

Operation

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Introduction

Qualified Persons

WARNING

Only qualified persons 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 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 IntelliCap 2000 Automatic Capacitor Control. Become familiar with the Safety Information on page 3 and Safety Precautions on page 4. The latest version of this publication is available online in PDF format at sandc.com/en/contact-us/product-literature/.

Retain This Instruction Sheet

This instruction sheet is a permanent part of the IntelliCap 2000 Automatic Capacitor Control. Designate a location where users can easily retrieve and refer to this publication.

Proper Application

WARNING

The equipment in this publication must be selected for a specific application. The application must be within the ratings furnished for the selected equipment. Refer to S&C Descriptive Bulletin 1024-30.

Understanding Safety-Alert Messages

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

⚠ DANGER
“DANGER” identifies the most serious and immediate hazards that will likely 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 unclear and assistance is needed, contact the nearest S&C Sales Office or S&C Authorized Distributor, or call the S&C Global Support and Monitoring Center at 1-888-762-1100. Telephone numbers are also listed on S&C’s website, sandc.com.

NOTICE	
Read this instruction sheet thoroughly and carefully before installing the IntelliCap 2000 Automatic Capacitor Control.	

Replacement Instructions and Labels

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

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

Safety Precautions

DANGER



IntelliCap 2000 Automatic Capacitor Control operate at high voltage. 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 an IntelliCap 2000 Automatic Capacitor Control 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. Remove tags only if instructed to do so.
- 5. MAINTAINING PROPER CLEARANCE.** Always maintain proper clearance from energized components.

Applicable Software

This instruction sheet was prepared for use with IntelliCap 2000 control software: IC2000Installer-2.3.x or higher.

The software identification is located on the IntelliLink® Setup Software *Setup > General > Software Versions* screen. For questions regarding the applicability of information in this instruction sheet to future product releases, please contact S&C Electric Company.

⚠ 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.

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.

This control is connected to capacitors operating at primary voltage levels. High voltage may be present in the wiring to the control or the control itself during certain failures of the capacitor bank wiring or grounding systems, or because of a failure of the capacitor bank itself. For this reason, access to the control 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 control.

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 control 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 control and associated mounting hardware, as if they were elevated to primary (high) voltage.

LCD Screen

The faceplate LCD screen provides information about the present state of the control. For an explanation of the LCD screen and faceplate controls, see the “Faceplate” section on page 7.

Viewing Control Data

IntelliLink® Setup Software *Operation, Diagnostics > Alarms, Metering, and Setup > General > Software Versions* screens display information about the IntelliCap 2000 control operating data and sensor data. For an explanation of these screens, see S&C Instruction Sheet 1024-550, “IntelliCap 2000 Automatic Capacitor Control: *Troubleshooting*.”

To view these screens, a Windows 7 or later computer, Microsoft® Edge, a USB 2.0 A to B cable, and IntelliLink Setup Software for the IntelliCap 2000 control are required. For more information about the required equipment and how to use IntelliLink Setup Software, see S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*.”

Electrical Diagrams

The electrical interconnect diagrams, at the back of S&C Instruction Sheet 1024-510, IntelliCap 2000 Automatic Capacitor Control: *Installation*,” show IntelliCap 2000 control wiring layouts.

Test Points

Test points are accessible below the faceplate. See Figure 1.

Hardware Components

This section describes control hardware. The “Control Operation” section that starts on page 12 explains how these components work together to monitor the distribution feeder and manage capacitor bank operation. Figure 1 shows parts needed to access during regular operation and troubleshooting.

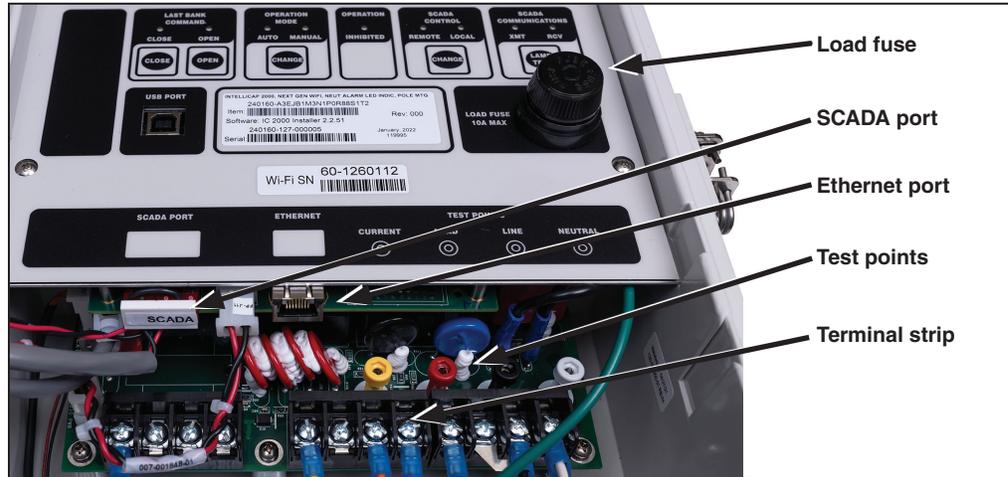


Figure 1. Capacitor control components.

SCADA port—When the control includes communication equipment, it will usually be connected to the SCADA PORT.

Terminal strip—The terminal names are shown on a label inside the enclosure. If necessary, reconfigure the wiring to the meter base or the connectors on the bottom of the enclosure.

Test points—These are labeled at the bottom of the faceplate and are used to check inputs to the control.

Faceplate

The IntelliCap 2000 control faceplate includes LEDs and buttons used to monitor and control the bank. The scroll buttons at the right are used for selecting data on the LCD screen. See Figure 2.

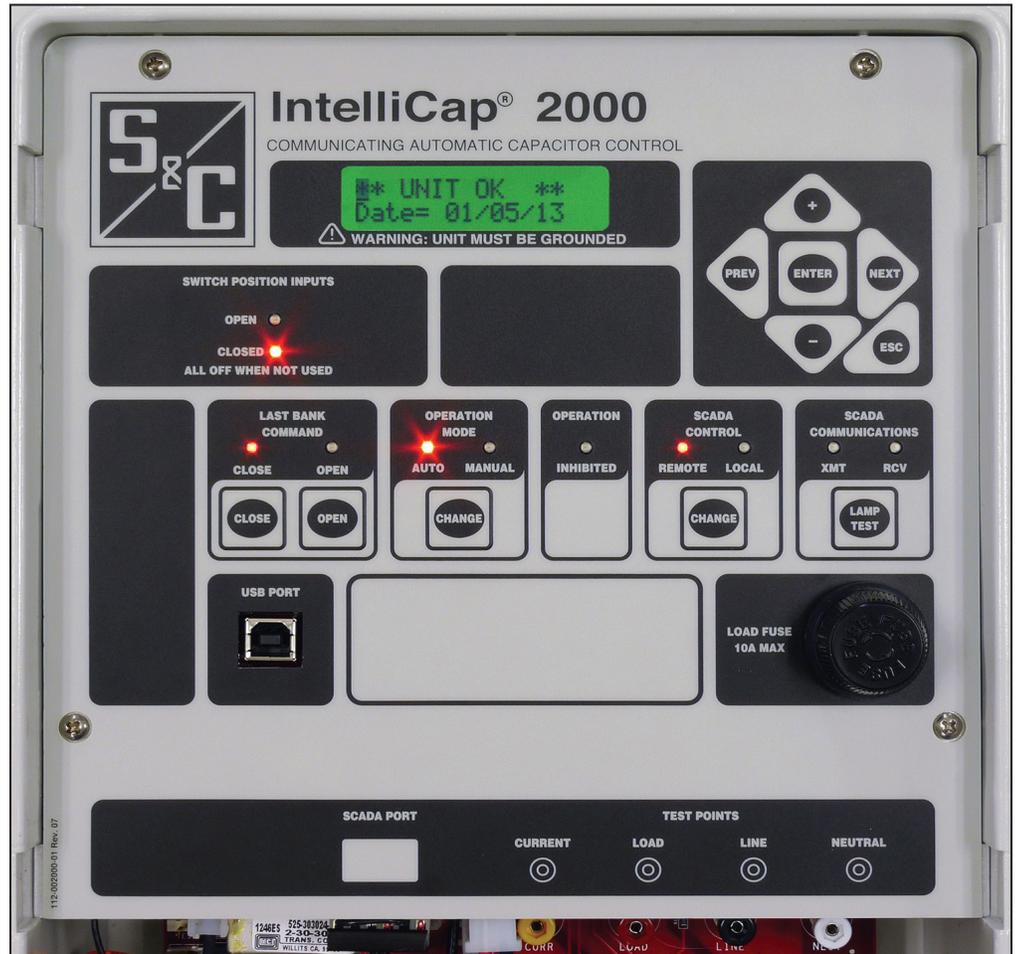


Figure 2. The faceplate controls and indicators.

Faceplate LED Indicators and Control Buttons

Last Bank Command: Close/Open

These indicators show the present position of the capacitor bank, unless a problem prevented bank operation. To initiate a **Close** or **Open** command, make sure the SCADA CONTROL: LOCAL indicator is in the **On** state and the OPERATION MODE: MANUAL indicator is in the **On** state, and then press the CLOSE or OPEN button. When automatic operation or remote operation is enabled, commands from the faceplate CLOSE and OPEN buttons are blocked.

Operation Mode: Auto/Manual

These indicators show whether operation of the capacitor control is automatic or manual. To change the state, make sure the SCADA CONTROL: LOCAL indicator is in the **On** state. Then, press the CHANGE button.

NOTICE

When **Automatic Operation** mode is enabled, the **Automatic-Control** logic may switch the capacitor bank regardless of whether **SCADA Control** mode is enabled or disabled. To have full local control of the capacitor bank, the MANUAL LED must also be lit.

Operation Inhibited

When lit, this indicator shows **Automatic Operation** mode is presently blocked.

SCADA Control: Remote/Local

These indicators show whether remote operation of the bank via SCADA is allowed. To change the state, press this CHANGE button.

SCADA Communications: XMT/RCV

These indicators blink when the control sends or receives one or more characters in a transmission. They only blink if remote communication equipment is installed, properly connected, and receiving power.

Lamp Test

Press this button to test LEDs on the faceplate. All LEDs should illuminate.

Switch Position Inputs: Open/Closed

When digital switch position inputs are enabled and the physical inputs are connected to a dry position contact on the capacitor switch, these indicators show the state of the closed and open digital input terminals 3 and 4 on the input terminal block. Terminal 1 is the return. The **Switch Position Input** settings are configured on the *Setup>General>Site-Related* screen.

The Faceplate LCD

The LCD screen is a 2-line, 16-character display. When the control is operating normally, the top line reads ****Unit OK****. The bottom line cycles through a list of real-time data, setpoints, and logged data, as well as other operating information, such as an active alarm or a reclose block.

Reclose Block

When the **Reclose Block** mode is enabled, the LCD screen shows information on both lines. See Table 1 on page 9. When **Reclose Block** mode is enabled, the **Reclose Block** timer can only be cleared from the faceplate and only when the control is in the **Manual Operation** state and **Local SCADA Control** state.

Table 1. Reclose Block Messages on the LCD Screen

Display	Meaning
[RECLOSE Blk: ###]	After opening the capacitor bank, the control will not reclose it for the duration of the reclose block timer. The default setting is 5 minutes. This allows the capacitors to discharge.
[RECLOSE Blk: ### Man ENTER=Cancel] [Sel Code & Enter Code: 0]	The first message appears if the Reclose Block Reset Password function is enabled and an attempt is made to close the bank while the reclose block is in effect. To bypass the block, press the faceplate ENTER button. Use the + and – keys to scroll through the password list, then press the ENTER button when the LCD screen shows the correct password. To end the procedure without bypassing the block, press the ESC button.

Real-Time Data

To access the Real-Time Data, press the NEXT button from top level menu. The top level menu typically reads ****Unit OK**** unless there is an active **Alarm, Warning, or Error** condition. To ensure the top level menu is displayed, press the ESC button. When the **Real-Time Data** menu is displayed, the LCD screen will read ****Menu**** on the top line and ****Data**** on the bottom line. Use the + and – keys to move through the menu. See Table 2.

Table 2. Real-Time Data Displayed on the LCD Screen (For a Var Control with Current Sensing)

Display	Meaning
[Date]	The date today
[Time]	Present time
[Volt]; [Ovr]	Line voltage (true RMS measured voltage) and shows that a voltage override is in effect
[Current]	Var controls only—Current level, in amperes
[Neu Fund]	Neutral amps (or voltage) fundamental
[Temperature:]	Present ambient temperature in °F
[Temperature:]	Present ambient temperature in °C
[kVARs]	Var controls only—kvar level
[kW]	Var controls only—real power level
[kVA]	Var controls only—kVA level
[PFactor]	Power factor
[Line kV]	Var controls only—Voltage level on the distribution line, in kV
[C. Phase]	Var controls only—Corrected phase angle
[Phase]	Var controls only—Uncorrected phase angle
[AkVars]	Var controls only—Adjusted kvars
[Curr Dir]	Var controls only—Current flow direction
[FPnl Edit]	LCD edit enabled/disabled
[Daily Cycles]	Daily automatic cycles
[Ann. Cycles]	Total operations this year (or since upgrade)

Note: The kvar level shown is calculated from measured sensor values; it is not an adjusted level.

Alarms

When any **Alarm**, **Warning**, or **Error** state is active, the LCD screen shows the high-level state on the top line. Any additional alarms, warnings, or errors can be viewed by pressing the NEXT button twice and using the + and – keys to scroll through the alarms list. When the LCD screen shows the **Alarms** menu, the top line will display ****Menu**** and the bottom line will display ****Alarm****. See Table 3. To clear a **Neutral Sensing Lockout** condition, press the OPERATION MODE: CHANGE button until the LED screens have cycled from **Manual** to **Auto** mode and back to the **Manual** mode.

Table 3. Alarms Displayed on the LCD Screen

Display	Meaning
TempSensorErr	The temperature sensor is reading outside of its range or may be faulty
VoltageDeltaErr	A Low Switching Voltage Delta message appears when the actual change in voltage levels during switching is below the minimum percentage of the expected change
VoltageBandErr	The Bank Voltage Change + Margin value has exceeded the Season Override High/Low Voltage differential. The bank switch is not locked out until the High/Low Band Error has existed continuously for High/Low Band Lockout Time Threshold time. At that point the Voltage Band Lockout error is set and the bank switch is locked out.
VarDeltaErr	A Low Switching Kvars Delta message appears when the actual change in kvar levels during switching is below the minimum percentage of the expected change
VoltageSensorErr	The voltage sensor is reading outside of its range or may be faulty
LoadFuseErr	Blown load fuse
VoltRangeErr	This error indicates a possible mismatch between the configured nominal operating voltage setting and actual system voltage as sensed by the control. It is not indicative of a line problem. When the control is configured for a nominal operating voltage of 220 V or higher and it senses a secondary voltage that is below 176 V, or when the control is configured for a nominal operating voltage of 127 V or lower and senses a secondary voltage higher than 152 V, this error becomes active
MaxAutoCyclesErr	The control reached the Maximum Automatic Control Cycles Per Day setting. Further automatic switching is inhibited until the next calendar day
NeutralSensorErr	Neutral sensing controls only. This message is displayed before the control locks out the bank following a neutral current or neutral voltage alarm
NeutLockoutErr	Neutral sensing controls only. The level of neutral current or neutral voltage has caused the control to lock out the bank. S&C Instruction Sheet 1024-530, "IntelliCap® 2000 Automatic Capacitor Control: <i>Setup</i> ," for more details
NeutralZeroErr	Neutral sensing controls only. The control detected zero neutral current or neutral voltage for the length of the Zero Neutral Detection setpoint. See S&C Instruction Sheet 1024-530, "IntelliCap® 2000 Automatic Capacitor Control: <i>Setup</i> ," for more details
LoadFuseAlarm	The load fuse on the faceplate has blown

Control Software

S&C controls are entirely software-driven. The control software is pre-loaded into the control at the factory. The control software manages the minute-by-minute functioning of the control. It continually monitors:

- Voltage, current, or neutral current/neutral voltage on the feeder
- Incoming SCADA commands
- State of the faceplate LED screens and buttons
- Ambient temperature at the control
- Internal capacitor control clock/calendar
- Software setpoint values
- Various other setpoints and data values as needed

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

The control software, the setpoint values, and historical data are all stored in non-volatile flash memory, which survives power interruptions.

IntelliLink Setup Software

IntelliLink Setup Software can be downloaded at the S&C Automation Customer Support Portal: sandc.com/support/automation-customer-support-portal.asp. This software runs on computers using Windows® operating system with a USB cable to communicate with the control. Use the software to:

- Change strategy (for example, from **Temperature** to **Time-Biased Voltage** strategy)
- Enter installation-dependent operating parameters (setpoints), such as a network address, the temperature-change time threshold, a voltage-override level, etc.
- Monitor real-time data, such as the present line voltage and current
- Examine the performance and operating history of an installed capacitor control
- Transfer all configuration, operating, and historical data from the capacitor control to a report file on the computer
- Download new control software into the capacitor control
- Troubleshoot assorted types of capacitor control installation problems

SCADA Communication Equipment

Most utility communication equipment can be mounted inside the enclosure on the back of the door. This eliminates pole clutter and provides a higher reliability level for the installation.

DNP 3.0 is the standard protocol for the IntelliCap 2000 Capacitor Control. See Instruction Sheet 1024-561, “IntelliCap® 2000 Automatic Capacitor Control: *DNP Points List and Implication*” for more information.

Data Acquisition

The control operation section explains how the capacitor control components work together to control the capacitor bank.

Signal Processing

The capacitor control reports voltage, current, and phase-related data in units of volts, amperes, kvars, kW, and kVA. The rated accuracy of these measurements is based on the combined accuracy of all the control components (exclusive of the sensor and sensor cable but including all sensor conditioning components).

Voltage readings are accurate for all distribution voltages. For var controls, phase-angle detection requires a minimum current of 0.5% of **Full Scale** values. Current magnitudes are still detected and displayed below the 0.5% threshold. The capacitor control uses the **phase-angle offset** values to calculate all ac waveform data sampled from the line sensor.

RMS Ac Displayed and Recorded Values

For real-time, steady-state monitoring and data logging, the capacitor control collects data at 0.3-second intervals. It then averages four samples and reports the **1.2-Second Averaged** value. This results in a 1.2-second net response time.

The control uses these **1.2-Second Averaged** values for the real-time display, reporting via the faceplate, SCADA communications, and most data logging. Daily highs and lows are the highest and lowest **Raw Sample** (unaveraged) values; they are stored for the present day and the preceding 31 days.

The control also uses these **1.2-Second Averaged** values to create **Interval Averaged** values (data averaged over the logging interval) for voltage and temperature, as well as current, kvars, power factor, kW, and neutral current/neutral voltage, if applicable. Choose a data-logging interval of 1, 5, 10, 15, 30, or 60 minutes. The period of logged **Interval Averaged** values depends on the chosen interval.

The control data logged values of voltage and current are RMS values.

Bank switching is based on voltage and current measurements on the fundamental frequency and is not affected by harmonics.

Neutral current switching is also based on the fundamental frequency and is not affected by harmonics. The control data logs the fundamental component of the neutral current.

Phase-Angle Measurements

The var capacitor controls calculate the phase angle between the voltage and current waveforms. Phase-angle measurements are on a 0-360 degree range.

As part of the capacitor control setup, enter an **Installation Phase Offset Angle** setpoint to compensate for various installation-dependent phase angle errors.

Control Strategies

The IntelliCap 2000 control can switch the capacitor bank automatically using a variety of control strategies: **Temperature**, **Timeclock**, **Timeclock with Temperature Override**, **Voltage Only**, **Time-Biased Voltage**, **Time-Biased Temperature**, **Automatic Offline**, or **Automatic Online** strategy. Var controls have four additional control strategies: **Current**, **Current with Temperature Override**, **Var**, and **Var with Temperature Override** strategy. These are all explained in this section. For information about how to use the faceplate buttons to enable **Automatic Operation** mode, see the “Switching the Capacitor Bank” section on page 32.

The capacitor control switches the bank based on a prioritized set of conditions. These conditions, from highest to lowest priority, are:

Reclose Block—After opening the capacitor bank, the control will not reclose it until the **Reclose Block** timer expires. The default setting is 5 minutes. This allows the capacitors to discharge. The bottom line of the LCD screen shows the time remaining before the control can switch the bank in. The time remaining also appears in the **Reclose Block** field on the *Operation* screen. **Reclose Block** mode is active only when the control is in the **Manual Operation** state and the **SCADA Local** state. **State of the Faceplate LEDs**—If the MANUAL LED is lit, the capacitor control blocks the **Automatic Operation** mode. The bank can only be operated from the faceplate CLOSE and OPEN buttons or from the *Operation* screen when the LOCAL LED is lit.

Remote Commands—If the REMOTE LED and the MANUAL LED are both lit, the capacitor control accepts commands from the SCADA master station.

Anti-Cycling Limit—If the capacitor control is in **Automatic Operation** mode, the **Maximum Automatic Control Cycles Per Day** setpoint on the *Setup>General* screen determines the maximum number of automatic switching cycles per calendar day. Once this limit is reached, the capacitor bank remains switched out until the next calendar day.

Emergency High-Voltage and Emergency Low-Voltage Override Setpoints—If the voltage remains outside the emergency override range for a specified period of time, the capacitor control switches the bank. See the *Setup>General* screen in S&C Instruction Sheet 1024-530, “IntelliCap 2000 Automatic Capacitor Control: *Setup*” for more details.

High-Voltage and Low-Voltage Override Setpoints—If the voltage remains outside the normal range for a specified period of time, the capacitor control switches the bank. See *Setup>General* screen in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*” for more details.

The Present Control Strategy—The capacitor control switches the bank according to the strategy presently in effect.

If the capacitor control has been in **Manual Operation** mode and is returned to **Automatic Operation** mode, it waits 60 seconds before switching the bank, when necessary. This timer is not configurable. This allows the operator to step away from the bank before it operates.

Temperature Control Strategy

When the **Automatic Operation** function is enabled and the capacitor control is in **Temperature** strategy, it switches the capacitor bank based on the present air temperature. The control can operate in both high- and low-temperature modes. The control uses the following logic to determine when to switch the capacitor bank:

- STEP 1.** The capacitor control monitors present air temperature.
- STEP 2.** When the control senses the temperature has passed the **Temperature at Which Bank Switches In** threshold (or the **Temperature at Which Bank Switches Out** threshold), it begins the **High-/Low-Temperature Change Time Threshold** timer. This is true for either high-temperature or low-temperature operation.
- STEP 3.** For high-temperature operation, if the temperature remains continuously above the **Temperature at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in. If it remains below the **Temperature at Which Bank Switches Out** threshold for the duration of the timer, the control switches the bank out.

For low-temperature operation, when the temperature remains continuously below the **Temperature at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in. If it remains above the **Temperature at Which Bank Switches Out** threshold for the duration of the timer, the control switches the bank out.

Note: The voltage must remain in a range where switching the capacitor bank will not cause a **Voltage Override** condition. Otherwise, the control will not switch the bank to avoid excessive cycling. See the “Voltage Override Operation” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*,” for details.

Note: A bad temperature sensor does not prevent the control from operating. It will still switch the bank if a **Voltage Override** condition becomes active.

Time-Biased Temperature Control Strategy

When the **Automatic Operation** mode is enabled and the capacitor control is in **Time-Biased Temperature** strategy, it switches the capacitor bank based on two sets of temperature setpoints. The **Time-Biased Temperature** strategy uses the same logic as the **Temperature** strategy, except:

- There is only one set of temperature setpoints in use.
- The capacitor bank is in **Offline** strategy during unscheduled times.

Note: If the bank was in **Online** mode when the unscheduled period began and the temperature does not go beyond the switch-out setpoint, the bank switches back in at the start of the next scheduled period. It does not wait for the temperature to go beyond the switch-in value.

For example, the bank is set to switch in at 80° F (27°C) and switch out at 70°F (21°C). The timeclock schedule period is 8:00-17:00. On Monday at 17:00, the bank switches out. During the unscheduled time, the temperature does not go below 70°F (21°C) for the length of the **Temperature Time** threshold. On Tuesday at 8:00, the bank switches in again, even if the temperature is below 80° F (27°C).

Note: The voltage must remain in a range where switching the capacitor bank will not cause a **Voltage Override** condition. Otherwise, to avoid excess cycling, the control will not switch the bank. See the “Voltage Override Operation” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*,” for details.

Note: A bad temperature sensor does not prevent the control from operating. It will still switch the bank if a **Voltage Override** condition becomes active.

Note: The bank will go active 1 minute after the scheduled start time and will go inactive 1 minute after the scheduled end time.

Timeclock Control Strategy

When the **Automatic Operation** mode is enabled and the capacitor control is in **Timeclock** strategy, it switches the capacitor bank based on a time schedule. Enter up to two different time schedules. The control uses the following logic to determine when to switch the capacitor bank:

- STEP 1.** The capacitor control checks to determine whether the present time falls within one of the scheduled On periods.
- STEP 2.** If the present time is within a scheduled On period and the calendar day is not a holiday, the control switches the bank in. If the bank is already online, it remains online.
- STEP 3.** When the time is no longer in a scheduled On period or the calendar day becomes a holiday, the control switches the bank out. If the bank is already offline, it remains offline.

Note: The voltage must remain in a range where switching the capacitor bank will not cause a **Voltage Override** condition. Otherwise, the control will not switch the bank. See the Voltage Override Operation section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*,” for details.

Note: The bank will go active 1 minute after the scheduled start time and will go inactive 1 minute after the scheduled end time.

Timeclock with Temperature Override Control Strategy

When the **Automatic Operation** mode is enabled and the capacitor control is in **Timeclock with Temperature Override** strategy, it switches the capacitor bank based on a time schedule. Up to two different time schedules can be entered. The control uses the following logic to determine when to switch the capacitor bank:

- STEP 1.** The capacitor control checks to see if the present time falls within one of the scheduled “on” periods.
- STEP 2.** If the present time is within a scheduled On period and the calendar day is not a holiday, the control switches the bank in. If the bank is already online, it remains online.
- STEP 3.** When the time is no longer in a scheduled On period or the calendar day becomes a holiday, the control switches the bank out. If the bank is already offline, it remains offline.
- STEP 4.** In addition, if the control senses that the air temperature has passed the **Temperature at Which Bank Switches In** threshold (or the **Temperature at Which Bank Switches Out** threshold), it starts the **High-/Low-Temperature Change Time** threshold timer. This is true for either high-temperature or low-temperature operation.

STEP 5. For high-temperature operation, if the temperature remains continuously above the **Temperature at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in, if it is not already switched in. If it remains below the **Temperature at Which Bank Switches Out** threshold for the duration of the timer, the control reverts to operation based on **Timeclock** control settings.

For low-temperature operation, when the temperature remains continuously below the **Temperature at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in, if it is not already switched in. If it remains above the **Temperature at Which Bank Switches Out** threshold for the duration of the timer, the control reverts to operation based on **Timeclock** control settings.

Note: The voltage must remain in a range where switching the capacitor bank will not cause a **Voltage Override** condition. Otherwise, to avoid excessive cycling, the control will not switch the bank. See the “Voltage Override Operation” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*,” for details.

Note: The bank will go active 1 minute after the scheduled start time and will go inactive 1 minute after the scheduled end time.

Voltage Only Control Strategy

When the **Automatic Operation** mode is enabled and the capacitor control is in **Voltage Only** strategy, it switches the capacitor bank based solely on the **High-** and **Low-Voltage** setpoints. A preferred capacitor bank position can also be selected. The control uses the following logic to determine when to switch the capacitor bank:

STEP 1. The capacitor control monitors voltage. When voltage remains within the normal range, the capacitor control switches the bank based on the **Preferred Capacitor Bank Position** setting. No action is taken if the **None** position is selected or if switching the bank would cause a **Voltage Override** condition.

To set the **Preferred Capacitor Bank Position** setting, go to the *Setup>Seasons>Main* screen to see which seasons have a **Voltage Only Strategy** setting. Then, select the tab for that season and select the **Preferred Capacitor Bank Position** setting for that season.

Figure 3 on page 17, Figure 4 on page 17, and Figure 5 on page 18 show when the capacitor bank switches for each **Preferred Capacitor Bank Position** setting. The capacitor control uses the **Voltage Override** setpoints and the **Bank Voltage Change + Margin** setting to avoid excessive cycling.

STEP 2. When the control senses that the voltage has passed the **High-Voltage Override Value** threshold (or **Low-Voltage Override Value** threshold), it starts the **High-Voltage Override Time** (or **Low-Voltage Override Time**) timer.

STEP 3. If the voltage remains continuously above the **High-Voltage Override Value** threshold for the duration of the **High-Voltage Override Time** timer, the control switches the bank out. If it remains continuously below the **Low-Voltage Override Value** threshold for the duration of the **Low-Voltage Override Time** timer, the control switches the bank in.

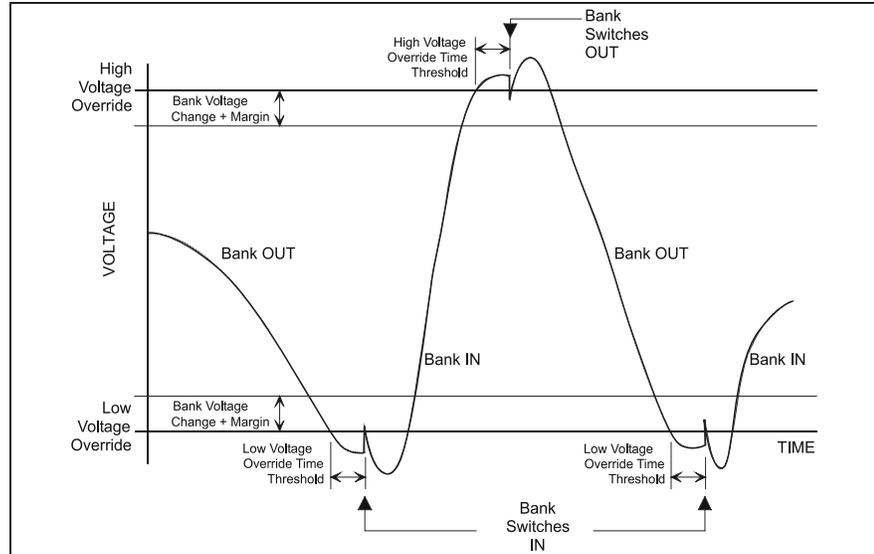


Figure 3. Voltage control switching, preferred capacitor bank position is "None."

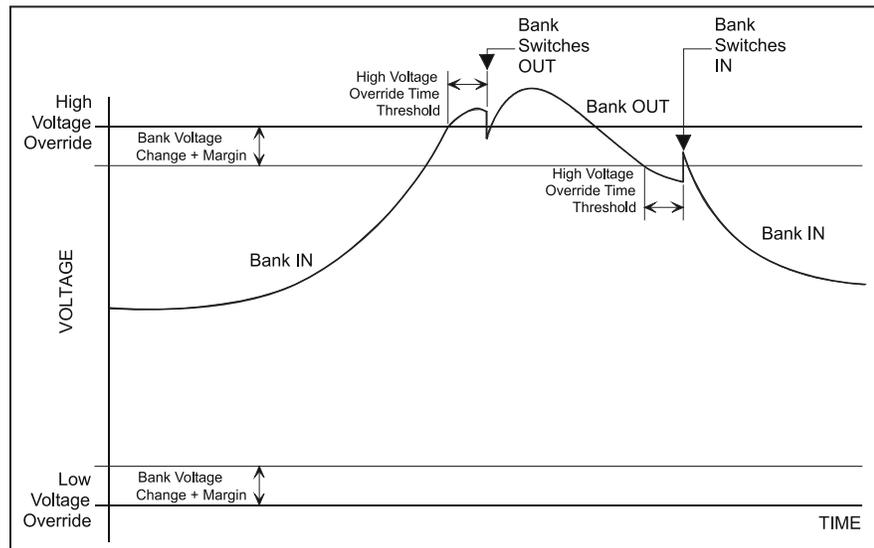


Figure 4. Voltage control switching, preferred capacitor bank position is "Online."

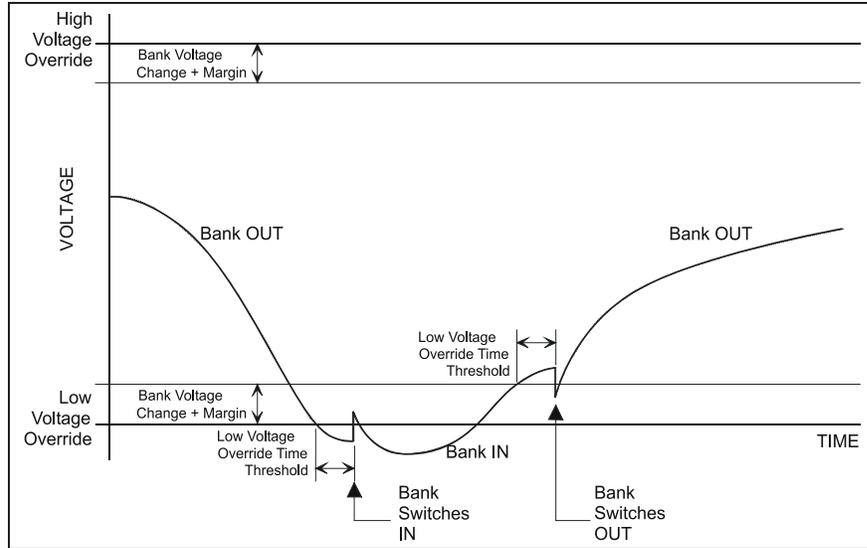


Figure 5. Voltage control switching, preferred capacitor bank position is “Offline.”

Time-Biased Voltage Control Strategy

When the **Automatic Operation** mode is enabled and the capacitor control is in **Time-Biased Voltage** strategy, it switches the capacitor bank based on two sets of **High-** and **Low-Voltage** setpoints. The **Time-Biased Voltage** strategy uses the same logic as the **Voltage Only** strategy, except:

- The voltage setpoints are different for scheduled and unscheduled times.
- There is only one **Voltage Change Time Threshold** setting.
- The capacitor control does not use the **Preferred Capacitor Bank Position** setpoint.

Automatic Offline Control Strategy

When the **Automatic Operation** mode is enabled and the capacitor control is in **Automatic Offline** strategy, the capacitor bank is always switched out. The control does not even switch the bank for a **Voltage Override** condition. For **Automatic Offline** mode, the bank will NOT switch in for an **Emergency Low Voltage Override** condition.

If the bank is switched online in **Manual** mode, the capacitor control switches it back offline when it returns to **Automatic Operation** mode after the 60-second safety delay.

Automatic Online Control Strategy

When the **Automatic Operation** mode is enabled and the capacitor control is in **Automatic Online** strategy, the capacitor bank is always switched in. The control does not even switch the bank for a **Voltage Override** condition.

If the bank is switched offline in **Manual** mode, the capacitor control switches it back online when it returns to **Automatic Operation** mode after the 60-second safety delay.

Current Control Strategy (*var controls only*)

When the **Automatic Operation** mode is enabled and the capacitor control is in **Current** strategy, it switches the capacitor bank based on measured single-phase current flow. The control uses the following logic to determine when to switch the capacitor bank:

- STEP 1.** The capacitor control monitors the single-phase line current.
- STEP 2.** When the control senses the current has passed the **Single-Phase Amps at Which Bank Switches In** threshold (or the **Single-Phase Amps at Which Bank Switches Out** threshold), it starts the **Current Change Time Threshold Timer** function.
- STEP 3.** If the single-phase current remains continuously above the **Single-Phase Amps at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in. If it remains continuously below the **Single-Phase Amps at Which Bank Switches Out** threshold for the duration of the timer, the control switches the bank out.

Note: The voltage must remain in a range where switching the capacitor bank will not cause a **Voltage Override** condition. Otherwise, to avoid excessive cycling, the control will not switch the bank. See the “Voltage Override Operation” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*,” for details.

Current with Temperature Override Control Strategy (*var controls only*)

When the **Automatic Operation** mode is enabled and the capacitor control is in **Current with Temperature Override** strategy, it switches the capacitor bank based on measured single-phase current flow. The control uses the following logic to determine when to switch the capacitor bank:

- STEP 1.** The capacitor control monitors the single-phase line current.
- STEP 2.** When the control senses current has passed the **Single-Phase Amps at Which Bank Switches In** threshold (or the **Single-Phase Current at Which Bank Switches Out** threshold), it starts the **Current Change Time Threshold** timer.
- STEP 3.** If the single-phase current remains continuously above the **Single-Phase Amps at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in. If it remains continuously below the **Single-Phase Amps at Which Bank Switches Out** threshold for the duration of the timer, the control switches the bank out.
- STEP 4.** In addition, if the control senses the air temperature has passed the **Temperature at Which Bank Switches In** threshold (or the **Temperature at Which Bank Switches Out** threshold), it starts the **High-/Low-Temperature Change Time Threshold** timer. This is true for either high-temperature or low-temperature operation.

For high-temperature operation, when the temperature remains continuously above the **Temperature at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in, if it is not already switched in. When it remains below the **Temperature at Which Bank Switches Out** threshold for the duration of the timer, the control reverts to operation based on **Current** settings.

For low-temperature operation, if the temperature remains continuously below the **Temperature at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in, if it is not already switched in. If it remains above the **Temperature at Which Bank Switches Out** threshold for the duration of the timer, the control reverts to operation based on **Current** settings.

Note: The voltage must remain in a range where switching the capacitor bank will not cause a **Voltage Override** condition. Otherwise, to avoid excessive cycling, the control will not switch the bank. See the “Voltage Override Operation” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*,” for details.

Var Control Strategy (*var controls only*)

When the **Automatic Operation** mode is enabled and the capacitor control is in **Var** strategy, it switches the capacitor bank based on single-phase kvars, kilovolt-amperes, reactive. The control uses the following logic to determine when to switch the capacitor bank:

- STEP 1.** The capacitor control monitors the single-phase kvar level.
- STEP 2.** When the control senses the kvars have passed the **Single-Phase kvars at Which Bank Switches In** threshold (or the **Single-Phase kvars at Which Bank Switches Out** threshold, it starts the **Var Change Time Threshold** timer.
- STEP 3.** If the single-phase kvar level remains continuously above the **Single-Phase kvars at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in. If it remains continuously below the **Single-Phase kvars at Which Bank Switches Out** threshold for the duration of the timer, the control switches the bank out.

Note: The voltage must remain in a range where switching the capacitor bank will not cause a **Voltage Override** condition. Otherwise, to avoid excessive cycling, the control will not switch the bank. See the “Voltage Override Operation” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*,” or details.

Var with Temperature Override Control Strategy (*var controls only*)

When the **Automatic Operation** mode is enabled and the capacitor control is in **Var with Temperature Override** strategy, it switches the capacitor bank based on single-phase kvars, kilovolt-amperes, reactive. The control uses the following logic to determine when to switch the capacitor bank:

- STEP 1.** The capacitor control monitors the single-phase kvar level.
- STEP 2.** When the control senses the kvars have passed the **Single-Phase kvars at Which Bank Switches In** threshold (or the **Single-Phase kvars at Which Bank Switches Out** threshold), it starts the **Var Change Time Threshold** timer.
- STEP 3.** If the single-phase kvar level remains continuously above the **Single-Phase kvars at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in. If it remains continuously below the **Single-Phase kvars at Which Bank Switches Out** threshold for the duration of the timer, the control switches the bank out.

STEP 4. In addition, when the control senses the air temperature has passed the **Temperature at Which Bank Switches In** threshold (or the **Temperature at Which Bank Switches Out** threshold), it starts the **High-/Low-Temperature Change Time Threshold** timer. This is true for either high-temperature or low-temperature operation.

For high-temperature operation, if the temperature remains continuously above the **Temperature at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in, if it is not already switched in. If it remains below the **Temperature at Which Bank Switches Out** threshold for the duration of the timer, the control reverts to operation based on **Var** settings.

For low-temperature operation, if the temperature remains continuously below the **Temperature at Which Bank Switches In** threshold for the duration of the timer, the control switches the bank in, if it is not already switched in. If it remains above the **Temperature at Which Bank Switches Out** threshold for the duration of the timer, the control reverts to operation based on **Var** settings.

Note: The voltage must remain in a range where switching the capacitor bank will not cause a **Voltage Override** condition. Otherwise, to avoid excessive cycling, the control will not switch the bank. See the “Voltage Override Operation” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*,” for details.

Sensor Location

Current Sensor Location and Reverse Current Flow

For var capacitor controls, the preferred location of the current sensor is on the source side of the bank. This lets the sensor measure the effect of the bank when it is online. However, the capacitor control can still account for the effect of the bank when the sensor is on the load side. This is particularly useful when abnormal circuit switching reverses the direction of power flow, flipping the relative position of the sensor.

When a **Reverse Current** condition exists, the value of the **Reverse Current Strategy** setpoint determines how the control responds. The **Adj. Var** setting is the default.

- **Adj. Var**—During a **Reverse Current** condition, if the current sensor is on the normal source side, the control calculates the Adjusted 3-Phase kvars level by subtracting the **3-Phase Bank Size** setpoint from the Measured 3-Phase kvars level. See the *Setup>Site-Related* screen. If the current sensor is on the normal load side, the control uses the measured kvars.
- **Trip & Inh.**—The control switches the bank offline during a **Reverse Current** condition and inhibits further switching until the condition clears.
- **Volt Only**—During a **Reverse Current** condition, the control switches the bank based only on the presently active **Normal** and **Emergency Voltage-Override** setpoints. If any neutral sensor strategies are enabled, they remain in effect.
- When the control is in one of the **Current** or **Var** control strategies when the current reverses, the **Volt Only** strategy takes precedence over the **High-/Low-Band Error** strategy; if applicable, the **Temperature Override** function is also discontinued. When current flow returns to normal, the control returns to switching the bank based on its regular strategy and the present conditions, including the **Bank Voltage Change + Margin** condition previously in use; this value does not change while current is reversed.

- When the control is not in one of the **Current** or **Var** strategies when the current reverses, it uses the **High-/Low-Band Error** logic in effect.

Figure 6 on page 23 shows the four possible combinations of the current sensor location and direction of current flow:

1. **Sensor on Normal Source Side with Normal Current Flow**

The kvar level measured at the sensor location already reflects the effect of the bank. The Adjusted 3-Phase kvars level equals the Measured 3-Phase kvars level (which is the measured single-phase kvars multiplied by 3).

2. **Sensor on Normal Source Side with Reverse Current Flow**

Abnormal circuit switching has caused the current direction to reverse. In this case, the effect of the bank is not reflected in the measured kvars at the sensor location. The capacitor control calculates the Adjusted 3-Phase kvars level by subtracting the **3-Phase Bank Size** setpoint on the *Setup>Site-Related* screen from the Measured 3-Phase kvars level.

For example, an online 1200-kvar capacitor bank is set to switch out at -750 kvar. The sensors are on the source side and current flow is reversed. When the load at the sensor location is 450 kvar, the Adjusted 3-Phase kvars level is $450 - 1200 = -750$ kvar, and the bank switches out.

3. **Sensor on Load Side with Normal Current Flow**

This occurs when the current sensor is installed on the load side of the bank or if permanent circuit switching causes the sensor to be on the load side of the bank. See No. 2, “Sensor on Normal Source Side with Reverse Current Flow.”

4. **Sensor on Load Side with Reverse Current Flow**

See No. 1, “Sensor on Normal Source Side with Normal Current Flow.”

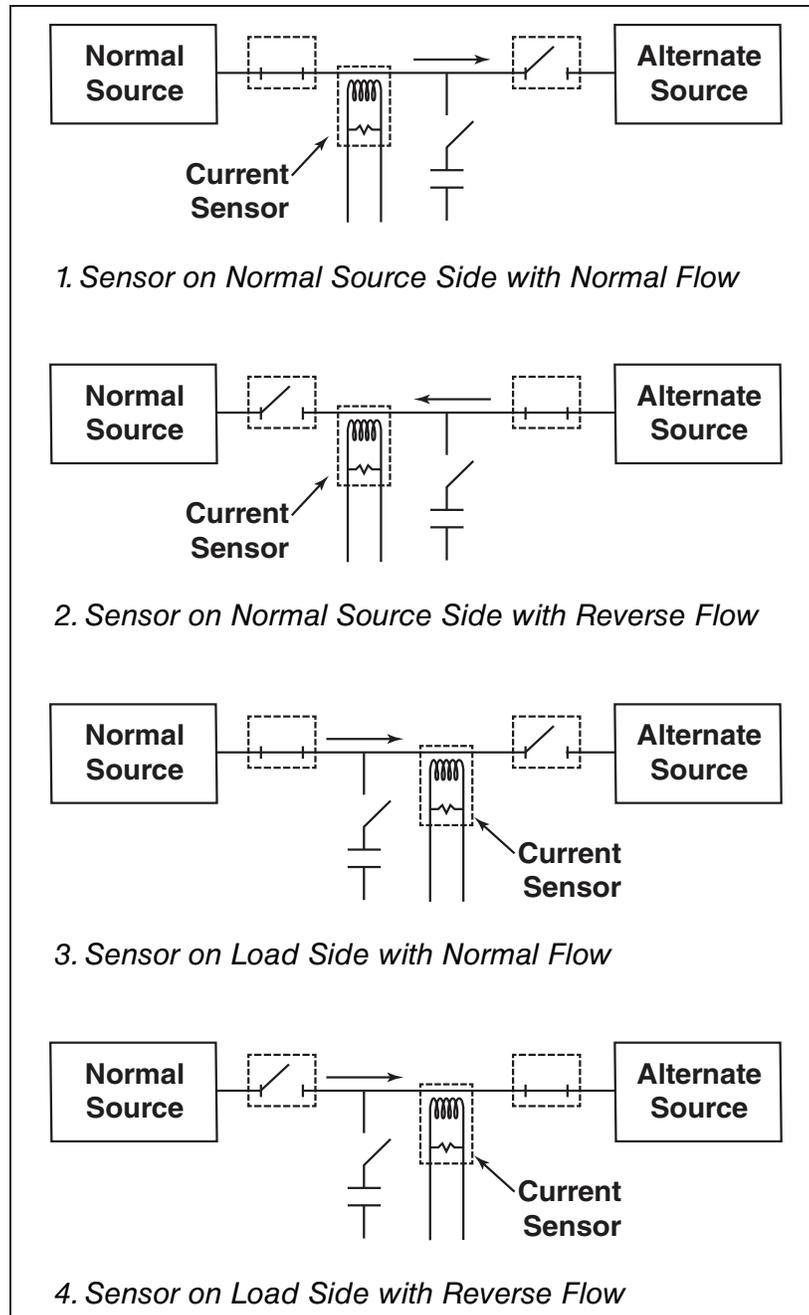


Figure 6. Combinations of current sensor location and direction of current flow.

Neutral Current Detection

The **Neutral Current Sensing** option allows the capacitor control to monitor and take action on abnormal levels of current flowing from the starpoint of a grounded, wye-connected bank to the system neutral and/or ground. See Figure 7. The sensed current is the vector sum of the three capacitor phase currents plus harmonic currents. Factors contributing to neutral current include:

- Unequal capacitance between phases of the capacitor bank (This may result from manufacturing tolerances or the partial failure of individual capacitor units.)
- A voltage imbalance between individual phases of the distribution circuit
- Harmonic distortion of the line current (A variety of sources can cause harmonic distortion, such as lightning, welding, solid state variable speed drives, and equipment using switching power supplies.)
- The opening or disconnection of one or two phases of the capacitor bank caused by a blown fuse, a failed switch, or defective wiring

Configure the capacitor control to detect abnormal levels of neutral current and generate alarms, both in **Automatic Operation** mode and in **Manual Operation** mode. If desired, a capacitor control in **Automatic Operation** mode can also take appropriate corrective action. See the *Setup>Neutral Sensor* screen in S&C Instruction Sheet 1024-530, "IntelliCap® 2000 Automatic Capacitor Control: *Setup*," for details. Maintenance personnel can then diagnose and correct the identified problem.

WARNING

The individual capacitor units retain a high-voltage charge for several minutes after they are disconnected and must be short circuited and grounded before running tests. To avoid risk of serious injury only trained personnel should clear and test the capacitors.

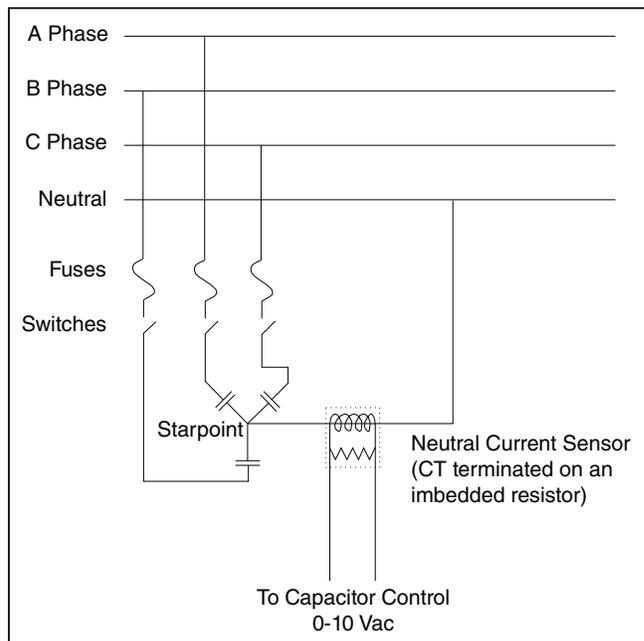


Figure 7. Neutral current sensor and wye-connected bank with starpoint.

The capacitor control uses the following logic to determine when to trigger the **Neutral Current** alarm:

- STEP 1.** The capacitor control monitors current flowing between the starpoint and the system neutral and ground.
- STEP 2.** When the control senses current flow has exceeded the **Neutral Current Alarm Level** threshold, it starts the **Neutral Current Change Time Threshold** timer.

The capacitor control uses the following logic to determine when to trigger the **Neutral Current** alarm:

- STEP 1.** The capacitor control monitors current flowing between the starpoint and the system neutral and ground.
- STEP 2.** When the control senses current flow has exceeded the **Neutral Current Alarm Level** threshold, it starts the **Neutral Current Change Time Threshold** timer.
- STEP 3.** If the neutral current remains continuously above the setpoint for the duration of the timer, the control takes one of the following actions:
 - When the **Neutral Current Corrective Action** setpoint is disabled, the capacitor control displays error messages on the *Operation* and *Diagnostics>Alarms* screens, and ****Active Alarms**** on the LCD screen. The **Automatic Operation** mode is disabled until someone clears the alarm from the faceplate or from the *Diagnostics>Alarms* screen
 - When the **Neutral Current Corrective Action** setpoint is enabled and there was no recent switching activity (see Instruction Sheet 1024-530, “IntelliCap 2000 Automatic Capacitor Control: *Setup*”), the capacitor control takes the bank offline, if it is not already offline. The capacitor control displays error messages on the *Operation* and *Diagnostics>Alarms* screens, and ****Active Alarms**** on the LCD screen. **Automatic Operation** mode is disabled until someone clears the alarm from the faceplate or from the *Diagnostics>Alarms* screen
 - When the **Neutral Current Corrective Action** setpoint is enabled and there was recent switching activity, the capacitor control tries to reverse the last action after the Reclose Block delay, if applicable

When the **Neutral Current Retry** setting is also enabled, the control operates the bank again. If the neutral current level is normal, the alarms clear and the control returns to normal operation. Otherwise, the control returns the bank to the **Corrective Action** state. The **Automatic Operation** mode is blocked until someone clears the alarm from the faceplate or from the *Diagnostics>Alarms* screen. The capacitor control displays error messages on the *Operation* and *Diagnostics>Alarms* screens and ****Active Alarms**** on the LCD screen.

When the **Neutral Current Retry** setting is disabled, the control blocks the **Automatic Operation** mode after the corrective action. The capacitor control displays error messages on the *Operation* and *Diagnostics>Alarms* screens and ****Active Alarms**** on the LCD screen.

Automatic Operation mode is disabled until someone clears the alarm from the faceplate or from the *Diagnostics>Alarms* screen.

Note: If a switch-out attempt triggers the **Neutral Current** alarm and the **Neutral Current Corrective Action** setpoint is enabled, the capacitor control switches the bank back online in case one of the bank switches did not operate correctly. The control does this to avoid system imbalances caused by only some of the phases being online.

- STEP 4.** In addition, if the control detects a **Zero Neutral Current** condition for a period of time specified by the **Zero Neutral Current Detection** threshold (if enabled), it sets the **Zero Neutral Current** alarm. The control does not try any corrective action and does not lockout the bank. The alarm clears when the **Zero Neutral Current** condition clears or when a **Lockout Reset** procedure is performed.
- STEP 5.** The user may select whether the control alarms on the Fundamental (60 Hz) component of the neutral current or on its **Total RMS** value. The user may also select if the control data logs **Fundamental** or **Total RMS** values.

NOTICE

Do not enable **Automatic Operation** mode until the condition that triggered the **Neutral Current** alarm is cleared.

When trying to reset the alarm and the condition is still present, the alarm messages become active again.

Neutral Voltage Detection

The **Neutral Voltage Sensing** option allows the capacitor control to monitor and take action on abnormal levels of voltage on the starpoint of an ungrounded, wye-connected bank. See Figure 8 on page 27. The sensed voltage is the vector sum of the three capacitor phase voltages plus harmonic voltages. Factors contributing to neutral voltage include:

- Unequal capacitance between phases of the capacitor bank (This may result from manufacturing tolerances or the partial failure of individual capacitor units.)
- A voltage imbalance between individual phases of the distribution circuit
- Harmonic distortion of the line voltage (A variety of sources can cause harmonic currents, which can cause harmonic voltage distortion. Examples include lightning, welding, solid state variable speed drives, and equipment using switching power supplies.)
- The opening or disconnection of one or two phases of the capacitor bank due to a blown fuse, a failed switch, or defective wiring

Configure the capacitor control to detect abnormal levels of neutral voltage and generate alarms, both in **Automatic Operation** mode and in **Manual Operation** mode. If desired, a capacitor control in **Automatic Operation** mode can also take appropriate corrective action. See the *Setup>Neutral Sensor* screen in Instruction Sheet 1024-530, “IntelliCap 2000 Automatic Capacitor Control: *Setup*,” for details. Maintenance personnel can then diagnose and correct the identified problem.

⚠ WARNING

The individual capacitor units retain a high voltage charge for several minutes after they are disconnected and must be short circuited and grounded prior to running tests. To avoid risk of serious injury only trained personnel should clear and test the capacitors.

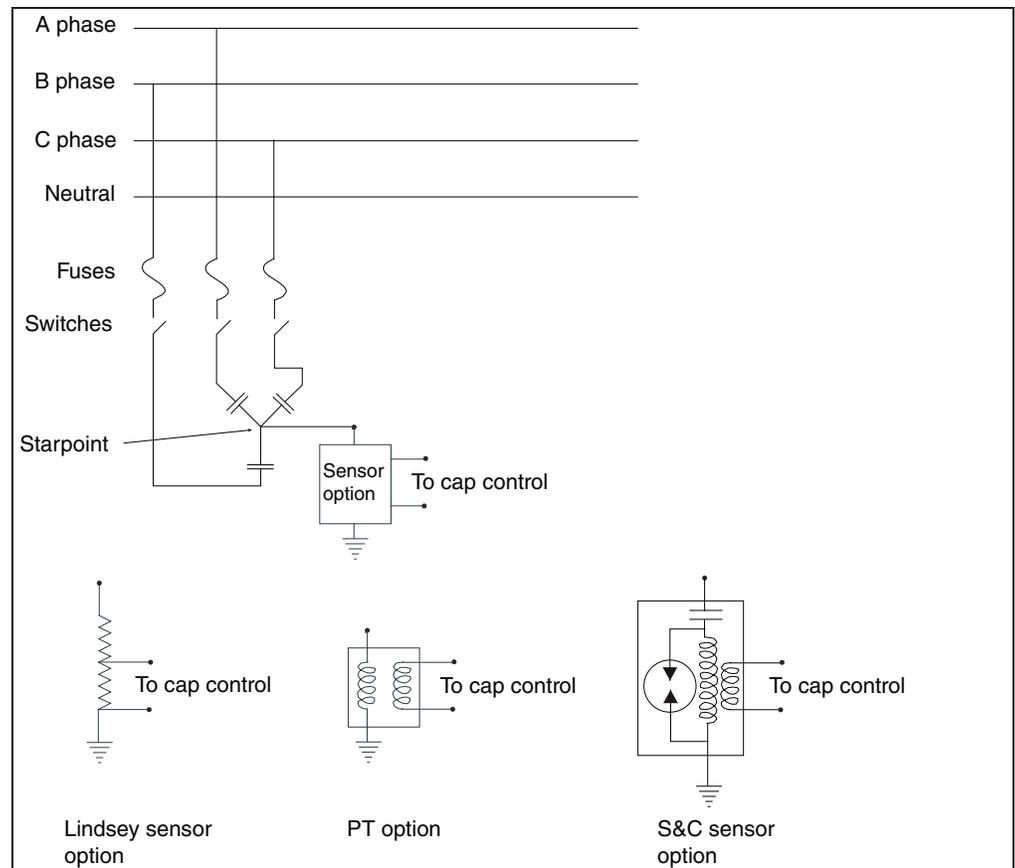


Figure 8. The neutral voltage sensor and wye-connected bank with starpoint.

The capacitor control uses the following logic to determine when to trigger the **Neutral Voltage** alarm:

- STEP 1.** The capacitor control monitors the voltage between the starpoint and ground.
Note: Neutral voltage monitoring begins 5 minutes after opening the capacitor bank so trapped voltages can discharge.
- STEP 2.** When the control senses voltage has exceeded the **Neutral Voltage Alarm Level** threshold, it starts the **Neutral Voltage Change Time Threshold** timer.
- STEP 3.** If the neutral voltage remains continuously above the setpoint for the duration of the timer, the control takes one of the following actions:
- When the **Neutral Voltage Corrective Action** setpoint is disabled, the capacitor control displays error messages on the *Operation* and *Diagnostics>Alarms* screens and the **Active Alarms** field on the LCD screen. **Automatic Operation** mode is disabled until someone clears the alarm from the faceplate or from the *Diagnostics>Alarms* screen.

- When the **Neutral Voltage Corrective Action** setpoint is enabled and there was no recent switching activity (see S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*”), the capacitor control takes the bank offline if it is not already offline. The capacitor control displays error messages on the *Operation* and *Diagnostics>Alarms* screens and the **Active Alarms** field on the LCD screen. **Automatic Operation** mode is disabled until someone clears the alarm from the faceplate or from the *Diagnostics>Alarms* screen.
- When the **Neutral Voltage Corrective Action** setpoint is enabled and there was recent switching activity, the capacitor control tries to reverse the last action after the **Reclose Block** delay, if applicable.

When the **Neutral Voltage Retry** function is also enabled, the control operates the bank again. If the Neutral Voltage level is normal, the alarms clear and the control returns to normal operation. Otherwise, the control returns the bank to the **Corrective Action** state. **Automatic Operation** mode is blocked until someone clears the alarm from the faceplate or from the *Diagnostics>Alarms* screen. The capacitor control displays error messages on the *Operation* and *Diagnostics>Alarms* screens, and the **Active Alarms** field on the LCD screen.

When the **Neutral Voltage Retry** function is disabled, the control blocks the **Automatic Operation** mode after the corrective action. The capacitor control displays error messages on the *Operation* and *Diagnostics>Alarms* screens, and the **Active Alarms** field on the LCD screen. **Automatic Operation** mode is disabled until someone clears the alarm from the faceplate or from the *Diagnostics>Alarms* screen.

Note: If a switch-out attempt triggers the **Neutral Voltage** alarm and the **Neutral Voltage Corrective Action** setpoint is enabled, the capacitor control switches the bank back online in case one of the bank switches did not operate correctly. The control does this to avoid system imbalances caused by only some of the phases being online.

- STEP 4.** In addition, if the control detects a **Zero Neutral Voltage** condition for a period of time specified by the **Zero Neutral Voltage Detection** threshold (if enabled), it sets the **Zero Neutral Voltage** alarm. The control does not try any corrective action and does not lock out the bank. The alarm clears when the **Zero Neutral Voltage** condition clears or when a **Lockout Reset** procedure is performed.
- STEP 5.** The user may select whether the control alarms on the Fundamental (60 Hz) component of the neutral voltage or on its **Total RMS** value. The user may also select whether the control data logs **Fundamental** or **Total RMS** values.

NOTICE

Do not enable **Automatic Operation** mode until the condition that triggered the **Neutral Voltage** alarm is cleared.

If the condition is still present and the alarm is reset, the alarm messages become active again.

SCADA Override Strategy

When the **SCADA Override** setpoint is enabled via the IntelliLink software or a SCADA command, the SCADA master station can choose the capacitor bank state and the voltage range in which the **SCADA Override** function is active. The capacitor control uses the following logic to determine when to switch the capacitor bank:

- STEP 1.** The SCADA master station sends a **Close** or **Open** request to the capacitor control.
- STEP 2.** The control switches the bank and stays in that state for the length of the **SCADA Override Timeout Threshold** setting. If the setpoint is set to the **Latched** setting, the control remains in that state indefinitely, except during **Voltage Override** conditions. If the control does not receive a new **SCADA Override** command during this time period, the **SCADA Override** state ends and the control returns to its regular **Automatic** strategy.
- Note:** The control will not switch the capacitor bank if the control is already in **Voltage Override** mode or if switching would put it into **Voltage Override** mode. If the voltage later returns to a level where switching is allowed and the **SCADA Override** function is still active, the control remembers the SCADA command and switches the bank.
- STEP 3.** If the **Use the Following Voltage Overrides** setpoint is set to the **Yes** setting, the control uses the **Voltage Override** values on the *Setup > Communications > SCADA Override* screen while the **SCADA Override** state is active. Otherwise, it uses the **Voltage Override** values for the present season.
- Note:** The voltage must remain in a range where switching the capacitor bank will not cause a **Voltage Override** condition. Otherwise, to avoid excessive cycling, the control will not switch the bank. See the “Voltage Override Operation” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*,” for details.

Detecting Switching Errors

Use the voltage and/or var values before and after switching in the *Voltage Levels During Switching* and *Kvar Levels During Switching* screens to find possible switching errors.

Note: These screens do not exist now but will be included in a future software release. Voltage and kvar levels are now shown on the *Logs > Historic Log* screen.

An **Error** condition exists when the change in voltage (ΔV) is less than the **Minimum Percentage of Average Delta Voltage** threshold over the last four switching operations or if the change in kvars (Δkvar) is less than the **Minimum Percentage of Average Delta kvars** threshold over the last four switching operations. These percentages are set on the *Setup > General > Site-Related > Bank-Related* screen.

If the average ΔV is at least 0.80 V, the capacitor control can use ΔV to detect errors. If current sensors are on the source side of the bank, it can use Δkvar . When conditions are favorable for both methods, the capacitor control uses ΔV and Δkvar and flags an error only when they agree that an error occurred. If conditions are favorable for one method only, the control uses that method to flag errors.

Note: For error-detection analysis, the capacitor control does not use the ΔV and Δkvar from a forced retry (the attempt to manually switch the bank into the state already indicated).

High/Low Voltage Band Error Operation

The **High-/Low-Voltage Band Error** condition occurs when the Bank Voltage Change + Margin (BVC+M) voltage exceeds the voltage difference of the **Season Strategy High-/Low-Voltage Override** setpoints on the *Setup>Seasons* screen. When this condition occurs, the **High-/Low-Voltage Band Error** condition is set. The **Control Status** display on the IntelliLink *Operations* screen shows “ERROR.” The **High-/Low-Voltage Band Error** condition status is reported on the *Diagnostics>Error* screen and the *Logs>Status Point Log* screen. The **Emergency High-/Low-Voltage Override** modes are used in place of the **Season Override** mode while the **High-/Low-Voltage Band Error** condition is active. When the condition persists continuously for the duration of the **High-/Low-Band Lockout Time Threshold** timer, the **High-/Low-Voltage Band Lockout** error is set.

When either the High-/Low-Voltage Band Lockout or the Emergency High-/Low-Voltage Band Lockout error is set, automatic operation of the bank switch is inhibited, except to allow the bank switch to open for a **High-Voltage** condition. This status is reported on the *Diagnostics>Error* screen and the *Logs>Status Point Log* screen. The High-/Low-Voltage Band Lockout error is also set if either **Emergency Voltage Override Time Threshold** setting is in the **Disabled** state or the BVC+M value is greater than the difference of the **Emergency High-/Low-Voltage Override** settings, during a **High-/Low-Voltage Band Error** condition.

The **High-/Low-Voltage Band Error** condition will automatically clear if the BVC+M value is being automatically calculated, and subsequent switch operations result in the calculated BVC+M value becoming less than the difference of the **Season Strategy High-/Low-Voltage Override** settings. The High-/Low-Voltage Band Lockout error cannot be automatically cleared.

Faceplate Operation States

The state of the faceplate LEDs determines which method(s) can be used to switch the capacitor bank in and out. Table 4 shows the possible combinations and how each affects the ability to operate the bank.

Table 4. Capacitor Bank Operation and Control States

Faceplate State		Control Operating Mode	Operate Bank From		
Operation Mode	SCADA Control		Faceplate	Operation Screen (IntelliLink software)	SCADA Master Station
Manual	Local	Manual	Yes	Yes	No
Manual	Remote	SCADA	No	Yes	Yes
Auto	Local	Automatic	No	No	No
Auto	Remote	Automatic	No	No	Yes

The following rules apply for whatever method used to switch the bank:

- An energized capacitor bank cannot be reclosed until the **Reclose-Block** timer expires after the bank is opened. The **Reclose Block** feature provides time for the capacitor charge to bleed off. The bottom line of the LCD screen and the **Reclose Block** field on the *Operation* screen show the time remaining until the control can switch in the bank. The OPEN LED on the faceplate blinks slowly when the **Reclose Block** state is in effect. (For details about cancelling the **Reclose Block** function during in-shop testing, see S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*.”)
- The **Manual-Operation Delay** setpoint on the *Setup>General>Site-Related>Operation* screen (for both opening and closing the bank) can be configured to allow time for an operator to step away from the bank after pressing the CLOSE or OPEN button. When this delay is set, the CLOSE or OPEN LED starts blinking to indicate the pending action. The operation can be cancelled at any time before the **Manual-Operation Delay** timer expires by switching to the **Auto Operation** mode.

Note: When an operation is manually cancelled, be sure to set the **Manual** mode to prevent the bank from switching automatically.

- The red CLOSE LED illuminates when the capacitor bank switch is closed; it blinks while the **Reclose-Block Timer** is running. The green OPEN LED illuminates when the capacitor bank switch is open; it blinks while the **Reclose-Block** timer is running.
- When powering-up the capacitor control for the first time or if the control software has been reloaded (not updated), the LEDs do NOT indicate the bank state until a switching operation has been performed. To make the LEDs indicate the bank state, operate the bank manually or wait for an automatic operation to occur. If the capacitor control was in **Manual** mode and set to **Automatic** mode, it waits 60 seconds before switching. This allows the operator to step away from the bank before it operates

Manual Operation

NOTICE

When the MANUAL and LOCAL LEDs are on, the capacitor control blocks **Automatic** and **SCADA** operation of the capacitor bank. The bank can only be operated from the faceplate or from the *Operation* screen.

To use the faceplate buttons to switch the capacitor bank in or out:

STEP 1. Confirm that:

- (a) The faceplate LCD screen shows ****Unit OK****. If the display does not show ****Unit OK****, see the “Faceplate” section on page 7.
- (b) The OPEN LED is NOT blinking, If the OPEN LED is blinking slowly, the **Reclose Block** timer is running. Wait until blinking stops before trying to switch the bank.
- (c) The MANUAL LED is lit. When the AUTO LED is lit, pressing the CLOSE or OPEN button has no effect.
- (d) The LOCAL LED is lit.

STEP 2. Following company procedures, press the CLOSE or OPEN button on the faceplate to operate the capacitor bank.

- (a) To transmit a **Close** command to the capacitor bank switch, press the CLOSE button.
- (b) To transmit an **Open** command to the capacitor bank switch, press the OPEN button.

Local Bank Operation with IntelliLink Software

To use IntelliLink software to switch the capacitor bank:

STEP 1. On the *Operation* screen, confirm that:

- (a) The OPEN LED is NOT blinking. If the OPEN LED is blinking slowly, the **Reclose Block** timer is running. Wait until blinking stops before trying to switch the bank.
- (b) The MANUAL LED is lit. If the AUTO LED is lit, clicking the **Close** or **Open** field has no effect.
- (c) The LOCAL LED is lit.

STEP 2. Following company procedures, click on the **Close** or **Open** field on the *Operation* screen to operate the capacitor bank.

- (a) To transmit a **Close** command to the capacitor bank switch, click the **Close** field.
- (b) To transmit an **Open** command to the capacitor bank switch, click the **Open** field.

Remote Bank Operation from the SCADA Master Station or WinMon Graphical User Interface Software

The capacitor bank can be closed or opened from a SCADA master station or with S&C WinMon software. The control must be in **Remote** mode (the REMOTE LED is lit) to accept commands from the SCADA master station or the WinMon software. For more information about WinMon Graphical User Interface Software, contact your local S&C Sales Representative.

Automatic Operation

To enable automatic operation of the capacitor bank, confirm the faceplate AUTO LED is lit. The software in the capacitor control switches the bank automatically, based on the values entered when the control was configured. For an explanation of the available switching strategies, see the “Control Strategies” section on page 13.

High-Low Graphs

The *Graphs>High-Low* screen contains graphs that plot the high and low values for Voltage, Temperature, Current, Power Factor, kvar, kW, and Neutral Sensor. Each graph is a first-in first-out buffer showing the most data the time line allows.

The displayed data cannot be extracted from the *Graphs* screens. However, 52 Daily High-Low files can be downloaded from the Metering Data folder by opening the **Tools** drop-down menu and then clicking on the Compact Flash Access entry. Any of the 52 files can be selected and saved. Use the **Modification Time** field to find the most recent data. Use the S&C WaveWin program to view the file content and export data to a .csv file.

The control automatically scales each graph to show as much detail as possible.

Note: Generation of the Power Factor high and low values uses the **Power Factor Sign Convention** setpoint on the *Setup>General>Site-Related* screen.

Sensor Profile Graphs

The *Graphs>Sensor Profiles* screen contains graphs that plot the daily averaged values for Voltage, Temperature, Current, Power Factor, kvar, kW, and Neutral Sensor. Each graph is a first-in, first-out buffer showing the most recent data the timeline allows. The **Time Average for Metering** function is configured on the *Setup>General>Site-Related>Log* screen. See Figure 9 on page 35.

The displayed data cannot be extracted from the *Graphs* screens. However, 30 Daily High-Low files can be downloaded from the Metering Data folder by opening the **Tools** drop-down menu and then clicking on Compact Flash Access entry. Any of the 30 files can be selected and saved. Use the **Modification Time** field to find the most recent data. Use the S&C WaveWin program to view the file content and export data to a .csv file.

Note: Neutral sensor data may be logged as either Fundamental or Total RMS data, which is selected on the *Setup>General>Sensor Configuration>Neutral Current Sensor* screen with the **Alarm Base Component** setting.

Note: Generation of the Power Factor graph uses the **Power Factor Sign Convention** setpoint on the *Setup>General>Site-Related* screen.

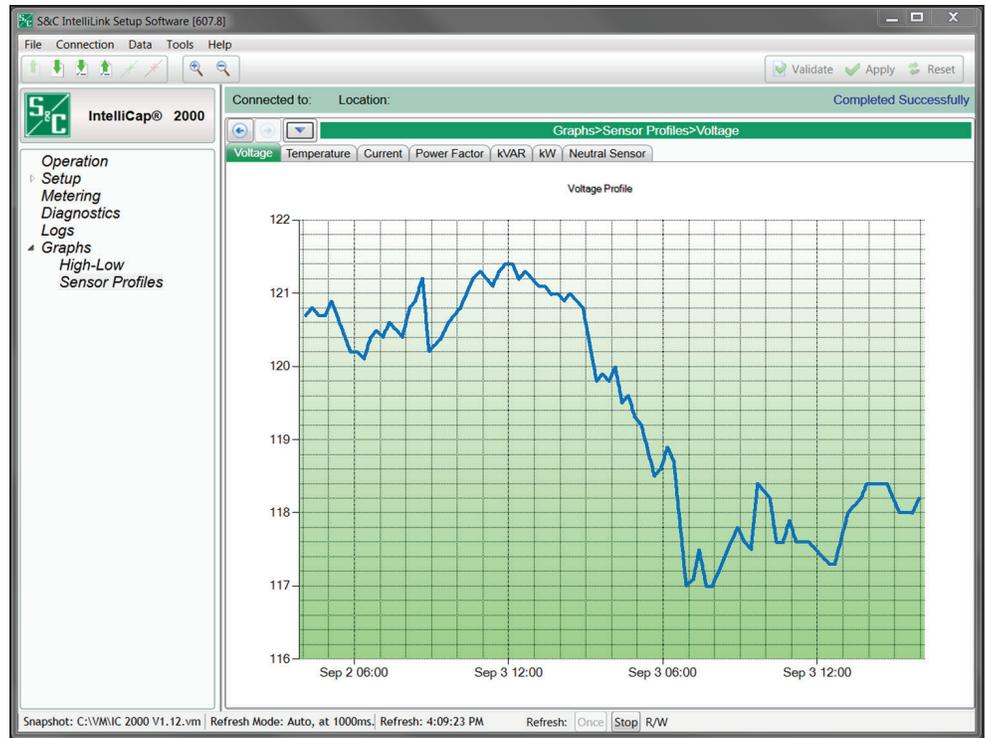


Figure 9. The Graphs>Sensor Profiles>Voltage screen.

Use the **Report** feature to save the control software settings and stored data to the computer as a comma-separated value (CSV) file. The report can be kept as a permanent record and the report data used in spreadsheets or other program types.

Follow these steps to use the **Report** feature:

STEP 1. Connect the computer to the capacitor control and start the IntelliLink software.

For details, see the “To Start the IntelliLink Software” section in Instruction Sheet 1024-530, “IntelliCap 2000 Automatic Capacitor Control: *Setup*.” If the computer is already connected to the capacitor control, skip this step.

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

STEP 3. In the dialog box, select the type of report to be generated. Then, click on the **OK** button. There are four types of reports:

- (a) **Full**—Includes all the information contained in the capacitor control
- (b) **System Setup and Operation**—Contains the configuration data for the capacitor control
- (c) **Troubleshooting Information**—Contains the information recorded in the troubleshooting logs
- (d) **Historical Data**—Contains the daily statistics, sensor profiles, switching data, and log of power outages

STEP 4. In the Save Report dialog box, specify the name and location for this report. Then, click on the **OK** button. If a file location is not specified, the file is saved to the same directory as the program files for this type of control (for example, the default location for PCSD1-S report files is C:\S&C Electric\PCSD--S\). The extension “.csv” is added automatically.

STEP 5. When the report is complete, the **Task completed** message appears on the status line of the Writing Report dialog box.

When several capacitor controls use a similar setup configuration, the configuration file can be saved from one control and load into the others, replicating the saved configuration. Then, specific setpoints can be manually adjusted in each control.

A configuration file should be used with control software that is the same revision as the software used to create the configuration file. However, a file created by a different software revision can be used. Software revisions may add setpoints for new features. If the configuration file was created with older software, only the setpoints available in the older software will be configured, and setpoints for new features will be set to the default value. If newer software created the configuration file, setpoints not present in the target control will not be added by the configuration file.

NOTICE

With firmware version 2.3.x and later, the default passwords for all user accounts, including the admin account, must be changed before IntelliLink software can connect to and configure a control. See S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*,” for more information.

Saving a Setup Configuration

To save a setup configuration:

- STEP 1.** Determine which capacitor control contains the configuration to be saved.
- STEP 2.** Connect the computer to the selected control and start IntelliLink software.
For details, see the “Start IntelliLink Software” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*.” If the computer is already connected to the capacitor control, this step can be skipped.
- STEP 3.** Click on the **File** button. Then, click on the **Save Setpoints** button. The Save Setpoints dialog box will open.
- STEP 4.** In the Save Setpoints dialog box, specify a name and location for this configuration file, select the setpoints to include, and then click on the **Save** button.

If a location does not need to be specified, the file is saved to the same directory as the program files for this type of control (for example, the default location for PCSD1-S report files is C:\S&C Electric\PCSD--S\). The extension “.cfg” is added automatically.

Note: This process does not save the information on the *Setup>General>Site-Related>Device* screen.

Loading a Saved Configuration

Follow these steps to load a saved configuration:

- STEP 1.** If necessary, connect the computer to the capacitor control where the configuration is to be loaded. Then, start the IntelliLink software.
For details, see the “Start IntelliLink Software” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*.” If the computer is already connected to the capacitor control, skip this step.
- STEP 2.** From the **File** menu, choose the **Load Setpoints** option.
- STEP 3.** In the dialog box, select the “.cfg” file for the configuration to be loaded. Then, click on the **Open** button.

STEP 4. Make any setpoint changes that are required for this capacitor control.

For details, see Instruction Sheet 1024-530, “IntelliCap 2000 Automatic Capacitor Control: *Setup*.”

When loading a configuration file that was saved from a previous software revision, it may not configure all the setpoints included with the newer software. The older configuration file will successfully load the data it contains, and the new setpoints will remain set at their default values. If the default values need to be changed, they must be manually configured. Refer to the ReadMe.txt file included with the new software for information about newly added setpoints.

NOTICE

Be sure to enter the correct values on the *Setup>General>Site-Related>Device* and the *Setup>Communications* screens.

Using a Screenset

To view the IntelliLink software screens and Help file without connecting to a control or a snapshot:

- STEP 1.** Start the IntelliLink software on the computer.
- STEP 2.** During startup, click on the **Cancel** button to close the Connect dialog box.
If the IntelliLink software is already running, choose the **Disconnect** option from the **Connection** menu. Then, screenset from memory.
- STEP 3.** From the **File** menu, choose the **Open Screenset** option.
- STEP 4.** In the Open Screenset dialog box, find and select the .WMN file whose name matches the version name on the setup software for this control.

Saving a Snapshot

The operational and data-logging information can be saved in snapshots, which are “.vm” virtual memory files. The snapshots are used to view data, generate a report, and save or change setpoint configuration files, even when the computer is not connected to a capacitor control. To access the stored information, connect to the snapshot instead of the physical control. Capacitor control setup software includes a sample snapshot.

To save control settings and data to a snapshot:

- STEP 1.** Connect the computer to the capacitor control from which the information is to be saved. Then, start the IntelliLink software.
For details, see the “Start IntelliLink Software” section in S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*.” When the computer is already connected to the capacitor control, skip this step.
- STEP 2.** From the **File** 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 file location is not specified, the file is saved to the same directory as the program files for this type of control (for example, the default location for PCSD1-S report files is C:\S&C Electric\PCSD—S). The extension “.vm” is added automatically.

Viewing a Snapshot

To view (connect to) a snapshot:

- STEP 1.** Start the IntelliLink software on the computer. During startup, click on the **Cancel** button to close the Connect dialog box.
If the IntelliLink software is already running, choose the **Disconnect** option from the **Connection** menu. Then, choose the **Close Screenset** option from the **File** menu to clear the present screenset from memory.
- STEP 2.** From the **File** menu, choose the **Open Snapshot** option. The Open Controller Data File dialog box opens.
- STEP 3.** Select the snapshot to use. Then, click on the **Open** button.
- STEP 4.** If planning to change the configuration settings in the snapshot, click on the **Yes** button at the Connect to File dialog box. To avoid accidentally changing a setting, click on the **No** button.
The IntelliLink software opens and displays the contents of the selected snapshot.

Using a Snapshot

To save any 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.

To generate a report from a snapshot

Follow the same procedure as when connected to a capacitor control. For details, see the “Generating Reports” section on page 36.

To create a CFG file from a snapshot

This procedure allows preparing a setpoint configuration for a control in the field while there is no access to a comparable control:

STEP 1. Connect to the snapshot.

For details, see the “Viewing a Snapshot” section on page 39.

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

For details, see S&C Instruction Sheet 1024-530, “IntelliCap® 2000 Automatic Capacitor Control: *Setup*.”

STEP 3. From the **File** menu, choose the **Save Setpoints** option.

STEP 4. In the Save Setpoints dialog box, specify a name and location for this configuration file. Then, click on the **Save** button.

When a location to save the file is not specified, it is saved to the same directory as the program files for this type of control (for example, the default location for PCSD1-S report files is C:\S&C Electric\PCSD--S\). The extension “.cfg” is added automatically.

NOTICE

Be sure to enter the correct values on the *Setup>General>Site-Related>Device* and the *Setup>Communications* screens.

Occasionally, the software in a capacitor control may need to be updated. The update program, installed with IntelliLink software, easily replaces the existing control software with a newer revision.

NOTICE

The setpoint values and historical data stored in the capacitor control may be lost during the update process.

To capture the data, always generate all needed reports using the old IntelliLink and control software before updating the control software.

NOTICE

Starting with firmware later than version 2.3.x, settings validation will be performed at the beginning of the update process. If any validation errors are found, these must be corrected before upgrading the firmware. Otherwise the control settings may not be retained. If this occurs after the upgrade is complete, settings can be restored by uploading a saved IntelliLink software setpoint file to the control.

To update the software:

- STEP 1.** Install the contents of the new software installer on the computer.
For details, see the “Start IntelliLink Software” section in Instruction Sheet 1024-530, “IntelliCap 2000 Automatic Capacitor Control: *Setup*.”
- STEP 2.** Connect the computer to the USB port on the capacitor control.
- STEP 3.** Select the **IntelliLink** option from *Start>All Programs>S&C Electric* screen. See Figure 10 on page 42.

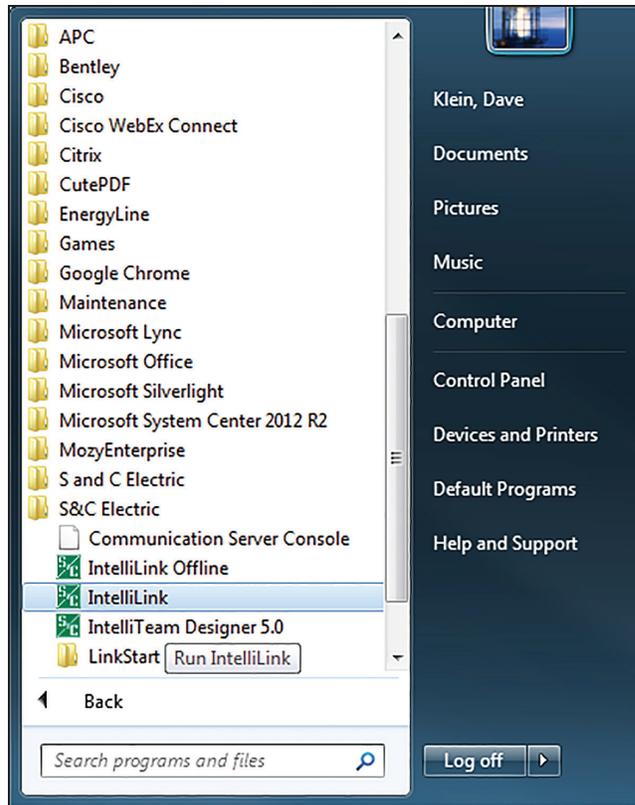


Figure 10. Start button program selection screen.

STEP 4. Select the **Local Connection** option. See Figure 11.

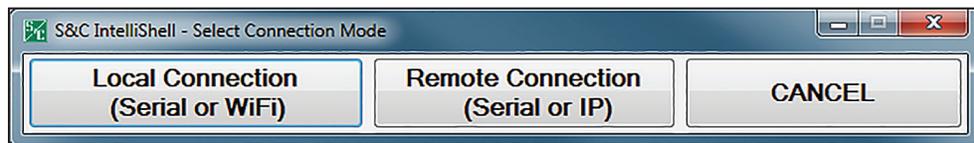


Figure 11. The IntelliShell connection program—Select Connection Mode dialog box.

STEP 5. Select the **IntelliCap 2000** option from the **Product Family** menu, and select either the **Serial** or the **Wi-Fi** button. See Figure 12 on page 43.

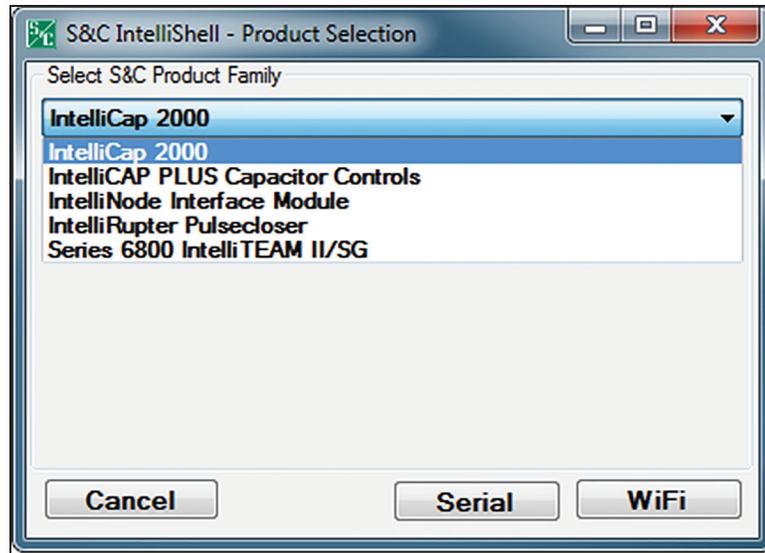


Figure 12. The IntelliShell connection program—Product Family selection dialog box.

STEP 6. Select the **Comm Port** option used to connect to the control, and select the **Update Firmware** button. See Figure 13.

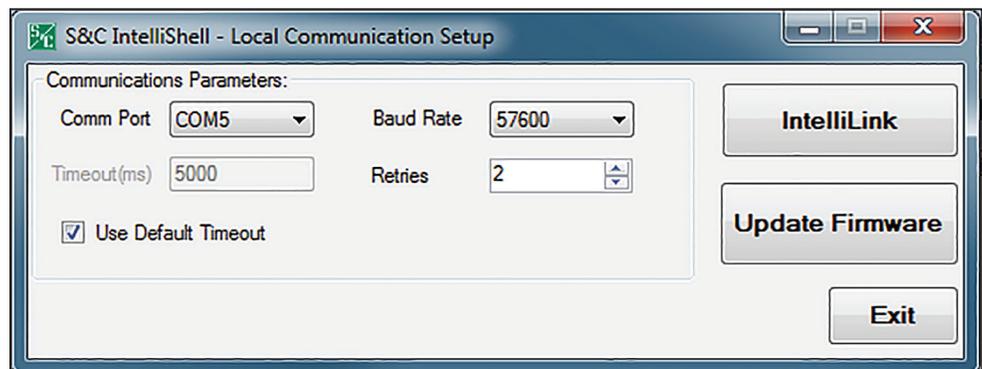


Figure 13. The IntelliShell connection program—Local Communication Setup dialog box.

STEP 7. Log in to the control and follow the dialog instructions. If prompted during the upgrade, enter the default username and password. See Figure 14 on page 44.

Note: If the upgrade is from 2.3.x to a later software release, enter the admin non-default password at this step.

Do not skip any of the software components unless instructed by S&C Electric Company to do so. If the default username and password are not known, contact S&C Electric Company.

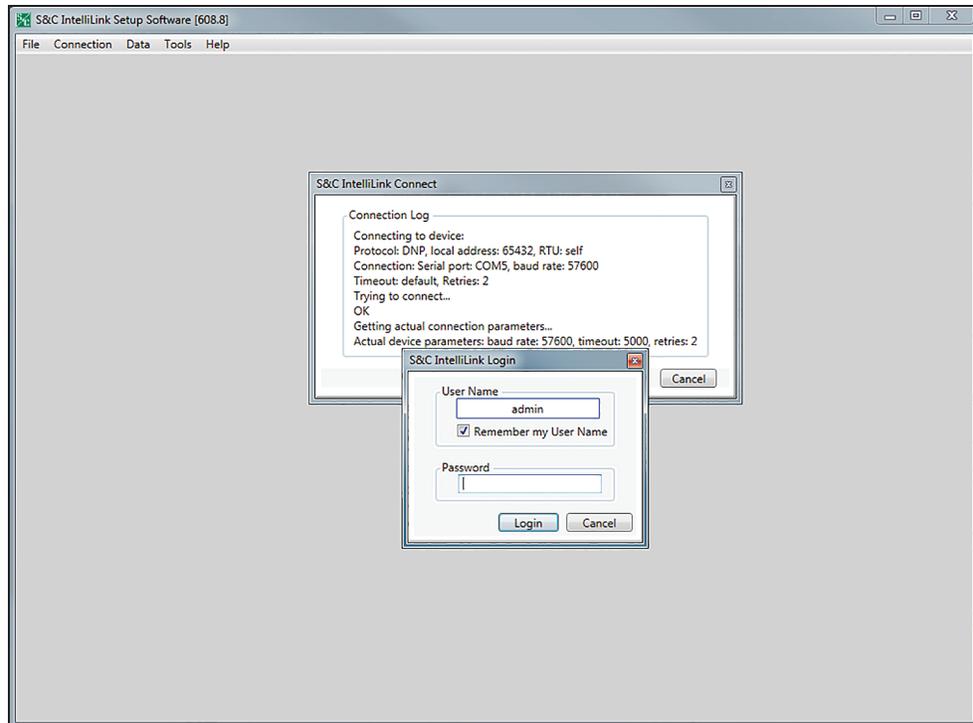


Figure 14. The IntelliLink Setup Software Login dialog box.

NOTICE

When upgrading the control software to version 2.3.x and later, the choice is offered to retain the passwords or revert to default passwords. When retaining passwords, the admin password must not be the default password and must meet the new complexity requirements. When reverting to default passwords, all default passwords must be changed at the initial login after the upgrade. See S&C Instruction Sheet 1024-530, "IntelliCap® 2000 Automatic Capacitor Control: *Setup*," for more information.

The following describes the process for converting IntelliCap Plus Automatic Capacitor Control settings for use with an IntelliCap 2000 Automatic Capacitor Control:

Note: Windows® PowerShell version 3 or later will be required to execute this procedure.

STEP 1. Click on the **Windows Start** menu. Open the Accessories>Windows Powershell folders, and run Windows Powershell ISE (x86) program. See Figure 15.

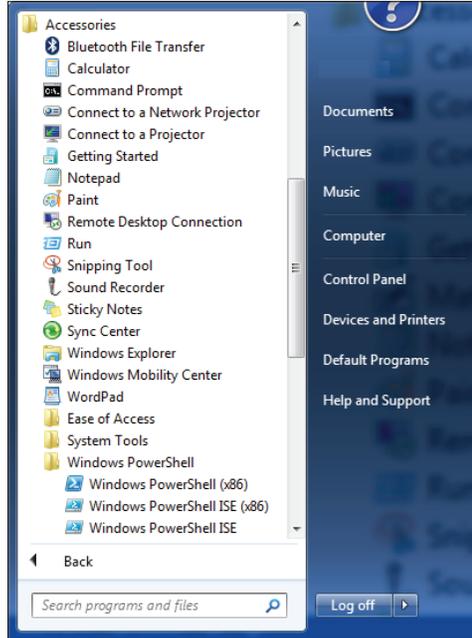


Figure 15. The Windows Accessories drop-down menu.

Note: If Windows PowerShell ISE is accidentally chosen, the script will end with a message reporting an error.

STEP 2. Select the **File Open** option on the main menu and open the UpgradeICPlus-toIC2000.ps1 script file. See Figure 16 on page 46. The file is located at: C:\Program Files (x86)\S&C Electric\Products\IC2000\Firmware\Upgrades\UpgradeICPlustoIC2000.ps1.

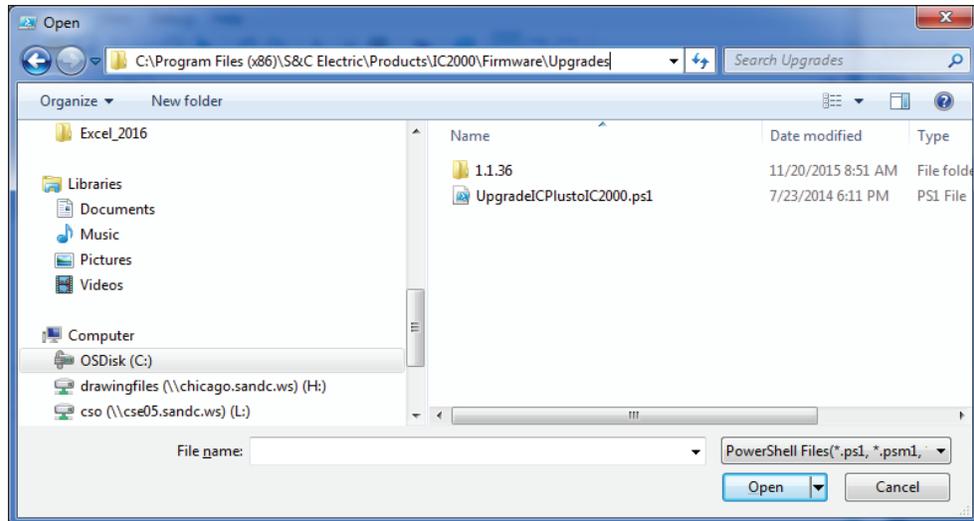


Figure 16. The IntelliCap Plus control firmware upgrade window.

- STEP 3.** Press the <F5> key to run the upgrade script. A file selection dialog box will open. Choose the IntelliCap Plus control settings to be converted. The IntelliCap Plus control setting files have a file extension of .cfg. The default location for these files is C:\ELINE\PCVD--S. More than one at a time can be chosen to upgrade. After selecting the desired files, click on the **Open** button.
- STEP 4.** As the script is running, the progress is logged in a blue window within the PowerShell window. When the script is finished, a log file opens to show which files were converted, what the resulting IntelliCap 2000 control .xspt settings files are named, and where they are located. The files are time-stamped.
- STEP 5.** To upgrade a device with a converted settings file, connect to the device with IntelliLink software, and choose the **Load Settings** option. See Figure 17. Choose the file to load, and select which groups of settings to load.

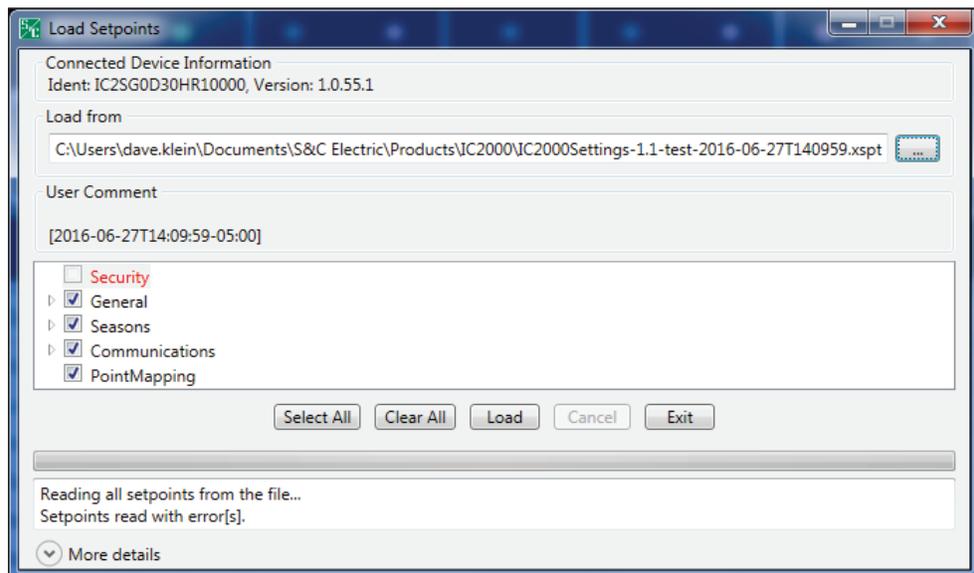


Figure 17. The Load Setpoints setting type selection dialog box.