25-3. Specifications

Electronics Module (1C31194)
Personality Module (1C31197)

Table 25-2. Valve Positioner Module Specifications

Description	Value
Valve positioning field interface channels	One
LVDT position feedback Input range	25 V AC peak to peak (LVDT A and LVDT B) maximum
LVDT position feedback input impedance	20 kΩ (LVDT A and LVDT B) differential input with floating source 10 kΩ (LVDT A and LVDT B) one input line referenced to common
LVDT excitation output voltage	17 V AC peak to peak ± 11% @ 1.0 kHz ± 10% (1C31194G01) 23.75 V AC peak to peak ± 11% @ 3.0 kHz ± 10% (1C31194G02) 500 Ω minimum load impedance (1C31194G01 & G02) Drift 0.5% max/yr
Peak servo valve coil output voltages	(1C31197G01) up to three 82 Ω coils, ±2.04 V (1C31197G02) up to three 250 Ω coils, ±4.20 V (1C31197G03) up to three 1000 Ω coils, ±8.26 V (1C31197G04) up to two 125 Ω coils, ±4.5 V
Servo valve coil output voltage accuracy	0.4% of full scale output
Field interface dielectric isolation	1000 V DC The valve positioning field interface has 50 V and 150 V short term isolation from the logic common/Ovation I/O bus
SLIM interface serial port	RS-485
SLIM interface serial port baud rate	9600
SLIM interface dielectric isolation	±1000 V DC
Local serial port	RS-232, non-isolated
Local serial port baud rate	19200
SHUTDOWN digital input Input voltage range Propagation delay of contact change of state Cable length Dielectric isolation	 24 V/48 V DC nominal 18 V DC minimum, 60 V DC maximum 1.9 mSec minimum; 25.5 mSec maximum 1000 feet maximum (cable capacitance ≤ 50 pF/ft) ±1000 V DC

Table 25-2. Valve Positioner Module Specifications (Cont'd)

Description	Value
MANUAL digital output Output voltage Off voltage (maximum) On voltage (maximum) Output current Off current (maximum) On current Maximum propagation time Dielectric isolation	 60 V DC 1.0 V @ 500 mA 0.2 V @ 100 mA 25 µA @ 60 V, TA = 25° C 250 µA @ 60 V, TA = 60° C 500 mA 2.5 mSec for Rload = 500 Ω ±1000 V DC
Module power	Main: 4.3 2W typical, 6.5 W maximum Aux: Digital Input: 0.09 W (24V) typical 0.18 W (48V) typical Digital Output (100mA load) 2.4 W (24V) typical 4.8 W (48V) typical
Logic board processor	80C196KB (16-bit microcontroller)
Operating temperature range	0 to 60˚C (32˚F to 140˚F)
Storage temperature range	-40˚C to 85˚C (-40˚F to 185˚F)
Humidity (non-condensing)	0 to 95%

25-4. Valve Positioner Modes

Rapid or erratic valve movement can damage the turbine. The Valve Positioner enforces a set of rules to accomplish bumpless transfer between modes. The description of each mode includes mode transfer.

25-4.1. Start Mode

When the Valve Positioner is powered-up or restarted, its primary objective is to avoid an indeterminate output that would result in valve movement, and possible damage to the valve or turbine. There are a number of hardware and software features that prevent an indeterminate output.

The hardware is designed so that when the Valve Positioner is powered-up, the power supply to the servo output is turned off. With no current flow to the servo valve, it is left under the influence of its mechanical bias adjustment, the assumed state prior to power-up. In addition, the coil drive D/A convertor is not turned on until it receives the first output pattern.

As part of the microcontroller's start sequence, the power supply is turned on, and then a pattern is written to the coil drive D/A convertor representing 0 volts. The result is that the servo output is under software control, no current flows between the Valve Positioner and the servo valve, and no valve movement has occurred.

The Valve Positioner will not remain in Start mode unless a diagnostic error is detected. The Valve Positioner transitions from Start to Local mode if all of the following functions execute and return "normal" or "ok" status codes:

- Program the FPGA.
- Go to Factory Configure Mode if PE pin is 1.
- Check PE pin. Go to Factory Test Mode, if required.
- EPROM checksum check.
- EEPROM checksum check.
- RAM read/write test.
- D/A convertor readback diagnostic.
- UART scratchpad read/write test.
- Shared memory readback check.

The Valve Positioner will set target valve demand equal to demand feedback before transferring to Local mode.

25-4.2. Local-Manual Mode

The purpose of local-manual mode is:

- Maintain stable valve position when the Controller fails or is reset.
- Smooth operation using manual raise/lower function.
- Bumpless transfer to normal mode. (Tracking by the Controller is required, and is enforced by the Valve Positioner in local-manual mode.)

In local-manual mode, the Valve Positioner controls the valve using a set point that is only changed through the SLIM interface, or through the local serial interface.

Local-manual mode will be entered from normal mode if the Controller fails or stops updating the Valve Positioner card. When the Valve Positioner is powered up, local-manual mode is always entered as long as there are no diagnostic failures.

The preferred mode of Valve Positioner operation is normal mode. The Valve Positioner transfers from local-manual to normal if the following conditions are met: (1) Controller is updating the set point, thus keeping the watchdog timer from expiring. (2) Controller is tracking.

In local-manual mode, the following functions are performed:

- PI position control loop.
- Writes current valve position to Ovation memory.
- Writes coil voltages to Ovation memory.
- Open coil diagnostic.
- Shorted coil diagnostic.
- EPROM checksum diagnostic.
- RAM diagnostic.
- Watchdog timing.
- SLIM interface (Raise, Lower, and update SLIM values.)
- Valve contingency diagnostic.

25-4.3. Normal Mode

Normal is the preferred mode of the Valve Positioner card. In normal mode, the Valve Positioner is receiving a position set point from the Controller and controlling valve position.

In normal mode, the following functions are performed:

- PI position control loop (Demand position comes from the Controller via the Ovation memory).
- Writes current valve position to Ovation I/O memory.

- Writes coil voltages to Ovation I/O memory.
- Open coil diagnostic.
- Shorted coil diagnostic.
- EPROM checksum diagnostic.
- RAM diagnostic.
- Watchdog timing.
- SLIM interface (Updates SLIM values, no raise/lower function.)
- Valve contingency diagnostic.

25-4.4. Calibrate Mode

Calibrate mode is a submode of local-manual mode. Calibration sequences are commanded through the local serial port.

The Valve Positioner is commanded to calibrate when the appropriate bit in the command word is set. This causes the Valve Positioner to enter the calibrate mode and begin its travel sequence. During the travel sequence, the Valve Positioner will report a position feedback calculated using the most recent calibration numbers. The controlling MASTATION will enter manual mode and track the position demand feedback. The Valve Positioner moves the valve at a programmable rate during the travel sequence.

The Valve Positioner can exit calibrate mode **without** enforcing a bumpless transfer rule.

The following calibrate sequences are supported:

- Zero Hot Cal

  This calibration sequence is executed to re-establish the 0% position. It is useful after the valve has been fully calibrated and the mechanical assembly has been heated and expanded. It avoids fully opening the valve.

  Feedback gain is not adjusted during the hot cal sequence.

- Top Hot Cal

  This calibration sequence is executed to re-establish the 100% position. It is useful after the valve has been fully calibrated and the mechanical assembly has been heated and expanded. It avoids fully closing the valve.

Feedback gain is not adjusted during the hot cal sequence.

- Null-Point Cal

  This calibration sequence causes the valve to travel to the electrical null point of the LVDT. Null point calibration can be requested at the same time as full calibration, in which case the movement sequence is the full calibration sequence. However, the valve stops at the null point when it is encountered.

- Full Calibration

  This calibration sequence is executed to re-establish 0% position, 100% position, and feedback gain.

  When full calibration is requested the module enters local mode, requiring the Controller to track. The module then moves the value to the 0% position. The firmware checks for position feedback between the arbitrary limits of –9.7 volts and –2.0 volts. If the voltage is less (more negative) than –9.7 volts, the firmware reduces gain to make the voltage more positive than –9.7. If the voltage is more positive than –2.0 volts, the gain is increased until the voltage is more negative than –2.0 volts. During these two sequences, the gain is tested to insure it does not go out of allowable range.

  If the voltage is between –9.7 and –2.0, then gain is recalculated to set the voltage to the arbitrary target voltage of –0.35 volts, and the firmware sequence advances to the next state, which will take the value to 100%.

  At this point in the sequence, the demodulator gain has been set to a value that is a maximum allowable value. The gain may be reduced at the other end of the stroke, but will not be increased.

  Now the valve moves to the 100% position. The feedback voltage is examined, and if it exceeds 10.0 volts, feedback gain is reduced. Once feedback voltage is less than +10.0 volts, it is recorded as the 100% calibration value.

  The valve moves back to 0% and the voltage at 0% is recorded. Feedback gain is not adjusted.

  The last step is to write 0% position, 100% position, and feedback gain to the EE memory.

  Once the data is recorded in EE memory, the firmware clears a restriction flag, allowing the module to transfer from local mode back to normal mode. At this point the valve is under the control of the MA station and will return to the previous position according to the tuning of the MA.

25-5. Using the Serial Port for Calibration

25-5.1. Settings

The local serial port is used in the field to calibrate and diagnose Valve Positioner problems. It is used in the factory to cause the Valve Positioner to perform necessary testing prior to shipment. This interface is implemented using the external UART.

The settings of the local serial port are:

- Baud rate = 19200
- Bits = 8 bits
- Stop Bits = One stop bit
- Parity = No parity

Status messages are printed during calibration sequences, such as

‘Calibrate - Go to 100%’

OR

‘Calibrate - Reduce feedback gain’

Warning

The EE memory can be corrupted if constants are modified during the calibration sequence. This occurs because the checksum is recalibrated based only on new values for 0%, 100% and feedback gain, not on the entire EE memory image.

25-5.2. Connections

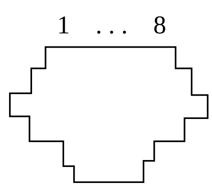
The Personality module RS-232 connector is used to connect the Valve Positioner module to the COM1 or COM2 serial port of a personal computer.

Use cable 5A26448 or make a cable using the information in Table 25-3.

Table 25-3. RS-232 Connector (J2) Pin Assignments

Pin Number	Signal Name (Function)	Signal Direction
1		
2		
3	TXD2/ (Transmit Data)	Output
4		
5	RXD2/ (Receive Data)	Input
6	GND (Logic Common) [1]	
7		
8		

Front View of J2 Connector (Modular Jack)



[1] This serial port is not electrically isolated from logic ground.

25-6. Performing Calibration

Calibration is performed by connecting a PC (running terminal emulation software) or a dumb terminal to the Valve Positioner, then typing commands on the PC keyboard or terminal. Using a PC is recommended because you can record/reload tuning constants to/from a disk.

The goals of calibration are:

- To determine the endpoints of mechanical stroke.
- Help the plant set up the LVDT for optimum performance.
- Perform the calibration quickly to avoid startup delay.

25-6.1. Calibration Required

Calibration is required after the following:

- After a mechanical overhaul

  If the mechanical stroke remains the same after the overhaul, and the same LVDT is installed, simply adjust the LVDT so the position feedback on the Ovation system indicates 0% (with the valve fully closed), then tighten down the LVDT assembly (that is, return to its former position).

- After the LVDT is changed

  Calibration is required to find the null point and proper demodulator gain adjustment. However, if it is the same model, time can be saved by entering the same constants before running the calibration sequence.

- If a secondary wire pair is swapped

  The valve positioner is not affected because the demodulator is a diode rectifying type. Also, the secondary pairs (A and B), can be swapped. The result will be a change in sign of the calibration values. Arithmetic in valve positioner firmware will yield the correct result. However, the user should follow the recommended hookup that will yield negative values at 0% and positive values at 100%, and avoid confusion.

25-6.2. Calibration Procedure

1. Use a standard cable to make the connection between the PC (or dumb terminal) and the Valve Positioner (refer to “Connections” in Section 25-5 for connection details).

2. Configure the serial port on the PC as described in “Settings” in Section 25-5

3. To run a calibration sequence, perform the following:

   A. Hook up the serial cable between the COM port and the user port on the Valve Positioner.

   B. Start the terminal emulation software.

   C. Ensure the settings are correct.

   D. Type HELP<return> to see a list of commands (described in Table 25-4).
   Note the following:

   — Commands are case sensitive.

   — Syntax is strict.

   — There is no line buffering.

   — Backspace invalidates any typed command.

4. Type CALFULL<return> to run the full calibration sequence.

5. If any constants are entered manually, type SC<return> to save the new constants to the EEPROM.

6. Use the command CALFULL after an overhaul, to fully calibrate the valve.

7. Use the command CALBOT just prior to startup, to reestablish the 0% calibration value if thermal expansion is detected.

Table 25-4. Calibration Commands

Command	Description
DC<return>	Dump configuration constants from EEPROM.
SC<return>	Save configuration constants to EEPROM.
DG<return>	Display group 1 data - This function would repeatedly display important operating parameters such as demand, feedback, gain, and so forth.

Table 25-4. Calibration Commands (Cont'd)

Command	Description
HELP<return>	Print command list.
EXIT<return>	Exits test mode. raise/lower function, or calibration sequence. Causes a soft reset of the valve positioner.

25-6.3. Calibration Ideal

During the calibration sequence, observe the valve to ensure it is moving, and that it is moving in the proper direction. Also, review the calibration constants and compare them with the ideal setup described below:

- The range of calibration values corresponds to the hexadecimal range of the AD converter, and is presented to the user in decimal, ranging from -31768 to 31767.
- When an LVDT is properly adjusted and calibrated, the calibration constants (0% and 100%) will be equal in amplitude and opposite in sign. The amplitudes for this ideal setup would be approximately 30000. This result suggest the following:
  - — The LVDT is adjusted so that its electrical null point (where secondary A amplitude = secondary B) matches the midpoint of the mechanical stroke.
  - — The programmable gain amplifier on the demodulator is adjusted so that the electrical 'stroke' stays within the input range of the AD converter. Thus, the valve positioner can detect incremental movement for all valve positions.
  - — If thermal expansion occurs, the valve positioner will continue to detect incremental movement, because the calibration is not to the extreme end of the AD converter range, and because the magnitude of thermal expansion is small.

25-6.4. Simplify Diagnostics

Rolled servo wires can cause the valve to move in the opposite direction. Be sure to observe and verify the correct movement of the valve. If only one pair is rolled, then the two pairs will be "fighting" each other. Use the following procedure to simplify diagnosis:

1. Disconnect one pair of wires.
2. Calibrate the valve, verifying the correct movement of the valve.

3. Reconnect the first pair of wires.
4. Disconnect the other pair of wires.
5. Calibrate the valve, verifying the correct movement of the valve.
6. Reconnect all the servo wires.
7. Calibrate the valve, verifying the correct movement of the valve.

25-6.5. On-Board Diagnostics

The mechanical bias adjustment of the servo valve can affect the results of on-board diagnostics. A set-screw on the servo valve causes a deflection from center position of the servo valve spool. This allows hydraulic fluid to escape the actuator, and the valve to close at controlled rate, in the absence of an electrical signal.

For a typical hookup, a small negative voltage on the servo valve is required to center the spool, and hold the valve in a steady position. This voltage is typically from -100 to -300 mV. Servo valves are delivered from the factory with this adjustment. On board diagnostics assume that the servo valve is set up in this way. If another setup is used, program the Ovation Controller to ignore the results of diagnostic bits.

25-7. Performing Calibration Using a Graphic

Calibration can be performed by using the Valve Positioner Upload/Download/ Calibrate graphic (diagram 8719) to view and modify the VP tuning constants. All the constants can be modified. The 0% and 100% calibration values, and demodulator gain, can be determined by the calibration sequence, and can be adjusted by the user with this graphic.

The graphic has upload/download buttons so that the two sets of numbers can be synchronized (made the same). This synchronization is initiated by the user and is the responsibility of the user. In addition to the constants, there are four fields that provide operator feedback.

The constants exist in two places:

- EE memory on the Valve Positioner module.
- In the VPSTATUS algorithm record (typically, the constants contained in the algorithm record are considered as the master set).

If an VP module fails and is replaced, the user simply downloads the constants to the new VP and it is ready to operate. The constants are not automatically copied to the algorithm record upon completion of a calibration sequence.

Note

Each constant shown on the graphic can also be entered through a serial port interface. Refer to Section 25-6 for information on using a serial port for VP calibration. Table 25-4 describes each calibration command.

25-7.1. Calibration Goals

The goals of calibration are:

- To determine the endpoints of mechanical stroke.
- Help the plant set up the LVDT for optimum performance.
- Perform the calibration quickly to avoid startup delay.

25-7.2. Calibration Required

Calibration is required after the following:

- After a mechanical overhaul

  If the mechanical stroke remains the same after the overhaul, and the same LVDT is installed, simply adjust the LVDT so the position feedback on the Ovation system indicates 0% (with the valve fully closed), then tighten down the LVDT assembly (that is, return to its former position).

- After the LVDT is changed

  Calibration is required to find the null point and proper demodulator gain adjustment. However, if it is the same model, time can be saved by entering the same constants before running the calibration sequence.

- If a secondary wire pair is swapped

The valve positioner is not affected because the demodulator is a diode rectifying type. Also, the secondary pairs (A and B), can be swapped. The result will be a change in sign of the calibration values. Arithmetic in valve positioner firmware will yield the correct result. However, the user should follow the recommended hookup that will yield negative values at 0% and positive values at 100%, and avoid confusion.

25-7.3. Calibration Procedure

1. Access a turbine valve graphic. The turbine valve graphic shows a list of all the turbine valves.

2. Click on the desired valve symbol to display the VP calibration graphic (see Figure 25-3) and show the constants associated with that particular VP and valve. This graphic is provided with the project graphics. Customizing of the turbine valve graphic and VP calibration graphic is not in the scope of this document.

3. Perform the desired calibrations. All the calibration procedures cause the VP to enter local mode. While the VP is calibrating in local mode, VP firmware adjusts target demand accordingly. The Controller unconditionally tracks the VP when it is in local mode.

4. Refer to Table 25-5 for descriptions of the graphic fields.

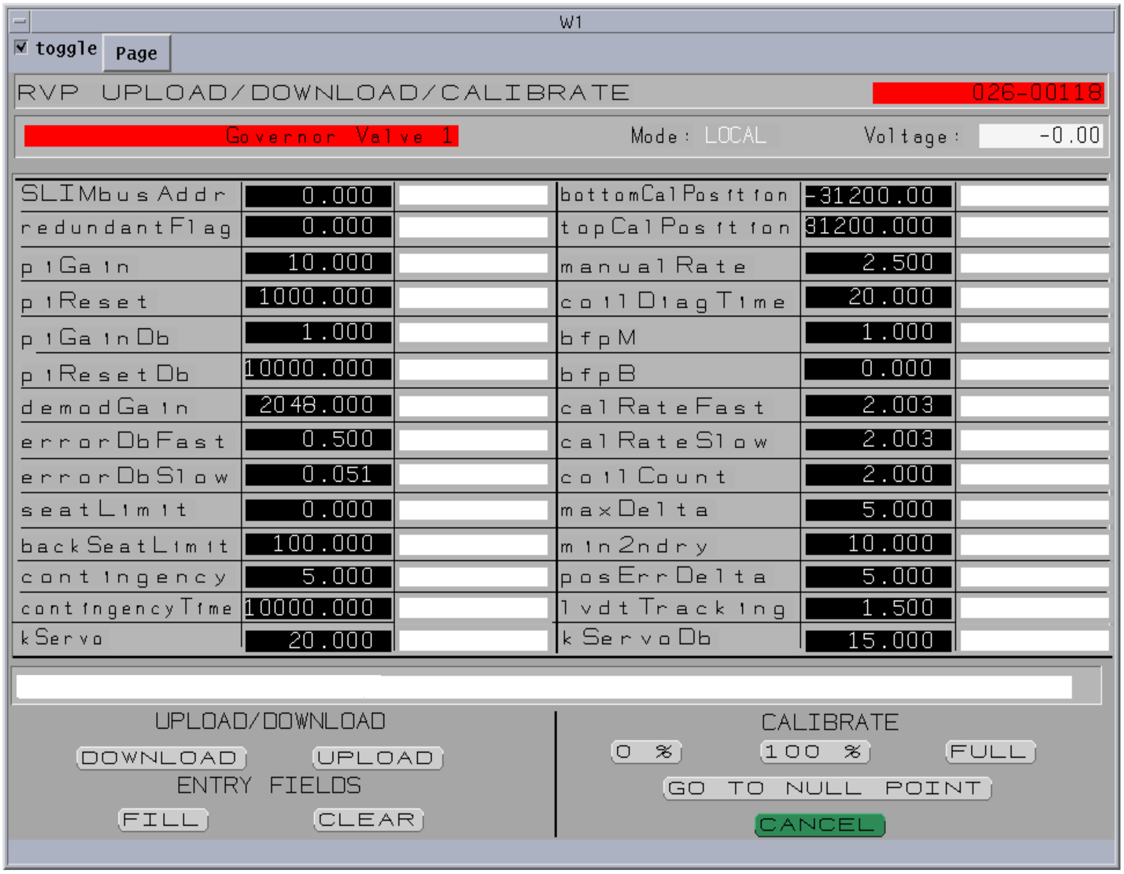


Figure 25-3. VP Upload/Download/Calibrate Graphic

Table 25-5. Calibration Graphic Fields

Field	Description
CALIBRATE Buttons	
0%	This button executes the CALZERO procedure. Demodulator gain is not adjusted during this procedure. When this procedure is completed, upload the calibration data to the algorithm.
100%	This button executes the CAL100 procedure. Demodulator gain is not adjusted during this procedure. When this procedure is completed, upload the calibration data to the algorithm.
FULL	This button executes the CALFULL procedure. Demodulator gain is adjusted during this procedure. When the procedure is completed, upload the calibration data to the algorithm.

Table 25-5. Calibration Graphic Fields (Cont'd)

Field	Description
GO TO NULL POINT	This button executes the GO TO NULL POINT procedure. During this procedure, the VP enters local mode and trims target position until position feedback voltage equals 0. Select the **CANCEL** button to exit this mode.
CANCEL	This button exits calibration.
UPLOAD/DOWNLOAD Buttons (Upload and download are **never** executed automatically.)	
UPLOAD	This button copies the data set contained in VP memory to the algorithm record in the workstation.
DOWNLOAD	This button copies the data set contained in the algorithm record to the VP and is written onto the VP's EE memory. Some limit-checking is performed prior to the download.
ENTRY FIELDS Buttons	
FILL	This button fills all the text editing windows with the values in the algorithm record.
CLEAR	This button clears all the values from the text editing windows.

Table 25-5. Calibration Graphic Fields (Cont'd)

Field	Description
Operator Feedback Fields	
Algorithm Record Name	Information field located on the top right of the graphic.
Voltage	Located below the algorithm name. The voltage shown is the voltage at the output of the programmable gain stage. If the VP is properly calibrated and nulled, the electrical 'stroke' will occupy most of the +-10 volt range of the AD converter input, thus giving good resolution. This field shows activity as the valve is traveling during calibration, and as the demodulator gain is adjusted at the endpoint.
Mode (MA)	Located to the left of the Voltage field. VP firmware is designed to stay in 'normal' mode, and if it is not in 'normal' mode, to establish communications with the Controller and then enter the 'normal' mode. In 'normal' mode, the VP receives its target position from the Controller. The MA algorithm that drives the VP target position may be in AUTO, MANUAL, or LOCAL mode.When the VP is in 'normal' mode, it is not aware of the MA mode. It receives target position from the Controller in MA AUTO and MANUAL. The field will usually show AUTO unless there is an error condition or the VP enters local mode due to a calibration sequence. During calibration, the VP enters local mode, which corresponds to MA local mode. The MA unconditionally tracks the VP until the calibration sequence completes. When the operator selects a calibration sequence, the mode is shown as 'local'. The voltage will change as the valve is moving. When the valve is at the endpoint and the demodulator gain is adjusting, the voltage will change as the gain is adjusted. A calibration complete message is displayed at the bottom field. In some cases in a full calibration, the results may yield poor values. A message will display telling the operator to repeat the calibration.
Valve Identification	Located to the left of the Mode field. Usually a text string that identifies the valve that is to be calibrated (name is provided by the turbine valve graphic).
Text Messages	Located under the table of values. This field displays messages about the progress of the calibration. For example, "calibration in progress" or "calibration complete."

25-8. Performing Redundant VP Calibration

VPs in a redundant subsystem can be calibrated as a pair or independently. The same commands are used to perform either calibration.

If you want to calibrate the VPs independently, the easiest method is to pull one of the VPs out of the mounting unit. In this case, calibration is the same as for a non-redundant VP (see Section 25-6). When a VP is calibrated and the Backup is not in service, and the RDNDNT flag is set, a warming message is printed to inform the operator that he is calibrating only one VP of the pair.

In any case, only the Primary VP or a pair can be calibrated. If you attempt to calibrate with the terminal connected to the Backup VP, the VP will print a message stating that the request is refused.

If you request a calibration of the Primary VP, and the Backup VP is also in service, the Backup is calibrated unconditionally. During calibration, the Primary disables the redundancy software state machine so failovers are eliminated.

The message packet exchange between the Primary and Backup VPs includes command/status bits related to calibration. The following table lists those commands and descriptions.

Table 25-6. Redundant Calibration Commands

Command	Description
RRVP_CAL_REC_TOP	Primary VP is commanding the Backup VP to record the 100% endpoint value.
RRVP_CAL_REC_BOT	Primary VP is commanding the Backup VP to record the 0% endpoint value.
RRVP_CAL_IN_ PROGRESS	Primary VP is informing the Backup VP that a calibration is in progress.
RRVP_CAL_BACKUP_ HOLD	Backup VP is performing a gain adjustment or is measuring the endpoint and is informing the Primary VP to wait for the process to be completed.
RRVP_CAL_WRITE_EE	Primary VP is commanding the Backup VP to commit the new calibration data to EEPROM memory at the end of the calibration process.
RRVP_CAL_HOT	Primary VP is informing the Backup VP that the calibration process is a “hot” calibration. A “hot” calibration is performed at only one end of the mechanical stroke. The important implication is that demodulator gain adjustment is not allowed during “hot” calibrations.

25-9. Valve Positioner Control

In normal, local, and calibrate modes the Valve Positioner is always controlling valve position. The PI routine runs unconditionally every 10 msec. Typically, it will execute the PI equation as described below. The PI routine has some conditionally executed parts to handle seating and backseating.

25-9.1. Seating and Backseating

Seating and backseating are important features of valve position control. The purpose of seating is to ensure that the hydraulic system is forcing the valve closed and admitting no steam into the turbine. Backseating is desirable because it can affect efficiency, and because, for certain valve assemblies, a leakoff into other steam systems are designed, assuming the valve is fully backseated.

The demand position from the Controller to the Valve Positioner is designed for a range of -5% to 105% and resolution exceeding 13 bits. Seating is in effect when the position demand is equal to or less than a programmable value, typically 0%, and actual position feedback is less than 5%. When seating is in effect, the output is driven to the maximum possible value in the direction that closes the valve. A timer is started. After 10 seconds, the output is reduced to 50% of the maximum value in the direction that closes the valve. A similar limit and function is provided for backseating.

25-9.2. PI Position Control

The equation for PI position control is

$$K_p\left[e(t) + \frac{1}{K_i}\int e(t)dt\right]$$

where:

K_p = Proportional gain

K_I = Integral time

e(t) = Position error

If seating or backseating is in effect, normal PI Controller calculation is halted.

25-9.3. Shutdown Input

Position control is affected by a shutdown input, intended to be used in emergency or abnormal situations. It is a standard 24 volt digital input circuit.

Typically, the Valve Positioner will rapidly drive the valve to the 0% position when the shutdown input is energized. The Valve Positioner then transfers to local-manual mode for the purpose of requiring the Controller to track position feedback. Once the Controller tracks, the Valve Positioner will transfer back to normal mode.

The state of the shutdown input is available to the Controller via a Valve Positioner module Ovation register.

A control bit in the shared memory can cause the Valve Positioner to ignore the shutdown input while in normal mode. This is used when the customer prefers trip logic in the Controller, not on the card. However, in local-manual mode, the Valve Positioner will drive the valve shut when the shutdown input is energized, regardless of the state, or previous state, of the control bit.

25-10. Diagnostics

One important feature of the servo valve is an adjustable mechanical bias mechanism. This mechanism creates a slight deflection in the valve spool so that a small amount of hydraulic fluid can escape the actuator and close the valve. Therefore, if there is no voltage applied to the servo valve, the actuator will slowly move toward the closed position. This deflection is typically overcome by -200 millivolts, so that when the valve is positioned and steady, this small voltage is seen on the servo valve.

The servo valve has two voltage coils, either of which can deflect the spool when excited. The combination of these features provides a redundancy feature that protects against broken wires or shorted coils, the ability to be diagnosed, and a predictable shutdown mechanism in the event the firmware diagnoses a catastrophic error and executes a shutdown, or an error mode occurs that allows a hardware watchdog timer to expire and de-power the Electronics module’s FVP field card.

The Valve Positioner continuously runs diagnostics to ensure that the circuit is operating properly. Certain conditions can cause the Valve Positioner to “dive,” essentially removing the output signal and allowing the valve to drift shut.

As a general rule, the card will view error conditions on start up as “no-go” or fatal errors. This means that the Valve Positioner will not generate an output to the valve. See the following error descriptions for specifics.

25-10.1. DA Readback Error

The Valve Positioner has the ability to read and convert the coil drive D/A convertor output signal that drives the valve. If the value readback (converted by the A/D converter) and the value that was output do not match within a deadband, and for a pre-defined period of time, a severe fatal error is assumed. In this case, the Valve Positioner is “flying blind.” It cannot confidently determine valve position or control the output. The Valve Positioner will remove drive power (dive) from the entire Electronics module’s FVP field card and go through a reset sequence. The coil drive D/A convertor readback check is a diagnostic that runs continuously.

25-10.2. EPROM Checksum Error

The EPROM checksum check runs continuously as a low priority function. Failure of the checksum diagnostic is considered a severe fatal error.

25-10.3. Contingency Check Error

Contingency is defined as the difference between a target position and the actual position, when that difference is greater than a defined limit. In the Valve Positioner, the contingency bit is set if the difference exceeds a programmable limit (default value is 5%) for a programmable time period (default value is 10 seconds). Contingency is not a fatal condition.

25-10.4. Memory Read/Write Check Error

A failure of any memory to read back correctly is considered a severe fatal error.

25-10.5. Open Coil Diagnostic Error

An open coil is detected by measuring voltage across the current limiting resistors on the servo output. When zero volts are detected, either the coil is open, the servo output is at zero, or the mechanical bias on the servo valve is incorrect. When an error condition is detected, an internal “open” bit is set.

Typically, the servo coil voltage is -200 mV when the valve is in a stable, controlled position and the servo valve mechanical bias is properly adjusted. If the servo output amplifier voltage amplitude falls below 100 mV, the internal bit is cleared, as though no error condition exists. If servo output voltage is greater than 100 mV, the difference between servo output voltage and coil voltage is compared to 50 mV, and if it is less, the ‘open’ bit is set.

If the open bit stays set for five seconds, the error condition is reported to the Controller in the module status register.

25-10.6. Shorted Coil Diagnostic

For each of the three coil outputs, an internal shorted bit is set if the converted value of terminal voltage is near 0 volts. Behavior of this diagnostic changes when servo output amplifier voltage is near zero.

Typically, the servo output coil is -200 mV when the valve is in a stable, controlled position and the servo valve mechanical bias is properly adjusted. If the servo output amplifier voltage falls below 50 mV, the internal bit is cleared, as though no error condition exists.

For servo output voltages greater in amplitude than 400 mV, the module status register voltage is compared to 50 mV, and a shorted bit is set if it is less. If the shorted coil bit remains active for five seconds, the condition is reported to the Controller in status word 1.

For servo amplifier voltage values between 50 and 400 mV, the comparison value is calculated as the servo amplifier voltage divided by eight. The timing described above is used. When the shorted bit becomes inactive, the corresponding bit in status word 1 is cleared immediately.

25-10.7. Diagnostics of LVDT Problems for Redundant VP

Diagnosing an LVDT failure is complex. Depending on the failure, the valve may go open, closed, or to a different intermediated position, which can be above or below the target position. If the valve is positioned at the LVDT null point, an oscillator failure would not be detected because the position feedback would continue to be equal to zero (0) volts.

- If |(Position Feedback - Previous Position Feedback)| < MAXDELTA, and POSITIONERRORFLAG is not set, all conditions are considered normal, and the REDUNDANCY STATE is set to NORMAL. Previous Position Feedback is set equal to Position Feedback prior to exiting the PI routine.
- If (Position Feedback - Previous Position Feedback) > MIN2NDRY and the backup is OK, the VP executes the failover.

- If |(Position Feedback - Previous Position Feedback)| > MAXDELTA, a problem is suspected. VP firmware refuses to "believe" the new position feedback value, and does not update Previous Position Feedback or run the PI loop. If REDUNDANCY STATE is NORMAL, it is updated to POOR. If it is POOR, it is updated to BAD. If it is BAD, and the backup is OK, the VP executes the failover. This means that it can take 30 msec for the VP to determine that it should execute its failover.
- If POSITION ERROR FLAG is set, and the partner's reported position is within LVDTTRACKING of Position Feedback, the condition is not due to a failed LVDT, but for another reason. No action to fail over is taken.
- If POSITION ERROR FLAG is set, and both Position Feedback voltage and Previous Position Feedback voltage are equal or close to zero volts, the problem is suspected to be a failed oscillator, or broken oscillator wire, and the failover is executed as long as the Backup is OK.
- If POSITION ERROR FLAG is set, and Position Feedback differs from Partner's Position Feedback by more than LVDTTRACKING, and the Backup is OK, an LVDT problem is suspected and the failover is executed.

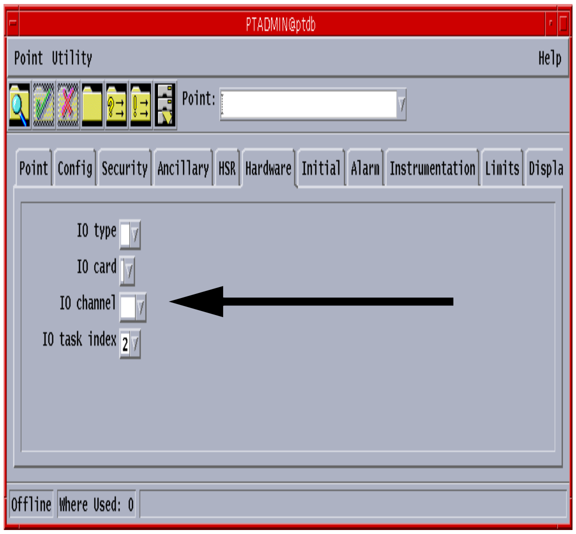
25-11. Controller Interface

This section defines direct-access Ovation shared memory registers from the Controller point of view. The Controller point-of-view is at the internal workings of the algorithm (the MASTATION is assumed). Conversions may occur between the applications level and the level described here. This format is used for start up, local, and normal operating modes. In test mode, the format changes except for the mode bits in register 6 (status register 1), Bits 0 through 3, and the FIFO control bits in both the command register and status register 2.

25-11.1. Memory Map

Table 25-7 describes the Controller registers for the Valve Positioner module.

It also defines the I/O Channel Number that must be selected in the Point Builder Hardware Tab (shown below) when configuring points associated with this module (refer to "Ovation Point Builder User's Guide" (U3-1041), "Ovation Developer Studio User Guide" (N T-0060 or W IN60) for details).



Use the information in Table 25-7 to determine how to scan the card and retrieve card status bits. The status bits will influence your control strategy.

Table 25-7. Operating Mode Memory Map

Valve Positioner Card Register	I/O Channel Number in the Point Builder	R/W	Definition
0	N/A	N/A	Indirect ram pointer (Output FIFO Put Pointer)
1	N/A	N/A	Indirect ram data register
2	4	R	Position feedback (-1560 to 32760 equals -5.0 to 105%)
3	5	R	Coil voltage 1 (traditionally called S1)
4	6	R	Coil voltage 2 (traditionally called S2) (non-redundant configuration only)
5	7	R	Coil voltage 3 (non-redundant configuration only)
6	8	R	Raw demodulator voltage
7	N/A	R	Status Word 2 Bits 0 through 15 - Not used.

Table 25-7. Operating Mode Memory Map (Cont'd)

Valve Positioner Card Register	I/O Channel Number in the Point Builder	R/W	Definition
8		R	Status Word 1 Bits 0 through 3 - modes 0000 - not used 0001 - PE mode 0010 - start mode 0011 - test mode 0100 through 0111 - not used 1000 through 1011 - local modes 1000 - local mode 1001 - calibrating in local - seated 1010 - calibrating in local - backseated 1011 - calibrating in local 1100 through 1111 - normal modes 1100 - normal mode 1101 - calibrating in normal - seated 1110 - calibrating in normal - backseated 1111 - calibrating in normal mode Bit 4 - Shutdown input status, 0 = inactive, 1 = activated
	1		Bit 5 - Auxiliary voltage sense
	2		Bit 6 - SLIM-ON signal
	3		Bit 7 - VP alive flag. The VP toggles this bit to indicate that it is running.
			Bit 8 - At null point (Bits 9 through 14 - for redundant configuration) Bit 9 - Quality- Used by redundant VP configuration Bit 10 - Primary/Backup status for redundancy, 0 = Primary, 1 = Backup Bit 11 - LVDT Trouble - LVDT problem indicator for redundant configuration. Held True for five seconds. Bit 12 - Failover Annunciator - Redundant configuration If a VP switches to/from Primary or Backup, this bit is held True for five seconds. Bit 13 - Data Validation Error - The position demand over the Ovation and redundancy link do not match. Bit 14 - Mode mismatch - In a redundant pair, one VP is in Normal mode and the other VP is in Local mode. Bit 15 - Write EE complete

Table 25-7. Operating Mode Memory Map (Cont'd)

Valve Positioner Card Register	I/O Channel Number in the Point Builder	R/W	Definition
9		R	Demand feedback (-1560 to 32760 equals -5.0 to 105%) = (Position feedback - bfpB) / bfpM (bfpM and bfpB are described below) For non-boiler feed pump applications, bfpM = 1.0 and bfpB = 0.0, therefore "Demand feedback" and "Position feedback" are exactly equal.
A		W	Command Register Bit 0, 1, and 2 – calibration requests 000 = no request 001 = zero hot cal request 010 = top hot cal 011 = full calibration 100 = go to null point 101 invalid 110 invalid 111 = full calibration and stop at null point Bit 3 - Not used Bit 4 - Partner Quality (redundant VP configuration) 0=OK, 1=BAD Bit 5 - Partner Alive Bit (redundant VP configuration) from register 8, bit 7 or Partner VP Bit 6 - Redundant VP's Partner's Primary/Backup Status. The Controller copies Bit 10 from the partner's status register 1 to inform the VP that the partner is a Primary or Backup drop. Bit 7 through 15 - Not used
B		W	Demand (-1560 to 32760 equals -5.0 to 105.0%)
C			Point Status Register
D		R/W	Module Configuration Status Register (see Table 25-12)
E		R	Secondary Module Configuration Status Register (see Table 25-13)
F			Electronic ID

25-12. Valve Positioner Commands

25-12.1. Configuration Commands

The following commands are used to set the values of important tuning constants. The format of each command is indicated and must be followed. The values shown for each command are default values.

Table 25-8. Configuration Commands

Command	Description
piGain = 10.0	PI Controller gain outside of deadband. This value is the higher of two gain values used in the position PI loop. This value is used when the valve is moving. When the valve is in a stable position, a lower value is used to avoid noise-induced control action.
piResetT = 1000	PI Controller reset time outside of deadband. Used in PI equation along with the gain value described previously. This value is one of two used in the PI equation. This one is used when the valve is in motion, and causes faster wind-up. It is given in milliseconds.
piGainDb = 1.0	PI Controller gain inside of deadband. When the valve is in a steady position, the PI gain is reduced to this value. This helps avoid noise-induced control action.
piResetTDb = 10000	PI Controller reset time inside of deadband. This is one of two values used, and causes slower control action. It is given in units of milliseconds.
demodGain = 2048	The LVDT secondary feedback sum is multiplied by this value to achieve a voltage range representing 0 to 100% position that is close to the input range of the A/D converter. The value is printed as a raw decimal value. The hexadecimal equivalent is written to the feedback D/A converter to adjust feedback gain. This value can be entered by the customer, but it is also modified automatically during the full calibration sequence. Feedback gain can be calculated by the following formula: gain = 4096 / D/A converter input word (decimal value) Examples of some gain values are as follows: **DAC word** — **Decimal value** — **Gain** 0 — 0 — Infinity [1] 1 — 1 — 4096 . — . — . 8 — 8 — 512 . — . — . 100H — 256 — 16 . — . — . 800H — 2048 — 2 . — . — . FFFH — 4095 — 1.00024 [1] Feedback gain D/A converter output saturates.

Table 25-8. Configuration Commands (Cont'd)

Command	Description
errorDbF = 0.5	When the absolute value of the difference between target position and actual position is greater that this value, the valve is considered to be in motion. Gain and reset values are selected to cause rapid control action. When the difference is less than this value, control action is softened.
errorDbS = 0.05	When the absolute value of the difference between target position and actual position is less than this value, the valve is considered to be stable. Gain and reset values are selected to soften control action. When the difference is greater than this value, gain is increased to yield sharper control.
seatLimit = 0.0	When target valve position is equal to or less than this value, seating action controls the output.
backSeatLimit = 100.0	When the target valve position is equal to or greater than this value, backseating action controls the output.
contingency = 5.0	If the absolute value of the difference between Valve Positioner target position and actual position is greater than this value, then a contingency condition may exist. The condition must exist until a timer expires for it to be reported. The timer is described below. A situation could arise where the Valve Positioner target position and the Controllers' target are not equal. One example would be if the shutdown input was true, the Valve Positioner set the target position to 0, but the Controller did not track. In this situation contingency would not be reported if the valve went to 0% position
contingencyTime = 10000	If the error between target position and actual position exceeds contingency for this amount of time, then the condition is reported to the Controller. This number is given in milliseconds.
manualRate = 300	This value selects the magnitude of adjustment when target position is controlled by the SLIM. This value is given in percent per minute.
bfpM = 1.0	Gain in the equation y = bfpM * x + bfpB where y = actual demand; x = demand written by the Controller The purpose of this is to create staggered valve operation in the boiler feed-pump application. This value is normally set to 1.0.
bfpB = 0.0	Zero intercept in the equation y = bfpM * x + bfpB where y = actual demand; x = demand written by the Controller The purpose of this is to create staggered valve operation in the boiler feed-pump application. This value is normally set to 0.0.

Table 25-8. Configuration Commands (Cont'd)

Command	Description
SlimAddr = 0	Each device on the SLIM serial bus has an address. This provides a method for the SLIM to talk individually to each card. The SLIM serial port is used for redundancy serial communications. Setting the address to zero (0) disables SLIM transmit/receive code.
calhndrd = 31200	This value is displayed in decimal. It is the converted hexadecimal A/D converter reading for the 100% position. It can be entered by the customer; however, it is normally determined automatically by the calibration sequence.
calzero = -31200	This value is displayed in decimal. It is the converted hexadecimal A/D converter reading for the 0% position. It can be entered by the customer; however, it is normally determined automatically by the calibration sequence.
calrateF = 1664	This value is given in percent per minute and is the movement rate used when calibrating from the Laptop computer via the serial port. It is typically the **F**aster rate.
calrateS = 1664	This value is given in percent per minute and is the movement rate used when calibrating via a command from the Ovation I/O interface. It is typically the **S**lower rate. **Note** When the raise/lower button is pressed, the Valve Positioner will respond to the keystroke if the address is 1 through 8 inclusive. This means that all valves will move together.
posErrDelta = 5.0	A tunable parameter which sets a limit for the difference between target and actual position. When the difference is greater than this limit, POSITION ERROR FLAG is set TRUE, otherwise it is FALSE. This variable is similar to contingency except that it is devoted to the redundant calculations.
maxdelta = 5.0	A tunable parameter which sets a limit for the difference between position feedback and previous position feedback. The default value is 5%. Expressing the value as a derivative would yield 5% per 10 msec (= looptime) or 500% per second. This value is intended to represent the maximum rate of movement of the valve. This value has a function similar to MIN2NDRY. It is assumed that MAXDELTA will always be the smaller of the two.
min2ndry = 5.0	The minimum secondary value is similar to MAXDELTA because it represents a position feedback derivative. However, MIN2NDRY describes the minimum value in percent of a contribution of either secondary signal. If the secondary wire were to break, position feedback would suddenly change by at lease this amount. The default value is 10%. If the difference between position feedback and previous position feedback were to change by this value, or greater, it suggests a broken secondary wire. It is assumed that MIN2NDRY is larger than MAXDELTA.
lvdtTrack = 1.5	The maximum difference between LVDT readings in a redundant configuration

Table 25-8. Configuration Commands (Cont'd)

Command	Description
RDNDNT	If RDNDNT = 0, the VP is a standalone module If RDNDNT = 1, the VP is a redundant module This is the MOST important constant and MUST be set prior to inserting the VP into its mounting slot. If the VP is installed without this constant being set, and the unit is on line, the results are unpredictable. In some cases, such as when a VP module is being replaced by another VP from stock, the VP should be placed into an unused slot to power it up and modify the constant. Remember to type SC to save the constants to EEPROM memory. Setting this constant changes the Baud Rate for COM Port 2 (SLIM port) to 25 k baud
demand = 10.0	This command sets target value position to 10%, sets the VP made to local, and sets a restriction bit to prevent the VP from entering Normal mode. Type "EXIT" to clear the restriction bit
CoilCount	If CoilCount = 1, the VP is a redundant module and only coil 1 from the VP is used. Failure to set this constant will typically result in servo coil diagnostic failures, which cause the VP to fail to its Backup. If CoilCount = 2, coils 1 and 2 are used, and coil 3 (diagnostic) is disabled.
diagtime = 20	Timer value in millisecond increments for the coil short/open timer. The conditions must exist for this amount of time before it is reported to the Controller.

Table 25-8. Configuration Commands (Cont'd)

Command	Description
diags	Displays status information in hexadecimal format. Included is the operating mode, restrictions, signals, and Severe Fatal Errors (SFE) bits. The following message is displayed: mode=0xmmmm restrictions=0xrrrrrrr signals=0xssss sfe's=0xeeee where mmmm = Hex value of operating mode: 0 through 0x05 are **start** modes 0x14 through 0x19 are **local** modes 0x28 through 0x2B are **normal** modes 0x3C through 0x3F are **test** modes rrrrrrr = Restriction bit array: bit 0 - PROM checksum error bit 1 - Memory diagnostic error bit 2 - A/D, D/A subsystem error bit 3 - Contingency restriction bit 4 - Ovation I/O not configured bit 5 - Constants are mismatched bit 6 - Controller is not updating bit 7 - Controller is not tracking bit 8 - EEPROM checksum error bit 9 - Hold until oscillator is stable bit 10 - Serial port control (local mode) restriction ssss = Signal flags: bit 0 - Coil 1 diagnostic bit 1 - Coil 2 diagnostic bit 2 - Coil 3 diagnostic bit 3 - DAC diagnostic bit 4 - Coil 1 open bit 5 - Coil 1 short bit 6 - Coil 2 open bit 7 - Coil 2 short bit 8 - Coil 3 open bit 9 - Coil 3 short bit A- AD/DA error bit B - Contingency bit C - Repetitive display bit D - Raise pushbutton on SLIM bit E - Lower pushbutton on SLIM eeee = Severe fatal error bits: bit 0 - EEPROM checksum bit 1 - PROM checksum bit 2 - Shared memory error bit 3 - Processor memory error bit 4 - FPGA won't program bit 5 - UART readback error bit 6 - Processor error bit 7 - AD/DA error bit 8 - PSD memory error bit 9 - EE write sequence error

Table 25-8. Configuration Commands (Cont'd)

Command	Description
kServo = 20.0	kServo is a parameter, given in percentage, that models the impedance relationship of the Personality module (PMOD) and the servo coil. For example, if the user has a PMOD with an impedance of 300 ohms, and the coil impedance is 82 ohms, then kServo should be set to 21.0 or 82 / (300 + 82). VP diagnostic firmware uses this parameter to predict coil voltage based on amplifier output voltage. Wire impedance is included in coil impedance. The user can take a direct measurement with a standard voltmeter by removing the VP from the base unit. The user can also measure the ratio directly. One method is to measure amplifier output voltage at B13, a coil output that is normally unconnected, then measure coil voltage at B14 or B15. With the unit off line, amplifier voltage at B13 would be saturated to 10 volts or 5 volts depending on the state of the current reduction algorithm. This parameter can be used when servo coils are wired in parallel. For this example, kServo would be set to 11.7 or 40 / (300 + 40). If one of the coils burned out, the relationship would change to 21.0. By setting kServoDb to 5.0, an alarm would be generated when the servo coil went open circuit.
kServoDb = 5.0	Deadband value used to calculate the allowable coil voltage range when comparing predicted voltage to actual voltage.

25-13. SLIM (Small Loop Interface Module) Interface

A standard SLIM will be used to control a group of valves on a common serial bus (refer to Section 23) for more information about the SLIM module).

25-13.1. Modes

The SLIM has four modes:

- Local
- Auto
- Cascade
- Manual

Only two of the four (local and auto) correspond to Valve Positioner modes. Local mode corresponds to Valve Positioner local-manual mode. However, the operator does not request "local' mode." It is only entered when the Controller stops or fails to update the Valve Positioner card.

SLIM auto mode corresponds to Valve Positioner normal mode. In this mode, the Controller is writing its desired position to the Valve Positioner. In normal mode, the valves' position and set point can be viewed on the SLIM, but the SLIM has no control over the Valve Positioner.

These modes should not be confused with auto and manual modes of software loops within the Controller. The important thing to remember is that the Valve Positioner is always in normal mode, receiving its position from the Controller, unless the Controller fails, in which case the Valve Positioner switches to local mode.

When raise and lower on the SLIM are pressed, all Valve Positioners respond to the key action. This means that all valves will move together as a group. It also suggests that no other devices (Loop Interfaces) should be connected on the serial bus with a group of Valve Positioners.

In abnormal situations, such as during maintenance, some valves may be in normal mode, and some may be in local mode. In this situation the valve in local mode will respond to raise/lower action, but the valves in normal mode will not. The Controller application will warn or notify the operator of the mode of each valve.

Since the SLIM will be connected to a group of Valve Positioners, each Valve Positioner must control its own transmit enable. Each SLIM enables its transmitter when placing a response into the transmit buffer. It also starts a 25 mSec timer, which, when expired, disables the transmitter.

25-13.2. SLIM Pushbuttons

The purpose of this section is to highlight and clarify SLIM operation as it differs from normal operation when connected to the Ovation Loop Interface.

The actions that occur when a SLIM pushbutton is used are described in Table 25-9:

Table 25-9. SLIM Pushbutton Actions

Button	Description
Loop	The next Valve Positioner on the serial bus is selected. Set point and target position are displayed on the vertical bargraphs.
Display	Display cycles the top left hex display from target position, actual position, and servo voltage output.
Up	Up increases target valve position for the valve group. Only the valves in local mode respond to the Up button.

Table 25-9. SLIM Pushbutton Actions (Cont'd)

Button	Description
Down	Down decreases target valve position for the valve group. Only the valves in local mode respond to the Down button.
Manual, Auto, Cascade, Mode, Left, Right	Not used.

The SLIM indicators and LEDs provide information about the operation of the Valve Positioner. These displays are described in Table 25-10:

Table 25-10. SLIM Indicators and LEDs

Indicator	Description
PV Bargraph	Indicates actual valve position
SP Bargraph	Indicates target valve position of the selected valve
Output Bargraph	The horizontal output bargraph on the bottom of the SLIM indicates servo output voltage ranging from -10 volts to +10 volts, mapped to 0 to 100% available on the bargraph. For a stable valve in a controlled position, approximately 50% (+/- mechanical bias adjustment) would be indicated.
Top Left digits	Indicators for set point, actual, or output voltage.
Top Right digits	Indicate engineering units of the value being displayed.
LEDs: **M, C, and T**	In local manual mode, C (control) is indicated. In normal mode, M is indicated (monitor). The operator does not have any control over the 'M', 'C', or 'T' function.
LEDs: **Casc and Man**	Not used.
Auto LED	Illuminated if the valve is in **normal** mode.
Loc LED	Illuminated if the valve is in **local** mode.

25-14. Valve Positioner Terminal Block Wiring Information

Each Personality module has a simplified wiring diagram label on its side, which appears above the terminal block. This diagram indicates how the wiring from the field is to be connected to the terminal block in the base unit. The diagram for the Valve Positioner Personality module is shown in Figure 25-4.

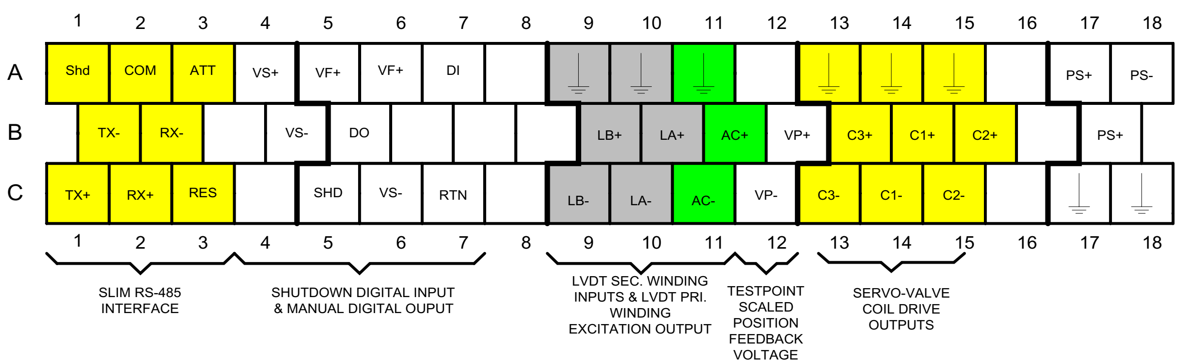
The following table lists and defines the abbreviations used in this diagram.

Abbreviation	Definition
COM	Common terminal of the SLIM interface circuit.
⏚	Earth ground terminals used to connect to input signal's shield (see Figure 25-5 and Figure 25-6 for field connections) (for non-CE Mark systems only).
ATT	SLIM cable attached input, it may have to be connected to COM. See Figure 25-4.
VS+, VS-	Auxiliary voltage input terminals (+24V or +48V)
VF+	Fused auxiliary voltage source terminal connection
SHD	Shield of digital I/O signals' cable (see Figure 25-5 and Figure 25-6 for field connection) (for non-CE Mark systems only).
DI	Shutdown digital input.
PS+, PS-	Auxiliary power supply terminals.
TX+, TX-	RS-485 transmit data (output). SLIM interface.
RX+, RX-	RS-485 receive data (input). SLIM interface.
DO	Manual digital output.
LB+, LB-	LVDT secondary winding B input.
LA+, LA-	LVDT secondary winding A input.
AC+, AC-	LVDT primary winding AC excitation output.
VP+, VP-	Demodulated scaled valve position testpoint voltage.
C1+, C1-	Servo valve actuator coil #1 voltage output.
C2+, C2-	Servo valve actuator coil #2 voltage output.
RES	SLIM RS-485 receiver circuit input termination resistor. If receiver termination is desired, RES is connected to RX+.

Abbreviation	Definition
RTN	Return for digital input. Connect to VS-.
C3+, C3-	Servo valve actuator coil #3 voltages output.

Note

Do **not** use unmarked terminal block locations.



Notes

1. If the SLIM communication cable assembly is terminated to the base unit termination block, a wire jumper must be installed between terminal A2 (COM) and A3 (ATT). The SLIM communications cable assembly shield should be connected to terminal A1 (SHD).

2. If the SLIM interface is to have a line receiver parallel termination resistor, a wire jumper must be installed between terminals C2 (RX+) and C3 (RES). This jumper is added if either the base unit termination block or the personality module SLIM female DB9 connector is used to interface the SLIM communications cable assembly.

3. All of the field interface signals must use twisted-pair copper wire conductors inside a shielded cable assembly. The cable assembly shield must be tied to earth ground via one or more of the Earth terminals. For CE Mark systems, the cable assembly shield is not connected to any of the termination block terminals.

4. In CE Mark systems, SLIM cable 5A26429 MUST be used and grounded at the entry point of the cabinet using the recommended hardware (refer to “Cable Guidelines” in U3-1000 and U3-1005).

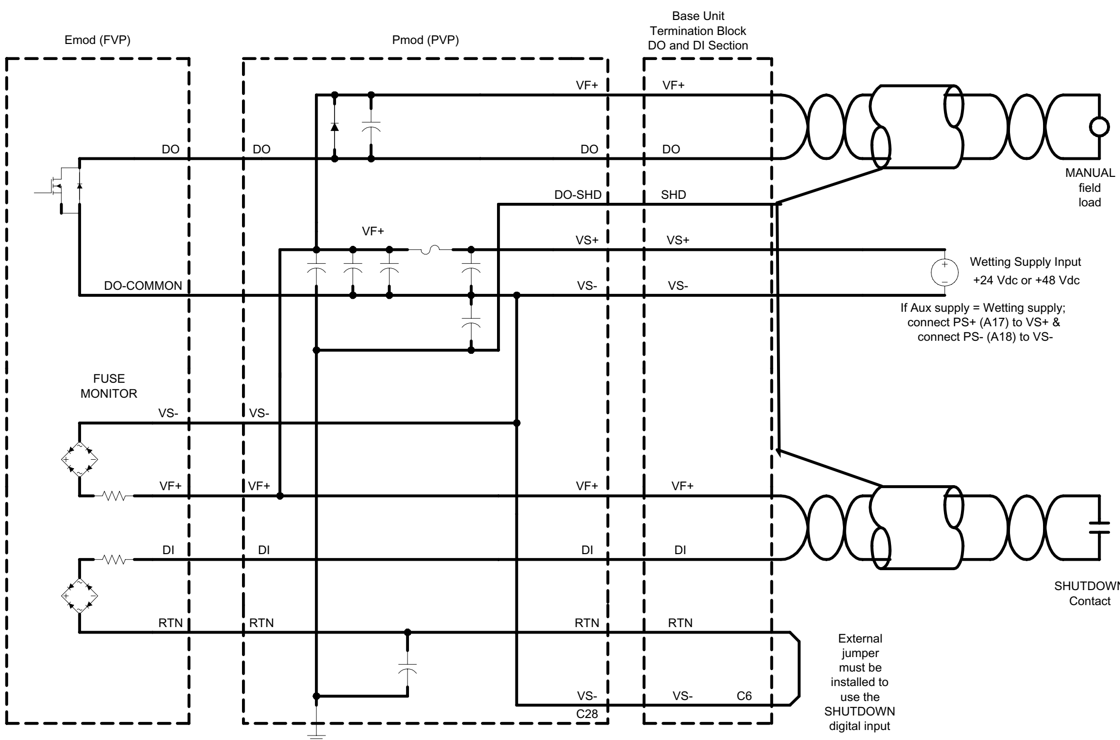
5. C3+ and C3- coil drive outputs are not available for Group 4 Personality modules.

6. Terminals VP+ and VP- are intended to provide a test point voltage that is to be measured by a high input impedance volt meter. If an external device is to be permanently connected to the VP+ and VP- terminals, an interposing buffer is required within the cabinet that houses the VP module. The buffer must have an input impedance greater than 100k ohms and must be able to accommodate an input span of +/- 10 Volts.

Figure 25-4. Terminal Block Connections for the Valve Positioner Personality Module

25-15. Valve Positioner Field Connection Wiring Diagrams

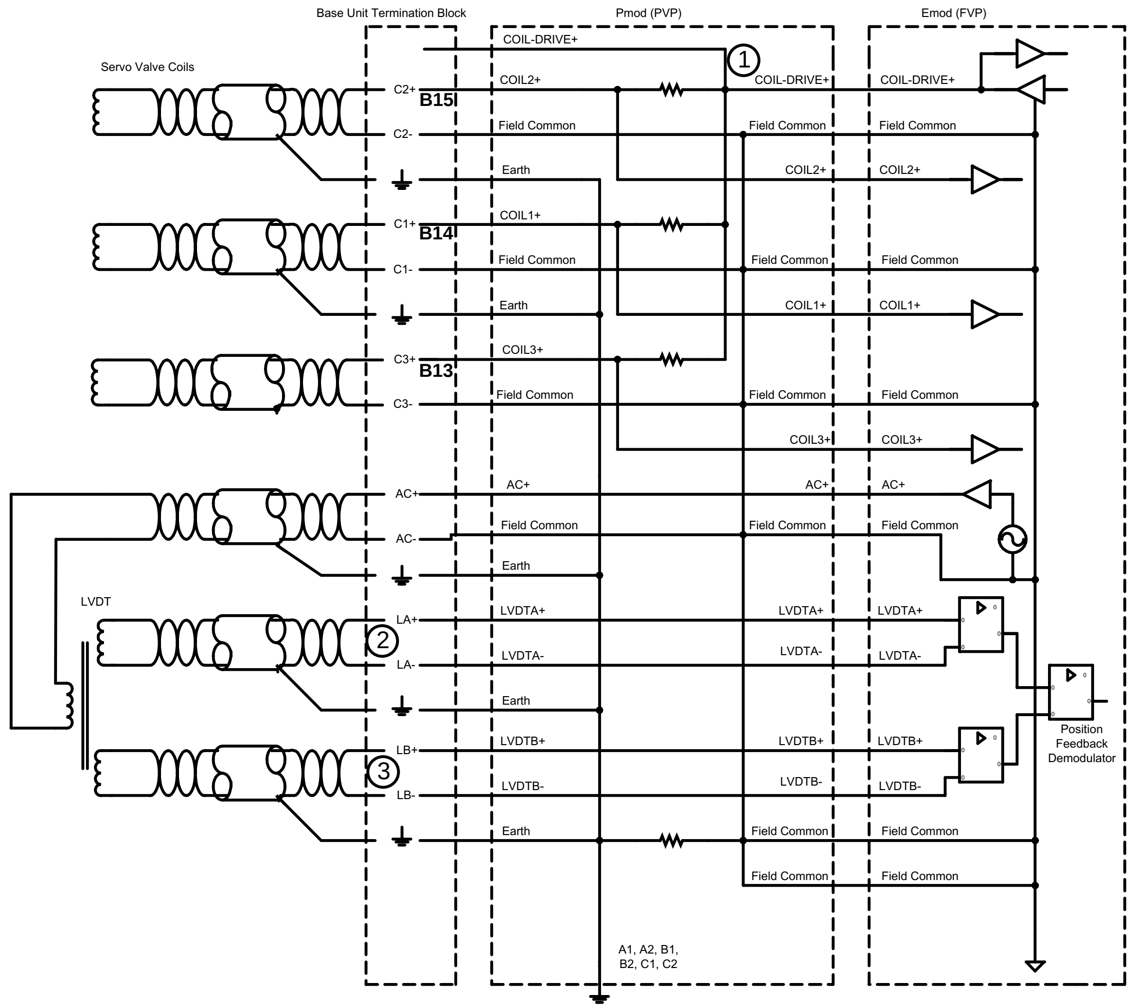
Non-CE Mark Certified Systems



Note

A fault on the MANUAL digital output or on the SHUTDOWN/digital input that causes the personality module fuse to open will disconnect the internal auxiliary supply from both the digital input and the digital output circuit.

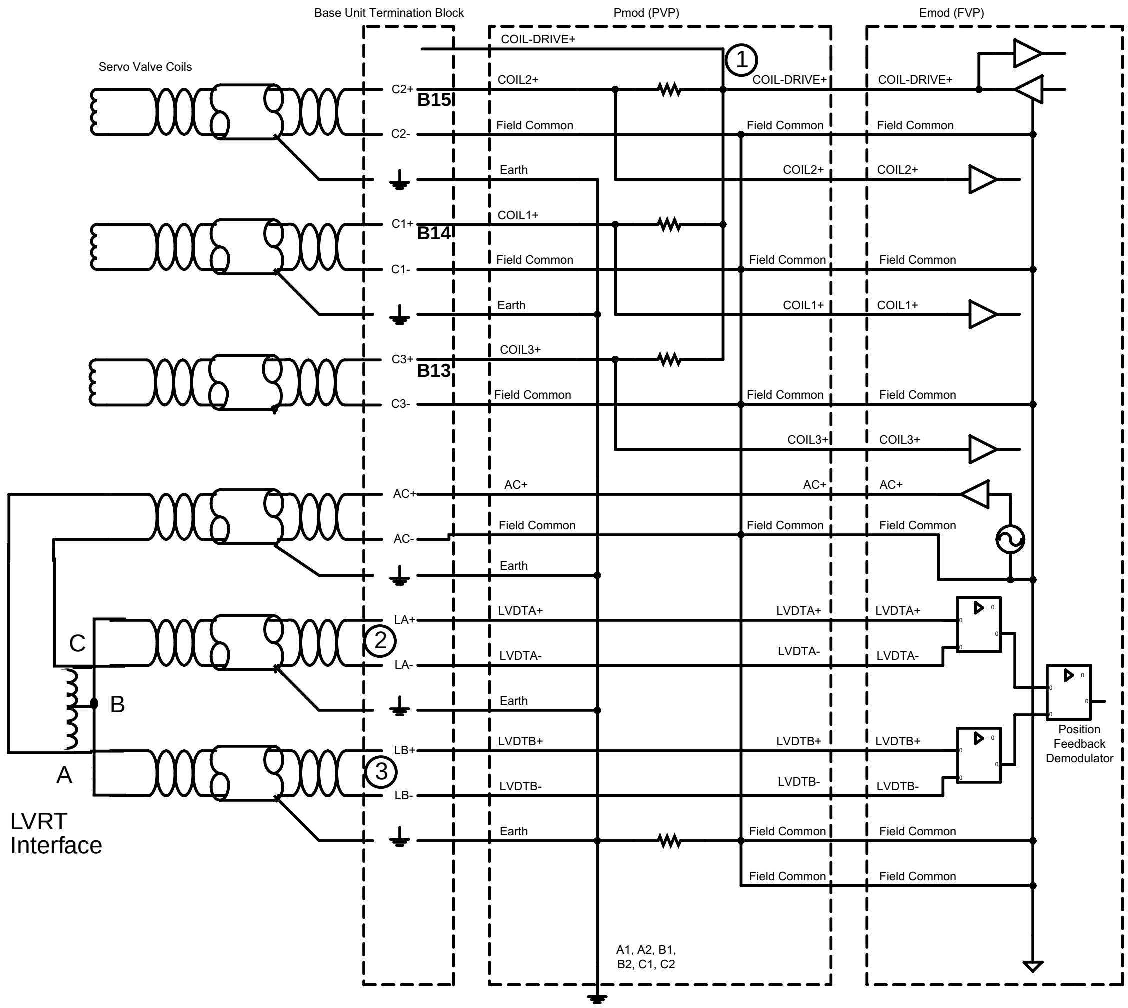
Figure 25-5. Digital Output and Digital Input (internal auxiliary supply) Field Connections (Non-CE Mark)



Notes

1. Negative voltages on terminals B15, B14, and B13 cause the valve to open.
2 The amplitude of this signal decreases as the valve goes open.
3. The amplitude of this signal increases as the valve goes open.

Figure 25-6. Analog Input and Analog Output Connection (Non-CE Mark)

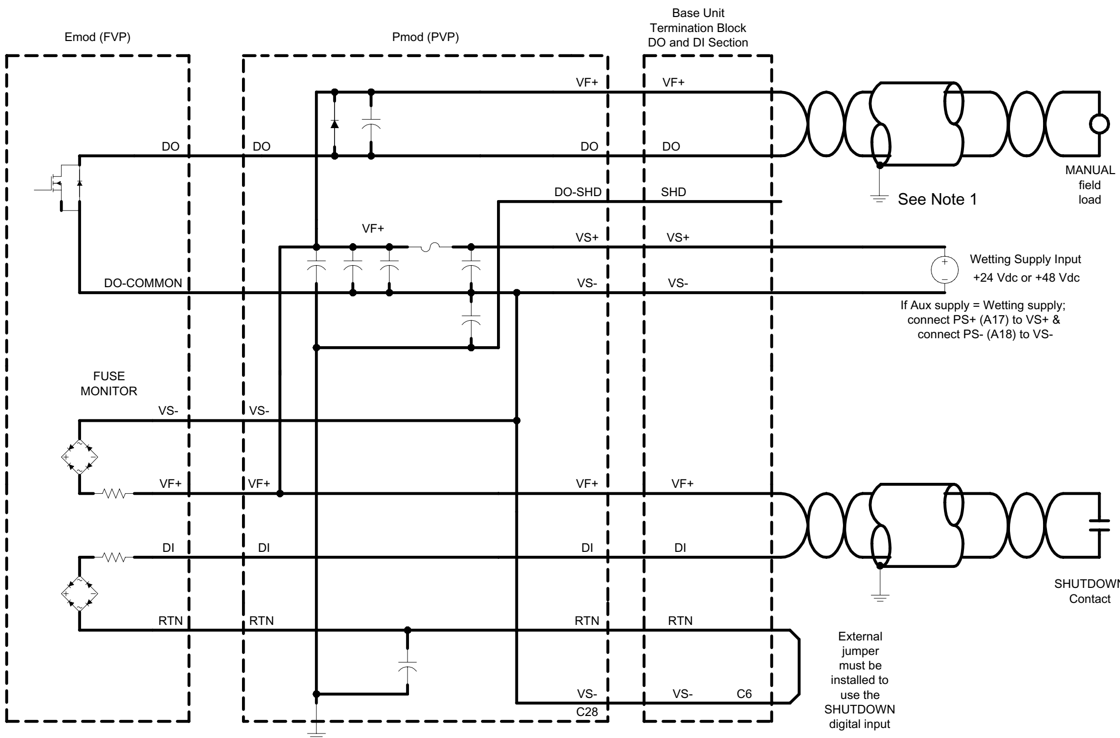


Notes

1. Negative voltages on terminals B15, B14, and B13 cause the valve to open.
2 The amplitude of this signal decreases as the valve goes open.
3. The amplitude of this signal increases as the valve goes open.
4. Node A is connected to terminals AC+ and LB+,
Node B is connected to terminals LB- and LA+,
Node C is connected to terminals AC- and LA-.

Figure 25-7. Analog Input/Output Example Using 3-Wire LVRT (Non-CE Mark)

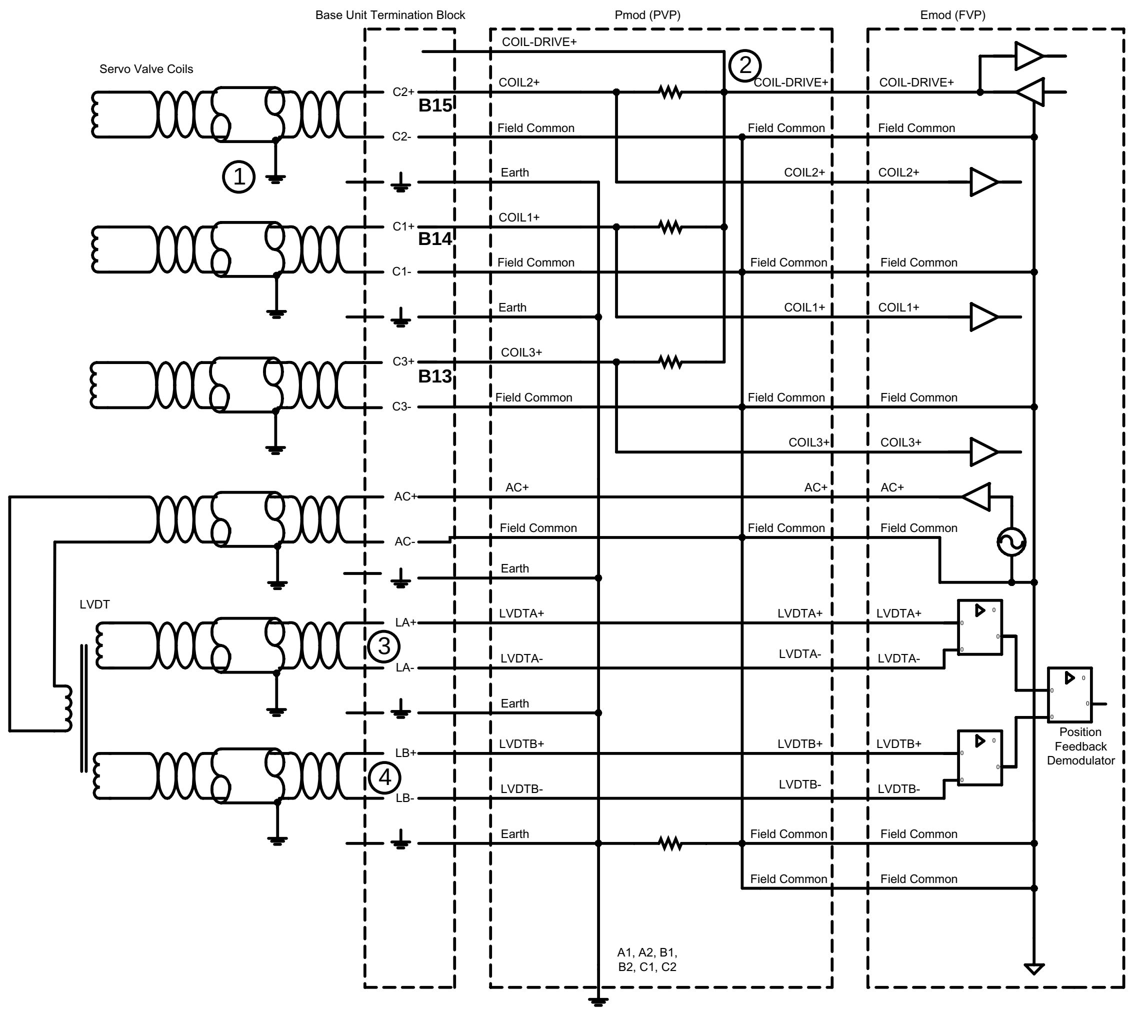
CE Mark Certified Systems



Note

1. All field wiring must be braid-shielded and grounded at the entry point of the cabinet using the recommended hardware (refer to “Cable Guidelines” in U3-1000 and U3-1005).

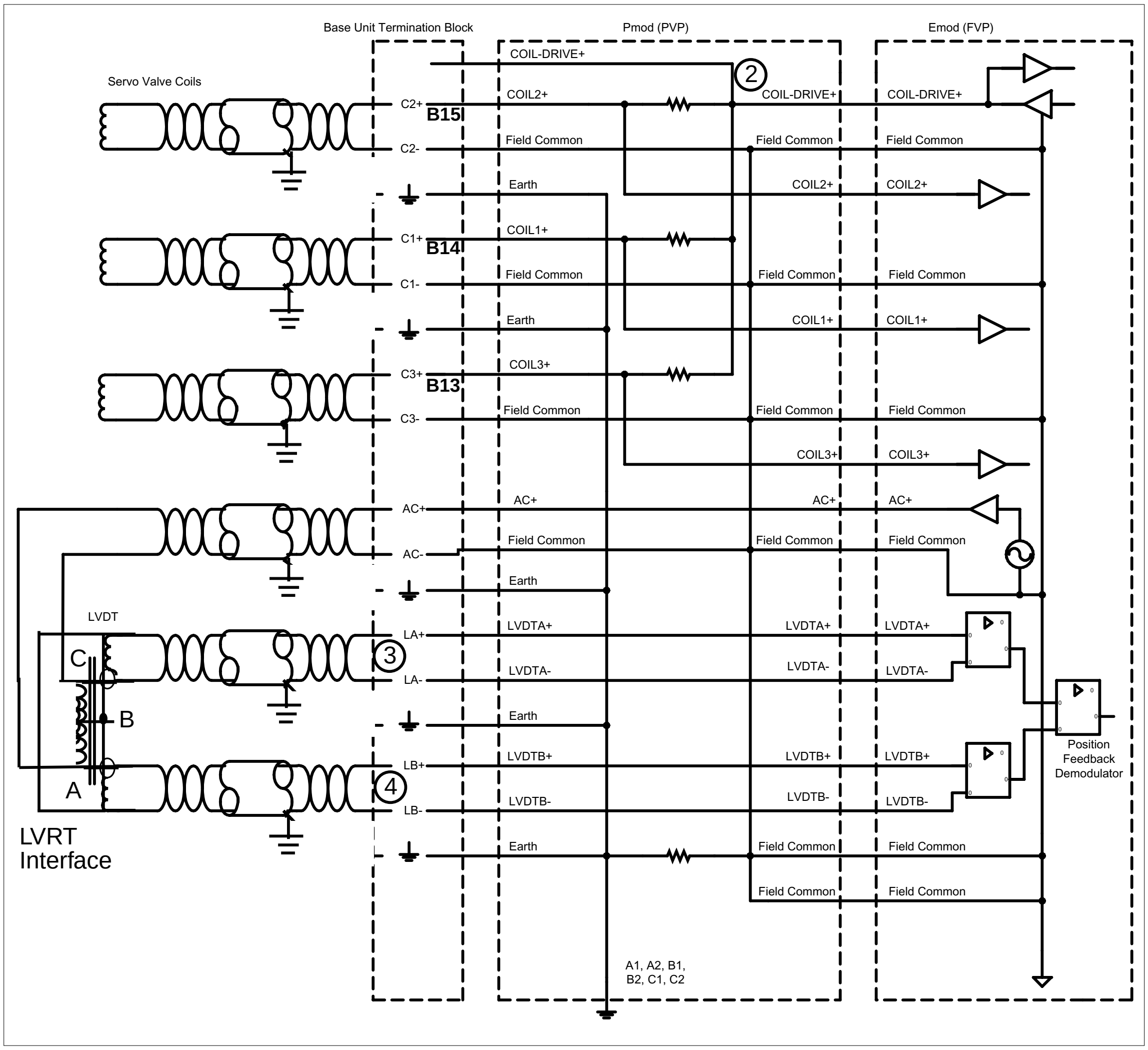
Figure 25-8. Digital Output and Digital Input (internal auxiliary supply) Field Connections (CE Mark)



Notes

1. All field wiring must be braid-shielded and grounded at the entry point of the cabinet using the recommended hardware (refer to “Cable Guidelines” in U3-1000 and U3-1005).
2. Negative voltages on terminals B15, B14, and B13 cause the valve to open.
3. The amplitude of this signal decreases as the valve goes open.
4. The amplitude of this signal increases as the valve goes open.

Figure 25-9. Analog Input and Analog Output Connection (CE Mark)



Notes

1. All field wiring must be braid-shielded and grounded at the entry point of the cabinet using the recommended hardware (refer to “Cable Guidelines” in U3-1000 and U3-1005).
2. Negative voltages on terminals B15, B14, and B13 cause the valve to open.
3. The amplitude of this signal decreases as the valve goes open.
4. The amplitude of this signal increases as the valve goes open.
5. Node A is connected to terminals AC+ and LB+,
   Node B is connected to terminals LB- and LA+,
   Node C is connected to terminals AC- and LA-.

Figure 25-10. Analog Input/Output Example Using 3-Wire LVRT (CE Mark)

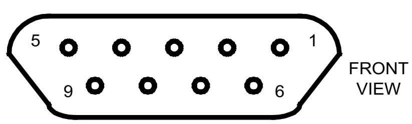
25-16. SLIM Serial Port Connector

The Personality module SLIM connector is used to connect the Valve Positioner module to a SLIM module (refer to Section 23).

Table 25-11. SLIM Connector (J1 RS-485) Pin Assignments

Pin Number	Signal Name (Function)	Signal Direction
1	SP-COMMON	
2	RX - (Receive Data)	Input
3	Shd (Cable Shield)	
4	RX+ (Receive Data)	Input
5	SLIM-ATT/(SLIM Cable Connector Attached) [1]	Input
6	TX+ (Transmit Data)	Output
7	No connection	
8	TX- (Transmit Data)	Output
9	SP-COMMON	

Front View of J1 Connector (Female DB 9)



[1] The mating connector of the SLIM cable assembly must connect pin 5 to pin 9.

25-17. Valve Positioner Address Locations

25-17.1. Configuration and Status Register

Word address 13 (D in Hex) is used to write to the Module Configuration Register and to read the Module Status Register. The status register can be read by using the Point Information window at an Operator Station (see the Bit Pattern Field on the Hardware Tab).

Table 25-12. Valve Positioner Configuration/Status Register (Address 13 or D in Hex)

Bit	Data Description - Configuration Register (Write)	Data Description - Status Register (Read)
0	Configure Module (1=configure)	Module is configured (1 = configured; 0 = unconfigured)
1	Force Error (1=error; 0=no error)	Internal or Forced Error (1 = error; 0 = no error)
2 - 4	Communications Timeout Setting 000 = 16 sec 001 = 4 sec 010 = 2 sec 011 = 1 sec 100 = 500 ms 101 = 250 ms 110 = 120 ms 111 = 60 ms	Communications Timeout Setting 000 = 16 sec 001 = 4 sec 010 = 2 sec 011 = 1 sec 100 = 500 ms 101 = 250 ms 110 = 120 ms 111 = 60 ms
5	Not applicable	Ignore shutdown input (1 = ignore input; 0 = obey input) (This function is only valid when the Controller is running in normal mode. Otherwise, the Valve Positioner obeys the shutdown input.)
6	Redundant RVP Link Status Bit (1=good; 0=bad)	Redundant RVP Link Status Bit (1=good; 0=bad)
7	Not applicable	Severe Fatal Error - Check Register E
8	Not applicable	Coil 1 may be shorted
9	Not applicable	Coil 2 may be shorted
10	Not applicable	Coil 3 may be shorted
11	Not applicable	Coil 1 may be open
12	Not applicable	Coil 2 may be open
13	Not applicable	Coil 3 may be open
14	Not applicable	Contingency (1 = contingency; 0 = no contingency)
15	Not applicable	Handshake bit for download of calibration data

25-17.2. Secondary Configuration and Status Register

Word address 14 (E in Hex) provides for additional module configuration and module status. The bit definitions for this register are encoded as shown in Table 25-13.

Table 25-13. Secondary Configuration/Status Register (Address 14 or E in Hex)

Bit	Data Description - Configuration Register (Write)	Data Description - Status Register (Read)
0	Not applicable	EEPROM checksum error
1	Not applicable	PSD 302 EPROM checksum error
2	Not applicable	Shared memory readback error
3	Not applicable	Processor memory readback error
4	Not applicable	FPGA error
5	Not applicable	UART error
6	Not applicable	Processor diagnostic error
7	Not applicable	Coil drive D/A converter output readback error
8	Not applicable	PSD 302 RAM error
9	Not applicable	EEPROM write error
10	Not used	Not used
11	Not used	Not used
12 - 15	Not used	Not used

25-18. Diagnostic LEDs

Table 25-14. Valve Positioner Diagnostic LEDs

LED	Description
P (Green)	Power OK LED. Lit when the +5V power is OK.
C (Green)	Communications OK LED. Lit when the Controller is communicating with the module. In a Redundant configuration, C is lit if both the Controller and Serial Communication are OK. It blinks if only one is OK. It is NOT lit if both are not OK.
E (Red)	External Fault LED. Possible causes: SLIM not connected (Set "SlimAddr=0" to disable) No auxiliary voltage (Set “ignore shutdown” config bit to disable)
I (Red)	Internal Fault LED. Possible causes: Force Error bit (Bit 1) of the Configuration Register (see Table 25-12) is set. Also lit when a timeout of the watchdog timer occurs when Controller stops communicating with module. Any of the hardware errors listed in Table 25-13(Secondary Status Register)
1 - MANUAL (Green)	Lit whenever the module is operating in Local Manual mode.
2 - SERVO OK (Green)	Lit to indicate the servo coil diagnostic has passed. The coil 1, 2, and 3 open/short bits that are reported to the Controller are delayed by a timer. The timer value is set by “diagtime=xx.” The LED is extinguished immediately for any of the six coil problems.
3 - NORMAL (Green)	Lit whenever the module is operating in Normal mode. Blinks if it is the Primary in a redundant configuration.
4 - PI DETUNE (Green)	Lit whenever PI is detuned.
5 - CALIBRATE (Green)	Lit whenever the module is calibrating.
6 - BACKSEAT (Green)	Lit whenever seating or backseating is in effect.
7 - CONTINGCY (Red)	Lit whenever the module is operating in contingency condition.
8 - SHUTDOWN (Red)	Lit when the module is driving the valve fully closed due to the module shutdown digital input.

25-19. Valve Positioner Troubleshooting

25-19.1. Online VP Replacement

A Valve Positioner module can be replaced online when the module fails.

Use the following procedure to remove an VP module and safely install a replacement module.

Caution

Observe all the precautions and then modify the procedure steps to suit your particular situation.

Precautions

- If the valve is closed, isolate it hydraulically to prevent any bump when inserting the new VP.
- Switch the MA driving the VP position to manual, and move the target position to zero. This is done to avoid jostling the valve when the new VP is inserted.
- For large machines, switch the valves to ‘single’ or ‘full arc’ mode from ‘sequential’ or ‘partial arc’ mode.
- Keep first stage, or impulse pressure, control loops in service to respond to any upset during the maintenance.
- If the replacement is due to a suspected or intermittent problem, that can only be corrected by replacement, but the VP is operating, first close the valve by switching the MA to manual, driving the valve to 0%, and then isolate it hydraulically.

Procedure

1. Once the valve is closed and in a safe condition, remove the bad VP.
2. Insert the replacement VP into the base unit.
3. Download constants using the Valve Positioner Upload/Download/Calibrate graphic.
4. View the reported feedback position. It should be close to 0%. If it is, the valve can be operated without calibration.

5. View the servo voltage at terminal screws 14B and C, and 13B and C. Note that if the servo voltage has integrated to a few volts negative, and hydraulic fluid is applied suddenly, the valve will ‘pop’, and the on-board PI will respond and bring the valve back to the target position of 0%. If the target position of 0% is less than ‘seatLimit’, servo voltage will be positive, thus driving the valve hard to the seat.

6. With the valve closed, you can execute the 0% calibration sequence to find the exact reading for the 0% position. If you believe the 100% calibration is close, the valve can then be operated without calibrating the 100% position, since there is little flow change when the valve is fully opened.

7. Verify that the VP is in the normal operating mode as indicated by the card edge LED.

8. When you determine that it is time to operate the valve, un-isolate the valve hydraulically, drive the target position of the MA to the desired position, and then switch the MA back to ‘auto.’

25-19.2. Servo Wiring Problems

Valve Wired Backwards

If a servo valve is wired backwards (that is, the wire pair is rolled), the valve will move in the opposite direction. This is a positive feedback situation. The movement of the valve does not cure the position error, it increases it, thus causing the output voltage to move even faster, and drive the valve harder in the wrong direction.

One Pair of Servo Coil Wires, Wired Incorrectly

Another problem is with dual coil servo valves when one pair is wired correctly, and the other is rolled. Thus, the wire pairs are in opposition, and valve movement is indeterminate.

Use the following procedure to correct this problem:

1. Disconnect one of the pairs, since the valve will move with only one pair connected (typically, the first step when diagnosing wiring problems).

2. Calibrate the valve with only one pair of servo wires, since it is the LVDT being calibrated, not the servo valve.

3. After the correct direction of movement is established, reconnect the wires and re-verify correct valve movement and responsiveness.

For typical dual coil servos adjusted according to the recommendations, the coil voltage is a few hundred millivolts in a steady holding position, 200 mV perhaps. If one coil is disconnected, the valve will remain in a steady position, but the coil voltage will double to 400 mV.

Once all wiring is connected, the user should observe the movement of the valve, such as during a step change, to determine if PI gain is set properly.

25-19.3. LVDT Wiring Problems (6-wire LVDT)

When an LVDT is wired incorrectly, it is typically a case where secondary pair A is swapped with secondary pair B.

The LVDT inputs on the VP are implemented with an amplifier stage that includes diode rectification. Therefore, the two individual wires of a secondary can be swapped and it makes no difference to the VP.

The wires of the excitation oscillator could also be swapped with no effect. The excitation coil and secondary coils are all isolated, so the VP can see only the AC component.

If the secondaries are wired correctly, and the LVDT is in approximately the correct position, feedback voltage shown on the VP calibration graphic is negative when the valve is closed, and positive when the valve is open.

The position feedback voltage is also available on terminals B12 and C12. This signal is used for factory testing and can be used for response testing in the field. It is inverted from the signal shown on the calibration graphic. (One way to avoid confusion is to connect voltmeter GND to B12, and voltmeter input to C12.)

25-19.4. Demodulator Gain

Demodulator gain directly affects the calibration values at the endpoints. Reducing demodulator gain can be helpful in diagnosing VP problems. Note that the VP must be re-seated, or must be reset, in order to make any new demodulator gain setting effective.

A simple test can be performed to verify correct wiring and polarity.

1. Set 0 and 100% calibration values to –31000 and +31000.

2. Reduce demodulator gain to a low value (2000).

3. Reseat or reset the VP to cause the new demodulator gain to take effect.

4. Set target position to 0%, 100%, then 50% and observe valve movement at all settings.

In this test, you are informing the VP that the electrical valve ‘stroke’ is +/- 10 volts, but you have adjusted demodulator gain so that the actual electrical stroke is much smaller. (Perhaps +/- 1 volt, depending upon the LVDT.) The idea is to force the actual electrical ‘stroke’ to be fully contained within the range of the VP input system.

By setting the target position to 0% or 100%, you can verify correct wiring and polarity. If the valve goes to the correct endpoints, then you should set the target position to 50% as an additional test. The valve should go to the LVDT’s midpoint and hold there.

If the valve does not go to the correct endpoint, then there is a wiring error, and you should first remove one of the servo wire pairs, and repeat the test. The next step would be to swap the wires of the remaining servo wire pair, followed by swapping the wire pairs of LVDT input A with input B.

When the valve moves correctly, verify that the valve operates according to the recommended practice where negative voltage opens the valve, and positive voltage closes it.

During Automatic Calibration

Another problem with demodulator gain can occur during automatic calibration. When the value is backseated and demodulator gain is undergoing an adjustment, it is also predicting the new calibration value at the seated position. If the seated position goes out of range, then the value is cilpped and the user receives a message that a new calibration is necessary.

One of the underlying assumptions of the VP is that, in the worst case, the user positions the LVDT so that the 100% position is at the end of the linear range of the LVDT (possibly non-linear and accurate). Then during calibration, the firmware accepts a value of 100% that is higher in magnitude than the 0% calibration value. If the LVDT is not positioned this way, then you may receive a message that the calibration must be repeated.

If LVDT is not adjusted in this fashion, the user can enter his own demodulator gain, reseat the VP, then perform both the 0% and 100% endpoint calibration. If the results do not yield a calibration value approaching the endpoint, then demodulator gain can be increased, and the process repeated.

Section 26. Ovation Local I/O

26-1. Section Overview

This section describes the Ovation local I/O subsystem.

Note

Ovation local I/O is applicable for use in CE Mark certified systems except where noted.

The Ovation Distributed Control System provides modulating control, sequential control, and data acquisition for a variety of system applications. The local Ovation I/O consists of a mix of functional I/O units (modules) that communicate on the I/O bus to the Controller in the Controller's cabinet.

Ovation I/O also provides for remote I/O functions (described in Section 27). Remote I/O is typically used where a process requires that I/O modules be located near the process, even though the Controller is not. The remote I/O modules are connected to the Controller through long distance, serial media, such as fiber-optic cables.

Typically, the Ovation local I/O subsystem contains:

- Controller cabinet containing the redundant Ovation Controller, applicable I/O Interface Controller (IOIC) cards (PCQL or PCRL) power supplies, and I/O modules as described in Section 26-3,.
- Extended I/O cabinet containing additional I/O modules and power supplies (described in Section 26-4).
- Appropriate cable and connections between the cabinets (described in Section 26-6 and in "Planning and Installing Your Ovation System" (U 3-1000 for FDDI or U 3-1005 for Fast Ethernet)).

Note

Optional Ovation Marshalling cabinet configurations are also available, that provides for halfshell wiring terminations. Refer to "Planning and Installing Your Ovation System" (U 3-1000 or U 3-1005) for additional information on cabinet configuration.

26-2. Local I/O Features

The Ovation local I/O subsystem has the following features:

- Maximum number of Local Ovation modules per Controller: **128**.
- Modular, “plug-in” components.
- Quick installation and configuration of the modules.
- DIN Rail mounting of the I/O base units.
- Wiring schematic labels are provided on Personality modules and foam inserts.
- Wiring directions (**N**ormally **C**losed, **N**ormally **O**pen, **C**ommon) are provided on the Base Unit for Relay Output modules.
- Writeable surface labels are provided on Electronics modules so that up to 16 point names can be identified on each label.
- The labels on the Personality and Electronics modules are color-coded to match the appropriate modules.
- Unique base unit interconnection scheme eliminates power and communications wiring.
- Module style, group, serial number, and revision are stored electronically on each I/O module.
- “Hot swapping” capabilities streamline system maintenance.
- Status indicators that display standardized diagnostic LED color codes.
- Base unit common to all standard I/O modules.
- Testpoint/probe holder on each field terminal (in standard I/O Base Units).
- Built-in spare fuse holders and wire strip gauge (in standard I/O Base Units).
- Two Base Unit styles (G2R and KUEP) are available for Relay Output modules.

26-3. Controller Cabinet Components (Local I/O)

The Ovation I/O Controller cabinet (see Figure 26-1) contains the following:

Note

Refer to “Planning and Installing Your Ovation System” (U 3-1000 and U 3-1005) for additional cabinet and cable information.

- Redundant Ovation Controller Chassis - Housing two separate Controllers (refer to Figure 26-2). Each Controller contains:
  - — Pentium PC Processor Board - To perform I/O control.
  - — Power Supply Board - Converts +24V to +5V and 12V to power all components of the Controller chassis.
  - — Network Interface Card - Provides the interface between the Ovation Controller and other highway components of the system, FDDI/CDDI and Fast Ethernet versions are supported.
  - — PCRL Board - PCI to local Ovation I/O interface board, used only if controlling local I/O modules from this cabinet (up to two PCRL cards per each Controller).
  - — PCQL Board - PCI to local Q-Line interface board, used only if controlling local Q-Line I/O boards from this cabinet (up to two PCQL cards per each Controller). (Not applicable for CE Mark certified systems.) Refer to “Q-Line Installation Manual” (M0-0053) for Q-Line I/O installation information.
- Power Supply - DIN Rail Mounted. Generates +24V to power the electronics in the I/O Controller Cabinet, as well as +24V auxiliary power. Two are required for redundancy. An optional separate +48V auxiliary power supply is also available.
- Power Distribution Module (5A26304) - Provides connectors for cables used to distribute +24V to the Redundant Controller Chassis, and +24V and auxiliary power to branches of local I/O (refer to Figure 26-4).
- Standard I/O Modules and Bases - Standard Ovation I/O modules which interface to field devices (refer to Figure 26-5).
- Relay Output Module and Bases - Relay module base, 1.5 times larger than a standard I/O base unit, containing electronics module and relays to control field devices (refer to Figure 26-6 and Figure 26-7).

- I/O Transition Panel (ROP - 4D33922) - Connects to two branches of I/O, providing a point to bring in +24V redundant power, auxiliary power, and the local I/O communications bus (refer to Figure 26-8).

  Connections are provided on the I/O Transition Panel to daisy-chain the local I/O communications bus from one ROP to the next (up to eight I/O branches maximum may be daisy-chained together).

- I/O Branch Terminator Board A or B (1B30023) - Connects to the A or B-side of a standard I/O base at the end of a branch having no Attachment Unit Module to terminate the local I/O bus (refer to Figure 26-1).

Caution

The I/O addressing for the Ovation database is determined from the positions of the bases installed in the cabinets.

We recommends that all possible bases (typically four) be installed in the right-most branch of each side of a cabinet, even if they are not all filled with I/O modules. This will prevent disruption of the database if additional I/O modules are installed in the future.

I/O modules should be installed in the right-most branch of each side of a cabinet from the BOTTOM UP.

I/O modules should be installed in the left-most branch of each side of a cabinet from the TOP DOWN.

If Relay Output modules are mixed with Standard I/O modules on the same branch, the Standard I/O module base must always start in an odd-numbered position on the branch (positions 1/2, 3/4, 5/6, or 7/8).