VICI Valco Instruments Co. Inc.

Multiposition Microelectric Valve Actuators

Models EMH and EMT with controller EMH2CA or EMT2CA

(Shipping since January 2019)

The microelectric multiposition actuator consists of a control module, a steppermotor/gearbox assembly, a manual controller (use is optional), a universal AC input (100-240 VAC, 50-60 Hz) to 24 VDC power supply, and the interconnecting cables.

The time it takes to step a valve from one position to another depends upon the actuator model, the number of positions for which the actuator is set, and the total amount of rotation involved. Actual times can be computed from the tables below.

EMH (high speed) actuator		
Number of positions set	Time req. to move one position	Time per additional position
4	237 ms	228 ms
6	165 ms	148 ms
8	124 ms	115 ms
10	102 ms	94 ms
12	90 ms	74 ms
16	69 ms	60 ms

EMT (high torque) actuator		
Number of positions set	Time req. to move one position	Time per additional position
4	1057 ms	1010 ms
6	718 ms	674 ms
8	547 ms	506 ms
10	446 ms	405 ms
12	380 ms	339 ms
16	294 ms	256 ms

NOTE: With the exception of legacy Valco P type valves (which have a visible coil spring), all our multiposition valves are keyed to provide automatic alignment on a microelectric actuator. However, not all standoffs (an extension which holds the valve away from the actuator) are keyed. Therefore, if you are ordering components separately or retrofitting a valve and actuator with a standoff, make sure you specify a keyed standoff so that you can take full advantage of the ease of alignment provided by a keyed standoff, microelectric actuator, and valve.

Installation and Use

Getting Started

Figure 1 on the next page shows the functions of the cables supplied with the actuator. There are four connectors on the control module, keyed and sized to prevent incorrect connection.
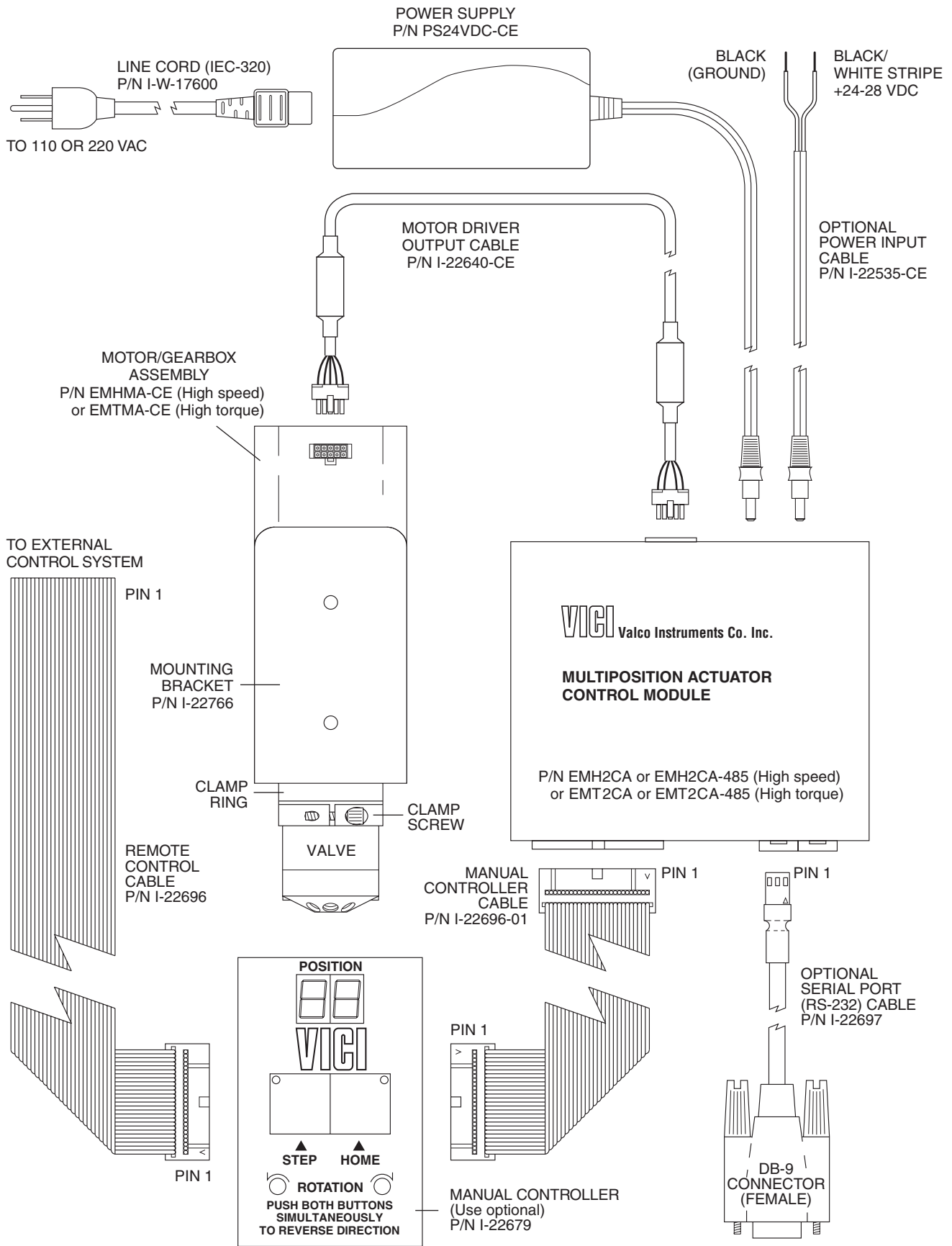
POWER SUPPLY
P/N PS24VDC-CE

LINE CORD (IEC-320)
P/N I-W-17600

TO 110 OR 220 VAC

BLACK
(GROUND)

BLACK/
WHITE STRIPE
+24-28 VDC

MOTOR DRIVER
OUTPUT CABLE
P/N I-22640-CE

OPTIONAL
POWER INPUT
CABLE
P/N I-22535-CE

MOTOR/GEARBOX
ASSEMBLY
P/N EMHMA-CE (High speed)
or EMTMA-CE (High torque)

TO EXTERNAL
CONTROL SYSTEM

PIN 1

VICI **Valco Instruments Co. Inc.**

**MULTIPOSITION ACTUATOR
CONTROL MODULE**

MOUNTING
BRACKET
P/N I-22766

P/N EMH2CA or EMH2CA-485 (High speed)
or EMT2CA or EMT2CA-485 (High torque)

CLAMP
RING

CLAMP
SCREW

VALVE

REMOTE
CONTROL
CABLE
P/N I-22696

MANUAL
CONTROLLER
CABLE
P/N I-22696-01

PIN 1

PIN 1

OPTIONAL
SERIAL PORT
(RS-232) CABLE
P/N I-22697

PIN 1

POSITION

VICI

PIN 1

▲
STEP

▲
HOME

○ **ROTATION** ○

**PUSH BOTH BUTTONS
SIMULTANEOUSLY
TO REVERSE DIRECTION**

MANUAL CONTROLLER
(Use optional)
P/N I-22679

DB-9
CONNECTOR
(FEMALE)

PIN 1

Figure 1: Actuator and controller connections

Mounting

The actuator should be oriented so that any potential leakage of liquid from the valve or fittings flows away from rather than into the actuator. *(below)* **Figure 2** provides the mounting dimensions for the stepper motor/gearbox assembly and the controller.
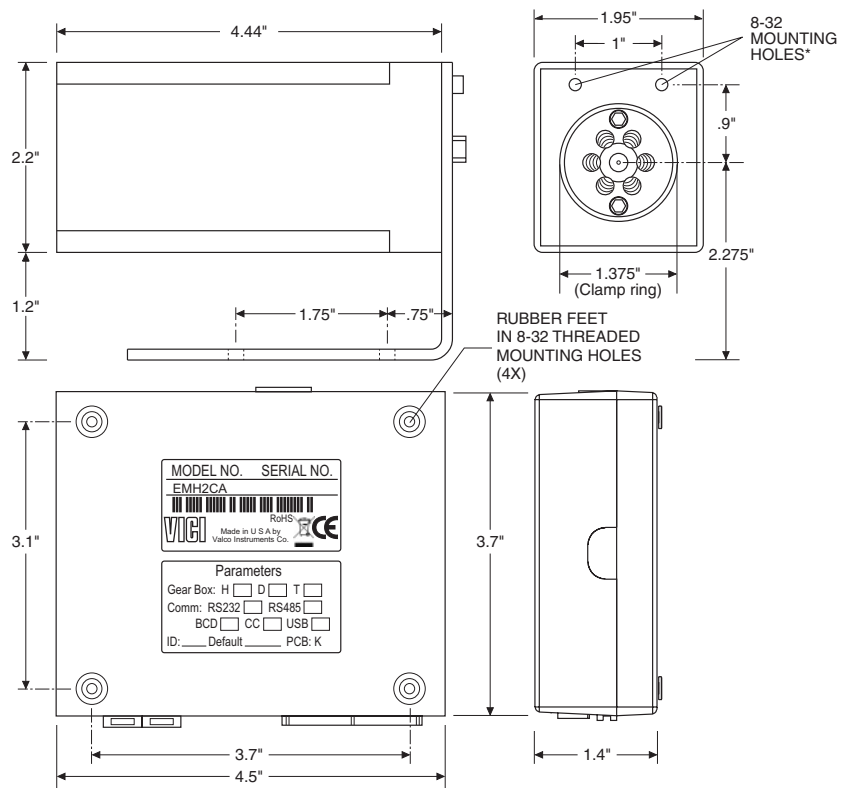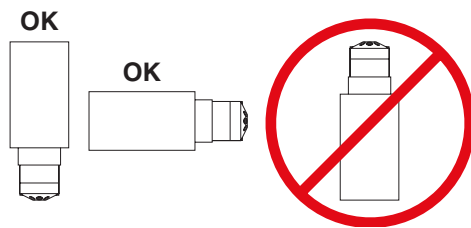

OK

OK

Figure 2: Mounting dimensions for the motor/gearbox (top) and controller (bottom)

Cable and Connector Functions

Input power (20 – 30 VDC, with 24 – 28 VDC preferred) is supplied through a miniature power connector: the inner pin is + voltage and the outer is ground. Average DC current requirement is 2.5 amps. Standby current is less than 100 milliamps. The actuator should not share a power supply with other noise-sensitive electronics, as the high current draw can cause problems.

Motor driver output is through the 10 pin connector. The 26-pin connector is for the manual controller and remote digital input/output signals; the actuator can be controlled by *either* or *both*. The manual controller has a pass-through port, so an additional cable can provide simultaneous control by an external system. The three-pin connector is for RS-232 interface. The serial and digital functions are fully described on pages 4 - 8.

Manual Controller

The manual controller allows the user to select the rotation direction, set the total number of positions, and control the STEP and HOME functions. The controller is connected to the actuator control module with the 26 pin ribbon cable. The manual controller has two functional modes – the operating mode and the setup mode. The display indicates the current position in the operating mode, the total number of positions in the setup mode, and an "EP" when there is a positioning error.

Operating Mode
This is the default mode; that is, the controller will be in this mode when it is initially powered. In this mode the STEP and HOME functions are clearly labelled as the primary functions of the left and right switches, respectively. To change the direction of rotation, momentarily depress the STEP and HOME switches simultaneously. The DIRECTION LEDs will change, indicating that the direction has reversed.

Setup Mode
To shift into the setup mode, depress the STEP and HOME switches and hold them down for 8 seconds. The position display LEDs will begin to flash, displaying the current setting for the total number of positions in a full rotation. Use the STEP switch to increase or the HOME switch to decrease this setting to the desired number of positions. To return to the operating mode, depress both switches until the LEDs stop blinking.

Simultaneous Use of the Manual Controller and an External Control System

The manual controller has two identical connectors for input and/or output, permitting an external system to be used simultaneously with the manual STEP and HOME commands. However, *the following precaution should be observed:*

If the STEP and HOME functions are to be used by *both* systems, the external system control output cannot be in the form of TTL signals; instead, the output must be a momentary signal asserted by a contact closure or open collector driver. While TTL signals will cause no damage to either system, they will effectively override the manual controller.

Connecting External Systems
An external control system can be connected to the actuator in several ways:

1. The Digital Input/Output connector is a 26 pin dual in-line connector which can mate to a mass terminatable flat cable connector available from a number of manufacturers. The flat cable can then be integrated into the control system.

2. The manual controller can be connected to the control module, and then a 26 pin dual in-line connector and flat cable assembly can be attached to the manual controller. This allows dual control as well as a visual indication of the actuator position.

3. A serial port can be connected from a host control system to the actuator, using the optional RS-232 cable (Product No. I-22697).

Digital Protocols

Hardware Input / Output Protocols
Digital input/output control of the multiposition actuator is designed for simplicity and flexibility of function. The simplest control of the actuator can be accomplished with two output control lines – STEP and HOME. The chart on the next page lists other control options.

The **inputs** are held to a logical high (+5 volts) by pull-up resistors, and are designed to be driven low either by contact closure, 5 volt digital logic, or open collector transistor outputs. The polarity for the BCD input signals is defined as "negative true" – asserting the signal involves shorting the signal (in the case of contact closure) or driving it (in the case of logic or transistor signals) to within 0.8 volts of ground potential. These input signals must be at least 30 milliseconds in duration. All **outputs** are driven by standard high speed CMOS gates, capable of driving standard logic input gates. They include the BCD position bits which are "negative true" logic, and the motor run, direction, and error signals, which are "positive true" output bits. If the actuator stops out of position due to a stuck valve, the BCD outputs are set to "0" (all lines high for a negative true output). The error bit will also go high, indicating a positioning error.

The digital interface is made through a 26 pin connector which also provides power (+5 volts/100 ma maximum) and ground outputs. The ground should be connected to the control system to maintain commonality between the actuator and the controlling device. If you intend to provide your own power supply, make sure that it has an isolated output or that it shares a common ground with the controlling system.

Software Input Protocols

Pin	Color	Signal	Direction	Pin	Color	Signal	Direction
1	brown	Home	Input	14	yellow	4 BCD	Output
2	red	Motor run	Output	15	green	20 BCD	Output
3	orange	Step	Input	16	blue	2 BCD	Output
4	yellow	Error	Output	17	violet	10 BCD	Output
5	green	Manual Dir.	Input	18	gray	1 BCD	Output
6	blue	Direction	Output	19	white	80 BCD	Input
7	violet	Auto Dir.	Input	20	black	8 BCD	Input
8	gray	Data latch	Input	21	brown	40 BCD	Input
9	white	+5 VDC 100 ma	Output	22	red	4 BCD	Input
10	black	Ground	Output	23	orange	20 BCD	Input
11	brown	80 BCD	Output	24	yellow	2 BCD	Input
12	red	8 BCD	Output	25	green	10 BCD	Input
13	orange	40 BCD	Output	26	blue	1 BCD	Input

Pin signal definitions for the Digital Input/Output cable

Mode:	SD0	SD2	SD3	Data Input Lines							
Input type:	BCD	Parallel	Binary	1 BCD	2 BCD	4 BCD	8 BCD	10 BCD	20 BCD	40 BCD	80 BCD
Position:	1	1	1	X	–	–	–	–	–	–	–
	2	2	2	–	X	–	–	–	–	–	–
	3	*	3	X	X	–	–	–	–	–	–
	4	3	4	–	–	X	–	–	–	–	–
	5	*	5	X	–	X	–	–	–	–	–
	6	*	6	–	X	X	–	–	–	–	–
	7	*	7	X	X	X	–	–	–	–	–
	8	4	8	–	–	–	X	–	–	–	–
	9	*	9	X	–	–	X	–	–	–	–
	*	*	10	–	X	–	X	–	–	–	–
	*	*	11	X	X	–	X	–	–	–	–
	*	*	12	–	–	X	X	–	–	–	–
	*	*	13	X	–	X	X	–	–	–	–
	*	*	14	–	X	X	X	–	–	–	–
	*	*	15	X	X	X	X	–	–	–	–
	10	5	16	–	–	–	–	X	–	–	–
	11	*	17	X	–	–	–	X	–	–	–
	12	*	18	–	X	–	–	X	–	–	–
	13	*	19	X	X	–	–	X	–	–	–
	14	*	20	–	–	X	–	X	–	–	–
	15	*	21	X	–	X	–	X	–	–	–
	16	*	22	–	X	X	–	X	–	–	–
	17	*	23	X	X	X	–	X	–	–	–
	18	*	24	–	–	–	X	X	–	–	–
	19	*	25	X	–	–	X	X	–	–	–
	*	*	26	–	X	–	X	X	–	–	–
	*	*	27	X	X	–	X	X	–	–	–
	*	*	28	–	–	X	X	X	–	–	–
	*	*	29	X	–	X	X	X	–	–	–
	*	*	30	–	X	X	X	X	–	–	–
	*	*	31	X	X	X	X	X	–	–	–
	20	6	32	–	–	–	–	–	X	–	–
				Code sequence break							
	40	7	64	–	–	–	–	–	–	X	–
				Code sequence break							
	80	8	128	–	–	–	–	–	–	–	X

Pin signal definitions for the various input modes

Software Input Protocols

The input modes are selected by the serial port command "**SD***n*", with *n* = 0, 1, 2, or 3. Mode information is stored in non-volatile memory and maintained during power up/down sequences. The modes are:

SD0 (default) Binary Coded Decimal (BCD) input mode. For the 96 possible input positions, all 8 digital input data lines are required. Refer to the chart on the previous page for the signal line definitions.

SD1 Disables the digital inputs to prevent user intervention during automated control via the serial port. It resets to SD0 during the power up sequence.

SD2 Redefines the data input lines so that each input line equates to only one actuator position; any and all combinations of data input lines are invalid. This mode can support *only 8 positions:* 1 BCD = position 1; 2 BCD = position 2; 4 BCD = position 3; 8 BCD = position 4; 10 BCD= position 5; 20 BCD = position 6; 40 BCD = position 7; and 80 BCD = position 8. (See the chart on the next page for more explanation of **NP** and **SO**.)

SD3 Redefines the data input lines to a binary input instead of BCD. This reduces the number of input lines required to select positions above 9. For example, BCD mode inputs for any position between 10 and 15 requires the use of data input lines 1, 2, 4, 8, and 10 BCD. In the binary mode, only lines 1, 2, 4, and 8 BCD are required. The position values for the binary mode are calculated the same way as those for the BCD mode, except that all combinations of the input lines are valid numerical positions.

Serial Control of the Actuator

This actuator includes both RS-232 and RS-485 hardware. If you ordered an EMH2CA or EMT2CA, it is set up for RS-232 operation. EMH2CA-485 and EMT2CA-485 are configured for RS-485 operation. Instructions for changing from one serial mode to the other are found in the section called "Serial Options" on page 9. The section also includes important information about RS-485 protocols.

Establishing Serial Communications

Items required:
- Valco cable assembly I-22697 or equivalent
- Terminal emulation or communication software such as VCOM, CoolTerm, PuTTY, or Tera Term, running on a PC-compatible computer

1. Connect the I-22697 cable to the actuator as indicated in **Figure 1**, and set the serial port at 9600 baud, no parity, 8 data bits, 1 stop bit, no hardware or software handshaking.

2. With the software running, check the bi-directional communication link between the keyboard/monitor of the computer and the serial port by typing VR<enter>. If the link is functioning and an actuator ID has not been set, a message similar to the following will appear on your monitor, giving the program number and date of the actuator firmware.

<div align="center">

MUA_MAIN_D.4
Jan 9 2019
(The date may be different, but will be in the format of (MMM)(DD)(YYYY)

</div>

If there is no response, it is possible that the ID has already been set. To force a response from a device with an unknown ID, type ***VR**<enter>. The asterisk is a substitute ID wild card which will elicit a response from all devices on line, no matter what their ID is. NOTE: The first line of the response to the VR command can be customized for compatibility with older customer systems. See the "LG" command, option 2.

Serial Commands	
Command	**Description**
AL<enter>	Moves the actuator drive shaft to the reference position prior to valve installation
CCnn<enter>	Sends the actuator in the "negative" or "down" direction to position nn (from 1 to NP)
CNTn<enter>	Displays the number of actuations, from 0 - 2,000,000,000
CP<enter>	Displays the current position
CWnn<enter>	Sends the actuator in the "positive" or "up" direction to position nn (from 1 to NP)
GOnn<enter>	Sends the actuator to position nn (from 1 to NP), in the direction assigned by the **SM** command
HM<enter>	Moves the valve to postion 1 (home), in the direction assigned by the **SM** command
ID<enter>	Displays the current device ID setting
IDn<enter>	Sets the device ID to value n, from 0 to 9 NOTE: When the ID feature is enabled, all commands to the device must be prefaced by the ID. To clear the ID, enter iID*, where i is the currently assigned ID. If the ID is not known, enter *ID*. For more information on the ID feature specific to RS-485 operation, refer to "RS-485 Protocols" on the last page.
IFMn<enter>	Sets the interface response mode to [0] no response string when an action command is sent, [1] basic response to action commands, or [2] extended response to action commands (needed for BCD interface)
LGn<enter>	Sets the interface response mode to [0] no extra characters, [1] longer response string to be fully backwards compatible with VICI microelectric actuators, or [2] legacy response strings with user re-programmable first line for **VR** command
MA///<enter>	Sets the motor assembly to EMH or EMT
NP<enter>	Displays the number of positions the actuator is currently set to index
NPnn<enter>	Sets the number of positions (nn) for the current valve. (Must be an even number between 2 and 96)
SB<enter>	Displays the current baud rate
SBnnnn<enter>	Sets the baud rate to 2400, 4800, 9600 (default), 19200, or 38400. The parity setting, number of data bits, and number of stop bits cannot be changed.
SD<enter>	Displays the digital input status where 0 = enabled and 1 = disabled
SDn<enter>	Sets the digital input status to [0] BCD, [1] disabled, [2] parallel, or [3] binary. NOTE: Setting the status to [1] locks out communication through the manual controller and remote control cables, so digital input status defaults to [0] at power up.
SL<enter>	Displays current Data Latch signal status
SLn<enter>	This command displays or changes the requirement for a Data Latch signal to accompany BCD inputs. When set to [0] (factory default), the data latch is required for BCD inputs. When set to [1], the data latch is NOT required. This feature can reduce the number of control lines required for a system with a dedicated BCD output port and only one actuator connected. NOTE: Be sure all the BCD inputs are asserted within 20 milliseconds of each other or the actuator may be misdirected.
SM<enter>	Displays the rotational direction for the serial port commands **HM**, **GO**, and **ST**
SMl<enter>	Sets the default rotational direction to [F] for forward rotation, [R] for reverse rotation, or [A] to automatically choose the shortest route..
SO<enter>	Displays the current offset value
SOnn<enter>	Sets the offset value of the first position to be any number from 1 to 96 minus the total number of positions. Example: for a 10 position valve, the offset can be set from 1 to 86. See section entitled "Using the Offset Feature" beginning on the next page.)
ST<enter>	Steps the actuator one position in the direction set by the **SM** command
VR<enter>	Displays the part number and date of the firmware
?<enter>	Displays a list of valid commands

Notes: In this chart, n represents a numeric entry, l an alphabetic entry, and <enter> represents a CR(0x0D) entry.

Serial Communication Protocol

Serial communication is based on an ASCII string protocol. Carriage return (OD hex) characters parse the communications by defining the end of each command. Line feed characters (OA hex) are ignored. A three-pin connector is used for the RS-232 interface: pin assignments are indicated at right. Software flow control (Xon/Xoff) and hardware handshaking are not supported.

Serial Port (RS-232) Cable	
Pin #	Signal Description
1	Ground
2	Transmit to host
3	Receive from host

With the software-settable device "ID" feature enabled, the serial port output (transmit line) of the actuator is disabled (high impedance). Thus, as many as ten actuators can be controlled from a single host serial port for a temporary multidrop application. For permanent multidrop applications, the RS-485 option is the factory-recomended solution. The table on the previous page describes and explains all the commands available.

Using the Device ID Feature

Actuators are shipped from the factory with this feature disabled. When it's enabled, the actuator responds only to commands which begin with the correct ID prefix, allowing up to 10 actuators to be controlled from one serial port. A single command can be broadcast to all actuators by using an asterisk (*) as the command prefix. *Note:* Any broadcast command which elicits a response from the serial port (such as *VR or *ID1) will receive a combined and unintelligible response.

To set the ID of an actuator, connect it to an RS-232 serial port as shown in **Figure 1** on page 2. *Caution: When installing or replacing actuators on a shared serial port, make sure that no two devices have been set to the same ID number.*

1. Remove all of the actuators from the serial daisy chain except the one for which you are setting the ID.
2. Type **VR** <enter>. You should get a response giving the firmware version, indicating that serial communication with the actuator is established. If there is no response, type ***VR**<enter> to see if the ID is already set. If there is still no response, check the cabling and connections.
3. To *set* an ID, type **ID***n*<*enter*>, where *n* is the new ID, from 0 to 9.
   To *change* an ID, type *i***ID***n*<enter>, where *i* is the current ID and *n* is the new ID.
   To *disable* the ID feature, type ***ID*** or *i***ID***<enter> where *i* is the current ID.

Programmer's note: In order for multiple RS-232 slave devices to be controlled from one serial port, they must all keep their outputs deactivated until they need to respond. When a device responds, it asserts its output low for 2 milliseconds before sending the first character to clear the host UART's input. Nevertheless, it is possible that the UART will sense a framing error or receive a bogus character. The programmer should be prepared to handle this possibility in software.

Using the Offset Feature

This feature makes it possible to control more than one actuator without increasing the number of BCD input lines. The actuator's SO value can be set from "1" to "96", minus the current NP value (the number of positions the actuator is set to index). Once an SO value is set, that value is the first (or lowest) position an actuator will recognize. The factory SO setting is "1", so an actuator with an NP value of 10 responds to move commands for positions "1" to "10". If the SO value is changed to "10", the actuator will respond only to move commands for positions "10" through "19". For any setting of SO and NP, the lowest valid position will be the SO value and the highest valid position will be the SO value plus the NP value minus 1; *i.e.,* the actuator will respond to commands for position SO through position {SO + NP - 1}.

Here is an example of how this can be used to set up a 31-stream stream selection system using six dedicated BCD lines and two 16-position valves and actuators. First, use the serial port command "SL1" to enable the auto-latching feature on both actuators. (This eliminates the need for a data latch signal.) Configure the second actuator using the serial port command "SO16", giving it a valid position range of 16 to 31. Use a piece of tubing to connect port 16 of the first valve (on the actuator with the SO value still at the factory setting of "1") to the common port of the valve on the second actuator (which now has the SO set to "16"). Connect streams 1 through 15 to ports 1 through 15 on the first valve, and streams 16 through 31 to ports 1 through 15 on the second valve.
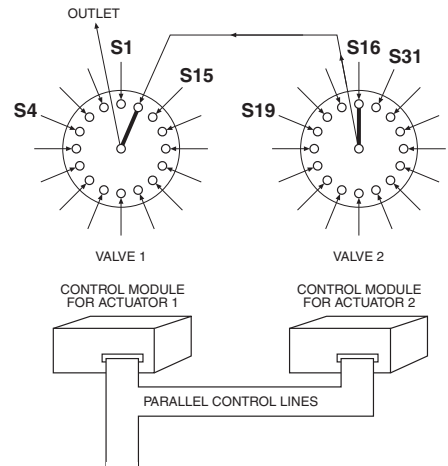
Figure 3: Use of the offset feature

This system will step *sequentially* from 1 through 31 with a single BCD instruction. However, when positions are selected in a *random* sequence, position 16 must always be requested before any positions higher 16 are selected. **Figure 3** helps illustrate this: since both actuators respond to a command to go to position 16, stream 16 will flow through valve 1/port 1, out the common port of valve 2, into valve 1/port 16, and out of the common port of valve 1. Thereafter, any stream select command that is above 16 will move only valve 2; when a move command for a position less than 16 is given, valve 1 will move and cut off all flow from valve 2.

Serial Options

This actuator includes both RS-232 and RS-485 hardware. The serial control mode is selected using the "COMM" jumper board shown in **Figure 4**. The arrow and board markings show which output option is selected for each rotational setting. The second jumper board (labeled "TERM") is used only in the RS-485 mode, enabling or disabling signal termination.

To access the COMM and TERM jumper boards:

1. Grip the lower section of the control module enclosure on the two opposing sides that have the curved release tabs.

2. Carefully depress the tabs while lifting the top section with the other hand. We recommend that the enclosure be opened in a static free environment, following all proper ESD protection techniques. NOTE: Once the control module cover has been removed, the printed circuit board can fall out.
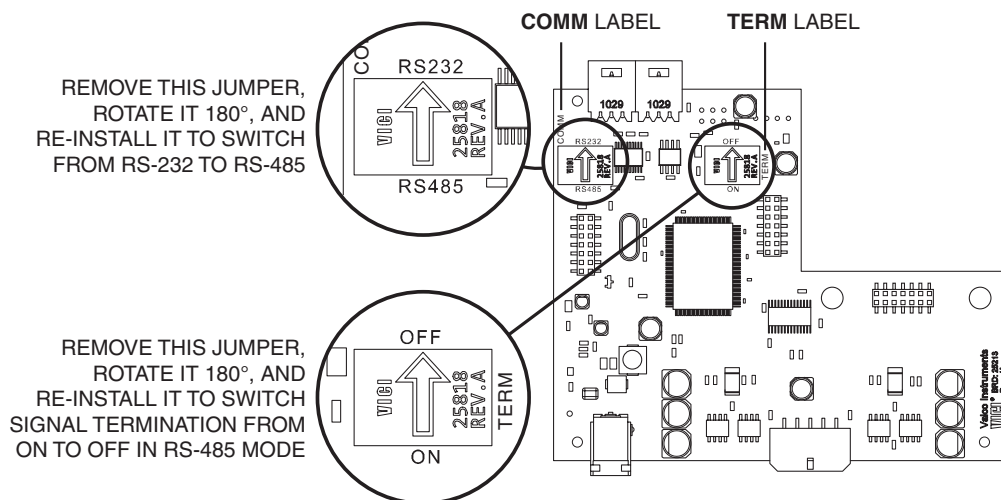

Figure 4: Location of jumpers which set serial options

RS-485 Protocols

The RS-485 option involves some minor software adaptations to the RS-232 protocol. The first adaptation is that all commands must have a forward slash [/] added to the command as the start-of-message character.

The second difference is that the actuator *must* have an ID included in all commands. The ID can be a number from 0 to 9 or a letter from A to Z, with upper and lower case treated as identical. If no ID is set, the ID will automatically be set to 'Z'.

An asterisk (*) can be used as a broadcast command ID when multiple units are daisy chained. For example, typing **/*GO**<enter> will cause all the actuators to move in their default direction. Broadcast commands that illicit a serial port response should be avoided, as multiple responses will collide and produce garbled data.

IDs are retained when switching from RS-232 to RS-485, and vice versa. If no ID is desired in the RS-232 mode, it can be removed using the ID command as shown in the command list or in the instructions on page 8. Since in RS-485 mode the actuator must always have an ID, the ID can be changed, but not cleared.

Hardware

The RS-485 hardware includes two 3-pin connectors (**Figure 5**) used as in/out connectors for easy daisy-chaining of additional devices. Wired in parallel, the signal assignments are as follows: Pin 1 is Ground, Pin 2 is Phase A(-), and Pin 3 is Phase B(+).

The RS-485 hardware specifications require termination at each end of the communication line, so in a daisy-chaining application the jumpers should be removed from all the intermediate devices. The RS-485 port on the host computer or controlling device generally includes terminating resistors, so only the actuator at the far end of the communication string needs to have the jumpers installed.

PIN 1   PIN 1
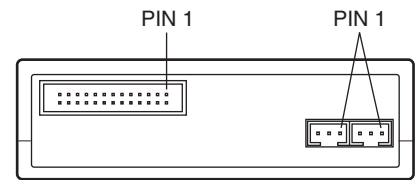
Serial Port (RS-485) Cable	
Pin #	Signal Description
1	Ground
2	A (−)
3	B (+)

Figure 5: Pin assignments