Operation

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Qualified Persons

⚠ WARNING

Only qualified persons who are knowledgeable in the installation, operation, and maintenance of overhead and underground electric distribution equipment, along with all associated hazards, may install, operate, and maintain the equipment covered by this publication. A qualified person is someone who is trained and competent in:

- The skills and techniques necessary to distinguish exposed live parts from nonlive parts of electrical equipment
- The skills and techniques necessary to determine the proper approach distances corresponding to the voltages to which the qualified person will be exposed
- The proper use of special precautionary techniques, personal protective equipment, insulated and shielding materials, and insulated tools for working on or near exposed energized parts of electrical equipment

These instructions are intended only for such qualified persons. They are not intended to be a substitute for adequate training and experience in safety procedures for this type of equipment.

Read this Instruction Sheet

NOTICE

Thoroughly and carefully read this instruction sheet and all materials included in the product's instruction handbook before installing or operating the 6801M Automatic Switch Operator. Become familiar with the Safety Information on page 4 and Safety Precautions on page 5. The latest version of this publication is available online in PDF format at **sandc.com/en/support/product-literature/**.

Retain this Instruction Sheet

This instruction sheet is a permanent part of the 6801M Automatic Switch Operator. Designate a location where this publication can be easily retrieved.

Proper Application

⚠ WARNING

The equipment in this publication is only intended for a specific application. The application must be within the ratings furnished for the equipment. See S&C Specification Bulletin 1045M-31.

Special Warranty Provisions

The standard warranty contained in S&C's standard conditions of sale, as set forth in Price Sheets 150 and 181, applies to the 6801M Automatic Switch Operator, except that the first paragraph of the said warranty is replaced by the following:

(1) General: The seller warrants to the immediate purchaser or end user for a period of 10 years from the date of shipment that the equipment delivered will be of the kind and quality specified in the contract description and will be free of defects of workmanship and material. Should any failure to conform to this warranty appear under proper and normal use within 10 years after the date of shipment, the seller agrees, upon prompt notification thereof and confirmation that the equipment has been stored, installed, operated, inspected, and maintained in accordance with

the recommendations of the seller and standard industry practice, to correct the nonconformity either by repairing any damaged or defective parts of the equipment or (at the seller's option) by shipment of necessary replacement parts. The seller's warranty does not apply to any equipment that has been disassembled, repaired, or altered by anyone other than the seller. This limited warranty is granted only to the immediate purchaser or, if the equipment is purchased by a third party for installation in third-party equipment, the end user of the equipment. The seller's duty to perform under any warranty may be delayed, at the seller's sole option, until the seller has been paid in full for all goods purchased by the immediate purchaser. No such delay shall extend the warranty period.

Replacement parts provided by the seller or repairs performed by the seller under the warranty for the original equipment will be covered by the above special warranty provision for its duration. Replacement parts purchased separately will be covered by the above special warranty provision.

For equipment/services packages, the seller warrants for a period of one year after commissioning that the 6801M Automatic Switch Operator will provide automatic fault isolation and system reconfiguration per agreed-upon service levels. The remedy shall be additional system analysis and reconfiguration of the IntelliTeam® SG Automatic Restoration System until the desired result is achieved.

Warranty of the 6801M Automatic Switch Operator is contingent upon the installation, configuration, and use of the control or software in accordance with S&C's applicable instruction sheets.

Warranty Qualifications

This warranty does not apply to major components not of S&C manufacture, such as batteries and communication devices. However, S&C will assign to the immediate purchaser or end user all manufacturer's warranties that apply to such major components.

Warranty of equipment/services packages is contingent upon receipt of adequate information on the user's distribution system, sufficiently detailed to prepare a technical analysis. The seller is not liable if an act of nature or parties beyond S&C's control negatively impact performance of equipment/services packages; for example, new construction that impedes radio communication, or changes to the distribution system that impact protection systems, available fault currents, or system-loading characteristics.

Understanding Safety-Alert Messages

Several types of safety-alert messages may appear throughout this instruction sheet and on labels and tags attached to the 6801M Automatic Switch Operator. Become familiar with these types of messages and the importance of these various signal words:

⚠ DANGER

"DANGER" identifies the most serious and immediate hazards that will result in serious personal injury or death if instructions, including recommended precautions, are not followed.

⚠ WARNING

"WARNING" identifies hazards or unsafe practices that can result in serious personal injury or death if instructions, including recommended precautions, are not followed.

⚠ CAUTION

"CAUTION" identifies hazards or unsafe practices that can result in minor personal injury if instructions, including recommended precautions, are not followed.

NOTICE

"NOTICE" identifies important procedures or requirements that can result in product or property damage if instructions are not followed.

Following Safety Instructions

If any portion of this instruction sheet is not understood and assistance is required, contact the nearest S&C Sales Office or S&C Authorized Distributor. Their telephone numbers are listed on S&C's website **sandc.com**, or call the S&C Global Support and Monitoring Center at 1-888-762-1100.

NOTICE

Read this instruction sheet thoroughly and carefully before installing a 6801M Automatic Switch Operator.

Replacement Instructions and Labels

If additional copies of this instruction sheet are needed, contact the nearest S&C Sales Office, S&C Authorized Distributor, S&C Headquarters, or S&C Electric Canada Ltd.

It is important that any missing, damaged, or faded labels on the equipment be replaced immediately. Replacement labels are available by contacting the nearest S&C Sales Office, S&C Authorized Distributor, S&C Headquarters, or S&C Electric Canada Ltd.

⚠ DANGER

The 6801M Automatic Switch Operator line voltage input range is 93 to 276 Vac. Failure to observe the precautions below will result in serious personal injury or death.

Some of these precautions may differ from your company's operating procedures and rules. Where a discrepancy exists, follow your company's operating procedures and rules.

1. **QUALIFIED PERSONS.** Access to the 6801M Automatic Switch Operator must be restricted only to qualified persons. See the "Qualified Persons" section on page 2.
2. **SAFETY PROCEDURES.** Always follow safe operating procedures and rules.
3. **PERSONAL PROTECTIVE EQUIPMENT.** Always use suitable protective equipment, such as rubber gloves, rubber mats, hard hats, safety glasses, and flash clothing, in accordance with safe operating procedures and rules.
4. **SAFETY LABELS.** Do not remove or obscure any of the "DANGER," "WARNING," "CAUTION," or "NOTICE" labels.
5. **MAINTAINING PROPER CLEARANCE.** Always maintain proper clearance from energized components.

Applicable Software

This instruction sheet is used with software versions ST6801MSS-7.6.x and SG6801MSX-7.6.x. The "x" can indicate any number from 0 to 255. Other related software component version information is found on the *Setup>General>Revisions* screen.

The software revision is shown in the installer file name (-7.6.x) and on the *Setup>General>Revisions* screen. For questions regarding the applicability of information in this instruction sheet to future software releases, please contact S&C Electric Company.

NOTICE

Several procedures in this document require logging in to the IntelliLink® Setup Software. With firmware versions later than 7.3.100, the default passwords for all user accounts, including the Admin user, must be changed before the IntelliLink software can connect to and configure a control. See S&C Instruction Sheet 1045M-530, "6801M Automatic Switch Operators: *Setup,*" for more information.

⚠ WARNING

Serious risk of personal injury or death may result from contact with electric distribution equipment when electrical isolation and grounding procedures are not followed. The equipment described in this document must be operated and maintained by qualified persons who are thoroughly trained and understand any hazards that may be involved. This document is written only for such qualified persons and is not a substitute for adequate training and experience in safety procedures for accessing high-voltage equipment.

⚠ WARNING

These instructions do NOT replace the need for utility operation standards. Any conflict between the information in this document and utility practices should be reviewed by appropriate utility personnel and a decision made as to the correct procedures to follow.

The 6801M Automatic Switch Operator is connected to switchgear operating at primary voltage levels. High voltage may be present in the wiring to the switch operator or the switch operator itself during certain failures of the switchgear wiring or grounding system because of to a failure of the switch itself. For this reason, access to the switch operator should be treated with the same safety precautions that would be applied when accessing other high-voltage lines and equipment. Follow all locally approved safety procedures when working on or around this switch operator.

Before attempting to access an existing switch installation, check carefully for visible or audible signs of electrical or physical malfunction (do this before touching or operating the switch operator or any other part of the installation). These warning signs include such things as smoke, fire, open fuses, crackling noises, loud buzzing, etc. If a malfunction is suspected, treat all components of the installation, including the switch operator and associated mounting hardware, as though they were elevated to primary (high) voltage.

Whenever manually reconfiguring the circuit (for example, during repairs), follow your company's operating procedures to disable automatic operation of the IntelliTeam SG system. This prevents any unexpected operation of a team member.

The IntelliTeam SG Automatic Restoration System can be disabled by selecting the **Prohibit Restoration** state in any team member of the team being disabled.

Switch Operator Components

This section describes various switch operator components. The "Operational Overview" section on page 19 explains how these components work together to monitor the distribution feeder and manage switch operation. The switch operator electronics modules are shown in Figure 1.

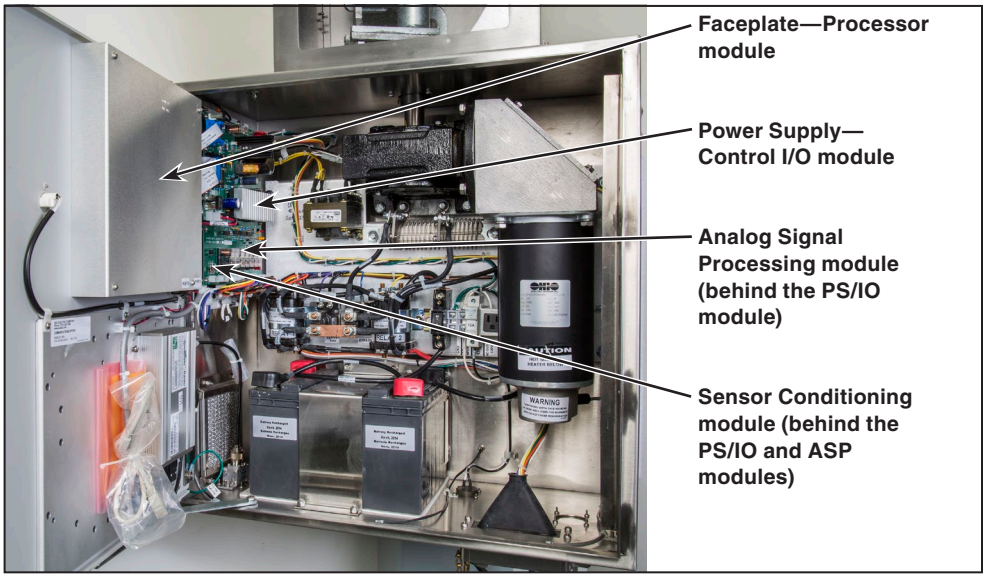

Figure 1. Location of switch operator modules.

Faceplate Processor Module

This printed circuit board is attached to the back of the faceplate. It includes all the electronics for the faceplate touch switches and the switch operator microprocessor.

Power Supply and Control I/O Module (PS/IO)

This is the source of all low-voltage power used by the switch operator and communication equipment. It is also the digital interface. The PS/IO module performs all data acquisition, control, and basic communication interface functions.

Analog Signal Processing Module

This module digitizes analog signals and is located behind the power supply and control I/O module.

Sensor Conditioning Module

This module processes sensor-data waveforms and is located behind the Analog Signal Processing module.

Faceplate

The 6801M Operator faceplate (Figure 2 on page 8) includes an alphanumeric display, LEDs, and switches that allow monitoring and control of the line switches and switch operator. To conserve battery power, the switch operator turns off power to the faceplate LEDs and LCD screen when the enclosure door or low-voltage cabinet door is closed. The manual operation handle is stored on the faceplate, and its storage is indicated electronically.

Figure 2. The 6801M Switch Operator faceplate.

Faceplate LEDs

The faceplate includes the following LEDs:

Overcurrent Fault Indicator

This LED is on when the switch operator detects an overcurrent condition on any phase. Depending on the configured reset method, the LED is off when the overcurrent condition ends and:

- The switch is closed and 45 minutes have elapsed (default)
- The switch is closed and the configured **Fault Indicator Reset** timer expires
- The switch is closed and voltage returns
- The switch is manually reset via SCADA, IntelliLink software, or a **User Assigned** button

Note: If reinitializing the switch operator using IntelliLink software, the LED turns off regardless of whether the conditions above are met.

Remote Communication RCV/XMT Indicator

These LEDs blink when the switch operator sends or receives signals through remote communication equipment installed in the operator enclosure. There are separate indicators for Port A and Port B. The RCV indicator blinks when the switch operator detects an incoming character. The XMT indicator blinks when the switch operator sends one or more characters.

Activity on these LEDs will be seen only if remote communications equipment is installed, properly connected, and receiving power. The XMT LED blinks any time a transmission is attempted, regardless of whether the communications equipment is properly installed.

Error Detected Indicator

This LED is on when the switch operator detects any of the following conditions:

- **Battery charger overvoltage—**When the charger attempts to overcharge the battery, the switch operator turns the charger off.
- **Open/close contacts are not mutually exclusive—**The switch position contacts are either both open or both closed.
- **Temperature sensor failure—**The temperature sensor (on the PS/IO board) reads abnormally high or low, which is generally caused by an open or shorted circuit.

Processor Status Indicator

This LED blinks once per second when the switch operator has power and control software is running normally.

Battery Low Indicator

This LED is off when the battery system is working normally and the battery is charged.

The LED is on when battery power is low. It is normal for this LED to be on when the switch operator is operating on battery power and the battery is nearly exhausted. The battery may be defective when this LED is on and ac power is also on (the battery normally would have an adequate charge).

This LED blinks during any battery test. The switch operator automatically runs the battery test at scheduled intervals. A SCADA command or the faceplate BATTERY TEST button can start a battery test at any time.

Be sure to initiate a battery test immediately when replacing a defective battery to update the battery status.

Closed Indicator

This red LED is on when the line switch is closed. The LED indicates the sensed position of the line switch based on the state of the closed-status input from the switch. It blinks when the **Shots-to-Lockout** mode is enabled. Each CLOSED LED provides information about one line switch.

Trip Indicator

This yellow LED is on when the switch operator trips open the line switch using automatic logic (sectionalizing, phase loss protection, etc.). It is off when the switch is closed. Each TRIP LED provides information about one line switch.

If the switch tripped because of phase-loss protection and the **Phase Loss Protection with Automatic Reclose** mode is enabled, the LED blinks while waiting to reclose the switch.

The LED goes off when you cycle the SCADA CONTROL switch. If the switch operator is reinitialized using IntelliLink software, the LED turns off regardless of whether the switch is closed.

Open Indicator

This green LED is on when the line switch is open. The LED indicates the sensed position of the line switch based on the state of the open status input from the switch. Each OPEN LED provides information about one line switch.

Local Indicator

This LED is on when remote (SCADA) operation of the switch operator is in the **Disabled** state and only local operation is allowed. The LED is off when local operation is in the **Blocked** state and remote operation is in the **Enabled** state.

Automatic Operation Enabled Indicator

This LED is on when automatic operation of the switch operator is in the **Enabled** state.

⚠ WARNING

When automatic operation is in the **Enabled** state, the automatic-control logic may trip the switch regardless of the state of the SCADA CONTROL switch. Unexpected automatic operation could cause serious injury.

Automatic Operation Disabled Indicator

This LED is on when automatic operation of the switch operator is in the **Disabled** state.

Faceplate Switches

Data Scroll Keys

Use these switches to scroll and enter LCD data.

Battery Test Switch

This switch starts a battery test. The test lasts approximately 30 seconds if the operator is operating on battery power or three minutes if the operator is operating on ac power. The BATTERY LOW LED blinks during the test.

Lamp Test Switch

This switch tests the faceplate LEDs and all the LEDs should blink.

Close/Open Switch(es)

Press the CLOSE button to transmit a close pulse to the line switch. Press the OPEN button to transmit an open pulse to the line switch. Each CLOSE/OPEN switch operates one line switch.

If the SCADA CONTROL switch is in the **Remote** state, pressing a CLOSE or OPEN switch has no effect.

SCADA CONTROL Switch

This switch to toggles the SCADA CONTROL mode to the **Remote/Local** state.

Press the CHANGE button to set the **SCADA Control** mode to the **Local** state. This disables remote SCADA operation of the line switch(es) and enables commands from the faceplate CLOSE/OPEN switch(es) and the AUTOMATIC OPERATION ENABLE/DISABLE switch. The LOCAL LED is on when the **SCADA Control** mode is set to the **Local** state.

To disable local automatic operation and take full control of the switch(es), press the CHANGE button to set the **Automatic Operation** mode to the **Disabled** state. When automatic operation is set to the **Disabled** state on the *Setup>General>Automatic Operation* screen (for both switches, if applicable), the AUTOMATIC OPERATION switch will have no effect.

Automatic Operation Switch

Press the CHANGE button to toggle the **Automatic Operation** mode to the **Enabled** state. Press the CHANGE button to toggle the **Automatic Operation** mode to the **Disabled** state. This switch affects automatic operation of both line switches, if applicable.

If the **IntelliTeam SG Restoration** mode is in the **Disabled** state on the *IntelliTeam SG>Team Summary* screen (for both switches, if applicable), the AUTOMATIC OPERATION switch will have no effect.

NOTICE

Setting one team switch to the **Disabled** state will cause the teams associated with that switch to go into the **Not Ready** or **Stop Transfer** mode. Other teams on the same circuit will remain in the **Ready** state.

Automatic Restoration Switch

Press the CHANGE button to toggle the **Automatic Restoration** mode to the **Enabled** state. Press the CHANGE button to toggle the **Automatic Restoration** mode to the **Disabled** state. This switch affects automatic operation of both line switches, if applicable.

When the **IntelliTeam SG Restoration** mode is in the **Disabled** state on the *IntelliTeam SG>Team Summary* screen (for both switches, if applicable), the AUTOMATIC RESTORATION switch will have no effect.

NOTICE

Setting one team switch to the **Disabled** state will cause the teams associated with that switch to go into the **Not Ready** or **Stop Transfer** mode. Other teams on the same circuit will remain in the **Ready** state.

User Select 1 and 2 Switches

Press the CHANGE button to toggle the USER SELECT 1 or USER SELECT 2 buttons to enable or block the configured **Command Function** mode. The command functions are configured on the *Setup>General>User Commands* screen.

Faceplate LCD Screen

The LCD alphanumeric screen allows users to quickly access key information while at the switch-operator site. The displays provides specific information:

Team Status Info

This displays the team ID and **Ready**, **Fault**, or **Alarm** status for each team where this operator is a member. The **Ready** state indicates the team is ready to take action (even if a transfer event has already taken place) and there are no errors, faults, battery problems, or team-communication problems present. The **Fault** state indicates this team is isolating a faulted line segment. This information is also displayed on the *IntelliTeam SG>Team Summary* screen.

Real-time Data

This displays the total operation count, the present phase and ground current levels, line voltage, reverse current conditions, phase angles, and total kvar flow for both feeders, if applicable. This information is also displayed on the *Metering* screen.

Auto Operation (Switch 1 and Switch 2, if applicable)

This displays the automatic operation features that are enabled and the present automatic operation status. These values are also displayed on the *Setup>General>Automatic Operation* screen.

Fault Events

This displays the date, time, event, switch-operator interpretation, and action for the most recent protection-related fault event. This message may appear as coded versions of the messages displayed on the *Diagnostics>Fault Info* screen. See S&C Instruction Sheet 1045M-550, "6801M Automatic Switch Operators: *Diagnostics*," for an explanation of the codes.

Fault Magnitudes

This displays the date, time, phase, peak magnitude, and duration for the most recent overcurrent fault event. This information is also displayed on the *Diagnostics>Fault Info* screen.

Maintenance

This displays the software version installed in the switch operator, assorted battery status information, and the present cabinet temperature. The software version is also displayed on the *Setup>General>Revisions* screen.

Fault Settings

This displays the present fault-detection status for Switch 1 and Switch 2, if applicable. These values are also displayed on the *Setup>General>Fault Detection* screen.

The 2 x 40 character LCD screen can only display one field from a large data page. See Table 1 on page 13. Use the PREV and NEXT buttons to scroll each field into view.

User Commands

Four user commands can be assigned to the two USER SELECT buttons on the front panel. See S&C Instruction Sheet 1045M-530, "6801M Automatic Switch Operators: *Setup*" for configuration information. Each available command can be operated from the LCD screen. The user commands are the last data page in the LCD screen. See Table 1. The user-command data page shows which commands are assigned to the **User Select** buttons and shows how each command can be executed. Use the "+" and "-" keys to navigate the user-command data page to the desired command and press the **Enter** button to execute that command.

Table 1. LCD Data Page for 6801M with IntelliTeam SG System Functionality

	CATEGORY							
Fields	**1. Team Information**	**2. Real-Time Data**	**3. Auto Operation**	**4. Fault Events**	**5. Fault Magni-tude**	**6. Main-tenance**	**7. Fault Settings**	**8. User Commands**
	Team Status Summary—Ready, Alarm, Faulted, Team Not Configured (indicated for each team by number) Team Switch Errors Prohibit Restoration Status Team Information (by Team Number) Team Name Team Load (Amps x 1.0) Team Capacity (Amps x 1.0)	Operations Counter Line Current (Amps) Ground Current (Amps) Line Voltage (Volts) Phase Angle (Degrees) Reverse Current (Active or None) Line kVARs	Automatic Operation Features Enabled IntelliTeam SG Prohibit Restoration State	Most Recent	Most Recent	Software Version AC Power/ Battery Status Battery Low/ Bad Setpoints Battery Voltage w/o Surface Charge Predicted Voltage Under Load Power Supply Voltage/ Battery Impedance Cabinet Temperature Maintenance Required Electronics Problem Hot Line Tag (Scada-Mate Only)	Phase Fault Detected Current Level (Amps) Ground Fault Detected Current Level (Amps)	User Select 1: Assignment◆ User Select 2: Assignment◆ Press ENTER to run command: Manual Operation Press ENTER to run command: Clear Faults Press ENTER to run command: Hot Line Tag Press ENTER to run command: Shots to Lockout Press ENTER to run command: Clear Electronics Bad

◆ Assignments are made on the *Setup>General>User Command* screen. See S&C Instruction Sheet 1045M-530, "6801M Automatic Switch Operators: *Setup*," for more information.

Power Management System

Power Supply/Control I/O module

The Power Supply/Control I/O (PS/IO) module is a highly efficient computer-controlled, uninterrupted power-supply system specifically designed to meet the specialized power requirements of automated electric power distribution equipment.

The PS/IO module provides steady-state current flow for switch-operator operation, pulsed current flow for communication equipment, and occasional large current surges for line-switch operation. It also provides battery charging (12, 24, or 36 Vdc) and other dc voltages from a single 24- or 36-Vdc source. This design provides superior battery life and capacity compared to systems that "center tap" a 24- or 36-Vdc system to supply their 2-Vdc requirements or that use multiple, non-interchangeable batteries.

The PS/IO module supplies accurate, temperature-compensated charging voltages with current-limiting and other safety mechanisms to maximize battery capacity and to minimize the possibility of battery off-gassing or explosion. This system meets or exceeds ANSI surge-withstand and dielectric specifications, including ANSI C62.41-1992 6KV3KA surge and C37.90a 2.5kV 125 MHz ring wave and 5 kV fast transient waveform specifications.

The power-management system uses the PS/IO module and a Hawker/Gates 24-Vdc or 36-Vdc battery. When ac power is available, the PS/IO converts ac to dc and uses the dc power to run the switch operator, charge the battery, and operate the communication equipment. The battery supplies only the current needed to operate the switch. When the sensor power option is installed and external ac power is not available, the PS/IO uses power from the sensors. The PS/IO draws on the stored battery power for all switch-operator operations when external ac power and sensor power are not available.

The power-management system can be monitored and controlled from the switch operator faceplate with IntelliLink software or from a SCADA master station.

Power Supply/Control I/O module LEDs

LEDs on the PS/IO circuit board provide information about the state of battery and ac power.

AC ON

This LED is on when the switch operator has a power source, either external ac or sensor power. It is located at the middle on the left side of the board.

The ac line fuse is not intended for field replacement. Replacing a blown ac line fuse may result in further damage.

CHG ON

This LED is on when the battery charger is connected to the battery, the AC ON LED is on, and the battery charger and battery are within the proper voltage range: 20.0-30.5 Volts for 24 Vdc batteries and 30.0-45.75 Volts for 36-Vdc batteries. This LED is located at the middle on the left side of the board.

BAT ON Button

The BATTERY ON LED is on when the battery is connected to the 24-Volt or 36-Volt dc power supply bus. It is yellow and located at the bottom on the right side of the board. When the battery is connected and the LED is off, press the BAT ON button to turn on the battery circuit.

ANALOG PWR

This LED is on when power is supplied to the analog processors. It is located at the middle of the board on the top.

Battery Management

The battery-management system ensures the switch operator can operate the line switch with available battery capacity and provides advanced warning of a weak battery condition before the switch cannot be operated. Battery capacity is affected by several variables, including age, temperature, load cycling, and loading.

The switch operator continuously monitors battery voltage. It also tests the battery at regular, scheduled intervals. The interval depends on the power conditions:

- During battery discharge, the test is run hourly.
- After a power outage, the test is run every two hours for 24 hours to monitor the battery status while the battery is being recharged.
- After 24 hours of continuous operation on ac power (or power from the sensors, if applicable), the test is run once a day.

The BATTERY TEST switch or a SCADA command can be used to manually test the battery at any time.

During the battery test, the switch operator applies various loads to the battery to determine how it will perform under load. These tests include:

- **Actual battery voltage—**Determines the true open-circuit battery voltage
- **Battery impedance—**Determines the internal impedance of the battery
- **Calculated voltage under load—**Determines the minimum voltage predicted during switch operation (When the switch operator is operating on battery power, the operator continuously evaluates the **Calculated Voltage Under Load** value. Otherwise, it evaluates this value only during the battery test cycles.)

Based on monitoring and testing results, the switch operator may take the following actions:

- **Battery Low—**When the battery **Calculated Voltage Under Load** value drops below 22.75 Volts (for a 24-Vdc battery) or 34.125 Volts (for a 36-Vdc battery), the switch operator displays a **Battery Low** message, turns on the faceplate BATTERY LOW LED, and sets the **Battery System Low** DNP Status point. At voltages below this value, switch operation is still possible, but only for a limited time.
- **Battery Bad—**When the battery **Calculated Voltage Under Load** value drops below 22.25 Volts (for a 24-Vdc battery) or 33.375 Volts (for a 36-Vdc battery), the switch operator sets the **Battery Bad** DNP Status point and displays a **Battery Bad** message on certain IntelliLink software screens. The switch will not reliably operate at voltages below this value.
- **Battery Is Disconnected on Battery Power—**When the battery steady-state voltage drops below 22.0 Volts (for a 24-Vdc battery) or 33.0 Volts (for a 36-Vdc battery) while the switch operator is operating on battery power, the switch operator automatically disconnects all load to prevent deep discharge. Power is restored when ac power (or sensor power, if applicable) is restored or the battery is replaced.

- **Battery Is Disconnected on AC Power—**When the battery voltage falls outside the proper range 22.25-30.5 Volts (for a 24-Vdc battery) or 33.375-45.75 Volts (for a 36-Vdc battery) while the switch operator is operating on ac power (or sensor power, if applicable), the switch operator disconnects the battery from the system, turns off the BAT ON LED (on the Power Supply/Control I/O board), and sets the **Battery Bad** DNP Status point.

Because the battery supplies wetting voltage on some switch-status contacts, disconnecting the battery may also generate alarms.

Based on field experience, a weak battery may fail the battery test in very cold temperatures but pass at a warmer temperature. When a **Battery Low** or **Battery Bad** alarm occurs, battery replacement should be scheduled. In warmer climates or seasons, the battery may function a week or two longer when a battery test indicates a **Battery Low** condition.

Battery Care and Maintenance

Typical battery life for 6801M Automatic Switch Operators is five to seven years. The battery should be replaced when its present capacity has reduced to 80% of the capacity when new. Increased temperature accelerates battery aging so installations in warmer climates will have shorter battery life.

6801M Automatic Switch Operators automatically test and record battery capacity, and battery replacement is the only routine maintenance they require. For noncommunicating operators, early site inspection of the BATTERY LOW LED and the physical condition of the battery is recommended. More frequent inspection should be scheduled for older batteries. The battery should be replaced every five years. Communicating operators report the **Battery Low** state to SCADA when capacity is near 80% and the battery will still power the switch operator.

The following procedures can improve battery life:

- **Store batteries at room temperature—**Store all batteries at or below room temperature. When in service, the battery will probably be exposed to higher temperatures, which will shorten its lifespan.
- **Keep stored batteries charged—**When storing batteries longer than 6 months, it is critical to recharge them periodically. When recharging every month, storage can be extended for years without significant damage.
- **Rotate the battery inventory—**Store the smallest possible battery inventory, and put the oldest batteries into service first.
- **Use batteries known to be good—**Do not install a used battery in battery-backed equipment unless it has been properly tested. The cost of a battery-replacement service call is usually higher than the cost of a new battery. Although a battery may be good enough to provide temporary standby power, a line switch has a brief but substantial power requirement that may exceed the weak battery's ability to deliver current rapidly.
- **Avoid installing the enclosure in a sunny location—**If at all possible, install the switch-operator enclosure in a shady area. Because battery life is decreased by a hot environment, try to minimize peak operating temperatures.

Control Software

Control firmware is factory installed and manages switch operator operation. It continually monitors:

- Feeder voltage and current
- SCADA commands
- Faceplate switch commands
- Battery condition
- Temperature inside the operator enclosure
- Internal clock and calendar
- Software setpoint values
- Fault and voltage loss information stored in the operator
- Other setpoints and data values as needed

Based on this information, the operator software decides how to respond to a possible overcurrent fault, a change in voltage, a command from the faceplate or SCADA master station, and other conditions.

The operator software, setpoint values, and historical data are stored in non-volatile flash memory that can survive power interruptions, including complete failure of the switch operator battery system.

IntelliLink® Setup Software

The IntelliLink Setup Software is downloaded from the S&C Automation Customer Support Portal and runs on personal computers (PCs). This software allows users to communicate with the operator while at the switch-operator site. IntelliLink software can:

- Configure installation-dependent operating parameters (setpoints), such as the network address, automatic-operation features, etc.
- Monitor real-time data, such as the present line voltage and current
- Examine the performance and operating history of an installed switch operator
- Transfer all configuration, operating, and historical data from the switch operator to a report file on the computer
- Download new control software into the switch operator
- Troubleshoot switch-operator installation problems

SCADA Communications Equipment

The S&C IntelliTeam SG Automatic Restoration System uses the DNP 3.0 protocol for team communication. When the SCADA system uses DNP users can remotely monitor, control, and change setpoints for all IntelliTeam SG controls. The DNP points are configurable to match the existing SCADA configuration.

The communication hardware (radio, modem, etc.) is mounted inside the switch operator enclosure on the Universal Communication Mounting Plate on the back of the faceplate. This provides better reliability for the entire installation.

See S&C Instruction Sheet 1045M-560, "6801M Automatic Switch Operator: *DNP Points List and Implementation*," and the communication equipment documentation for more information. If you have any questions, contact S&C.

IntelliLink Setup Software Remote Functionality

IntelliLink software can remotely access S&C automation products that communicate using the DNP 3.0 protocol from any computer connected to your DNP network. Users can configure controls, access historical and real-time data, and troubleshoot equipment as though they were connected directly to the faceplate of the control being communicated with. To activate the remote functionality, purchase a software license from S&C. A temporary license is available for evaluation. See S&C Instruction Sheet 1045M-530, "6801M Automatic Switch Operators: *Setup*," for computer requirements.

Operational Overview

This section explains how the switch-operator components work together to detect and respond to overcurrent faults and voltage outages.

Signal Processing

The switch operator has separate electronic paths to accommodate the different requirements of peak and normal operating-current measurements. For normal operating-current measurements, full scale is 800 amps RMS. For peak measurements, full scale varies with the switch type. For S&C switches, the value is approximately 4000 amps RMS and depends on the switch model.

Peak detection emphasizes speed, with several samplings taken for each sinusoidal peak and instantaneous analysis of the incoming data. Measurement of normal operating current is slower and produces better accuracy.

The switch operator reports current, voltage, and phase-related data in units of amperes, volts, and kvars respectively. The rated accuracy of these measurements is based on the combined accuracy of all operator components (excluding the sensor and sensor cable and including all sensor conditioning components). The switch operator uses the switch sensor calibration data and the phase-angle offset values to correct all ac waveform data sampled from the switch sensors.

Users can field configure wye or delta distribution line applications by using the jumpers supplied with the switch operator. Based on the selected configuration and setpoint values, the operator normalizes voltage to nominal 120- or 240-Vac values.

RMS Ac Waveform Analysis

The switch operator uses RMS detectors with 1/100 60-Hz harmonic accuracy to produce true RMS amplitude data for current, neutral current, and voltage waveforms. This is particularly important when measuring neutral current because the effects of harmonic distortion of any single phase are multiplied in the summing of phases.

Because the circuitry has some response latency, voltage and current changes that occur within a few tenths of a second are sensed as a single, steady value.

For real-time, steady-state monitoring and data logging, the switch operator collects data at 0.2-second intervals. It then averages eight samples and reports the 1.6 second-averaged value. This results in a net response time of 1.6 seconds.

The switch operator uses these 1.6 second-averaged values for the real-time display, reporting via SCADA communication, and data logging. Daily high and low values are stored for today and the preceding seven days.

Waveform Analysis for Power System with Delta-Connected Customer Transformers

The switch operator treats power systems with delta-connected customer transformers as a special case.

When the line switch has three voltage sensors and the sensor conditioning module is configured with the delta jumper, the switch operator reproduces the delta-voltage waveform before any transducer functions are performed. This is useful for comparing the measured voltage against that seen by customers served by phase-to-phase connected transformers. For S&C voltage sensors, this configuration is necessary for accurate phase-to-phase voltage measurement because these sensors measure phase-to-neutral voltages, even in a delta-distribution system.

For switches with one voltage transformer for voltage sensing and control power and three CVMI current sensors, the sensor-conditioning module must always be configured with the wye jumper. Voltage sensing and reporting is determined by the way the voltage transformer is connected: phase-to-phase (delta) or phase-to-neutral (wye).

Voltage Sensing for S&C Switches

The 6801M Switch Operator software supports 15-kV, 25-kV, and 34.5-kV S&C switches.

The nominal voltage sensor ratios for the line switch(es) with corresponding maximum voltage levels are shown in Table 2.

Table 2. Maximum Voltage Levels Supported in S&C Switches

Nominal S&C Switch Voltage	S&C Nominal Voltage Sensor Ratio	Maximum Phase-to-Phase Voltage (Delta Jumper)	Maximum Phase-to-Ground Voltage (Wye Jumper)
15 kV	1386:1	20.0 kV	15.0 kV
25 kV	2440:1	27.3 kV	20.4 kV
34.5 kV	3389:1	38.7 kV	29.0 kV

The maximum voltage levels represent the highest voltage measurements supported by the operator software. The maximum voltage levels in Table 2 are based on nominal sensor ratios. Actual maximum voltages may vary slightly, based on the S&C factory sensor calibration data supplied with each switch. See the applicable S&C literature for information on the physical and electrical specifications for each switch. Contact S&C Electric Company when support for higher voltage levels is required.

The third column in Table 2 shows the maximum voltage levels supported for installations configured for phase-to-phase delta voltage reporting. These installations require the delta jumper in the sensor conditioning module.

The fourth column in Table 2 shows the maximum voltage levels supported for installations configured for phase-to-ground wye voltage reporting. These installations require the wye jumper in the sensor conditioning module.

Accurate voltage reporting requires that the actual sensor ratios supplied by S&C Electric Company be entered for each sensor when the switch operator is configured. The correct voltage-reporting method (phase-to-phase or phase-to-neutral) must be selected, consistent with customer transformers on the feeder and their associated step-down ratios.

Phase Angle Measurements

Phase angles between the voltage and current waveforms on each phase are measured by the precise proprietary S&C Electric Company zero-crossing detection scheme that is not influenced by the multiple zero-crossings of noisy or harmonic-contaminated signals.

The switch operator samples the phase angle every 0.2 seconds. It then averages eight samples and reports the 1.6 second-averaged value. The phase-angle range is 0 to 360 degrees.

When configuring the switch operator, phase-angle offset values are entered to compensate for both sensor-dependent and installation-dependent phase-angle characteristics.

Overcurrent Fault & Voltage Loss Detection

Overcurrent faults are measured with peak-current detection hardware for phase faults and separate true-RMS amplitude-detection hardware for the harmonic-sensitive neutral current faults.

To determine whether an overcurrent fault exists, the switch operator compares the sensed current to setpoint values that define the fault current level and fault duration. The **Current Level** setpoint value can be specified in 10-amp RMS increments for phase faults and 1-amp RMS increments for ground faults.

The **Fault Duration Time Threshold** setpoint can be specified in 6.25-millisecond (approximately ⅓ cycle) increments for phase faults and 50-millisecond increments for ground faults. This scheme allows the software to measure fault currents with a scaling appropriate to the higher amplitude signals encountered with faults and to detect the peaks of the arrow spikes caused by CT saturation that trick many other digital sampling schemes.

Phase-Overcurrent Detection

Phase-overcurrent conditions are sensed using a combination of analog and digital techniques. The switch operator fault-detection resolution is ⅓ cycle for peak values of approximately 4000 amps RMS. Overcurrent measurements are accurate to 0.5% of full scale, excluding sensor-calibration accuracy. Contact S&C Electric Company for scaling requirements above 4000 amps.

The 6802/6803 Switch Operator monitors each feeder independently and responds to changes on that feeder regardless of the condition of the other pad-mounted switch and feeder.

To detect a phase-overcurrent fault:

- The switch operator monitors the current on all three phases and compares it to the **Phase Fault Detection Current Level** setpoint.
- When at least one peak overcurrent sample is above that setpoint for 18.75 milliseconds (slightly longer than one cycle), the switch operator registers an overcurrent condition and a pending fault on that phase and starts the **Phase Fault Duration Time Threshold** timer.
- If the overcurrent condition persists for the duration of that timer, the switch operator reports a phase overcurrent fault and responds accordingly.
- If overcurrent is not detected during any 18.75-millisecond window, the switch operator considers the overcurrent condition to be no longer present and resets the **Phase Fault Duration Time Threshold** timer.
- When a reported phase-overcurrent fault ends after the timer has expired, the maximum RMS current measured during the fault and the fault duration are recorded. Any fault longer than 6.82 minutes is reported as 6.82 minutes.

Ground Overcurrent Detection

The switch-operator hardware measures ground current as the analog-vector sum of the three individually sensed phase currents. A very accurate harmonic-independent true RMS detecting circuit integrates the analog-vector sum over several cycles. The multi-cycle integration produces a slight response-time delay that is inversely proportional to the magnitude of the change in ground current. The circuit responds faster to larger-magnitude ground-current changes, resulting in time-current characteristics very similar to a protective relay.

The operator software samples the true RMS detection hardware on 50-millisecond intervals and compares the sample to the **Ground Fault Detection Current Level** setpoint. When the setpoint is exceeded and this current persists for the duration of the **Ground Fault Duration Time Threshold** setting, an overcurrent-fault condition is reported and appropriate action taken.

Because reporting an overcurrent-fault condition is affected by the relationship between the minimum fault current-detection level and RMS detector rise and fall times, a family of time-current characteristic curves is generated. Each of these curves corresponds to a single setting of the **Ground Fault Detection Current Level** setpoint. The points on each curve represent the minimum amount of time that the ground current must be present to register a fault. For example, when the **Ground Fault Detection Current Level** setpoint is set to 150 amps, a 500-amp ground current must be present for approximately 42 milliseconds before the switch operator will register a fault.

The minimum registration time for this example is less than the 50-millisecond software sampling interval. Therefore, short-duration high-magnitude ground-overcurrent faults can be detected using low-magnitude overcurrent thresholds.

Voltage Loss Detection

The switch operator checks the voltage on all three phases at 50-millisecond intervals. Any voltage drop below the **Loss of Voltage Threshold** setpoint is considered a loss of voltage.

Inrush Restraint

The **Inrush Restraint** feature prevents phase or ground overcurrent conditions from the hot or cold load pickup that can occur during outage restoration from falsely indicating as a fault. It is also applied when the switch is closed from the faceplate or via SCADA command when the line is energized. The **Current Inrush Restraint Multiplier** setting enables the switch operator to differentiate between the moderate overcurrents caused by cold load pickup and large overcurrents caused by a fault condition during the **Inrush Restraint** timer duration.

Inrush restraint is applied in this manner:

- During the power outage, the switch operator continuously monitors the switch status, RMS voltage sensors, and phase overcurrent detectors for any indication that the voltage has returned.
- When voltage rises above the **Loss of Voltage Threshold** setpoint on any phase or overcurrent is detected on any phase, the switch operator checks its switch position.

- When the switch is closed, the switch operator starts the **Phase Current Inrush Restraint** timer and the **Ground Current Inrush Restraint** timer.
- When both of the **Current Inrush Restraint Multiplier** values are set to **Time Block** mode, the switch operator ignores all overcurrent conditions until the **Inrush Restraint** timer expires.
- When one or both **Current Inrush Restraint Multiplier** values are set to a value other than the **Time Block** value, the switch operator considers any overcurrent condition that exceeds the specified multiplier value to be a fault.
- After the **Inrush Restraint** timers expire, the switch operator will respond to overcurrent conditions with the normally programmed routine.
- When the **Inrush Restraint** time values are set to "0," no inrush restraint occurs.

Switch Operator Response to Overcurrent and Voltage Loss Events

The switch-operator response to an overcurrent condition or voltage loss depends on the settings in effect when the event occurs. For example, the values selected for the **Fault Detection Current Level** and **Fault Duration Time Threshold** setpoints determine whether the switch operator recognizes an overcurrent event as a fault. The automatic operation features enabled and the selection of the faceplate AUTOMATIC OPERATION ENABLED/PROHIBITED switch determine how the switch operator will operate when a recognized fault occurs.

Ground Overcurrent Detection

The switch operator records each recognized event, the assumed cause of the event, and any action taken. All recognized events are recorded, regardless of the setting of the AUTOMATIC OPERATION ENABLED/DISABLED switch or the SCADA CONTROL REMOTE/LOCAL switch.

The switch operator maintains a chronological log of historic event data. Information is recorded so the newest entry always overwrites the oldest. Events are logged with millisecond time-stamping and 6.25-millisecond resolution.

On the *Diagnostics>Fault Info* screen, the latest fault event (for example, an overcurrent condition followed by voltage loss) and a fault-related action taken by the switch operator (for example, the line switch opened because of a phase imbalance condition) are listed. This information is also displayed on the faceplate LCD screen.

The **Last Fault Magnitude** display shows magnitude and duration information for the latest fault. The recorded magnitude is the maximum RMS current amplitude encountered during the fault. The duration is recorded in units of milliseconds, with 6.25-millisecond resolution and a maximum recordable fault duration of 409 seconds (6 minutes, 9 seconds). This information is also displayed on the faceplate LCD screen.

Because of the delayed rise and fall times of the hardware, the logged time for detection of ground-overcurrent faults may be delayed relative to the logged time for the phase-overcurrent faults caused by the same event. Also, the accuracy of recorded duration times for ground-overcurrent faults is affected by the 50-millisecond sampling interval and hardware rise and fall times. Peak magnitude data of ground overcurrent are also affected by the amount of time the event is present. Accurate magnitude recording requires the condition to persist for at least 400 milliseconds.

Switch Operator Automatic Operations

A 6801M Switch Operator can perform several automatic operations: sectionalizing, phase imbalance protection, phase imbalance protection with automatic reclose, and the one- or two-shot-lockout of a faulted circuit.

The appropriate value for the **Loss of Voltage Threshold** setpoint must be entered for the automatic operation features to work correctly. See the "Site-Related Configuration" section in S&C Instruction Sheet 1045M-530, "6801M Automatic Switch Operator: *Setup*" for configuration details.

Line Sectionalizing

The switch operator can sectionalize a distribution circuit based on the detected fault current and voltage fluctuations associated with source-side recloser operation.

The 6801M Switch Operator monitors each feeder (or branch) independently and responds to changes on that feeder regardless of the condition of the other pad-mounted switch and feeder.

When sectionalizing is enabled, the switch operator uses the following logic to determine when to trip open the switch:

- The switch operator continuously monitors all sensed voltage phases and compares the voltage to the **Loss of Voltage Threshold** setpoint value.
- When the voltage drops below the setpoint value on all sensed phases, the switch operator starts the **Sectionalizer Reset and Extended Voltage Loss Time** timer. In addition, the operator sets the internal counter for recloser operations to "1."
- When a phase or ground overcurrent fault was present within 0.6 seconds before the detected loss of voltage, the operator assumes the voltage loss was caused by a source-side breaker or recloser opening in response to a load-side overcurrent fault.
- When an overcurrent fault was not detected before the loss of voltage, the operator assumes the voltage loss was caused by a source-side breaker or recloser opening in response to a source-side overcurrent fault.
- The switch operator continues to monitor the voltage levels. The operator adds one count to the recloser operation counter for each time the source-side recloser/breaker opens.
- When the **Successful Reclose Reset Time** value is greater than zero, then the reset on successful reclose logic is also active. The **Sectionalizing** mode is canceled and the **Sectionalizing Counts** value and **Memory** timer are reset when voltage increases above the **Loss of Voltage** threshold on all sensed phases and current is below the fault detection threshold without interruption for longer than the **Successful Reclose Reset Time** value.

- When the **Sectionalizer Reset and Extended Voltage Loss Time** timer expires before the counter reaches the appropriate **Recloser Counts to Trip** value, the switch operator resets the counter to zero. Later voltage losses will be considered part of a new reclose sequence. However, if three-phase voltage is not present when the timer expires, an extended voltage-loss condition exists and the switch operator opens the switch. This only applies when the team is in the **Ready** state.

When the counter reaches the setpoint value before the timer expires and the problem was a load-side fault, the operator trips open the switch.

When the counter reaches the setpoint value before the timer expires, the team is ready, and the problem was a source-side fault, the operator trips open the switch.

When the **Fault Current Required Before First/All Voltage Loss(es)** setpoint is set to the **All** mode, the switch will not trip open unless all voltage losses were preceded by fault current. However, it may still operate based on the **Recloser Counts to Trip, Voltage Loss Only** setpoint.

When the counter reaches the setpoint value before the timer expires and the problem was a source-side fault, the operator records the events but does not trip open the switch.

To Enable Sectionalizing:

In the **Features Enabled** field on the *Setup>General>Automatic Operation* screen, select a combination that includes sectionalizing.

When needed, at the *Setup>General>Automatic Operation* screen, configure the **Successful Reclose Reset Time** setpoint to coordinate with the reclosers.

Use either the faceplate AUTOMATIC OPERATION ENABLE/DISABLE switch or a SCADA command to enable the **Automatic Operation** mode.

Phase Loss Protection:

When the **Phase Loss Protection** feature is enabled, the switch operator trips open the switch in response to a persistent phase imbalance condition to prevent phase-loss damage to customer equipment.

When the **Phase Loss Protection** mode is enabled, the switch operator uses this logic to determine when to trip open the switch:

- When the switch operator detects a loss of voltage on one or two phases, it starts the **Phase Loss Protection Time Threshold** timer.
- When the voltage loss persists and true RMS current remains below the **Phase Loss Protection Current Threshold** setpoint until the timer expires, the switch operator trips open the switch.
- When voltage returns before the timer expires, the switch operator resets the timer.
- When voltage returns on one phase before the timer expires and is then lost on another phase, the switch operator restarts the timer.

Follow these steps to enable phase-loss protection:

STEP 1. In the **Features Enabled** field on the *Setup>General>Automatic Operation* screen, select a combination that includes the **Phase Loss Protection** feature.

STEP 2. On the *Setup>General>Automatic Operation* screen, configure the **Phase Loss Protection Time Threshold** setting and the **Phase Loss Protection Current Threshold** setting. Users can also enter the **Phase Loss Protection Voltage Threshold** setting; otherwise, the switch operator uses the **Loss of Voltage Threshold** value on the *Setup>General>Site Related* screen.

NOTICE

Be sure to select a conservative value for the **Phase Loss Protection Current Threshold** setting that is clearly below the loadbreak rating for the line switch.

STEP 3. Select either the faceplate AUTOMATIC OPERATION ENABLED/DISABLED switch or a SCADA command to enable the **Automatic Operation** mode.

Shots to Lockout

The **Shots-to-Lockout** feature allows testing a potentially faulted line by reducing the **Counts to Trip** setting to either one or two counts for a specified time period. When the circuit is then de-energized by a source-side protective device (recloser, breaker, etc.) and the switch operator sees the transition from voltage present to loss of voltage, the switch operator opens the switch immediately. This allows the faulted line segment to be isolated and prevents the source-side device from reclosing into a fault multiple times.

When the source-side device opens and recloses very quickly, sensors on the load side of the switch may not have enough time to sense both the voltage increase (when the switch closes) and the voltage loss (when the source-side device opens) before the source-side device recloses. Under these conditions, the switch operator cannot complete the **Shots-to-Lockout** operation, except during a transfer event. For best results, always install the switch oriented so that the sensors are on the source side.

During a transfer event, the IntelliTeam SG system uses the **Shots-to-Lockout** feature every time it automatically closes a switch to restore load. However, because of the location of the voltage sensors, it may not know whether voltage had been restored up to the switch. For this reason, when the IntelliTeam system does not see a transition from voltage present to loss of voltage, it still trips open the switch following the **Shots-to-Lockout Time Threshold** value when no voltage is present. Be sure to coordinate this timing with the breaker at the source.

NOTICE

It is very important that the **Shots-to-Lockout Time Threshold** value and source-breaker operation are coordinated. Operation of the breaker at the same time the switch opens could result in switch damage.

When the line switch is closed, users can enable the **Shots-to-Lockout** mode by enabling the assigned **User Select** command. This feature is useful for providing the **Shots-to-Lockout** function to a load-side manual switch. The feature is enabled indefinitely (latched) until disabled by changing the assigned **User Select** command to the **Blocked** state.

When the switch is open and the **Shots-to-Lockout** feature is enabled, the switch is closed into a fault, and the source-side protective device (recloser, circuit breaker, etc.) detects the fault, the source-side device opens and voltage is lost on all phases.

When the switch is closed and the **Shots-to-Lockout** feature is enabled, a load-side manual switch closes into a fault, and the source-side protective device (recloser, circuit breaker, etc.) detects the fault, the source-side device opens, and voltage is lost on all phases.

The switch operator recognizes that the source-side device opened. When the **Number of Shots Required for Lockout** setpoint is set to "1," the switch operator immediately trips open the switch. When the value is "2," the switch operator waits until the source-side device recloses and opens a second time, and the switch operator trips open its switch. When the **Overcurrent Required before Shots-To-Lockout Operation** feature is also enabled, the switch operator only opens the switch when the three-phase voltage loss is preceded by an overcurrent event.

Setting the **Number of Shots Required for Lockout** setpoint to "2" prevents the switch operator from trying to open the switch at the same time the source-side protective device is performing an instantaneous reclose. When the **Overcurrent Required before Shots-To-Lockout Operation** feature is also enabled, the relationship between the detection of overcurrent and voltage losses follows the **Fault Current Required before First/All Voltage Loss(es)** setpoint.

The switch remains open until it is closed with a SCADA command or manually from the switch operator faceplate.

Local Shots to Lockout

The **Shots-to-Lockout** feature can be enabled from the front panel in two ways: through the LCD screen and with a **User Select** button if it is configured to enable the **Shots-to-Lockout** feature.

Remote Shots to Lockout

Users can set the **Shots-to-Lockout** feature with a SCADA command, but the feature cannot be latched with a remote command. The faceplate SCADA CONTROL switch must be in the **Remote** mode and the AUTOMATIC OPERATION switch set to **Enabled** mode for the operator to accept a remote **Shots-to-Lockout** feature command.

Automatic Load Transfer

The IntelliTeam SG system defines a team as two or more switch controls that protect a given line segment by transferring load to an alternate source. The switch control may be a member of one or more teams.

After completing the sectionalizing and/or phase-loss logic, the switch control can reclose the switch to transfer load to an adjacent distribution circuit or to restore service to load on the source side of the fault. The switch control uses information it receives from other team members to do this.

Team members use an independent software agent—the coach—to distribute data and coordinate operation. The coach visits each team member within a prescribed time period, carrying with it an ID number and incrementing visit counter. When the coach arrives at a team member that has already seen that ID and visit counter, the coach assumes it is a duplicate and dies.

The team member generates a new coach when the coach has not visited that team member within a prescribed time period. The new coach will have an ID one number higher than the last visiting coach and a visit counter reset to zero. The new coach determines the state of the team line segment and takes any necessary action. When an arriving coach finds that a new coach with a higher ID has visited, the arriving coach with the lower ID dies.

Any team member that witnesses an event tells all other team members and the coach about the event. The transmission includes a sequence number, the nature of the event, and which team member made the report. All members continually monitor for this report.

When the report requires local team restoration, the coach visits the other normally closed team members to verify they are now open and then follows the alternate source sequence list, visiting team members that could become an alternate source.

When the report requires service restoration for an adjacent team, the coach immediately moves to the team member that is also a member of the team with the outage.

Load averaging stops when an event begins so the load value before the event will be used for reconfiguration negotiations.

Loading Restrictions

As the default, a team decides whether to restore a line segment based only on the available capacity of the feeder. It is updated as the reconfiguration progresses and with any restrictions placed on the line segment because of wire size, switch capacity, or other limiting factor.

This method does not prevent circuit overloading when non-continuous line segments (a bifurcated circuit) assume that loading information is correct and both close simultaneously to restore independent loads.

When a line segment cannot handle any overloading, set the ***Contract Required*** mode (on the *Setup>Restoration>IntelliTeam SG>Team X* screen) to "Yes" for all teams. When team members encounter a line segment in a restoration path that requires a contract, they communicate with all subsequent line segments in the direction of the alternate source to ensure the alternate source will not be overloaded. This slows the reconfiguration process.

The number of line segments a team can pick up is restricted by using the **Line Segment Limit** setpoint on the *Setup>Restoration>IntelliTeam SG>Team X* screen. For example, the **Add 1** setting inhibits any other line segments from being restored through a member after it restores its first line segment. When set to the **N/A** setting, the team can pick up as many line segments as capacity will allow. The line segment limit may be configured in any or all teams, but it is a global value for all members in that team. The limit is continuously propagated outward from the source segment as the coach travels from team member to team member. As the limit propagates outward, limits with a lower configured count take precedence and are then propagated further.

When the coach arrives at the team member for the switch it would like to close, it looks for the coach from the adjacent team. If it's not already there, the first coach calls, and the second coach will move to the shared team member. Both coaches decide whether to close the switch based on available capacity, contracts for resources, and other restrictions. As switches close, the IntelliTeam SG system updates available capacity on the feeders used to restore service. When a transfer with a known load value occurs, it resets the loading data to reflect the new value. This updates information more quickly than the **Two-Minute Load Averaging** feature.

As load is restored, some team members may want to begin the **Return to Normal** process for their team(s). But the **Return to Normal** process is blocked by the Two-Coach Rule. When a coach knows its team is not being fed from its normal source, it will not allow an adjacent team coach to start the **Return to Normal** process.

When a team is in the reconfigured state and the alternate source experiences a new event, the team can look for a new alternate source, if available, to supply its line segment.

A normally open switch in a source/substation location must have the voltage sensors on the substation side. Otherwise, transfer operations will not work correctly. If this is an existing installation with voltage sensors on the wrong side and they cannot be moved, contact S&C Electric Company for more information.

To enable automatic load transfer:

- Set the **Team Logic** setpoint on the *Setup>Restoration>IntelliTeam SG>Team X* screen to **Enabled** mode for each team if applicable.
- Use either the faceplate AUTOMATIC OPERATION ENABLED/DISABLED switch or a SCADA command to enable the **Automatic Operation** mode for the switch operator.

Contracts

A large IntelliTeam SG system may have reconfigurations occurring simultaneously at more than one location. To prevent circuit overloading, the system uses contracts to ensure that it will not pick up more line segments than the circuit can supply. Contracts travel across teams to safely secure resources needed to energize the line segment.

As the IntelliTeam SG system transfers load to an alternate source, a contract is required if the **Line Segment Limit** setpoint has been set or if a **Line Segment Limit** value has been propagated from the source. A contract is generally not required unless the line segment being energized will be directly or indirectly fed from an alternate source. For example, a source/substation switch never requires a contract to close, but a tie switch will always require a contract to close.

Every team member has a contract agent. Unlike the coach, contract agents are static, and only the contract is communicated. The contract agent obtains contracts and maintains outstanding contracts.

A contract is required when:

- During a transfer event the coach of the requesting line segment asks a team member to close an alternate source switch to energize the segment
- A team member contacts the coach of the alternate-source line segment to verify circuit resources
- A team member finds the line-segment limit has not yet been exceeded and it issues a request to the local contract agent (While the contract agent works to obtain a contract, both the requesting coach and the alternate-source coach must remain at this team member (except to satisfy the **Visit** timer). The team member also waits while the contract is being obtained.)
- The contract agent prepares and sends the contract to the agent of the team member presently the source for the alternate-source line segment (The requesting agent waits for the contract to be returned.)
- The receiving contract agent checks the requested resource availability (When there is not enough excess capacity, the agent updates the contract to decline the request and returns the contract to its sender. When sufficient excess capacity is available at this team member, the contract agent adds its ID to the routing list and forwards the contract to the next team member in the direction of the absolute source.)
- The contract reaches the source/substation switch agent and the agent checks for available excess capacity (When the contract request exceeds excess capacity, the agent declines the contract and returns the contract directly to the originating contract agent.)
- Circuit resources are sufficient and the contract agent accepts the contract, lists its ID as the granting contract agent, increments its local count of line segments that have been transferred, and keeps a copy
- Following the contract routing table, the accepted contract returns, through each previous contract agent, back to the originating agent (When the contract is declined it goes directly to the originating contract agent.)
- The contract is declined and the requesting agent reports to its team member that the transfer is not allowed and dissolves the contract (When the contract is accepted, the agent reports that the transfer may continue and the agent saves the contract.)

An accepted contract must be maintained and carry an associated **Maintenance** timer. The requesting contract agent or an intermediate agent can initiate contract maintenance. When the timer expires, the agent sends a maintenance message along the contract route to verify the existence of the contract and reset the **Maintenance** timer.

The requesting contract agent may also dissolve the contract when a manual switching operation energizes the line segment from another source, a local **Return-to-Normal** operation occurs or a second event occurs that causes additional circuit reconfiguration. To dissolve the contract, the requesting agent sends a message down the contract route. Each contract agent then dissolves the contract and decrements the local line-segment count.

Return to Normal

Following the reconfiguration event and subsequent repair and restoration of the faulted line section, team members can return to their normal state. When the **Return-to-Normal** timers expire, the coaches begin the process of returning each team to its normal configuration. The **Return-to-Normal** process begins at the team closest to the normal source and works outward. The closed transition **Return-to-Normal** mode must notify the normal tie switch before it continues.

Each team member may be configured for an open or closed transition. Teams with no tie switches allow their members to follow the needs of the adjacent teams.

A load switch between teams where an open transition is required will remain closed. It relays the **Return-to-Normal** request, becomes de-energized, and returns a go-ahead message before finally being reenergized from the normal source.

The team member at a tie switch will automatically open the switch after a prescribed timeout. This ensures a circuit parallel condition will not be left in place indefinitely.

Follow these steps to enable the **Return to Normal** mode:

STEP 1. Set the **Rtn to Norm Mode** setpoints on the *Setup>Restoration>IntelliTeam SG>Team X* screen to the **Open** or **Closed** state for each team member in each team, if applicable.

STEP 2. Use either the faceplate AUTOMATIC OPERATION ENABLED/DISABLED switch or a SCADA command to enable the **Automatic Operation** mode.

Prohibit Restoration

This feature disables the team **Automatic Restoration** feature (automatic closing of switches) in case of emergency or for circuit anomalies where restoration would be undesirable. The feature is enabled and disabled by SCADA (with DNP Control Point Code #21) and also with the IntelliLink Enable/Prohibit Restoration selection on the *Setup>Restoration> IntelliTeam SG>Team Summary* screen. See Figure 3 on page 32. The **Prohibit Restoration** command affects all teams associated with the switch control receiving the command.

The **Prohibit Restoration** command will not prevent the auto-sectionalizing logic from acting on fault conditions to open the switch. When a team is not ready to transfer (such as when in the **Prohibit Restoration** state), the auto-sectionalizing logic reverts to standard sectionalizing logic. Standard sectionalizing logic does not include sectionalizing on three-phase voltage loss or on an extended three-phase voltage loss. If needing to stop all automatic operation, the **DNP Disable Automatic** command must be sent (with DNP Control Point Codes 13 or 14) to each switch individually.

Indications that a team is in the **Prohibit Restoration** state are:

- The *Setup>Restoration>IntelliTeam SG>Team Summary* screen will indicate ***Alarm*** in the **Ready Status** field.
- The LCD screen will indicate ***Alarm*** instead of the **Ready** state for that team.
- The DNP Status Point Code #47 will be set.

Prohibit Restoration Selection

The **IntelliTeam SG Restoration** feature can be enabled or disabled on the *IntelliTeam SG>Team Summary* screen. See Figure 3.

When the **Prohibit Restoration** mode is active, view the *Logs>Status Point Log* screen to determine whether this was the result of a SCADA command or a **Prohibit Restoration Timer** operation.

The **Prohibit Restoration** mode also may be enabled automatically through use of the **Prohibit Restoration** timer configured on the *Setup>Restoration>IntelliTeam SG>Team X* screen. Enabling this feature automatically with the timer is useful when needing a predetermined time limit for the team to perform restoration. If restoration does not occur within this time limit, all restoration activity will be stopped and the team will remain in an alarm state until the **Prohibit Restoration** feature is disabled.

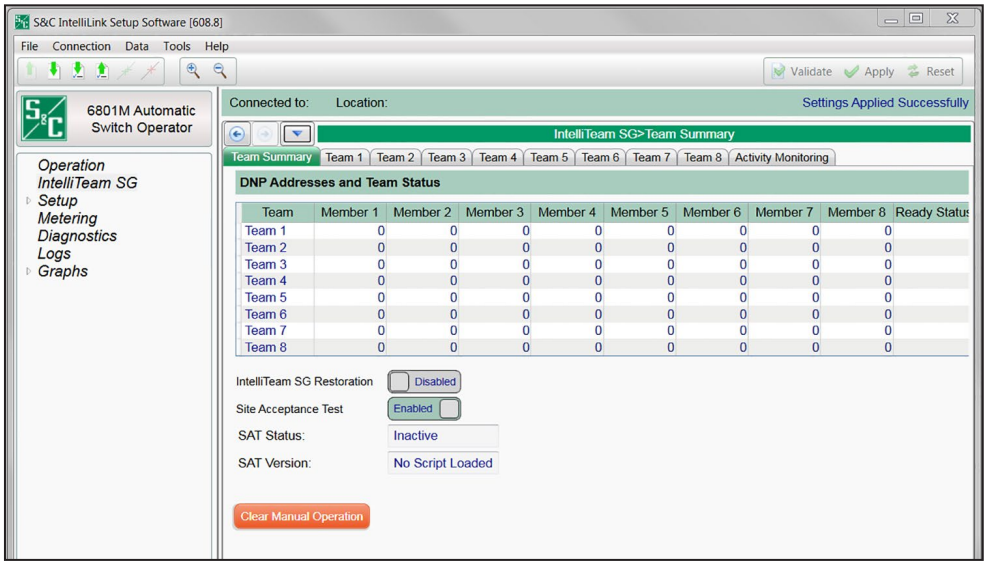

Figure 3. Prohibit Restoration command on the *IntelliTeam SG>Team Summary* screen.

The **Report** feature will save the switch operator software settings and stored data to the computer in a CSV (comma-separated value) file. A report can be saved as a permanent record, and report data can be used in spreadsheets or other programs.

Follow these steps to generate reports:

STEP 1. Connect the computer to the switch operator and start the IntelliLink software.

STEP 2. From the Data menu, choose the **Reports** option.

STEP 3. Select the report and click on the **OK** button.

STEP 4. In the Save Report dialog box, specify a name and location for the report and click on the **Save** button.

When a location is not specified, the file is saved to the same directory as the program files for this team member (the default location is C:\Program Files\ S&C Electric\). The extension ".CSV" is added automatically. When the report is complete, the message ***Task completed*** appears on the status line of the Writing Report dialog box.

STEP 5. Click on the **OK** button. The software closes the dialog box.

Saving a Setup Configuration

When two or more team members use a similar setup configuration and the same software version, the configuration can be saved from one team member and loaded into the other(s). Users then only need to manually adjust the setpoints that are unique for each individual team member.

This process also can be used to save the setpoint values on the *Setup> Restoration> IntelliTeam SG>TeamX* screen and then load these setpoints into each team member. This ensures the *Setup>Restoration>IntelliTeam SG>TeamX* screen is identical for all members of the same team. Follow these steps to save the setpoint values:

STEP 1. Select the team member that contains the configuration to save.

STEP 2. Connect the computer to the selected team member and start the IntelliLink software.

For information about starting the IntelliLink software, see the "Start IntelliLink Software" section in S&C Instruction Sheet 1045M-530, "6801 Automatic Switch Operators: *Setup*." If the computer is already connected to the team member, skip this step.

STEP 3. In the screen menu, select the **File** step-down menu and click on the "Save Setpoints" entry.

STEP 4. In the Select Setpoint Profile dialog box, choose the setpoint values to save.

(a) To save the stand-alone setpoint values, click on the **PROFILE: Non-Team Setpoints** option, and click on the **OK** button.

(b) To save the team setpoint values, click on the **PROFILE: Team x Setpoints** option for the desired team, and click on the **OK** button.

(c) To save all setpoint values, including values for teams that may not have been configured, click on the **Save Configuration Data** option, and click on the **OK** button.

STEP 5. In the Save Setpoints dialog box, specify a name and location for this configuration (CFG) file, then click on the **Save** button and click on the **OK** button.

Be sure to name team setpoint profiles logically. For example, use the Team2 name for the Team 2 setpoints. When loading the setpoint profile into another team member, the IntelliLink software will automatically place the profile into the *Setup>Restoration> IntelliTeam SG>TeamX* screen with the matching team number.

If a location is not specified, the file is saved to the same directory as the program files for this team member. The default location is C:\Program Files\S&C Electric\. The extension ".CFG" is added automatically.

For the stand-alone setpoints, this process does not save the **Physical Location**, the **Local Device DNP Address** setting (on the *Setup>Communications>DNP* screen), or the sensor-configuration data (on the *Setup>General>Sensor Cfg* screen), if applicable.

Loading a Setup Configuration

When two or more team members use a similar setup configuration and the same software version, the configuration can be saved from one team member and loaded into the other(s). Users then only need to manually adjust the setpoints that are unique for each individual team member.

Follow these steps to load a setup configuration:

STEP 1. Connect the computer to the team member whose configuration is being saved and start the IntelliLink software.

For information about starting IntelliLink software, see the "Start IntelliLink Software" section in S&C Instruction Sheet 1045-530, "6800 Series Automatic Switch Controls: *Setup*." If your computer is already connected to the team member, you can skip this step.

STEP 2. In the screen menu, select the **File** option and click on the **Load Setpoints** option.

STEP 3. In the dialog box, select the CFG file for the configuration to load and click on the **Open** button.

STEP 4. Make any setpoint changes that are required for this team member. For more information see S&C Instruction Sheet 1045M-530, "6801M Automatic Switch Operators: *Setup*."

Note: If loading the stand-alone setpoints, be sure to enter the correct value for the **Physical Location** setting, the **Local Device DNP Address** setting (on the *Setup>Communications>DNP* screen), or the sensor configuration data (on the *Setup>General>Sensor Cfg* screen), if applicable.

Viewing IntelliLink Software Without a Connection

Follow these steps to view the IntelliLink screens and help file without connecting to a team member or a snapshot:

STEP 1. Start the IntelliLink software on the computer. During startup, click on the **Cancel** button to close the Connect dialog box.

STEP 2. When the IntelliLink software is already running, choose the **Disconnect from the Connection** option, then in the **File** pull-down menu choose the **Close Screenset** option to clear the present screenset from memory.

STEP 3. From the **File** pull-down menu, choose the **Open Screenset** option.

STEP 4. In the Open Screenset dialog box, find and select the .WMN file whose name matches the software version name for this switch operator.

Saving Settings and Data to a Snapshot

Follow these steps to save operational and data-logging information in Snapshots (.VM, virtual memory files). Snapshots let users view data, generate a report, and save or change setpoint configurations even when not connected to a switch operator. To access the stored information, connect to the snapshot instead of the physical switch operator.

STEP 1. Connect the computer to the switch operator used for saving information, and start the IntelliLink software.

For information about starting IntelliLink software, see the "Start IntelliLink Software" section in S&C Instruction Sheet 1045M-530, "6801M Automatic Switch Operators: *Setup*." If the computer is already connected to the team member, skip this step.

STEP 2. From the **File** pull-down menu, choose the **Save Snapshot** option.

STEP 3. In the dialog box, specify a file name and location for this snapshot, then click on the **Save** button.

If a location is not specified, the file is saved to the same directory as the program files for this team member (the default location is C:\Program Files\S&C Electric\). The extension ".VM" is added automatically.

Viewing a Snapshot

Follow these steps to open the snapshot with the IntelliLink Offline software:

STEP 1. Start the IntelliLink software on the computer. During startup, click on the **Cancel** button to close the Connect dialog box.

STEP 2. When the IntelliLink software is already running, choose the **Connection** option and click on the **Disconnect** option. If wanting to view a snapshot for a different type of control, select the **File** pull-down menu and click on the **Close Screenset** option to clear the present screenset from memory.

STEP 3. From the **File** pull-down menu, click on the **Open Snapshot** option. The Open Controller Data File dialog box opens. Select the snapshot to view, and click on the **Open** button.

STEP 4. When planning to change the configuration settings in the snapshot in the Connect to File dialog box, click on the **Yes** button. When wanting to avoid accidentally changing a setting, click on the **No** button. The IntelliLink software opens and displays the contents of the selected snapshot.

Saving Changes Made in the Snapshot

All changes made to configuration settings in the snapshot are automatically saved to disk immediately. There is no need to save the changes in a separate operation.

Generating a Report from a Snapshot

Follow the same procedure as when connected to a switch operator.

Creating a Configuration File from a Snapshot

This procedure allows preparing a setpoint configuration for a team member in the field and there is no access to a comparable device. Follow these steps:

STEP 1. Connect to the snapshot.

STEP 2. Change the configuration settings in the snapshot as needed.

STEP 3. To save a configuration, follow the same procedure as when connected to the control.

For stand-alone setpoint values, this process does not save the **Physical Location** or the **Local Device DNP Address** setting (on the *Setup>Communications>DNP* screen), if applicable.