relay *n*.
R1P4	High-set fault detector in direction of Bus A received from Relay 4.
R2P4	High-set fault detector in direction of Bus B received from Relay 4.
R3P*n*, where *n* = 1 to 7	LOP condition NOT declared by Relay *n*.
R4P*n*, where *n* = 1 to 7	Breaker failure initiation from Relay *n* qualified by local low-set overcurrent element.
R5P4	Medium-set fault detector in direction away from Bus B received from Relay 4.
R6P4	Medium-set fault detector in direction away from Bus A received from Relay 4.
T1P*n*, where *n* = 1 to 7	Trip signal to each Relay 1 through 7.
T2P*n*, where *n* = 1 to 7, except 4	Scheme OK for associated bus section sent to Relay *n*.
T2P4	Scheme OK for Bus A sent to Relay 4.
T3P4	Scheme OK for Bus B sent to Relay 4.

Table 3.2: Relay Word Bits and SELOGIC Control Equations Used for Bus Protection Scheme of Figure 3.5

Relay Word Bit or SELOGIC Control Equation	Functional Description
RB1 through RB7	Pulse Remote Bits 1 through 7 to inform the SEL-2100 that Relays 1 through 7, respectively, have been removed from service or placed back into service.
SET1 through SET7 RST1 through RST7 LT1 through LT7	Latch Bits 1 through 7 store relay status (in service or out of service) in nonvolatile memory.
SV1, SV1T, SV2, and SV2T	SV1T and SV2T assert when any relay in service on Bus A or Bus B, respectively, has detected a fault in the direction away from the bus in the last 10 cycles.
LV1 and LV2	Logic variables 1 and 2 assert when the bus protection scheme is enabled for Bus A and Bus B, respectively.
LV3	LV3 asserts when a breaker failure condition has timed out for any of Relays 1 through 4.
LV4	LV4 asserts when a breaker failure condition has timed out for any of Relays 4 through 7.
SV11 through SV17	SV11T through SV17T assert when a breaker failure condition has timed out for Relays 1 through 7, respectively.
OUT101	Contact output OUT101 closes when bus protection for Bus A is disabled.
OUT102	Contact output OUT102 closes when bus protection for Bus B is disabled.
OUT103	Contact output OUT103 closes when any of the seven relays are taken out of service.

SEL-2100 Logic Settings

All relays on the bus section trip if any relay detects a fault in the direction of the bus, and no relays detect a fault in the direction away from the bus.

This logic needs to be refined to allow for a relay taken out of service, to allow for a relay or communications-channel failure, and to avoid race conditions between forward and reverse directional elements dropping out when a line fault is cleared.

Note: A nominal frequency of 60 Hz is assumed for the timer settings.

Relay Taken Out of Service

The SEL-2100 must be notified when a relay connected to the SEL-2100 is taken out of service so that it removes that relay from the bus protection logic. To accomplish this, seven remote bits in the SEL-2100 indicate when each of the seven relays is taken out of service. See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic*** for more information about Remote Bits.

After power is removed and restored to the SEL-2100, all remote bits are reset, so a latch bit is used to make the out-of-service indication nonvolatile. For example, remote bit RB1 is used to indicate that Relay 1 is being taken out of service, or is being returned to service. Remote bit RB1 sets and resets Latch Bit LT1, which retains its state even after power is removed and restored to the SEL-2100. The SEL-2100 uses LT1 to determine if Relay 1 is in service (LT1 set) or is out of service (LT1 cleared). The following logic sets and clears Latch Bit LT1.

SET1 = /RB1 * !LT1

RST1 = /RB1 * LT1

To set Latch Bit 1 and indicate to the SEL-2100 that Relay 1 is in service, pulse remote bit RB1 when LT1 is reset. To clear Latch Bit 1 and indicate to the SEL-2100 that Relay 1 is out of service, pulse remote bit RB1 when LT1 is set.

The other six latch bits and remote bits, LT2–LT7 and RB2–RB7, similarly indicate when Relays 2 through 7 are in service or out of service. Bits LT1 through LT7 are used in the SELOGIC bus protection settings.

Scheme OK and Alarm Logic

The SEL-2100 must inform each relay if bus protection is not enabled for the associated bus section. Bus protection is enabled if MIRRORED BITS communications is OK and a loss-of-potential condition does not exist for all relays in service. The SEL-2100 uses logic variables LV1 and LV2 to create the scheme OK logic for Bus A and Bus B, respectively. See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic*** for more information about logic variables.

The scheme OK indication is transmitted to all relays on Transmit MIRRORED BIT 2. The SEL-2100 also transmits scheme OK indication to Relay 4 for Bus B on Transmit MIRRORED BIT 3. The scheme OK bits, LV1 and LV2, also control Alarm contact outputs OUT101 for Bus A, and OUT102 for Bus B. OUT103 closes if any relay is removed from service.

LV1 = (ROK1 * R3P1 + !LT1) * (ROK2 * R3P2 + !LT2) * (ROK3 * R3P3 + !LT3) *
(ROK4 * R3P4 + !LT4)

LV2 = (ROK5 * R3P5 + !LT5) * (ROK6 * R3P6 + !LT6) * (ROK7 * R3P7 + !LT7) *
(ROK4 * R3P4 + !LT4)

T2P1 = LV1

T2P2 = LV1

T2P3 = LV1

T2P4 = LV1

T2P5 = LV2

T2P6 = LV2

T2P7 = LV2

T3P4 = LV2

OUT101 = !LV1

OUT102 = !LV2

OUT103 = !LT1 + !LT2 + !LT3 + !LT4 + !LT5 + !LT6 + !LT7

External Fault Transient Blocking

When an external fault occurs, the feeder relay associated with the faulted line declares a forward fault, and the adjacent relays may detect a fault in the direction of the bus. When the line relay trips the associated circuit breaker, the line fault is cleared, and the line relay and adjacent relay directional elements reset. If the line relay directional element resets faster than the adjacent relay directional elements, an inadvertent bus trip may occur.

To avoid this, the SEL-2100 extends an external (away from bus) fault detection from any relay. The following SELOGIC variable equation combines all of the external fault detections from any relay on Bus A into a single declaration. A one-cycle pickup delay qualifies this condition. The SELOGIC control equation timer dropout then extends the external fault detection for 10 cycles.

SV1 = LT1 * R2P1 + LT2 * R2P2 + LT3 * R2P3 + LT4 * R6P4

SV1PU = 15 ms (~1 cycle)

SV1DO = 160 ms (~10 cycles)

Recall that LT*n* is set when Relay *n* is in service. SV1 asserts if any relay on Bus A is in service and detects a fault in the direction external to Bus A. SV1T asserts one cycle after SV1 asserts, and stays asserted for 10 cycles after SV1 deasserts.

The logic for Bus B is similar:

SV2 = LT5 * R2P5 + LT6 * R2P6 + LT7 * R2P7 + LT4 * R5P4

SV2PU = 15 ms (~1 cycle)

SV2DO = 160 ms (~10 cycles)

Breaker Failure Logic

Receive MIRRORED BIT 4 on Port *n* is the Breaker Failure Initiation (BFI) input from Relay *n* qualified by a low-set overcurrent element in Relay *n*. The SEL-2100 qualifies the BFI signal with a nine-cycle timer (assumed breaker failure time), and issues a bus section trip if the BFI timer times out.

SV11 = LT1 * R4P1

SV12 = LT2 * R4P2

SV13 = LT3 * R4P3

SV14 = LT4 * R4P4

SV15 = LT5 * R4P5

SV16 = LT6 * R4P6

SV17 = LT7 * R4P7

SV11PU = SV12PU = SV13PU = SV14PU = SV15PU = SV16PU = SV17PU = 150 ms (nine cycles)

SV11DO = SV12DO = SV13DO = SV14DO = SV15DO = SV16DO = SV17DO = 0 ms

LV3 = SV11T + SV12T + SV13T + SV14T

LV4 = SV14T + SV15T + SV16T + SV17T

Trip Logic (Breaker Failure and Bus Protection)

To create the trip signals to each relay, first create bus trip conditions SV3T and SV4T for bus sections 1 and 2, respectively.

SV3 = !(SV1T + SV1) * (R1P1 * LT1 + R1P2 * LT2 + R1P3 * LT3 + R1P4 * LT4) * LV1

SV4 = !(SV2T + SV2) * (R1P5 * LT5 + R1P6 * LT6 + R1P7 * LT7 + R2P4 * LT4) * LV2

SV3PU = 12 ms

SV3DO = 0

SV4PU = 12 ms

SV4DO = 0

The bus trip signal SV3T for Bus A asserts if no in-service relay on Bus A detects a fault in the direction away from the bus (SV1T + SV1), AND any in-service relay on Bus A detects a fault in the direction toward the bus, AND the bus protection scheme is OK (LV1), AND those conditions exists for 12 ms. The bus trip logic for Bus B (SV4) is similar.

Next, combine the bus trip conditions SV3T and SV4T with breaker failure trip conditions, LV3 and LV4, and transmit the trip signals to the relays on Transmit MIRRORED BIT 1. The SEL-2100 transmits a trip condition to Relay 4 for bus trips or breaker failure time-outs on either Bus A or Bus B.

T1P1 = SV3T + LV3

T1P2 = SV3T + LV3

T1P3 = SV3T + LV3

T1P5 = SV4T + LV4

T1P6 = SV4T + LV4

T1P7 = SV4T + LV4

T1P4 = (SV3T + LV3) + (SV4T + LV4)

SEL-2100 Logic Diagram

Figure 3.7 shows all of the logic used for bus and breaker failure protection for Relays 1, 2, and 3. Logic for the other relays is similar, and also uses many parts of this logic diagram.

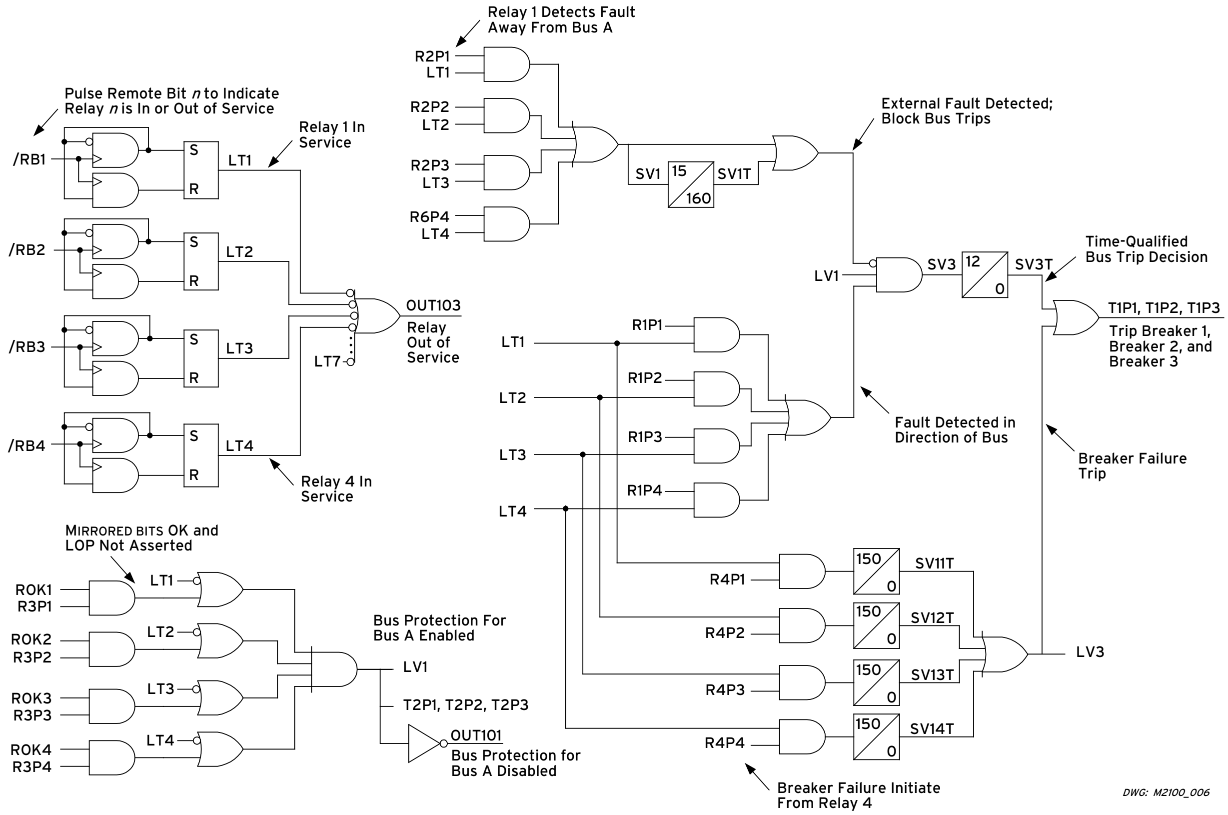

Figure 3.7: SEL-2100 Bus and Breaker Failure Protection Logic for Bus A

Relay Settings

Directional time-overcurrent elements in the feeder relays pick up for any forward (line) fault, and are blocked for reverse (bus or adjacent line) faults.

Directional overcurrent elements are used as forward- and reverse-fault detectors (and transmitted to the SEL-2100). Loss-of-potential and breaker failure initiate conditions are also sent to the SEL-2100.

The relay trip equation only contains the bus protection trip signal from the SEL-2100 and the time-overcurrent element.

For backup purposes, definite-time directional overcurrent elements torque-control (enable) the time-overcurrent elements for reverse faults. The time-overcurrent elements are enabled after 30 cycles during a high-magnitude reverse fault. These delays allow time for the bus protection to operate, if necessary, or for an adjacent relay to clear its faulted line.

The reverse time-overcurrent elements enable and become nondirectional any time the “scheme OK” signal is not received, or the local loss-of-potential Relay Word bit asserts, allowing standard time-overcurrent element coordination between protective relays as a fall-back measure.

Bus Relays 1 and 5 have similar settings to the feeder relays, except the forward and reverse definitions are swapped, and the time-overcurrent element pickup and time-dial settings are higher.

Bus sectionalizing Relay 4 has similar settings to 1 and 5, except its time-overcurrent elements are normally blocked in both directions (with separate enable logic for each bus), and it transmits two sets of directional fault-detector results to the SEL-2100.

In all relays, qualify receive trip signals by a two-count pickup debounce MIRRORED BIT counter to achieve the security recommended by IEC-834 for direct tripping applications. See ***Section 8: MIRRORED BITS Communications*** for more information on MIRRORED BITS security.

Advanced Application Logic

The SEL-2100 supports Advanced Application Logic modules that perform specific functions. You can specify Advanced Application Logic when you order an SEL-2100, or purchase this logic as a firmware upgrade.

One implementation of Advanced Application Logic module is the Crosspoint Switch. A possible application for this logic is an adaptive load-shedding scheme implemented with the SEL-2100 and other, supporting SEL devices. See ***Appendix L: Crosspoint Switch Advanced Application Logic Module*** for more details on the Crosspoint Switch Advanced Application Logic module and a load-shedding scheme example. For complete power system and industrial protection solutions, including adaptive load-shedding schemes and customized Advanced Application Logic, contact SEL. See ***Appendix K: Advanced Application Logic*** for general information on Advanced Application Logic modules in the SEL-2100.

SEL-2100 SERIAL PORT CONNECTION EXAMPLES

Local or Remote User Interface

Serial Port F on the SEL-2100 is the local ASCII user-interface port. Ports 1 through 16 can also be programmed as remote user-interface ports as well as for MIRRORED BITS and DNP protocols. All ports are factory-set as ASCII user-interface ports in a standard SEL-2100 shipment.

For local communications, connect any serial port on the SEL-2100 configured as an SEL-ASCII port to a computer serial port. Use a terminal emulation program on your personal computer to connect to and control the SEL-2100, and to view settings, status reports, and SER reports. Refer to ***Section 4: Serial Port Communications and Commands*** for more details.

The default settings for all serial ports are:

Protocol	=	SEL
Baud Rate	=	2400
Data Bits	=	8
Parity	=	N
Stop Bits	=	1

To change the port settings, use the **SET P** command. View and change the settings for any port from any SEL-ASCII port.

Use Cable SEL-C234A as shown in Figure 3.8 to connect the SEL-2100 to a computer. If a different cable is used to connect to one of the rear ports on the SEL-2100, be sure to remove the jumper connecting +5 V to Pin 1 of the EIA-232 connector on the SEL-2100. (See ***Section 2: Installation***.)

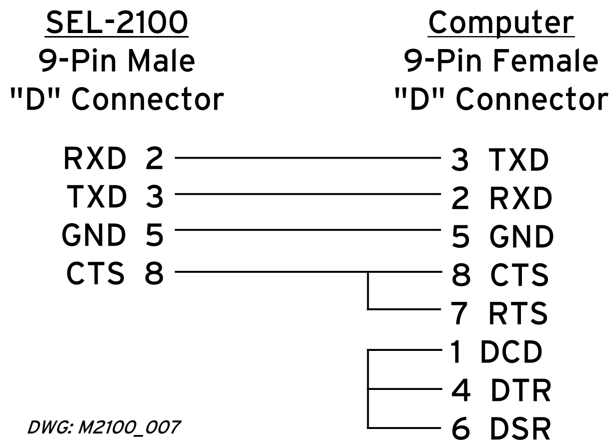

Figure 3.8: Communications Cable for Local User Interface (Cable SEL-C234A)

MIRRORED BITS Connections to SEL Relays

SEL-2100 to SEL Relay Cable Connections

To connect an SEL-2100 to an SEL relay with MIRRORED BITS communications in the same equipment rack, use Cable SEL-C273A as shown in Figure 3.9, or an equivalent cable. Refer to ***Section 4: Serial Port Communications and Commands*** for a complete list of available cables. EIA-232 connections longer than 50 feet are not recommended nor supported by the EIA-232 standard. Use the SEL-2800, SEL-2810, or SEL-2815 Fiber-Optic Modems for longer connections.

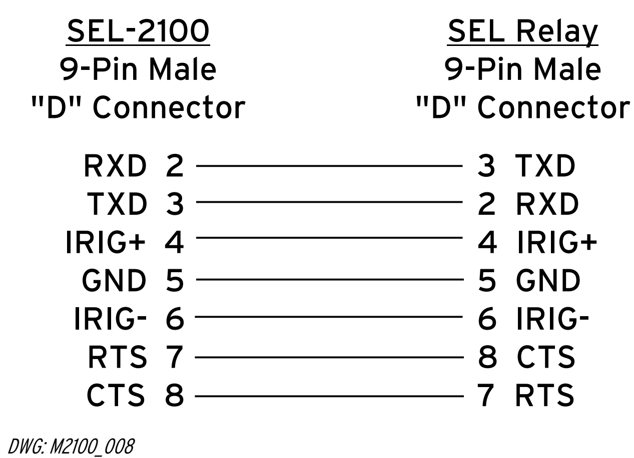

Figure 3.9: SEL-2100 to SEL-311 or SEL-351 Cable Connections (Cable SEL-C273A)

Fiber-Optic Connection Using the SEL-2800 Family of Fiber-Optic Transceivers

The SEL-2800 family of Fiber-Optic Transceivers plug directly onto the DB-9 EIA-232 ports on SEL products. The transceivers derive power from the EIA-232 ports of the SEL-2100. There are no settings required to make these modems operate with the SEL-2100.

SEL-2505 Remote I/O Module Connection

The SEL-2505 Remote I/O module converts contact inputs and contact outputs to/from MIRRORED BITS. The SEL-2505 connects non-MIRRORED BITS devices to SEL products with MIRRORED BITS communications. To connect an SEL-2505 to an SEL-2100, use an SEL-2800M (“V” pin connector) or an SEL-2815M (ST connector), depending on the specific SEL-2505 model. Make sure that the transmit fiber from the SEL-2505 is connected to the receive port on the SEL-2800M.

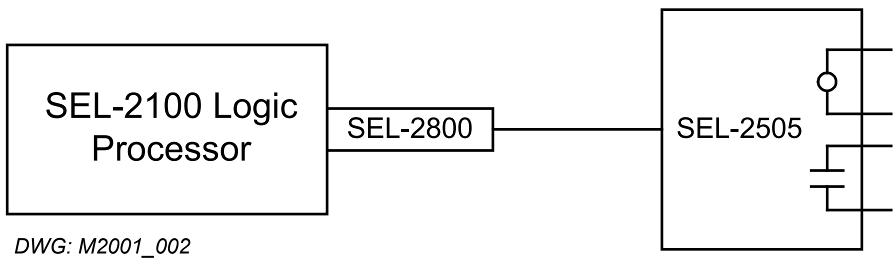

Figure 3.10: SEL-2100 Connected to an SEL-2505

SEL-2505 Settings

The SEL-2505 settings for the SEL-2100 to SEL-2505 connection shown in Figure 3.10 are:

- SW 1 and 2–Set the TX address to match the RXID setting on the SEL-2100.
- SW 3 and 4–Set the RX address to match the TXID setting on the SEL-2100.
- SW 5 to 8–Set the data security counter to “ON” if the application can tolerate an additional 4 ms delay.

SEL-2100 Settings

The SEL-2100 port settings for the SEL-2100 to SEL-2505 connection shown in Figure 3.10 are as follows:

- PROTO = MB8
- SPEED = 38400
- RXID = (the same setting as the TX address of the SEL-2505)
- TXID = (the same setting as the RX address of the SEL-2505)

The connection is working when the SEL-2505 ROK, TX, and RX LED indicators illuminate, or SEL-2100 Relay Word bit ROK*n* asserts (where *n* is the port number connected to the SEL-2505). To verify ROK*n* is asserted in the SEL-2100, connect a computer to any user-interface serial port, and type **TAR ROK*n* <Enter>** (*n* is the port number connected to the

SEL-2505). The Relay Word bit containing ROK*n* will be displayed. A one (1) under ROK*n* indicates that Port *n* is exchanging data via MIRRORED BITS communications.

```
=>TAR ROK1 <Enter>

ROK8    ROK7    ROK6    ROK5    ROK4    ROK3    ROK2    ROK1
0       0       0       0       0       0       1       1

=>
```

Pulsar MBT9600 Modem

SEL-2100 Settings and Main Board Jumpers

The MBT9600 modem requires +5 V power from Pin 1 of the EIA-232 serial port. The SEL-2100 supplies this power. See ***Section 2: Installation*** for more information about the +5 V power jumpers on the serial ports.

Set the SEL-2100 for MB protocol with MBT = Y to use the MBT9600 modem.

Spread Spectrum Radio Using MIRRORED BITS Communications

Most spread spectrum radios require a data format with 8 data bits, no parity, and 1 stop bit (8N1). Set PROTO to MB8 to connect the SEL-2100 to devices that require 8N1.

Usually, setting the baud rate higher than 19,200 baud does not increase performance in this application.

The connection is working when the SEL-2100 Relay Word bit ROK*n* asserts (where *n* is the port number connected to the radio). To verify ROK*n* is asserted, connect a computer to any user-interface serial port and type **TAR ROK*n* <Enter>** (*n* is the port number connected to the radio). The Relay Word bit containing ROK*n* will be displayed. A one (1) under ROK*n* indicates that Port *n* is exchanging data via MIRRORED BITS communications.

```
=>TAR ROK14 <Enter>

ROK16   ROK15   ROK14   ROK13   ROK12   ROK11   ROK10   ROK9
0       0       1       0       0       0       0       0

=>
```

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TABLES

FIGURES

SECTION 4: SERIAL PORT COMMUNICATIONS AND COMMANDS

INTRODUCTION

The SEL-2100 Logic Processor has 17 EIA-232 serial communications ports. Port F is located on the front panel, and Ports 1–16 are located on the rear panel. Table 4.1 shows the capabilities of each port.

Table 4.1: Serial Port Protocols

	SEL ASCII and LMD	**DNP***	**MIRRORED BITS®**
Front Port	< 9600 baud†	No	No
Rear Port 16	Yes	Yes	No
Rear Ports 1–15	Yes	Yes	Yes

* DNP available on one port at a time.

† When more than two rear ports are used for MIRRORED BITS, it may be necessary to reduce the front-panel baud rate to 4800, 2400, or 1200 baud.

The SEL ASCII protocol allows the user to interrogate, control, and set the SEL-2100 through ASCII commands. The SEL ASCII protocol also contains the Fast Meter protocol described in ***Appendix E: Fast Meter Protocol***, the Compressed ASCII protocol described in ***Appendix D: Compressed ASCII Commands***, and the LMD protocol described in ***Appendix F: SEL Distributed Port Switch Protocol***. ***Appendix C: Distributed Network Protocol (DNP3)*** describes the DNP protocol. ***Section 8: MIRRORED BITS Communications*** describes the MIRRORED BITS protocol.

Note: Set PROT = MB and SPEED = 300 to disable access on any of Ports 1 through 15. With setting PROT = MB the port cannot be used to access, change settings, or control the SEL-2100. Setting SPEED = 300 prevents the unused port from consuming valuable processor time. The ports may still be used for MIRRORED BITS at 300 bps.

This section of the manual describes the ASCII commands available in the SEL ASCII protocol, and the connections and cables necessary to use the SEL-2100 serial communications ports. The factory-default settings for all serial ports are:

Baud Rate = 2400
Data Bits = 8
Parity = N
Stop Bits = 1

See the Serial Port Settings Sheets in ***Appendix H: Settings Sheets*** for more information regarding serial port settings.

SEL ASCII PROTOCOL

Command and Response Format

1. All commands received by the relay must be of the form:

   <command><CR> or <command><CRLF>

   A command transmitted to the relay should consist of the command followed by either a CR (carriage return) or a CRLF (carriage return and line feed). You may truncate commands to the first three characters. For example, **SHOW <Enter>** would become **SHO <Enter>**. Upper and lowercase characters may be used without distinction, except in passwords.

   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 relay.

2. The SEL-2100 transmits all messages in the following format:

   <STX><MESSAGE LINE 1><CRLF>
   <MESSAGE LINE 2><CRLF>
   .
   .
   .
   <LAST MESSAGE LINE><CRLF>< ETX>

   Each message begins with the start-of-transmission character (ASCII 02) and ends with the end-of-transmission character (ASCII 03). Each line of the message ends with a carriage return and line feed.

Flow Control

1. The SEL-2100 implements XON/XOFF flow control.

   The SEL-2100 transmits XON (ASCII hex 11) and asserts the RTS output (if hardware hand-shaking enabled) when the SEL-2100 input buffer drops below 25 percent full.

   The SEL-2100 transmits XOFF (ASCII hex 13) when the buffer is more than 75 percent full. If hardware handshaking is enabled, the SEL-2100 deasserts the RTS output when the buffer is approximately 95 percent full. Automatic transmission sources should monitor for the XOFF character so they do not overwrite the buffer. Transmission should terminate at the end of the message in progress when XOFF is received and may resume when the SEL-2100 sends XON.

2. When the SEL-2100 receives XOFF during transmission, it pauses until it receives an XON character. If there is no message in progress when the SEL-2100 receives XOFF, it blocks transmission of any message presented to its buffer. Messages are accepted after the SEL-2100 receives XON.

   The CAN character (ASCII hex 18) aborts a pending transmission. This is useful in terminating an unwanted transmission.

Control characters can be sent 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)

Note: In this manual, commands you type appear in bold/uppercase: **SET**. Computer keys you press appear in bold/brackets: **<Enter>**.

Serial Port Access Levels

Table 4.2 shows all serial port commands. The commands can be executed only from the corresponding access level as shown in Table 4.2. The access levels are:

- Access Level 0. The commands available at Access Level 0 allow access to Access Level 1.
- Access Level 1. The commands available at Access Level 1 primarily allow the user to only look at information (settings, reports, etc.), but do not allow the user to change information.
- Access Level 2. The commands available at Access Level 2 primarily allow the user to change SEL-2100 settings and control the SEL-2100.
- Access Level C (restricted access level, should be used under direction of SEL only).

The commands are shown in uppercase letters, but they can also be entered with lowercase letters.

All commands available at an access level are also available at higher access levels.

Table 4.2: Serial Port Command Summary

Access Level	Prompt	Command	Description
0	=	**ACC**	Go to Access Level 1
1	=>	**2AC**	Go to Access Level 2
1	=>	**COM**	MIRRORED BITS communications statistics
1	=>	**DAT**	View/change date
1	=>	**DNP**	View/change DNP map
1	=>	**GRO**	View the active setting group
1	=>	**IRI**	Synchronize to IRIG-B
1	=>	**QUI**	Quit access level
1	=>	**SER**	Display/clear sequential events records
1	=>	**SHO**	Display settings
1	=>	**STA**	Relay self-test status
1	=>	**TAR**	Display Relay Word bits
1	=>	**TIM**	View/change time
2	=>>	**CAL**	Go to Access Level C
2	=>>	**CON**	Control remote bit
2	=>>	**COP**	Copy setting group
2	=>>	**FILE**	Lists or transfers files between a PC and the logic processor
2	=>>	**GRO *n***	Change active setting group
2	=>>	**LOO**	Loop back
2	=>>	**PAS**	View/change passwords
2	=>>	**PUL**	Pulse output contact or Relay Word bit
2	=>>	**SET**	Change settings
2	=>>	**VER**	Display version and configuration information

The relay responds with “Invalid Access Level” if a command is entered from an access level lower than the specified access level for the command. Also, the relay responds:

```
Invalid Command
```

for commands not listed above or entered incorrectly.

Many of the command responses display the following header at the beginning:

```
SEL-2100                          Date: 12/21/1999    Time: 17:03:26.484
STATION A
```

SEL-2100:	This is the RID setting (the SEL-2100 is shipped with the default setting RID = SEL-2100).
STATION A:	This is the TID setting (the relay is shipped with the default setting TID = STATION A).
Date:	This is the date the command response was given. Change the date format (Month/Day/Year or Year/Month/Day) with the GLOBAL DATE_F setting.
Time:	This is the time the command response was given.

Access Level 0

The SEL-2100 sends the following prompt when serial port communications are established:

```
=
```

This is referred to as Access Level 0. The only commands available at Access Level 0 are the **ACC** command and the **QUI** command (see Table 4.2). Enter the **ACC** command at the Access Level 0 prompt:

=**ACC <Enter>**

The **ACC** command takes the relay to Access Level 1.

Access Level 1

The relay sends the following prompt when the relay is in Access Level 1:

```
=>
```

Commands **ACC** through **TIM** in Table 4.2 are available from Access Level 1. For example, enter the **DAT** command at the Access Level 1 prompt to view the date:

=>**DAT <Enter>**

The **2AC** command allows the relay to go to Access Level 2. Enter the **2AC** command at the Access Level 1 prompt:

=>**2AC <Enter>**

Access Level 2

The relay sends the following prompt when the relay is in Access Level 2:

```
=>>
```

Commands **ACC** through **VER** in Table 4.2 are available from Access Level 2. For example, enter the **VER** command at the Access Level 2 prompt to display version and configuration data.

=>>**VER <Enter>**

Access Level C

The CAL access level 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.

The **CAL** command allows the relay to go to Access Level C. Enter the **CAL** command at the Access Level 2 prompt:

```
=>>CAL <Enter>
```

SEL ASCII Commands

The serial port command explanations that follow are in the same order as the commands listed in Table 4.2, except the **2AC** command.

Access Level 0 Commands

ACC, 2AC, and CAL Commands (Go to Access Level 1, 2, or C)

The **ACC**, **2AC**, and **CAL** commands provide entry to Access Levels 1, 2, and C. Commands **ACC**, **2AC**, and **CAL** are explained together because they operate similarly.

ACC moves from any access level to Access Level 1.

2AC moves from Access Level 1 to Access Level 2.

CAL moves from Access Level 2 to Access Level C.

Password Requirements and Default Passwords

Passwords are required if the main board password jumper is not in place. Passwords are not required if the main board password jumper is in place. Refer to ***Section 2: Installation*** for password jumper information. See the **PAS** Command explanation later in this section for more information on passwords.

Access Level Attempt (Password Required)

Assume the password jumper is not in place and Access Level = 0.

At the Access Level 0 prompt, enter the **ACC** command:

=**ACC <Enter>**

Because the password jumper is not in place, the SEL-2100 asks for the Access Level 1 password to be entered. Factory-default passwords are shown under ***PAS Command*** later in this section.

```
=ACC <Enter>
Password: ? ***** <Enter>

SEL-2100                          Date: XX/XX/XXXX    Time: 22:22:58.483
STATION A


Level 1
=>
```

The "=>" prompt indicates the SEL-2100 is now in Access Level 1.

If the entered password is incorrect, the SEL-2100 responds with "Invalid Password" and asks for the password again (Password: ?). The relay will ask as many as three times. If the requested password is incorrectly entered three times, the relay asserts the ALARM Relay Word bit for one second and remains at the previous access level.

If a user attempts to access any password-protected level and provides three consecutive incorrect passwords, the device sends the following message:

```
Invalid Password
Level X Denied

WARNING:  ACCESS BY UNAUTHORIZED PERSONS STRICTLY PROHIBITED

Access Temporarily Denied
```

Access Level Attempt (Password Not Required)

Assume the password jumper is in place and Access Level = 0.

At the Access Level 0 prompt, enter the **ACC** command:

=**ACC <Enter>**

Because the Password jumper is in place, the SEL-2100 does not ask for a password; it goes directly to Access Level 1:

```
=ACC <Enter>

SEL-2100                         Date: 12/15/2000    Time: 22:24:12.591
STATION A


Level 1
=>
```

The above two examples demonstrate how to go from Access Level 0 to Access Level 1. The procedure to go from Access Level 1 to Access Level 2 is similar, with command **2AC** entered at the access level screen prompt.

Access Level 1 Commands

COM Command (Communication Data)

The **COM P *n*** command displays MIRRORED BITS communications channel data for Port *n*. For more information on how to interpret these data, see ***Section 8: MIRRORED BITS Communications***. To get a summary report, enter the command with the channel parameter (1 through 15).

```
=>>COM P 1 <Enter>

SEL-2100                         Date: 12/21/1999    Time: 08:05:59.380
STATION A

FID=SEL-2100-R100-V0-Z001001-D19991221       CID=72BF
Summary for Mirrored Bits Port 1

For 12/21/1999 07:34:32.862 to 12/21/1999 08:05:59.377

    Total failures      5                  Last error  Re-Sync
    2100 Disabled       1
    Data error          2                  Longest Failure     7.832 sec.
    Re-Sync             1
    Underrun            0                  Unavailability  0.004656
    Overrun             0
    Parity error        0
    Framing error       1                  Loop-back     0
    Bad Re-Sync         0

=>>
```

The **COM P *n* L** command generates a summary report, followed by a listing of the COM records for Port *n*. The first record in the report is always “2100 Disabled”. This record is simply a placeholder for the beginning time of the report.

```
=>>COM P 1 L <Enter>

SEL-2100                          Date: 12/21/1999    Time: 08:10:39.754
STATION A

FID=SEL-2100-R100-V0-Z001001-D19991221       CID=72BF
Summary for Mirrored Bits Port 1

For 12/21/1999 07:34:32.862 to 12/21/1999 08:10:39.751

    Total failures      5                  Last error  Re-Sync
    2100 Disabled       1
    Data error          2                  Longest Failure     7.832 sec.
    Re-Sync             1
    Underrun            0                  Unavailability  0.004054
    Overrun             0
    Parity error        0
    Framing error       1                  Loop-back     0
    Bad Re-Sync         0


    Failure                  Recovery
#   Date       Time          Date       Time          Duration  Cause
1   12/21/1999 08:00:01.903  12/21/1999 08:00:02.315     0.412  2100 Data error
2   12/21/1999 07:59:33.586  12/21/1999 07:59:33.878     0.292  2100 Re-sync
3   12/21/1999 07:58:34.509  12/21/1999 07:58:42.341     7.832  2100 Data error
4   12/21/1999 07:58:00.872  12/21/1999 07:58:01.120     0.248  2100 Framing error
5   12/21/1999 07:34:32.862  12/21/1999 07:34:32.862     0.000  2100 Disabled

=>>
```

The extended report contains as many as 255 records. To limit the number of COM records displayed in the report to the 10 most recent records, type **COM P *n* L 10 <Enter>**. To select lines 10 through 20 of the COM records for display in the report, type **COM P *n* L 10 20 <Enter>**. To reverse the order of the COM records in the report, supply a range of row numbers, with the larger number first, i.e., **COM P *n* L 40 20 <Enter>**. To display all the COM records that started on a particular day, supply that date as a parameter, i.e., **COM P *n* L 2/8/1999 <Enter>**. To display all the COM records that started between a range of dates, supply both dates as parameters, i.e., **COM P *n* L 2/21/98 2/7/1999 <Enter>**. Reversing the order of the dates will reverse the order of the records in the report. To receive a summary report for a subset of the records, use one of the above methods while omitting the L parameter.

Use the **COM P 1 C** command to clear the COM records for Port 1.

```
=>>COM P 1 C <Enter>
Clear the communications buffer for port 1
Are you sure (Y/N) ? Y <Enter>
Clearing Complete

=>>
```

Omitting the channel specifier in the clear command clears all programmed MIRRORED BITS channel reports.

DAT Command (View/Change Date)

Use the DAT command to view or set the date.

```
=>>DAT <Enter>
12/21/1999
=>>
```

```
=>>DAT 12/21/00 <Enter>
12/21/2000
=>>
```

Separate the month, day, and year parameters with spaces, commas, slashes, colons, or semicolons.

Set the date format (Y/M/D or M/D/Y) with the Global setting DATE_F. See ***SET G–Global Settings*** later in this section for more information.

DNP Command (Display the DNP maps)

See ***Appendix C: Distributed Network Protocol (DNP3)***.

GRO Command (Display Active Setting Group Number)

Use the **GRO** command to display the active settings group number. See the ***GRO n Command*** in ***Access Level 2 Commands*** that follows in this section and ***Multiple Setting Groups*** in ***Section 6: Inputs, Outputs, Timers, and Other Control Logic*** for further details on settings groups.

IRI Command (Synchronize to IRIG-B Time Code)

The **IRI** command directs the SEL-2100 to read the demodulated or modulated IRIG-B time code at the BNC connector. The SEL-2100 normally resynchronizes with the IRIG-B input once per minute.

```
=>>IRI <Enter>
IRIG SYNC IN PROGRESS


SEL-2100                        Date: 12/13/2000    Time: 15:36:28.144
STATION A

=>>
```

If no IRIG-B code is present at the BNC input, or if the code cannot be read successfully, the SEL-2100 responds “IRIG-B DATA ERROR.”

```
=>>IRI <Enter>
IRIG SYNC IN PROGRESS

IRIG-B DATA ERROR
=>>
```

If an IRIG-B signal is present, the SEL-2100 synchronizes its internal clock with IRIG-B. It is not necessary to issue the **IRI** command to synchronize the SEL-2100 clock with IRIG-B. Use the **IRI** command to determine if the SEL-2100 is properly reading the IRIG-B signal.

QUI Command (Quit Access Level)

The **QUI** command returns the SEL-2100 to Access Level 0 and terminates an LMD connection.

```
=>>QUI <Enter>

SEL-2100                        Date: 12/13/2000    Time: 23:00:01.953
STATION A

=
```

The “=” prompt indicates the SEL-2100 is back in Access Level 0.

SER Command (Sequential Events Recorder Report)

Use the **SER** command to view the Sequential Events Recorder report. For more information on SER reports, see ***Section 7: Sequential Events Recorder.***

SHO Command (Show/View Settings)

Use the **SHO** command to view SEL-2100 group settings, SELOGIC® control equations, global settings, serial port settings, and Sequential Events Recorder settings.

SHO *n*	Show settings for Group *n* (1, 2, 3, 4, 5, or 6); *n* defaults to the active setting group if not listed.
SHO L *n*	Show SELOGIC control equation settings for Group *n* (1, 2, 3, 4, 5, or 6); *n* defaults to the active setting group if not listed.
SHO G	Show global settings.
SHO P *n*	Show serial port settings for Port *n* (1…16 or F); *n* defaults to the active port if not listed.
SHO R	Show Sequential Events Recorder trigger settings.

You may append a setting name to each of the commands to specify the first setting displayed (e.g., **SHO 1 SV1PU** displays the Group 1 settings starting with SV1PU).

The **SHO** commands display only the enabled settings. To display all settings, including disabled/hidden settings, append an A to the **SHO** command (e.g., **SHO P 1 A**).

STA Command (Relay Self-Test Status)

The **STA** command displays the self-test status report.

```
=>>STA <Enter>

SEL-2100                          Date: 12/21/1999    Time: 08:52:58.065
STATION A

FID=SEL-2100-R100-V0-Z001001-D19991221       CID=72BF

SELF TESTS

RAM       ROM       CR_RAM    EEPROM    +15V_PS   -15V_PS
OK        OK        OK        OK        OK        OK

IRIG-B Input: ABSENT
I/O Board: OK

Processing Interval: 4 ms

Port   Port Type        Status
1      Mirrored Bits    OK
2      Mirrored Bits    OK
3      SEL ASCII        NA
4      Mirrored Bits    OK
5      SEL ASCII        NA
6      SEL ASCII        NA
7      SEL ASCII        NA
8      Mirrored Bits    OK
9      SEL ASCII        NA
10     SEL ASCII        NA
11     SEL ASCII        NA
12     SEL ASCII        NA
13     SEL ASCII        NA
14     SEL ASCII        NA
15     SEL ASCII        NA
16     SEL ASCII        NA
F      SEL ASCII        NA

SEL-2100 Enabled
=>>
```

Status Report Row and Column Definitions

FID	FID is the firmware identifier string. It identifies the firmware revision.
CID	CID is the firmware checksum identifier.
+15V_PS, –15V_PS	These fields display OK if the power supply is operating properly and FAIL if the power supply has failed.
RAM, ROM, CR_RAM, and EEPROM	These fields display OK if memory is functioning properly, and FAIL if the memory area has failed.

IRIG-B INPUT — This field displays PRESENT if the relay is synchronized to an external IRIG source, otherwise ABSENT is displayed.

I/O BOARD — I/O board status is ABSENT, OK, or FAIL.

Port Type — This field displays the port protocol setting.

Status — The following port types always report N/A status: SEL ASCII, DNP, and LMD. MIRRORED BITS port status is defined as follows:

(RBAD*n* + CBAD*n*) * !ROK*n* = `Fail`
(RBAD*n* + CBAD*n*) * ROK*n* = `Warn`
!RBAD*n* * !CBAD*n* = `OK`

See ***Section 8: MIRRORED BITS Communications*** for more information regarding Relay Word bits RBAD*n*, CBAD*n*, and ROK*n*.

TAR Command (Display Relay Element Status)

The **TAR** command displays the status of SEL-2100 Relay Word bits. The Relay Word bits are listed in rows of eight, called Relay Word rows.

A Relay Word bit is either logical 1 (asserted) or logical 0 (deasserted). Relay Word bits are used in SELOGIC control equations.

TAR *n k* — Shows Relay Word row number *n* (0–69). *k* is an optional parameter to specify the number of times (1–32767) to repeat the Relay Word row display. If *k* is not specified, the Relay Word row is displayed once.

TAR *name k* — Shows Relay Word row containing Relay Word bit *name* (e.g., **TAR IN109** displays Relay Word Row 5). Valid names are shown in Table 5.4. *k* is an optional parameter to specify the number of times (1–32767) to repeat the Relay Word row display. If *k* is not specified, the Relay Word row is displayed once.

```
=>TAR IN105 10 <Enter>

IN101  IN102  IN103  IN104  IN105  IN106  IN107  IN108
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0

IN101  IN102  IN103  IN104  IN105  IN106  IN107  IN108
0      0      1      0      0      1      0      0
0      0      1      0      0      1      0      0

=>
```

Note that Relay Word row containing the IN105 bit is repeated 10 times. In this example, inputs IN103 and IN106 of the SEL-2100 are asserted.

See ***Section 5: SELOGIC Control Equations and the Relay Word*** for more information on the Relay Word.

TIM Command (View/Change Time)

TIM displays the SEL-2100 time. To set the clock, type **TIM** and the desired setting, then press **<Enter>**. Separate the hours, minutes, and seconds with colons, semicolons, spaces, commas, or slashes. To set the clock to 11:30 p.m., enter:

```
=>TIM 23:30:00 <Enter>
23:30:00
=>
```

Access Level 2 Commands

CON Command (Control Remote Bit)

The **CON** command is a two-step command that controls Relay Word bits RB1 through RB64 (see Rows 0–3 and Rows 66–69 in Table 5.4). At the Access Level 2 prompt, type **CON**, a space, the number of the remote bit you wish to control (1–64), and then **<Enter>**. The SEL-2100 repeats your command followed by a colon. At the colon, type the control subcommand you wish to perform (see Table 4.3).

Table 4.3: SEL-2100 Remote Control Subcommands

Subcommand	Description
SRB *n*	Set Remote Bit *n* (“ON” position)
CRB *n*	Clear Remote Bit *n* (“OFF” position)
PRB *n*	Pulse Remote Bit *n* for one processing interval (“MOMENTARY” position)

The following example shows the steps necessary to pulse Remote Bit 5 (RB5):

```
=>>CON 5 <Enter>
CONTROL RB5: PRB 5 <Enter>
=>>
```

You must enter the same remote bit number in both steps in the command. If the bit numbers do not match, the relay responds “Invalid Command.”

See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic*** for more information on how to use Remote Bits.

COP Command (Copy Setting Group)

Copy Group and SELOGIC control equation settings from setting Group *m* to setting Group *n* with the **COP *m n*** command. There are six setting groups. After entering settings into one setting group with the **SET** and **SET L** commands, copy them to the other groups with the **COP** command. Use the **SET** and **SET L** commands to modify the copied settings. The ALARM bit pulses if you copy settings into the active group.

For example, to copy settings from Group 1 to Group 3 issue the following command:

```
=>>COP 1 3 <Enter>
Copy 1 to 3
Are you sure (Y/N) ? Y <Enter>

Please wait...
Settings copied
=>>
```

FILE Command (View Directory, Read Files, or Write Files)

The **FILE** command transfers files between intelligent electronic devices (IEDs) and external support software (ESS). Use the **FILE** commands for sending Advanced Application Logic modules to the SEL-2100. See ***Appendix K: Advanced Application Logic*** for information on Advanced Application Logic in the SEL-2100.

FILE DIR	Returns a list of SEL-2100 files. Available at Access Level 1 and higher.
FILE WRITE *filename*	Transfer the file *filename* from the PC to the logic processor using YMODEM protocol. Available at Access Level 2.
FILE READ *filename*	Transfer the file *filename* from the logic processor to the PC using YMODEM protocol. Available at Access Level 1 and higher.

The following shows sample **FILE DIR** response from the SEL-2100. The right column indicates file access availability (R is 'read' and W is 'write'). The final entry, CUSTOM.APP, is a write-only file which is the destination filename for the Advanced Application Logic module. This filename does <u>not</u> change when a module is loaded. Other SEL software, such as ACSELERATOR QuickSet® SEL-5030 Software, uses the remaining files for reading and writing SEL-2100 settings.

```
=>FILE DIR<ENTER>
SET_ALL.TXT                     R
CFG.TXT                         R
ERR.TXT                         R
SET_P1.TXT                      RW
SET_P2.TXT                      RW
.                               .
.                               .
SET_P17.TXT                     RW
SET_G.TXT                       RW
SET_1.TXT                       RW
SET_2.TXT                       RW
.                               .
.                               .
SET_6.TXT                       RW
SET_L1.TXT                      RW
SET_L2.TXT                      RW
.                               .
.                               .
SET_L6.TXT                      RW
SET_R.TXT                       RW
SET_DNPB.TXT                    RW
CUSTOM.APP                       W

=>
```

Note: If the **FILE DIR** response does not include the CUSTOM.APP filename, the logic processor firmware must be upgraded to firmware version R103 or greater to support Advanced Application Logic.

GRO *n* Command (Change Active Setting Group)

The **GRO *n*** command changes the active setting group to setting Group *n*. For example, the **GRO 2** command changes to settings Group 2.

```
=>>GRO 2 <Enter>
Change to Group 2
Are you sure (Y/N) ? Y <Enter>
 Changing
Active Group = 2
=>>
```

If the serial port AUTO setting = Y, the relay sends the group switch report.

```
SEL-2100                         Date: 12/15/2000    Time: 23:50:45.639
STATION A

Active Group = 2
=>>
```

If any of the SELOGIC control equations settings SS1 through SS6 are asserted to logical 1, the active setting group cannot be changed with the **GRO** command. SELOGIC control equations settings SS1 through SS6 have priority over the **GRO** command in active setting group control.

For example, assume setting Group 1 is the active setting group and the SELOGIC control equation SS1 is asserted to logical 1 (e.g., SS1 = IN101 and optoisolated input IN101 is asserted). An attempt to change to setting Group 2 with the **GRO 2** command will not be accepted.

```
==>GRO 2 <Enter>
Change to Group 2
Are you sure (Y/N) ? Y <Enter>
 Changing
No group change (see manual)
Active Group = 1
==>
```

For more information, see ***Multiple Setting Groups*** in ***Section 6: Inputs, Outputs, Timers, and Other Control Logic***.

LOO Command (Loop back)

To perform a loop back test, physically loop back the transmit data line to the receive data line somewhere in the MIRRORED BITS communications channel. The SEL-2100 will begin to receive its own data, and will deassert ROK. Issue the **LOO** (**LOO P**) command. If the channel is looped back and operating properly, LBOK asserts. When in loop back mode, MIRRORED BITS uses LBOK instead of ROK to perform channel monitoring. This allows you to monitor the channel performance during the loop back test.

While in loop back mode, MIRRORED BITS can either use the received data, or it can set all receive MIRRORED BITS for the looped port to the default receive value. See ***Section 8: MIRRORED BITS Communications***, for more information on the **LOO P** command, and default received values.

The **LOO** command format is:

LOO P *n t*

or

LOO P *n* DATA *t*

where *n* is the port number to loop back

t is the number of minutes to allow the loop back test to run (1 to 5000)

DATA allows the received data to be used for testing, such as round trip delay tests

If parameter *t* is not entered, the SEL-2100 allows the loop back condition to run for five minutes.

LOO R *n* resets loop back mode on Port *n*. If the parameter *n* is omitted, loop back is terminated on all ports that are presently looped back.

```
=>> LOO P 2 <Enter>
Loop back will be enabled on Mirrored Bits Port 2 for the next 5 minutes.
The RMB values will be forced to default values while loop back is enabled
Are you sure (Y/N) ? Y <Enter>
=>>
```

```
=>> LOO P 5 DATA 10 <Enter>
Loop back will be enabled on Mirrored Bits Port 5 for the next 10 minutes.
The RMB values will be allowed to change while loop back is enabled.
Are you sure (Y/N) ? N <Enter>
Canceled.
=>>
```

```
=>> LOO R <Enter>
loop back is disabled on all channels.
=>>
```

PAS Command (Change 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 use the Password command, **PAS**, to change existing passwords. The factory-default passwords for Access Levels 1, 2 and C are:

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

Use the **PAS** command to change existing passwords at Access Level 2. To change passwords, enter **PAS** ***x***, where ***x*** is the access level of the password you want to change. The relay will prompt for the old password and the new password. It will then confirm the change to the new password as follows:

```
=>>PAS 1 <Enter>

Old Password: *****

New Password: ************
Confirm New Password: ************

Password Changed
=>>
```

The new password will not echo on the screen, so type slowly and carefully. Record the new password in a safe place for future reference.

To prevent unauthorized access to your SEL device, the device does not display passwords. Passwords can include as many as 12 characters. Valid characters are listed in Table 4.4.

Table 4.4: Valid Password Characters

<table>
<tr><td>Alpha</td><td>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z</td></tr>
<tr><td>Numeric</td><td>0 1 2 3 4 5 6 7 8 9</td></tr>
<tr><td>Special</td><td>! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~</td></tr>
</table>

Upper- and lowercase letters are treated as different characters. Strong passwords consist of the maximum allowable characters, with at least one special character, number, lowercase letter, and uppercase letter. Strong passwords do not include a name, date, acronym, or word. The relay issues a weak password warning (as shown below) if you can strengthen the new password.

```
=>>PAS 1 <Enter>

Old Password: *****

New Password: *****
Confirm New Password: *****

CAUTION: This password can be strengthened. Strong passwords do not include a name,
date, acronym, or word. They consist of the maximum allowable characters, with at
least one special character, number, lowercase letter, and uppercase letter. A change
in password is recommended.

Password Changed

=>>
```

Examples of valid, distinct passwords include:

SDFdfa098&^# &*LKJoi09873 m,nYIO689&(*

If the passwords are lost or you wish to operate the recloser control without password protection, put the main board Password jumper in place (Password jumper = ON). Refer to page 2-4 and page 2-5 for Password jumper information.

If you wish to disable password protection for a specific access level [even if Password jumper is not in place (Password jumper = OFF)], simply set the password to DISABLE.

PUL Command (Pulse Relay Word bits)

The **PULSE** command allows the user to pulse any of the Relay Word bits (see ***Table 5.4: SEL-2100 Relay Word Bits***) for a specified amount of time in seconds.

For example, the command **PUL OUT101 *n*** asserts Relay Word bit OUT101 for *n* seconds. This command also energizes the contact output OUT101 for *n* seconds.

```
=>>PUL OUT101 1 <Enter>
Are you sure (Y/N) ? Y <Enter>
=>>
```

SET Command (Change Settings)

The **SET** command allows the user to change the SEL-2100 settings.

See ***Appendix H*** for Settings Sheets.

Table 4.5: Serial Port SET Commands

Command	Settings Type	Description	Settings Sheets in Appendix H
SET *m*	Group Setting	Identifier and Timer settings (*m* = 1, 2, 3, 4, 5, 6) See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic*** for more information on timer settings.	1
SET L *m*	Logic	SELOGIC control equations for settings Group *m* (*m* = 1, 2, 3, 4, 5, 6) See ***Section 5: SELOGIC Control Equations and the Relay Word*** for more information on SELOGIC control equation settings.	3–9
SET G	Global	Optoisolated input debounce timers, date format, group-change delay. See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic*** for more information on contact input debounce timer settings.	10
SET R	SER	Sequential Events Recorder triggers See ***Section 7: Sequential Events Recorder*** for more information on the SER.	11
SET P *m*	Port	Serial port settings for Port *m* (*m* = 1–16, or F).	12–13

To change a specific setting, enter the command:

SET *n m s* TERSE

where *n* = L, G, R, or P (parameter *n* is not entered for group settings).

m = group (1...6) or port (F, 1...16). The SEL-2100 selects the active group or port if *m* is not specified.

s = the name of the specific setting. If *s* is not entered, the SEL-2100 starts at the first setting.

TERSE = instructs the SEL-2100 to skip the SHOWSET display after the last setting. Use this parameter to speed up the **SET** command. If you wish to review the settings before saving, do not use the TERSE option.

When the **SET** command is issued, the SEL-2100 presents a list of settings one at a time. Either enter a new setting and press **<Enter>** to accept, or use the editing keystrokes shown in Table 4.6.

Table 4.6: Set Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains setting and moves to the next setting.
^ <Enter>	Returns to previous setting.
< <Enter>	Returns to previous section.
> <Enter>	Moves to next section.
END <Enter>	Exits editing session and moves ahead to the save settings.
<Ctrl+X>	Aborts editing session without saving changes.

The SEL-2100 checks each entry to ensure that it is within the setting range. If it is not within range, the SEL-2100 generates an "Out of Range" message and prompts for the setting again.

When all the settings are entered, the SEL-2100 displays the new settings and prompts for approval to enable them. Answer **Y <Enter>** to enable the new settings. If Global, SER, or Port settings are changed (see Table 4.5), or the active group settings are changed, the SEL-2100 is disabled while it saves the new settings. The SEL-2100 is disabled for about 1 second. If Logic settings are changed for the active group, the SEL-2100 can be disabled for as long as 15 seconds.

If changes are made to the group settings or Logic settings for a setting group other than the active setting group, the SEL-2100 is not disabled while it saves the new settings.

SET—Group Settings

Use the **SET** command to set the Relay ID, Terminal ID, and SELOGIC Variable Timer pickup/dropout settings.

SET P—Port Configuration and Communication Settings

Use the **SET P** command to configure a serial port for LMD, SEL ASCII, DNP, or MIRRORED BITS protocols.

After the **SET P** ***n*** command is issued (where *n* is the port number) the SEL-2100 prompts for configuration and communication parameters.

SET R—SER Settings

Use the **SET R** command to define which bits are monitored by the Sequential Events Recorder (SER).

Enter the names of the SEL-2100 Relay Word bits that you wish to monitor for SER tracking. See Table 5.4 for all Relay Word bits.

See ***Section 7: Sequential Events Recorder*** for more information on SER Settings.

SET G—Global Settings

Use the **SET G** command to:

- Set group-change delay.
- Set date format to MDY or YMD.
- Set debounce timers for optional contact inputs IN101 through IN116.

See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic*** for more information.

SET L—SELOGIC Control Equations Command

Use the **SET L** command to set SELOGIC control equations.

See ***Section 5: SELOGIC Control Equations and the Relay Word*** for more information.

VER Command (Display SEL-2100 Configuration)

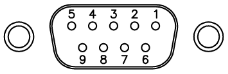
Use the **VER** command to verify the SEL-2100 is configured as expected, especially following a firmware upgrade.

```
=>>VER <Enter>
Partnumber: 2100XA344H

Appearance: Horizontal Rack mount
Power Supply: 48 V
Data FLASH Size:  1024 KBytes
Extended Features:
  I/O Board with 125 V Contact Inputs
  DNP
  Mirrored Bits
  Crosspoint Switch (R100)

FID=SEL-2100-R103-V0-Z003003-D20050318

If above information is unexpected,
contact SEL for assistance
=>>
```

The **VER** command also indicates the presence of an Advanced Application Logic module, if loaded in the SEL-2100. The sample **VER** command response, above, shows an entry for the Crosspoint Switch at the end of the Extended Features listing.

If there is no Advanced Application Logic module present, no entry is displayed in the Extended Features listing. Refer to ***Appendix K: Advanced Application Logic*** for more information on Advanced Application Logic modules, including instructions for loading and unloading the module.

SERIAL PORT CONNECTOR AND COMMUNICATIONS CABLES



(Female chassis connector, viewed from outside panel.)

Figure 4.1: Nine-Pin Connector

Table 4.7: Pinout for EIA-232 Serial Ports 1–16 and F

Pin	Ports 1–16	Port F
1	N/C or +5 Vdc[1]	N/C
2	RXD	RXD
3	TXD	TXD
4	+IRIG-B	N/C
5, 9	GND	GND
6	-IRIG-B	N/C
7	RTS	RTS
8	CTS	CTS

[1] See ***EIA-232 Serial Port Jumpers*** in ***Section 2: Installation***.

Communications Cables

Table 4.8: Communication Cables for Devices Connected to SEL-2100

SEL Cable #	**Connect SEL-2100 To:**	**Remote Connector (on cable)**	**Port Type**	**RTS/CTS Supported**	**IRIG-B Included**
SEL-C222	25-pin DCE devices: Standard modem	DB-25P	DCE	No	No
SEL-C225	9-pin DCE devices: 9-pin modem	DB-9P	DCE	No	No
SEL-C227A	25-pin DTE devices: Standard 25-pin computer	DB-25S	DTE	No	No
SEL-C234A	9-pin DTE devices: Standard computer	DB-9S	DTE	No	No
SEL-C239	9-pin DTE devices with IRIG-B: SEL-321 Series Relays	DB-9P, DB-9P	DTE/ IRIG-B	Yes	Yes
SEL-C241	25-pin DCE devices: Black Box COS Port Switch (DCE), Baytech Port Switch	DB-25P	DCE	No	No

SEL Cable #	Connect SEL-2100 To:	Remote Connector (on cable)	Port Type	RTS/CTS Supported	IRIG-B Included
SEL-C245A	9-pin DCE devices: RFL-9660 Digital Port Switch	DB-9S	DCE	Yes	No
SEL-C247	25-pin DTE devices: Systems Northwest RTU	DB-25P	DTE	No	No
SEL-C273A	9-pin DTE devices with IRIG-B: SEL-300 Series Relays except SEL-321	DB-9P	DTE/ IRIG-B	Yes	Yes
SEL-C276	9-pin DTE device with IRIG-B: SEL-2100, SEL-2020, and SEL-2030 EIA-232 and IRIG-B	DB-9P, BNC	DTE/ IRIG-B	Yes	Yes

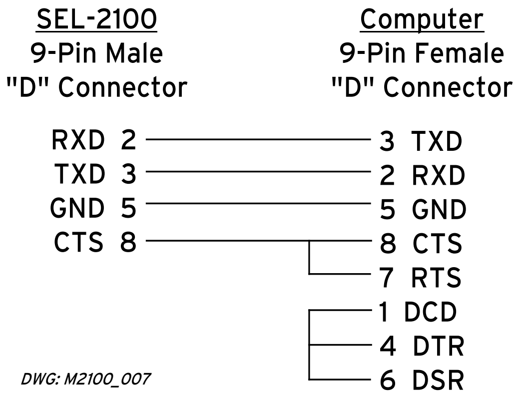
To ensure successful communications when using EIA-232 serial connections:

- 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 should always be shielded for communication circuit lengths greater than 10 feet.
- 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. Fault current on primary conductors can induce significant current, in even shielded communications cables.
- Isolate the communications ports with modems or fiber-optic transceivers such as the SEL-2800 when there is any doubt regarding the use of copper cables.

The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-2100 to other devices. These and other cables are available from SEL. Contact the factory for more information.

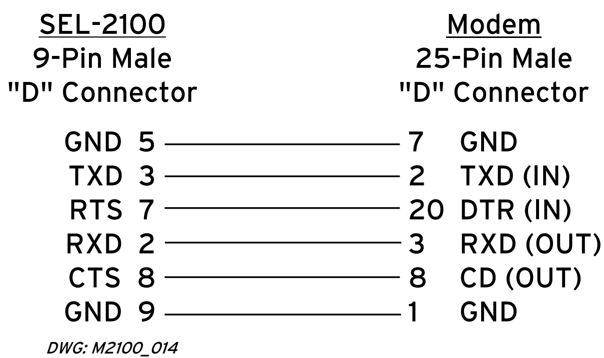
SEL-2100 to Computer

Cable SEL-C234A:



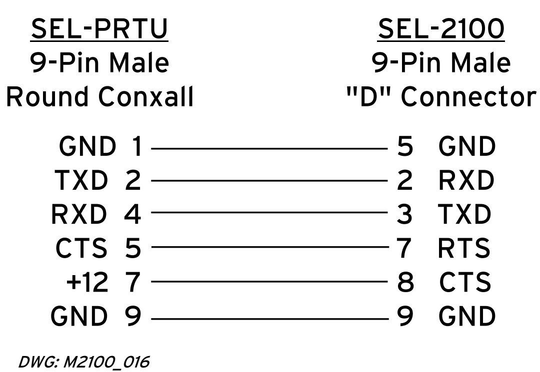
SEL-2100 to Modem

Cable SEL-C222:



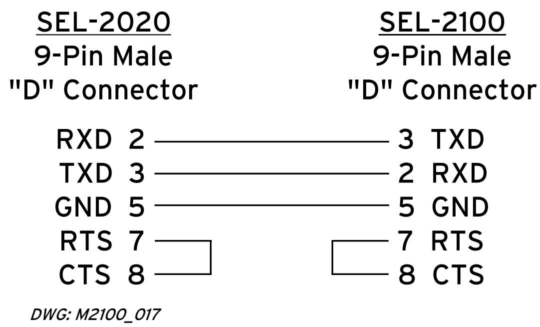
SEL-2100 to SEL-PRTU

Cable SEL-C231:



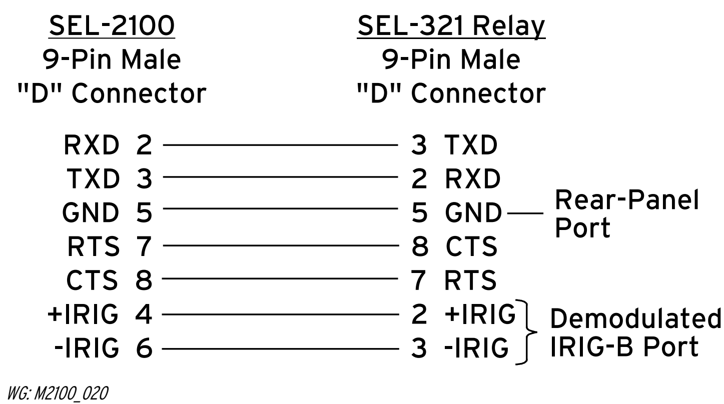
SEL-2100 to SEL-2020

Cable SEL-C272A:

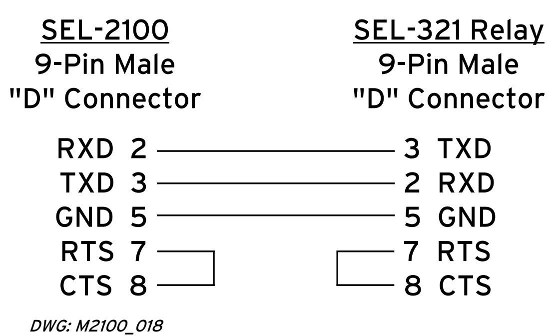


SEL-2100 to SEL-321

Cable SEL-C239 (Data and IRIG-B):



Cable SEL-C272A (Data Only):



SEL-2100 to SEL-351 or SEL-311C

Cable SEL-C273A:

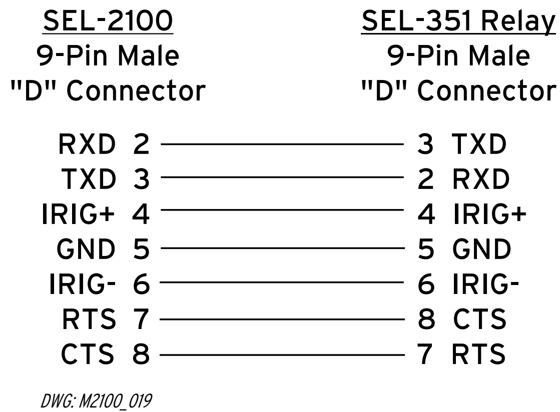


Table 4.9 shows the definitions for all signal names used in the previous cable diagrams.

Table 4.9: Serial Communications Port Pin/Terminal Function Definitions

Pin Function	Definition
N/C	No Connection
+5 Vdc (0.5 A limit)	5 Vdc Power Connection
RXD, RX	Receive Data
TXD, TX	Transmit Data
IRIG-B	IRIG-B Time-Code Input
GND	Ground
SHIELD	Shielded Ground
RTS	Request To Send
CTS	Clear To Send
DCD	Data Carrier Detect
DTR	Data Terminal Ready
DSR	Data Set Ready

For long-distance communications as far as 80 km and for electrical isolation of communications ports, use the SEL-2800 family of fiber-optic transceivers. Contact SEL for more details on these devices.

TABLE OF CONTENTS

TABLES

FIGURES

SECTION 5: SELOGIC CONTROL EQUATIONS AND THE RELAY WORD

INTRODUCTION

SELOGIC® control equations use Boolean logic operators to combine binary values stored in the SEL-2100 Relay Word to create custom protection and control schemes. For example, the SELOGIC control equation

T1P1 = R1P1 + R1P2

sets Transmit MIRRORED BIT® 1 on Port 1 (T1P1) equal to the logical OR (+) of Receive MIRRORED BIT 1 on Ports 1 and 2 (R1P1, R1P2). The other Boolean operators available are logical AND (*), logical inversion (!), and rising and falling edge detectors (/, \). A single level of parenthesis is also available.

This section describes how to write and enter SELOGIC control equation settings for the SEL-2100. SELOGIC in the SEL-2100 is very similar to SELOGIC in the SEL-351 and SEL-311 Relays. If the user is familiar with SELOGIC in either of those products, it is not necessary to read this section.

SELOGIC EQUATION INPUTS AND OUTPUTS

Each SELOGIC control equation has one or more inputs on the right hand side of the equals sign. In the example above, SELOGIC control equation setting T1P1 has inputs R1P1 and R1P2. Inputs to SELOGIC control equations are called Relay Word bits. Each Relay Word bit has a unique name. Table 5.4 and Table 5.5 show the Relay Word bit names and describe their function. Logical one (1) and logical zero (0) are also valid inputs to SELOGIC control equations.

Each SELOGIC equation controls some output or intermediate logic point in the SEL-2100. In the example above, SELOGIC control equation T1P1 controls the value of Transmit MIRRORED BIT 1 on Port 1. The output of most SELOGIC control equations are stored in Relay Word bits with the same name as the SELOGIC control equation. Latch bits and settings group selectors are the exception. Table 5.1 shows all the SELOGIC control equation settings in the SEL-2100, and the resulting Relay Word bits. See ***Section 8: MIRRORED BITS Communications*** for more information about Transmit MIRRORED BIT SELOGIC control equations. See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic*** for more information about the function of the other SELOGIC control equations listed in Table 5.1.

Table 5.1: SELOGIC Control Equations

Operation	SELOGIC Control Equation	Resulting Relay Word Bit
Latch Bit Control	SET1–SET32; RST1–RST32	LT1–LT32
Contact Output Control	OUT101–OUT104	OUT101–OUT104
Transmit MIRRORED BIT Control	T1P*n*–T8P*n*, *n* = 1 to 15	T1P*n*–T8P*n*, *n* = 1 to 15
SELOGIC Variable/Timer	SV1–SV32	SV1–SV32; SV1T–SV32T
Setting Group Selector	SS1–SS6	SG1–SG6
Logic Variable	LV1–LV32	LV1–LV32

SELOGIC CONTROL EQUATION OPERATORS

Table 5.2 lists the SELOGIC control equation operators in the order in which they are processed (top to bottom). The following examples demonstrate the function of each operator.

Table 5.2: SELOGIC Control Equation Operators (Listed in Processing Order)

Operator	Logic Function
/	rising edge detect
\	falling edge detect
( )	parentheses
!	NOT
*	AND
+	OR

SELOGIC Control Equation Parentheses Operator ( )

More than one set of parentheses ( ) can be used in a SELOGIC control equation setting. For example, the following SELOGIC control equation setting has two sets of parentheses:

SV7 = (SV7 + IN101) * (R1P1 + R1P2)

In the above example, the logic within the parentheses is processed first and then the two parentheses resultants are ANDed together. Parentheses cannot be “nested” (parentheses within parentheses) in a SELOGIC control equation setting.

SELOGIC Control Equation NOT Operator !

The NOT operator ! is applied to a single Relay Word bit and also to multiple elements (within parentheses). For example, in the SELOGIC control equation setting

T1P2 = !(R1P3 + R1P4) * !IN102

the NOT operator in front of IN102 logically inverts IN102. IN102 must be deasserted for T1P2 to assert. The NOT operator in front of the parenthetical term (R1P3 + R1P4) inverts the entire term. (R1P3 + R1P4) must evaluate to a logical 0 for T1P2 to assert.

SELOGIC Control Equation Rising and Falling Edge Operators / and \

In the following SELOGIC control equation, Latch 1 is set and reset using rising and falling edge operators:

SET1 = /IN101

RST1 = \R3P3

When IN101 transitions from logical 0 to logical 1, /IN101 pulses from logical 0 to logical 1 for one processing interval (four or five ms). When IN101 transitions from logical 1 to logical 0, /IN101 does not assert. Note there is a one processing interval delay associated with the rising and falling edge operators as shown in Figure 5.1.

When R3P3 transitions from logical 1 to logical 0, \R3P3 pulses to logical 1 for one processing interval. When R3P3 transitions from logical 0 to logical 1, \R3P3 does not assert.

Rising and falling edge operators are particularly useful in latching logic. In the example of Figure 5.1, Latch Bit 1 resets when R3P3 deasserts. The falling edge operator on \R3P3 in the SELOGIC control equation setting for RST1 limits the duration of the reset pulse to one processing interval, regardless of how long R3P3 is deasserted. Thus, asserting IN101 sets Latch Bit 1 even if R3P3 is deasserted.

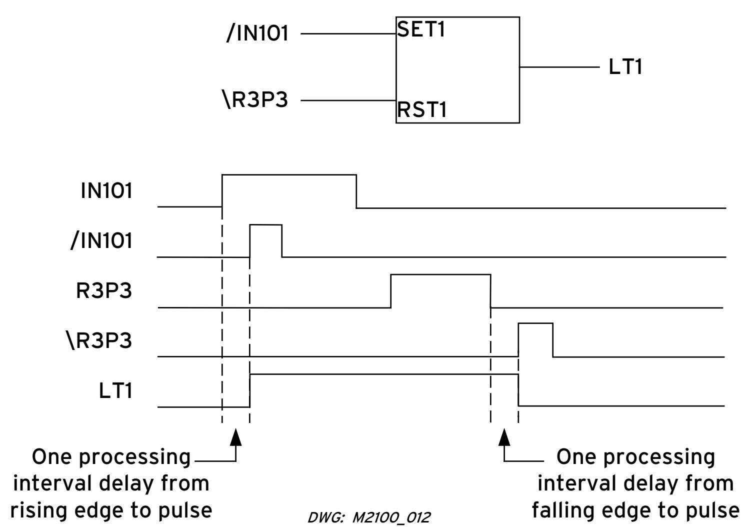


Figure 5.1: Result of Rising and Falling Edge Operators Used to Set and Reset Latch Bit 1

Note: The rising and falling edge operators / and \ are applied to individual Relay Word bits only, not to groups of elements within parentheses.

All SELOGIC Control Equations Must Be Set

All SELOGIC control equations are set in one of the following ways (they cannot be "blank"):

- Single Relay Word bit (e.g., OUT101 = ROK1)
- Combination of Relay Word bits (e.g., T3P1 = ROK2 * ROK4)
- Directly to logical 1 (e.g., T4P5 = 1)
- Directly to logical 0 (e.g., T4P5 = 0)

SELOGIC Control Equation Limitations

Any single SELOGIC control equation setting in the SEL-2100 allows as many as 20 Relay Word bits combined with the SELOGIC control equation operators listed in Table 5.2. For expressions that require more than 20 Relay Word bits, use a SELOGIC variable (SELOGIC control equation settings SV1 through SV32) or a SELOGIC intermediate logic variable (SELOGIC control equation settings LV1 through LV32) as an intermediate setting step.

For example, assume that the SELOGIC control equation contact output setting OUT101 should be asserted when Receive MIRRORED BIT 1 on any port asserts, or when any contact input asserts. This would require 31 Relay Word bits in the setting for OUT101, which is not allowed. Instead of placing 31 Relay Word bits into OUT101, program some of them into the SELOGIC control equation setting SV1. Next, use the resultant SELOGIC control equation variable output (Relay Word bit SV1) in the SELOGIC control equation contact output setting OUT101.

SV1 = R1P1 + R1P2 + … + R1P15

OUT101 = SV1 + IN101 + IN102 + IN103 + … + IN116

SELOGIC control equation settings that are set directly to 1 (logical 1) or 0 (logical 0) count as one Relay Word bit.

After the SEL-2100 saves new SELOGIC control equation settings, it responds with the following message:

xxx Elements and yy Edges remain available

indicating that "xxx" Relay Word bits can still be used and "yy" rising or falling edge operators can still be applied in the SELOGIC control equations for the particular settings group.

PROCESSING INTERVAL

The standard processing interval for the SEL-2100 is 4 ms. With more than 10 MIRRORED BIT ports enabled at or above 19,200 baud, the SEL-2100 adds 1 ms to the processing interval. When less than 700 elements or 116 edges are available in the active SELOGIC settings, the SEL-2100 adds 1 ms to the processing interval. To see how fast the SEL-2100 is presently processing, view the "Processing Interval" field in the STATUS report with the **STA** command.

Table 5.3 summarizes the relationship between port settings, SELOGIC element and edge availability, and processing interval.

Table 5.3: SEL-2100 SELOGIC Control Equation Capacity*

Table Row	Number of MIRRORED BITS ports with SPEED ≥ 19,200 baud	Number of SELOGIC Elements		Number of SELOGIC Edges		Resulting Processing Interval**
		In use	Available	In use	Available	
1	< 10	≤ 600	≥ 700	≤ 100	≥ 116	4 ms
2	< 10	≤ 1300	< 700	≤ 216	< 116	5 ms
3	≥ 10	≤ 600	≥ 700	≤ 100	≥ 116	5 ms
4	≥ 10	≤ 1300	< 700	≤ 216	< 116	6 ms

* SELOGIC capacity is reduced when an Advanced Application Logic module is loaded. Refer to the Advanced Application Logic module documentation for details—see ***Appendix K: Advanced Application Logic***.

** If two results are indicated by the elements and edges entries, use the greater processing interval.

Example Processing Interval Determination

Five MIRRORED BITS ports are configured at 19200 baud, six MIRRORED BITS ports are configured at 9600 baud, and four ports are unused. After entering some logic settings with the **SET L** command, the SEL-2100 reports as follows:

```
=>>SET L<Enter>
   .
   .
   .

Save Changes(Y/N)? y

822 Elements and 112 Edges remain available.

Settings saved
=>>
```

Use Table 5.3 to determine the processing interval. Choose Row 2 of the table for the following reasons:

- Only five ports set to MIRRORED BITS protocol have SPEED ≥ 19200 baud; which indicates Row 1 or Row 2 of Table 5.3
- There are 822 elements available; which indicates Row 1
- There are 112 edges available; which indicates Row 2.

The greater interval, 5 ms in this example, is valid, as instructed in the table footnote.

PROCESSING ORDER

The SELOGIC control equation settings and resultant Relay Word bits are processed in the order shown in Table 5.4 (top to bottom).

The SEL-2100 updates Relay Word bits every 4 to 6 ms, depending upon MIRRORED BIT port settings and SELOGIC Settings described in Table 5.3.

When a Relay Word bit asserts or deasserts it retains that state (logical 1 or logical 0) until it is updated again in the next processing interval.

RELAY WORD BITS

The Relay Word bit row numbers shown in Table 5.4 correspond to the row numbers used in the TAR command (see ***TAR Command [Display Relay Element Status]*** in ***Section 4: Serial Port Communications and Commands***).

Table 5.4: SEL-2100 Relay Word Bits

Row	Relay Word Bits							
0	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
1	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16
2	RB17	RB18	RB19	RB20	RB21	RB22	RB23	RB24
3	RB25	RB26	RB27	RB28	RB29	RB30	RB31	RB32
4	IN108	IN107	IN106	IN105	IN104	IN103	IN102	IN101
5	IN116	IN115	IN114	IN113	IN112	IN111	IN110	IN109
6	ROK8	ROK7	ROK6	ROK5	ROK4	ROK3	ROK2	ROK1
7	*	ROK15	ROK14	ROK13	ROK12	ROK11	ROK10	ROK9
8	LBOK8	LBOK7	LBOK6	LBOK5	LBOK4	LBOK3	LBOK2	LBOK1
9	*	LBOK15	LBOK14	LBOK13	LBOK12	LBOK11	LBOK10	LBOK9
10	R8P1	R7P1	R6P1	R5P1	R4P1	R3P1	R2P1	R1P1
11	R8P2	R7P2	R6P2	R5P2	R4P2	R3P2	R2P2	R1P2
12	R8P3	R7P3	R6P3	R5P3	R4P3	R3P3	R2P3	R1P3
13	R8P4	R7P4	R6P4	R5P4	R4P4	R3P4	R2P4	R1P4
14	R8P5	R7P5	R6P5	R5P5	R4P5	R3P5	R2P5	R1P5
15	R8P6	R7P6	R6P6	R5P6	R4P6	R3P6	R2P6	R1P6
16	R8P7	R7P7	R6P7	R5P7	R4P7	R3P7	R2P7	R1P7
17	R8P8	R7P8	R6P8	R5P8	R4P8	R3P8	R2P8	R1P8

Row	Relay Word Bits							
18	R8P9	R7P9	R6P9	R5P9	R4P9	R3P9	R2P9	R1P9
19	R8P10	R7P10	R6P10	R5P10	R4P10	R3P10	R2P10	R1P10
20	R8P11	R7P11	R6P11	R5P11	R4P11	R3P11	R2P11	R1P11
21	R8P12	R7P12	R6P12	R5P12	R4P12	R3P12	R2P12	R1P12
22	R8P13	R7P13	R6P13	R5P13	R4P13	R3P13	R2P13	R1P13
23	R8P14	R7P14	R6P14	R5P14	R4P14	R3P14	R2P14	R1P14
24	R8P15	R7P15	R6P15	R5P15	R4P15	R3P15	R2P15	R1P15
25	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8
26	SV1	SV2	SV3	SV4	SV1T	SV2T	SV3T	SV4T
27	SV5	SV6	SV7	SV8	SV5T	SV6T	SV7T	SV8T
28	SV9	SV10	SV11	SV12	SV9T	SV10T	SV11T	SV12T
29	SV13	SV14	SV15	SV16	SV13T	SV14T	SV15T	SV16T
30	SV17	SV18	SV19	SV20	SV17T	SV18T	SV19T	SV20T
31	SV21	SV22	SV23	SV24	SV21T	SV22T	SV23T	SV24T
32	SV25	SV26	SV27	SV28	SV25T	SV26T	SV27T	SV28T
33	SV29	SV30	SV31	SV32	SV29T	SV30T	SV31T	SV32T
34	LV1	LV2	LV3	LV4	LV5	LV6	LV7	LV8
35	LV9	LV10	LV11	LV12	LV13	LV14	LV15	LV16
36	LV17	LV18	LV19	LV20	LV21	LV22	LV23	LV24
37	LV25	LV26	LV27	LV28	LV29	LV30	LV31	LV32
38	OUT101	OUT102	OUT103	OUT104	*	*	*	*
39	*	*	*	*	*	*	*	*
40	SS1	SS2	SS3	SS4	SS5	SS6	ALARM	IRIGOK
41	SG1	SG2	SG3	SG4	SG5	SG6	*	*
42	T8P1	T7P1	T6P1	T5P1	T4P1	T3P1	T2P1	T1P1
43	T8P2	T7P2	T6P2	T5P2	T4P2	T3P2	T2P2	T1P2
44	T8P3	T7P3	T6P3	T5P3	T4P3	T3P3	T2P3	T1P3
45	T8P4	T7P4	T6P4	T5P4	T4P4	T3P4	T2P4	T1P4
46	T8P5	T7P5	T6P5	T5P5	T4P5	T3P5	T2P5	T1P5
47	T8P6	T7P6	T6P6	T5P6	T4P6	T3P6	T2P6	T1P6
48	T8P7	T7P7	T6P7	T5P7	T4P7	T3P7	T2P7	T1P7
49	T8P8	T7P8	T6P8	T5P8	T4P8	T3P8	T2P8	T1P8

Row	Relay Word Bits							
50	T8P9	T7P9	T6P9	T5P9	T4P9	T3P9	T2P9	T1P9
51	T8P10	T7P10	T6P10	T5P10	T4P10	T3P10	T2P10	T1P10
52	T8P11	T7P11	T6P11	T5P11	T4P11	T3P11	T2P11	T1P11
53	T8P12	T7P12	T6P12	T5P12	T4P12	T3P12	T2P12	T1P12
54	T8P13	T7P13	T6P13	T5P13	T4P13	T3P13	T2P13	T1P13
55	T8P14	T7P14	T6P14	T5P14	T4P14	T3P14	T2P14	T1P14
56	T8P15	T7P15	T6P15	T5P15	T4P15	T3P15	T2P15	T1P15
57	LP9	LP10	LP11	LP12	LP13	LP14	LP15	LP16
58	LT1	LT2	LT3	LT4	LT5	LT6	LT7	LT8
59	LT9	LT10	LT11	LT12	LT13	LT14	LT15	LT16
60	LT17	LT18	LT19	LT20	LT21	LT22	LT23	LT24
61	LT25	LT26	LT27	LT28	LT29	LT30	LT31	LT32
62	RBAD8	RBAD7	RBAD6	RBAD5	RBAD4	RBAD3	RBAD2	RBAD1
63	*	RBAD15	RBAD14	RBAD13	RBAD12	RBAD11	RBAD10	RBAD9
64	CBAD8	CBAD7	CBAD6	CBAD5	CBAD4	CBAD3	CBAD2	CBAD1
65	*	CBAD15	CBAD14	CBAD13	CBAD12	CBAD11	CBAD10	CBAD9
66	RB33	RB34	RB35	RB36	RB37	RB38	RB39	RB40
67	RB41	RB42	RB43	RB44	RB45	RB46	RB47	RB48
68	RB49	RB50	RB51	RB52	RB53	RB54	RB55	RB56
69	RB57	RB58	RB59	RB60	RB61	RB62	RB63	RB64

Table 5.5: Relay Word Bit Definitions for the SEL-2100

Row	Bit	Definition	Primary Application
0, 1, 2, 3	RB*n*	Where *n* = 1–32 Remote Bit *n* Asserted (See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic***)	Control via serial port
4	IN108	Optoisolated input IN108 asserted (See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic***)	Status, control via optoisolated inputs
	IN107	Optoisolated input IN107 asserted	
	IN106	Optoisolated input IN106 asserted	
	IN105	Optoisolated input IN105 asserted	
	IN104	Optoisolated input IN104 asserted	

Row	Bit	Definition	Primary Application
	IN103	Optoisolated input IN103 asserted	
	IN102	Optoisolated input IN102 asserted	
	IN101	Optoisolated input IN101 asserted	
5	IN116	Optoisolated input IN116 asserted	
	IN115	Optoisolated input IN115 asserted	
	IN114	Optoisolated input IN114 asserted	
	IN113	Optoisolated input IN113 asserted	
	IN112	Optoisolated input IN112 asserted	
	IN111	Optoisolated input IN111 asserted	
	IN110	Optoisolated input IN110 asserted	
	IN109	Optoisolated input IN109 asserted	
6, 7	ROK*n*	Where *n* = 1–15 Port *n* received data ok (See ***Section 8: MIRRORED BITS Communications***)	MIRRORED BITS channel monitoring
8,9	LBOK*n*	Where *n* = 1–15 Port *n* looped back ok	
10–24	R*x*P*y*	Where *x* = 1–8 and *y* = 1–15 Receive MIRRORED BIT *x*, Port *y*	Status, control, and protection via Received MIRRORED BITS
25	LP*n*	Where *n* = 1–8 Logic Point *n* asserted. Reserved for use by Advanced Application Logic. (See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic***)	
26–33	SV*n*	Where *n* = 1–32 SELOGIC control equation variable timer input SV*n* asserted	Testing, seal-in functions, etc.
	SV*n*T	SELOGIC control equation variable timer output SV*n*T asserted	Control
34–37	LV*n*	Where *n* = 1–32 Logic Variable equation LV*n* asserted	
38	OUT101	Output contact OUT101 asserted (See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic***)	
	OUT102	Output contact OUT102 asserted	
	OUT103	Output contact OUT103 asserted	

Row	Bit	Definition	Primary Application
	OUT104	Output contact OUT104 asserted	
40	SS1	Go to (or remain in) setting Group 1 (See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic***)	
	SS2	Go to (or remain in) setting Group 2	
	SS3	Go to (or remain in) setting Group 3	
	SS4	Go to (or remain in) setting Group 4	
	SS5	Go to (or remain in) setting Group 5	
	SS6	Go to (or remain in) setting Group 6	
	ALARM	ALARM Bit (See Table 9.1 in ***Section 9: Maintenance and Troubleshooting***)	
	IRIGOK	Asserts when IRIG-B is connected and SEL-2100 is time synchronized	
41	SG1	Setting group 1 active (See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic***)	Indication
	SG2	Setting group 2 active	
	SG3	Setting group 3 active	
	SG4	Setting group 4 active	
	SG5	Setting group 5 active	
	SG6	Setting group 6 active	
	*		
42–56	T*x*P*y*	Where *x* = 1–8 and *y* = 1–15 Transmit MIRRORED BIT *x*, Port *y* (See ***Section 8: MIRRORED BITS Communications***)	Status, control, and protection via MIRRORED BITS
57	LP*n*	Where *n* = 9–16 Logic Point *n* asserted. Reserved for use by Advanced Application Logic. (See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic***)	
58–61	LT*n*	Where *n* = 1–32 Latch Bit *n* asserted. (See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic***)	Control–replacing traditional latching relays

Row	Bit	Definition	Primary Application
62–63	RBAD*n*	Where *n* = 1–15 Port *n* outage duration over threshold (See ***Section 8: MIRRORED BITS Communications***)	MIRRORED BITS channel monitoring
64–65	CBAD*n*	Where *n* = 1–15 Port *n* channel unavailability over threshold	
66-69	RB*n*	Where *n* = 33–64 Remote Bit *n* Asserted (See ***Section 6: Inputs, Outputs, Timers, and Other Control Logic***)	Control via serial port

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TABLES

FIGURES

SECTION 6: INPUTS, OUTPUTS, TIMERS, AND OTHER CONTROL LOGIC

This section explains the settings and operation of:

Optional optoisolated inputs	IN101–IN116
Contact outputs	OUT101–OUT104
Remote bits	RB1–RB64
Latch bits	LT1–LT32
Logic variables	LV1–LV32
Logic points	LP1–LP16
Settings group selectors	SS1–SS6
SELOGIC® variables/timers	SV1–SV32, SV1T–SV32T
Optional output contacts	OUT101–OUT104

OPTOISOLATED INPUTS

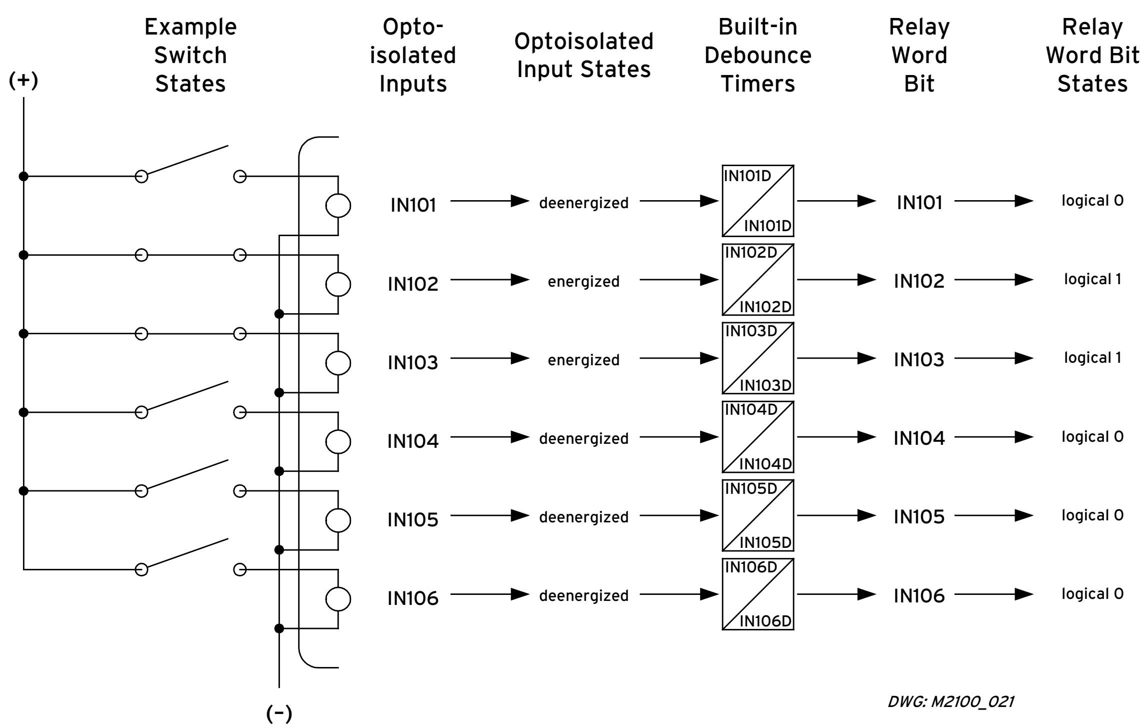

Figure 6.1: Example Operation of Optoisolated Inputs IN101 Through IN106

Apply rated dc voltage of either polarity to activate optoisolated inputs.

Inputs can be individually configured to sense ac voltages by making the "AC" selection for the corresponding input debounce timer in global settings. For more information, see the ***Input Debounce Timers*** subsection.

To verify that Relay Word bits IN102 and IN103 are asserted in the example shown in Figure 6.1, use the **TAR** command. In this example, both Relay Word bits of interest are in the same Relay Word row, so one command shows the status of both.

```
=>>TAR IN102 <Enter>
IN108  IN107  IN106  IN105  IN104  IN103  IN102  IN101
0      0      0      0      0      1      1      0
=>>
```

The "1" under IN103 and IN102 indicates the output of the debounce timers for those contact inputs are asserted. The "0" under the other Relay Word bits in that row indicate the output of the debounce timers for those contact inputs are deasserted.

Input Debounce Timers

In Figure 6.1, closed switches apply rated control voltage to optoisolated inputs IN102 and IN103. This energizes inputs IN102 and IN103, which asserts the input to the debounce timers for those two inputs. Debounce timer settings are "global" settings, which means they are the same for all setting groups. Change global settings with the **SET G** command.

```
==>SET G IN102D <Enter>

Global Settings:
Input IN102 Debounce in ms(AC, 0-15)            IN102D= 4         ?
```

The debounce time (0–15 ms) is used for both the pickup and the dropout delay of the debounce timer. For example, if rated input voltage is applied to contact input IN102 for longer than global setting IN102D, Relay Word bit IN102 asserts. If voltage is then removed from contact input IN102 for longer than setting IN102D, Relay Word bit IN102 deasserts.

DC Control Signals

The input debounce timers are set in increments of 1 ms. The SEL-2100 processes the input debounce timers every millisecond. In a standard relay shipment, all contact input debounce timers are set for 4 ms.

AC Control Signals

The ac setting allows the input to sense ac control signals. The input has a maximum pickup time of 16 ms and a maximum dropout time of 20 ms. The ac setting qualifies the input by not asserting until two successive 1 ms input samples are higher than the optoisolated input voltage threshold and not deasserting until sixteen successive 1 ms samples are lower than the optoisolated input voltage threshold.

Optoisolated Input Voltage Ranges

The nominal contact input voltage for the SEL-2100 is specified at order time. Five ranges are available, as shown in Table 6.1.

Table 6.1: Optoisolated Input Voltage Range

Nominal Voltage (Vdc)	Operating Range (Vdc)	Operating Range (Vac)
24	15–30	13.0–30.0
48	38.4–60	33.2–60.0
110	88–132	76.1–132.0
125	105–150	90.7–150.0
250	200–300	172.9–300.0

Settings Examples

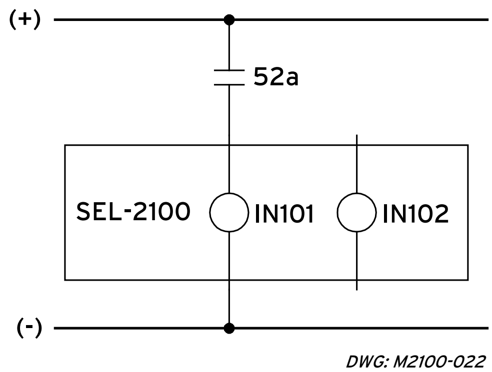

Figure 6.2: Circuit Breaker Auxiliary Contact Connected to Optoisolated Input IN101

For this example, Relay Word bit IN101 transmits the status of a circuit breaker to a remote device via Transmit MIRRORED BIT® 5 on Port 8:

T5P8 = IN101

With this logic setting and wiring, Transmit MIRRORED BIT 5 on Port 8 asserts whenever the circuit breaker is "closed." Use this information at the remote end to activate an indicator light on a control panel, or use it in a protection scheme.

If only a 52b circuit breaker auxiliary contact is available, change the setting as follows:

T5P8 = !IN101 [!IN101 = NOT(IN101)]

In that case, T5P8 still asserts (logical 1) whenever the circuit breaker is closed.

Contact Outputs

SELOGIC control equations OUT101–OUT104 control four optional contact outputs. Form A contacts close when the corresponding SELOGIC control equation asserts. See ***Optional Contact Output Jumpers*** in ***Section 2: Installation*** for instructions to change contact outputs to form B.

The SEL-2100 contact outputs are trip rated. See ***Appendix G: Specifications*** for more information.

REMOTE BITS

Remote bits emulate control switches and are operated via a serial communications port set for SEL-ASCII, LMD, or DNP protocols. The following diagram is a schematic representation of a remote bit.

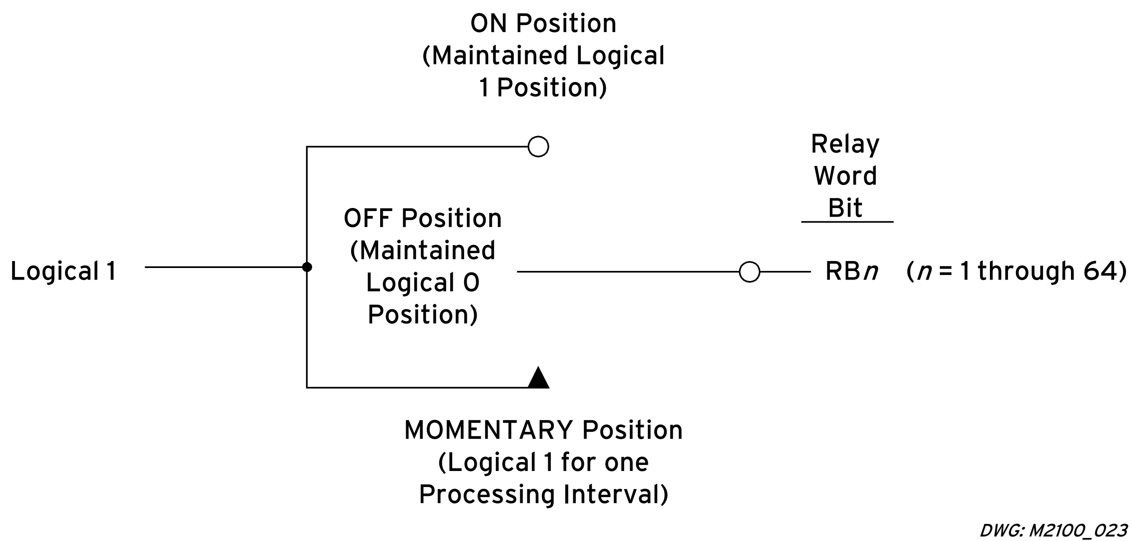

Figure 6.3: Remote Bits RB1 Through RB64

The SEL-2100 supports 64 remote bits, RB1 through RB64. Use remote bits as inputs to SELOGIC control equations to replace remote control switches.

Remote Bit Control

SCADA Control of Remote Bits

SCADA systems use remote bits to emulate remote control switches. A SCADA system would probably use the Fast Operate protocol described in ***Appendix E: Fast Meter Protocol*** to control remote bits. The ASCII commands described next are typically used to test control schemes using remote bits.

Set Remote Bit (Turn a Remote Bit ON)

To set or turn on a remote bit, (e.g., RB1), type **CON 1 <Enter>**. The relay prompts "CONTROL RB1:". Then type **SRB 1 <Enter>**.

```
=>>CON 1 <Enter>
CONTROL RB1: SRB 1 <Enter>
=>>
```

Verify the remote bit is set with the **TAR RB1** command, if desired.

Clear A Remote Bit (Turn a Remote Bit OFF)

To clear or turn off a remote bit, (e.g., RB1), type **CON 1 <Enter>**. The relay prompts “CONTROL RB1:”. Then type **CRB 1 <Enter>**.

```
=>>CON 1 <Enter>
CONTROL RB1: CRB 1 <Enter>
=>>
```

Pulse a Remote Bit (Momentarily Turn a Remote Bit ON)

To pulse or momentarily turn on a remote bit, (e.g., RB1), type **CON 1 <Enter>**. The relay prompts “CONTROL RB1:”. Then type **PRB 1 <Enter>**.

```
=>>CON 1 <Enter>
CONTROL RB1: PRB 1 <Enter>
=>>
```

Remote Bit Applications

See the following discussion of latch bits for an application example of remote bits.

Remote Bit States Not Retained When Power Is Lost

All remote bits (Relay Word bits RB1 through RB64) deassert if power to the SEL-2100 is removed and then restored.

Remote Bit States Retained When Settings Changed or Active Setting Group Changed

The state of each remote bit is retained if relay settings are changed or if the active setting group is changed.

LATCH BITS

The latch bits in the SEL-2100 operate the same as traditional latching relays. All latch bits states are retained through a loss of power and settings changes.

The SEL-2100 supports 32 latch bits, LT1 through LT32 with set conditions SET1 through SET32 and reset conditions RST1 through RST32. Assert the set input to close or set the latch. Assert the reset input to open or reset the latch.

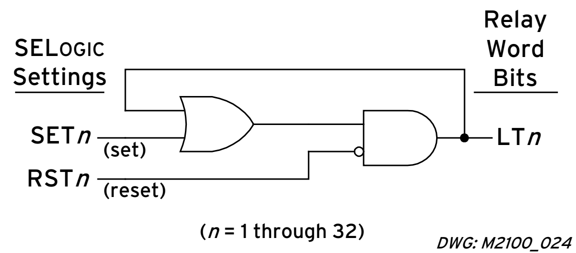

Figure 6.4: Latch Control Switches Drive Latch Bits LT1 Through LT32

Note that in Figure 6.4, RST*n* has priority over SET*n*. So if both RST*n* and SET*n* are asserted, Latch Bit LT*n* is reset.

Latch Bit States Retained When Power Is Lost

The state of each latch bit (Relay Word bits LT1 through LT32) is retained if power to the SEL-2100 is lost and then restored.

Note: Make Latch Control Switch Settings With Care

The latch bit states are stored in nonvolatile memory so they can be retained during power loss, settings change, or active setting group change. The nonvolatile memory is rated for a finite number of “writes” for all cumulative latch bit state changes. Exceeding the limit can result in an EEPROM self-test failure. An average of 150 cumulative latch bit state changes per day can be made for a 25-year relay service life.

This requires that SELOGIC control equation settings SET*n* and RST*n* for any given Latch Bit LT*n* be set with care. Settings SET*n* and RST*n* cannot result in continuous cyclical operation of Latch Bit LT*n*. Use timers to qualify conditions set in settings SET*n* and RST*n*. If any optoisolated inputs IN101 through IN116 are used in settings SET*n* and RST*n*, the inputs have their own debounce timer that can help in providing the necessary time qualification.

Latch Bit States Retained When Settings Changed or Active Setting Group Changed

The state of each latch bit is retained if relay settings are changed or if the active setting group is changed.

Latch Bit Application Ideas

Combine latch bits and remote bits to provide an alarm annunciator. Use the logical OR of a remote bit and a control input as a reset source. Acknowledge the alarm from the serial port, or externally from a contact input.

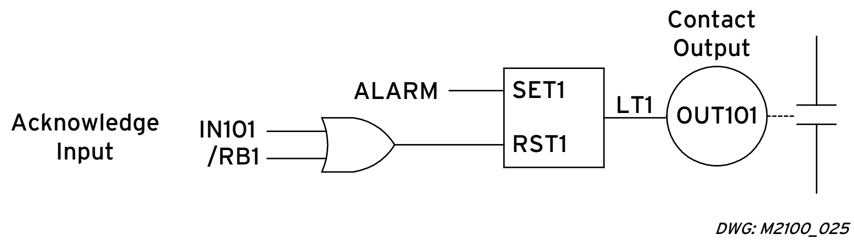

Figure 6.5: Latch Bit Forms Alarm Annunciator

The SELOGIC control equations for Figure 6.5 are as follows:

OUT101 = LT1

SET1 = ALARM

RST1 = /RB1 + IN101

For this application, relay OUT101 closes whenever the ALARM bit asserts and IN101 is deasserted. The alarm relay is latched and maintained until the alarm condition clears and the alarm is acknowledged either by energizing control input IN101 OR by asserting remote bit RB1. The rising-edge detect on RB1 prevents RB1 from blocking the alarm. IN101 is allowed to block the alarm. This allows a local control switch to turn the alarm off by asserting IN101 until the alarm condition is rectified.

SELOGIC VARIABLES/TIMERS

The SEL-2100 supports 32 SELOGIC Variables/Timers, SV1 through SV32. Figure 6.6 shows the timer inputs and outputs.

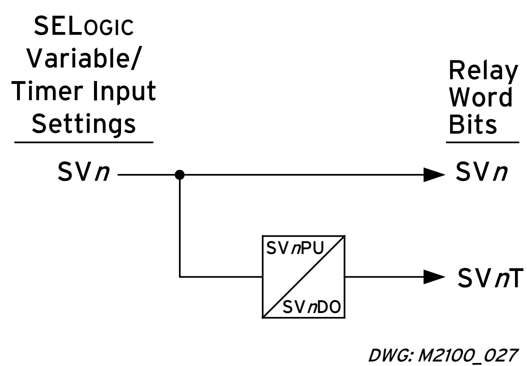

Figure 6.6: SELOGIC Control Equation Variables/Timers

SELOGIC timer pickup/dropout settings for SELOGIC variables SV1T to SV6T have settings ranges from 0 to 999,999 ms. SELOGIC timer pickup/dropout settings for SELOGIC variables SV7T through SV32T have settings ranges from 0 to 32,000 ms.

It is important to note that although the timer setting resolution is 1.0 ms, the timer operates in steps based on the SEL-2100 processing interval. A pickup timer setting of 0 ms allows input SV*n* to propagate through to output SV*n*T without delay. A pickup timer setting of 1 through 4 ms allows input SV*n* to propagate through to output SV*n*T after a delay of one processing interval. A pickup timer setting of 5–8 ms allows input SV*n* to propagate through to output SV*n*T after two processing intervals. This discussion applies to an SEL-2100 processing every 4 ms.

The SEL-2100 updates Relay Word bits every 4 to 6 ms, depending upon MIRRORED BIT port settings and SELOGIC settings.

The standard processing interval for the SEL-2100 is 4 ms. With more than 10 MIRRORED BIT ports enabled at or above a baud rate of 19200, the SEL-2100 adds 1 ms to the processing interval. When less than 700 elements or 116 edges are available in the active SELOGIC settings, the SEL-2100 adds 1 ms to the processing interval. Use the status (**STA**) command to verify the processing interval.

Table 6.2 shows the effects of different SELOGIC timer pickup and dropout settings when the SEL-2100 processing interval is 4 ms, 5 ms, or 6 ms.

Table 6.2: Effect of Processing Interval on SELOGIC Variable Timer Operation

Delay (Processing Intervals)	SV*n*PU or SV*n*DO Setting with 4 ms Processing Interval	SV*n*PU or SV*n*DO Setting with 5 ms Processing Interval	SV*n*PU or SV*n*DO Setting with 6 ms Processing Interval
0	0	0	0
1	1 through 4	1 through 5	1 through 6
2	5 through 8	6 through 10	7 through 12
3	9 through 12	11 through 15	13 through 18
…	…	…	…

LOGIC VARIABLES

The SEL-2100 supports 32 logic variables (LV1 through LV32).

These logic variables are the same as SELOGIC variables, except they do not have pickup/dropout timers. Use logic variables as intermediate SELOGIC terms, which help break one long, complex SELOGIC setting into more than one smaller, simpler expressions.

Logic Variable Application Ideas

Use a logic variable when more than 20 elements are required in a SELOGIC setting. The ***Sectionalized Bus Protection with Looped Feeders*** example in ***Section 3: Applications Examples*** demonstrates how to use a logic variable to break a long SELOGIC setting into multiple smaller settings.

LOGIC POINTS

The SEL-2100 reserves Logic Point 1 through Logic Point 16 (LP1–LP16) for use by Advanced Application Logic modules. If no module is loaded into the SEL-2100, Relay Word bits LP1–LP16 are nonfunctional, and will remain in a deasserted state. If an Advanced Application Logic module is loaded, the logic point Relay Word bits LP1–LP16 might be functional, depending on the design of the specific module.

Advanced Application Logic modules can alter the operation of some Relay Word bits. The main body of this instruction manual contains information for an SEL-2100 with no installed Advanced Application Logic modules. A new appendix is added for each Advanced Application Logic module, with details on affected Relay Word bits if the module alters these logic-processor elements. See ***Appendix K: Advanced Application Logic*** for more information on Advanced Application Logic modules.

MULTIPLE SETTING GROUPS

The SEL-2100 has six (6) independent setting groups. Each setting group also has independent SELOGIC control equation settings.

Active Setting Group Indication

Only one setting group can be active at a time. Relay Word bits SG1 through SG6 indicate the active setting group as shown in Table 6.3.

Table 6.3: Relay Word Bits SG1 Through SG6 Indicate Active Setting Group

Relay Word Bit	Definition
SG1	Asserts when setting Group 1 is the active setting group
SG2	Asserts when setting Group 2 is the active setting group
SG3	Asserts when setting Group 3 is the active setting group
SG4	Asserts when setting Group 4 is the active setting group
SG5	Asserts when setting Group 5 is the active setting group
SG6	Asserts when setting Group 6 is the active setting group

For example, if setting Group 4 is the active setting group, Relay Word bit SG4 asserts (logical 1) and all other SG*n* Relay Word bits are deasserted (logical 0).

Selecting the Active Setting Group

Select the active setting group with:

- SELOGIC control equation settings SS1 through SS6.
- Serial port **GROUP** command (**GRO 1** through **GRO 6**).

SELOGIC control equation settings SS1 through SS6 shown in Table 6.4 have priority over the serial port **GROUP** command in selecting the active setting group. If SS4 is asserted and the presently active setting group is 4, then the setting group cannot be changed with the serial port **GROUP** command.

Settings group selectors SS1 through SS6 are qualified for a time equal to global setting TGR. If SS1 through SS6 assert for a time less than TGR, then the settings group does not change. Set TGR from 0 to 500 seconds.

Table 6.4: Definitions for Active Setting Group Switching SELOGIC Control Equation Settings SS1 Through SS6

Setting	Definition
SS1	Go to (or remain in) setting Group 1
SS2	Go to (or remain in) setting Group 2
SS3	Go to (or remain in) setting Group 3
SS4	Go to (or remain in) setting Group 4
SS5	Go to (or remain in) setting Group 5
SS6	Go to (or remain in) setting Group 6

Assume the active setting group starts out as setting Group 3. Corresponding Relay Word bit SG3 asserts indicating that setting Group 3 is the active setting group (see Table 6.3).

With setting Group 3 as the active setting group, setting SS3 has priority. If setting SS3 is asserted to logical 1, setting Group 3 remains the active setting group, regardless of the activity of settings SS1, SS2, SS4, SS5, and SS6, and regardless of the use of the **GROUP** command. With settings SS1 through SS6 all deasserted to logical 0, setting Group 3 still remains the active setting group.

With setting Group 3 as the active setting group, if SS3 deasserts to logical 0 and setting SS5 asserts to logical 1, the relay switches from setting Group 3 to setting Group 5, after qualifying SS5 for time TGR.

SEL-2100 Disabled Momentarily During Active Setting Group Change

The SEL-2100 is disabled for a few seconds while in the process of changing active setting groups.

Active Setting Group Switching Example

Use a single optoisolated input to switch between two setting groups in the SEL-2100. In this example, optoisolated input IN105 on the SEL-2100 is connected to a SCADA contact. Each pulse of the SCADA contact changes the active setting group from one setting group (e.g., setting Group 1) to another (e.g., setting Group 4). The SCADA contact is not maintained, rather it is just pulsed to switch from one active setting group to another.

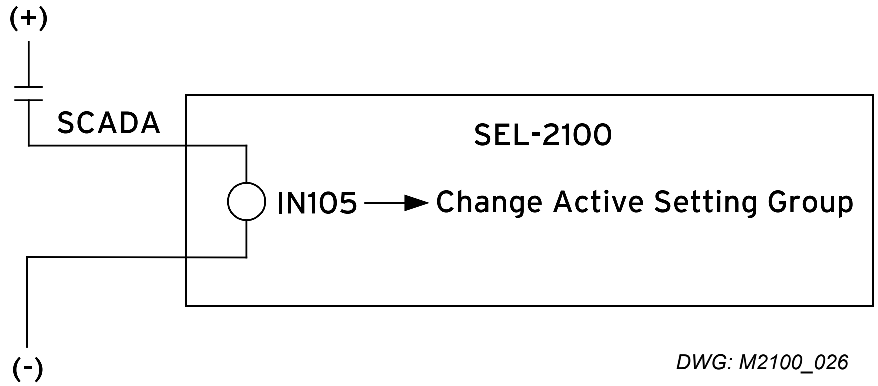

Figure 6.7: SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4

The following SELOGIC control equation settings in the SEL-2100 accomplish this group switch.

Table 6.5: SELOGIC Control Equation Settings for Switching Active Setting Group Between Setting Groups 1 and 4

Setting Group 1	Setting Group 4
SV8 = SG1	SV8 = SG4
SS1 = 0	SS1 = IN105 * SV8T
SS2 = 0	SS2 = 0
SS3 = 0	SS3 = 0
SS4 = IN105 * SV8T	SS4 = 0
SS5 = 0	SS5 = 0
SS6 = 0	SS6 = 0

Contact input IN105 must be pulsed longer than global setting TGR. If contact input IN105 is pulsed for less time than TGR, no setting change will take place. However, if contact input IN105 is still asserted when the SEL-2100 enters the new setting group, and it remains asserted for longer than time TGR after the settings group is changed, the settings group would change back to the original group. To prevent multiple group changes for a single contact pulse, the settings group selectors SS1 and SS4 are qualified with SELOGIC variable SV8T in this example. SV8T begins to time when the settings group changes to Group 1 or Group 4. SV8T prevents changing the group again until the timer expires after time SV8PU. With SV8PU set longer than the longest SCADA contact pulse width, only one group change occurs for each contact pulse.

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SECTION 7: SEQUENTIAL EVENTS RECORDER

INTRODUCTION

The Sequential Events Recorder (SER) records state changes of user-selected Relay Word bits. The SER logs the Relay Word bit name, new state, and time stamp in a nonvolatile report for retrieval via the **SER** command.

SER SETTINGS

SER trigger settings SER1 through SER6 each contain a list of as many as 24 Relay Word bits for a total of 144 Relay Word bits. The SER stores a new record if any Relay Word bit in any of the six SER trigger settings changes state. For example, the settings

SER1 = R1P1 R2P1 R3P1 R4P1 R5P1 R6P1 R7P1 R8P1
SER2 = 0
SER3 = 0
SER4 = 0
SER5 = 0
SER6 = 0

trigger a new SER record each time any Receive MIRRORED BIT® on Port 1 changes state (asserts or deasserts). An SER setting of zero or NA clears that SER trigger setting.

MAKE SER SETTINGS WITH CARE

The SEL-2100 triggers a row in the SER report for any change of state in any one of the elements listed in the SER1 through SER6 trigger settings. Nonvolatile memory is used to store the latest 32,768 rows of the SER event report so they can be retained during power loss. The nonvolatile memory is rated for a finite number of "writes." An average of 333 state changes per minute can be made for a 25-year service life.

SER REPORT

The **SER** command displays the SER report.

```
=>>SER <Enter>

SEL-2100                          Date: 12/15/2000    Time: 01:13:52.875
STATION A

FID=SEL-2100-R100-V0-Z001001-D19991221       CID=ECB6

#      DATE        TIME           ELEMENT         STATE

   10  12/15/2000  01:13:33.628   RB1             Asserted
    9  12/15/2000  01:13:33.628   SV1             Asserted
    8  12/15/2000  01:13:33.664   SV1T            Asserted
    7  12/15/2000  01:13:33.664   LV1             Asserted
    6  12/15/2000  01:13:33.680   T1P2            Asserted
    5  12/15/2000  01:13:36.376   RB1             Deasserted
    4  12/15/2000  01:13:36.376   SV1             Deasserted
    3  12/15/2000  01:13:36.400   SV1T            Deasserted
    2  12/15/2000  01:13:36.400   LV1             Deasserted
    1  12/15/2000  01:13:36.404   T1P2            Deasserted

=>>
```

Each line in the SER report contains the report row number, the trigger date and time, the Relay Word bit (element) name, and the new state of the Relay Word bit (asserted or deasserted). The report contains a maximum of 43,690 records. Filter the report contents by date, date range, row number, or row number range, in either ascending or descending order. For example, the command

SER 25 <Enter>

displays the 25 most recent SER rows. The command

SER 10 20 <Enter>

displays an SER report consisting of rows 10 through 20 inclusive, if those rows exist. The command

SER 1/1/2001 1/31/2001 <Enter>

displays all SER records triggered on or between the dates listed. To reverse the order of the display, reverse the order of the parameters. For example,

SER 1/31/2001 1/1/2001 <Enter>

displays the same SER records as the previous command, but in reverse chronological order.

If there are no rows of data in the range selected, the SEL-2100 responds

```
=>>SER <Enter>
No SER Data

=>>
```

Clear the SER report with the **SER C** command.

```
=>>SER C <Enter>
Clear the SER
Are you sure (Y/N) ? Y <Enter>
Clearing Complete

=>>
```

APPLICATION EXAMPLE

The SER is very useful when reconstructing a disturbance, or when testing new logic settings or new MIRRORED BITS connections. The SER is also useful in checking that the system performs as expected. For example, assume we wish to measure the round trip delay of a new MIRRORED BITS connection to an SEL-311C Relay on Port 12. In the SEL-311C, make the following SELOGIC® control equation setting.

TMB1A = RMB1A

This loops Receive MIRRORED BIT 1 to Transmit MIRRORED BIT 1 in the SEL-311C.

In the SEL-2100 make the following SER trigger setting using the **SET R** command.

SER1 = T1P12 R1P12

Assign Transmit MIRRORED BIT 1 to Remote Bit 1 using the **SET L** command.

T1P12 = RB1

Assert Remote Bit 1, then inspect the SER report.

```
=>>CON 1 <Enter>
CONTROL RB1: SRB 1 <Enter>
=>>SER

SEL-2100                          Date: 12/15/2000    Time: 01:04:51.939
STATION A

FID=SEL-2100-R100-V0-Z001001-D19991221       CID=ECB6

#      DATE        TIME           ELEMENT         STATE

    2  12/15/2000  01:04:50.068   T1P12           Asserted
    1  12/15/2000  01:04:50.080   R1P12           Asserted

=>>
```

The SER indicates the round trip delay is 12 ms in this case.

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SECTION 8: MIRRORED BITS COMMUNICATIONS

OVERVIEW

MIRRORED BITS® allows devices to exchange as many as eight bits of information with protection level security and speed at minimal expense. Because MIRRORED BITS uses standard EIA-232 ports, no special equipment is required. A MIRRORED BITS link often involves nothing more than an EIA-232 cable, but it replaces eight contact inputs, eight contact outputs, and all the associated control wiring.

MIRRORED BITS continually monitors the communications channel for errors or dropouts. Unlike a contact-to-control input connection, MIRRORED BITS informs you immediately if the connection is lost, damaged, or even if a noise source begins to corrupt the data. See ***MIRRORED BITS Security*** below for more information about how MIRRORED BITS detects data transmission errors.

Setup

To setup a MIRRORED BITS link:

1. Connect the two MIRRORED BITS devices with an EIA-232 communications channel. The channel can be as simple as a communications cable, or as flexible as a communications network such as a SONET ring.
2. Enable MIRRORED BITS in the two devices, and set the baud rate, transmit ID, and receive ID in both of them using the **SET P *n*** command. See ***MIRRORED BITS Settings*** below for more information on settings.
3. At this point, the MIRRORED BITS link should be operational. View the ROK*n* (or receive OK) Relay Word bit for the MIRRORED BITS channel to verify that the link is operational. If ROK*n* indicates that MIRRORED BITS is operational in one device, then MIRRORED BITS is also operational in the other device. See ***MIRRORED BITS Channel Monitoring*** below for more information about the ROK*n* indicators, and other channel status indicators.

Configuration

As described above, each MIRRORED BITS link exchanges as many as eight bits of information. After the MIRRORED BITS channel is setup and the MIRRORED BITS link is operational, all that remains is to configure each MIRRORED BIT to exchange the required data. Configure only the bits required. If only one bit is required, configure just that one bit. Use SELOGIC® control equations to define the function of each Transmit MIRRORED BIT. Use the Receive MIRRORED BITS in SELOGIC control equations to create protection, control, or monitoring schemes.

For example, to pass the status of SEL-2100 contact input IN101 to another MIRRORED BITS device connected to Port 1 using Transmit MIRRORED BIT 2, use the following SELOGIC control equation:

T2P1 = IN101

To use Receive MIRRORED BIT 2 on Port 1 to close output contact OUT101, use the following SELOGIC control equation:

OUT101 = R2P1

MIRRORED BITS SECURITY

Security is the probability that a transmission error will be detected by the receiving device. Each received MIRRORED BITS message contains three copies of all eight MIRRORED BITS. In addition, the message contains framing bits, and parity check bits. Each message is also encoded with the sending device's TXID setting. The receiving device decodes the MIRRORED BITS message, checks that all the start, stop and parity bits are correct, checks to ensure that all three copies of the eight data bits match, and also checks to see that the encoded address matches the receiving relay's RXID setting. On average, MIRRORED BITS detects all but one in more than 16 million transmission errors using these data integrity checks. This exceeds the security recommended by standard IEC-834 for permissive tripping functions.

Debounce Pickup/Dropout Counters

Use the debounce pickup/dropout counters on each received MIRRORED BIT to increase security even further. A pickup and dropout counter setting of one allows every state change of a Receive MIRRORED BIT to propagate into the Relay Word. This results in the security mentioned above. A setting of two requires reception of two consecutive messages with the specific Receive MIRRORED BIT asserted or deasserted before that bit propagates into the Relay Word. With a pickup or dropout security counter of two, MIRRORED BITS will detect all but one in (16 million • 16 million) = 256 X 10^{12} errors.

See ***MIRRORED BITS Settings*** below for more information about setting the pickup and dropout debounce counters.

Default Receive Values

When the SEL-2100 detects an error in a received MIRRORED BITS message, it discards the entire message and deasserts ROK*n*. The Receive MIRRORED Bits in the Relay Word take on their respective default receive values until MIRRORED BITS communications is restored. Set the default receive values (setting RXDFLT) depending on your application. Note that when MIRRORED BITS serial port settings are changed, the received MIRRORED BITS reset to zero regardless of the RXDFLT setting.

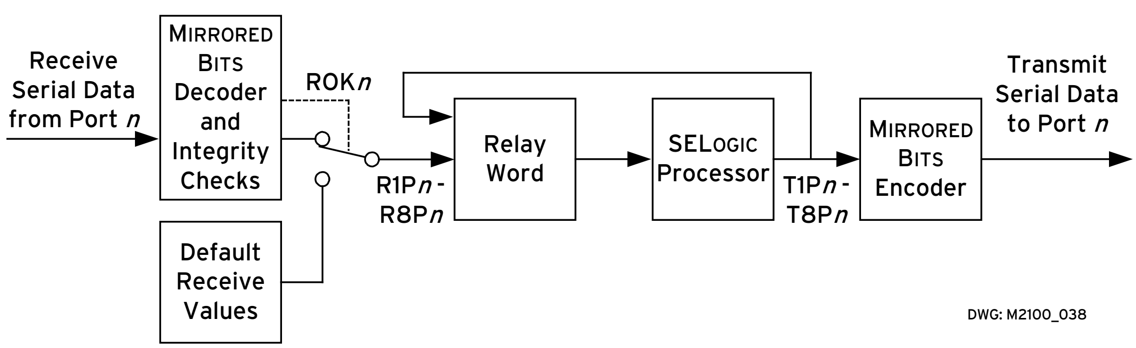

Figure 8.1: MIRRORED BITS Processing

For example, suppose one MIRRORED BIT is used to exchange a Block Trip message between two protective devices. When MIRRORED BITS communications are disrupted or disabled entirely, the user may elect to have the received MIRRORED BIT corresponding to Block Trip assert. When the communications channel fails, the protective relay will then block communications-assisted tripping, and revert to some backup protection scheme, such as time-stepped distance protection.

Alternatively, suppose one MIRRORED BIT is used to exchange a Permissive-Trip message between two protective devices. When MIRRORED BITS communications is disrupted or disabled entirely, the user may elect to have the received MIRRORED BIT corresponding to Permissive Trip deassert. When the communications channel fails, the protective relay will then block communications-assisted tripping, and revert to some backup protection scheme, such as time-stepped distance protection.

See ***MIRRORED BITS Settings*** later in this section to set the default receive values.

Receive and Transmit ID

Two settings, RXID and TXID, prevent a MIRRORED BITS port from accepting its own transmission. This is important because some communications channels may become inadvertently looped back. To defeat this feature for loop back testing, use the **LOO** command described later in this section.

MIRRORED BITS SPEED

The MIRRORED BITS communications protocol continually transmits the status of all eight Transmit MIRRORED BITS encoded into a MIRRORED BITS message. When a Transmit MIRRORED BIT changes state, the new state is transmitted in the next MIRRORED BITS message. The rate at which messages are transmitted depends on the MIRRORED BITS device and the baud rate. Table 8.1 shows the message transmission rate measured in both cycles per message and milliseconds per message. Table 8.1 assumes a 4 ms processing interval.

Table 8.1: MIRRORED BITS Message Transmission Speed

Speed (baud)	SEL-321[1] cycles (ms)	SEL-351[1] cycles (ms)	SEL-311[1] cycles (ms)	SEL-2100[2] cycles (ms)	SEL-2505[2] cycles (ms)
600	4 (68)	4 (68)	4 (68)	4 (64)	N/A
1,200	2 (34)	2 (34)	2 (34)	2 (32)	N/A
2,400	1 (17)	1 (17)	1 (17)	1 (16)	N/A
4,800	1/2 (8)	1/2 (8)	1/2 (8)	1/2 (8)	N/A
9,600	1/4 (4)	1/4 (4)	1/4 (4)	1/4 (4)	1/3 (5)
19,200	1/8 (2)	1/4 (4)	1/4 (4)	1/4 (4)	1/6 (3)
38,400	1/8 (2)	1/4 (4)	1/4 (4)	1/4 (4)	1/8 (2)

[1] Millisecond values are approximate
[2] Cycle values are approximate (Cycle information based on a 60-Hz nominal system frequency)

MIRRORED BITS CHANNEL MONITORING

MIRRORED BITS communications replaces as many as eight control inputs and eight contact outputs per MIRRORED BITS port. This greatly reduces wiring complexity, increases reliability, and reduces cost. MIRRORED BITS provides another benefit over hardwired control inputs and outputs: MIRRORED BITS communications is self-monitoring.

When a control input is connected to a control switch or contact output, the contact inputs are not capable of detecting when the wire between the input and the control switch or contact output is cut. Conversely, MIRRORED BITS instantly detects, and can alarm for, a destroyed, damaged, disrupted, or degraded communications channel.

Three Relay Word bits, ROK*n*, RBAD*n*, and CBAD*n*, reflect the status of the MIRRORED BITS communications channel connected to SEL-2100 Port *n*. Use Relay Word bits ROK*n*, RBAD*n*, and CBAD*n* to issue communications alarms, and to enable backup protection schemes.

ROK*n*

ROK*n* (Receive OK on channel *n*) deasserts the instant the SEL-2100 detects any of several types of transmission errors, or any time the SEL-2100 detects that it has not received a MIRRORED BITS message in the time required to transmit three messages. The local ROK*n* also deasserts if the remote MIRRORED BITS device detects an error. Each time ROK*n* deasserts, the SEL-2100 time tags the state change, and records an entry in a special Sequential Events Recorder dedicated to each MIRRORED BITS port. Each time-tagged entry is labeled with the cause of the entry. View the contents of the special communications Sequential Events Recorder with the **COM** command. (For more information regarding the **COM** command and the contents of the communications report, see ***Communications Report*** later in this section.)

RBAD*n*

If ROK*n* deasserts for longer than setting RBADPU, Relay Word bit RBAD*n* asserts. In other words, RBAD*n* gives an indication that the MIRRORED BIT has been disrupted on Port *n* longer than the RBADPU threshold. A typical setting for RBADPU is several seconds.

The setting range of RBADPU is 1 to 10,000 seconds. The factory-default setting for RBADPU on each port is 60 seconds. RBAD*n* is intended for use as a communications alarm and should be set long enough to avoid nuisance alarms.

CBAD*n*

Assume RBADPU for Port 1 is set for one second, and the MIRRORED BITS channel connected to Port 1 is disrupted 0.5 seconds out of every second. MIRRORED BITS communications on Port 1 are unavailable 50 percent of the time, but RBAD1 does not assert because MIRRORED BITS is not disrupted for longer than 1 second at any time. Setting CBADPU and Relay Word bit CBAD*n* solve this problem.

When the data stored in the communications report for MIRRORED BITS Port *n* indicate that MIRRORED BITS has been unavailable, on average, more than setting CBADPU, the SEL-2100 asserts Relay Word bit CBAD*n*.

Assume CBADPU is set for 10,000 parts per million (0.01 per unit, or one percent), and the same MIRRORED BITS channel as in the previous example is disrupted 0.5 second out of every second.

MIRRORED BITS on Port 1, as indicated by the communications report for Port 1, is unavailable 0.5 per unit, or 500,000 parts per million, or 50 percent of the time. This exceeds the CBADPU setting, and Relay Word bit CBAD1 asserts.

The setting range for CBADPU is 1 to 30,000 parts per million (ppm). The factory-default setting for CBADPU on each port is 1,000 ppm.

For the sample long communications report shown in Figure 8.2 the unavailability is 4054 ppm. This is calculated by dividing the total outage durations (0.412 + 0.292 + 7.832 + 0.248) or 8.784 seconds, by the total time span for this record (08:10:39.751–07:34:32.862) or 2,167 seconds, 8.784 / 2,167 = 0.004054 or 4054 ppm unavailability.

Note: CBAD*n* cannot assert for five minutes after the communications report is cleared.

The following table lists some recommended CBAD settings based on channel type and expected performance. To clear a CBAD*n* bit, reset the events record in the communications report using the **COM P *n* C** command, where *n* is the port number (1–15). Or use the **COM C** command which clears the communications report for all of the ports.

Table 8.2: CBAD Setting Examples

Channel Type	Typical Bit Error Rate	Expected MIRRORED BITS Unavailability	CBAD Setting
Fiber-Optic	10^{-12}	0.002 ppm	10
Digital Channel	10^{-9}	0.2 ppm	100
Analog Channel	10^{-6}	200 ppm	2000

Communications Report

Based on the results of data checks described below, the SEL-2100 collects information regarding the 255 most recent communications errors per MIRRORED BIT port. Each record contains the following fields:

- Time when the problem started
- Time when the problem stopped
- Duration of problem
- Reason for dropout (See Table 8.3)

Table 8.3: Error Types Reported by the Communications Report

Error Type	Description
Parity error	Data failed UART parity check.
Underrun	Three MIRRORED BIT messages transmitted without one being received.
Overrun	UART data buffer overrun.
Re-sync	The MIRRORED BITS device at the other end of the link detected an error.
Data error	Received data were not self-consistent, or the address was wrong.
Relay disabled	Relay protection functions disabled, as during turn-on or a change in settings or settings group.
Loop Back	Loop back enabled. Error conditions followed by "(L)" occurred while the system was in loop back.
Framing error	The UART did not detect a stop bit in the received MIRRORED BIT data.

The **COM P *n* L** command (where *n* is the port number 1–15), generates a summary report followed by a detailed listing of each communications problem on MIRRORED BITS Port *n*.

There is only a single record in the communications report for each channel problem, but an outage can evolve. For example, the initial cause could be a data error, but the outage can be perpetuated by framing errors. If the channel is presently down, the communications record will only show the initial cause, but the last error field in the communications summary will display the present cause of failure.

Figure 8.2 shows a long communications report from Port 6. The report was generated on 12/21/1999 at 08:10 and shows that there have been five communications disturbances since the last time the report was cleared.

```
=>>COM P 6 L <Enter>

SEL-2100                          Date: 12/21/1999    Time: 08:10:39.754
STATION A

FID=SEL-2100-R100-V0-Z001001-D19991221       CID=72BF
Summary for Mirrored Bits port 6

For 12/21/1999 07:34:32.862 to 12/21/1999 08:10:39.751

    Total failures      5                  Last error  Re-Sync
    2100 Disabled       1
    Data error          2                  Longest Failure     7.832 sec.
    Re-Sync             1
    Underrun            0                  Unavailability  0.004054
    Overrun             0
    Parity error        0
    Framing error       1                  Loop-back     0
    Bad Re-Sync         0


    Failure                     Recovery
#   Date       Time             Date       Time           Duration  Cause
1   12/21/1999 08:00:01.903  12/21/1999 08:00:02.315     0.412  2100 Data error
2   12/21/1999 07:59:33.586  12/21/1999 07:59:33.878     0.292  2100 Re-sync
3   12/21/1999 07:58:34.509  12/21/1999 07:58:42.341     7.832  2100 Data error
4   12/21/1999 07:58:00.872  12/21/1999 07:58:01.120     0.248  2100 Framing error
5   12/21/1999 07:34:32.862  12/21/1999 07:34:32.862     0.000  2100 Disabled

=>>
```

Figure 8.2: Sample Communications Report

LOOP BACK TESTING

Use the **LOO P** command to enable loop back testing. Note this command does not physically loop back the data, it only enables the LBOK*n* output. While in loop back mode, ROK*n* is deasserted, and another user accessible bit, LBOK*n*, asserts and deasserts based on the received data checks described previously in this section. Use this command to check the integrity of the data circuit as shown in Figure 8.3.

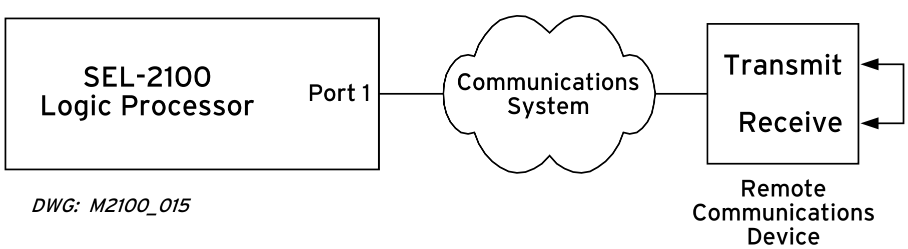

Figure 8.3: Remote Loop Back Test on Port 1

In this example, LBOK1 asserts at the SEL-2100 when the **LOO P 1** command is entered and the SEL-2100 receives the same data it transmits. This test proves that the communications channel is operating. To use the received data for testing, use the **LOO P 1 DATA** command in this example. Refer to ***Section 4: Serial Port Communications and Commands*** for more information on the **LOO** command.

MIRRORED BITS SETTINGS

Use the **SET P *n*** command to set the serial port for MIRRORED BITS communications. Usually only settings PROTO, SPEED, RXID, and TXID are required to setup a MIRRORED BITS link.

```
Protocol (SEL,LMD,DNP,MB,MB8)                    PROTO = MB       ?
```

Set PROTO = MB to enable the MIRRORED BITS protocol on this port. Set PROTO = MB8 for MIRRORED BITS operation with devices that require eight data bits, no parity, and one stop bit.

```
MBT9600 (Y,N)                                    MBT   = N         ?
```

Set MBT = Y only when using a Pulsar MBT9600 modem. Make sure to connect +5 V power to Pin 1 of the serial port with the appropriate jumper as described in ***Section 2: Installation***. The SEL-2100 supports no more than four MBT9600 modems simultaneously because of power supply constraints.

```
Baud Rate (300-38400)                            SPEED = 9600   ?
```

Use the SPEED setting to control the baud rate at which the MIRRORED BITS messages are transmitted. Table 8.1 shows how this setting affects the MIRRORED BITS message transmission rate. Set the baud rate to the highest rate supported by the communications channel. Set the baud rate to 38,400 if the channel is a direct connection using a cable, SEL-2800, or SEL-2815 Fiber-Optic Modems, and if the connection is to an SEL-2505 Remote I/O Module.

```
Seconds to Mirrored Bits Rx Bad Pickup (1-10000)   RBADPU= 60        ?
```

The RBADPU setting determines how long a channel error must last before the relay element RBAD*n* asserts. RBAD*n* deasserts when the channel error is corrected. Set RBADPU based on expected channel performance to avoid nuisance alarms.

```
PPM Mirrored Bits Channel Bad Pickup (1-30000)     CBADPU= 1000      ?
```

The CBADPU setting determines the fraction of time the channel is down before the relay element CBAD*n* asserts. Table 8.2 gives typical settings for CBADPU. Reset the CBAD bit with the **COM P *n* C** command described in ***Section 4: Serial Port Communications and Commands***.

```
Mirrored Bits Receive Identifier (1-4)            RXID  = 1         ?
Mirrored Bits Transmit Identifier (1-4)           TXID  = 2         ?
```

Set the RXID of the SEL-2100 to match the TXID of the remote device. For example:

	TXID	RXID
SEL-2100	1	2
Remote Device	2	1

```
Mirrored Bits receive default state (string of 1s, 0s or Xs)
       87654321
RXDFLT=0011XX00
     ?
```

Use the RXDFLT setting to determine the default state the MIRRORED BITS should use in place of received data when an error condition or loss of channel is detected. The setting is a mask of 1s, 0s, and/or Xs, for R8P*n*–R1P*n*. A setting of 1 causes the corresponding Receive MIRRORED BIT to assert when an error condition or loss of channel is detected. A setting of zero or X causes the corresponding Receive MIRRORED BIT to deassert or freeze respectively when an error condition or loss of channel is detected. In the example setting above, Receive MIRRORED BITS 1, 2, 7, and 8 deassert when the SEL-2100 detects an error. Receive MIRRORED BITS 3 and 4 retain their present values, and Receive MIRRORED BITS 5 and 6 assert when the SEL-2100 detects an error. Note that when MIRRORED BITS serial port settings are changed, the received MIRRORED BITS reset to zero regardless of the RXDFLT setting.

```
Mirrored Bits RMB_ Debounce PU time (1-8 msgs)    RMB1PU= 1      ?
Mirrored Bits RMB_ Debounce DO time (1-8 msgs)    RMB1DO= 1      ?
.
.
.
Mirrored Bits RMB_ Debounce PU time (1-8 msgs)    RMB8PU= 1      ?
Mirrored Bits RMB_ Debounce DO time (1-8 msgs)    RMB8DO= 1      ?
```

Supervise the transfer of received data to Relay Word bits R1P*n*–R8P*n* with the MIRRORED BITS debounce pickup and dropout counters. Set the pickup and dropout counters individually for each bit. See ***MIRRORED BITS Security*** earlier in this section.

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TABLES

SECTION 9: MAINTENANCE AND TROUBLESHOOTING

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 Carbon Monofluoride coin cell, IEC No. BR2335 or equivalent. At room temperature (25°C) the battery will last for at least 10 years with power removed from the SEL-2100. The battery cannot be recharged.

The battery experiences a low self-discharge rate when the SEL-2100 is powered from an external source.

Perform the following battery replacement procedure if the SEL-2100 resets the time and date to the default value of 1/1/1999 12:00 PM when power is lost, or about 10 years after installation (shelf life of the battery).

⚠ 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. Dispose of used batteries according to the manufacturer's instructions.

To change the battery, perform the following steps:

1. Remove power from the SEL-2100.
2. Remove any cables connected to Port F of the SEL-2100.
3. Remove the front-panel screws and front panel.

⚠ CAUTION

The SEL-2100 contains devices sensitive to electrostatic discharge (ESD). When working on the relay with front or top cover removed, work surfaces and personnel must be properly grounded or equipment damage may result.

4. Locate the battery on the front left-hand side of the main board.
5. Remove the battery from beneath the clip and install a new one. The positive side (+) of the battery faces up.
6. Replace the front panel and front-panel screws and tighten securely.
7. Replace any cables removed from the SEL-2100.
8. Apply power to the SEL-2100, and set the date and time again. If an IRIG-B input is present, issue an **IRI** command to verify the correct time is received. The correct date will still need to be entered. Set the date using the **DATE** command.

ALARM CONDITIONS

The SEL-2100 closes the main board Alarm contact for self-test failures. The SEL-2100 also asserts the ALARM Relay Word bit for a number of conditions. In units with I/O boards, assign

ALARM to an output contact using the **SET L** command to monitor these other conditions. Table 9.1 lists the various conditions that cause Alarm contact and ALARM bit operations.

Table 9.1: Alarm Conditions

Command or Condition	Closes Main Board Alarm Contact	Asserts ALARM Bit	Comment
2ACCESS	No	Yes	One second pulse when entering Access Level 2 and if password is entered incorrectly on three successive attempts.
ACCESS	No	Yes	One second pulse if password is entered incorrectly on three successive attempts. See ***ACC, 2AC, and CAL Commands (Go to Access Level 1, 2, or C)*** in ***Section 4***.
PASSWORD	No	Yes	One second pulse when password is changed.
SET	No	Yes	One second pulse on settings change.
COPY	No	Yes	One second pulse if settings are changed in the active group.
Self-Test Failure	Yes	N/A	Latches if SEL-2100 fails a critical self-test (contact the factory). See Table 9.2.

Note: Use the **TAR ALARM** command to view the status of the ALARM bit.

SELF-TESTS

The SEL-2100 continually runs the self-tests shown in Table 9.2. If any of these self-tests fail, return the SEL-2100 for repair.

Table 9.2: Self-Test Alarm Conditions

Self-Test	Condition	Logic Processing Disabled	Alarm Output
RAM	OK	No	
	Failure	Yes	Latched
ROM	OK	No	
	Failure	Yes	Latched
CR_RAM	OK	No	
	Failure	Yes	Latched
EEPROM	OK	No	
	Failure	Yes	Latched
+15V P_S	OK	No	
	Failure	No	Pulse
-15V P_S	OK	No	
	Failure	No	Pulse
I/O Board	OK	No	
	Failure	Yes	Latched

TROUBLESHOOTING

Table 9.3: Troubleshooting Tips

Symptom	Probable Cause	Corrective Action
All front-panel LEDs remain dark when the 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 communications port(s).	Jumper(s) not installed on main board.	See the jumper settings in ***Section 2: Installation***.
SEL-2100 does not communicate with PC.	Serial cable damaged or wrong cable connected.	Inspect the cabling for damage and proper connection.
	Port and baud rate settings of PC may be incorrect.	Set the port and baud rate settings of the PC terminal to match the SEL-2100.
	Serial port has received an XOFF, halting communications.	Type **<Ctrl+Q>** to send an XON and restart communications.

Symptom	Probable Cause	Corrective Action
	With more than two rear ports set for MIRRORED BITS, the maximum useful baud rate on the front-panel serial port is reduced to 4800, 2400, or 1200 baud.	Reduce the front-panel serial baud rate.
SEL-2100 MIRRORED BITS® communications is not working.	Serial cable damaged or wrong cable connected.	Inspect the cabling for damage and proper connection. Make sure appropriate cable is connected.
	Port settings do not match the Relay settings.	Use the SET P *n* command to correct the port settings.
	Data communications equipment not properly configured.	Loop back the transmit to receive data at various points in the channel and test the looped channel with the **LOO** command. See ***Section 8: MIRRORED BITS Communications***.
SELOGIC® elements in the SEL-2100 do not operate as described in the instruction manual.	An Advanced Application Logic module is loaded, affecting Relay Word bit operation.	If the Advanced Application Logic module is not required in the system application, unload the module (see ***Appendix K: Advanced Application Logic***).
		If the Advanced Application Logic module functions are required in the system application, refer to the appropriate appendix for information on the effects of the module.
The SEL-2100 processing interval is slower than expected.	Ten or more serial ports are set to MIRRORED BITS protocol and have SPEED ≥ 19200.	Refer to ***Table 5.3***. Possible solutions are to reduce serial port SPEED settings or reduce the number of SELOGIC elements and edges used in logic settings.

Symptom	Probable Cause	Corrective Action
	An Advanced Application Logic module is loaded and using sufficient capacity to affect the processing interval.	Unload the Advanced Application Logic module (refer to ***Appendix K: Advanced Application Logic)*** or reduce the number of SELOGIC elements and edges used in logic settings.
The SEL-2100 number of available SELOGIC edges and elements are lower than expected.	An Advanced Application Logic module is loaded, affecting SELOGIC control equation capacity.	Unload the Advanced Application Logic module (refer to ***Appendix K: Advanced Application Logic)*** or reduce the number of SELOGIC elements and edges used in logic settings.

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 A: FIRMWARE AND MANUAL VERSIONS

FIRMWARE

Determining the Firmware Version in Your Relay

To find the firmware revision number in the SEL-2100 Logic Processor, view the status report through the serial port **STATUS** command. The status report displays the firmware identification (FID) label:

FID=SEL-2100-Rxxx-Vx-Z000000-Dxxxxxxxx

The firmware revision number is after the “R” and the release date is after the “D”.

For example:

FID = SEL-2100-R100-V0-Z001001-D19991221

In this example, the firmware revision number is 100, with release date December 21, 1999.

This manual covers SEL-2100 Logic Processors. 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

Firmware Part/Revision No.	Description of Firmware	Manual Date Code
SEL-2100-R105-V0-Z003003-D20080527	– Internal change to improve manufacturability.	20080527
SEL-2100-R104-V0-Z003003-D20080507	– Improved contact output security during power-up.	20080507
SEL-2100-R103-V0-Z003003-D20050318	– Added relay remote bits RB33–RB64. – Improved password security. – Added Alternate and Extended Fast Messages for set, clear, and pulse of remote bits. – Increased SELOGIC® Capacity. – Added compatibility for IRIG-B time code with extended control fields. – Added support for Advanced Application Logic modules.	20050318
SEL-2100-R102-V0-Z002002-D20010713	– Added a new power supply option. – Added warning for three consecutive incorrect password attempts.	20011017

Firmware Part/Revision No.	Description of Firmware	Manual Date Code
SEL-2100-R101-V0-Z002002-D20010528	– Internal changes to support Flash memory revision and battery-backed clock hardware change. – A5C0 Relay Definition Block Changed. – Added AC mode for optoisolated input debounce timers in global settings IN101-IN116. This allows AC control signals to be sensed on selected inputs. – Added Unsolicited SER Protocol. – Revised latch bit operation to improve nonvolatile latch memory storage during loss of power. – Changed “msec” to “ms” in setting prompts and relay reports.	20010529
SEL-2100-R100-V0-Z001001-D19991221	– Initial version.	19991221

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

Revision Date	Summary of Revisions
20250127	Appendix K – Removed reference to CD-ROM.
20230411	Appendix B – Updated Firmware Upgrade Instructions.
20170619	Appendix F – Updated *Operation*. Appendix G – Changed *Certifications* to *Compliance* and moved to the top of *Specifications*.
20110909	Section 3 – Updated Fiber-Optic Connection Using the SEL-2800 Family of Fiber-Optic Transceivers. Section 4 – Added note in *Introduction* regarding settings to disable access on ports. – Added information about Access Level C in *Serial Port Access Levels* and in *SEL ASCII Commands*. – Added CAL command entry in Table 4.2: Serial Port Command Summary. – Updated text in *Access Level Attempt (Password Required)* to clarify relay response to incorrect password entry. Section 9 – Updated Table 9.3: Troubleshooting Tips. Appendix G – Added note to Communications Ports. Appendix K – Updated the three paragraphs preceding *Step 7*. Command Summary – Added entries for **CAL** and **PAS C** commands.
20100226	Section 1 – Added note to *Table 1.1: Protocol Settings* regarding front-panel baud rate. Section 3 – Added notification in *Setting the SEL-2100* that when MIRRORED BITS serial port settings are changed, the received MIRRORED BITS reset to zero regardless of the RXDFLT setting. Section 4 – Added note to *Table 4.1: Serial Port Protocols* regarding front-panel baud rate. Section 8 – Added notification in *Default Receive Values* and *MIRRORED BITS Settings* that when MIRRORED BITS serial port settings are changed, the received MIRRORED BITS reset to zero regardless of the RXDFLT setting. Section 9 – Updated *Table 9.3: Troubleshooting Tips* with cause and corrective action regarding front-panel baud rate. Appendix G – Added note to Communications Ports specification regarding front-panel baud rate.

Revision Date	Summary of Revisions
20080527	Appendix A – Updated for firmware version R105.
20080507	Appendix A – Updated for firmware version R104.
20051207	Section 1 – Added subsection Advanced Application Logic. Section 3 – Added subsection Advanced Application Logic. Section 4 – Added **FILE** Command. – Updated **VER** Command information. Section 5 – Added subsection Processing Interval. – Added Table 5.3: SEL-2100 SELOGIC Control Equation Capacity. – Updated Table 5.5: Relay Word Bit Definitions for the SEL-2100. Section 6 – Added subsection *Logic Points*. Section 8 – Added entries to Table 8.1: MIRRORED BITS Message Transmission Speed. Section 9 – Added entries to Table 9.3: Troubleshooting Tips. Appendix A – Updated for new manual, Date Code 20051207. Appendix B – Updated Firmware Upgrade Instructions. Appendix E – Added subsection A546 Unsolicited Write. – Updated subsection *ID Message*. Appendix K – Added Appendix K: Advanced Application Logic. Appendix L – Added Appendix L: Crosspoint Switch Advanced Application Logic Module. Command Summary – Added **FILE** commands.
20050318	Updated manual to include updated password security information. Noted that 64 remote bits are available. Section 4 – Updated **PAS** command for improved password security. – Updated **CON** command for 64 remote bits. – Updated **PUL** command to include all Relay Word bits. – Updated **TAR** command to include new Relay Word bits. Section 5 – Updated SELOGIC limitations to 20 Relay Word bits allowed per control equation. – Updated Processing Interval information to include 6 ms, maximum. – Added LP1–16 and RB33–64 to Table 5.3 and Table 5.4. Section 6 – Updated remote bits to 64.

Revision Date	Summary of Revisions
	Appendix A – Updated Table A.1 and Table A.2.
	Appendix C – Added note on DNP response for 6-ms processing intervals when SPEED is set greater than 9600 baud. – Added Data Map information for remote bits RB33–RB64 to Table C.3. – Added Control Relay Block object information for indices 56–115. Appendix E – Added Alternate and Extended Fast Operate to set, clear, and pulse remote bits. – Updated A5D1 for 70 digital banks. – Updated DNA Message to include new Relay Word bits. Command Summary – Updated **PAS** command for improved password security. – Updated **TAR** command to include added Relay Word bit rows.
20040123	Product name change.
20011017	This revision includes the following changes: – Added new Appendix J: ACSELERATOR SEL-5030 Software.
20010713	This revision includes the following changes: Appendix A – Updated Firmware information. Section 4 – Added warning for incorrect password attempts in *Access Level Attempt (Password Required*).
20010529	Revised caution and warning information and replaced Standard Product Warranty page with warranty statement on the back of the manual cover page. Section 3 – Updated Direct Transfer Trip (DTT) name. Section 6 – Updated *Optoisolated Inputs* subsection to include ac input selection. Section 7 – Added subsection Make Sequential Events Recorder (SER) Settings with Care. Appendix A – Updated Firmware information. Appendix E – Made changes to A5CO block to include Fast Message (unsolicited SER messaging). – Added A5CE Fast Operate Configuration Message subsection. – Added *SNS Message* subsection. Appendix G – Updated minimum temperature rating for *Terminal Connections* in *Specifications*. – Added optoisolated inputs ratings for ac control signals to *Specifications*. – Updated Type Test information. Appendix H – Revised SELOGIC Control Equation Variable Timers range information. – Added ac setting choice to optoisolated input timers on Setting Sheet 10. – Added note on Port F baud rate. Appendix I – Added Appendix I: Unsolicited SER Protocol.

Revision Date	Summary of Revisions
20010305	Reissued Entire Manual. – Added cautions, warnings, and dangers in English and French to the reverse of the title page. Section 1 – Updated password information. Section 2 – Updated Figure 2.1 and Figure 2.4. Section 3 – Updated Figure 3.9. Section 4 – Updated cable information in SEL-2100 to SEL-351 or SEL-311C. – Updated password information. Section 9 – Added battery Caution statement. Appendix E – Updated information in A5E0 Fast Operate Remote Bit Control subsection. Appendix G – Added information on Tightening Torque, Terminal Connections, and Power Supply in *General Specifications* subsection. – Updated IEC specification numbers.
20000410	Section 2 – Added rear-panel drawing (Figure 2.4). Renumbered subsequent figures. Section 3 – Corrected Figure 3.6. Appendix C – Corrected information in the DNP 3.0 Subset Definitions document. Appendix H – Corrected cycle information in the *SELOGIC Control Equation Variable Timers* section (Settings Sheet 1 and 2).
20000120	Reissued entire manual.
991221	Initial version.

APPENDIX B: FIRMWARE UPGRADE INSTRUCTIONS

Note: SEL-2100 Logic Processors manufactured after January 20th, 2023, must be returned to the factory for firmware upgrade. If the serial number of your Logic Processor exceeds 1230200088, it was manufactured on or after this date. Upon receipt of your Logic Processor, SEL will perform the firmware upgrade and return the unit to you within a few days.

To install new firmware, perform the following steps:

A. Check settings,
B. Turn off the SEL-2100 Logic Processor,
C. Remove the SEL-2100 from the equipment rack (panel),
D. Remove the front panel and top cover,
E. Pull out the optional I/O board if present,
F. Exchange the integrated circuit (IC) chips,
G. Reassemble the hardware,
H. Reestablish settings, and
I. Check or load Advanced Application Logic.

To convert the SEL-2100 to an SEL-2100 with Advanced Application Logic see ***Advanced Application Logic***.

If you do not want to perform the installation SEL can assist you. Simply return the SEL-2100 and ICs to SEL. We will install the new ICs and return the unit to you within a few days. If you perform the upgrade, please follow these step-by-step instructions.

⚠ CAUTION This procedure requires that you handle components sensitive to Electrostatic Discharge (ESD). If your facility is not equipped to work with these components, we recommend that you return the relay to SEL for firmware installation.

The logic processor preserves settings and passwords during the firmware upgrade process. However, interruption of power during the upgrade process can cause the relay to lose settings.

Step 1. Note or capture all of your settings using the **SHO *n***, **SHO L *n*** (where *n* is 1–6), **SHO G**, **SHO R**, **SHO P *n*** (where *n* is 1–16 or F), and **SHO C** commands, for reference in the event that these settings are lost during the upgrade. One convenient method is to connect a PC to the SEL-2100 and read the device settings using ACSELERATOR QuickSet SEL-5030 Software.

Note: If the SEL-2100 contains Sequential Events Recorder (SER) data that you want to retain, it must be retrieved prior to performing the firmware upgrade, because all of these data sets may be erased in the upgrade procedure.

Step 2. If the SEL-2100 is in service, remove power to the device. Disconnect any cables attached to the ports. Remove the chassis from the equipment rack.

Step 3. Remove the front panel and top cover.

CAUTION

The SEL-2100 contains devices sensitive to electrostatic discharge (ESD). When working on the relay with front or top cover removed, work surfaces and personnel must be properly grounded or equipment damage may result.

Step 4. If the optional I/O board is installed, disconnect the cable(s) attached to the I/O board and remove the I/O board.

Step 5. Locate the ICs to be replaced (U18 and U39) (refer to Figure B.1). Note the orientation mark of the ICs to be replaced. (The orientation mark is typically a half-circle indentation in one end of the IC.) Use an IC removal tool or a small screwdriver to pry the indicated ICs from their sockets being careful not to bend the IC pins or damage adjacent components.

Step 6. Carefully place the new ICs in the appropriate sockets. Check the orientation of the ICs. Be sure that each IC is in its corresponding socket. Look for IC pins that are bent under or did not enter a socket hole.

CAUTION

Verify proper orientation of any replaced integrated circuit(s) (ICs) before reassembling the SEL-2100. Energizing the SEL-2100 with an IC reversed irrecoverably damages the IC. If you mistakenly re-energize the relay with an IC reversed, do not place the SEL-2100 in service using that IC, even if you correct the orientation.

Step 7. Replace the I/O board and reconnect the cable(s) removed from the I/O board.

Step 8. Replace the front panel and top cover, remount the chassis in the equipment rack, and reconnect all cables removed in Step 2. If a new serial-number label is included with the upgrade, remove the new-label backing and cover the old label with the new serial-number label.

Step 9. Perform the ***Initial Checkout*** procedures described in ***Section 1: Introduction*** of the SEL-2100 Instruction Manual. In the event that the settings are lost when upgrading, you must reenter all of your settings using the **SET *n***, **SET L *n***, **SET G**, **SET R**, and **SET P *n*** commands.

If you encounter CR_RAM, EEPROM, and IO_BRD Fail Status messages enter Access Level 2 and type **R_S <Enter>** to restore factory-default settings. If the SEL-2100 does not accept the **R_S** command, or if any failure status messages still appear, see the troubleshooting section in the SEL-2100 instruction manual or contact your customer service representative or the SEL factory for assistance.

Step 10. Once the checkout is complete, and settings have been reentered as necessary, use the **SHO C** command to check the calibration settings.

After completing the above steps, the SEL-2100 status should be normal with all settings valid. If the SEL-2100 Alarm contact is closed, call SEL for factory assistance.

ADVANCED APPLICATION LOGIC

Refer to ***Appendix K: Advanced Application Logic*** to A) convert the SEL-2100 to an SEL-2100 with Advanced Application Logic, B) remove Advanced Application Logic, or C) reload Advanced Application Logic after a reset or firmware upgrade.

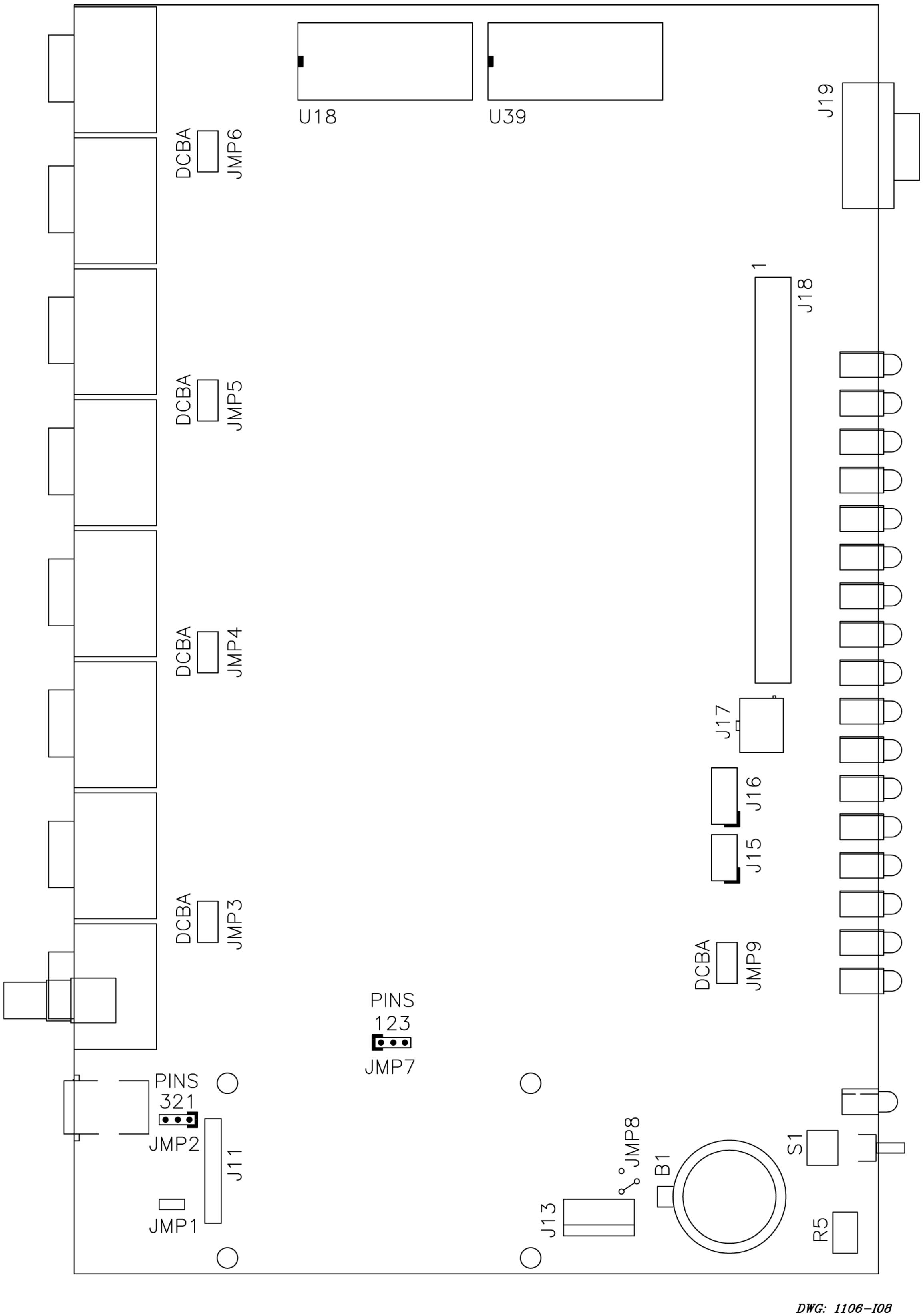

Figure B.1: SEL-2100 Main Board

APPENDIX C: DISTRIBUTED NETWORK PROTOCOL (DNP3)

OVERVIEW

The SEL-2100 Logic Processor supports Distributed Network Protocol (DNP3) Level 2 Slave protocol. This includes access to the Relay Word, contact I/O, targets, Sequential Events Recorder (SER), data settings groups, and time synchronization. The SEL-2100 supports DNP point remapping.

CONFIGURATION

To configure a port for DNP, change the port PROTO setting to DNP. Although DNP may be selected on any of the available ports, DNP may not be enabled on more than one port at a time. The following information is required to configure a port for DNP3 operation:

Label	Description	Default
SPEED	Baud Rate (300–38400)	2400
DNPADR	DNP Address (0–65534)	0
CLASSB	Class for Binary Event Data (0–3)	2
CLASSC	Class for Counter Event Data (0–3)	1
TIMERQ	Minutes for Request Interval (0–3267)	0
STIMEO	Seconds to Select/Operate Time-Out (0.0–30.0 seconds)	1.0
DRETRY	Number of Data-Link Retries (0–15)	3
DTIMEO	Seconds to Data-Link Time-out (0–5 seconds)	1
MINDLY	Minimum Seconds from DCD to Tx (0.00–1.00 seconds)	0.05
MAXDLY	Maximum Seconds from DCD to Tx (0.00–1.00 seconds)	0.10
PREDLY	Settle Time from RTS ON to Tx (OFF, 0.00–30.00 seconds)	0.00
PSTDLY	Settle Time from Tx to RTS OFF (0.00–30.00 seconds)	0.00
ETIMEO	Seconds to Event Message Confirm Time-Out, (1–50 counts)	2
UNSOL	Enable Unsolicited Reporting (Y, N)	N
PUNSOL	Enable Unsolicited Reporting at Power-Up (Y, N)	N
REPADR	DNP Address of Report to (0–65534)	0
NUMEVE	Number of Events to Transmit On (1–200)	1.0
AGEEVE	Seconds Until Oldest Event to Tx On (0.0–60.0 seconds)	2.0

Note: If the SEL-2100 has a processing interval of 6 ms (**STA** Command), DNP may not respond to requests if the speed setting is greater than 9600 baud.

The RTS signal may be used to control an external transceiver. The CTS signal is used as a DCD input, indicating when the medium is in use. Transmissions are only initiated if CTS is deasserted. When CTS drops, the next pending outgoing message may be sent once an idle time is satisfied. This idle time is randomly selected between the minimum and maximum allowed idle times (i.e., MAXDLY and MINDLY). In addition, the SEL-2100 monitors received data and treats receipt of data as a DCD indication. This allows RTS to be looped back to CTS in cases where the external transceiver does not support DCD.

When the SEL-2100 transmits a DNP message, it delays transmitting after asserting RTS by at least the time in the PREDLY setting. After transmitting the last byte of the message, the

SEL-2100 delays for at least PSTDLY milliseconds before deasserting RTS. If the PSTDLY time delay is in progress (RTS still high) following a transmission, and another transmission is initiated, the SEL-2100 transmits the message without completing the PSTDLY delay and without any preceding PREDLY delay.

RTS/CTS handshaking may be completely disabled by setting PREDLY to OFF. In this case, RTS is forced high and CTS is ignored, with only received characters acting as a DCD indication. The timing is the same as above, but PREDLY functions as if it were set to 0, and RTS is not actually deasserted after the PSTDLY time delay expires.

Data-Link Operation

It is necessary to make two important decisions about the data-link layer operation. One is how to handle data-link confirmation, the other is how to handle data-link access. If a highly reliable communications link exists, the data-link access can be disabled altogether, which significantly reduces communications overhead. Otherwise, it is necessary to enable confirmation and determine how many retries to allow and what the data-link time-out should be. The noisier the communications channel, the more likely a message will be corrupted. Thus, the number of retries should be set higher on noisy channels. Set the data-link time-out long enough to allow for the worst-case response of the master, plus transmission time.

When the SEL-2100 decides to transmit on the DNP link, it has to wait if the physical connection is in use. The SEL-2100 monitors physical connections by using CTS input (treated as a Data Carrier Detect) and monitoring character receipt. Once the physical link goes idle, as indicated by CTS being deasserted and no characters being received, the SEL-2100 will wait a configurable amount of time before beginning a transmission. This hold-off time will be a random value between the MINDLY and MAXDLY setting values. The hold-off time is random which prevents multiple devices waiting to communicate on the network from continually colliding.

Data Access Method

Based on the capabilities of the system, it is necessary to determine which method is desired to retrieve data on the DNP connection. The following table summarizes the main options, listed from least to most efficient, and corresponding key related settings are indicated.

Table C.1: Data Access Methods

Data Retrieval Method	Description	Relevant SEL-2100 Settings
Polled Static	The master polls for static (Class 0) data only.	Set CLASS = 0, Set UNSOL = 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 = 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 = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent.
Quiescent	The master never polls and relies on unsolicited reports only.	Set CLASS to a non-zero value, Set UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent.

DEVICE PROFILE

The following is the device profile as specified in the ***DNP3 Subset Definitions*** document:

<table>
<tr><td colspan="2">DNP3
DEVICE PROFILE DOCUMENT
This document must be accompanied by a table having the following headings:
Object Group   Request Function Codes   Response Function Codes
Object Variation   Request Qualifiers   Response Qualifiers
Object Name (optional)</td></tr>
<tr><td colspan="2">Vendor Name: Schweitzer Engineering Laboratories, Inc.</td></tr>
<tr><td colspan="2">Device Name: SEL-2100</td></tr>
<tr><td>Highest DNP Level Supported:
For Requests Level 2
For Responses Level 2</td><td>Device Function:
☐ Master ☑ Slave</td></tr>
<tr><td colspan="2">Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

<u>Supports enabling and disabling of unsolicited reports on a class basis.</u></td></tr>
</table>

Maximum Data-Link Frame Size (octets):	Maximum Application Fragment Size (octets):
Transmitted 292	Transmitted 2048 (if >2048, must be configurable)
Received (must be 292)	Received 2048 (must be >249)

Maximum Data-Link Retries:	Maximum Application Layer Retries:
☐ None ☐ Fixed at ________ ☑ Configurable, range 0 to 15	☑ None ☑ Configurable, range _____ to _____ (Fixed is not permitted)

Requires Data-Link Layer Confirmation:

- ☐ Never
- ☐ Always
- ☐ Sometimes If 'Sometimes', when? ________
- ☑ Configurable If 'Configurable', how? by settings.

Requires Application Layer Confirmation:

- ☐ Never
- ☐ Always (not recommended)
- ☑ When reporting Event Data (Slave devices only)
- ☐ When sending multi-fragment responses (Slave devices only)
- ☐ Sometimes If 'Sometimes', when? ________
- ☐ Configurable If 'Configurable', how? ________

Timeouts while waiting for:

Data-Link Confirm	☐ None	☐ Fixed at ____	☐ Variable	☑ Configurable
Complete Appl. Fragment	☑ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Application Confirm	☐ None	☐ Fixed at ____	☐ Variable	☑ Configurable
Complete Appl. Response	☑ None	☐ Fixed at ____	☐ Variable	☐ Configurable

Others ________

Attach explanation if 'Variable' or 'Configurable' was checked for any time-out.

Sends/Executes Control Operations:

WRITE Binary Outputs	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE—NO ACK	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
Count > 1	☑ Never	☐ Always	☐ Sometimes	☐ Configurable
Pulse On	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
Pulse Off	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
Latch Off	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
Queue	☑ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☑ Never	☐ Always	☐ Sometimes	☐ Configurable

Attach explanation if 'Sometimes' or 'Configurable' was checked for any operation.

FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:

Expects Binary Input Change Events:

- ☐ Either time-tagged or non-time-tagged for a single event
- ☐ Both time-tagged and non-time-tagged for a single event
- ☐ Configurable (attach explanation)

FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY	
Reports Binary Input Change Events when no specific variation requested: ☐ Never ☑ Only time-tagged ☐ Only non-time-tagged ☐ Configurable to send both, one or the other (attach explanation)	Reports time-tagged Binary Input Change Events when no specific variation requested: ☐ Never ☑ Binary Input Change With Time ☐ Binary Input Change With Relative Time ☐ Configurable (attach explanation)
Sends Unsolicited Responses: ☐ Never ☑ Configurable (attach explanation) ☐ Only certain objects ☐ Sometimes (attach explanation) ☑ ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: ☑ Never ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ☐ No Counters Reported ☐ Configurable (attach explanation) ☑ Default object 20 ☐ Default variation 6 ☐ Point-by-point list attached	Counters Roll Over at: ☐ No Counters Reported ☐ Configurable (attach explanation) ☑ 16 Bits ☐ 32 Bits ☐ Other Value ☐ Point-by-point list attached
Sends Multi-Fragment Responses: ☐ Yes ☑ No	

When an item in the device profile is configurable, it is controlled by SEL-2100 settings.

OBJECT TABLE

The following object table shows the supported object, function, and qualifier code combinations.

Table C.2: SEL-2100 DNP3 Object Table

OBJECT			REQUEST (supported)		RESPONSE (may generate)	
Obj	**Var *def**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes (dec)**	**Qual Codes (hex)**
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*	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	Binary Input Change without Time	1	6,7,8	129	17, 28
2	2*	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

OBJECT			REQUEST (supported)		RESPONSE (may generate)	
Obj	**Var *def**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes (dec)**	**Qual Codes (hex)**
10	0	Binary Output–All Variations	1	0,1,6,7,8		
10	1	Binary Output				
10	2*	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				
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*	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				

OBJECT			REQUEST (supported)		RESPONSE (may generate)	
Obj	**Var *def**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes (dec)**	**Qual Codes (hex)**
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*	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
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				
30	1	32-Bit Analog Input				
30	2	16-Bit Analog Input				
30	3	32-Bit Analog Input without Flag				
30	4*	16-Bit Analog Input without Flag				

OBJECT			REQUEST (supported)		RESPONSE (may generate)	
Obj	**Var *def**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes (dec)**	**Qual Codes (hex)**
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				
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				
32	1	32-Bit Analog Change Event without Time				
32	2*	16-Bit Analog Change Event without Time				
32	3	32-Bit Analog Change Event with Time				
32	4	16-Bit Analog Change Event with Time				
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*	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				

OBJECT			REQUEST (supported)		RESPONSE (may generate)	
Obj	**Var *def**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes (dec)**	**Qual Codes (hex)**
51	0	Time and Date CTO–All Variations				
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO				07, quan-tity=1
52	0	Time Delay–All Variations				
52	1	Time Delay Coarse				
52	2	Time Delay Fine			129	07, quan-tity=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				
		No object	13,14,23			

DATA MAP

Table C.3: SEL-2100 Data Map

DNP3 Object Type	Index	Description
01,02	000–799	Processor Word, where index is divided by 8 to get the row, and the remainder is used as a bit index.
01,02	800–1599	Processor Word from the SER, encoded same as inputs 000–799 with 800 added.
01,02	1600–1615	Reserved.
01,02	1616	Logic Processor Disabled.
01,02	1617	Logic Processor diagnostic failure.
01,02	1618	Logic Processor diagnostic warning.
01,02	1619	Reserved.
01,02	1620	Settings change or unit restart.
10,12	00–31	Remote bits RB1–RB32.
10,12	32–39	Reserved.
10,12	40–55	Remote bit pairs RB1–RB32.
10,12	56–59	Reserved.
10,12	60–91	Remote bits RB33–RB64.
10,12	92–99	Reserved.
10,12	100–115	Remote bits pairs RB33–RB64.
20,22	00	Active settings group.
40,41	00	Active settings group.

Binary Inputs (objects 1 and 2) are supported as defined by the previous table. The default variation for both static and event inputs is 2. Only the Read function code (1) is allowed with these objects. All variations are supported. Object 2, variation 3 will be responded to, but will contain no data. When flags are requested, only the on-line (always set) and the state bit are used (the others are reported as 0).

Binary Inputs 0–799, and 1616–1618, and 1620 are scanned approximately once per second to generate events. When time is reported with these event objects, it is the time at which the scanner observed the bit change. This may be significantly delayed from when the original source change and should not be used for sequence-of-events determination. Binary Inputs 800–1599 are derived from the SER and carry the time stamp of actual occurrence. Static reads from these inputs will show the same data as a read from the corresponding index in the 0–799 group.

Binary Input 1616 is derived from the relay status variable. Binary Inputs 1617 and 1618 are derived from the diagnostic task data. Binary Input 1620 is derived from the SER and carries the time stamp of actual occurrence. Static reads from this input will always show 0. Binary Event data will be available in the class specified in the CLASSB setting. Setting CLASSB to 0 disables Binary Events.

Control Relay Output Block objects (object 12, variation 1) are supported. The control relays correspond to the remote bits and other functions, as shown above. The control field is interpreted as follows:

Index	Close(0x4X)	Trip(0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0–31	Set	Clear	Set	Clear	Pulse	Clear
32–39	Reserved					
40	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1
41	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3
42	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5
43	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7
44	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9
45	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11
46	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13
47	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15
48	Pulse RB18	Pulse RB17	Pulse RB18	Pulse RB17	Pulse RB18	Pulse RB17
49	Pulse RB20	Pulse RB19	Pulse RB20	Pulse RB19	Pulse RB20	Pulse RB19
50	Pulse RB22	Pulse RB21	Pulse RB22	Pulse RB21	Pulse RB22	Pulse RB21
51	Pulse RB24	Pulse RB23	Pulse RB24	Pulse RB23	Pulse RB24	Pulse RB23
52	Pulse RB26	Pulse RB25	Pulse RB26	Pulse RB25	Pulse RB26	Pulse RB25
53	Pulse RB28	Pulse RB27	Pulse RB28	Pulse RB27	Pulse RB28	Pulse RB27
54	Pulse RB30	Pulse RB29	Pulse RB30	Pulse RB29	Pulse RB30	Pulse RB29
55	Pulse RB32	Pulse RB31	Pulse RB32	Pulse RB31	Pulse RB32	Pulse RB31
56–59	Reserved					
60-91	Set	Clear	Set	Clear	Pulse	Clear
92-99	Reserved					
100	Pulse RB34	Pulse RB33	Pulse RB34	Pulse RB33	Pulse RB34	Pulse RB33
101	Pulse RB36	Pulse RB35	Pulse RB36	Pulse RB35	Pulse RB36	Pulse RB35
102	Pulse RB38	Pulse RB37	Pulse RB38	Pulse RB37	Pulse RB38	Pulse RB37
103	Pulse RB40	Pulse RB39	Pulse RB40	Pulse RB39	Pulse RB40	Pulse RB39
104	Pulse RB42	Pulse RB41	Pulse RB42	Pulse RB41	Pulse RB42	Pulse RB41
105	Pulse RB44	Pulse RB43	Pulse RB44	Pulse RB43	Pulse RB44	Pulse RB43
106	Pulse RB46	Pulse RB45	Pulse RB46	Pulse RB45	Pulse RB46	Pulse RB45
107	Pulse RB48	Pulse RB47	Pulse RB48	Pulse RB47	Pulse RB48	Pulse RB47
108	Pulse RB50	Pulse RB49	Pulse RB50	Pulse RB49	Pulse RB50	Pulse RB49
109	Pulse RB52	Pulse RB51	Pulse RB52	Pulse RB51	Pulse RB52	Pulse RB51
110	Pulse RB54	Pulse RB53	Pulse RB54	Pulse RB53	Pulse RB54	Pulse RB53
111	Pulse RB56	Pulse RB55	Pulse RB56	Pulse RB55	Pulse RB56	Pulse RB55
112	Pulse RB58	Pulse RB57	Pulse RB58	Pulse RB57	Pulse RB58	Pulse RB57
113	Pulse RB60	Pulse RB59	Pulse RB60	Pulse RB59	Pulse RB60	Pulse RB59
114	Pulse RB62	Pulse RB61	Pulse RB62	Pulse RB61	Pulse RB62	Pulse RB61
115	Pulse RB64	Pulse RB63	Pulse RB64	Pulse RB63	Pulse RB64	Pulse RB63

The Status field is used exactly as defined. All other fields are ignored. A pulse operation is asserted for a single processing interval. Qualifier codes of 17h and 28h are supported in both the request and response messages. Only Select (3), Operate (4), Direct Operate (5), and Direct

Operate, No Ack (6) function codes are allowed with these objects. The Select/Operate interval is given by the settings.

Binary Output status (object 10, variation 2) is supported. Only the Read function code (1) is allowed on this object. Reads from points 0–31 and 60–91 respond with the on-line bit set and the state of the requested remote bit. Reads from points 40–55 and 100–115 respond with the on-line bit set and a state of 0.

Counter objects default to 16-bit counters without flag (object 20, variation 6). Variation 5 is also allowed. Frozen Counters (object 21) are not supported. Event Counters (object 22) are supported with a default variation of 2. Variations 1, 5, and 6 are also allowed. Only the Read function code (1) is allowed on this object. Counters are scanned at a 1 second rate and the event time stamp is based on this scan. Counter Event data will be available in the class specified by the CLASSC setting. Setting CLASSC to 0 disables Counter Events.

All variations of Analog Inputs (30) and Analog Change Events (32) are not supported. Frozen analogs (objects 31 and 33) are not supported.

Of the Time and Date objects, only object 50, variation 1, and object 52, variation 2 are supported. The Unsynchronized Time and Date CTO object (object 51, variation 1) is only used in conjunction with Binary Input Event Relative Time Objects. Qualifier code 7 is supported for these objects.

Class Objects (60) are supported. Class 0 requests include all static data in its default variations. Class 1, 2, or 3 may be supported, based on the user-settings. If the supported event class is selected, all unread events are supplied in their default variations.

The only device object that is supported is Internal Indications (80). Only the Write function code (2) is allowed on this object, to clear the RESTART bit.

Point Remapping

The binary input points (objects 1and 2) may be remapped via the **DNP** command. The map is composed of a list of indices that correspond to those given by the SEL-2100's DNP data map. The order they occur in the list determines the index that the corresponding value is reported as to the DNP master. If a value is not in the list, it is not available to the DNP master. All 1621 binaries may be included in the list, but must only occur once. The maps are stored in EEPROM and are protected with a checksum. The **DNP** command is only available if DNP has been selected on one of the ports. The **DNP** command has the following format:

DNP [B|BI|T] [VIEW]

If the **DNP** command is issued either without parameters, the SEL-2100 displays the binary map, which has the following format:

```
==>DNP <Enter>
Binaries = 112 28 17 35 1 56 57 58 59 60 61 62 63 64 65 \
66 67 100 101 102 103
==>
```

If the map checksum is determined to be invalid, the map will be reported as corrupted during a display command, as follows:

```
==>DNP BI VIEW <Enter>
Binary Inputs = Map Corrupted
==>
```

If the map is determined to be corrupted, DNP will respond to all master data requests with an unknown point error. If the **DNP** command is issued with a B or BI parameter at level 2 or greater, the SEL-2100 requests the user enter indices for the Binary list. The SEL-2100 accepts lines of indices until a line without a final continuation character (\) is entered. Each line of input is constrained to 80 characters, but all the points may be remapped, using multiple lines with continuation characters (\) at the end of the intermediate lines. For example, the first example remap could be produced with the following commands:

```
==>DNP B <Enter>
Enter the new DNP Binary Input map
112 28 17 \<Enter>
35 1 56 57 58 59 60 61 62 63 64 65 66 67 100 101 102 \<Enter>
103<Enter>

Save Changes (Y/N)? Y <Enter>
==>
```

If a single blank line is entered as the first line, remapping is disabled (i.e. the SEL-2100 uses the default map).

```
==>DNP BI <Enter>
Enter the new DNP Binary Input map
<Enter>

Save Changes (Y/N)? Y <Enter>
==>
```

The **DNP** command will report an error if an index is used twice, an invalid index is used or non-numeric data are entered.

```
xx is referenced more than once, changes not saved

xx is not a valid index, changes not saved

Invalid format, changes not saved
```

SETTINGS SHEET–DNP3 PORT–SET P

Baud Rate (300–38400)	SPEED	= ________________
DNP Address (0–65534)	DNPADR	= ________________
Class for Binary Event Data (0–3)	CLASSB	= ________________
Class for Counter Event Data (0–3)	CLASSC	= ________________
Minutes for Request Interval (0–323767)	TIMERQ	= ________________
Seconds to Select/Operate Time-Out (0.0–30.0 seconds)	STIMEO	= ________________
Number of Data-Link Retries (0–15)	DRETRY	= ________________
Seconds to Data-Link Time-out (0–5 seconds)	DTIMEO	= ________________
Minimum Seconds from DCD to Tx (0.00–1.00 seconds)	MINDLY	= ________________
Maximum Seconds from DCD to Tx (0.00–1.00 seconds)	MAXDLY	= ________________
Settle Time from RTS ON to Tx (OFF, 0.00–30.00 seconds)	PREDLY	= ________________
Settle Time from Tx to RTS OFF (0.00–30.00 seconds)	PSTDLY	= ________________
Seconds to Event Message Confirm Time-Out (1–50 counts)	ETIMEO	= ________________
Enable Unsolicited Reporting (Y, N)	UNSOL	= ________________
Enable Unsolicited Reporting at Power-Up (Y, N)	PUNSOL	= ________________
DNP Address of Report (0–65534)	REPADR	= ________________
Number of Events to Transmit On (1–200)	NUMEVE	= ________________
Seconds Until Oldest Event to Tx On (0.0–60.0 seconds)	AGEEVE	= ________________

APPENDIX D: COMPRESSED ASCII COMMANDS

INTRODUCTION

The SEL-2100 provides Compressed ASCII versions of some of the ASCII commands. The Compressed ASCII commands allow an external device to obtain data from the SEL-2100 in a format which directly imports into spreadsheet or database programs, and which can be validated with a checksum.

The SEL-2100 provides the following Compressed ASCII commands:

Command	Description
CASCII	Configuration Message
CSTATUS	Status Message

CASCII COMMAND—GENERAL FORMAT

The Compressed ASCII configuration message provides data for an external computer to extract data from other Compressed ASCII commands. To obtain the configuration message for the Compressed ASCII commands available in an SEL-2100, type:

CAS <CR>

The SEL-2100 sends:

```
<STX>"CAS",n,"yyyy"<CR>
"COMMAND 1",ll,"yyyy"<CR>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR>
"COMMAND 2",ll,"yyyy"<CR>
"#h","ddd","ddd",......,"ddd","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR>
   •
   •
   •
"COMMAND n",ll,"yyyy"<CR>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy"<CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy"<CR><ETX>
```

where: *n* is the number of Compressed ASCII command descriptions to follow.

COMMAND is the ASCII name for the Compressed ASCII command as sent by the requesting device. The naming convention for the Compressed ASCII commands is a “C” preceding the typical command. For example, **CSTATUS** (abbreviated to **CST**) is the compressed **STATUS** command.

"ll" is the minimum Access Level at which the command is available.

"#H" identifies a header line to precede one or more data lines; “#” is the number of subsequent ASCII names. For example, “21H” identifies a header line with 21 ASCII labels.

"#h" identifies a header line to precede one or more data lines; “#” is the number of subsequent format fields. For example, “8h” identifies a header line with 8 format fields.

"Xxxxx" is an ASCII name for corresponding data on following data lines. Maximum ASCII name width is 10 characters.

"#D" identifies a data format line; "#" is the maximum number of subsequent data lines.

"ddd" identifies a format field containing one of the following type designators:

- I Integer data
- F Floating point data
- Ms String of maximum m characters (e.g., 10S for a 10-character string)

"Yyyy" is the 4-byte hex ASCII representation of the checksum.

A Compressed ASCII command may require multiple header and data configuration lines.

If a Compressed ASCII request is made for data that are not available, (e.g., invalid event request), the SEL-2100 responds with the following message:

<STX>"No Data Available","0668"<CR><ETX>

CASCII Command—SEL-2100

Display the SEL-2100 Compressed ASCII configuration message by sending:

CAS <CR>

```
<STX>
"CAS",1,"01A4"<CR>
"CST",1,"01B7"<CR>
"1H","FID","022C"<CR>
"1D","45S","0211"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0BB9"<CR>
"1D","I","I","I","I","I","I","I","05F4"<CR>
"7H","RAM","ROM","CR_RAM","EEPROM","IO_BRD","+15V_PS","-
15V_PS","0F0C"<CR>
"1D","9S","9S","9S","9S","9S","9S","9S","07C9"<CR>
<EXT>
```

CSTATUS COMMAND—SEL-2100

Display status data in Compressed ASCII format by sending:

CST <CR>

```
<STX>"FID"," yyyy "<CR>
"FID=SEL-2100-R100-V0-Z001001-D19991221"," yyyy "<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC"," yyyy "<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx," yyyy "<CR>
"RAM","ROM","CR_RAM","EEPROM","IO_BRD","+15V_PS","-15V_PS"," yyyy "<CR>
" xxxx "," xxxx "," xxxx "," xxxx "," xxxx "," xxxx "," xxxx "," yyyy "<CR>
<ETX>
```

where: "xxxx" are the data values corresponding to the first line labels and
"yyyy" is the 4-byte hex ASCII representation of the checksum.

APPENDIX E: FAST METER PROTOCOL

INTRODUCTION

SEL relays have two separate data streams that share the same serial port. The human data communications with the relay consist of ASCII character commands and reports that are intelligible to humans using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to access this feature. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

SEL Application Guide AG95-10: Configuration and Fast Meter Messages, is a comprehensive description of the SEL binary messages. Below is a description of the messages provided in the SEL-2100.

MESSAGE LISTS

Introduction

The SEL-2100 supports the following SEL Fast Meter and configuration messages:

A5C0	Fast Meter definition block
A5C1	Fast Meter configuration block
A5D1	Fast Meter data message
A5B9	Status bits clear command
A5CE	Fast Operate configuration message
A5EO	Fast Operate remote bit control
A5CF	Alternate Fast Operate definition block
A5E7	Alternate or extended Fast Operate set Remote Bit
A5E8	Alternate or extended Fast Operate clear Remote Bit
A5E9	Alternate or extended Fast Operate pulse Remote Bit
BNA	ASCII names of status bits
ID	ASCII FID and TID strings
DNA	ASCII names of digital I/O
SNS	ASCII names of SER settings

Processing

The SEL-2100 receives and transmits Fast Meter messages interleaved with ASCII messages.

Upon startup and when settings change, the SEL-2100 sets the Settings Change bit in the Fast Meter Status byte.

A5C0 Fast Meter Definition Message

In response to the A5C0 request, the SEL-2100 sends the definition block as described below.

A5C0	Command
1C	Length
04	Support four protocols
01	Support one Fast Meter message
01	Support one status flag command
A5C1	Fast Meter configuration command
A5D1	Fast Meter command
0004	Settings change bit
A5C100000000	Fast Meter configuration message
0300	SEL protocol with Fast Operate and Fast Message (unsolicited SER messaging)
0301	LMD protocol with Fast Operate and Fast Message (unsolicited SER messaging)
0005	DNP protocol, no Fast Operate
0006	MIRRORED BITS® protocol, no Fast Operate
00	Reserved
checksum	Checksum

A5C1 Fast Meter Configuration Message

In response to the A5C1 request, the SEL-2100 sends the Fast Meter configuration block as described below.

A5C1	Fast Meter command
12	Length
01	One status flag byte
00	Scale factors in Fast Meter message
00	# of scale factors
00	# of analog input channels
02	# of samples per channel
46	# of digital banks (70)
00	No calculation blocks
0004	Analog channel offset
0004	Time stamp offset
000C	Digital offset
00	Reserved
checksum	

A5D1 Fast Meter Message

In response to the A5D1 request, the SEL-2100 sends the Fast Meter block as described below.

2 bytes	Command codes, A5D1
1 byte	Message length, 0x52.
1 byte	1 Status byte
8 bytes	Time stamp.
70 bytes	70 digital banks. TAR0–TAR69
1 byte	reserved
1 byte	Checksum calculated by addition of all the above bytes.
84 bytes	Total message length.

A5B9 Fast Meter Status Acknowledge Message

In response to the A5B9 request, the SEL-2100 clears the Fast Meter Status byte. The status byte includes:

Bit	Usage
0	Not used
1	Not used
2	Not used
3	Not used
4	Setting changes. Set in the event of a settings change and when the SEL-2100 is turned on. Cleared by the status acknowledge message.

A5CE Fast Operate Configuration Message

In response to the A5CE request, the SEL-2100 sends the following block:

A5CE	Command
6A	Length
00	Support zero circuit breakers
0020	Support 32 remote bits set/clear
0100	Allow remote bit pulse commands
00	Operate code, clear remote bit RB1
20	Operate code, set remote bit RB1
40	Operate code, pulse remote bit RB1
01	Operate code, clear remote bit RB2
21	Operate code, set remote bit RB2
41	Operate code, pulse remote bit RB2
02	Operate code, clear remote bit RB3
22	Operate code, set remote bit RB3
42	Operate code, pulse remote bit RB3
03	Operate code, clear remote bit RB4
23	Operate code, set remote bit RB4
43	Operate code, pulse remote bit RB4
04	Operate code, clear remote bit RB5
24	Operate code, set remote bit RB5
44	Operate code, pulse remote bit RB5
05	Operate code, clear remote bit RB6

25	Operate code, set remote bit RB6
45	Operate code, pulse remote bit RB6
06	Operate code, clear remote bit RB7
26	Operate code, set remote bit RB7
46	Operate code, pulse remote bit RB7
07	Operate code, clear remote bit RB8
27	Operate code, set remote bit RB8
47	Operate code, pulse remote bit RB8
08	Operate code, clear remote bit RB9
28	Operate code, set remote bit RB9
48	Operate code, pulse remote bit RB9
09	Operate code, clear remote bit RB10
29	Operate code, set remote bit RB10
49	Operate code, pulse remote bit RB10
0A	Operate code, clear remote bit RB11
2A	Operate code, set remote bit RB11
4A	Operate code, pulse remote bit RB11
0B	Operate code, clear remote bit RB12
2B	Operate code, set remote bit RB12
4B	Operate code, pulse remote bit RB12
0C	Operate code, clear remote bit RB13
2C	Operate code, set remote bit RB13
4C	Operate code, pulse remote bit RB13
0D	Operate code, clear remote bit RB14
2D	Operate code, set remote bit RB14
4D	Operate code, pulse remote bit RB14
0E	Operate code, clear remote bit RB15
2E	Operate code, set remote bit RB15
4E	Operate code, pulse remote bit RB15
0F	Operate code, clear remote bit RB16
2F	Operate code, set remote bit RB16
4F	Operate code, pulse remote bit RB16
10	Operate code, clear remote bit RB17
30	Operate code, set remote bit RB17
50	Operate code, pulse remote bit RB17
11	Operate code, clear remote bit RB18
31	Operate code, set remote bit RB18
51	Operate code, pulse remote bit RB18
12	Operate code, clear remote bit RB19
32	Operate code, set remote bit RB19
52	Operate code, pulse remote bit RB19
13	Operate code, clear remote bit RB20
33	Operate code, set remote bit RB20
53	Operate code, pulse remote bit RB20
14	Operate code, clear remote bit RB21
34	Operate code, set remote bit RB21
54	Operate code, pulse remote bit RB21
15	Operate code, clear remote bit RB22
35	Operate code, set remote bit RB22
55	Operate code, pulse remote bit RB22
16	Operate code, clear remote bit RB23

36	Operate code, set remote bit RB23
56	Operate code, pulse remote bit RB23
17	Operate code, clear remote bit RB24
37	Operate code, set remote bit RB24
57	Operate code, pulse remote bit RB24
18	Operate code, clear remote bit RB25
38	Operate code, set remote bit RB25
58	Operate code, pulse remote bit RB25
19	Operate code, clear remote bit RB26
39	Operate code, set remote bit RB26
59	Operate code, pulse remote bit RB26
1A	Operate code, clear remote bit RB27
3A	Operate code, set remote bit RB27
5A	Operate code, pulse remote bit RB27
1B	Operate code, clear remote bit RB28
3B	Operate code, set remote bit RB28
5B	Operate code, pulse remote bit RB28
1C	Operate code, clear remote bit RB29
3C	Operate code, set remote bit RB29
5C	Operate code, pulse remote bit RB29
1D	Operate code, clear remote bit RB30
3D	Operate code, set remote bit RB30
5D	Operate code, pulse remote bit RB30
1E	Operate code, clear remote bit RB31
3E	Operate code, set remote bit RB31
5E	Operate code, pulse remote bit RB31
1F	Operate code, clear remote bit RB32
3F	Operate code, set remote bit RB32
5F	Operate code, pulse remote bit RB32
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5E0 Fast Operate Remote Bit Control

The external device sends the following message to perform a remote bit operation:

A5E0	Command
06	Length
1-byte	Operate code: 00–1F clear remote bit RB1–RB32 20–3F set remote bit RB1–RB32 40–5F pulse remote bit for RB1–RB32 for one processing interval
1-byte	Operate validation: 4 • Operate code + 1
checksum	1-byte checksum of preceding bytes

The relay performs the specified remote bit operation if the following conditions are true:

1. The Operate code is valid.
2. The Operate validation = 4 • Operate code + 1
3. The message checksum is valid.
4. The FASTOP port setting is set to Y.
5. The relay is enabled.

Remote bit set and clear operations are latched by the relay. Remote bit pulse operations assert the remote bit for one processing interval.

A5CF Alternate Fast Operate definition block

In response to the A5CF request, the SEL-2100 sends the following block:

A5CF	Command
0C	Message length (12 bytes)
01	Port quantity
00	Breaker quantity
40	Remote bit quantity (64 remote bits per port)
00	Open breaker code (E5 not supported)
00	Open breaker code (E6 not supported)
E8	Clear remote bit code
E7	Set remote bit code
E9	Pulse remote bit code
Checksum	1-byte checksum of all preceding bytes

A5E7, E8, E9 Alternate Fast Operate Control Remote Bit

The external device sends the following Alternate Fast Operate Control Remote Bit message to perform the control operation:

2-bytes	Command	
	A5E7	Set remote bit
	A5E8	Clear remote bit
	A5E9	Pulse remote bit
1-byte	08 (Length)	
2-bytes	Operate code Unsigned 16 bit number where: Bit 15: Always 0 Bit 14: Always 0 for alternate Fast Operate Bit 13–8: Fast output port number port (always Port 1) Bits 7–0 indicate remote bit number. Most significant byte 01 (alternate Fast Operate — 1 port) Least significant byte 01–40 (remote bit 1–64)	
2-bytes	Operate validation: (4 • operate code) + 1	
1-byte	Checksum of preceding bytes	

A5E7, E8, E9 Extended Fast Operate Control Remote Bit

The external device sends the following Extended Fast Operate Remote Bit message to perform the control operation:

2-bytes	Command	
	A5E7	Set remote bit
	A5E8	Clear remote bit
	A5E9	Pulse remote bit
1-byte	08 (Length)	
2-bytes	Operate Code Unsigned 16 bit number where: Bit 15: Always 0 Bit 14: Always 1 for extended Fast Operate Bit 13–10: Fast output port index (always Port 1) Bits 9–0 indicate remote bit. Most significant byte 40 (Extended Fast Operate — 1 port) Least significant byte 00-3F (Remote bit 1–64)	
2-bytes	Operate validation: (4 • operate code) + 1	
1-byte	Checksum of preceding bytes	

A546 Unsolicited Write

The SEL Fast Message Unsolicited Write message has the following form:

Hexadecimal Representation	Description (numbers are in hexadecimal unless otherwise noted)
A546	Header (SEL Fast Message)
xx	Message length (bytes). Minimum 16 (22 decimal), maximum F8 (248 decimal)
0000000000	Routing
00	Status Byte (must be zero, indicating that no acknowledge is required)
20	Function code (Unsolicited Write)
C0	Sequence byte (must be C0)
00	Response Number (leave at 00)
01	Port number (must be 01)
00	Reserved
aaaa	2-byte destination address
cccc	2-byte register count (Number of 2-byte data values. Does not include checksum. Minimum of 1, maximum of 73 (115 decimal))
xxxx	Data register 1
xxxx	Data register 2

Hexadecimal Representation	Description (numbers are in hexadecimal unless otherwise noted)
…	…
xxxx	Data register n
yyyy	2-byte CRC-16 (Cyclic Redundancy Check) check code for message, most significant byte first

The CRC-16 entry is based on the Modbus standard, except the bytes are arranged differently. The details of the calculation are available on the Internet at: modbus.org/docs/PI_MBUS_300.pdf

SEL Communications Processors, such as the SEL-2030 and SEL-2032, can generate A546 Unsolicited Write messages using the **WRITE \W** command, including all of the header and CRC information for the message. For more information on this method refer to the communications processor instruction manuals. The SEL-3351 System Computing Platform can also generate SEL Fast Message commands as a part of an installed application.

BNA Message

In response to the **BNA** command, the SEL-2100 sends the names of the status bits as described below.

<STX>"*","*","*","STSET","*","*","*","*","yyyy"<CR>
<ETX>
where “yyyy” is the 4-byte ASCII representation of the checksum.

ID Message

In response to the ID command, the SEL-2100 sends the firmware identification (FID), firmware checksum (CID), device TID setting (DEVID), Modbus device code (DEVCODE, used by SEL-2032, SEL-2030, and SEL-2020 Communications Processors), device part number (PARTNO), and configuration string (CONFIG, used by other intelligent electronic devices (IED) or software). A sample response is shown below; responses differ depending on specific model and firmware:

<STX>
"FID=SEL-2100-R103-V0-Z003003-D20050318","yyyy"<CR><LF>
"CID=cccc","yyyy"<CR><LF>
"DEVID=STATION A","yyyy"<CR><LF>
"DEVCODE=45","yyyy"<CR><LF>
"PARTNO=2100XX344H","yyyy"<CR><LF>
"CONFIG=000000","yyyy"<CR><LF><ETX>

where <STX> is the STX character (start of text, ASCII hex 02),
<ETX> is the ETX character (end of text, ASCII hex 03),
yyyy is the 4-byte ASCII hex representation of the checksum for each line,
cccc is the 4-byte ASCII hex representation of the checksum of the relay firmware.

The ID message is available from Access Level 0 and higher.

DNA Message

In response to the **DNA** command, the SEL-2100 sends names of the Relay Word bits transmitted in the A5D1 message. The first name is associated with the most significant byte (MSB) and the last name with the least significant byte (LSB). The **DNA** command is available from Access Level 1 and higher.

The DNA message for a SEL-2100 is:

<STX>

```
"RB1","RB2","RB3","RB4","RB5","RB6","RB7","RB8","09C4"
"RB9","RB10","RB11","RB12","RB13","RB14","RB15","RB16","0B15"
"RB17","RB18","RB19","RB20","RB21","RB22","RB23","RB24","0B4F"
"RB25","RB26","RB27","RB28","RB29","RB30","RB31","RB32","0B59"
"IN108","IN107","IN106","IN105","IN104","IN103","IN102","IN101","0CE4"
"IN116","IN115","IN114","IN113","IN112","IN111","IN110","IN109","0CE5"
"ROK8","ROK7","ROK6","ROK5","ROK4","ROK3","ROK2","ROK1","0C84"
"*","ROK15","ROK14","ROK13","ROK12","ROK11","ROK10","ROK9","0CAC"
"LBOK8","LBOK7","LBOK6","LBOK5","LBOK4","LBOK3","LBOK2","LBOK1","0E64"
"*","LBOK15","LBOK14","LBOK13","LBOK12","LBOK11","LBOK10","LBOK9","0E50"
"R8P1","R7P1","R6P1","R5P1","R4P1","R3P1","R2P1","R1P1","0BBC"
"R8P2","R7P2","R6P2","R5P2","R4P2","R3P2","R2P2","R1P2","0BC4"
"R8P3","R7P3","R6P3","R5P3","R4P3","R3P3","R2P3","R1P3","0BCC"
"R8P4","R7P4","R6P4","R5P4","R4P4","R3P4","R2P4","R1P4","0BD4"
"R8P5","R7P5","R6P5","R5P5","R4P5","R3P5","R2P5","R1P5","0BDC"
"R8P6","R7P6","R6P6","R5P6","R4P6","R3P6","R2P6","R1P6","0BE4"
"R8P7","R7P7","R6P7","R5P7","R4P7","R3P7","R2P7","R1P7","0BEC"
"R8P8","R7P8","R6P8","R5P8","R4P8","R3P8","R2P8","R1P8","0BF4"
"R8P9","R7P9","R6P9","R5P9","R4P9","R3P9","R2P9","R1P9","0BFC"
"R8P10","R7P10","R6P10","R5P10","R4P10","R3P10","R2P10","R1P10","0D3C"
"R8P11","R7P11","R6P11","R5P11","R4P11","R3P11","R2P11","R1P11","0D44"
"R8P12","R7P12","R6P12","R5P12","R4P12","R3P12","R2P12","R1P12","0D4C"
"R8P13","R7P13","R6P13","R5P13","R4P13","R3P13","R2P13","R1P13","0D54"
"R8P14","R7P14","R6P14","R5P14","R4P14","R3P14","R2P14","R1P14","0D5C"
"R8P15","R7P15","R6P15","R5P15","R4P15","R3P15","R2P15","R1P15","0D64"
"LP1","LP2","LP3","LP4","LP5","LP6","LP7","LP8","0A04"
"SV1","SV2","SV3","SV4","SV1T","SV2T","SV3T","SV4T","0BAC"
"SV5","SV6","SV7","SV8","SV5T","SV6T","SV7T","SV8T","0BCC"
"SV9","SV10","SV11","SV12","SV9T","SV10T","SV11T","SV12T","0CD6"
"SV13","SV14","SV15","SV16","SV13T","SV14T","SV15T","SV16T","0D44"
"SV17","SV18","SV19","SV20","SV17T","SV18T","SV19T","SV20T","0D52"
"SV21","SV22","SV23","SV24","SV21T","SV22T","SV23T","SV24T","0D3C"
"SV25","SV26","SV27","SV28","SV25T","SV26T","SV27T","SV28T","0D5C"
"SV29","SV30","SV31","SV32","SV29T","SV30T","SV31T","SV32T","0D46"
"LV1","LV2","LV3","LV4","LV5","LV6","LV7","LV8","0A34"
"LV9","LV10","LV11","LV12","LV13","LV14","LV15","LV16","0B85"
"LV17","LV18","LV19","LV20","LV21","LV22","LV23","LV24","0BBF"
"LV25","LV26","LV27","LV28","LV29","LV30","LV31","LV32","0BC9"
"OUT101","OUT102","OUT103","OUT104","*","*","*","*","0A56"
"*","*","*","*","*","*","*","*","04D0"
"SS1","SS2","SS3","SS4","SS5","SS6","ALARM","IRIGOK","0BCB"
```

```
"SG1","SG2","SG3","SG4","SG5","SG6","*","*","08A5"
"T8P1","T7P1","T6P1","T5P1","T4P1","T3P1","T2P1","T1P1","0BCC"
"T8P2","T7P2","T6P2","T5P2","T4P2","T3P2","T2P2","T1P2","0BD4"
"T8P3","T7P3","T6P3","T5P3","T4P3","T3P3","T2P3","T1P3","0BDC"
"T8P4","T7P4","T6P4","T5P4","T4P4","T3P4","T2P4","T1P4","0BE4"
"T8P5","T7P5","T6P5","T5P5","T4P5","T3P5","T2P5","T1P5","0BEC"
"T8P6","T7P6","T6P6","T5P6","T4P6","T3P6","T2P6","T1P6","0BF4"
"T8P7","T7P7","T6P7","T5P7","T4P7","T3P7","T2P7","T1P7","0BFC"
"T8P8","T7P8","T6P8","T5P8","T4P8","T3P8","T2P8","T1P8","0C04"
"T8P9","T7P9","T6P9","T5P9","T4P9","T3P9","T2P9","T1P9","0C0C"
"T8P10","T7P10","T6P10","T5P10","T4P10","T3P10","T2P10","T1P10","0D4C"
"T8P11","T7P11","T6P11","T5P11","T4P11","T3P11","T2P11","T1P11","0D54"
"T8P12","T7P12","T6P12","T5P12","T4P12","T3P12","T2P12","T1P12","0D5C"
"T8P13","T7P13","T6P13","T5P13","T4P13","T3P13","T2P13","T1P13","0D64"
"T8P14","T7P14","T6P14","T5P14","T4P14","T3P14","T2P14","T1P14","0D6C"
"T8P15","T7P15","T6P15","T5P15","T4P15","T3P15","T2P15","T1P15","0D74"
"LP9","LP10","LP11","LP12","LP13","LP14","LP15","LP16","0B55"
"LT1","LT2","LT3","LT4","LT5","LT6","LT7","LT8","0A24"
"LT9","LT10","LT11","LT12","LT13","LT14","LT15","LT16","0B75"
"LT17","LT18","LT19","LT20","LT21","LT22","LT23","LT24","0BAF"
"LT25","LT26","LT27","LT28","LT29","LT30","LT31","LT32","0BB9"
"RBAD8","RBAD7","RBAD6","RBAD5","RBAD4","RBAD3","RBAD2","RBAD1","0DEC"
"*","RBAD15","RBAD14","RBAD13","RBAD12","RBAD11","RBAD10","RBAD9","0DE7"
"CBAD8","CBAD7","CBAD6","CBAD5","CBAD4","CBAD3","CBAD2","CBAD1","0D74"
"*","CBAD15","CBAD14","CBAD13","CBAD12","CBAD11","CBAD10","CBAD9","0D7E"
"RB33","RB34","RB35","RB36","RB37","RB38","RB39","RB40","0B63"
"RB41","RB42","RB43","RB44","RB45","RB46","RB47","RB48","0B64"
"RB49","RB50","RB51","RB52","RB53","RB54","RB55","RB56","0B65"
"RB57","RB58","RB59","RB60","RB61","RB62","RB63","RB64","0B6F"

<ETX>
```

where: <STX> is the STX character (02).
<ETX> is the ETX character (03).
the last field in each line (yyyy) is the 4-byte ASCII hex representation of the checksum for the line.
"*" indicates an unused bit location.

SNS Message

In response to the **SNS** command, the relay sends the name string of the SER (SER1 SER2 SER3 SER4 SER5 SER6) settings. **SNS** command is available at Access Level 1.

The relay responds to the **SNS** command with the name string in the SER settings. The name string starts with SER1, followed by SER2 and SER3.

For example: If SER1 = OUT101; SER2 = OUT102; SER3 = OUT103, the name string will be “OUT101”,“OUT102”,“OUT103”.

If there are more than eight settings in SER, the SNS message will have several rows. Each row will have eight strings, followed by the checksum and carriage return. The last row may have less than eight strings.

SNS message for the SEL-2100 is :

<STX>"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR><LF>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR><LF>
"xxxx","xxxx","xxxx", <CR><LF><ETX>

where: xxxx is a string from the settings in SER (SER1, SER2, SER3, SER4, SER5, and SER6)
yyyy is the 4-byte ASCII representation of the checksum

APPENDIX F: SEL DISTRIBUTED PORT SWITCH PROTOCOL

SEL Distributed Port Switch Protocol (LMD) permits multiple SEL relays 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 serial port **SET P** command to activate the LMD protocol. Change the port PROTO setting from the default SEL to LMD to reveal the following settings:

PREFIX: One character to precede the address. This should be a character that does not occur in the course of other communications with the relay. Valid choices are one of the following: “@”, “#”, “$”, “%”, “&”. The default is “@”.

ADDR: Two-character ASCII address. The range is “01” to “99”. The default is “01”.

SETTLE: 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 relay ignores all input from this port until it detects the prefix character and the two-byte address.
2. Upon receipt of the prefix and address, the relay enables echo and message transmission.
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 relay connection terminates, you can use the standard commands that are available when PROTO is set to SEL.
5. The **QUIT** command terminates the connection. If no data are sent to the relay before the port time-out period, it automatically terminates the connection.
6. Use **<Ctrl+X>,** type **QUIT,** and press **<Enter>** before entering the prefix character if all relays in the multidrop network do not have the same prefix setting.

Note: You can use the front-panel SET pushbutton to change the port settings to return to SEL protocol.

APPENDIX G: SPECIFICATIONS

Compliance:

Designed and manufactured under an ISO 9001 certified quality management system

UL Listed to U.S. and Canadian safety standards (File E202915; NRAQ, NRAQ7)

Terminal Connections:

Terminal Block:
- Minimum: 0.9 Nm (8-in-lb)
- Maximum: 1.4 Nm (12-in-lb)

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

Output Contacts:

Per IEC 255-0-20–1974, using the simplified method of assessment.
- 30 A make
- 6 A continuous carry at 70°C
- 50 A for one second
- MOV protected: 270 Vac RMS/330 Vdc continuous.

Note: Make per IEEE C37.90–1989.

Optoisolated Input Ratings:

When used with dc control signals:
- 250 Vdc: on for 200–300 Vdc; off below 150 Vdc
- 125 Vdc: on for 105–150 Vdc; off below 75 Vdc
- 110 Vdc: on for 88–132 Vdc; off below 66 Vdc
- 48 Vdc: on for 38.4–60 Vdc; off below 28.8 Vdc
- 24 Vdc: on for 15–30 Vdc

When used with ac control signals:
- 250 Vac: on for 172.9–300.0 Vac; off below 106.0 Vac
- 125 Vac: on for 90.7–150.0 Vac; off below 53.0 Vac
- 110 Vac: on for 76.1–132.0 Vac; off below 46.6 Vac
- 48 Vac: on for 33.2–60.0 Vac; off below 20.3 Vac
- 24 Vac: on for 13.0–30.0 Vac

AC mode is selectable for each input via Global settings IN101D–IN116D. AC input recognition delay from time of switching: 16 ms maximum pickup; 20 ms maximum dropout.

Note: 24, 48, 125, and 250 Vdc optoisolated inputs draw approximately 5 mA of current, 110 Vdc inputs draw approximately 8 mA of current. All current ratings are at nominal inputs voltages.

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: 18–60 Vdc polarity dependent
- Burden: < 25 W

Jumper Selectable +5 Vdc out on Pin 1, Ports 1–16: as much as 0.5 A total.

Operating Temperature Range:

-40° to +85°C (-40° to +185°F)

Relay Weight:	3.50 kg (7 lb., 12 oz)	

Type Tests:

Electromagnetic Compatibility Emissions

Product Specific:	IEC 60255-25–2000 Electrical relays, Part 25: Electromagnetic emission tests for measuring relays and protection equipment.

Electromagnetic Compatibility Immunity

Conducted RF:	IEC 61000-4-6 First Edition–1996 [EN 61000-4-6 First Edition–1996] Electromagnetic compatibility (EMC), Part 4: Testing and measurement techniques, Section 6: Immunity to conducted disturbances, induced by radio-frequency fields. Severity Level: 10 Vrms.
Digital Radio Telephone RF:	ENV 50204–1995 Radiated electromagnetic field from digital radiotelephones–Immunity test. Severity Level: 10 V/m at 900 MHz and 1.89 GHz.
Electrostatic Discharge:	IEC 60255-22-2 Second Edition–1996 [EN 60255-22-2 Second Edition–1996] Electrical disturbance tests for measuring relays and protection equipment, Section 2: Electrostatic discharge tests. Severity Level: Equipment is tested at both polarities at levels 1, 2, 3, 4
	IEC 61000-4-2 First Edition–1995 [EN 61000-4-2 First Edition–1995] Electromagnetic compatibility (EMC), Part 4: Testing and measurement techniques, Section 4.2: Electrostatic discharge immunity test–Basic EMC Publication. Severity Level: Equipment is tested at both polarities at levels 1, 2, 3, 4.
Fast Transient/Burst:	IEC 61000-4-4 First Edition–1995 [EN 61000-4-4 First Edition–1995] Electromagnetic compatibility (EMC), Part 4: Testing and measurement techniques, Section 4: Electrical fast transient/burst immunity test–Basic EMC publication. Severity Level: 4 kV at 2.5 kHz.
	IEC 60255-22-4 First Edition–1992 Electrical disturbance tests for measuring relays and protection equipment, Section 4: Fast transient disturbance test. Severity Level: 4 kV at 2.5 kHz.
Generic Standard:	EN 50082-2–1995 Electromagnetic compatibility–Generic immunity standard, Part 2: Industrial environment.
Magnetic Field:	IEC 61000-4-8 First Edition–1993 [EN 61000-4-8 First Edition–1993] Electromagnetic compatibility (EMC), Part 4: Testing and measurement techniques, Section 8: Power frequency magnetic field immunity test. Severity Level: 1000 A/m for 3 seconds, 100 A/m for 1 minute.
	IEC 61000-4-9 First Edition–1993 [EN 61000-4-9 First Edition–1993] Electromagnetic compatibility (EMC), Part 4: Testing and measurement techniques, Section 9: Pulse magnetic field immunity test. Severity Level: 1000 A/m.

Radiated Radio Frequency: | IEC 60255-22-3 First Edition–1989 Electrical relays, Part 22: Electrical disturbance tests for measuring relays and protection equipment, Section 3: Radiated electromagnetic field disturbance tests. Severity Level: 10 V/m.

Exceptions: 4.3.2.2 Frequency sweep approximated with 200 frequency steps per octave.

IEC 61000-4-3 First Edition–1998 [EN 61000-4-3 First Edition–1996] Electromagnetic compatibility (EMC), Part 4: Testing and measurement techniques, Section 3: Radiated, radio-frequency, electromagnetic field immunity. Severity Level: 10 V/m.

IEEE C37.90.2–1995 IEEE standard for withstand capability of relay systems to radiated electromagnetic interference from transceivers. Severity Level: 35 V/m.

Surge Withstand Capability: IEC 60255-22-1 First Edition–1988 Electrical disturbance tests for measuring relays and protection equipment, Part 1: 1 MHz burst disturbance tests. Severity Level: 2.5 kV peak common mode, 2.5 kV peak differential mode.

IEEE C37.90.1–1989 IEEE standard surge withstand capability (SWC) tests for protective relays and relay systems. Severity Level: 3.0 kV oscillatory, 5.0 kV fast transient.

Environmental

Cold: IEC 60068-2-1 Fifth Edition–1990 [EN 60068-2-1 Fifth Edition–1993] Environmental testing, Part 2: Tests–Test Ad: Cold. Severity Level: 16 hours at -40°C.

Dry Heat: IEC 60068-2-2 Fourth Edition–1974 [EN 60068-2-2 Fourth Edition–1993] Environmental testing, Part 2: Tests–Test Bd: Dry heat. Severity Level: 16 hours at +85°C.

Damp Heat, Cyclic: IEC 60068-2-30 Second Edition–1980 Basic environmental testing procedures, Part 2: Tests–Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle). Severity Level: 25°C to 55°C, 6 cycles, Relative Humidity: 95%.

Vibration: IEC 60255-21-1 First Edition–1988 [EN 60255-21-1 First Edition–1995] Electrical relays, Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment, Section 1: Vibration tests (sinusoidal). Severity Level: Class 1.

IEC 60255-21-2 First Edition–1988 [EN 60255-21-2 First Edition–1995] Electrical relays, Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment, Section 2: Shock and bump tests. Severity Level: Class 1.

IEC 60255-21-3 First Edition–1993 [EN 60255-21-3 First Edition–1995] Electrical relays, Part 21: Vibration, shock, bump, and seismic tests on measuring relays and protective equipment, Section 3: Method A seismic tests (not tested below 5 Hz). Severity Level: Class 2 (Quake Response).

Safety

Dielectric Strength:	IEC 60255-5 First Edition–1977 Electrical relays, Part 5: Insulation tests for electrical relays, Section 6: Dielectric tests. Severity Level: 2500 Vac on contact inputs, contact outputs, and analog inputs. 3100 Vdc on power supply. Type tested for 1 minute. IEEE C37.90–1989 IEEE standard for relays and relay systems associated with electrical power apparatus, Section 8: Dielectric tests. Severity Level: 2500 Vac on contact inputs, contact outputs, and analog inputs. 3100 Vdc on power supply. Type tested for 1 minute.
Impulse:	IEC 60255-5 First Edition–1977 Electrical relay, Part 5: Insulation tests for electrical relays, Section 8: Impulse voltage tests. Severity Level: 0.5 Joule, 5 kV.

Communications Ports:	1 front-panel/16 rear-panel ports, DB-9 connectors, MOV protected Baud Rate: 300–38400 Note: The front-panel serial port baud rate may be limited to 1200 baud when several rear ports are used for MIRRORED BITS
Real-Time Clock/Calendar:	Battery Type: IEC No. BR2335 Lithium Battery Life: 10 years
Clock Accuracy:	±20 min/yr @ 25°C (without power applied) ±1 min/yr @ 25°C (with power applied) ±5 ms with IRIG-B time-code input
Time-Code Input:	Connector: Female BNC Modulated IRIG-B 1,000 Vdc isolation Demodulated IRIG-B TTL-compatible
Time-Code Output:	Pinout: Pin 4 TTL-level signal Pin 6 Chassis ground reference Connectors: All 16 rear DB-9 port connectors Outputs are generated from IRIG-B input (when present)
MIRRORED BITS® Communications Time	1 ms at 38400 baud
SELOGIC® Control Equation Update Time	4–6 ms

APPENDIX H: SETTINGS SHEETS

This appendix includes one set of sheets for the SEL-2100 Logic Processor settings.

For convenience, you can print or photocopy these settings sheets to use when designing settings, especially when using multiple settings groups.

Identifier Labels (See *Serial Port Access Levels* in *Section 4*)

Relay Identifier (30 characters)	RID = ________________
Terminal Identifier (30 characters)	TID = ________________

SELOGIC® Control Equation Variable Timers (See *Section 6*)

SV1 Pickup Time (0–999999 ms in 1-ms steps)	SV1PU = ________
SV1 Dropout Time (0–999999 ms in 1-ms steps)	SV1DO = ________
SV2 Pickup Time (0–999999 ms in 1-ms steps)	SV2PU = ________
SV2 Dropout Time (0–999999 ms in 1-ms steps)	SV2DO = ________
SV3 Pickup Time (0–999999 ms in 1-ms steps)	SV3PU = ________
SV3 Dropout Time (0–999999 ms in 1-ms steps)	SV3DO = ________
SV4 Pickup Time (0–999999 ms in 1-ms steps)	SV4PU = ________
SV4 Dropout Time (0–999999 ms in 1-ms steps)	SV4DO = ________
SV5 Pickup Time (0–999999 ms in 1-ms steps)	SV5PU = ________
SV5 Dropout Time (0–999999 ms in 1-ms steps)	SV5DO = ________
SV6 Pickup Time (0–999999 ms in 1-ms steps)	SV6PU = ________
SV6 Dropout Time (0–999999 ms in 1-ms steps)	SV6DO = ________
SV7 Pickup Time (0–32000 ms in 1-ms steps)	SV7PU = ________
SV7 Dropout Time (0–32000 ms in 1-ms steps)	SV7DO = ________
SV8 Pickup Time (0–32000 ms in 1-ms steps)	SV8PU = ________
SV8 Dropout Time (0–32000 ms in 1-ms steps)	SV8DO = ________
SV9 Pickup Time (0–32000 ms in 1-ms steps)	SV9PU = ________
SV9 Dropout Time (0–32000 ms in 1-ms steps)	SV9DO = ________
SV10 Pickup Time (0–32000 ms in 1-ms steps)	SV10PU = ________
SV10 Dropout Time (0–32000 ms in 1-ms steps)	SV10DO = ________
SV11 Pickup Time (0–32000 ms in 1-ms steps)	SV11PU = ________
SV11 Dropout Time (0–32000 ms in 1-ms steps)	SV11DO = ________
SV12 Pickup Time (0–32000 ms in 1-ms steps)	SV12PU = ________
SV12 Dropout Time (0–32000 ms in 1-ms steps)	SV12DO = ________
SV13 Pickup Time (0–32000 ms in 1-ms steps)	SV13PU = ________
SV13 Dropout Time (0–32000 ms in 1-ms steps)	SV13DO = ________
SV14 Pickup Time (0–32000 ms in 1-ms steps)	SV14PU = ________
SV14 Dropout Time (0–32000 ms in 1-ms steps)	SV14DO = ________
SV15 Pickup Time (0–32000 ms in 1-ms steps)	SV15PU = ________
SV15 Dropout Time (0–32000 ms in 1-ms steps)	SV15DO = ________
SV16 Pickup Time (0–32000 ms in 1-ms steps)	SV16PU = ________
SV16 Dropout Time (0–32000 ms in 1-ms steps)	SV16DO = ________

SV17 Pickup Time (0–32000 ms in 1-ms steps)	SV17PU = __________
SV17 Dropout Time (0–32000 ms in 1-ms steps)	SV17DO = __________
SV18 Pickup Time (0–32000 ms in 1-ms steps)	SV18PU = __________
SV18 Dropout Time (0–32000 ms in 1-ms steps)	SV18DO = __________
SV19 Pickup Time (0–32000 ms in 1-ms steps)	SV19PU = __________
SV19 Dropout Time (0–32000 ms in 1-ms steps)	SV19DO = __________
SV20 Pickup Time (0–32000 ms in 1-ms steps)	SV20PU = __________
SV20 Dropout Time (0–32000 ms in 1-ms steps)	SV20DO = __________
SV21 Pickup Time (0–32000 ms in 1-ms steps)	SV21PU = __________
SV21 Dropout Time (0–32000 ms in 1-ms steps)	SV21DO = __________
SV22 Pickup Time (0–32000 ms in 1-ms steps)	SV22PU = __________
SV22 Dropout Time (0–32000 ms in 1-ms steps)	SV22DO = __________
SV23 Pickup Time (0–32000 ms in 1-ms steps)	SV23PU = __________
SV23 Dropout Time (0–32000 ms in 1-ms steps)	SV23DO = __________
SV24 Pickup Time (0–32000 ms in 1-ms steps)	SV24PU = __________
SV24 Dropout Time (0–32000 ms in 1-ms steps)	SV24DO = __________
SV25 Pickup Time (0–32000 ms in 1-ms steps)	SV25PU = __________
SV25 Dropout Time (0–32000 ms in 1-ms steps)	SV25DO = __________
SV26 Pickup Time (0–32000 ms in 1-ms steps)	SV26PU = __________
SV26 Dropout Time (0–32000 ms in 1-ms steps)	SV26DO = __________
SV27 Pickup Time (0–32000 ms in 1-ms steps)	SV27PU = __________
SV27 Dropout Time (0–32000 ms in 1-ms steps)	SV27DO = __________
SV28 Pickup Time (0–32000 ms in 1-ms steps)	SV28PU = __________
SV28 Dropout Time (0–32000 ms in 1-ms steps)	SV28DO = __________
SV29 Pickup Time (0–32000 ms in 1-ms steps)	SV29PU = __________
SV29 Dropout Time (0–32000 ms in 1-ms steps)	SV29DO = __________
SV30 Pickup Time (0–32000 ms in 1-ms steps)	SV30PU = __________
SV30 Dropout Time (0–32000 ms in 1-ms steps)	SV30DO = __________
SV31 Pickup Time (0–32000 ms in 1-ms steps)	SV31PU = __________
SV31 Dropout Time (0–32000 ms in 1-ms steps)	SV31DO = __________
SV32 Pickup Time (0–32000 ms in 1-ms steps)	SV32PU = __________
SV32 Dropout Time (0–32000 ms in 1-ms steps)	SV32DO = __________

SELOGIC control equation settings consist of Relay Word bits (see Table 5.4) and SELOGIC control equation operators * (AND), + (OR), ! (NOT), / (rising edge), \ (falling edge), and ( ) (parentheses). Numerous SELOGIC control equation settings examples are given in ***Section 6***. SELOGIC control equation settings can also be set directly to 1 (logical 1) or 0 (logical 0).

Latch Bits Set/Reset Equations (See *Section 6*)

Set Latch Bit LT1	SET1 = ______
Reset Latch Bit LT1	RST1 = ______
Set Latch Bit LT2	SET2 = ______
Reset Latch Bit LT2	RST2 = ______
Set Latch Bit LT3	SET3 = ______
Reset Latch Bit LT3	RST3 = ______
Set Latch Bit LT4	SET4 = ______
Reset Latch Bit LT4	RST4 = ______
Set Latch Bit LT5	SET5 = ______
Reset Latch Bit LT5	RST5 = ______
Set Latch Bit LT6	SET6 = ______
Reset latch Bit LT6	RST6 = ______
Set Latch Bit LT7	SET7 = ______
Reset Latch Bit LT7	RST7 = ______
Set Latch Bit LT8	SET8 = ______
Reset Latch Bit LT8	RST8 = ______
Set Latch Bit LT9	SET9 = ______
Reset Latch Bit LT9	RST9 = ______
Set Latch Bit LT10	SET10 = ______
Reset Latch Bit LT10	RST10 = ______
Set Latch Bit LT11	SET11 = ______
Reset Latch Bit LT11	RST11 = ______
Set Latch Bit LT12	SET12 = ______
Reset Latch Bit LT12	RST12 = ______
Set Latch Bit LT13	SET13 = ______
Reset Latch Bit LT13	RST13 = ______
Set Latch Bit LT14	SET14 = ______
Reset latch Bit LT14	RST14 = ______
Set Latch Bit LT15	SET15 = ______
Reset Latch Bit LT15	RST15 = ______
Set Latch Bit LT16	SET16 = ______
Reset Latch Bit LT16	RST16 = ______
Set Latch Bit LT17	SET17 = ______
Reset Latch Bit LT17	RST17 = ______

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

Set Latch Bit LT18	SET18 = ________
Reset Latch Bit LT18	RST18 = ________
Set Latch Bit LT19	SET19 = ________
Reset Latch Bit LT19	RST19 = ________
Set Latch Bit LT20	SET20 = ________
Reset Latch Bit LT20	RST20 = ________
Set Latch Bit LT21	SET21 = ________
Reset Latch Bit LT21	RST21 = ________
Set Latch Bit LT22	SET22 = ________
Reset latch Bit LT22	RST22 = ________
Set Latch Bit LT23	SET23 = ________
Reset Latch Bit LT23	RST23 = ________
Set Latch Bit LT24	SET24 = ________
Reset Latch Bit LT24	RST24 = ________
Set Latch Bit LT25	SET25 = ________
Reset Latch Bit LT25	RST25 = ________
Set Latch Bit LT26	SET26 = ________
Reset Latch Bit LT26	RST26 = ________
Set Latch Bit LT27	SET27 = ________
Reset Latch Bit LT27	RST27 = ________
Set Latch Bit LT28	SET28 = ________
Reset Latch Bit LT28	RST28 = ________
Set Latch Bit LT29	SET29 = ________
Reset Latch Bit LT29	RST29 = ________
Set Latch Bit LT30	SET30 = ________
Reset latch Bit LT30	RST30 = ________
Set Latch Bit LT31	SET31 = ________
Reset Latch Bit LT31	RST31 = ________
Set Latch Bit LT32	SET32 = ________
Reset Latch Bit LT32	RST32 = ________

SELOGIC Control Equation Variable/Timer Input Equations (See *Section 6*)

SELOGIC Variable/Timer SV1	SV1 = ________
SELOGIC Variable/Timer SV2	SV2 = ________
SELOGIC Variable/Timer SV3	SV3 = ________
SELOGIC Variable/Timer SV4	SV4 = ________
SELOGIC Variable/Timer SV5	SV5 = ________
SELOGIC Variable/Timer SV6	SV6 = ________
SELOGIC Variable/Timer SV7	SV7 = ________
SELOGIC Variable/Timer SV8	SV8 = ________

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

SELOGIC Variable/Timer SV9	SV9 = ____________________
SELOGIC Variable/Timer SV10	SV10 = ____________________
SELOGIC Variable/Timer SV11	SV11 = ____________________
SELOGIC Variable/Timer SV12	SV12 = ____________________
SELOGIC Variable/Timer SV13	SV13 = ____________________
SELOGIC Variable/Timer SV14	SV14 = ____________________
SELOGIC Variable/Timer SV15	SV15 = ____________________
SELOGIC Variable/Timer SV16	SV16 = ____________________
SELOGIC Variable/Timer SV17	SV17 = ____________________
SELOGIC Variable/Timer SV18	SV18 = ____________________
SELOGIC Variable/Timer SV19	SV19 = ____________________
SELOGIC Variable/Timer SV20	SV20 = ____________________
SELOGIC Variable/Timer SV21	SV21= ____________________
SELOGIC Variable/Timer SV22	SV22 = ____________________
SELOGIC Variable/Timer SV23	SV23 = ____________________
SELOGIC Variable/Timer SV24	SV24 = ____________________
SELOGIC Variable/Timer SV25	SV25= ____________________
SELOGIC Variable/Timer SV26	SV26 = ____________________
SELOGIC Variable/Timer SV27	SV27 = ____________________
SELOGIC Variable/Timer SV28	SV28 = ____________________
SELOGIC Variable/Timer SV29	SV29 = ____________________
SELOGIC Variable/Timer SV30	SV30 = ____________________
SELOGIC Variable/Timer SV31	SV31 = ____________________
SELOGIC Variable/Timer SV32	SV32 = ____________________

Logic Variables (See *Section 6*)

Logic Variable LV1	LV1 = ____________________
Logic Variable LV2	LV2 = ____________________
Logic Variable LV3	LV3 = ____________________
Logic Variable LV4	LV4 = ____________________
Logic Variable LV5	LV5 = ____________________
Logic Variable LV6	LV6 = ____________________
Logic Variable LV7	LV7 = ____________________
Logic Variable LV8	LV8 = ____________________
Logic Variable LV9	LV9 = ____________________
Logic Variable LV10	LV10 = ____________________
Logic Variable LV11	LV11 = ____________________
Logic Variable LV12	LV12 = ____________________
Logic Variable LV13	LV13 = ____________________
Logic Variable LV14	LV14 = ____________________

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

Logic Variable LV15	LV15 = ______________
Logic Variable LV16	LV16 = ______________
Logic Variable LV17	LV17 = ______________
Logic Variable LV18	LV18 = ______________
Logic Variable LV19	LV19 = ______________
Logic Variable LV20	LV20 = ______________
Logic Variable LV21	LV21 = ______________
Logic Variable LV22	LV22 = ______________
Logic Variable LV23	LV23 = ______________
Logic Variable LV24	LV24 = ______________
Logic Variable LV25	LV25 = ______________
Logic Variable LV26	LV26 = ______________
Logic Variable LV27	LV27 = ______________
Logic Variable LV28	LV28 = ______________
Logic Variable LV29	LV29 = ______________
Logic Variable LV30	LV30 = ______________
Logic Variable LV31	LV31 = ______________
Logic Variable LV32	LV32 = ______________

Output Contact Equations for Models 2100xxx4 (See *Section 6*)

Output Contact OUT101	OUT101 = ____________
Output Contact OUT102	OUT102 = ____________
Output Contact OUT103	OUT103 = ____________
Output Contact OUT104	OUT104 = ____________

Setting Group Selection Equations (See *Section 6*)

Select Setting Group 1	SS1 = _______________
Select Setting Group 2	SS2 = _______________
Select Setting Group 3	SS3 = _______________
Select Setting Group 4	SS4 = _______________
Select Setting Group 5	SS5 = _______________
Select Setting Group 6	SS6 = _______________

Transmit Mirrored Bit Transmit Equations (See *Section 8*)

Transmit Bit 1 Port 1	T1P1 = ______________
Transmit Bit 2 Port 1	T2P1 = ______________
Transmit Bit 3 Port 1	T3P1 = ______________
Transmit Bit 4 Port 1	T4P1 = ______________
Transmit Bit 5 Port 1	T5P1 = ______________
Transmit Bit 6 Port 1	T6P1 = ______________
Transmit Bit 7 Port 1	T7P1 = ______________

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

Transmit Bit 8 Port 1	T8P1 = ____________________
Transmit Bit 1 Port 2	T1P2 = ____________________
Transmit Bit 2 Port 2	T2P2 = ____________________
Transmit Bit 3 Port 2	T3P2 = ____________________
Transmit Bit 4 Port 2	T4P2 = ____________________
Transmit Bit 5 Port 2	T5P2 = ____________________
Transmit Bit 6 Port 2	T6P2 = ____________________
Transmit Bit 7 Port 2	T7P2 = ____________________
Transmit Bit 8 Port 2	T8P2 = ____________________
Transmit Bit 1 Port 3	T1P3 = ____________________
Transmit Bit 2 Port 3	T2P3 = ____________________
Transmit Bit 3 Port 3	T3P3 = ____________________
Transmit Bit 4 Port 3	T4P3 = ____________________
Transmit Bit 5 Port 3	T5P3 = ____________________
Transmit Bit 6 Port 3	T6P3 = ____________________
Transmit Bit 7 Port 3	T7P3 = ____________________
Transmit Bit 8 Port 3	T8P3 = ____________________
Transmit Bit 1 Port 4	T1P4 = ____________________
Transmit Bit 2 Port 4	T2P4 = ____________________
Transmit Bit 3 Port 4	T3P4 = ____________________
Transmit Bit 4 Port 4	T4P4 = ____________________
Transmit Bit 5 Port 4	T5P4 = ____________________
Transmit Bit 6 Port 4	T6P4 = ____________________
Transmit Bit 7 Port 4	T7P4 = ____________________
Transmit Bit 8 Port 4	T8P4 = ____________________
Transmit Bit 1 Port 5	T1P5 = ____________________
Transmit Bit 2 Port 5	T2P5 = ____________________
Transmit Bit 3 Port 5	T3P5 = ____________________
Transmit Bit 4 Port 5	T4P5 = ____________________
Transmit Bit 5 Port 5	T5P5 = ____________________
Transmit Bit 6 Port 5	T6P5 = ____________________
Transmit Bit 7 Port 5	T7P5 = ____________________
Transmit Bit 8 Port 5	T8P5 = ____________________
Transmit Bit 1 Port 6	T1P6 = ____________________
Transmit Bit 2 Port 6	T2P6 = ____________________
Transmit Bit 3 Port 6	T3P6 = ____________________
Transmit Bit 4 Port 6	T4P6 = ____________________
Transmit Bit 5 Port 6	T5P6 = ____________________
Transmit Bit 6 Port 6	T6P6 = ____________________
Transmit Bit 7 Port 6	T7P6 = ____________________

Transmit Bit 8 Port 6	T8P6 = ________________
Transmit Bit 1 Port 7	T1P7 = ________________
Transmit Bit 2 Port 7	T2P7 = ________________
Transmit Bit 3 Port 7	T3P7 = ________________
Transmit Bit 4 Port 7	T4P7 = ________________
Transmit Bit 5 Port 7	T5P7 = ________________
Transmit Bit 6 Port 7	T6P7 = ________________
Transmit Bit 7 Port 7	T7P7 = ________________
Transmit Bit 8 Port 7	T8P7 = ________________
Transmit Bit 1 Port 8	T1P8 = ________________
Transmit Bit 2 Port 8	T2P8 = ________________
Transmit Bit 3 Port 8	T3P8 = ________________
Transmit Bit 4 Port 8	T4P8 = ________________
Transmit Bit 5 Port 8	T5P8 = ________________
Transmit Bit 6 Port 8	T6P8 = ________________
Transmit Bit 7 Port 8	T7P8 = ________________
Transmit Bit 8 Port 8	T8P8 = ________________
Transmit Bit 1 Port 9	T1P9 = ________________
Transmit Bit 2 Port 9	T2P9 = ________________
Transmit Bit 3 Port 9	T3P9 = ________________
Transmit Bit 4 Port 9	T4P9 = ________________
Transmit Bit 5 Port 9	T5P9 = ________________
Transmit Bit 6 Port 9	T6P9 = ________________
Transmit Bit 7 Port 9	T7P9 = ________________
Transmit Bit 8 Port 9	T8P9 = ________________
Transmit Bit 1 Port 10	T1P10 = ________________
Transmit Bit 2 Port 10	T2P10 = ________________
Transmit Bit 3 Port 10	T3P10 = ________________
Transmit Bit 4 Port 10	T4P10 = ________________
Transmit Bit 5 Port 10	T5P10 = ________________
Transmit Bit 6 Port 10	T6P10 = ________________
Transmit Bit 7 Port 10	T7P10 = ________________
Transmit Bit 8 Port 10	T8P10 = ________________
Transmit Bit 1 Port 11	T1P11 = ________________
Transmit Bit 2 Port 11	T2P11 = ________________
Transmit Bit 3 Port 11	T3P11 = ________________
Transmit Bit 4 Port 11	T4P11 = ________________
Transmit Bit 5 Port 11	T5P11 = ________________
Transmit Bit 6 Port 11	T6P11 = ________________
Transmit Bit 7 Port 11	T7P11 = ________________

SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

Transmit Bit 8 Port 11	T8P11 = ________________
Transmit Bit 1 Port 12	T1P12 = ________________
Transmit Bit 2 Port 12	T2P12 = ________________
Transmit Bit 3 Port 12	T3P12 = ________________
Transmit Bit 4 Port 12	T4P12 = ________________
Transmit Bit 5 Port 12	T5P12 = ________________
Transmit Bit 6 Port 12	T6P12 = ________________
Transmit Bit 7 Port 12	T7P12 = ________________
Transmit Bit 8 Port 12	T8P12 = ________________
Transmit Bit 1 Port 13	T1P13 = ________________
Transmit Bit 2 Port 13	T2P13 = ________________
Transmit Bit 3 Port 13	T3P13 = ________________
Transmit Bit 4 Port 13	T4P13 = ________________
Transmit Bit 5 Port 13	T5P13 = ________________
Transmit Bit 6 Port 13	T6P13 = ________________
Transmit Bit 7 Port 13	T7P13 = ________________
Transmit Bit 8 Port 13	T8P13 = ________________
Transmit Bit 1 Port 14	T1P14 = ________________
Transmit Bit 2 Port 14	T2P14 = ________________
Transmit Bit 3 Port 14	T3P14 = ________________
Transmit Bit 4 Port 14	T4P14 = ________________
Transmit Bit 5 Port 14	T5P14 = ________________
Transmit Bit 6 Port 14	T6P14 = ________________
Transmit Bit 7 Port 14	T7P14 = ________________
Transmit Bit 8 Port 14	T8P14 = ________________
Transmit Bit 1 Port 15	T1P15 = ________________
Transmit Bit 2 Port 15	T2P15 = ________________
Transmit Bit 3 Port 15	T3P15 = ________________
Transmit Bit 4 Port 15	T4P15 = ________________
Transmit Bit 5 Port 15	T5P15 = ________________
Transmit Bit 6 Port 15	T6P15 = ________________
Transmit Bit 7 Port 15	T7P15 = ________________
Transmit Bit 8 Port 15	T8P15 = ________________

Settings Group Change Delay (See *Multiple Setting Groups* in *Section 6*)

Group change delay (0.00–500.00 seconds in 0.01 second steps)	TGR = ____________

Date Format (See *Section 4*)

Date format (MDY, YMD)	DATE_F = _________

Optoisolated Input Timers for Models 2100xxx4 (See *Section 6*)

Input IN101 debounce time (AC, 0–15 ms in 1-ms steps)	IN101D = __________
Input IN102 debounce time (AC, 0–15 ms in 1-ms steps)	IN102D = __________
Input IN103 debounce time (AC, 0–15 ms in 1-ms steps)	IN103D = __________
Input IN104 debounce time (AC, 0–15 ms in 1-ms steps)	IN104D = __________
Input IN105 debounce time (AC, 0–15 ms in 1-ms steps)	IN105D = __________
Input IN106 debounce time (AC, 0–15 ms in 1-ms steps)	IN106D = __________
Input IN107 debounce time (AC, 0–15 ms in 1-ms steps)	IN107D = __________
Input IN108 debounce time (AC, 0–15 ms in 1-ms steps)	IN108D = __________
Input IN109 debounce time (AC, 0–15 ms in 1-ms steps)	IN109D = __________
Input IN110 debounce time (AC, 0–15 ms in 1-ms steps)	IN110D = __________
Input IN111 debounce time (AC, 0–15 ms in 1-ms steps)	IN111D = __________
Input IN112 debounce time (AC, 0–15 ms in 1-ms steps)	IN112D = __________
Input IN113 debounce time (AC, 0–15 ms in 1-ms steps)	IN113D = __________
Input IN114 debounce time (AC, 0–15 ms in 1-ms steps)	IN114D = __________
Input IN115 debounce time (AC, 0–15 ms in 1-ms steps)	IN115D = __________
Input IN116 debounce time (AC, 0–15 ms in 1-ms steps)	IN116D = __________

Sequential Events Recorder (SER) settings are comprised of four trigger lists. Each trigger list can include as many as 24 Relay Word bits delimited by commas. Enter NA to remove a list of these Relay Word bit settings. See ***Section 7: Sequential Events Recorder***.

SER Trigger List 1	SER1 = ______________________
SER Trigger List 2	SER2 = ______________________
SER Trigger List 3	SER3 = ______________________
SER Trigger List 4	SER4 = ______________________
SER Trigger List 5	SER5 = ______________________
SER Trigger List 6	SER6 = ______________________

Port Number (F*, 1—16) Port = ________________

Protocol = SEL

Protocol Setting	PROTO = SEL
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = ________
Data Bits (6, 7, 8)	BITS = ________
Parity (O, E, N) {Odd, Even, None}	PARITY = ________
Stop Bits (1, 2)	STOP = ________
Minutes to Port Time-Out (0–30)	T_OUT = ________
Number of Lines in Terminal (OFF, 20–50)	TLINES = ________
Send Auto Messages to Port (Y, N)	AUTO = ________
Enable Hardware Handshaking (Y, N)	RTSCTS = ________
Fast Operate Enable (Y, N)	FASTOP = ________

Port Number (F*, 1—16) Port = ________________

Protocol = LMD

Refer to ***Appendix F*** for more details about the LMD protocol.

Protocol Setting	PROTO = LMD
LMD Prefix (@, #, $, %, &)	PREFIX = ________
LMD Address (1–99)	ADDR = ________
LMD Settling Time (0.00–30.00 seconds)	SETTLE = ________
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = ________
Data Bits (6, 7, 8)	BITS = ________
Parity (O, E, N) {Odd, Even, None}	PARITY = ________
Stop Bits (1, 2)	STOP = ________
Minutes to Port Time-Out (0–30)	T_OUT = ________
Number of Lines in Terminal (OFF, 20–50)	TLINES = ________
Send Auto Messages to Port (Y, N)	AUTO = ________
Enable Hardware Handshaking (Y, N)	RTSCTS = ________
Fast Operate Enable (Y, N)	FASTOP = ________

* Port F baud rate (300, 1200, 2400, 4800, 9600)

Port setting information not described elsewhere in this instruction manual:

Minutes to Port Time-Out: Set T_OUT to the number of minutes of serial port inactivity for an automatic log out. Set T_OUT = 0 for no port time-out.

Number of Lines in Terminal: Set TLINES to the number of lines displayed on the terminal before the "Press RETURN to continue" prompt is displayed and line scrolling is paused. Set TLINES = OFF for line scrolling without pauses.

Send Auto Messages to Port: Set AUTO = Y to enable Auto messages on the serial port. Automatic messages are ASCII messages sent to the port to indicate a power on condition or status failure without a user request. Set AUTO = N to disable AUTO messages.

Fast Operate Enable: Set FASTOP = Y to enable binary Fast Operate messages on the serial port. Refer to ***Appendix E: Fast Meter Protocol*** for a description of Fast Operate commands. Set FASTOP = N to disable this feature.

Port Number (1—16) Port = ______________

Protocol = DNP

Refer to ***Appendix C*** for more details about DNP3 protocol.

Protocol Setting	PROTO = DNP
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = ______________
DNP Address (0–65534)	DNPADR = ______________
Class for Binary Event Data (0–3)	CLASSB = ______________
Class for Counter Event Data (0–3)	CLASSC = ______________
Minutes for Request Interval (0–32767)	TIMERQ = ______________
Seconds to Select/Operate Time-Out (0.0–30.0)	STIMEO = ______________
Data Link Retries (0–15)	DRETRY = ______________
Seconds to Data Link Time-Out (0–5)	DTIMEO = ______________
Minimum Seconds from DCD to Tx (0.00–1.00)	MINDLY = ______________
Maximum Seconds from DCD to Tx (0.00–1.00)	MAXDLY = ______________
Settle Time from RTS ON to Tx (OFF, 0.00–30.00 sec)	PREDLY = ______________
Settle Time from Tx to RTS OFF (0.00–30.00 sec)	PSTDLY = ______________
Seconds to Event Message Confirm Time-Out (1–50)	ETIMEO = ______________
Enable Unsolicited Reporting (Y, N)	UNSOL = ______________
Enable Unsolicited Reporting at Power-up (Y, N)	PUNSOL = ______________
DNP Address to Report (0–65534)	REPADR = ______________
Number of Events to Transmit On (1–200)	NUMEVE = ______________
Seconds Until Oldest Event to Tx On (0.0–60.0)	AGEEVE = ______________

Port Number (1—15) Port = ____________________

Protocol = MB or MB8

Refer to ***Section 8*** for more details about MIRRORED BITS® communications.

Protocol (MB, MB8)	PROTO = ____________
MBT9600 (Y, N) {for MB protocol only}	MBT = ____________
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = ____________
Seconds to MIRRORED BITS Rx Bad Pickup (1–10000)	RBADPU = ____________
PPM MIRRORED BITS Channel Bad Pickup (1–30000)	CBADPU = ____________
MIRRORED BITS Receive Identifier (1–4)	RXID = ____________
MIRRORED BITS Transmit Identifier (1–4)	TXID = ____________
MIRRORED BITS Receive Default State (string of 1s, 0s, or Xs)	RXDFLT = ____________
MIRRORED BITS R1 Pickup Debounce msgs (1–8)	R1PU = ____________
MIRRORED BITS R1 Dropout Debounce msgs (1–8)	R1DO = ____________
MIRRORED BITS R2 Pickup Debounce msgs (1–8)	R2PU = ____________
MIRRORED BITS R2 Dropout Debounce msgs (1–8)	R2DO = ____________
MIRRORED BITS R3 Pickup Debounce msgs (1–8)	R3PU = ____________
MIRRORED BITS R3 Dropout Debounce msgs (1–8)	R3DO = ____________
MIRRORED BITS R4 Pickup Debounce msgs (1–8)	R4PU = ____________
MIRRORED BITS R4 Dropout Debounce msgs (1–8)	R4DO = ____________
MIRRORED BITS R5 Pickup Debounce msgs (1–8)	R5PU = ____________
MIRRORED BITS R5 Dropout Debounce msgs (1–8)	R5DO = ____________
MIRRORED BITS R6 Pickup Debounce msgs (1–8)	R6PU = ____________
MIRRORED BITS R6 Dropout Debounce msgs (1–8)	R6DO = ____________
MIRRORED BITS R7 Pickup Debounce msgs (1–8)	R7PU = ____________
MIRRORED BITS R7 Dropout Debounce msgs (1–8)	R7DO = ____________
MIRRORED BITS R8 Pickup Debounce msgs (1–8)	R8PU = ____________
MIRRORED BITS R8 Dropout Debounce msgs (1–8)	R8DO = ____________

APPENDIX I: UNSOLICITED SER PROTOCOL

INTRODUCTION

This appendix describes special binary Sequential Events Recorder (SER) messages that are not included in ***Section 4: Serial Port Communications and Commands*** of the instruction manual. Devices with embedded processing capability can use these messages to enable and accept SEL Fast SER messages from the SEL-2100.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible to people using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information, and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data. To exploit this feature, the device connected to the other end of the link requires software that uses the separate data streams. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

MAKE SEQUENTIAL EVENTS RECORDER (SER) SETTINGS WITH CARE

The SEL-2100 triggers a row in the Sequential Events Recorder (SER) event report for any change of state in any one of the elements listed in the SER1 through SER6 trigger settings. Nonvolatile memory is used to store the latest 32,768 rows of the SER event report so they can be retained during power loss. The nonvolatile memory is rated for a finite number of “writes.” <u>An average of 333 state changes per minute can be made for a 25-year service life</u>.

RECOMMENDED MESSAGE USAGE

Use the following sequence of commands to enable SEL Fast SER messaging in the SEL-2100:

1. On initial connection, send the **SNS** command to retrieve and store the ASCII names for the digital I/O points assigned to trigger SER records. The order of the ASCII names matches the point indices in the SEL Fast SER messages. Send the “Enable Unsolicited Data Transfer” message to enable the SEL-2100 to transmit SEL Fast SER messages.

2. When SER records are triggered in the SEL-2100, it responds with an SEL Fast SER message. If this message has a valid checksum, it must be acknowledged by sending an acknowledge message with the same response number as contained in the original message. The SEL-2100 will wait approximately 100 ms to 500 ms to receive an acknowledge message, at which time the SEL-2100 will resend the same unsolicited SER message with the same response number.

3. Upon receiving an acknowledge message with a matching response number, the SEL-2100 increments the response number, and continues to send and seek acknowledgment for unsolicited SER messages, if additional SER records are available. When the response number reaches three it wraps around to zero on the next increment.

Functions and Function Codes

In the messages shown below, all numbers are in hexadecimal unless otherwise noted.

01—Function Code: Enable Unsolicited Data Transfer, Sent From Master to Relay

Upon power-up, the SEL-2100 disables its own unsolicited transmissions. This function enables the SEL-2100 to begin sending unsolicited data to the device which sent the enable message, if the SEL-2100 has such data to transfer. The message format for function code 01 is shown below.

Data	Description
A546	Message header
12	Message length in bytes (18 decimal)
0000000000	Five bytes reserved for future use as a routing address
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
01	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 00, 01...).
18	Function to enable (18—unsolicited SER messages)
0000	Reserved for future use as function code data
nn	Maximum number of SER records per message, 01–20 hex
cccc	Two-byte CRC-16 check code for message

The SEL-2100 verifies the message by checking the header, length, function code, and enabled function code against the expected values. It also checks the entire message against the CRC-16 field. If any of the checks fail, except the function code or the function to enable, the message is ignored.

If an acknowledge is requested as indicated by the least significant bit of the status byte, the SEL-2100 transmits an acknowledge message with the same response number received in the enable message.

The “nn” field is used to set the maximum number of SER records per message. The SEL-2100 checks for SER records approximately every 500 ms. If there are new records available, the SEL-2100 immediately creates a new unsolicited SER message and transmits it. If there are more than “nn” new records available, or if the first and last record are separated by more than 16 seconds, the SEL-2100 will break the transmission into multiple messages so that no message contains more than “nn” records, and the first and last record of each message are separated by no more than 16 seconds.

If the function to enable is not 18 or the function code is not recognized, the relay responds with an acknowledge message containing a response code 01 (function code unrecognized), and no functions are enabled. If the SER triggers are disabled (SER1, SER2, SER3, SER4, SER5, and SER6 are all set to NA), the unsolicited SER messages are still enabled, but the only SER records generated are the result of settings changes and power being applied to the relay. If the SER1, SER2, SER3, SER4, SER5, or SER6 settings are subsequently changed to any non-NA value and SER entries are triggered, unsolicited SER messages will be generated with the new SER records.

02—Function Code: Disable Unsolicited Data Transfer, Sent From Master to SEL-2100

This function disables the SEL-2100 from transferring unsolicited data. The message format for function code 02 is shown below.

Data	Description
A546	Message header
10	Message length (16 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
02	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
18	Function to disable (18 = Unsolicited SER)
00	Reserved for future use as function code data
cccc	Two-byte CRC-16 check code for message

The SEL-2100 verifies the message by checking the header, length, function code, and disabled function code against the expected values, and checks the entire message against the CRC-16 field. If any of the checks fail, except the function code or the function to disable, the message is ignored.

If an acknowledge is requested as indicated by the least significant bit of the status byte, the relay transmits an acknowledge message with the same response number received in the enable message.

If the function to disable is not 18 or the function code is not recognized, the relay responds with an acknowledge message containing the response code 01 (function code unrecognized) and no functions are disabled.

18—Function: Unsolicited SER Response, Sent From Relay to Master

The function 18 is used for the transmission of unsolicited Sequential Events Recorder (SER) data from the SEL-2100. This function code is also passed as data in the “Enable Unsolicited Data Transfer” and the “Disable Unsolicited Data Transfer” messages to indicate which type of unsolicited data should be enabled or disabled. The message format for function code 18 is shown below.

Data	Description
A546	Message header
ZZ	Message length (as much as 34 + 4 · nn decimal, where nn is the maximum number of SER records allowed per message as indicated in the “Enable Unsolicited Data Transfer” message.)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status Byte (01 = need acknowledgment; 03 = settings changed and need acknowledgment. If YY=03, the master should re-read the SNS data because the element index list may have changed.)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)

XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
00000000	Four bytes reserved for future use as a return routing address.
dddd	Two-byte day of year (1–366)
yyyy	Two-byte, four-digit year (e.g., 1999 or 07CF hex)
mmmmmmmm	Four-byte time of day in milliseconds since midnight
XX	1st element index (match with the response to the SNS command; 00 for 1st element, 01 for second element, and so on)
uuuuuu	Three-byte time tag offset of 1st element in microseconds since time indicated in the time of day field.
XX	2nd element index
uuuuuu	Three-byte time tag offset of 2nd element in microseconds since time indicated in the time of day field.
.	
.	
.	
xx	last element index
uuuuuu	Three-byte time tag offset of last element in microseconds since time indicated in the time of day field.
FFFFFFFE	Four-byte end-of-records flag
ssssssss	Packed four-byte element status for as many as 32 elements (LSB for the 1st element)
cccc	Two-byte CRC-16 checkcode for message

If the SEL-2100 determines that SER records have been lost, it sends a message with the following format:

Data	Description
A546	Message header
22	Message length (34 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status Byte (01 = need acknowledgment; 03 = settings changed and need acknowledgment)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...)
00000000	Four bytes reserved for future use as a return routing address.
dddd	Two-byte day of year (1–366) of overflow message generation
yyyy	Two-byte, four-digit year (e.g., 1999 or 07CF hex) of overflow message generation.
mmmmmmmm	Four-byte time of day in milliseconds since midnight
FFFFFFFE	Four-byte end-of-records flag
00000000	Element status (unused)
cccc	Two-byte CRC-16 checkcode for message

Acknowledge Message Sent from Master to Relay, and From Relay to Master

The acknowledge message is constructed and transmitted for every received message which contains a status byte with the LSB set (except another acknowledge message), and which passes all other checks, including the CRC. The acknowledge message format is shown below.

Data	Description
A546	Message header
0E	Message length (14 decimal)
0000000000	Five bytes reserved for future use as a routing address.
00	Status byte (always 00)
XX	Function code, echo of acknowledged function code with MSB set.
RR	Response code (see below)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...) must match response number from message being acknowledged.)
cccc	Two-byte CRC-16 checkcode for message

The SEL-2100 supports the following response codes:

RR	Response
00	Success.
01	Function code not recognized.

Examples

1. Successful acknowledge for “Enable Unsolicited Data Transfer” message from a relay with at least one of SER1, SER2, SER3, SER4, SER5, or SER6 not set to NA:
   A5 46 0E 00 00 00 00 00 00 81 00 XX cc cc
   (XX is the same as the response number in the “Enable Unsolicited Data Transfer” message to which it responds)

2. Unsuccessful acknowledge for “Enable Unsolicited Data Transfer” message from a relay with all of SER1, SER2, SER3, SER4, SER5, and SER6 set to NA:
   A5 46 0E 00 00 00 00 00 00 81 02 XX cc cc
   (XX is the same as the response number in the “Enable Unsolicited Data Transfer” message to which it responds.)

3. Disable Unsolicited Data Transfer message, acknowledge requested:
   A5 46 10 00 00 00 00 00 01 02 C0 XX 18 00 cc cc
   (XX = 0, 1, 2, 3)

4. Successful acknowledge from the SEL-2100 for the “Disable Unsolicited Data Transfer” message:
   A5 46 0E 00 00 00 00 00 00 82 00 XX cc cc
   (XX is as same as the response number in the “Disable Unsolicited Data Transfer” message to which it responds.)

5. Successful acknowledge message from the master for an unsolicited SER message:

   A5 46 0E 00 00 00 00 00 00 98 00 XX cccc
   (XX is as same as the response number in the unsolicited SER message to which it responds.)

Notes:

Once the SEL-2100 receives an acknowledge with response code 00 from the master, it will clear the settings changed bit (bit 1) in its status byte, if that bit is asserted, and it will clear the settings changed bit in Fast Meter, if that bit is asserted.

An element index of FE indicates that the SER record is generated when the device is powered on. An element index of FF indicates that the SER record is generated because of a settings change. An element index of FD indicates that the element identified in this SER record is no longer in the SER trigger settings.

When the SEL-2100 sends an SER message packet, it will put a sequential number (0, 1, 2, 3, 0, 1, . . .) into the response number. If the SEL-2100 does not receive an acknowledge from the master before approximately 500 ms, the SEL-2100 will resend the same message packet with the same response number until it receives an acknowledge message with that response number. For the next SER message, the SEL-2100 will increment the response number (it will wrap around to zero from three).

A single SER message packet from the SEL-2100 can have a maximum number 32 records and the data may span a time period of no more than 16 seconds. The master may limit the number records in a packet with the third byte of function code data in the “Enable Unsolicited Data Transfer” message (function code 01). The SEL-2100 may generate an SER packet that with less than the requested number of records, if the record time stamps span more than 16 seconds.

The SEL-2100 always requests acknowledgment in unsolicited SER messages (LSB of the status byte is set).

Unsolicited SER messages can be enabled on multiple ports simultaneously.

APPENDIX J: ACSELERATOR QUICKSET SEL-5030 SOFTWARE

INTRODUCTION

The ACSELERATOR QuickSet® SEL-5030 Software is an easy-to-use yet powerful tool to help get the most out of your SEL-2100 Logic Processor.

Using ACSELERATOR QuickSet, you will be able to:

- Create, test, and manage settings with a Windows® interface.
- Visually design SELOGIC® control equations with a powerful Logic Editor.
- Verify SELOGIC control equations with an integrated Logic Simulator.
- Analyze power system events from SEL relays with integrated Waveform and Harmonic Analysis tools.
- Communicate with SEL devices via an HMI interface with integrated Meter and Control functions.
- Create, manage, copy, merge, and read relay settings with a settings database manager.

This document gives instructions for installing ACSELERATOR QuickSet. A Quick Tour guide is available as part of the online help. After installation, the Quick Tour will show how to create a circuit breaker (CB) simulator. The CB simulator is useful for testing and evaluation.

Note: Like all SEL relay products, the SEL-2100 can also be set and operated by a simple ASCII terminal.

ACSELERATOR SYSTEM REQUIREMENTS

CPU: Pentium class (recommended 90 MHz or faster)

Operating System: Windows 95/98 with 16 MB ram (32 MB ram recommended)
Windows NT4 SP3 or later with 32 MB ram (64 MB ram recommended)
Windows 2000 with 64 MB ram

Disk Space: 25 Mb

Communications: EIA-232 serial port for communicating with the relay

CD drive: required for installation

INSTALLATION

Note: Your PC must be restarted after the installation for the changes to take effect.

To install the software, perform the following steps.

1. Close all other software applications on your PC.
2. Insert the ACSELERATOR QuickSet CD into your PC's CD-ROM drive. The installation program should start automatically. If the install program does not start, select Run from the windows start menu and type in the following command **D:\SETUP** (substitute D:\ with your PC's CD-ROM drive letter).
3. Follow the steps that appear on the screen. The installation program will perform all the necessary steps to load ACSELERATOR QuickSet onto your PC.

It is necessary to have the correct comctl32.dll file installed on your computer in order to see the toolbar buttons. If you do not see the toolbar buttons, run the 40ComUpd.exe, located in the install directory. This file will install the proper windows system drivers.

STARTING ACSELERATOR QuickSet

You can start ACSELERATOR QuickSet the following ways:

1. Double-click the ACSELERATOR QuickSet icon if you have a desktop shortcut.
2. Choose "Programs | SEL Applications" and select the ACSELERATOR QuickSet icon to start the program.

APPENDIX K: ADVANCED APPLICATION LOGIC

The SEL-2100 supports Advanced Application Logic modules that perform specific functions. You can specify Advanced Application Logic when you order an SEL-2100 Logic Processor, or purchase this logic as a firmware upgrade. Table K.1 lists the available Advanced Application Logic modules.

Table K.1: Advanced Application Logic Modules for the SEL-2100

Name	Description or Application	Documentation
Crosspoint Switch	Dynamic routing of Transmit MIRRORED BITS® and logic points; driven by SEL Fast Message protocol. Used in fast load-shedding schemes and similar applications.	Appendix L

For complete power system and industrial protection solutions, or customized Advanced Application Logic, contact SEL.

STANDARD DEFINITION TABLES

The documentation for an Advanced Application Logic module contains a standardized definition table. This table lists the following module information:

- Identification
- Effect on SEL-2100 SELOGIC® capacity
- Inputs
- Outputs

ADVANCED APPLICATION LOGIC FUNCTIONING

SEL-2100 Advanced Application Logic modules function identically in each of the six settings groups. The documentation for a module defines any specific behavior after the initial application of logic-processor power or a settings group change.

DETERMINING INSTALLED ADVANCED APPLICATION LOGIC MODULE

The SEL-2100 **VER** Command, available at Access Level 2, lists the name of an installed Advanced Application Logic module under the Extended Features section. See ***VER Command (Display SEL-2100 Configuration)*** in the ***Access Level 2 Commands*** subsection of ***Section 4: Serial Port Communications and Commands*** for a sample response.

If no Advanced Application Logic module is loaded, the **VER** command does not display a module listing in the Extended Features section.

SELOGIC CONTROL EQUATION CAPACITY IS REDUCED

Advanced Application Logic modules consume a portion of available SELOGIC control equation elements and edges. To preserve the maximum amount of programming capability, SEL recommends ordering or specifying an Advanced Application Logic module only when the function is required for a specific application, not for general-purpose use. Refer to Table 5.3 for more information on SELOGIC control equation capacity.

UPGRADES/CONVERSIONS FOR ADVANCED APPLICATION LOGIC

Contact your SEL representative to order an upgrade or conversion package for your SEL-2100 Logic Processor. A firmware upgrade is required if the Logic Processor has firmware R102 or a prior version. Refer to ***Appendix A: Firmware and Manual Versions*** for information on determining the SEL-2100 firmware version. After checking that an appropriate firmware version is installed, use procedures in ***Installing or Removing an Advanced Application Logic Module*** for installing and removing Advanced Application Logic.

FILE NAMES

The procedures for installing and removing Advanced Application Logic are similar in that both require sending a special file to the SEL-2100. This file has a specific name and function for each case:

- "Installation" filename: <filename>.s19. This file has a unique name and is listed in the Application Logic Object Definition Table in the IM appendix that describes each Advanced Application Logic module. This file loads a specific module, effectively overwriting the default SEL-2100 functionality.
- "Removal" filename: app_default_r1002100.s19. This file loads the default SEL-2100 functionality, effectively overwriting an installed module. Loading this file is the only method for removing an installed Advanced Application Logic module.

The .s19 files are not settings files; as a result, these files do not contain information that can be edited. SEL creates the .s19 files specifically for the SEL-2100. Once loaded, the SEL-2100 stores the module in nonvolatile memory, and retains the programmed functionality even after power is removed from the logic processor. This nonvolatile storage is the same for logic processor settings.

For more information on sending files to the SEL-2100 see the **FILE Command** in the ***Access Level 2 Commands*** subsection of ***Section 4: Serial Port Communications and Commands***.

INSTALLING OR REMOVING AN ADVANCED APPLICATION LOGIC MODULE

Step 1. Remove the SEL-2100 from service.

Step 2. Note or capture all of your settings using the **SHO n**, **SHO L n** (where n is 1–6), **SHO G**, **SHO R**, **SHO P n** (where n is 1–16 or F), and **SHO C** commands, for reference in the event that these settings are lost during the upgrade. One convenient method is to connect a PC to the SEL-2100 and read the device settings using ACSELERATOR QuickSet SEL-2030 Software.

Step 3. Determine the correct removal or installation file explained in *File Name*: <filename.s19>. (Contact SEL customer service to obtain the latest firmware version file).

Step 4. Start a terminal emulator program with file transfer capability and establish serial communication with the Logic Processor at Access Level 2.

Step 5. Type **FILE WRITE CUSTOM.APP**<Enter> to begin loading the Advanced Application Logic module file.

Step 6. Use YMODEM protocol to upload (send) the .s19 file identified in Step 3 from your terminal program to the SEL-2100.

Typically this step requires the following actions in the terminal program:

- Select the Transfer > Send File menu item
- Browse to the file location containing the .s19 file, and select the file
- Select YMODEM protocol
- Click Send

Following is a sample file transfer terminal session.

```
=>>FILE WRITE CUSTOM.APPCCC#001 Transfer Complete


Please wait...
Settings copied
```

While you are configuring the terminal program to send the .s19 file the SEL-2100 sends the 'C' character. The file transfer can terminate if too much time elapses between the **FILE WRITE** command and initiation of the file transfer in the terminal emulator software. If this happens, repeat the procedure.

Once successfully loaded, the SEL-2100 returns the message:

```
#001 Transfer Complete.
```

The SEL-2100 sends an error message if the transfer failed. One possible error message is the following:

```
#101 Transfer Complete - Errors in file, not stored
```

This message indicates that the SELOGIC settings in any of the six SEL-2100 settings groups have too few elements or edges available if the module was loaded. If this or a similar message appears, retrieve and inspect file ERR.TXT from the SEL-2100 using the **FILE READ** command.

The Advanced Application Logic Definition Table in the appendix that describes each Advanced Application Logic module lists the amount of SELOGIC elements and edges that the module requires. If too few elements and edges are available then reduce the SELOGIC settings in the SEL-2100 before trying the module installation again.

Contact SEL for further assistance.

Step 7. Enter Access Level 2 and type **VER**<Enter>. Confirm that the Advanced Application Logic entry is correct in the Extended Features list, either reporting the proper name for the module, or no string for the default SEL-2100 mode.

Step 8. Perform the Initial Checkout procedures described in ***Section 1: Introduction*** of the SEL-2100 Instruction Manual. In the event that the settings are lost when upgrading, you must reenter all of your settings using the **SET n**, **SET L n**, **SET G**, **SET R**, and **SET P n** commands.

Step 9. Once the checkout is complete, and settings have been reentered as necessary, use the **SHO C** command to check the calibration settings.

After completing the above steps, the SEL-2100 status should be normal with all settings valid. If the SEL-2100 Alarm contact is closed, call SEL for factory assistance.

APPENDIX L: CROSSPOINT SWITCH ADVANCED APPLICATION LOGIC MODULE

INTRODUCTION

The Crosspoint Switch Advanced Application Logic Module is a powerful addition to the SEL-2100 that uses rules (instructions) transferred into the SEL-2100 from another IED to dynamically route Transmit MIRRORED BITS® and logic point values. The Crosspoint Switch is ideal for load-shedding applications, as described in the following subsection. See ***Appendix K: Advanced Application Logic*** for general information on Advanced Application Logic modules in the SEL-2100.

SEL-2100 Advanced Application Logic Module Definition Table

Table L.1 lists the interface details for the Crosspoint Switch Advanced Application Logic Module.

Table L.1: SEL-2100 Advanced Application Module Definition

Attribute	Description	
Name	Crosspoint Switch	
Filename	app_xpt_sw_r1002100.s19	
VER Command Extended Features String	Crosspoint Switch (R100)	
SELOGIC® Capacity Reduction	Number of elements: Number of edges:	200 50
Inputs	SEL Fast Message Unsolicited Write: Relay Word bits: SELOGIC control equations:	Database addresses 0xF800–0xF8FF LV1–LV32 T1P1–T8P15
Outputs Affected/Controlled	Relay Word bits: (LP1–LP8 are unused and remain at logical 0)	T1P1–T8P15 LP9–LP16

ADAPTIVE LOAD-SHEDDING SCHEME

Background

Some industrial power systems require intentional tripping (shedding) of loads when there is a power mismatch between source capacity and load requirements, such as when a local generator is disconnected from the system. The amount of load to shed differs during circumstances such as maintenance, high-load conditions, or contractual arrangement.

Several variables, including the previous state of the system and the specific outage detected, determine the decision about which load or loads to trip. Pre-programming the load-shedding response into intelligent electronic devices (IEDs) for anything more than a few contingencies is very cumbersome and often impossible. The IED connected to a given circuit breaker typically does not have knowledge of the state of the rest of the associated power system. A substation computer, using information from numerous locations in the power system, can determine load-shedding actions for a given system configuration.

As an example, consider an industrial facility with many power sources and interconnecting switchgear. The various source and load service combinations require different load-shedding actions determined by a specific lost source. A substation computer monitors the present state of the system and calculates the best load-shedding schedule for each outage contingency. This schedule-selection process creates a new set of load-shedding instructions every few seconds.

Upon losing a power source, the predetermined load-shedding instructions require an action that must be performed quickly, typically in less than 0.1 seconds. However, this performance goal is difficult to achieve with a centralized computer alone. Moving the high-speed decisions closer to the apparatus achieves the performance goal using a combination of centralized and local processing.

Advanced Application Logic Solution

The SEL-2100 Crosspoint Switch Advanced Application Logic Module implements the high-speed decisions for this type of application. Figure L.1 shows a simplified substation bus with SEL-2505 Remote I/O Modules at each circuit breaker connected via SEL-2815 Fiber-Optic Transceivers to an SEL-2100 Logic Processor. The SEL-2100 is running the Crosspoint Switch Application, with the SEL-3351 System Computing Platform sending the load-shedding instructions to the SEL-2100 every two seconds.

The SEL-2100 uses the received load-shedding instructions to populate a Crosspoint Switch matrix. Once loaded, the logic processor uses this matrix to issue trip commands via MIRRORED BITS communications every 4 to 6 ms.

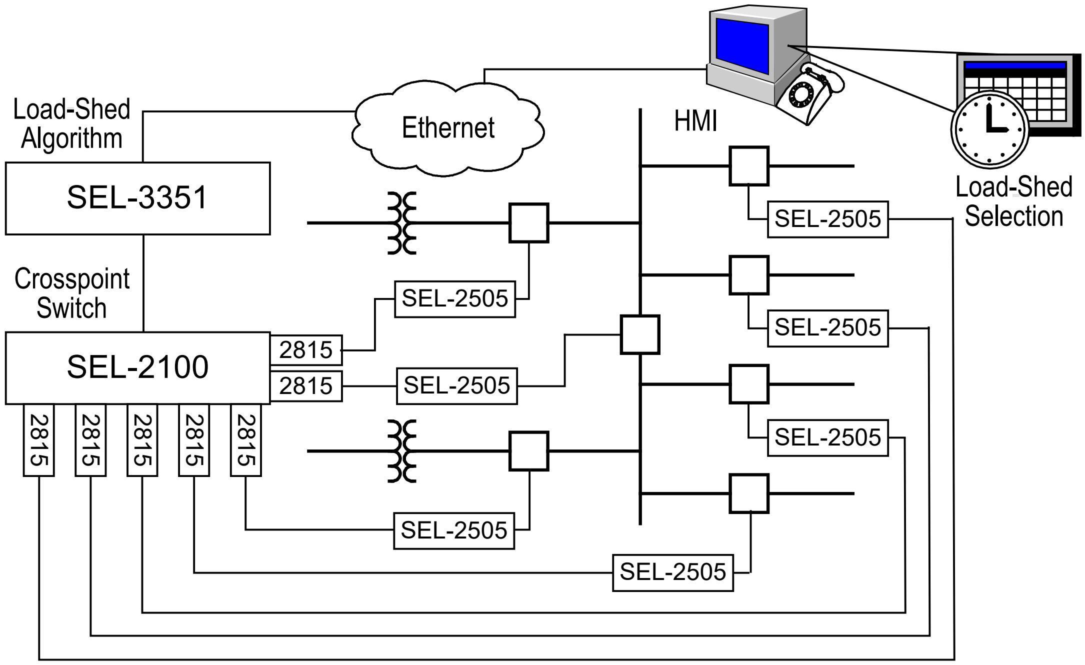

Figure L.1: Example Substation Bus and Load Shedding Connections

Expansion to larger systems is possible because the SEL-3351 can control more than one SEL-2100. Additionally, the Ethernet connection can include links to other SEL-3351 computers running similar schemes, and the HMI terminal allows remote or local access to any portion of the scheme.

The end-to-end performance of a load-shedding system with three tiers of SEL-2100s is less than 70 ms (timed between the initiating event and the issuing of the circuit breaker trip signal).

Other features available in this scheme include SEL *Fast Meter* commands that transmit circuit breaker status information from the SEL-2100 to the SEL-3351 over the same serial-port connection used for sending the load-shed instructions. Additional control actions can be sent from the SEL-3351 via SEL *Fast Operate* commands that control remote bits within the SEL-2100.

Further details of this example are application specific and are not included in this manual. However, for more information on the working details of the Crosspoint Switch Advanced Application Logic Module, see ***Crosspoint Switch Advanced Application Logic Module***. See ***Appendix K: Advanced Application Logic*** for general information on Advanced Application Logic modules in the SEL-2100.

CROSSPOINT SWITCH ADVANCED APPLICATION LOGIC MODULE

Figure L.2 shows a simplified view of the Crosspoint Switch (with three trigger inputs and three load-shed outputs). With the example matrix contents shown, if only Trigger 1 asserts, the logic processor asserts Shed 1 and Shed 2. If only Trigger 2 asserts, then the SEL-2100 asserts only Shed 1. If only Trigger 3 asserts, then there is no assertion of the Shed 1, 2, or 3 outputs.

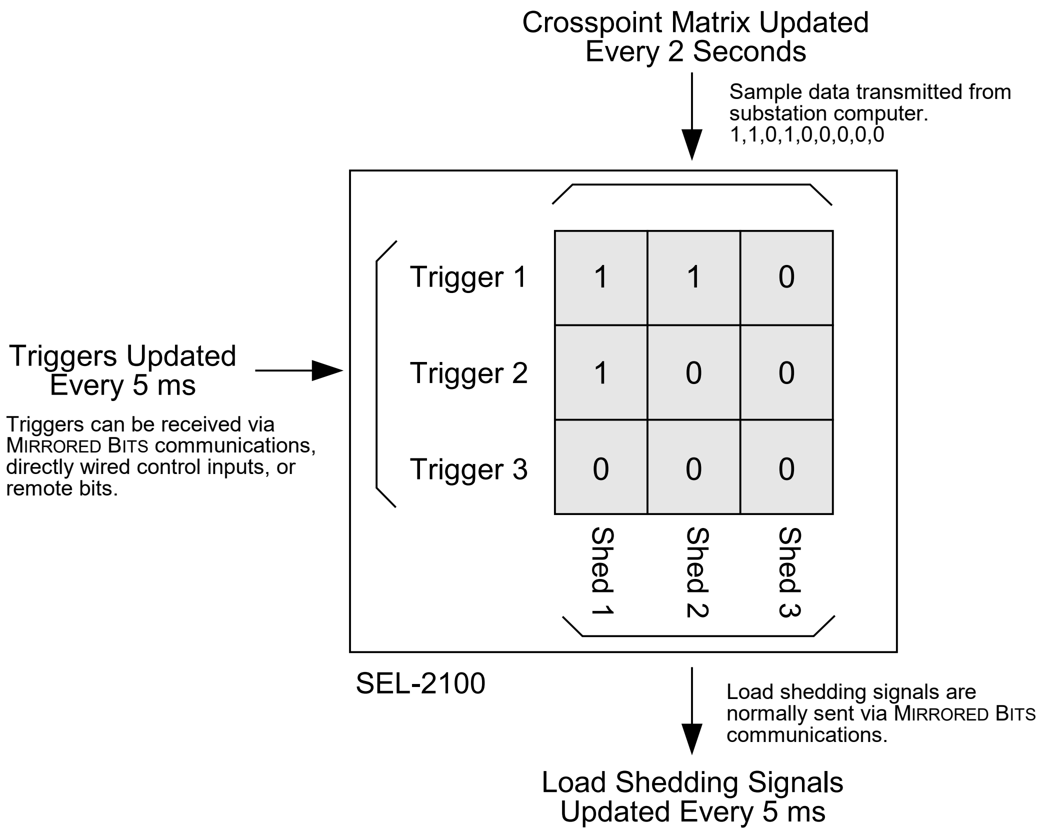

Figure L.2: Example Crosspoint Switch Matrix (simplified)

If the contents of the Crosspoint Switch matrix are represented by a function CP (row, column), then the operation is specified in a logical representation:

Shed 1 = [(Trigger 1) AND CP(1,1)] OR [(Trigger 2) AND CP(2,1)] OR [(Trigger 3) AND CP(3,1)]

Shed 2 = [(Trigger 1) AND CP(1,2)] OR [(Trigger 2) AND CP(2,2)] OR [(Trigger 3) AND CP(3,2)]

Shed 3 = [(Trigger 1) AND CP(1,3)] OR [(Trigger 2) AND CP(2,3)] OR [(Trigger 3) AND CP(3,3)]

The representation in Figure L.2 shows only a portion of the actual matrix in the SEL-2100.

DETAILS

Refer to the instructions in ***Appendix K: Advanced Application Logic*** to determine whether your SEL-2100 has the Crosspoint Switch Advanced Application Logic Module installed, and information on ordering this feature.

This section uses hexadecimal numeric representation to simplify references. Hexadecimal data is preceded by “0x;” for example, 0x18 represents the decimal number 24.

There are two components to the Crosspoint Switch Application:

- Crosspoint Switch Logic Operation (Routing Transmit MIRRORED BITS and Logic Points)
- Crosspoint Switch Matrix (Updating Contents from an IED)

Crosspoint Switch Logic Operation (Routing Transmit MIRRORED BITS and Logic Points)

The Crosspoint Switch module is a simple concept multiplied many times over. The entire logic diagram is large; the operation of a portion of the Crosspoint Switch logic is explained in small pieces.

Unlike the simplified diagram in Figure L.2, the SEL-2100 Crosspoint Switch Advanced Application Logic Module contains 32 input triggers and 128 Transmit MIRRORED BITS/logic points outputs. The resulting Crosspoint Switch matrix contains 32 • 128 = 4096 bits.

The 32 input triggers are Logic Variable 1 through Logic Variable 32, represented by Relay Word bits LV1–LV32. Use **SET L** to program these SELOGIC control equations.

The Crosspoint Switch outputs are organized into 15 groups of 8 bits, corresponding to SEL-2100 Port 1 through Port 15, which can be configured for MIRRORED BITS communications. An extra set of 8 output bits operate logic points LP9 through LP16, and these outputs are not associated with a serial-port MIRRORED BITS channel.

Figure L.3 shows the general layout of the Crosspoint Switch matrix, with sample data in hexadecimal representation. For readability, cells containing 0x00 are shown as blank entries.

	Column:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Row	Triggers	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB
1	LV1			04													B0
2	LV2			64													
3	LV3																03
4	LV4																
5	LV5																
6	LV6																
7	LV7																
8	LV8																
9	LV9																
10	LV10																
11	LV11																
12	LV12																
13	LV13																
14	LV14																
15	LV15																
16	LV16																
17	LV17																
18	LV18																
19	LV19																
20	LV20																
21	LV21																
22	LV22																
23	LV23																
24	LV24																
25	LV25																
26	LV26																
27	LV27																
28	LV28																
29	LV29																
30	LV30			01													
31	LV31			24													
32	LV32																80
Port number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**LP**
TAR row num.		**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**

Notes: MSB = most significant byte, LSB = least significant byte
LP = logic points LP9–LP16
In each column the least significant bit is on the right
Cell values are hexadecimal

Figure L.3: Crosspoint Switch Example Data

Example: Transmit MIRRORED BITS Port Operation (Column 3)

This example examines the details for Column 3, and the output logic corresponding to the "Load Shedding Signals" in Figure L.2.

Figure L.4 shows a close-up view of Column 3 of Figure L.3, with the cell value shown in binary. **SET L** SELOGIC control equation settings T8P3 through T1P3 are logically ORed with the Crosspoint Switch outputs to create Relay Word bits T8P3 through T1P3.

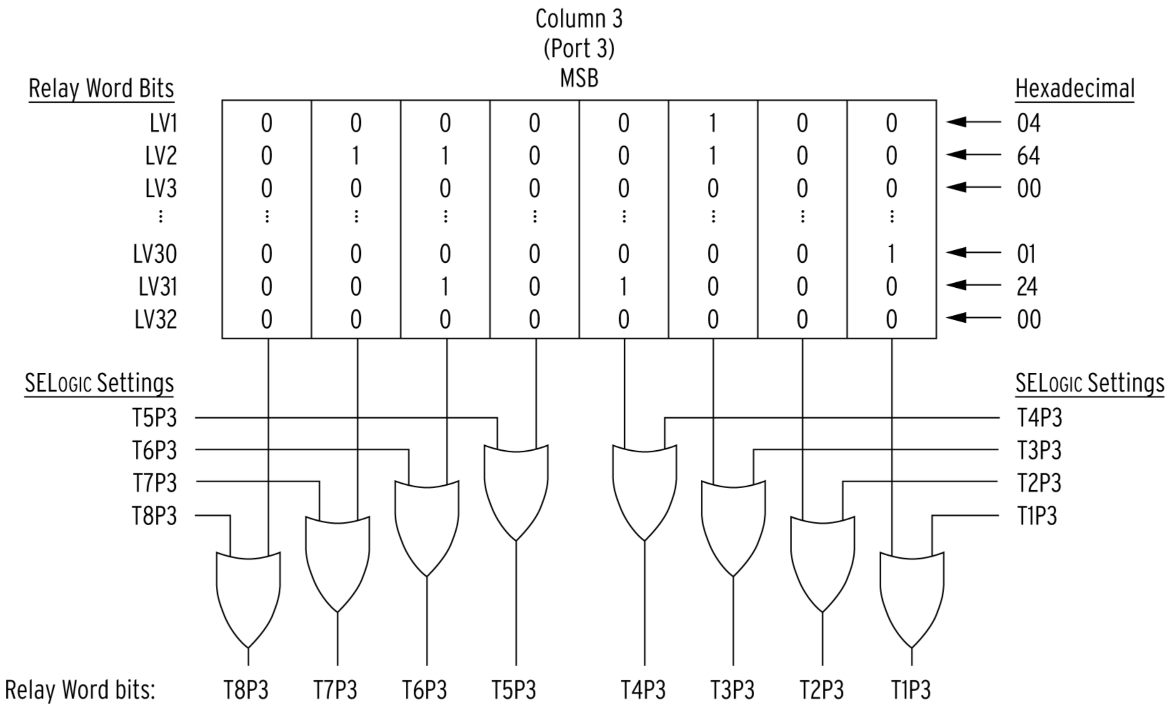

Figure L.4: Crosspoint Switch Example Data–Port 3 Details

The operation of the Port 3 Transmit MIRRORED BITS can be described in equation form, as shown in Table L.2.

Table L.2: Column-3 Example Operation

Relay Word bit		Equivalent SELOGIC Equation
T8P3	⇐	T8P3
T7P3	⇐	T7P3 + LV2
T6P3	⇐	T6P3 + LV2 + LV31
T5P3	⇐	T5P3
T4P3	⇐	T4P3 + LV31
T3P3	⇐	T3P3 + LV1 + LV2
T2P3	⇐	T2P3

T1P3	⇐	T1P3 + LV30

The results create the Transmit MIRRORED BITS message on Port 3 (provided that the **SET P 3** settings select the MIRRORED BITS protocol). The operation is similar for columns 1 through 15 (corresponding to Port 1 through Port 15).

In Figure L.4, note that SELOGIC control equations T8P3 through T1P3 can be set to logical 0, and the Crosspoint Switch logic still operates; this is a function of the virtual OR gate at the bottom of each bit column. SELOGIC control equations settings T8P3 through T1P3 can be used for testing or direct-trip commands, bypassing the output of the Crosspoint Switch.

The results shown in Table L.2 are valid only for the Crosspoint Switch matrix contents shown in Figure L.3 and Figure L.4. Altering the contents of the matrix changes the behavior, as described in ***Crosspoint Switch Matrix (Updating Contents from an IED)***.

Example: Logic Point Operation (Column 16)

The right column (Column 16) operates differently. Figure L.6 shows a close-up view of Column 16 of Figure L.3, with the cell value shown in binary.

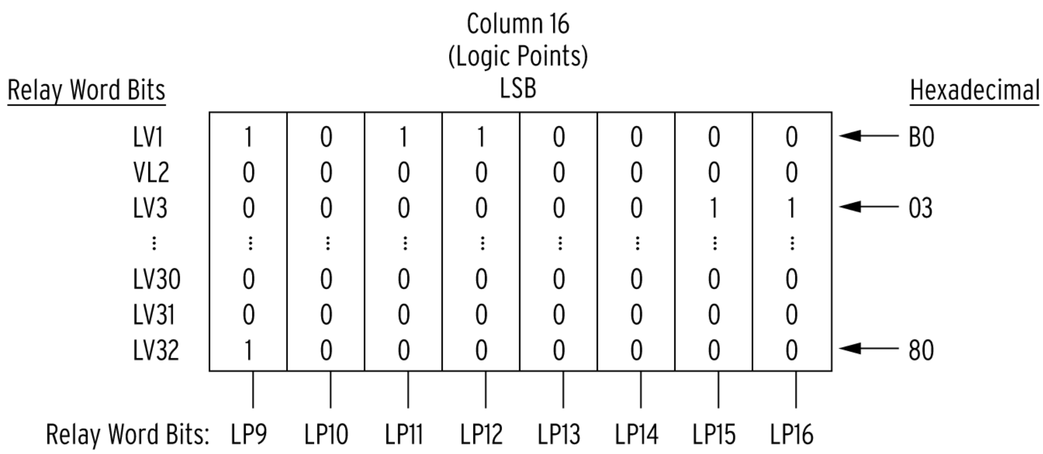

Figure L.5: Crosspoint Switch Example Data–Logic Point Details

The operation of logic points LP9–LP16 is described in equation form as shown in Table L.3.

Table L.3: Column-16 Example Operation

Relay Word bit		Equivalent SELOGIC Equation
LP9	⇐	LV1 + LV32
LP10	⇐	0
LP11	⇐	LV1
LP12	⇐	LV1
LP13	⇐	0
LP14	⇐	0

LP15	⇐	LV3
LP16	⇐	LV3

Outputs LP9–LP16 are not internally mapped to MIRRORED BITS functions. The results shown in Table L.3 are valid only for the Crosspoint Switch matrix contents shown in Figure L.3 and Figure L.5. Altering the contents of the matrix changes the behavior, as described in ***Crosspoint Switch Matrix (Updating Contents from an IED)***.

Crosspoint Switch Matrix (Updating Contents from an IED)

The Crosspoint Switch matrix is a set of 16-bit registers with addresses between 0xF800 and 0xF8FF, as illustrated in Figure L.6. The SEL-2100 automatically places logical 0 in all cells when newly powered or after an active settings change. In this state, the Crosspoint Switch logic is effectively disabled.

	Column:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Row	Triggers	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB
1	LV1	F800		F801		F802		F803		F804		F805		F806		F807	
2	LV2	F808		F809		F80A		F80B		F80C		F80D		F80E		F80F	
3	LV3	F810		F811		F812		F813		F814		F815		F816		F817	
4	LV4	F818		F819		F81A		F81B		F81C		F81D		F81E		F81F	
5	LV5	F820		F821		F822		F823		F824		F825		F826		F827	
6	LV6	F828		F829		F82A		F82B		F82C		F82D		F82E		F82F	
7	LV7	F830		F831		F832		F833		F834		F835		F836		F837	
8	LV8	F838		F839		F83A		F83B		F83C		F83D		F83E		F83F	
9	LV9	F840		F841		F842		F843		F844		F845		F846		F847	
10	LV10	F848		F849		F84A		F84B		F84C		F84D		F84E		F84F	
11	LV11	F850		F851		F852		F853		F854		F855		F856		F857	
12	LV12	F858		F859		F85A		F85B		F85C		F85D		F85E		F85F	
13	LV13	F860		F861		F862		F863		F864		F865		F866		F867	
14	LV14	F868		F869		F86A		F86B		F86C		F86D		F86E		F86F	
15	LV15	F870		F871		F872		F873		F874		F875		F876		F877	
16	LV16	F878		F879		F87A		F87B		F87C		F87D		F87E		F87F	
17	LV17	F880		F881		F882		F883		F884		F885		F886		F887	
18	LV18	F888		F889		F88A		F88B		F88C		F88D		F88E		F88F	
19	LV19	F890		F891		F892		F893		F894		F895		F896		F897	
20	LV20	F898		F899		F89A		F89B		F89C		F89D		F89E		F89F	
21	LV21	F8A0		F8A1		F8A2		F8A3		F8A4		F8A5		F8A6		F8A7	
22	LV22	F8A8		F8A9		F8AA		F8AB		F8AC		F8AD		F8AE		F8AF	
23	LV23	F8B0		F8B1		F8B2		F8B3		F8B4		F8B5		F8B6		F8B7	
24	LV24	F8B8		F8B9		F8BA		F8BB		F8BC		F8BD		F8BE		F8BF	
25	LV25	F8C0		F8C1		F8C2		F8C3		F8C4		F8C5		F8C6		F8C7	
26	LV26	F8C8		F8C9		F8CA		F8CB		F8CC		F8CD		F8CE		F8CF	
27	LV27	F8D0		F8D1		F8D2		F8D3		F8D4		F8D5		F8D6		F8D7	
28	LV28	F8D8		F8D9		F8DA		F8DB		F8DC		F8DD		F8DE		F8DF	
29	LV29	F8E0		F8E1		F8E2		F8E3		F8E4		F8E5		F8E6		F8E7	
30	LV30	F8E8		F8E9		F8EA		F8EB		F8EC		F8ED		F8EE		F8EF	
31	LV31	F8F0		F8F1		F8F2		F8F3		F8F4		F8F5		F8F6		F8F7	
32	LV32	F8F8		F8F9		F8FA		F8FB		F8FC		F8FD		F8FE		F8FF	
Port number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**LP**
TAR row num.		**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**

Notes: MSB = most significant byte, LSB = least significant byte
LP = logic points LP9–LP16
In each column the least significant bit is on the right

Figure L.6: Crosspoint Switch Hexadecimal Register Addressing

Fast Message Configuration

The Crosspoint Switch matrix contains 256 registers. Three SEL Fast Messages are required to populate the entire matrix. For example, transmitting two 96-bit register messages (12 rows each) and one 64-bit register message (8 rows) populates the entire matrix. Many applications do not use the entire Crosspoint Switch matrix and have no need to populate the unused registers with data. The SEL-2100 retains switch matrix register contents until overwritten, until the SEL-2100 performs a power-up initialization, or until an active-group settings change.

One SEL Fast Message packet can update between 1 and 115 consecutive registers in the Crosspoint Switch matrix. The SEL-2100 updates all of the matrix data addressed in one SEL Fast Message simultaneously upon verification of the message. Therefore, any Crosspoint Switch control action occurs in the same processing interval and contains the same Sequential Events Recorder (SER) report timestamp.

Updating Contents From an IED

Before using the module the Crosspoint Switch Advanced Application Logic switch matrix must be configured by another Intelligent Electronic Device (IED). This IED is typically a substation computer, such as the SEL-3351 System Computing Platform, sending a binary communications protocol called SEL Fast Message Unsolicited Write to transmit matrix configuration data to the SEL-2100.

Direct Manipulation of the Switch Matrix

For testing or Crosspoint Switch verification you can directly manipulate the switch matrix. To directly access the switch matrix, you should be familiar with binary communications protocols, have a working knowledge of hexadecimal representation of numbers, and have software tools to compose and send binary data messages.

You must select port setting PROTO = SEL for the port used for SEL Fast Message Unsolicited Write operations. This same port can be used for other SEL binary data, such as SEL Fast Meter or SEL Fast Operate commands, and the binary messages are interleaved with regular ASCII communications.

Reading the Switch Matrix

There is no direct method for reading the contents of the Crosspoint Switch matrix from the SEL-2100, although an indirect method exists. See ***Data Update and Verification*** for a method for performing the verification.

Example: Configuring The Switch Matrix Via Unsolicited Write Fast Messages

Two SEL Fast Message Unsolicited Write messages set the Crosspoint Switch matrix to the values shown in Figure L.3. Extra spaces and line breaks are shown for readability. ***A546 Unsolicited Write*** in ***Appendix E*** for details on the format for this Fast Message.

The first message length is 66 bytes (42 in hexadecimal), and sets matrix registers (addresses) F801 through F817.

```
A546 42 0000000000 00 20 C0 00 01 00
F801 0017
0400 0000 0000 0000 0000 0000 00B0 0000 6400 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0003
410F
```

The second message length is 68 bytes (44 in hexadecimal), and sets matrix registers (addresses) F8E8 through FBFF.

```
A546 44 0000000000 00 20 C0 00 01 00
F8E8 0018
0000 0100 0000 0000 0000 0000 0000 0000 0000 2400 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0080
51C4
```

These two example messages do not send data to all of the blank cells from Figure L.3. In a real-world application all registers in the required matrix rows should be sent with each update.

Data Update and Verification

The host processor updates the matrix on a regular basis, even when the contents are not changing. You should provide a time delay of 500 ms between successive messages to minimize the chance of losing messages.

To verify operation, program a unique pattern or serial number into unused matrix cells. The unique pattern could be a simple state change of one logic point (LP9–LP16) in each message. Use the host computer to read unused switch matrix columns using SEL Fast Meter (A5D1) requests while asserting the proper logical variable trigger condition. The host processor determines that a new Fast Message has been received by analyzing the received copy of the SEL-2100 Relay Word.

You can use this method during commissioning to determine the appropriate inter-message time delay settings in the host computer. During operation this method acts as a monitor for the application scheme, including an alarm status if too many messages are lost.

SEL-2100 COMMAND SUMMARY

Access Level 0 Command	The only thing that can be done at Access level 0 is to go to Access Level 1. The screen prompt is: =
ACC	Enter Access Level 1. If the main board password jumper is not in place, the relay prompts for the entry of the Access Level 1 password to enter Access Level 1.
Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, reports). The screen prompt is: =>
2AC	Enter Access Level 2. If the main board password jumper is not in place, the relay prompts for the entry of the Access Level 2 password to enter Access Level 2.
COM P *n* L	Show a long format communications summary report for all events on MIRRORED BITS® channel *n*.
COM P *n*	Show a communications summary for MIRRORED BITS channel *n*.
COM P *n k l*	Show a communications summary report for events *k* through *l* on MIRRORED BITS channel *n*.
COM P *n d1*	Show a communications summary report for events occurring on date *d1* on MIRRORED BITS channel *n*.
COM P *n d1 d2*	Show a communications summary report for events occurring between dates *d1* and *d2* on MIRRORED BITS channel *n*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
COM P *n* C	Clear the communications summary report for Port *n*.
DAT	Show date.
DAT m/d/y	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT y/m/d	Enter date in this manner if Date Format setting DATE_F = YMD.
FILE DIR	Show a list of files.
FILE READ *filename*	Transfer the file *filename* from the logic processor to the PC.
GRO	Display active group number.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
QUI	Quit. Returns to Access Level 0 and terminates SEL Distributed Port Switch Protocol (LMD) protocol connection.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER *m n*	Show rows *m* through n in the Sequential Events Recorder (SER) event report.
SER *d1*	Show rows in the Sequential Events Recorder (SER) event report from date *d1*.
SER *d1 d2*	Show rows in the Sequential Events Recorder (SER) event report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SHO *n*	Show relay settings (timers, etc.) for Group *n*.
SHO L *n*	Show SELOGIC® control equation settings for Group *n*.
SHO G	Show global settings.
SHO P *n*	Show Port *n* settings.
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status. **STA C** resets self-test warnings/failures.
TAR *n k*	Display Relay Word row. If *n* = 0 through 69, display row *n*. If *n* is an element name (e.g., ROK1), display the row containing element *n*. Repeat the display *k* times.
TIM	Show or set time (24-hour time). Show time presently in the relay by entering just **TIM**.

Access Level 2 <u>Commands</u>	The Access Level 2 commands allow unlimited access to relay settings, parameters, and output contacts. All Access Level 1 commands are available from Access Level 2. The screen prompt is: =>>
CAL	Enter Access Level C. If the main board password 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.
CON *n*	Control Relay Word bit RB*n* (Remote Bit *n*; *n* = 1 through 64). Execute **CON *n*** and the relay responds: CONTROL RB*n*. Then reply with one of the following: **SRB *n*** set Remote Bit *n* (assert RB*n*). **CRB** *n* clear Remote Bit *n* (deassert RB*n*). **PRB *n*** pulse Remote Bit *n* (assert RB*n* for 1 processing interval).
COP *m n*	Copy relay and logic settings from Group *m* to Group *n*.
FILE WRITE *filename*	Transfer the file *filename* from the PC to the logic processor.
GRO *n*	Change active settings group to Group *n*.
LOO P *n*	Set MIRRORED BITS Port *n* to loopback for 5 minutes.
LOO P *n* T	Set MIRRORED BITS Port *n* to loopback for T minutes.
LOO P *n* R	Reset loopback Port *n* prior to time-out.
LOO R	Reset all active loopbacks.
PAS 1	Change Access Level 1 password.
PAS 2	Change Access Level 2 password.
PAS C	Change Access Level C password.
PUL *n k*	Pulse Relay Word bits such as output contact OUT101–OUT104 for *k* (1–30) seconds. Parameter *n* must be specified; *k* defaults to 1 if not specified.
SET *n*	Change relay settings (timers, etc.) for Group *n*.
SET L *n*	Change SELOGIC control equation settings for Group *n*.
SET G	Change global settings.
SET P *n*	Change Port *n* settings.
SET R	Change Sequential Events Recorder (SER) settings.
VER	Display version and configuration information.

SEL-2100 COMMAND SUMMARY

Access Level 0 <u>Command</u>	The only thing that can be done at Access level 0 is to go to Access Level 1. The screen prompt is: =
ACC	Enter Access Level 1. If the main board password jumper is not in place, the relay prompts for the entry of the Access Level 1 password to enter Access Level 1.
Access Level 1 <u>Commands</u>	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, reports). The screen prompt is: =>
2AC	Enter Access Level 2. If the main board password jumper is not in place, the relay prompts for the entry of the Access Level 2 password to enter Access Level 2.
COM P *n* L	Show a long format communications summary report for all events on Mirrored Bits® channel *n*.
COM P *n*	Show a communications summary for Mirrored Bits channel *n*.
COM P *n k l*	Show a communications summary report for events *k* through *l* on Mirrored Bits channel *n*.
COM P *n d1*	Show a communications summary report for events occurring on date *d1* on Mirrored Bits channel *n*.
COM P *n d1 d2*	Show a communications summary report for events occurring between dates *d1* and *d2* on Mirrored Bits channel *n*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
COM P *n* C	Clear the communications summary report for Port *n*.
DAT	Show date.
DAT m/d/y	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT y/m/d	Enter date in this manner if Date Format setting DATE_F = YMD.
FILE DIR	Show a list of files.
FILE READ *filename*	Transfer the file *filename* from the logic processor to the PC.
GRO	Display active group number.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
QUI	Quit. Returns to Access Level 0 and terminates SEL Distributed Port Switch Protocol (LMD) protocol connection.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER *m n*	Show rows *m* through n in the Sequential Events Recorder (SER) event report.
SER *d1*	Show rows in the Sequential Events Recorder (SER) event report from date *d1*.
SER *d1 d2*	Show rows in the Sequential Events Recorder (SER) event report from date *d1* to *d2*. Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SHO *n*	Show relay settings (timers, etc.) for Group *n*.
SHO L *n*	Show SELogic® control equation settings for Group *n*.
SHO G	Show global settings.
SHO P *n*	Show Port *n* settings.
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status. **STA C** resets self-test warnings/failures.
TAR *n k*	Display Relay Word row. If *n* = 0 through 69, display row *n*. If *n* is an element name (e.g., ROK1), display the row containing element *n*. Repeat the display *k* times.
TIM	Show or set time (24-hour time). Show time presently in the relay by entering just **TIM**.

Access Level 2 <u>Commands</u>	The Access Level 2 commands allow unlimited access to relay settings, parameters, and output contacts. All Access Level 1 commands are available from Access Level 2. The screen prompt is: =>>
CAL	Enter Access Level C. If the main board password 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.
CON *n*	Control Relay Word bit RB*n* (Remote Bit *n*; *n* = 1 through 64). Execute **CON *n*** and the relay responds: CONTROL RB*n*. Then reply with one of the following: **SRB *n*** set Remote Bit *n* (assert RB*n*). **CRB** *n* clear Remote Bit *n* (deassert RB*n*). **PRB *n*** pulse Remote Bit *n* (assert RB*n* for 1 processing interval).
COP *m n*	Copy relay and logic settings from Group *m* to Group *n*.
FILE WRITE *filename*	Transfer the file *filename* from the PC to the logic processor.
GRO *n*	Change active settings group to Group *n*.
LOO P *n*	Set MIRRORED BITS Port *n* to loopback for 5 minutes.
LOO P *n* T	Set MIRRORED BITS Port *n* to loopback for T minutes.
LOO P *n* R	Reset loopback Port *n* prior to time-out.
LOO R	Reset all active loopbacks.
PAS 1	Change Access Level 1 password.
PAS 2	Change Access Level 2 password.
PAS C	Change Access Level C password.
PUL *n k*	Pulse Relay Word bits such as output contact OUT101–OUT104 for *k* (1–30) seconds. Parameter *n* must be specified; *k* defaults to 1 if not specified.
SET *n*	Change relay settings (timers, etc.) for Group *n*.
SET L *n*	Change SELOGIC control equation settings for Group *n*.
SET G	Change global settings.
SET P *n*	Change Port *n* settings.
SET R	Change Sequential Events Recorder (SER) settings.
VER	Display version and configuration information.