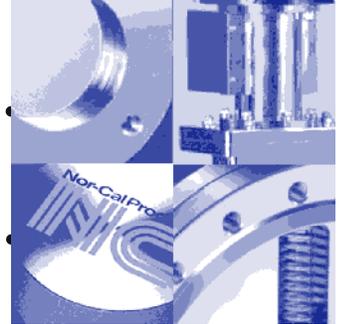


# Intellisys™ IQ PLUS

## Adaptive Pressure Controller

IQ+ OP-LIT 9/08

### OPERATOR'S



### MANUAL



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Information in this manual is subject to change without notice.



## 1.0 - Introduction

Thank you for purchasing the new Intellisys™ IQ+ downstream adaptive pressure controller from Nor-Cal Products. Before installing and operating the product, please read this manual thoroughly as it contains critical correction, interface and operating tips. If you encounter any problems, or if you have any questions, please contact our Intellisys Customer Service Support at 800-824-4166, ext. 186 or visit our web site at [www.n-c.com](http://www.n-c.com).

Nor-Cal Products' IQ+ pressure controllers are designed for downstream pressure control over a wide range of vacuum control applications. The IQ+ controller is a self-contained unit that incorporates all control electronics and associated pressure control software. IQ+ controllers are available in Analog, DeviceNet and Ethernet communication protocols. Buried box versions connect to the valve via a valve cable, while QPA, QPD and QPE controllers are mounted directly on the valve. Any IQ+ controller, regardless of type, accepts the inputs from one or two pressure gauges as well as communications to the host controller, thus making it the heart of a pressure control loop.

All models have local open/close switches, LED status lights and RS232 communication.

### Important Personnel Safety and Product Protection Information

Throughout this manual, information that is of particular importance to the installation, the safety of operating personnel and the protection of equipment are highlighted by the following three symbols. The **WARNING** symbol is also used on the equipment wherever necessary.



**NOTE:** Calls attention to helpful tips about proper installation, maintenance or use of the controller.



**CAUTION:** Highlights areas of concern that, if overlooked, could result in damage to the controller or surrounding equipment.



**WARNING:** Alerts the installation, operating or maintenance personnel of hazardous aspects of the controller, which, if ignored could result in serious personal injury or death.





## 2.0 - Device Specification

The following tables summarize specifications essential to the installation and hook-up of the IQ+ product. Please note that the information herein is limited to the IQ+ controller. For valve installation instructions and guidelines, please refer to the appropriate Valve Operating Manual.

**TABLE 2.1 – IQ+ CONTROLLER GENERAL EQUIPMENT SPECIFICATIONS**

FEATURE	SPECIFICATION
Dimensions	Please refer to the diagram specific to sections <b>3.1</b> to <b>3.5</b>
Weight, in lbs (kg)	1.1 lb (0.5 kg)
Rated Input Voltage	24 VDC ±10%
Rated Current	5.0 A @ 24 VDC max, 1.5 A @ 24 VDC average
Rated Input Protection	29 Volts max, reverse and current limited
Gauge Power Supply (Optional)	± 15 VDC @ 1400 mA
Protection Class	I
Degree of Protection (IP)	X0
Laser Class	1 (LED's)
Certifications/EU Directives	CE Standard for Process Equipment including EMC Directive 89/336/EC for D/C powered models..
Maximum Altitude	6562 ft (2000 m)
Allowable Ambient Operating Temperature	32°F to 113°F (0°C to 45°C)
Allowable Ambient Humidity	0 to 95% non-condensing
Installation Clearance	3" (75 mm) on all perforated sides. A minimum of 3½" (90 mm) is needed to allow for connectors. If access and line of sight is required for LED's and switches a minimum of 6" (150mm) is required on those sides.

**TABLE 2.2 – IQ+ CONTROLLER ANALOG TTL I/O**

FEATURE	SPECIFICATION
Analog (Gauge) Input	0 to 10V differential
Analog Output	0 to 10V unipolar @ 35 mA, short circuit protected
TTL Input	Diode protected at -0.4 VDC, compatible with open collector relay closure or standard logic signals, 25V max. Maximum low input voltage is 0.6V and minimum sink current is 1 mA. Minimum high input voltage is 2.5V, or open.
TTL Output	Open collector, optically isolated, 25V @ 10 mA max

**TABLE 2.3 –IQ+ CONTROLLER RS-232 SERIAL I/O**

FEATURE	SPECIFICATION
Communications Settings	Factory configured at 9600 baud, 1 stop bit, no parity, 8-bit character
Connections	Rxd Data, Txd data and Common. No handshake connections.
Communications Protocol	See <b>Section 6.0</b> in this manual
End of line delimiter	Carriage return (ASCII 0x0D) or Line Feed (ASCII 0x0A) or carriage return then line feed in that order

**TABLE 2.4 – IQ+ CONTROLLER PERFORMANCE**

FEATURE	BUTTERFLY VALVES	GATE & PENDULUM VALVES
Valve speed (open to closed)	125 to 250 msec, depending on valve size	2 to 5 sec, depending on valve size
Control range	0.5% to 100% of gauge	0.5% to 100% of gauge
Accuracy	0.25% of reading (5mV min)	0.25% of reading (5mV min)
Repeatability	0.12% of reading	0.12% of reading

**TABLE 2.5 – IQ+ CONTROLLER RELIABILITY**

FEATURE	BUTTERFLY VALVES	PENDULUM VALVE
Electronics MTBF	>10,000 hours	>10,000 hours
Warranty	1 year	1 year



## 3.0 - Unpacking and Installation

Inspect the shipping box before unpacking. Any damage should be reported to Nor-Cal Products or directly to the transportation carrier. Carefully remove the product from the box and visually inspect it for damage. If return of the product to Nor-Cal Products should become necessary, please contact Intellical Customer Service to obtain a Return Materials Authorization (RMA) Number.



**NOTE:** Do not discard the packing materials until the product has been inspected to your satisfaction.

### Pre-Installation Functionality Check

Nor-Cal Products carefully ensures that every product shipped is in perfect working condition. However, it is still a good idea to quickly check the functionality of the unit prior to installation into the vacuum system. To do so, for buried box IQ+ controllers, connect the controller to the valve and then to an appropriate +24DC, 4A power source. For all valve IQ+ controllers simply apply the +24DC, 4A power source. The butterfly valves will complete a 30 second valve initialization sequence ... the valve will stop in the open position. For soft shut (TSS) valves and pendulum (TPV) valves press the open and close buttons at the same time. The valves will begin the valve initialization sequence like the butterfly valve. The length of time to complete this sequence will vary from 40-60 seconds depending upon the type and size of valve. The valve will complete a 30-second initialization sequence during which the valve plate will cycle back-and-forth a few times while the OPEN/CLOSE LEDs blink in an alternating pattern. The valve will eventually stop in the open position. Further verification of the system can be done by toggling the "OPEN / CLOSE" switch (if available) on the controller front panel. If the valve does not operate as described please contact Nor-Cal Technical Support.



**WARNING:** When working with or troubleshooting Nor-Cal APC products extreme care must be taken to avoid putting bodily parts in or near the valve gate mechanism or other moving parts. These may move suddenly and unexpectedly, and many of them are driven with sufficient force so as to cause significant harm and possibly even dismemberment. Nor-Cal Products recommends that a lock-out and tag-out procedure be strictly followed whenever human physical intervention is required on all of its control valves.

### Installation

To allow for proper ventilation, make sure that at least 3 inches of unobstructed space is available adjacent to all perforated sides of the IQ+ controller. Then, complete all cable connections as required referring to the figures and pin assignment tables in Sections 3.1 – 3.3 of this manual. A list of pre-manufactured cable assemblies available from Nor-Cal Products can be found in Appendix I.



**CAUTION:** The optional +15V and -15V power supply pins of the IQ+ gauge connector are power sources that are intended to power the optional system pressure gauge(s). It can supply a maximum of 1500 mA. Do not use for any other purpose and do not connect to the tool main 15V supply as the two supplies would interfere with each other.



**NOTE:** Low voltage controller models do not have a power on/off switch. Consider installing an external power on/off switch between the DC power supply and the controller to allow for de-energizing the unit without having to disconnect the cable.

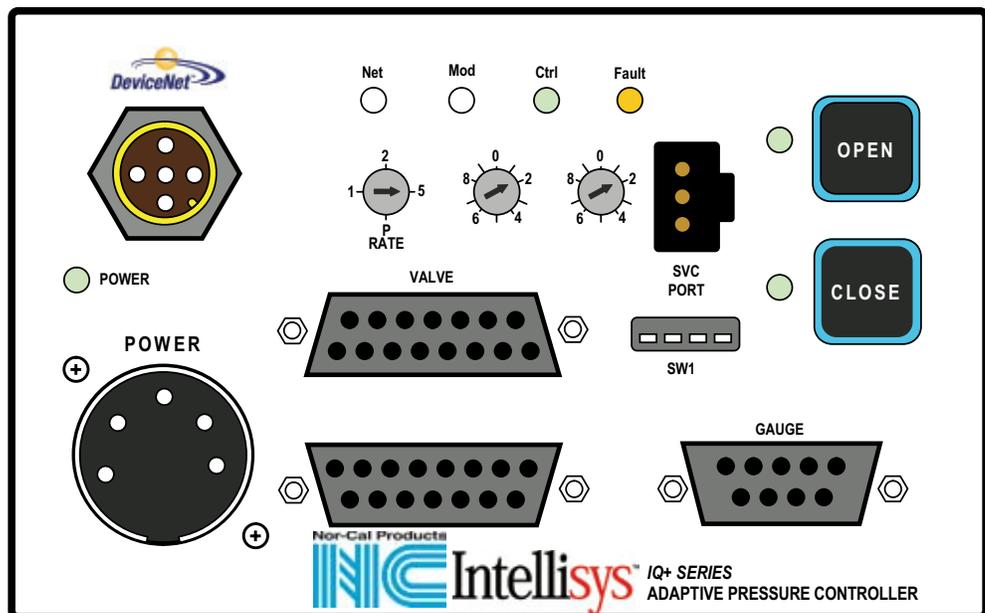


## 3.1 - Master Buried Box Controllers

TABLE 3.1 – BURIED BOX CONTROLLERS (MASTER)

POWER (XLR)		SERVICE PORT		VALVE		AUXILIARY		DEVICENET		GAUGE	
PIN	FUNCTION	PIN	FUNCTION	PIN	SIGNAL ASSIGNMENT	PIN	FUNCTION	PIN	FUNCTION	PIN	FUNCTION
1	+24VDC Power Input	1	Authorized Technicians Only	1	Drive A +	1	Reserved	1	Drain	1	CDG1 +
2	Power Return	2	Authorized Technicians Only	2	Drive A -	2	RS232 TX	2	DNET Power in +	2	+ 15VDC CDG Power (Optional)
3	Drain <sup>1</sup>	3	Authorized Technicians Only	3	Drive B -	3	RS232 RX	3	DNET Power in -	3	- 15VDC CDG Power (Optional)
4	N-C Net Hi <sup>2</sup>			4	Drive B +	4	Digital Ground	4	CAN H	4	Reserved
5	NC- Net Low <sup>2</sup>			5	Sense B -	5	Reserved	5	CAN L	5	CDG2 +
				6	Sense B +	6	RS485 A			6	CDG2 -
				7	Sense A -	7	Reserved			7	Reserved
				8	Sense A +	8	RS485 B			8	CDG1 -
				9	Reserved	9	TTL IN 0			9	CDG Power Ground
				10	Reserved	10	TTL IN 1				
				11	Reserved	11	Digital Ground				
				12	Reserved	12	TTL Com				
				13	Reserved	13	TTL Out 0				
				14	Reserved	14	TL Out 1				
				15	Reserved	15	Chassis Ground				

FIGURE 3.1 – BURIED BOX CONTROLLER (MASTER)



<sup>1</sup> Connect to Earth Ground at power supply

<sup>2</sup> N-C Net is a proprietary communication protocol. Do not connect these pins to anything other than approved Nor-Cal items.

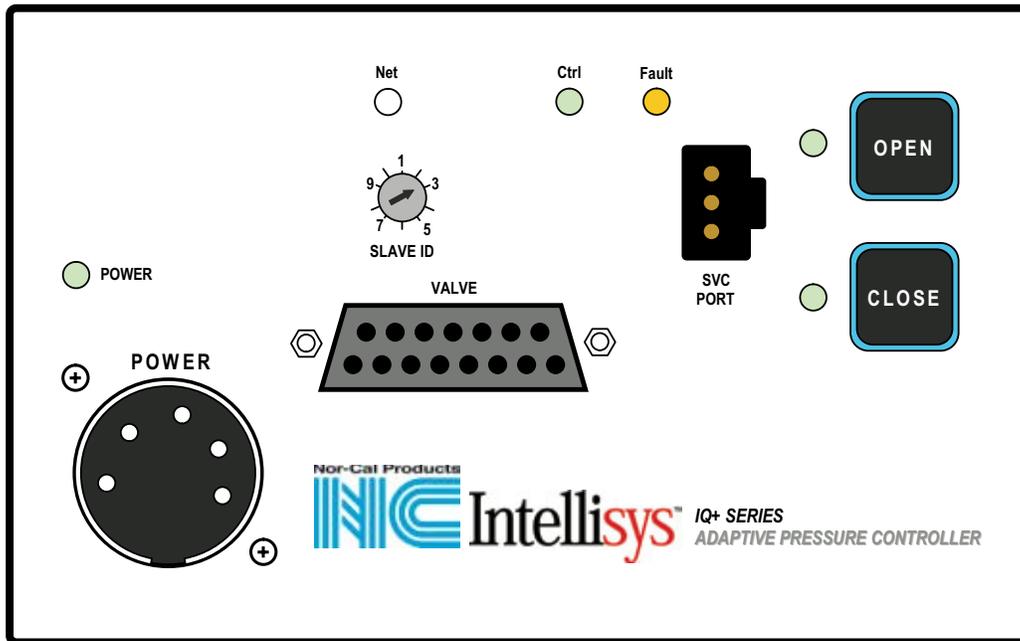


## 3.2 - Slave Buried Box Controllers

TABLE 3.2 – BURIED BOX CONTROLLERS (SLAVE)

POWER (XLR)		SERVICE PORT		VALVE	
PIN	FUNCTION	PIN	FUNCTION	PIN	SIGNAL ASSIGNMENT
1	+240VDC Power Input	1	Authorized Technicians Only	1	Drive A +
2	Power Return	2	Authorized Technicians Only	2	Drive A -
3	Drain <sup>1</sup>	3	Authorized Technicians Only	3	Drive B -
4	N-C Net Hi <sup>2</sup>			4	Drive B +
5	NC- Net Low <sup>2</sup>			5	Sense B -
				6	Sense B +
				7	Sense A -
				8	Sense A +
				9	Reserved
				10	Reserved
				11	Reserved
				12	Reserved
				13	Reserved
				14	Reserved
				15	Reserved

FIGURE 3.2 – BURIED BOX CONTROLLER (SLAVE)



<sup>1</sup> Connect to Earth Ground at power supply

<sup>2</sup> N-C Net is a proprietary communication protocol. Do not connect these pins to anything other than approved Nor-Cal items.



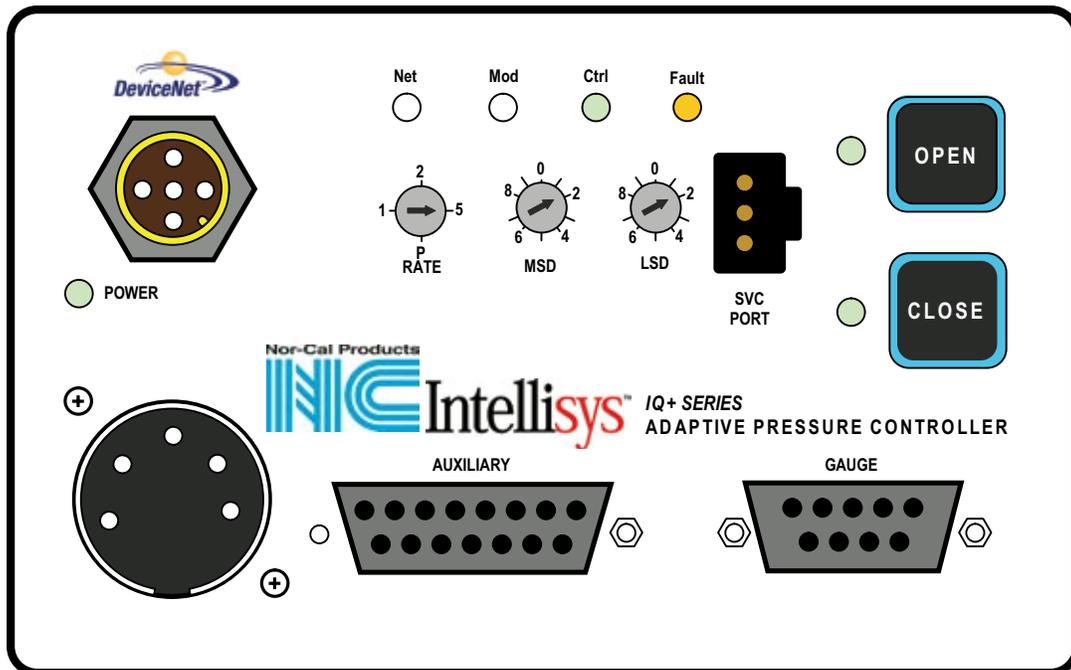


## 3.3 - Master On-Board Controllers

TABLE 3.3 – ON-BOARD CONTROLLER S(MASTER)

POWER (XLR)		SERVICE PORT		AUXILIARY		DEVICENET		GAUGE	
PIN	FUNCTION	PIN	FUNCTION	PIN	FUNCTION	PIN	FUNCTION	PIN	FUNCTION
1	+24VDC Power Input	1	Authorized Technicians Only	1	Reserved	1	Drain	1	CDG1 +
2	Power Return	2	Authorized Technicians Only	2	RS232 TX	2	DNET Power in +	2	+ 15VDC CDG Power (Optional)
3	Drain <sup>1</sup>	3	Authorized Technicians Only	3	RS232 RX	3	DNET Power In -	3	- 15VDC CDG Power (Optional)
4	N-C Net Hi <sup>2</sup>			4	Digital Ground	4	CAN H	4	Reserved
5	NC- Net Low <sup>2</sup>			5	Reserved	5	CAN L	5	CDG2 +
				6	RS485 A			6	CDG2 -
				7	Reserved			7	Reserved
				8	RS485 B			8	CDG1 -
				9	TTL IN 0			9	CDG Power Return (Optional)
				10	TTL IN 1				
				11	Digital Ground				
				12	TTL COM				
				13	TTL OUT 0				
				14	TL OUT 1				
				15	Chassis Ground				

FIGURE 3.3 – ON-BOARD CONTROLLER (MASTER)



<sup>1</sup> Connect to Earth Ground at power supply

<sup>2</sup> N-C Net is a proprietary communication protocol. Do not connect these pins to anything other than approved Nor-Cal items.

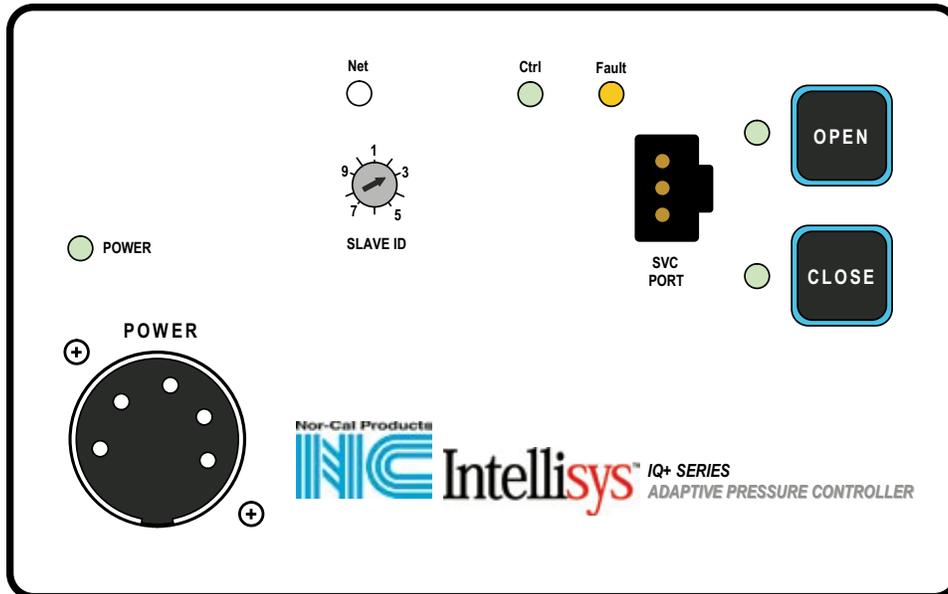


## 3.4 - Slave On-Board Controllers

TABLE 3.4 - ON-BOARD CONTROLLERS (SLAVE)

POWER (XLR)		SERVICE PORT	
PIN	FUNCTION	PIN	FUNCTION
1	+24VDC Power Input	1	Authorized Technicians Only
2	Power Return	2	Authorized Technicians Only
3	Drain <sup>1</sup>	3	Authorized Technicians Only
4	N-C Net Hi <sup>2</sup>		
5	NC- Net Low <sup>2</sup>		

FIGURE 3.4 – ON-BOARD CONTROLLER (SLAVE)



<sup>1</sup> Connect to Earth Ground at power supply

<sup>2</sup> N-C Net is a proprietary communication protocol. Do not connect these pins to anything other than approved Nor-Cal items.





## 4.0 - Theory of Operation

All IQ+ controllers are designed for downstream pressure control (see Fig 4.1 and 4.2). As such, it is one of several important components in a pressure control system. Other essential components include a host system computer, a throttle valve and one or two vacuum gauges, such as a Capacitance Diaphragm Gauge (CDG), and a pump system. Most manufacturers' vacuum gauges can be used to provide the vacuum measurement signal, provided they have a voltage output proportional to pressure. The IQ+ controller requires a pressure gauge signal output that is 0-10V linear and proportional to pressure.

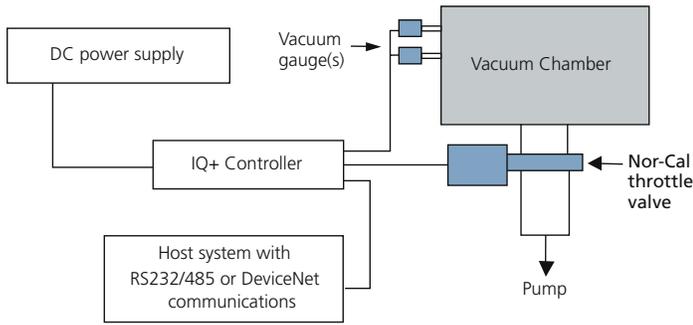


FIGURE 4.1 – TYPICAL INSTALLATION AND CONFIGURATION OF A BURIED BOX IQ+ PRESSURE CONTROL SYSTEM

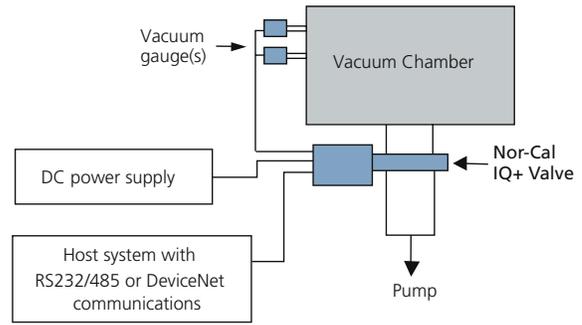


FIGURE 4.2 – TYPICAL INSTALLATION AND CONFIGURATION OF AN IQ+ PRESSURE CONTROL VALVE

### Initialization Sequence

When first powered up, butterfly valves with the IQ+ controller will run the valve through an initialization sequence that lasts for approximately 30 seconds. The primary purpose for this operation is for the controller to determine the fully open and closed points, as well as for certain motor and position calibration steps to occur. While the initialization sequence is active, the amber FAULT light will be illuminated and the OPEN/CLOSE LEDs both will be extinguished. Once the initialization sequence is complete, the valve will move to the fully open position and the green OPEN LED will illuminate.

**NOTE:** The controllers for TPV pendulum valves and TSS gate valves contain a valve initialization safety lock function. This safety lock will prevent valve initialization to occur until given a "clear-to-proceed" command. The RS-232 serial command for this is **T4**.

**CAUTION:** Never attempt to initialize a throttle valve with differential pressure across the sealing gate. Make sure the pressure on both sides is equalized to  $\pm 20$  Torr. Damage to pumps and other equipment can occur otherwise.

### Normal Operation

After the initialization sequence is complete normal operation of the valve is possible. There are two primary modes of operation, a) position control mode and b) pressure control mode.

In **position control mode**, the valve will move to any position in its range based on a position set-point command from the host. The valve will remain in that position until instructed to do otherwise. Position control mode can be useful in certain cases where pre-determined amount of throttling is necessary.

**Pressure control mode**, is used whenever control to a specific process pressure level is desired. The host provides the set-point value to the controller which, in turn, moves the valve to achieve that set point as quickly as possible. During pressure control mode, external perturbations such as flow changes and plasma events will automatically be compensated for by the controller so that the pressure set-point is maintained. The value can be changed by the host at any time.

### Tuning

The IQ+ controller contains an Adaptive Pressure Control Algorithm that has been designed to work over a wide range of flow and pressure combinations. In some cases 3 system parameters may have to be adjusted. These include system volume, system delay and speed. See **Section 6.1: How to configure IQ+ for your system.**



## 5.0 - IQ+ Controller Module Interfaces

IQ+ controllers have several interfaces available for communications and connectivity to peripheral devices, depending on model. These are described by function below. Please also refer to **Figures 3.1 – 3.4** and their associated Tables for the specific connectors and their pin assignments.

### Vacuum Gauge Interface

The pressure signal from one or two vacuum gauges can be interfaced to the IQ+ controller module through the connector labeled GAUGE. In addition,  $\pm 15$  VDC is available as an option to power such gauges from these ports.

 **NOTE:** *If the power requirement of the gauge(s) used exceeds the rated power output, then a separate power source must be used.  $\pm 15$ V@1500mA.*

When only one gauge is used, then the pressure signal must be connected to the CDG1+ and CDG1- signal pins. Use of two gauges requires adhering to the following:

The full scale range of the two gauges used must be set prior to use. See section 6.0.

### Serial interface

An RS-232 serial interface is available on all controller models. Please refer to the **Section 6.0** for a full description of the communications protocol and a listing of all active serial commands. A three-wire connection completes the communications consisting of Rxd (data from the IQ+), Txd (data to the IQ+) and digital ground.

 **NOTE:** *CTS, RTS and DSR connections are neither needed nor available.*

 **NOTE:** *The default factory RS-232 communications parameter settings are 9600 Baud, 1 stop bit and no parity. These settings can only be changed on models with DIP switches, and changing the setting requires cycling IQ+ input power off then back on.*

Every serial input command sent by the HOST has an end-of-line delimiter, carriage return ASCII 0x0D [hex], or the line feed character ASCII 0x0A [hex], or the carriage return and line feed character in that order. The IQ+ device end-of-line delimiter is the carriage return and line feed characters.

### DeviceNet Interface (not available on all models)

The five-pin circular DeviceNet port allows for complete remote control, monitoring and power supply of the IQ+ controller in a cost effective and reliable way. In addition to the connector are two status LEDs labeled Mod and Net, as well as three rotary switches labeled MSD, LSD and RATE. A complete explanation of the DeviceNet physical and software interfaces can be found in Sections 8 and 9.

### Service Port

The Service Port is reserved for factory authorized service technicians

### Indicating LEDs

There are a host of indicating LEDs on the IQ+ controller, depending on model. In general, the green Power LED is illuminated whenever power is applied to the device. The green Ctrl LED is illuminated whenever the IQ+ is in set point control (pressure or position). The amber Fault LED is illuminated briefly during the initialization sequence after power-up but primarily if the IQ+ device enters a fault state. Two LEDs are located adjacent to the OPEN and CLOSE switches, and are illuminated whenever the valve position is within 2% of either limit.

### Switches

Some controller models have a bank of four DIP switches labeled SW1. These switches are used to define valve size. Relative to the printed text on the overlay, switch 1 is on the left

A switch in the "up" position is OFF or "0"

A switch in the "down" position is ON or "1"

Refer to **table 5.1** below for a complete listing of valid DIP switch settings.

Primarily intended for operation during installation or troubleshooting, the IQ+ also features two push button switches on the face of the controller that can be used to drive the valve fully open or closed. To prevent inadvertent valve operation, these switches cannot be used if the IQ+ valve is in Control Mode (green Ctrl LED on).

**TABLE 5.1 – DIP SWITCH CONFIGURATION**

SW1	SW2	SW3	SW4	VALVE SIZE
0	0	0	0	1 inch
0	0	0	1	1.5 inch
0	0	1	0	2 inch
0	0	1	1	2.5 inch
0	1	0	0	3 inch
0	1	0	1	4 inch
0	1	1	0	6 inch
0	1	1	1	8 inch
1	0	0	0	10 inch
1	0	0	1	12 inch
1	0	1	0	14 inch
1	0	1	1	16 inch
1	1	0	0	TBD
1	1	0	1	TBD
1	1	1	0	TBD
1	1	1	1	TBD





## 6.0 - RS-232 Serial Interface and Commands

### Interface basics

All IQ+ controllers support RS-232 serial communications available through auxiliary port. A full description of the communications protocol and a listing of all active serial commands follows in this section. A three-wire connection needs to be completed to provide the communications lines, with Rxd (data from the IQ+), Txd (data to the IQ+) as well as signal common on. See Section 3.0 for details.

**NOTE:** Hardware handshaking is not available.

**NOTE:** The default factory RS-232 communications parameter settings are 9600 Baud, 1 stop bit, no parity and 8-bit character. These settings can only be changed using a serial command.

Every serial input command sent by the HOST has an end-of-line delimiter, carriage return ASCII 0x0D [hex], or the line feed character ASCII 0x0A [hex], or the carriage return and line feed character in that order. The IQ+-device end-of-line delimiter is the carriage return and line feed characters.

### Serial Commands Summary

Table 6.1 and 6.2 summarize the serial commands and responses available with the IQ+ controller. Additional commands may be included to enable customer specific functions. Please contact Nor-Cal Products Intellisys Customer Support for more details.

TABLE 6.1 – RS-232 SERIAL COMMANDS

SERIAL COMMAND	DESCRIPTION	NOTES / EXAMPLES
C	Close the valve	Same function as pressing the CLOSE button
O	Open the valve	Same function as pressing the OPEN button
H	Hold the valve in the current position	Stops active pressure control, if device is in that mode
T1x	Sets the type of set point #1. When x=0, the set-point type is position. When x=1, the set-point type is pressure.	
S1xx.xx	Used to program a value for set point xx.xx is any number between 0.00 and 100.00, representing the % of gauge full scale	S150, for example, programs the value of 50% for the setpoint. When using a 1 Torr gauge, this corresponds to 500 mTorr.
D1	Activates set-point #1.	Put the device in control mode, effectively making the setpoint active.
Vxx.xx	Go to valve position	xx.xx is 0 to 100% of full open
L0	Auto select CDG1 or CDG2 for best resolution	Default two gauge configuration.
L1	Control to and report CDG1 values only	Selects Gauge 1 for maintenance function.
L2	Control to and report CDG2 values only	Selects Gauge 2 for maintenance function.
N1xx	Sets the full scale range of CDG1	Values for xx can be found in Table 6.3
N2xx	Sets the full scale range of CDG2	Values for xx can be found in Table 6.3
J4	Clears the "initialization safety lock feature" included on some TPV and TSS controllers	Initializes Valve

### RS-232 Commands Examples

The following section provides examples of the most commonly used commands and responses. The serial command protocol is not case sensitive, though all the command examples in this section are listed in capital letters. Furthermore, whenever necessary the character Ø has been used to designate the number zero, so as to not confuse it with the letter O.

TABLE 6.2 – RS-232 SERIAL REQUESTS AND RESPONSES

SERIAL REQUEST	DESCRIPTION	RESPONSE
R1	Requests the set point value	S1+xxxx, where xxxx is a number from 0.00 to 100.00
R5	Requests the current pressure	P+xxxx, where xxxx is a number from 0.00 to 100.00
R6	Requests the current valve position	V+xxxx, where xxxx is a number from 0.00 to 100.00
R38	Requests the software version	IQ+3-[version #] [version date] (text)
R26	Report set point type	T1x, When x=0, the set-point type is position. When x=1, the set-point type is pressure.
GSN	Get the serial number of the device	SN: xxxxxxxx
RN1	Requests full scale range of CDG1	N1xx.xx, where xx.xx is the full scale range of CDG1 in Torr
RN2	Requests full scale range of CDG2	N2xx.xx, where xx.xx is the full scale range of CDG2 in Torr
RESET	Resets the device	Same as cycling power



## 6.0 - RS-232 Serial Interface and Commands *(continued)*

### Modifying the Setpoint

The IQ+ controller normally has five programmable set point selectable to be either pressure control or valve position control. Before using the set point to control either pressure or valve position, the set point value must be programmed. This is done by the following command:

**S1xx.xx** where xx.xx is a number from 0.00 to 100.00.  
One or no decimal places may also be used i.e. x.x or x.

### Reading the Setpoint

The set point can be read back to the Host controller only through the serial port.

**R1** To verify the set point  
The IQ controller will respond with  
**S1+xx.xx** where xx.xx is the set point value.

### Selecting Valve Position Control or Pressure Control

The set point input value is common for both valve position and pressure control. Therefore, it is necessary to program the IQ+ so that it controls to the correct type. The factory default setting is pressure control.

#### Set set point type

**T1x** where X=0 → position control  
**T1x** where X=1 → Pressure control (default)

### Verifying the Control Mode

Before starting either pressure control or position control operations it might be necessary to verify the setting of the set point type. This can only be accomplished through the serial port with the command

**R26**  
The IQ controller responds with:  
**T1x** where x is 0 for position control or 1 for pressure control (default).

### How to Control Valve Position

One of the two main functions of the IQ+ controller is Valve Position Control. In this mode the IQ+ controller will simply move the throttle valve plate to a prescribed position according to a set point. The set point is a value between 0% and 100%, where 0% is closed and 100% is open.

**OPEN:** The serial command is **O**.  
The controller will only respond by opening the valve.

**CLOSE:** The serial command is **C**.  
The controller will only respond by closing the valve.

**HOLD:** The serial command is **H**. The controller will only respond by stopping the valve at the current position.

**Any Valve Position: Vxx.xx** where xx.xx is a number from 0.00 to 100.00% of full open. One or no decimal places may also be used i.e. x.x or x.

Similarly use the **T10** command to set the set point type to position control. Then follow the information outlined in the How To Modify the Setpoint and How To Control System Pressure sections.

### Reading the Valve Position

The valve position may also be obtained through the serial port.

The valve position is reported as a % of full open using the command:

**R6**  
The Controller responds with the valve position using the format:  
**V+xxx.xx** where xx.xx is a number from 0.00 to 100% of valve open position.

### How to Control System Pressure

The principal function of the IQ+ controller is to control system pressure. To accomplish this, the controller needs to be put in "pressure control mode" while being supplied a pressure set point. The pressure set point is proportional to the vacuum gauge's full scale range.

Controlling pressure using the serial port provides additional flexibility.

To activate a set point issue the command:  
**D1**

The active set point must be set to the correct value before activating the pressure control set point. The set point can be modified any time before, during, or after pressure control. Also a different set point can be activated at any time.

**Note:** For pressure control mode, the setpoint type must = 1, i.e. **T11**

### Reading System Pressure

Pressure, as output by the system gauge(s) to the IQ+ Controller, can be read directly from the controller. Both the signals from CDG1 and CDG2 can be read independently.

The IQ+ controller will report the pressure via the serial port with the following command:

**R5**  
The controller will respond with:  
**P+xx.xx** where + indicates the polarity of the value and xx.xx is the value in % relative to CDG1 full scale.

The range of xx.xx is from 0.00 to 100.00 and represents the pressure as a percentage of the full scale of the CDG1 pressure gauge. The value can be less than 0 if the vacuum gauge electronics have drifted or greater than 100 but limited to 110%. For example, if the system uses a 100 Torr gauge and the pressure is actually 10 Torr, the controller response will be P+10.00. On the other hand, if the pressure is 10 Torr but the system has a 20 Torr gauge, the controller response will be P+50.00.

When two CDG's are used, the IQ+ will always report the pressure as a percentage of the high range gauge. For example, if the system has a 100 Torr gauge attached to CDG1 and a 1 Torr gauge attached to CDG2 and the actual system pressure is 0.1 Torr the response to the R5 command will be P+0.100.



## 6.0 - RS-232 Serial Interface and Commands *(continued)*

### Activating Dual Pressure Sensor Configuration

When two pressure gauges are attached to the IQ+ controller, the controller can operate in three distinct modes of operation.

#### Dedicated to the first gauge:

(This is the power-on default mode)

In that mode the controller only considers CDG1 for pressure control as well as reporting. This mode is initiated by the **L1** command

#### Dedicated to the second gauge:

In that mode the controller only considers CDG2 for pressure control as well as reporting. This mode is initiated by the **L2** command. Pressure is still reported as a % of full scale of CDG1.

The **L1** and **L2** commands particularly relevant to dual chamber systems venting to one single downstream exhaust valve. In that situation there are two distinct pressure gauges corresponding to each individual vacuum chamber. The IQ+ controller is then used alternatively control pressure in each chamber.

#### Dual range mode: (Default)

**L0** activates this mode, in which the controller utilizes the two gauges to optimize the pressure measurement. Two gauges are intended to be complementary in covering the dynamic pressure range. The high gauge is referred to as the primary gauge. The low gauge is designed to be the secondary gauge covering the low range measurements. In dual range mode gauges can be switched. The gauge range needs to be predefined as illustrated in the next section. The IQ+ controller will use the range information to determine the pressure at which the controller will switch from reading one CDG to another. The automatic switch over is at 90% of the full scale value of the lower range gauge when the pressure is decreasing and greater than 99% of the full scale value of the lower range gauge when the pressure is increasing. Please note that in Dual Range Mode, all set point commands are with respect to the primary gauge range (CDG1).

**L1** and **L2** are normally used for maintenance purposes only. Restore the IQ+ to dual range made upon completion of maintenance usign the **L0** serial command

### How to Configure Pressure Sensor Parameters

When two pressure gauges are used it is necessary to program the IQ+ with sufficient information so that it knows the full scale of each gauge and, hence, the ratio of the full scale pressure ranges. The factory default full-scale range for CDG1 is 10 Torr, and that for CDG2 is 0 Torr (not connected).



**NOTE:** Programming the gauge full scale range is not necessary when only one gauge is installed. First, program the full scale range of CDG1 using:

**N1xx** where **xx** is the number found in **Table 6.3** describing the full scale range of CDG1. For example, enter N1100 if CDG 1 is a 100 Torr gauge or N10.25 if it is a 250 milltorr gauge.

Then, program the CDG2 full scale range with:

**N2xx** where the value for **xx** can also be found in **Table 6.3**, representing the CDG2 full scale. The full scale of CDG1 must always be greater than that of CDG2. Ex N210 is a 10 Toor gauge 2.

### Reading the Pressure Sensor Configuration

The full scale setting of the CDG's can only be accessed through the serial port. Once the full scale ranges for CDG1 and CDG2 have been entered, the IQ+ controller will automatically calculate their ratio. A ratio of 1000:1 is the limit between the two pressure gauges.

Verify the CDG entries by querying the IQ+ controller for a CDG range report with the following commands:

#### RN1

The controller will respond with:

**N1xx.xx** where **xx.xx** is the full scale range of CDG1.

To check the full scale range of CDG2 send the command:

#### RN2

The controller will respond with

**N2xx.xx** where **xx.xx** is the full scale range of CDG2.

**TABLE 6.3 – VALUES TYPICAL OF XX FOR USE WITH DUAL RANGE MODE**

CDG1 OR CDG2 FULL SCALE (IN TORR)	VALUE OF XX
0.1	0.1
0.2	0.2
0.5	0.5
1	1
2	2
5	5
10	10 (CDG1 default)
50	50
100	100
500	500
1000	1000
0	Not connected (CDG2 default)



**NOTE:** Any number can be used for a gauge full scale.



## 6.1 - How to Configure IQ+ for Your System

### System Configuration Parameters

There are three parameters to adjust that will affect how the valve will react to changes in gas flow and pressure set points.

The parameters only need to be set once and will cover the full range of process pressure setpoints. The three parameters are:

- Volume
- Delay
- Speed

#### Volume

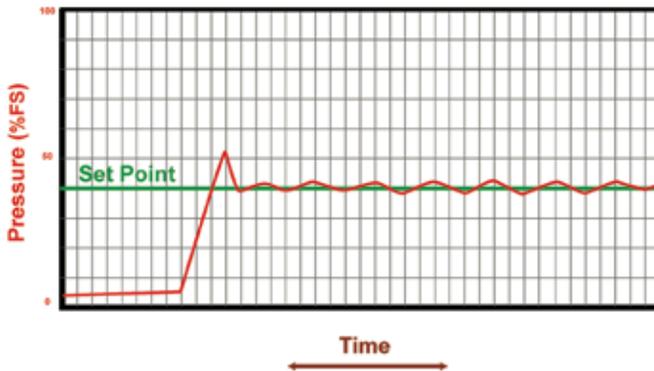
Volume is a Dependent phase multiplier and is based on the size of the pressure chamber and controls how fast the valve will react.

No specific relationship to physical chamber size (example: a setting of 50 does not equal a 50L chamber).

The default setting for **Volume** is 0. Range is 1-100.

If the pressure signal overshoots the set point, increase the value of **Volume**.

FIGURE 6.1 – VOLUME TOO LOW  
Slow Oscillations at set point



If the pressure signal undershoots the set point, decrease the value of **Volume**.

FIGURE 6.2 – VOLUME TOO HIGH  
Undershoot

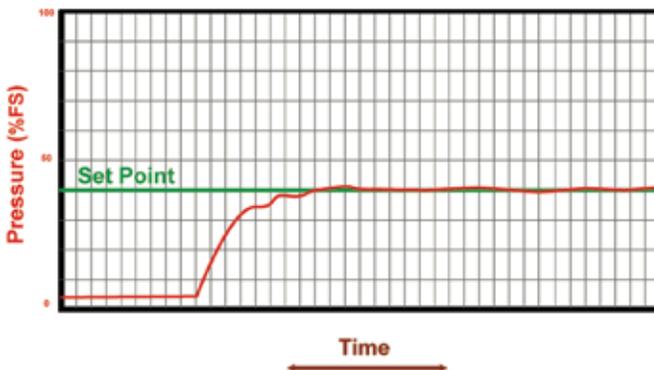
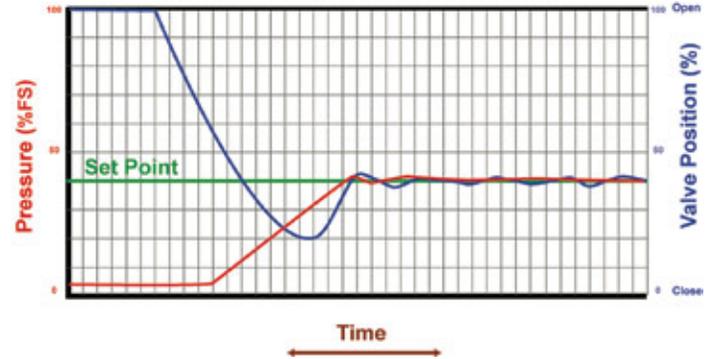


FIGURE 6.2.1 – VOLUME TOO HIGH  
Slow Valve Movement, Slow Response



#### Delay

Feedback delay compensates for the physical properties of the vacuum system that cause delays in the pressure gauge readings when a pressure change occurs.

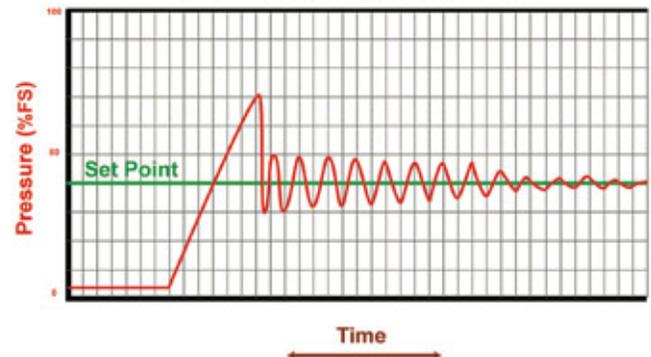
Keep the **Delay** setting as low as possible.

The default value of **Delay** is 0. Range is 0-10.

If **Delay** is adjusted, it should be set as low as possible.

If the pressure signal oscillates at set point then increase **Delay**.

FIGURE 6.3 – DELAY TOO LOW  
Overshoot and Pressure Oscillation



#### Speed

The default setting for **Speed** is 100 (100%). Range is 1-100. Normally this parameter does not require adjustment.

Reducing speed will help reduce low frequency oscillations. **Speed** should be reduced only after any adjustments to **Volume** and **Delay** have failed. When reducing **Speed**, set **Delay** to 0..

Maximum valve speed during pressure control does not affect the Open-Close, or Close-Open valve speed. If **Speed** is set too high the pressure will oscillate at set point (See Fig. 6.4). If **Speed** is set too low the valve will move slowly (See Fig. 6.5).





## 6.1 - How to Configure IQ+ for Your System (continued)

FIGURE 6.4 – SPEED TOO HIGH  
Low Speed Oscillations

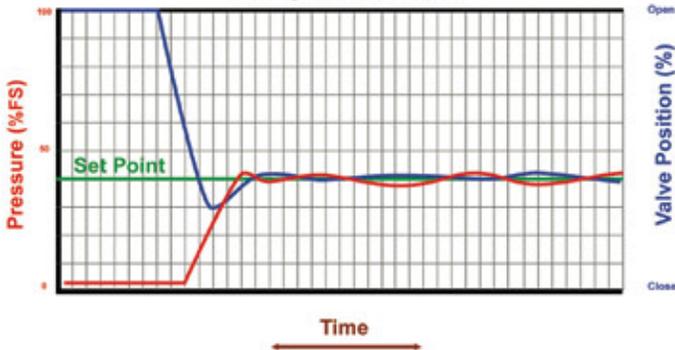
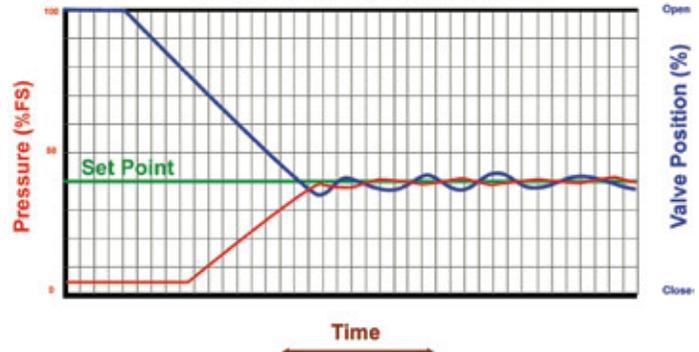


FIGURE 6.5 – SPEED TOO LOW  
Undershoot, slow valve movement



### System Configuration Commands

#### DeviceNet Commands

Class ID 33<sub>hex</sub>

Instance ID 1 (Process Control)

TABLE 6.4 – DEVICENET COMMANDS

ATTRIBUTE ID HEX	ACCESS CODE	NAME	FORMAT	VALUE
64	OE (get) 10 (set)	Volume	INT	1-100, default = 0
65	OE (get) 10 (set)	Delay	INT	0-10, default = 0
66	OE (get) 10 (set)	Speet	INT	1-100, default = 100

TABLE 6.5 – RS-232 SERIAL COMMANDS

SERIAL COMMAND	DESCRIPTION	RESPONSE
SVxxx	Set Volume where xxx is a number from 1 to 100	PID VOLUME: xxx
SDxxx	Set Delay where xxx is a number from 1 to 10	PID DELAY: xxx
SSxxx	Set Speed where xxx is a number from 1 to 100	PID SPEED: xxx

TABLE 6.6 – RS-232 SERIAL REQUESTS AND RESPONSES

SERIAL REQUEST	DESCRIPTION	RESPONSE
RV	Requests Volume value	PIC VOLUME: xxx
RD	Requests Delay value	PID DELAY: xxx
RS	Requests Speed value	PID SPEED: xxx
RPI	Requests values of Volume, Delay and Speed	SPEED: xxx VOLUME: xxx DELAY: xxx

### Setting Volume, Delay and Speed

- A** Record the current Volume, Delay, and Speed parameters.
- B** For serial interface set the serial port speed 100ms or less. For Devicenet set to 50ms. Or less.
- C** Start pressure control at a process critical set point, or a set point halfway between the system maximum and minimum process pressure set points.  
With the system GUI or a PC that can graph data observe the pressure and valve movement.
- D** If the pressure parameters need adjusting stop pressure control and Open the valve. Enter new value for pressure parameters.

Parameters are adjusted in this order: **Volume**

**Delay**

**Speed** (not normally adjusted)

- E** If the pressure response is satisfactory, input a set point at the system minimum pressure or another process critical set point. Make adjustments as necessary. If a change was made re-check pressure set point in step C.
- F** If the pressure response is satisfactory, input a set point at system maximum pressure. Adjust if necessary. If a change was made re-check set points in steps C and D.
- G** Record new parameters for Volume, Delay, and Speed.

### Setting Volume, Delay and Speed (Example)

The system has a 1 Torr pressure gauge. The pressure control range is 20mTorr - 600 mTorr. The process critical range is 120mTorr.

- A** Record values of Volume, Delay, and Speed.
- B** Start pressure control with a set point 120mTorr. Adjust the parameters if necessary.
- C** Start pressure control with a set point of 20mTorr. Adjust parameters if

- necessary. If any changes are made then re-check the 120mTorr set point.
- D** Start pressure control at 600mTorr. Adjust the parameters if necessary. If any changes are made then re-check the 120mTorr and 20mTorr set points.
- E** Record new values of Volume, Delay, and Speed.



## 7.0 - DeviceNet Interface

### 7.1. Overview and setup

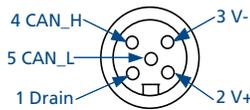
DeviceNet is a network communication protocol that provides a cost-effective solution to low-level device networking for semiconductor equipment tools. Process data and other information such as configuration parameters can be communicated for up to 64 nodes per network at data rate up to 500K baud. The DeviceNet pressure controller conforms to the ODVA & ControlNet International, Ltd. Process Control Valve (PCV) device profile. This device profile is available in the CIP Networks Library: Volume One, Edition 3.3 -- The Common Industrial Protocol (CIP™) of the official DeviceNet specification. Accordingly, the purpose of this manual is to provide an overview on the basic use of the DeviceNet communication interface as it relates to the IQ+ pressure controller, as well as report the different options supported by the controller software communication interface.

#### DeviceNet Connector:

The communication port is a sealed micro-style M12 male connector that conforms to the DeviceNet specification. The connector pin out is shown in **Figure 7.1**.

DeviceNet requires power input of 11-24 VDC provided through the DeviceNet connector. Separately, the controller unit requires a 24 VDC +/- 10% power source, which is provided through the power connector. See section 3.0.

**FIGURE 7.1 - DEVICENET CONNECTOR PIN ASSIGNMENT**



**Module Status:** A bicolor (red/green) Module status LED indicates the status of the communication module according to the logic in **Table 7.1**.

**TABLE 7.1 - DEVICENET MODULE LED STATUS**

LED	STATUS
Green	Module OK
Red	Fault condition
Flashing Red	Lost DeviceNet power
OFF	No DC power

#### Network Status:

A bicolor (red/green) Network status LED indicates the status of the communication link according to the logic in **Table 7.2**.

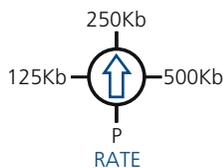
**TABLE 7.2 - DEVICENET NETWORK LED STATUS**

LED	STATUS
Flashing Green	Network OK device online
Green	Network OK connection established
Flashing Red	Recoverable fault
Red	Unrecoverable fault
OFF	No network detected

#### Baud Rate Selection:

The baud rate selector as shown in **Figure 7.2** is a 4 position rotary switch used to select the desired baud rate of the controller, respectively 125Kb, 250Kb, 500Kb and software programmable. The factory default setting is 125Kb. The software programmable baud rate is kept in non-volatile memory and settable through the DeviceNet object.

**FIGURE 7.2 - DEVICENET BAUD RATE SELECTION SWITCH**



#### No network detected:

This is an indication from the software that multiple attempts to publish a message (typically a duplicate MACID check message) have been made but no acknowledgement of that message has been received. It is the normal mode of operation if the network connection is not used.

#### Network OK device online:

If the device successfully detects a live bus it will transition to flashing green, that is the standby mode, the device is ready for the master node to establish a connection.

#### Network OK connection established:

When the device has successfully been attributed a connection by the master the network LED will transition to solid green.

#### Recoverable fault:

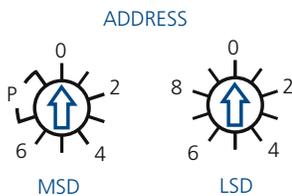
If the master unexpectedly drops the DeviceNet connection (lets the slave time out) the LED will transition to flashing red, signaling the occurrence of a time out fault. If the network master re-establishes the connection the device will then recover to normal operating mode.

#### Unrecoverable fault:

A red Network LED signals the occurrence of a major network fault such as two devices having the same MACID, an incompatible baud rate setting or a short in the communication signal lines.

#### MACID Selector:

Two rotary switches are used to set the MACID of the device on the network between 0 and 63 and software programmable. Note that MACID 0 is commonly reserved for the DeviceNet network master and should not be used by any device. The factory default setting is MACID 63. Additionally, positions 64 to 99 correspond to the software programmable setting. The MACID programmed in non-volatile memory will then be used.



**FIGURE 8.3 - DEVICENET ADDRESS SWITCHES**

The software programmable MACID is configurable via DeviceNet. However, note that a change to the baud rate and MACID switches only becomes effective once the device is reset. This happens automatically when setting the MACID in programmable mode.





## 7.1. Overview and setup (continued)

### Required Hardware:

A DeviceNet network is composed of a host controller, a bus and one or more external devices such as IQ+. The master node or host controller is commonly composed of a computer equipped with a DeviceNet interface card. The bus is made of cable connectors and junctions generally arranged in trunkline-dropline configuration as shown in **Figure 7.4**.

Interface and bus system part numbers are given as indication only. The IQD Controllers come ready to plug into any qualified DeviceNet network.

### Prior to power up, you must initially:

1. Select the appropriate baud rate.  
All the devices on the network must operate at the same baud rate.
2. Select an individual device MACID that is not already in use by another device.

IQ+ controller devices can be plugged in and removed from the network live, however, if an inappropriate baud rate setting is selected it will bring the IQ+ controller to a network fault and possibly bring other installed devices on the bus to a fault. Upon connection the IQ+ controller will transmit a duplicate MACID check to verify the uniqueness of its address. If another device with the same MACID address is detected the IQ+ Controller transitions to a red network LED status.

### Power Supply System and Typical Configuration:

It is essential for the controller to have dedicated access to the pressure gauge. Accordingly the preferred configuration is for the controller to host the gauge through the analog signal link while the controller takes charge of reporting the process parameter through the DeviceNet communication link.

The IQ+ controllers require external 24 VDC power for operation. This must be applied to the XLR power port. The DeviceNet interface requires separate power input via the DeviceNet cable connection. This DeviceNet link can be powered from 11 to 24 VDC.

### General Considerations for Valve Operation Using DeviceNet

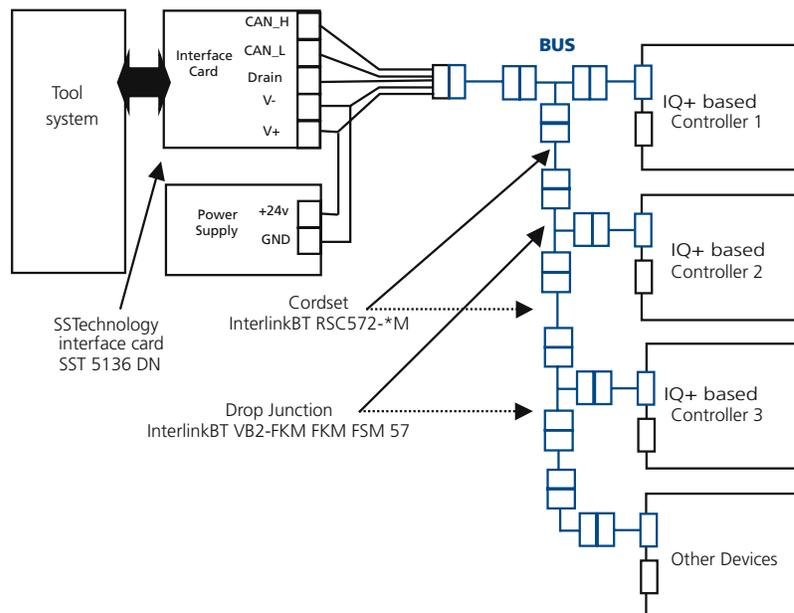
DeviceNet is an object oriented communications protocol. The Process Control Valve device type encompasses several objects from the Hierarchy of Semiconductor Equipment Device Objects (see figure 9.1). These objects are managed by the S-Device Supervisor Object, which tasks include reporting device status. The interaction with the device can be carried out in different ways. The Selection Object is a router object which directs setpoint data to the desired destination – pressure control or position control – via the S-Single Stage Controller Object. Instead of setting a setpoint through the Selection Object, it can be set directly in the S-Single Stage Controller Object. Process data is gathered from the S-Analog Sensor Object, which provides pressure data from up to two pressure gauges and valve position data. This document contains examples of how to set and get parameters through DeviceNet.

To be able to perform pressure or position control, the controller must first be transitioned to the device Executing state. This can be done in one of two ways; explicitly by means of executing a Start service request or by sending valid polled I/O data to the controller. See the DeviceNet Communications section for a more detailed description on how this is done. See figure 9.2 for more details on device states.

Pressure control is performed based on the selected process variable source. By default, the selection will be automatic based on the pressure range that each pressure gauge covers. Setting a setpoint using automatic switching will be relative to the high gauge range, if multiple gauges are used. The source can be forced to either the low or the high range gauge. When the source used is set to "automatic", the source actually reporting the pressure data can be retrieved through the S-Analog Sensor Object.

Some Nor-Cal valves require initialization before they are ready for operation. Nor-Cal has an Initialize service designed solely for this purpose. See S-Device Supervisor Object section for more information on which valve models are affected.

**FIGURE 7.4 - TYPICAL DEVICENET HARDWARE INSTALLATION**



IQ+ OP-LIT 9/08



## 7.2 - DeviceNet Communications

This section describes how to communicate with and control the controller using the DeviceNet port. DeviceNet has two basic message types: Explicit and I/O messaging

### Explicit Messaging:

Explicit messages are used to read or write an individual piece of information in the device. They are mainly used for initial configuration. Explicit messages include the path to locate the data of interest, this consists of the class ID, attribute ID, and instance number. They also specify an action to be taken. The table below lists some of the key information available through explicit messaging. Please refer to **Section 9** for the full device profile characteristic.

TABLE 7.3 - DEVICENET EXPLICIT MESSAGING

CLASS ID HEX	INSTANCE ID HEX	ATTRIBUTE ID HEX	SERVICE ID HEX	VARIABLE NAME
1	1	1	0E (get)	Vendor ID
1	1	6	0E (get)	Serial Number
1	1	7	0E (get)	Product Name
3	1	1	0E (get) 10 (set)	MACID
3	1	2	0E (get) 10 (set)	Baud Rate
31	1	6	0E (get)	Process input (low range)
31	2	6	0E (get)	Process input (high range)
31	3	6	0E (get)	Valve position
2E	1	5	0E (get) 10 (set)	Pressure control and position control
2E	1	9	0E (get) 10 (set)	Process setpoint

The most straightforward way of sending individual commands to the controller is to use a node-commissioning software utility. These utilities are part of the DeviceNet interface card package.

### Explicit messaging connection examples:

- Power up the device, the network LED will transition to flashing green
- Let the master open an explicit connection with the device
- The network LED will transition to solid green

Note that in DeviceNet communications, data to and from the device is always encoded least significant byte first as specified in the data management section of the DeviceNet protocol specification. For instance the value 12345678 hex is encoded as follow:

OCTET NUMBER	1st	2nd	3rd	4th
OUTPUT DATA	78	56	34	12

### How to get device identity information:

- Select the service code **0E** (get attribute)
- Select class ID **1** (select the identity object)
- Select instance ID **1** (there is only instance supported)
- Select attribute ID **1** (vendor ID attribute)
- The device will respond with data bytes **64 02** meaning 264 hex or 612 dec, which is the vendor ID that has been attributed to Nor-Cal Products Inc.
- Change the attribute ID for **6** (serial number attribute)
- The device will respond with data bytes on the form, **3A B1 02 00** meaning 2B13A hex or 176442 dec, which is the serial number of the device.  
(Nor-Cal device serial numbers are composed of at least 6 digits)

### How initialize the valve (not required on all valve types):

- Select the service code **32** (initialize service)
- Select class ID **30** (select the s-device supervisor object)
- Select instance ID **1**

### How to transition the controller to the executing state:

To be able to perform pressure or position control by means of explicit messaging, the controller has to be transitioned to the device Executing state.

- Select the service code **6** (start service)
- Select class ID **30** (select the s-device supervisor object)
- Select instance ID **1**

### How to control valve position:

- Select the service code **10** (set attribute)
- Select class ID **2E** (select the selection object)
- Select instance ID **1** (setpoint)
- Select attribute ID **0E** (destination used) followed by the data **02** (position control)  
**then**
- Select the service code **10** (set attribute)
- Select class ID **2E** (select the selection object)
- Select instance ID **1** (setpoint)
- Select attribute ID **0F** (source data value) followed by the setpoint **00 40**
- The device will move the valve to 50% of its stroke
- Select attribute ID **0F** (source data value) followed by the setpoint **00 00** The device will move the valve to 0% of its stroke or closed

### How to control pressure:

- Select the service code **10** (set attribute)
- Select class ID **2E** (select the selection object)
- Select instance ID **1** (setpoint)
- Select attribute ID **0E** (destination used) followed by **01** (pressure control)  
**then**
- Select the service code **10** (set attribute)
- Select class ID **2E** (select the selection object)
- Select instance ID **1** (setpoint)
- Select attribute ID **0F** (source data value) followed by the setpoint **00 20** (pressure control)
- The device will try to control pressure at 25% of full scale of the selected pressure source
- Select attribute ID **0F** (source data value) followed by the setpoint **FF 7F** The device will try to control pressure at 100% of full scale of the selected pressure source

### How to read the valve limit switch:

- Select the service code **0E** (get attribute)
- Select class ID **8** (select the discrete input point object)
- Select instance ID **1** (closed limit switch)
- Select attribute ID **3**
- The device will respond with data bytes **01** meaning that the close limit switch is activated and the valve is closed
- Select instance ID **2** (open limit switch)
- Select attribute ID **3**
- The device will respond with data bytes **00** meaning that the open limit switch is not activated and the valve is not opened



**Note:** The examples above assume that default data type (INT) and data units (Counts) is used.





## 7.2 - DeviceNet Communications (continued)

### How to read system pressure and valve position:

- Select the service code **0E** (get attribute)
- Select class ID **31** (select the s-analog sensor object)
- Select instance ID **1** (process input low range)
- Select attribute ID **6** (value attribute)
- The device will respond with data bytes 00 00 meaning that the measured pressure is 0
- Select instance ID **3** (valve position)
- Select attribute ID **6** (value attribute). The device will respond with data bytes **FF 7F** meaning that the valve position is fully open.

**TABLE 7.4**  
**OUTPUT ASSEMBLY FORMATS**

INSTANCE HEX	VARIABLES
7 (default)	Control setpoint Control instance
17	FP-Control setpoint Control instance
97 (Master / Slave)	Control mode Pressure setpoint Position setpoint Control instance Individual valve control (address) Individual valve control (action)

**TABLE 7.5**  
**INPUT ASSEMBLY FORMATS**

INSTANCE HEX	VARIABLES								
2 (default)	Exception status Process variable								
4	Exception status Process variable Control setpoint								
5	Exception status Process variable Control setpoint Valve position								
0B	Exception status Process variable Valve <table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <td style="width: 15px; height: 15px;"></td> </tr> </table> Discrete Input 2      Discrete Input 1								
12	Exception status FP-Process variable								
1A	Exception status FP - Process variable FP - Valve <table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <td style="width: 15px; height: 15px;"></td> </tr> </table> Discrete Input 2      Discrete Input 1								
96	Exception status Process variable input 1 (low range) Process variable input 2 (high range) Valve Active process input instance <table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <td style="width: 15px; height: 15px;"></td> </tr> </table> Discrete Input 2      Discrete Input 1								
97 (Master / Slave)	Control mode Pressure setpoint Position setpoint Control instance Individual valve control (address) Individual valve control (action)								

### Input/Output Messaging:

I/O messaging is used to read and write data to the device on a periodic basis. They are used for transmission of a continuous stream of data such as setpoint or process pressure. I/O messages have limited overhead and rely on a prearranged set of data called assemblies. The IQ+ controller handles input assemblies and output assemblies in a poll connection. In an I/O poll connection the tool DeviceNet controller periodically sends an output assembly and the IQ+ responds with an input assembly. The IQ+ supports 3 output and 8 input assembly formats. For polled I/O connections, the device will automatically transition to the device Executing state after the first valid I/O data has been received.

### Example of I/O messaging transactions:

The following is an example format of a typical poll connection, using default settings.

After having opened the I/O connection the master sends the following data:

BYTE	DESCRIPTION	DATA RANGE
1	Setpoint (low byte)	0 to 7FFFh
2	Setpoint (high byte)	
3	Setpoint destination (low byte)	00 for no operation 01 for pressure control
4	Setpoint destination (high byte)	02 for position control

**Note:** The setpoint is a number from 0000 hex to 7FFF hex covering the range 0 to 100%. In other words, in pressure control mode, 7FFF hex represent full scale of the selected pressure source. If the pressure gauge used is 1 Torr then a set point of 4000 hex will control pressure to 0.5 Torr.

In valve position control mode, 7FFF hex represents full open stroke. Respectively, 0000 hex setpoint corresponds to closing the valve and 7FFF hex corresponds to fully opening the valve.

The controller response is formatted accordingly:

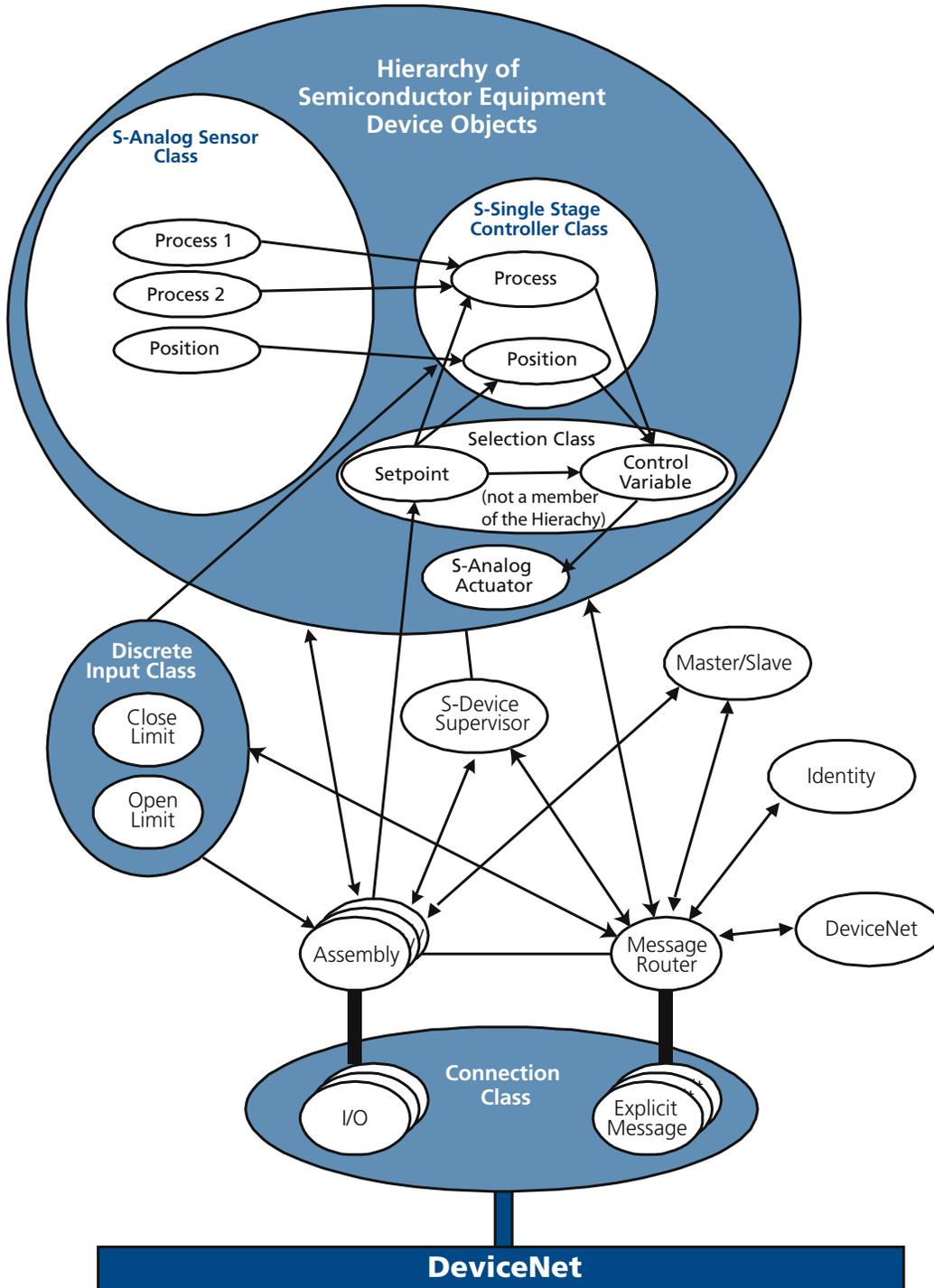
BYTE	DESCRIPTION	DATA RANGE
1	exception status	See table 8.8.2 on page 12
2	pressure (low byte)	0 to 6000h
3	pressure (high byte)	

**Note:** Data types and data units may be changed in application objects handling pressure and position related attributes. Data type can only be changed if no I/O connection has been established using a related attribute and the device is in idle state. Data units can only be changed when the device is in idle state. Changes to these attributes in application objects are non-volatile (recorded in NVRAM).



## 8.0 - DeviceNet Device Profile

Figure 8.1 - Object Model for the Process Control Valve Device





## 8.1 - Identity Object

**Class ID** 1<sub>hex</sub>  
**Instance ID** 1

- **Vendor ID:** Assigned number to Nor-Cal Products Inc. is 612
- **Device type:** The value of 1D<sub>hex</sub> is used for process control valve (cf. specification One, Edition 3.3, page 6-182)
- **Product code:** Nor-Cal Products attributes a specific product code as a function of the valve size or type.

**TABLE 8.1.1 – IDENTITY OBJECT ATTRIBUTES AND SERVICES**

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
1	0E (get)	Vendor ID	UINT	612 (264 h) (ROM)
2	0E (get)	Device Type	UINT	00 1D (ROM)
3	0E (get)	Product Code	UINT	00 xx (NVRAM)
4	0E (get)	Revision	UINT(maj.)+UINT(min.)	xx xx (ROM)
5	0E (get)	Status	WORD	See table 8.1.2
6	0E (get)	Serial Number	32 bits (6 digits)	xxxxxx (NVRAM)
7	0E (get)	Product Name	String <=32	"INTELLISYS" (ROM)
None	05 (reset)	Invokes reset service: 0 = DeviceNet reset (default reset) 1 = out of box reset (NVRAM reset + DeviceNet reset) 64h = device power cycle		

**TABLE 8.1.2 IDENTITY OBJECT STATUS BIT MAP**

BIT	DEFINITION
0	Owned
1	Reserved (=0)
2	Configured
3	Reserved (=0)
4-7	Extended device status
8	Minor recoverable fault
9	Minor unrecoverable fault
10	Major recoverable fault
11	Major unrecoverable fault
12-15	Reserved (=0)

## 8.2 - Message Router Object

**Class ID** 2<sub>hex</sub>  
**Instance ID** 1

No class or instance attributes supported.

## 8.3 - DeviceNet Object

**Class ID** 3<sub>hex</sub>  
**Instance ID** 1

- The values of attribute 1 and 2 are retrieved from NVRAM if the front panel switches are set to program mode; otherwise, the value selected by the front panel switch is reported.
- The set service of attribute 1 and 2 directly updates the value for these attributes in NVRAM. When setting the MAC ID, the device will automatically reset. To update baud rate, a manual hardware or software reset has to be executed.
- The value of attributes 2 and 9 are decoded as follows: 0=125Kb, 1=250Kb, 2=500Kb

**TABLE 8.3.1 – DEVICENET OBJECT ATTRIBUTES AND SERVICES**

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
1	0E (get) 10 (set)	MAC ID	USINT	0-63 (from NVRAM in P mode)
2	0E (get) 10 (set)	Baud Rate	USINT	0-2 (from NVRAM in P mode)
5	0E (get)	Allocation info	Byte+Byte	Allocation choice + master ID
6	0E (get)	MAC ID switch changed	BOOL	0 = No Change, 1 = Change since last reset or power-up
7	0E (get)	Baud rate switch changed	BOOL	0 = No Change, 1 = Change since last reset or power-up
8	0E (get)	MAC ID switch value	USINT	0-99
9	0E (get)	Baud rate switch value	USINT	0-9
None	4B	Allocate master/slave connection		
None	4C	Release master/slave connection		

## 8.4 - Assembly Object

**Class ID** 4<sub>hex</sub>  
**Instance ID** (see static assembly Table 9.5.1 and 9.5.2)

Get or set service selectively supported as a function of the selected instance in the connection object.

**TABLE 8.4.1 – ASSEMBLY OBJECT ATTRIBUTES**

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
3	0E (get) 10 (set)	Data	ARRAY	Static assembly



## 8.5 - I/O Assembly Instances

TABLE 8.5.1 – OUTPUT ASSEMBLY INSTANCES

INSTANCE <sub>HEX</sub>	BYTE	VARIABLES	EPATH <sub>HEX</sub>
7 (default)	0-1 2-3	Control setpoint Control instance	20 04 24 07 30 03
17	0-3 4-5	FP - Control setpoint Control instance	20 04 24 17 30 03
97 (Master Slave)	0 1-2 3-4 5 6 7	Control mode Pressure setpoint Position setpoint Control instance Individual valve control (address) Individual valve control (action)	20 04 24 97 30 03

The control instance indicates the significance of the control setpoint:  
**1** = pressure control  
**2** = position control.

TABLE 8.5.2 – INPUT ASSEMBLY INSTANCES

INSTANCE <sub>HEX</sub>	BYTE	VARIABLES	EPATH <sub>HEX</sub>
2 (default)	0 1-2	Exception status Process variable	20 04 24 07 30 03
4	0 1-2 3-4	Exception status Process variable Control setpoint	20 04 24 04 30 03
5	0 1-2 3-4 5-6	Exception status Process variable Control setpoint Valve position	20 04 24 05 30 03
0B	0 1-2 3-4	Exception status Process variable Valve	20 04 24 0B 30 03
	5		
12	0 1-4	Exception status FP - Process variable	20 04 24 12 30 03
1A	0 1-4 5-8	Exception status FP - Process variable FP - Valve	20 04 24 1A 30 03
	9		
96	0 1-2 3-4 5-6 7	Exception status Process variable input 1 (low range) Process variable input 2 (high range) Valve Active process input instance	20 04 24 96 30 03
	8		
98 (Master/Slave)	0 1-2 3-4 5-6 7 8 ... 8 + nn	Exception Status Process variable input 1 (low range) Process variable input 2 (high range) Valve Device Status Cluster information (address 00 - Master) ... Cluster information (address nn – Slave nn)	20 04 24 98 30 03



**Note:** The process variable will be based on the full scale range of the active sensor except for instance 96 hex and instance 98 hex, where it is based on the full scale range of each individual sensor. The active sensor can be determined from attribute 5F hex, Active instance number, of the S-Analog Sensor Object, class instance 0.



**Note:** After establishing an I/O connection, data types of application objects related to attributes included in the I/O assemblies will self-adjust to give consistency in data type between pressure related and position related attributes. This applies to attributes of the S-Analog Sensor Object, the S-Analog Actuator Object and the S-Single Stage Controller Object



**Note:** Assembly instances 97 hex and 98 hex are described in detail in the Master/Slave Object section.





## 8.6 - Connection Object

Class ID 5<sub>hex</sub>

Instance ID 1, 2 (1=EC, 2=IO)

- Attribute 0E & 10: Setting of this attribute is allowed only when in configure I/O state.
- Attempt to set unsupported EPATH returns an "invalid attribute value" error.
- The current assembly path is stored in the device's NVRAM and restored on power up.
- Watch dog timeout action:  
**0**= transition to timeout, (IO only)  
**1**= auto delete  
**2**= auto reset (IO only)  
**3**= deferred delete (EC only)
- Attribute 7 and 8: report 12 for explicit connection or the actual static assembly length in IO.

TABLE 8.6.1 – CONNECTION OBJECT ATTRIBUTES

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
1	0E (get)	State	UINT	0-5, 0=no cxn, 3=cxnted
2	0E (get)	Instance type	UINT	0=explicit, 1=IO
3	0E (get)	Transport class trigger	BYTE	80,82,83
4	0E (get)	Produced connection ID	UINT	FBh 05h (EC), FFh 03h (IO)
5	0E (get)	Consumed connection ID	UINT	FCh 05h (EC), FDh 05h (IO)
6	0E (get)	Initial com. char.	BYTE	21 for EC, 01 for IO
7	0E (get)	Produced connection size	UINT	12h (EC), 7h (IO)
8	0E (get)	Consumed connection size	UINT	12h (EC), 3h (IO)
9	0E (get) 10 (set)	Expected packet rate	UINT	Connection timing
0C	0E (get)	Watchdog time out action	UINT	1 for EC, 0 for IO
0D	0E (get)	Produced connection length	UINT	0 in EC, 6 in IO
0E	0E (get) 10 (set)	Produced connection path	EPATH	IO input assembly path
0F	0E (get)	Consumed connection length	UINT	0 in EC, 6 in IO
10	0E (get) 10 (set)	Consumed connection path	EPATH	IO output assembly path
11	0E (get)	Production inhibit time	UINT	00

## 8.7 - Discrete Input Point Object

Note: EC = Explicit Messaging Connection, IO = I/O Connection

Class ID 8<sub>hex</sub>

Instance ID 1 1 = closed 0 = not closed

Instance ID 2 1 = open 0 = not open

TABLE 8.7.1 - DISCRETE INPUT POINT OBJECT ATTRIBUTE; INSTANCE ID 1

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
1	0E (get)	Open limit switch	BOOL	0-1

TABLE 8.7.2 - DISCRETE INPUT POINT OBJECT ATTRIBUTE; INSTANCE ID 2

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
3	0E (get)	Open limit switch	BOOL	0-1

## 8.8 - S - Device Supervisor Object

Class ID 30<sub>hex</sub>

Instance ID 1

TABLE 8.8.1 – S-DEVICE SUPERVISOR OBJECT ATTRIBUTES AND SERVICES

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
3	0E (get)	Device Type	Short string	"PCV" (ROM)
4	0E (get)	SEMI rev. Level	Short string	"E54-0997" (ROM)
5	0E (get)	Manufacturer name	Short string	"NOR-CAL" (ROM)
6	0E (get)	Model number	Short string	(ROM)
7	0E (get)	Software revision level	Short string	(ROM)
8	0E (get)	Hardware revision level	Short string	(ROM)
9	0E (get)	Manufacturer's serial number	Short string	(ROM)
0B	0E (get)	Device status	USINT	See table 8.8.4
0C	0E (get)	Exception status	BYTE	See table 8.8.4
0D	0E (get)	Exception detail alarm	STRUCT	See table 8.11.3
0E	0E (get)	Exception detail warning	STRUCT	See table 8.11.3
None	05 (reset)	Resets device to self-testing state		
None	06 (start)	Move the device to executing state		
None	07 (stop)	Moves device to Idle state		
None	32 (initialize valve)	Initializes valve and transitions device from self-testing state to Idle state (not needed for all valve types)		
None	4B (abort)	Moves device to Abort state		
None	4C (recover)	Resets device to self-testing state		
None	4D (perform diagnostics)	Perform diagnostic routines (will return device to self-testing state if not in Abort state); parameters TBD		

TABLE 8.8.2 - S-DEVICE SUPERVISOR OBJECT DEVICE STATUS VALUE

ATTRIBUTE VALUE	STATE
0	Undefined
1	Self testing
2	Idle
3	Self test exception
4	Executing
5	Abort
6	Critical fault
7-50	Reserved
51-99	Devicenet specific



**NOTE:** At power on, butterfly valves proceed directly to idle state. Pendulum valves will rest at self-testing state until explicitly transitioned to idle state for safety purposes. (Access code 32 (initialize))

TABLE 8.8.3 – S-DEVICE SUPERVISOR OBJECT EXCEPTION STATUS BIT MAP

BIT	FUNCTION
0	Alarm device common
1	Alarm device specific
2	Alarm manufacturer specific
3	0 (reserved)
4	Warning device common
5	Warning device specific
6	Warning manufacturer specific
7	1= expanded method



**NOTE:** A logical 'OR' of the related detail bits determines the exception bits



## 8.8 - Device Supervisor Object *(continued)*

TABLE 8.8.4 - S-DEVICE SUPERVISOR OBJECT EXCEPTION DETAIL

DATA COMPONENT	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Comon exception detail size	0	0	0	0	0	0	1	0
Comon exception detail Byte #0	Reserved	Real-time fault	Reserved	Data memory	Non-volatile memory	Code memory	Microprocessor	Diagnostic
Comon exception detail Byte #1	Reserved	Reset exception	Mondify vendor	Scheduled maintenance due	PS input voltage	PS output voltage	Reserved	PS over current
PCV Device exception detail size	0	0	0	0	0	1	0	1
PCV Device exception detail Byte #0	Process variable high † S-Analog Sensor (2)	PProcess variable high † S-Analog Sensor (2)						
PVC Device exception detail Byte #1	0	0	0	0	0	0	0	0
PCV Device exception detail Blllyte #2	0	0	0	0	0	0	0	0
PVC Device exception detail Byte #3	0	0	0	0	0	0	0	0
PVC Device exception detail Byte #4	0	0	0	0	0	0	Status Discrete Input Point (2)	Status Discrete Input Point (1)
Manufacturer exception detail size	0	0	0	0	0	0	0	1
Manufacturer exception detail Byte #0	0	0	0	0	0	0	0	0

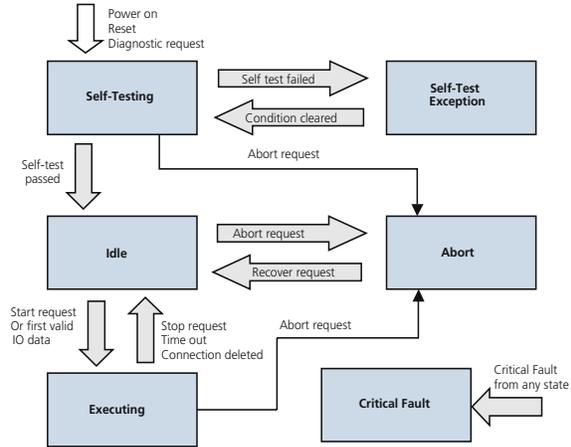
\* Only used in the warning exception detail. This bit is always = 0 in the Alarm exception detail  
 † Warning and alarm levels for S-Analog Sensor Object are the full scale and zero sensor readings  
 †† Warning and alarm bits are set for S-Single Stage Controller when setpoint cannot be reached

 **NOTE:** The bitmap for Warning exception detail and Alarm exception detail is the same.





FIGURE 8.2 - OBJECT STATE TRANSITION DIAGRAM



## 8.9 - S-Analog Sensor Object

Class ID 31<sub>hex</sub>

Instance ID 0 (class-level)



**NOTE:** This class subclass only apply to instances 1 and 2.

- Identifies the gauge providing the pressure value for input Assemblies and S-Single Stage Controller Object, Instance 1

Instance ID 1, 2 (process input)

- If two pressure sensors are used, instance 1 corresponds to the low range pressure sensor and instance 2 corresponds to the high range pressure sensor
- The process input value is a signed 16-bit integer encoded with least significant byte first and scaled according to

**6000 hex** = 100% of full scale sensor reading

**0000 hex** = 0

- The process input signal acquisition range is currently limited to -5% to 110%
- Attribute C7 is used to set the full scale value of the sensor in Torr

Instance 3 (valve position)



**NOTE:** There is no subclass for instance 3.

- The Valve position value is a signed 16-bit integer encoded with least significant byte first and scaled to
- 7FFF hex** = open  
**0000 hex** = closed

TABLE 8.9.3 - S-ANALOG SENSOR OBJECT STATUS BIT MAP

BIT	DEFINITION
0	High Alarm
1	Low Alarm
2	High Warning
3	Low Warning
4-7	Reserved

TABLE 8.9.0 - S-ANALOG SENSOR OBJECT CLASS ATTRIBUTES; INSTANCE 0

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
5F	0E (get)	Active instance number	UINT	1 = Low range CDG 2 = High range CDG
63	0E (get)	Subclass	UINT	1 = Instance Selector

TABLE 8.9.1 - S-ANALOG SENSOR OBJECT ATTRIBUTES; INSTANCE 1, 2

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
3	0E (get) 10 (set)	Data type	USINT	C3h = INT (default) CAh = REAL
4	0E (get) 10 (set)	Data units	UINT	1001h = Counts (default) 1007h = Percent 1301h = Torr
5	0E (get)	Reading valid	BOOL	0 = invalid reading 1 = valid reading
6	0E (get)	Value	Specified by Data type	Analog input value
7	0E (get)	Status	BYTE	See table 8.9.3
0A	0E (get)	Full Scale	REAL	The Value of full scale of the sensor
C7	0E (get) 10 (set)	Full Scale	REAL	The Value of full scale of the sensor Default 0.0 Torr (instance 1) Default 10.0 Torr (instance 2)
60	0E (get) 10 (set)	Pressure variable mapping function	USINT	0 = None (linear)
63	0E (get)	Subclass	UINT	6 = Transfer function

TABLE 8.9.2 - S-ANALOG SENSOR OBJECT ATTRIBUTES; INSTANCE 3

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
3	0E (get) 10 (set)	Data type	USINT	C3h = INT (default) CAh = REAL
4	0E (get) 10 (set)	Data units	UINT	1001h = Counts (default) 1007h = Percent 1703h = Degrees
5	0E (get)	Reading valid	BOOL	0 = invalid reading 1 = valid reading
6	0E (get)	Value	Specified by Data type	Analog input value
7	0E (get)	Status	BYTE	See table 9.9.3
0A	0E (get)	Full Scale	Specified by data type	The Value of full scale of the sensor



**NOTE:** High alarm and warning levels are 6000 hex for instance 1 and 7FFF hex for instance 2. Low alarm and warning levels are 0000 hex for both instances.



## 8.10 - S-Analog Actuator Object

Class ID 32<sub>hex</sub>

TABLE 8.10.1 – S-ANALOG ACTUATOR OBJECT ATTRIBUTES

Instance ID 1

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
3	0E (get) 10 (set)	Data type	USINT	C3h = INT (default) CAh = REAL
4	0E (get) 10 (set)	Data units	UINT	1001h = Counts (default) 1007h = Percent 1703h = Degrees
5	0E (get) 10 (set)	Override	USINT	Specifies the operational mode of the controller, see table 8.10.3
6	0E (get)	Value	Specified by data type	Analog output value
7	0E (get)	Status	BYTE	Alarm & Warning, Default = 0
15	0E (get) 10 (set)	Safe State	USINT	See table 8.10.4

**NOTE:** Use the Override attribute to override the Value attribute when in the device Executing state. For all other states, the Safe state will be used. This attribute has the same effect as Control Mode of the S-Single Stage Controller Object

TABLE 8.10.2 – S-ANALOG ACTUATOR EXCEPTION STATUS BITMAP

BIT	DEFINITION
0	High Alarm
1	NA
2	High Warning
3	NA
4-7	reserved

TABLE 8.10.3 – S-ANALOG ACTUATOR OBJECT OVERRIDE VALUE

ATTRIBUTE VALUE	STATE
0	Normal
1	Zero (closed)
2	Maximum value (open)
3	Hold
4	Safe State (See Table 8.10.4)
5-63	Reserved

TABLE 8.10.4 – S-ANALOG ACTUATOR OBJECT SAFE STATE VALUE

ATTRIBUTE VALUE	STATE
0	Closed
1	Open
2	Hold (Default)
3	Safe Value - Closed
4-63	Reserved

## 8.11 - S-Single Stage Controller Object

Class ID 33<sub>hex</sub>

TABLE 8.11.1 – S-SINGLE STAGE CONTROLLER OBJECT ATTRIBUTES; INSTANCE 1

Instance ID 1 (process control)

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
3	0E (get) 10 (set)	Data type	USINT	C3h = INT (default) CAh = REAL
4	0E (get) 10 (set)	Data units	UINT	1001h = Counts (default) 1007h = Percent 1301h = Torr
5	0E (get) 10 (set)	Control Mode	USINT	See table 8.11.3
6	10 (set)	Setpoint	UINT	0 to 7FFFh for 0 to 100%
7	0E (get)	Process variable (Pressure)	Specified by data type	Analog output value Linked to S-Analog Sensor Object, instance 1 and 2
9	0E (get) 10 (set)	Control Variable	Specified by S-Analog Actuator Object data type	Drive signal output Linked to S-Analog Actuator Object, instance 1 0000h - 7FFFh
0A	0E (get)	Status	BYTE	See table 8.11.4
11	0E (get) 10 (set)	Safe State	USINT	See table 8.11.5
59	0E (get) 10 (set)	Sensor crossover high	Specified by data type	0.9% of high range gauge full scale (default)
5A	0E (get) 10 (set)	Sensor crossover low	Specified by data type	100% of low range gauge full scale (default)
5C	0E (get)	Phase	REAL	Derivative gain
5C	0E (get)	Kap	REAL	Second derivative gain
5E	0E (get)	Gain	REAL	Proportional gain
60	0E (get) 10 (set)	Process variable source	BYTE	1 = Low range CDG 2 = High range CDG 3 = automatic
63	0E (get)	Subclass	UINT	1 = PID & source select
64	0E (get) 10 (set)	Volume	INT	Chamber volume-dependent phase multiplier 1-100, default = 0
65	0E (get) 10 (set)	Delay	INT	Feedback delay Kap multiplier 0-10, default = 0
66	0E (get) 10 (set)	Speet	INT	Max speed of valve during pressure control 1-100, default = 100



**NOTE:** This device uses an adaptive Gain and Phase adjustment mechanism and can not be changed

- Changes to sensor crossover attributes are non-volatile (recorded in NVRAM)
- Control optimization is done in real time and there is no learning calibration sequence





## 8.11 - S-Single Stage Controller Object *(continued)*

**TABLE 8.11.2 – S-SINGLE STAGE CONTROLLER OBJECT ATTRIBUTES; INSTANCE 2**

*Instance ID 2 (position control)*



**NOTE:** *There is no subclass for instance 2*

ATTRIBUTE ID <small>HEX</small>	SERVICE ID <small>HEX</small>	NAME	FORMAT	VALUE
3	0E (get) 10 (set)	Data type	USINT	C3h = INT (default) CAh = Real
4	0E (get) 10 (set)	Data units	UINT	1001h = Counts (default) 1007h = Percent 1703h = Degrees
5	0E (get) 10 (set)	Control Mode	USINT	See table 8.11.3
6	10 (set)	Setpoint	UINT	Specified by data type
7	0E (get)	Process variable (Position)	Specified by data type	Analog output value Linked to S-Analog Sensor Object, instance 3
9	0E (get) 10 (set)	Control variable	Specified by S-Analog Actuator Object data type	Drive signal output Linked to S-Analog Actuator Object, instance 1 0000h - 7FFFh
0A	0E (get)	Status	BYTE	See table 8.11.4
11	0E (get) 10 (set)	Safe State	USINT	See table 8.11.5

**TABLE 8.11.3 – S-STAGE CONTROLLER OBJECT CONTROL MODE VALUE**

ATTRIBUTE VALUE	STATE
0	Normal
1	Closed
2	Open
3	Hold
4	Safe State (Closed)
5-63	Reserved

**TABLE 8.11.4 – S-SINGLE STAGE CONTROLLER OBJECT STATUS BITMAP**

BIT	DEFINITION
0	Alarm exception 0 = cleared, 1 = set
1	Warning exception 0 = cleared, 1 = set
2-7	Reserved

**TABLE 8.11.5 – S-SINGLE STAGE CONTROLLER OBJECT SAFE STATE VALUE**

ATTRIBUTE VALUE	STATE
0	Closed
1	Open
2	Hold (Default)
3	Safe Value - Closed
4-63	Reserved



## 8.12 - Selection Object

Class ID 2E<sub>hex</sub>

Instance ID 1 (setpoint)

- Attribute 0E determines the selection between pressure control or valve control (1 for pressure control, 2 for position control), default is 1 after reset.
- A change on attribute 0E only becomes effective once a new setpoint is sent (attribute 0F)
- When in pressure control (destination used =1) writing a new setpoint is immediately tasking the controller to regulate to the designated pressure
- When in position control (destination used =2) writing a new setpoint will directly affect the valve position

TABLE 8.12.1 – SELECTION OBJECT ATTRIBUTES; INSTANCE 1

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
1	0E (get)	State	USINT	0 = Non-existent 1 = Idle 2 = Running
2	0E (get)	Max destinations	UINT	02
3	0E (get)	Number of destinations	UINT	02
4	0E (get)	Destination List	Array of STRUCT of {Path length (USINT) Destination path (EPATH)}	06 20 33 24 01 30 06 - S-Single Stage Controller, Instance 1, setpoint 06 20 33 24 02 30 06 - S-Single Stage Controller, Instance 2, setpoint
5	0E (get)	Max sources	UINT	00
6	0E (get)	Number of sources	UINT	00
8	0E (get)	Source used	UINT	00
0A	0E (get)	Algorithm type	USINT	04 = Programmable data flow
0D	0E (get)	Object source list	Array of STRUCT of {Path length (USINT) Destination path (EPATH)}	00
0E	0E (get) 10 (set)	Destination used	UINT	Range = 0-2
0F	0E (get) 10 (set)	Input data value	UINT	Data type determined by destination used

TABLE 8.12.2 – SELECTION OBJECT ATTRIBUTES; INSTANCE 2

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
1	0E (get)	State	USINT	0 = Non-existent 1 = Idle 2 = Running
2	0E (get)	Max destinations	UINT	01
3	0E (get)	Number of destinations	UINT	01
4	0E (get)	Destination list	Array of STRUCT of {Path length (USINT) Destination path (EPATH)}	06 20 32 24 01 30 06 - S-Analog Actuator Object, Instance 1, Value
5	0E (get)	Max Sources	UINT	02
6	0E (get)	Number of sources	UINT	02
8	0E (get)	Source used	UINT	00
0A	0E (get)	Algorithm type	USINT	04 = Programmable data flow
0D	0E (get)	Object source list	Array of STRUCT of {Path length (USINT) Destination path (EPATH)}	06 20 33 24 01 30 09 - S-Single Stage Controller Instance 1, Control Variable 06 20 33 24 02 30 09 - S-Single Stage Controller, Instance 2, Control Variable
0E	0E (get) 10 (set)	Destination used	UINT	01
0F	0E (get) 10 (set)	Input data value	UINT	Data type determined by S-Analog Actuator data type





## 8.13 - Master/Slave Object

Class ID 64<sub>hex</sub>

TABLE 8.13.1 – MASTER/SLAVE OBJECT ATTRIBUTES

Instance ID 1 (master)

- When setting attribute 70, Number of slaves, to a number greater than 0, the controller will automatically transition to Master mode. This attribute is only settable when no I/O connection using assembly instance 98 has been established.

ATTRIBUTE ID <sub>HEX</sub>	SERVICE ID <sub>HEX</sub>	NAME	FORMAT	VALUE
70	0E (get) 10 (set)	Number of Slaves	USINT	Range 0-10
73	0E (get) 10 (set)	Individual valve control (address)	USINT	Range 0 - nn = total number of Slaves (invalid value = no individual control)
74	0E (get) 10 (set)	Individual valve control (action)	USINT	See table 8.13.2
75	0E (get)	Device status information	BYTE	See table 8.13.3
76	0E (get)	Cluster information	Array of BYTE	See table 8.13.4
None	05 (reset)	Invokes power reset service: 0- <i>nn</i> =reset valve number <i>nn</i> 255=reset all valves		
None	32 (initialize valve)	Initializes valve and transitions device from self-testing state to Idle state (not needed for all valve types) 0- <i>nn</i> =initialize valve number <i>nn</i> 255=initialize all valves		
None	33 (reset faulted valve)	Invokes power reset service on faulted valves: 0- <i>nn</i> =reset faulted valve number <i>nn</i> 255=reset all faulted valves		

TABLE 8.13.2 – MASTER/SLAVE OBJECT INDIVIDUAL VALVE CONTROL (ACTION) VALUE

ATTRIBUTE VALUE	INDIVIDUAL VALUE ACTION
0, 3-254	No individual control
1	Freeze and close
2	Freeze and open
255	Unfreeze

TABLE 8.13.3 – MASTER/SLAVE OBJECT DEVICE STATUS VALUE

ATTRIBUTE VALUE	STATE
0	Unknown
2	Position control
3	Closed
4	Open
5	Pressure control
6	Hold
12	Power failure
13	Safety mode
14	Fatal error

TABLE 8.13.4 – MASTER/SLAVE OBJECT CLUSTER INFORMATION BITMAP

BIT	DEFINITION
None set	Normal operation
0	Closed
1	Open
2	Closed and frozen
3	Open and frozen
4	Fatal error
5	Power fail not ready warning
6	Reserved
7	Offline

### Master/Slave Operation:

If not previously set in the factory, set the number of Slaves through attribute 70 hex. After updating the attribute, the device will require a DeviceNet reset for all Master/Slave functions to work properly. Setting the 'Number of Slaves' attribute to a non-zero number will automatically configure the DeviceNet controller to act as a Master controller. After the DeviceNet controller has been set up as a Master, all connected Slaves will follow the Master's movements unless instructed differently by the Master.

The Master/Slave system is best controlled using assembly output instance 97 hex and assembly input instance 98 hex. Using these assemblies, the slave valves will follow the Master movements. The Master and slaves can be individually operated by setting the individual valve control attributes to desired values.

For system safety reasons, should any valve have a problem (valve fault, communication problem, loss of power), all other valves will stop at their current position. Should there be a problem with DeviceNet, all valves will close. This could happen if DeviceNet power is lost or if a DeviceNet connection times out.



**NOTE:** Slave device addresses have to be set up sequentially, i.e. for a system with three Slaves, the Slave addresses should be set to 01, 02, and 03 respectively. The Master controller will automatically have address 00.



## 8.13 - Master/Slave Object *(continued)*

TABLE – 8.13.5 SLAVE NETWORK LED STATUS

LED	STATUS
Flashing Green	Network OK device online
Green	Network OK connection established
Flashing Red	Connection timed out

 **NOTE:** *If a Slave valve has a problem of any kind, the Master will indicate this by flashing the fault LED. For all other conditions, the Master LEDs operate the same as a standard IQ+ controller.*

## 9.0 - Battery Back-Up

Some APC models, including the IQ+ controller, are available with a power safe battery back-up option. When installed, this feature will drive the valve closed in the event of a power interruption to the APC controller. This is more commonly of interest when throttling gate- or pendulum valves are used, because these valves typically also serve as the vacuum line isolation valve. The following describes the general functionality and specifications of the battery back-up feature.

### Battery Pack Information

Specially packaged 15-cell, 18V 500 mA·H Ni-Cd battery assembly.

### Battery Life

Depends on various factors including temperature, number of discharge cycles, battery age, starting charge and valve type. Generally, however, a new freshly charged battery should close a typical gate- or pendulum valve ten times, or more, without being depleted to the point where full actuation is no longer possible.

### Recharge Time

Depends on various factors including battery age, state of discharge and to a lesser degree temperature. Under normal conditions, a fully depleted battery should charge completely in approximately 5 hours. Recharging occurs automatically provided that the battery is still capable of being charged.

### Battery Status

The battery voltage can be read by issuing the RS232 serial command **GV**. The controller will respond with the internal Power Supply voltage and the battery voltage as measured on the main PCB.

 **NOTE:** *The battery voltage reported may not be a true indication of the battery's condition, because the voltage is read while the battery is in an unloaded state. Nor-Cal recommends replacing the battery approximately every 24 months, irrespective of apparent condition or usage history. Please refer to Appendix I for ordering information. Always obtain replacement battery packs from Nor-Cal Products.*

### Battery Back-up Activation and Operation

The controller software continuously monitors the operating voltage delivered to it by the internal Power Supply. If that voltage drops below a certain threshold level for more than 50 msec, then the IQ+ disconnects all external power outputs (such as  $\pm 15$  VDC), exits its present operational state and drives the valve closed using battery power. Once the valve is closed, the IQ+ disconnects itself altogether and shuts down.

### Valve Close Speed

The speed at which the valve closes under battery power is the same as during normal operation.

### Resuming Normal Operation

Once normal power is back on, the IQ+ controller will reinitialize the butterfly valve and be ready for operation after about 30 seconds. However, if the IQ+ controller is configured with the valve initialization safety lock function, then the **J4** serial command needs to be issued before valve initialization can occur.





## 10.0 - Product Support



**WARNING:** When working with or troubleshooting Nor-Cal APC products extreme care must be taken to avoid putting bodily parts in or near the valve gate mechanism or other moving parts. These may move suddenly and unexpectedly, and many of them are driven with sufficient force so as to cause significant harm and possibly even dismemberment. Nor-Cal Products recommends that a lock-out and tag-out procedure be strictly followed whenever human physical intervention is required on any of its control valves.



**CAUTION:** DO NOT open the enclosure. Damage to equipment may occur, and unauthorized access to internal parts will void the warranty.

### Troubleshooting

Some basic troubleshooting can be done by the user referring to the instructions and suggestions in the table below which describes common symptoms and recommended actions. The Nor-Cal Products' IQ+ controller module is designed for years of maintenance free operation. Electronics MTBF has been determined to be in excess of 10,000 hours continuous operation. There are no user serviceable parts or components inside the enclosure. If a problem does occur with the IQ+ control electronics or software, please refer to the basic troubleshooting instructions below or contact Nor-Cal Products Intellisys Customer Support to obtain additional instructions or a Return Materials Authorization number.

TABLE 10.1 – POSSIBLE FAILURE MODES AND RECOMMENDED ACTIONS

SYMPTOM	POSSIBLE CAUSES	RECOMMENDED ACTION
IQ+ does not appear to turn on. No LEDs are illuminated	The IQ+ is not receiving power properly	Check external power supply, cabling and pin assignments. Try to restart the IQ+ by reconnecting power supply. Operate OPEN/CLOSE switches.
The IQ+ is on (one or more LEDs illuminated) but it will not respond to commands	The initialization safety lock function is active. The amber FAULT LED should be on and the OPEN/CLOSE LEDs should be blinking	Execute an initialization sequence. Issue a DeviceNet initialization command or send the J4 command via the RS-232 serial port.
	The RS-232 serial connections are not properly made.	Check cabling and pin assignments. Make sure CTS, RTS and DSR connections are not made.
	Communication settings disagree between the IQ+ and the host	If RS-232 is used, make sure host is set for 9600 Baud, 1 stop bit and no parity. Cycle power to the IQ+ to refresh dip switch setting.
The IQ+ does not operate and only the amber FAULT LED is on.	A communications timeout has occurred	Call for Intellisys Technical Support
	The valve plate and/or actuator is jammed	Cycle power to attempt re-initialization of the valve. For Butterfly Valves, turn power OFF and try to move the valve plate by hand. If the valve plate is stuck, call of Intellisys Technical Support
Pressure control performance is unsatisfactory	There is something wrong with the motor drive circuitry or the internal power supply circuitry	Call to obtain an RMA#
	The IQ+ is not receiving the gauge pressure signal, or the signal is very noisy	Check the gauge cabling and signal stability. Also, check for electrical noise or system vibrations, especially if a 100 m Torr (or similar) gauge is used.
	The IQ+ is in valve position control mode	Put the IQ+ in the correct mode by issuing the proper RS-232 or DeviceNet command
The controller / valve will not respond to a new set-point value	System design or operating range may be outside the capabilities of the Adaptive Pressure Control Algorithm	Adjust System Parameters: Volume, Delay, Speed
	The new set-point value is too close to the old set-point value	When using serial communications, the difference between two set-point values should be more than 0.01%
The LEDs are illuminated in an unknown fashion	There is too much noise on the Gauge signal	Change the Gauge Cable
		Please refer to Table 12.2 describing valid LED combinations.



## 10.0 - Product Support *(continued)*

TABLE 10.2 – VALID STATUS LED COMBINATIONS

**TABLE 12.2 KEY**

- O** = LED Off
- G** = Green
- FG** = Flashing Green
- R** = Red
- FR** = Flashing Red
- A** = Amber

MOD	NET	CTRL	FAULT	OPEN/ CLOSE	COMMENTS
O	O	O	O	O / O	All LEDs off. IQ+ is not receiving power, or internal software is corrupt.
G	G	G	A	G / G	All LEDs on. This is valid for about 1 second after power-up for initial check-up sequence.
G	O	O	O	O / O	Mod, only, is illuminated (green) during initialization sequence.
R	O	O	O	O / O	Mod, only, is illuminated (red) when the DeviceNet module is in a non-recoverable fault mode
G	FG	O	O	O / O	Mod on (green), Net blinking (green) means DeviceNet module OK but waiting for a connection
G	FR	O	O	O / O	Mod on (green), Net blinking (red) means DeviceNet module OK but connection has timed out (a recoverable fault)
G	G	O	O	O / O	Mod and Net on (both green) means DeviceNet module OK and device is online
G	R	O	O	O / O	Mod (green) and Net (red) on means DeviceNet module OK but network has experienced an unrecoverable fault
G	G	G	O	O / O	(Mod, Net and Ctrl are green) IQ+ is in DeviceNet communications mode and it is acting on a set point with the valve somewhere between open and closed positions
O	O	O	A	O / O	Mod (green) and Fault (amber) are on indicates that IQ+ has either failed part of the initialization sequence, or the valve plate has jammed
G	G	G	O	G or G	(Mod, Net, Ctrl and OPEN or CLOSE are green) IQ+ is in DeviceNet communications mode and it is acting on a set point with the valve either in open or closed positions
G	O	G	O	O / O	(Mod and Ctrl are green) IQ+ is in RS-232 communications mode and it is acting on a set point with the valve somewhere between open and closed positions
G	O	G	O	G or G	(Mod, Ctrl and OPEN or CLOSE are green) IQ+ is in DeviceNet communications mode and it is acting on a set point with the valve either in open or closed positions
O	O	O	A	FG / FG	Fault (amber) is on and OPEN / CLOSE are flashing. This is an indication that the "initialization safety lock function" is active.

### ***Global Sales and Service***

Nor-Cal Products maintains sales and service centers in over 30 countries worldwide. Please visit our website at [www.n-c.com](http://www.n-c.com) to find the center nearest you.



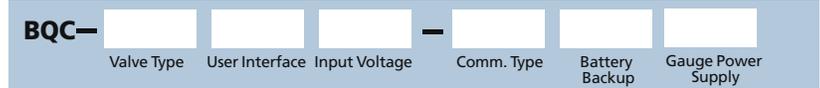


## APPENDIX I – Spare Parts and Ordering Information

To make the completion of an Intellisys downstream pressure control system easy, Nor-Cal Products offers a comprehensive selection of cables and related accessories. These include signal and communications cables, power cords, power supplies as well as spare parts.

### Model Number Matrix for Adaptive Pressure Controllers IQ+

Use the model number tree at right with the matrix below to define a valid Nor-Cal Products adaptive pressure controller model number. Choose one option from each column.



VALVE TYPE	USER INTERFACE	INPUT VOLTAGE	COMMUNICATIONS	OPTIONS
<b>1</b> = Geared Throttling Butterfly Valve or Universal Valve Drive (TBV or UVD)	<b>00</b> = Standard. Buried Box (limited switches & LEDs)		<b>A</b> = RS-232 + Analog/TTL	<b>Blank</b> = None
<b>2</b> = Direct Drive Throttling Butterfly Valve (TBV)		<b>L</b> = 24 VDC differential	<b>R</b> = RS-485 + Analog/TTL	<b>B</b> = Battery backup
<b>3</b> = Geared Drive Sealing Throttling Butterfly Valves (TBVS)			<b>D</b> = RS-232 + DeviceNet <sup>2</sup>	<b>G</b> = Gauge Power Supply
<b>7</b> = Throttling Soft-Shut Valve (TSS)			<b>E</b> = Ethernet	<b>Sxx</b> = Customer specific model, xx = 01, 02, etc.y
<b>8</b> = Throttling Pendulum Valve (TPV)				

### Controller Cables and Accessories

Most cable and cord part numbers listed below end with the number 10 as a suffix, which represents the cable length, measured in feet. Thus, Nor-Cal's standard cable length is 10' (3m). However, any length between 1' (0.3m) and 30' (9.1m) can be supplied as a special request. Please contact Nor-Cal Products for price and availability information.

VALVE CABLE	LENGTH	DESCRIPTION
TBV-CRD-10	10'	APC-to-Valve cable

GAUGE CABLES	LENGTH	DESCRIPTION
CDG-IQ-CRD-10	10'	DC powered APC-to-gauge cable, where gauge has 5-pole terminal block
CDG-IQ-CRD-DB9-10	10'	DC powered APC-to-gauge cable, where gauge has DB-9 plug connector
CDG-IQ-CRD-DB15-10	10'	DC powered APC-to-gauge cable, where gauge has DB-15 plug connector
CDG-IQ-CRD-Y	1'	Y-cable to be used with DC powered APCs when two-gauge connection is required. Use of this Y-cable also requires the use of CDG-CRD-10, CDG-CRD-DB9-10 or CDG-CRD-DB15-10 cables.

SERIAL CABLES	LENGTH	DESCRIPTION
IQ-CRD-RS232-10	10'	Connects any DC powered IQ+ to a standard PC or laptop DB-9 serial port

POWER CORDS	DIAGRAM #	LENGTH	DESCRIPTION
CRD-PWR-US1	1	7'	10A-125V rated appliance cable.
CRD-PWR-US2	2	7'	10A-250V rated appliance cable.
CRD-PWR-UK	3	7'	10A-250V rated appliance cable. For use in the UK
CRD-PWR-EU	4	7'	10A-250V rated appliance cable. For use in Continental Europe



AC Power Cord Plug Configurations

POWER SUPPLY	PART NUMBER
IQ+ Power Supply	Part number pending, call representative for information

BATTERY BACK-UP SPARE	PART NUMBER
IQ+ replacement battery	Part number pending, call representative for information

GAUGE POWER SUPPLY	PART NUMBER
TBD	Part number pending, call representative for information



APC-PSM-DB15 Power Supply



## Appendix II - Limited Warranty and Intellectual Property Coverage

Products manufactured by Nor-Cal Products, Inc. (hereinafter referred to as "Nor-Cal") are warranted against defects in material and workmanship for a period of twelve (12) months from the date of shipment from Nor-Cal to the buyer. Any modification to the product by the buyer or their agent voids this warranty. Liability under this warranty is expressly, limited to replacement or repair (at Nor-Cal's option) of defective parts. Nor-Cal may at any time discharge its warranty as to any of its products by refunding the purchase price and taking back the products. This warranty applies only to parts manufactured, and labor provided, by Nor-Cal under valid warranty claims received by Nor-Cal within the applicable warranty period and shall be subject to the terms and conditions hereof. Expendable items such as tubes, heaters, sources, bellows, etc., by their nature may not function for one year; if such items fail to give reasonable service for a reasonable period of time, as determined solely by Nor-Cal, they will be repaired or replaced by Nor-Cal at its election. All warranty replacement or repair of parts shall be limited to equipment malfunctions which, in the sole opinion of Nor-Cal, are due or traceable to defects in original materials or workmanship. Malfunctions caused by abuse or neglect of the equipment are expressly not covered by this warranty. Nor-Cal expressly disclaims responsibility for any loss or damage caused by the use of its products other than in accordance with proper operating and safety procedures. Reasonable care must be taken by the user to avoid hazards. In-warranty repaired or replacement parts are warranted only for the remaining unexpired portion of the original warranty period applicable to the parts that have been repaired or replaced. After expiration of the applicable warranty period, the buyer shall be charged at Nor-Cal's then current prices for parts and labor plus transportation. Except as stated herein, Nor-Cal makes no warranty, expressed or implied (either in fact or by operation of law), statutory or otherwise: and, except as stated herein, Nor-Cal shall have no liability for special or consequential damages of any kind or from any cause arising out of the sale, installation, or use of any of its products. Statements made by any person, including representatives of Nor-Cal, which are inconsistent or in conflict with the terms of this warranty shall not be binding upon Nor-Cal unless reduced to writing and approved by an officer of Nor-Cal. Merchandise may be returned at the sole discretion of Nor-Cal Products, but not more than 60 days after shipment. A fee may be charged for restocking the item. An RMA number must be obtained from Nor-Cal before returning any merchandise.

### Intellectual Property Coverage

The products described in this manual are covered under U.S. Patent numbers 5,134,349; 5,202,613; 5,321,342; and 6,612,331. Additional patents are pending.

