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Raising the Standard Across the Line

Joslyn Hi-Voltage

Zero Voltage Closing Control
(**VSV Switch**)
Instruction Manual

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Introduction

> ***Note: This updated Instruction Manual applies to enhanced VSV Zero Voltage Closing systems purchased and received from Joslyn Hi-Voltage after November 1999 (Joslyn Serial Numbers 99753 and newer with the first two digits representing the year code) or controls that have been upgraded in the field.***

The Joslyn Zero Voltage Closing (ZVC) control is a state-of-the-art microprocessor based capacitor control. The purpose of the Zero Voltage Closing system is to virtually eliminate capacitor energization transients by independently energizing each phase of the capacitor bank coincident with the occurrence of the phase's zero system voltage reference point.

The expected benefits include:

- Increased "power quality" by utilizing capacitor switching with significantly reduced voltage spikes which are a nuisance to sensitive equipment such as computers and adjustable speed drives.
- Increased capacitor and switch life.
- Reduction of induced voltages into the low voltage control wiring.
- Reduction of station ground transients and reduction of distribution ground transients.

The normal operating mode consists of the control monitoring an external close command input. When a close command is received the control then issues close commands to the individual switch poles so the contact closing of each pole occurs at a point that corresponds to the zero voltage crossing reference of that phase. The actual closing sequence of the poles is selected to minimize the time from first pole closure to last pole closure. A selected reference phase of the system voltage is used for determining the zero voltage crossing information and an internal calibration process is used for determining accurate closing time requirements. Using this information the microprocessor determines the individual close command delays required to ensure pole closures at points corresponding to the system zero voltage crossing.

The ZVC control is designed to provide accurate, independent pole closing time control. Based on detailed system studies and sophisticated system testing, the control is designed to automatically close the switches at strategic points that correspond to the zero voltage crossing and the bank's configuration. For a grounded bank configuration, the capacitor phases are energized at a target 0.3 milliseconds after each respective phase zero voltage crossing point. For Ungrounded capacitor bank configurations, the control initiates the first pole to close 0.3 milliseconds after the zero voltage crossing reference point. The second pole automatically closes 0.3 milliseconds after the voltage difference between the first and second phases is zero (which occurs 30 electrical degrees after the first poles zero voltage crossing point). The third pole is closed at 0.3 milliseconds after the zero voltage crossing reference point associated with that phase. The microprocessor control circuitry is intentionally designed to energize at these timing points to allow for any switch variations to have minimal affects on the intended transient reduction results.

A timing accuracy of +/- 0.75 milliseconds, with respect to the zero voltage crossing point, is expected to be maintained after initial set-up of the control system. With this level of accuracy and control, overvoltages can be reduced from a theoretical maximum of 2 per unit voltage to 0.1 per unit voltage. Also, overcurrents can be reduced to less than 0.2 per unit current of the maximum theoretical inrush currents that ranged from 40-100 per unit current for back-to-back capacitor bank switching and 5-20 per unit current for single bank switching.

Features Description

1.) Zero Voltage Closing

The Zero Voltage Closing control accepts the normal close command from an external signal, typically a capacitor controller or a manual control switch. Each single phase VSV is internally given separate close commands so that each switch contact closure occurs at a programmed target related to the zero voltage reference point.

2.) Low Close Energy

Each individual VSV switch is provided with consistent close energy from charged capacitors located in the control. The voltage on the close capacitors (one for each phase) is monitored and maintained by the microprocessor in the control. If a close command is received and proper close capacitor voltage cannot be attained, a “Low Capacitor Energy” error occurs. A repeating single flash of the “Calibrated” LED and a solidly illuminated “Self Check” LED indicates this error. When this error occurs, all close operations are blocked. The error will automatically clear itself when the proper capacitor close voltage is attained.

<u>Operating Note:</u>
*If desired, the capacitor voltage can be measured for each phase in the field by utilizing the test terminals points located in the upper right corner of the control and just above the front display panel. The acceptable capacitor voltage values range is between 185 to 205VDC (Nominal voltage of 195VDC) with the higher value being associated with internal low ambient temperature compensation logic. The common terminal point is located at test point TP1. Test point TP2 measures the control supply voltage (approximately 10VDC), TP3 measures Phase C, TP5 measures Phase B, and TP6 measures Phase A. See **Figure 1** for additional details on the terminal locations.*

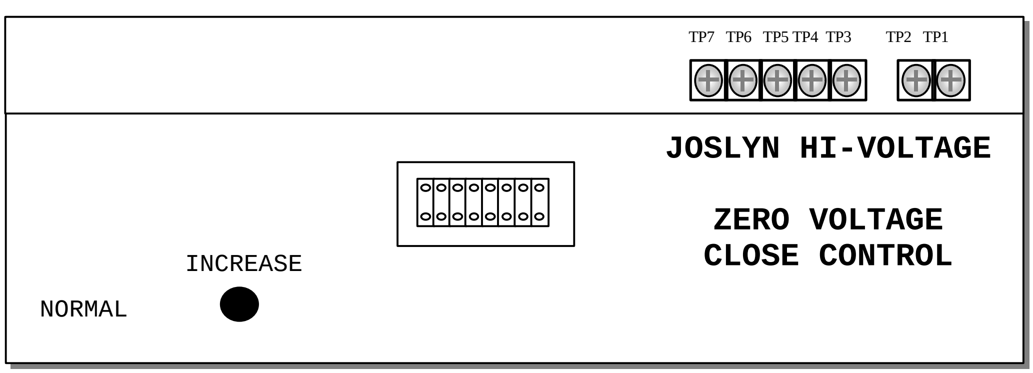


Figure 1: SCR Board Test Terminals

3.) Capacitor Temperature Compensation

The cabinet temperature is monitored by the microprocessor. Capacitor voltage is adjusted automatically to compensate for capacitor energy associated with temperature changes.

4.) Automatic Calibration

Prior to putting the control into service, the system **must** be calibrated. The only user intervention required for calibration associated with the standard control is to connect calibration cables to the switch terminals **(without high voltage being applied)** and then open the VSV switches when requested by the control during the calibration process. The control automatically performs 8 close operations on each VSV and confirms the time it takes for the individual switches to close. These 8 operations are analyzed by the control to determine when the exact close commands must be given so that the switch contacts close at the desired reference point. See the Programming Calibration Procedure section of this document for detailed instructions.

5.) Calibration Data Storage

Close timing constants are stored in non-volatile memory. When the control loses power, the timing constants are retained and will be reloaded automatically when power is returned. Calibration data is stored when the “Normal/Calibrate” switch is returned to the “Normal” position after calibration is complete. The user can abort the calibration process by moving the “Normal/Calibrate” switch to the “Normal” position before calibration is complete. This action will restore use of the previous calibration data.

6.) Self Adjusting Close Function

The control monitors each close operation and determines the actual close timing value for each phase. These timing values are used to automatically adjust the close timing constants to assure close timing accuracy throughout the life of the system. The control performs this function by adding 1/8 of the most recent close timing values to 7/8 of the previously recorded close timing values to create new close timing constants.

7.) Voltage Zero Synchronization

The detection of the zero crossing point of the reference phase is continuously monitored. If the zero voltage point does not occur where expected, a synchronization error occurs. This error is generated if the frequency varies more than +/- 0.1 Hz for the 60Hz standard and +/- 2 Hz for the 50 Hz standard. If the control senses a frequency error, all close operations will be blocked. After the frequency error occurs, the control will continue to monitor the input signal in an attempt to re-establish synchronization. Once synchronization is re-established, the close block is automatically removed and the ability for close operations is enabled.

8.) Flashing Self Check LED

When the "Self Check" LED is flashing, the control is operating normally. The "Self Check" LED will turn on and remain on if an error condition occurs. When the "Self Check" LED is off, the 120 VAC power is too low or turned off.

9.) Error Indication

If an error occurs, the “Calibrated” LED will flash to indicate the source of the error. The LED flashes the error code then turns off for 2 seconds and repeats this sequence. The errors are prioritized so that if more than one error is present, the higher priority error is indicated. Refer to the LED Indication Summary on page 10 and the Troubleshooting section for detailed description of error codes and potential corrective actions.

10.) Error Reset

Once an error occurs, it remains latched until it is acknowledged. To clear the error indication, press and hold both the Increase and Decrease pushbuttons at the same time. If the error condition is no longer present, the "Self Check" LED will begin flashing to indicate a Normal mode condition. If the error condition is still present, the error code indication will remain after the attempted reset. There are two errors that do not require manual acknowledgement. The frequency synchronization error and Low Capacitor Energy error will automatically reset once the abnormal condition is corrected or the system returns to within the control's defined parameters.

Control Panel

1.) Dip Switch Settings and Descriptions

The control is programmed using a bank of 8 dip switches. These dip switches are set to match the system parameters and capacitor bank configuration. To enable or turn "On" a desired setting, the switch is toggled up. To disable a setting, the switch is toggled down to the "Off" position. A detail layout of the dip switches is shown in Figure 2. The overall view of the front panel is shown in Figure 3.

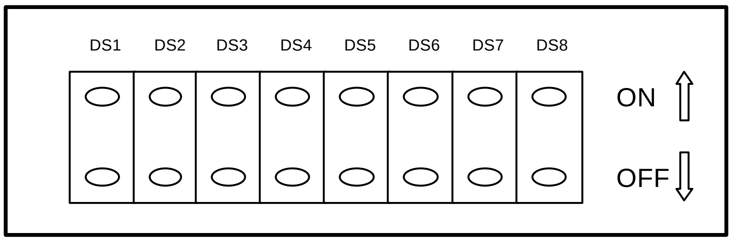


Figure 2: Dip Switch Configuration

<u>DS1 –</u> <u>"Phase Rotation"</u> - Set to the "Off" position for a system with ABC phase rotation. Set to the "On" position for a system with CBA phase rotation.

<u>DS2 –</u> <u>"Reference Phase 1"</u> - Used in combination with "Reference Phase 2" (DS3) to select the reference phase for close timing. See chart below.

<u>DS3 –</u> <u>"Reference Phase 2"</u> - Used in combination with "Reference Phase 1" (DS2) to select the reference phase for close timing. See chart below.

DS2	DS3	Phase-to-Ground Reference	Phase-to-Phase Reference **
Off	Off	A	A-B
On	Off	B	B-C
Off	On	C	C-A
On	On	Not Valid	Not Valid

** If the reference PT is connected phase-to-phase, select the appropriate phase-to-phase reference from the above chart and then place DS6 (Phase-to-Phase Reference) to the "On" position.

<u>DS4 –</u> <u>"Five Minute Close Block"</u> - Set to the "On" position to block the next close operation for a duration of five minutes after a trip operation. This option should always be used to prevent potential switching errors of re-energizing a charged capacitor bank that has been recently tripped off line. This option can be turned to the "Off" position if this feature is accomplished through an existing capacitor control or relay system.

<u>DS5 –</u> <u>"Ungrounded Bank"</u> - Set to the "Off" position if the capacitor bank configuration is grounded. Set to the "On" position if the capacitor bank configuration is ungrounded.

<u>DS6 –</u> <u>"Phase-to-Phase Reference"</u> - Set to the "Off" position if the reference PT is connected phase-to-ground. Set to the "On" position if the reference PT is connected phase-to-phase.

DS7 and **DS8** are not used at this time and the actual "On-Off" position has no impact on the control.

> ***<u>Operating Note:</u>***
> *After the system has been calibrated, the dip switches can be changed without the need for re-calibrating the system. It should be clearly noted that selections that do not match the correct system configuration or altering the settings without associated changes to the system configuration will have a negative impact on the goal of eliminating capacitor switching transients.*

2.) Control Command Switches

<u>Normal/Calibrate Toggle Switch</u> - When placed in the down position, the calibration procedure is started. The Calibration procedure continues until completed normally or aborted by moving the toggle switch back to the "Normal" position before the "Calibrated" LED is illuminated.

<u>Increase & Decrease Buttons</u> – The simultaneous pressing of these buttons resets any latched error conditions.

3.) Control Indication

<u>Self Check LED</u> - This red LED flashes at a constant one second rate when the system is functioning normally. Error conditions are shown by either steady on or steady off.

<u>Calibrated LED</u> - This green LED is steady on when the system has valid calibration data and is operating normally. This LED will flash with a defined error logic if an error condition is detected.

<u>Calibration in Progress LED</u> - This red LED is off during normal control operation. This LED is steady on only when the calibration procedure is in progress.

> ***Operating Note:***
> *All three LEDs flash at a one second rate to indicate the start of the calibration process. This condition should only occur when the "Normal/Calibrate" toggle switch is in the "Calibrate" position.*

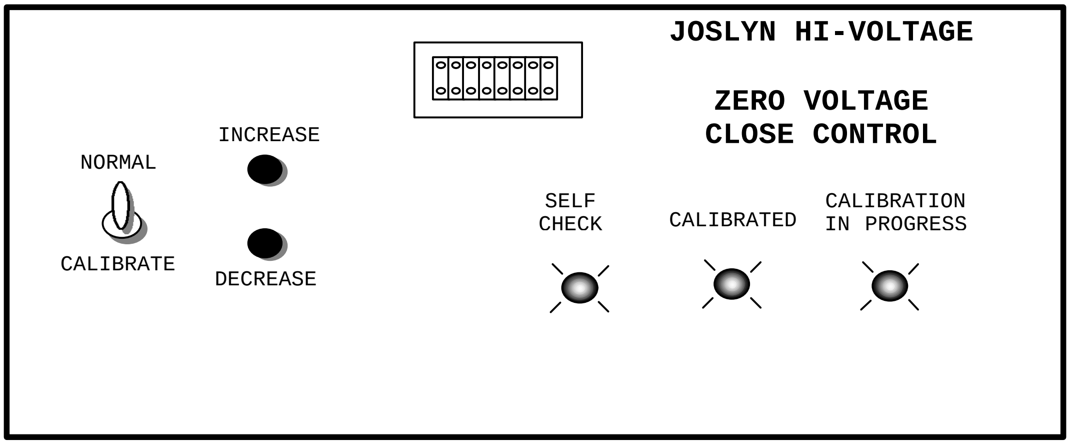


Figure 3: ZVC Front Panel View

4.) LED Indication Summary

Condition	Self Check LED	Calibrated LED	Cal. in Progress LED
Normal	Flashing	On	Off
Power off	Off	Off	Off
Error Conditions			
Low Cap Energy	On	1 Flashes	Off or On
Sync Error	On	2 Flashes	Off or On
Close Error	On	3 Flashes	Off or On
Calibration Error	On	4 Flashes	Off or On
Checksum Error	On	5 Flashes	Off
Close Sync Error	On	6 Flashes	Off
Cap. Discharge Error	On	7 Flashes	Off
Improper Sequence	On	8 Flashes	Off
Calibration Process			
Calibration Required	Flashing	Off	Off
Start of Calibration	Flashing	Flashing	Flashing
Calibration in Process	Flashing	Off	On
Open Switch	Flashing	Off	Flashing

Installation

Refer to the supplied Zero Voltage Closing interconnection drawing for detailed interface requirements. This drawing, along with the associated control wiring drawings, will highlight the details of any special options purchased and will identify the terminal strip in the control that is provided for the external connection of the required control power, close and open signals. A general layout of the system is shown in Figure 4. As a customer ordered option, the ZVC control can be mounted directly on the capacitor rack assembly. This application will eliminate the need for the junction box assembly.

The Joslyn Zero Voltage Closing control system consist of the following components:

- Zero Voltage Closing control
- Three VSV switches
- Junction box assembly that includes three separate VSV cables and one main control cable.

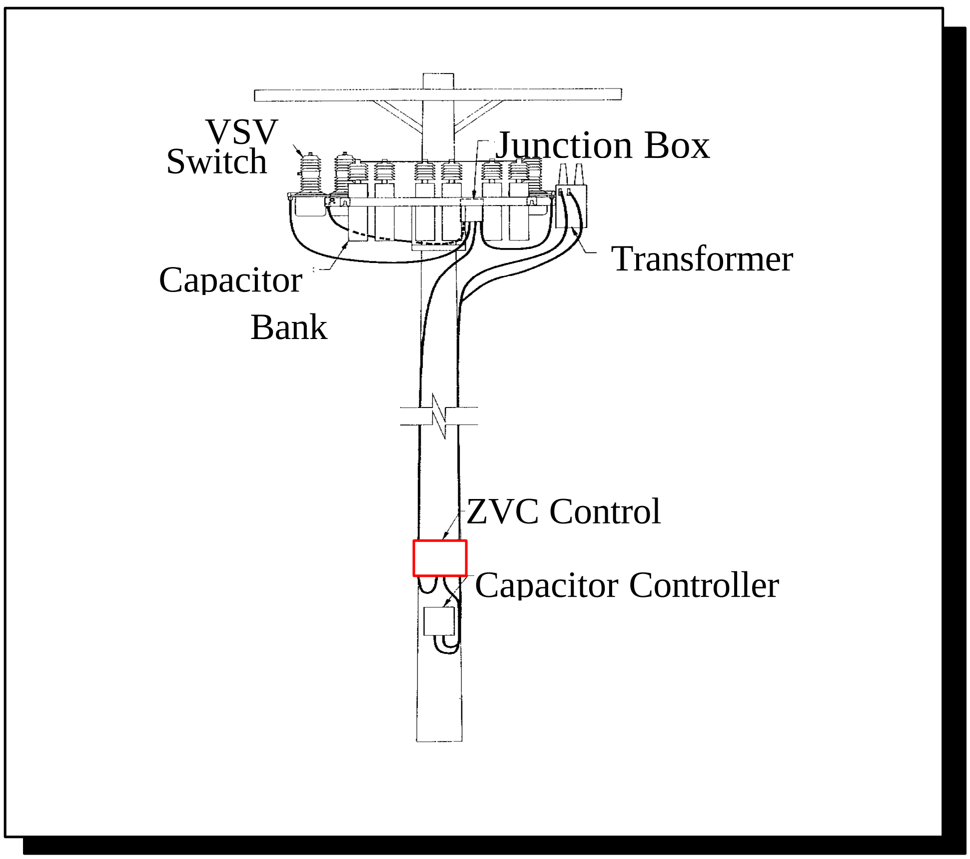


Figure 4: General Equipment Layout

Additional details on the junction box assembly are shown in Figure 5. The individual switches are connected to the junction box using cables with threaded pin connectors. Also, a keyed pin connector is provided for an easy and secure connection of the main control cable to the ZVC control. The main control cable runs from the junction box to the control. All necessary connections into the junction box for the individual VSV switch cables and the main control cable are made at the factory.

Operating Note:
Connection of the individual cables to the correct system phase designation is critical to obtain proper operation.

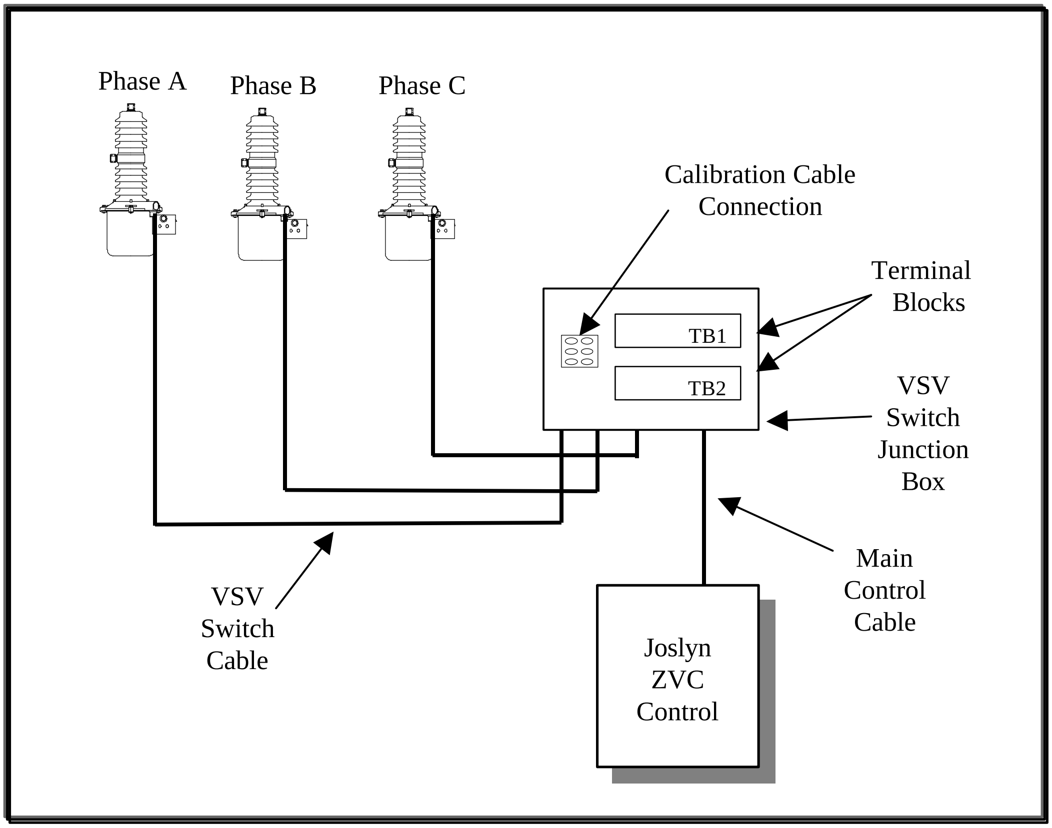


Figure 5: Junction Box Assembly

The following items represent the specific details and requirements for proper installation of the Joslyn ZVC system.

1.) VSV Switches

The VSV switches must be purchased or modified specifically for zero voltage closing applications. These switches are manufactured with a dedicated contact that provides a proper feedback signal to the control.

2.) AC Power

The standard control requires 120 VAC, 50 or 60 Hertz, to be connected to cabinet terminals TB1-3 & 4 to operate. The AC power may be connected to the system at the main control or at the junction box as shown on the supplied interconnection drawing. Do **not** connect AC power at both locations in the same installation.

> ***<u>Operating Note:</u>***
> *A single AC source can be utilized to power the control, supply the required wetting voltage for the external open and close contacts, and can supply the necessary timing reference signal. See note 3 below if the control AC power is to be used for timing signal reference.*
>
> *The 120VAC used in the open command must be capable of supplying the necessary power requirements associated with the VSV switches. Each solenoid requires 12 amps RMS (a total of 36 amps for the three single phase switches) for 1 1/2 cycles. The power source transformer and wiring to the control must be sized to allow no more than a 5% voltage drop during inrush current flow. The VSV switches require a minimum of 102 volts at the cable connector pins of the switches throughout the entire open command duration to assure proper switch performance. Failure to meet both of these requirements will significantly reduce the excepted long life of the solenoid operators and will also void the warranty of the switches. See Joslyn Technical Bulletin I. 750-271 on "VSV Installation Instructions" for further guidelines on calculating power supply voltage drops.*

3.) Zero Crossing Timing Reference Signal

The following parameters of the reference signal must be determined:

- Voltage signal represents system A, B, or C phase-to-ground reference.
- Voltage signal represents system A-B, B-C, or C-A phase-to-phase reference.

A single AC power source can be used as the AC timing reference signal and control power. As the standard configuration, the control is shipped with a jumper labeled JP1 on the I/O board. This configuration allows the use of a single source for both the control power and the timing reference signal. As an alternative, if the AC power source is too noisy for use as a timing reference, the control power can be connected at a separate location on the terminal strip on the I/O board. To accomplish this separation of the control power and voltage timing reference sources, the JP1 jumper on the I/O board **<u>must</u>** be removed before applying power to the control. Figure 6 is supplied as a reference for the standard I/O board terminal designations. Refer to the supplied interconnection wiring diagram for complete details on the terminal locations and designations for the specific control purchased.

> ***Operating Note:***
> *The zero voltage crossing of the voltage timing reference signal is constantly monitored. Internal software routines analyze the zero voltage crossing signals to minimize the possibility of triggering on false zero crossings which could occur due to noise on the reference source. Shielded control cable is* ***required*** *for this installation to assure maximum protection against the possibility of noise interference. The shield of the cable should only be grounded at the source end. The time reference signal source needs to be 120 VAC for either 50 or 60 Hertz. Upon powering up, the control automatically determines if the frequency is 50 or 60 Hz through a sampling method and then registers the system's frequency in the control's memory.*

4.) Open Commands

The open signal is connected to terminal TB1-6, 7, & 8 in the ZVC control cabinet. The command must be 120 VAC wetted contact and can be maintained or momentary. A minimum open command time of 0.2 seconds is recommended. A jumper can be used from terminal 6 to 7 and 8 to allow only one open signal cable to be brought into the control.

> ***Operating Note:***
> *The connection of the open signal is made in the control to the switches for wiring convenience. The open control circuit does not contain any special timing control when an external open command is initiated.*

5.) Close Commands

The external close command is connected to the terminal strip on the I/O Board through TB1-5. The command must be a 120 VAC wetted contact and can be maintained or momentary. A minimum close command time of 0.2 seconds is recommended. If the close command is maintained, it must be removed before an open command to prevent pumping.

6.) Calibration

Before the control can perform the desired close operations, it must be calibrated to match the system installation perimeters, which include:

- System phase rotation (ABC or CBA).
- Voltage signal phase representation and connection.
- Capacitor bank configuration (grounded or ungrounded).

The calibration process is performed automatically before high voltage is applied to the system. Refer to the section titled "Programming" for detailed information and connection requirements to initiate the automatic calibration process.

> ***Operating Note:***
> *The control will not issue close commands unless the control is calibrated.*

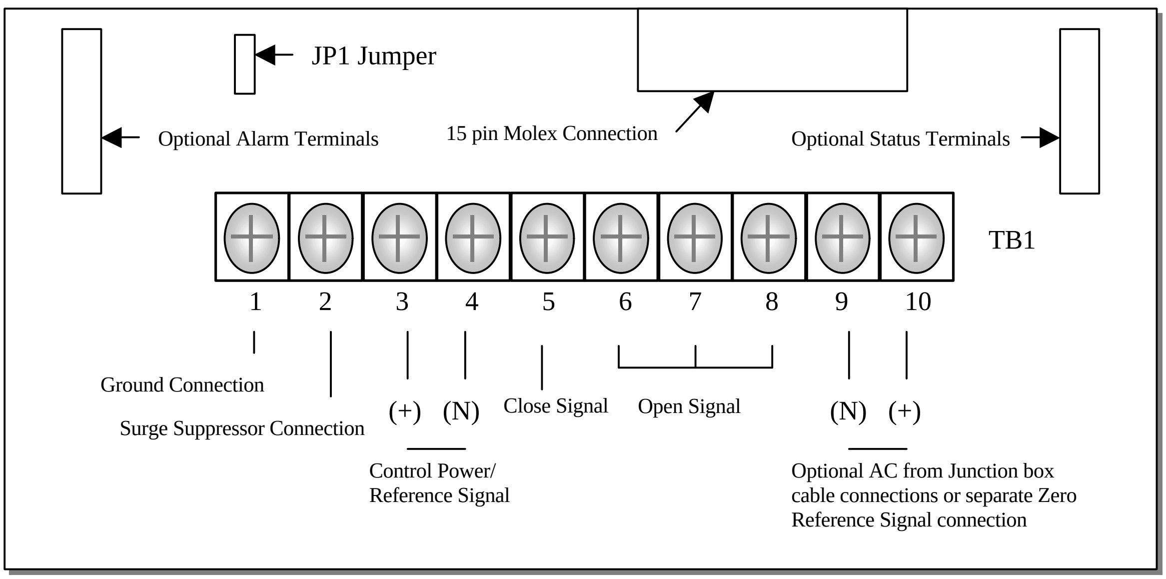


Figure 6: I/O Board Interface Connections

Programming

The control features can be set or adjusted at any time by placing the dip switches into the appropriate positions. To start the automatic calibration procedure, place the "Normal/Calibrate" switch into the "Calibrate" position. When the calibration procedure is finished, as indicated by the "Calibrated" LED being solidly on, place the calibration switch into the "Normal" position to store the obtained calibration data. If the "Normal/Calibrate" switch is placed in the "Normal" position before the "Calibrated" LED is on, the calibration will be aborted and the old calibration values will be retained in memory.

Calibration Procedure

The following is a description of the sequence for Automatic Calibration of the Zero Voltage Closing control used with VSV switches. The calibration procedure only needs to be performed upon initial setup of the system **or** if any of the VSV switches are replaced after the initial calibration process. The calibration process can be performed either in the field or at the user's service center. After the calibration procedure, the switches MUST stay in the same position (i.e. phase A identified in the shop is installed on phase A in the field) as used during the calibration process. If the switch locations are changed/altered, the calibration procedure needs to be repeated in the field.

A.) VSV Setup

1. Take the necessary steps to de-energize and/or isolate the system high voltage from the terminals of the VSV switches. If the calibration process is being performed in the shop, proceed to step 4.

2. Disconnect the high voltage cable leads from the VSV switch terminals.

3. Remove the cover from the junction box on the VSV/Capacitor mounting frame.

4. Connect the user supplied calibration cables from the VSV switch terminals to the designated TB1 terminal points in the **junction box** as follows:

Phase	VSV Top Terminal	VSV Side Terminal
A	TB1-4	TB1-1
B	TB1-6	TB1-2
C	TB1-8	TB1-3

> ***Operating Note:***
> *Controls purchased with an optional calibration cable assembly need only to plug the Molex pin connector into the mating connector within the junction box and clip the calibration cable leads to the switch terminals as marked on the cables. This cable connection eliminates wiring to the junction box terminals as described above. See Figure 5 for junction box and VSV switch assembly details.*

B.) Control Setup

1. Verify the "Normal/Calibrate" toggle switch is in the "Normal" position.

2. Place the "Normal/Calibrate" toggle switch in the "Calibrate" position. Once the toggle switch is in the "Calibrate" position, all three of the front panel's LEDs will start to flash which indicates that the control is ready to begin calibration.

C.) Calibration

1. To initiate the automatic calibration process, provide a "**close**" command to the control. If the switches are in the open position, the control will start calibration by automatically closing each switch independently. If the switches are in the close position, the control will indicate, through the flashing of the "Calibration in Progress" LED, for the user to open the switches.

2. Initiate an "**open**" command after the "Calibration in Progress" LED begins flashing.

> ***Operating Notes:***
> *1.) In order to complete thermal circuit recovery and optimize timing accuracy, the control will internally block the automatic closing of the switches until an internal three (3) minute timer expires.*
> *2.) The control will automatically close each switch independently. After a few seconds of processing timing data, the control will start flashing the "Calibration in Progress" LED indicating that the user is required to initiate an open command. The control will automatically cycle through 8 complete automatic close operation samples with the required 3 minutes duration between each open operation. The complete process needs to continue uninterrupted and will require about 24 minutes to complete.*
> *3.) If the control encounters a discrepancy, an error message will be displayed by flashing the "Calibrated" LED and will suspend the overall process. The user must acknowledge the error by initiating a reset command (simultaneous pressing of the Increase and Decrease arrows). If the calibration process is interrupted more than one time with the same error, stop and review the "Troubleshooting" section of this manual to help determine the root cause for the error.*

Control Option Note:
If the user purchased the "Improper Sequence" trip option, the control will internally issue the necessary open commands during the calibration process. No interaction with the control is required during the calibration process. The user will only be responsible for initiating the start of the process and then returning the "Normal/Calibrate" switch to the "Normal" position once the calibration process is completed.

3. When the control is finished processing the close time data, the "Calibrated" LED will turn on and the "Calibration in Progress" LED will turn off.

4. After the "Calibrated" LED turns on, place the "Normal/Calibrate" toggle switch to the "**Normal**" position. This action saves the calibration results to non-volatile memory. The control is now ready for service.

Operating Note:
If the "Normal/Calibrate" switch is placed into the "Normal" position before the "Calibrated" LED turns on, the calibration process is aborted and the previously stored data is retained. If the calibration is successful, the "Calibrated" LED will remain on, "Calibration in Progress" LED will turn off, and the "Self Check" LED will be flashing.

D.) Calibration Complete

1. Remove the calibration cable connections from the VSV terminals and the junction box as part of the "VSV Setup" procedure.

2. Re-install the primary cable leads that were disconnected during the calibration process.

3. Re-install the cover on the junction box.

4. Open the VSV switches.

5. Verify that the dip switch settings are correct for the application.

6. The control and switches are ready for the user to apply high voltage to the capacitor bank system.

Troubleshooting

1.) Condition:

VSV will not close.

Possible causes:

A. System not calibrated. Verify that the "Calibrated" LED is on. If not, perform automatic calibration process.

B. System internal error. Verify that "Self Check" LED is flashing at a regular rate. If it is steady on, then there is a system error. Note the number of flashes on the "Calibrated" LED, and then perform an error reset by pressing both the Increase and Decrease pushbuttons together.

Condition	Number of Flashes
Low Capacitor Energy	1
Synchronization Error	2
Close Error	3
Calibration Error	4
Checksum Error	5
Close Reference Error	6
Capacitor Discharge Error	7
Improper Sequence	8

C. System is in the automatic calibration mode. Verify the "Normal/Calibrate" switch is in the "Normal" position.

D. The five minute close block is on (dip switch DS4) and did not timeout.

2.) Condition:

No LEDs are on.

Possible causes:

A. System power is off or too low. Check AC power to the control.

B. AC is not connected to the correct terminals; verify AC termination is correct.

3.) Condition:

During the calibration process the system encounters a "Calibration Error" and displays 4 flashes on the "Calibrated" LED.

Possible causes:

A. The connections of the VSV switches to the system phases are not correct and do not match the interconnection drawing. The control monitors the closing of Phase A, Phase B, and then Phase C with respect to the designated reference signal. This error typically occurs immediately after the first calibration sequence when there is a cable connection problem.

B. Cable connections are not tight. Check all cable connection points.

C. The calibration cables are not connected to the correct terminal blocks or switch contact designations. This condition is recognized by all the switches closing during the first calibration sequence but one or more of the switches failing to close during the second operation. If the control fails to receive positive confirmation of the high voltage contacts changing states, the control will not initiate any further automatic close commands for the remaining switches. During the calibration process, the control closes in the same sequence: Phase A first, followed by phases B and C, respectively.

4.) Condition:

The system encounters a "Capacitor Discharge" error and displays 7 flashes on the "Calibrated" LED. This error occurs if any of the close capacitors have too high a voltage after a close command is issued.

Possible causes:

A. Cable connections are not tight. Check all cable connections and external termination points.
B. Defective SCR on the SCR board. Press the reset and attempt to continue normal operation. If the problem continues, place a meter on the terminals identified in Figure 1 to monitor the capacitor voltage levels. Verify that the capacitor voltage for each phase is discharged after a close operation.

5.) Condition:

The system encounters an "Improper Sequence" error and displays 8 flashes on the "Calibrated" LED. This error represents anti-single phasing protection and occurs if a switch fails to close within a designated amount of time.

Possible causes:

A. Only a single open command is wired to the I/O board (missing the jumpers for the other two phases).
B. Cable connections are not tight. Check all cable connections and external termination points.
C. A single switch was manually opened (VSV purchased manual trip handle).

6.) Condition:

Higher than expected close transients are encountered when system is energized. Accurate monitoring equipment displays and records high close transients.

Possible causes:

A. The control has encountered an error. Verify the appropriate flashing of the "Self Check" LED and identify any errors displayed on the "Calibrated" LED.
B. The Dip Switch settings do not accurately represent the actual capacitor configuration or the system phase rotation selected is not correct. Verify the system and bank configuration parameters.
C. The Dip Switch settings were altered/changed in error. Verify that the settings match the system and bank configuration.
D. The phase connected to the zero reference phase input does not match settings.

Specifications

Timing Accuracy:	+/- 0.75ms with respect to designated zero voltage crossing point
Close Response Time:	3 – 4 cycles after receiving external close command
Open Response Time:	2 – 3 cycles after receiving external open command
Temperature Range:	-30 C to +70 C *
Signal Voltage:	104 Vac to 130 Vac, 120 Vac nominal
Open Voltage:	120Vac nominal w/ min. 102Vac at end of max. 5% voltage drop
Weight:	25 lbs.
Surge Test:	ANSI C37-90.1
RFI Test:	150 MHz and 450 MHz at 1 meter from a 1/4 wave antenna driven by a 4 watt hand-held transmitter.

* Control is designed for operation through this range, however timing variances greater than 0.75ms could be encountered below –18 degree Celsius and above 60 degree Celsius. These variances are expected to remain within 1 ms of the zero voltage crossing reference point.

Specifications subject to change without notice.

Non-Standard Options Available

- Improper Sequence trip feature
- Switch position indication output contact
- Control Alarm output contact
- Control cabinet and junction box heaters
- Two pole control for ungrounded capacitor bank applications
- Extra switch auxiliary contacts
- Calibration Cable
- 125VDC control power

Manual Revision Notes

Date:	Scope:
10/18/95	Applies to ZVC controls purchased and installed before November 1999.
March 2000	Applies to ZVC controls with upgraded processors after November 1999. Systems purchased before November 1999 or not upgraded in the field will vary slightly in the details of this manual. The major differences in this manual and the units under version dated 4/18/95 are as follows: • Automatic calibration process was previously completed after 5 close operations. • Adjustments to the dip switches were not active unless the system was calibrated or re-calibrated. • The control does not have an internal timer to block consecutive close operations during the calibration process. • Dip switch DS4 position was inactive. • Dip switch DS8 previously provided manual timing adjustment capability.

Joslyn Hi-Voltage Reference Material

Appendix A Standard System Voltage Reference information (Included in this manual)

I. 750-271 VSV Switch Installation and Operating Procedure

D.B. 750-238 VerSaVac General Data Bulletin

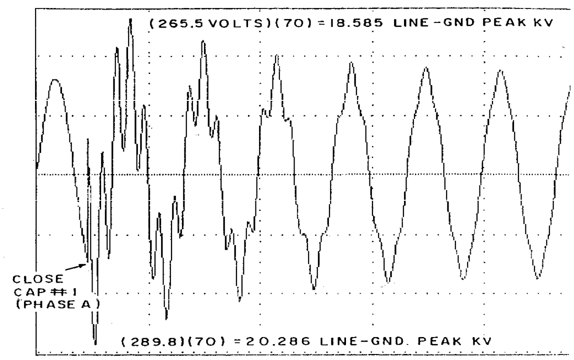
85 WM 221-7 Synchronous Closing Control for Shunt Capacitors – R. W.Alexander, Pennsylvania Power & Light Company, Allentown, Pennsylvania.

APPENDIX A

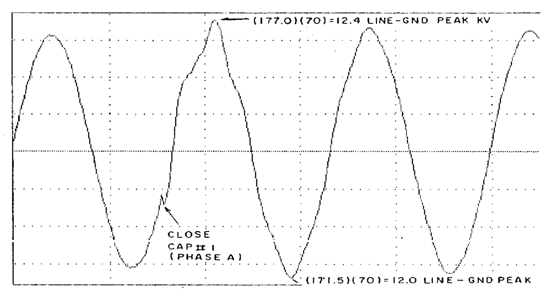
1.) Sample Wave forms

Oscilloscopes can be used to monitor and measure the actual transient reductions experienced by the application of zero voltage close control logic. The following is an example of expected results with the application of this product.

Capacitor #1
Field Test – Standard Control



Capacitor #1
Field Test – Zero
Voltage Control



2.) Power System Background Data

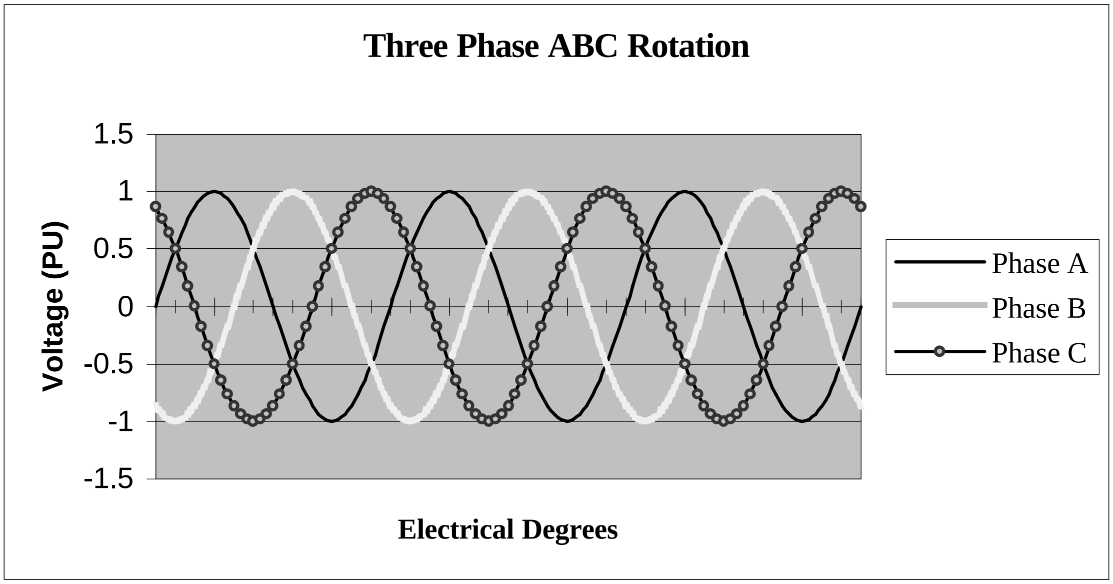
A.) Basic System Timing Principles

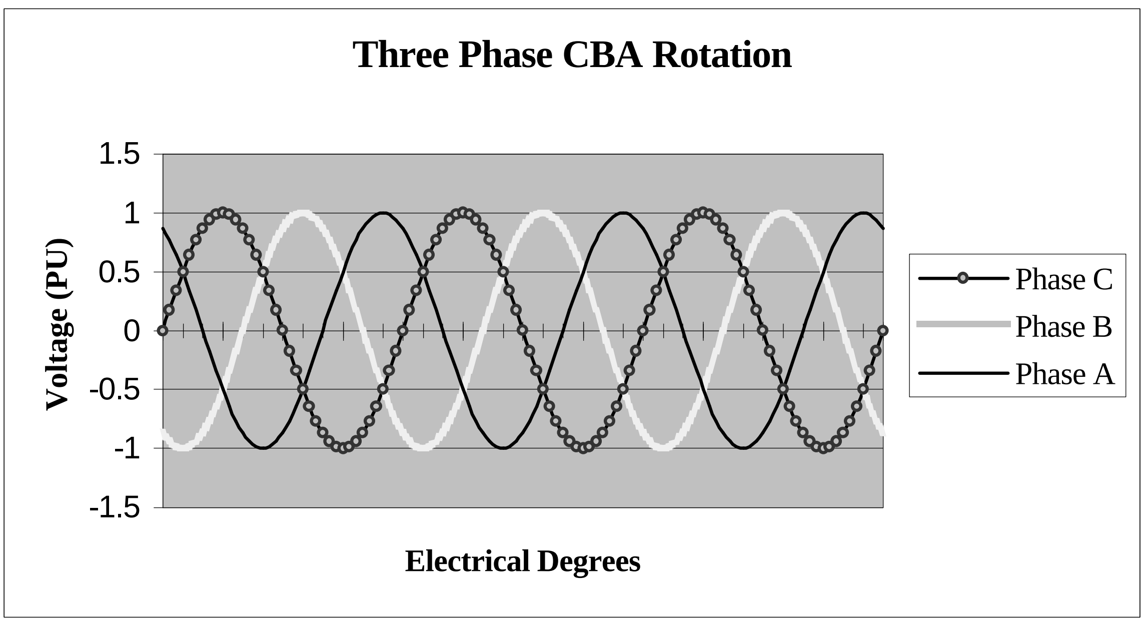
- On a balanced three phase electrical system, phases are 60 degrees apart.
- One cycle on a 60Hz system is equal to 16.667 milliseconds and 20 milliseconds on a 50 Hz system.
- One cycle corresponds to 360 electrical degrees.
- Conversion from degrees to seconds is performed by using the following equation:

X/360 x 16.667mS = Equivalent ms (60Hz system)
X/360 x 20.000mS = Equivalent ms (50Hz system)
Where: X = degrees

B.) ABC and CBA Voltage rotations

The following two graphs represent the two possible system voltage rotations. The correct selection of the applicable rotation allows the control to accurately close with respect to the corresponding phase voltages.





C.) Phase-to-Phase Reference Sensing

The following reference information relates to customers using Phase-to-Phase voltage sensing consideration:

<u>ABC Rotation:</u>
When the voltage reference source is connected phase-to-phase with an ABC rotation system, the resultant wave will lead each phase by 30 degrees. The actual timing equates to + 1.389mS for 60Hz (30/360 x 16.67mS = 1.389mS) and + 1.667mS for 50Hz (30/360 x 20mS = 1.667mS).

<u>CBA Rotation:</u>
When the voltage reference source is connected phase-to-phase with an CBA rotation system, the resultant wave will lag each phase by 30 degrees. The actual timing equates to a negative 1.389mS for 60Hz and a negative 1.667mS for 50Hz.

A summary for phase-to-phase transformers sensing with respect to the individual phase voltages is represented in the table below and demonstrated in a sample timing graph:

PT Connection	Phase Rotation ABC	Phase Rotation CBA
A and B	A - 30 degree lead B - 30 degree lag	A - 30 degree lag B - 30 degree lead
B and C	B - 30 degree lead C - 30 degree lag	B - 30 degree lag C - 30 degree lead
C and A	C - 30 degree lead A - 30 degree lag	C - 30 degree lag A - 30 degree lead