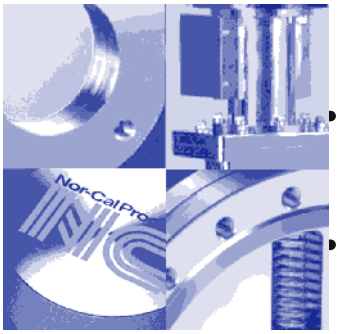
Intellisys™

Adaptive Pressure Controllers

APC-OP-LIT 1/12

OPERATOR'S



MANUAL

100-Series
for Geared Drive
Throttling Butterfly Valves
and Universal Valve Drives

200-Series
for Direct Drive
Throttling Butterfly Valves

300-Series
for Geared Drive
Sealing Butterfly Valves

700-Series
for Throttling
SoftShut Gate Valves

800-Series
for Throttling Pendulum Valves

IQA and IQD Series
for All Throttling Valves

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Yreka, CA 96097 USA

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Nor-Cal Products

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Contact Nor-Cal Products
Intellisys Customer Support
at 800-824-4166 ext. 186
or visit our website
at www.n-c.com

Information in this manual is subject to change without notice.

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1.0 - Introduction

Thank you for purchasing a new Intellisys™ adaptive downstream pressure controller (APC) from Nor-Cal Products. Before installing and operating the product, please read this manual thoroughly as it contains critical hook-up 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**.

Nor-Cal Products' APCs are designed for downstream pressure control over a wide range of vacuum control applications. The APC is a self-contained unit that incorporates all control electronics and associated pressure control software. APCs are available in different models. Line voltage and low voltage buried box versions connect to the valve via a valve cable. IQA and IQD controllers are already mounted on the valve. Any APC, 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.

Limited local operation is possible on some models via the on valve open/close switches. Other models offer full programmability and operation via a front panel display and interface. Local status lights also help the operator during operation, maintenance or troubleshooting. Remote operation or monitoring can be effected either through the serial RS-232, Analog/TTL and in some cases the DeviceNet communication interfaces.

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 APC-Series product. Please note that the information herein is limited to the APC controller. For valve installation instructions and guidelines, please refer to the appropriate Valve Operating Manual.

TABLE 2.1 – APC CONTROLLER GENERAL EQUIPMENT SPECIFICATIONS

FEATURE	SPECIFICATION
Dimensions	Please refer to the diagram specific to sections **3.1** to **3.5**
Weight, in lbs (kg)	IQA and IQD models: N/A, included in valve weight Low voltage models: 2.0 (0.9) A/C powered models: 3.5 (1.6)
Rated Input Voltage	Low voltage models: 24 VDC ±10%, differential A/C powered models: 100 to 240 VAC
Rated Frequency	A/C Powered models only: 50-60 Hz
Rated Current	Low voltage models: 3.0 A @ 24 VDC max, 1.0A @ 24 VDC average A/C powered models: 1.0A typ @ 115 VAC 3A max
Rated Input Protection	Low voltage models: 35 volts max, reverse- and internal current resettable fuse A/C powered models: 300 VA slow blow fuse
Rated Output Power (for gauge excitation)	Low voltage models: ± 15 VDC @ 700 mA A/C powered models: ± 15 VDC @ 800 mA, 2X
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. Low Voltage Directive 2006/95/EC to EN 61010-1:2001 for A/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 – APC CONTROLLER ANALOG TTL I/O

FEATURE	SPECIFICATION
Analog (Gauge) Input	0 to 10V differential
Analog Output	0 to 10V differential @ 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 – APC 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 **Section 6.0** 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 – APC 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 – APC 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 Intellisys 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, connect the APC controller to the valve and then to an appropriate power source. 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: *The valve plate movement presents a pinching hazard. Please keep fingers, hands or other objects away from the valve opening and associated moving parts.*

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 APC 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 +15V and –15V power pins of the APC's gauge connector are power sources that are intended to power the system pressure gauge(s). It can supply a maximum of 700 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.*

CAUTION: *For all low voltage controller models, the Power V+ and Power V- pins of the DeviceNet or Analog/TTL connector are directly linked to the Power V+ and Power V- pins of the Auxiliary Connector. Make sure to only use one or the 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 - A/C Powered Touch-Panel Controller Interface

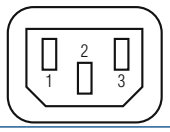
Refer to the following diagrams and tables when connecting to an A/C powered APC Touch Panel Controller including models **APC-150-A**, **APC-250-A**, **APC-350-A**, **APC-750-A** and **APC-850-A**.

TABLE 3.1.1 - (J3 & J4) "APC-X50-A" GAUGE CONNECTOR DB-9 RECEPTACLE (IDENTICAL PINOUTS)

PIN	SIGNAL ASSIGNMENT
1	Signal input from gauge
2	N/C
3	N/C
4	+15VDC output to gauge
5	-15VDC output to gauge
6	N/C
7	N/C
8	Signal common from gauge
9	Power common output to gauge

TABLE 3.1.2- (J1) "APC-X50-A" A/C POWER CONNECTOR

PIN	FUNCTION
1	Neutral
2	Ground
3	Line in 100 to 240 VAC



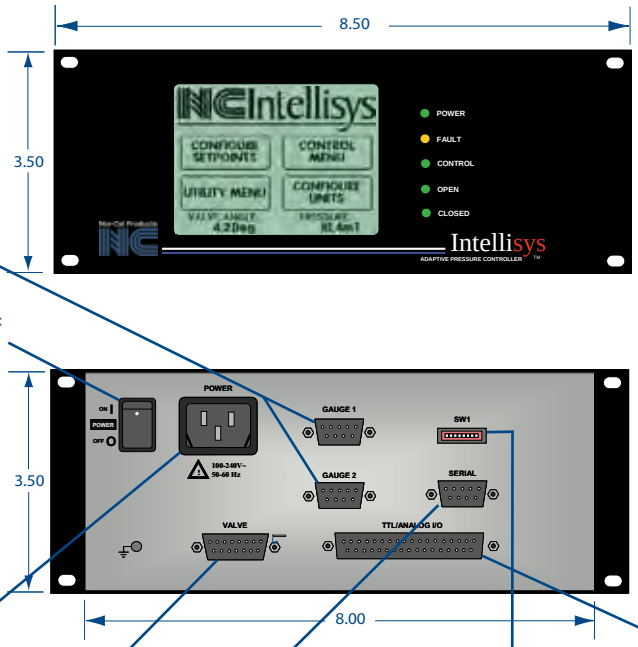


TABLE 3.1.3 - (J5) "APC-X50-A" VALVE CONNECTOR, DB-15 RECEPTACLE

PIN	SIGNAL ASSIGNMENT
1	Drive A+
2	Drive A-
3	Drive B-
4	Drive B+
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

TABLE 3.1.4 - (J2) "APC-X50-A" RS-232 SERIAL PORT, DB-9 RECEPTACLE

PIN	SIGNAL ASSIGNMENT
1	RS485 (B)
2	RS-232 TX (data from APC to host)
3	RS-232 RX (data from host to APC)
4	N/C
5	Signal Common
6	N/C
7	N/C
8	N/C
9	RS485 (A)

TABLES 3.1.5 - (SW1) "APC-X50-A" DIP SWITCH SETTINGS FOR SERIAL COMMUNICATIONS

BAUD RATE	SWITCH 1	SWITCH 2
19200	OFF (up)	OFF (up)
9600	ON (down)	OFF (up)
4800	OFF (up)	ON (down)
1200	ON (down)	ON (down)

PARITY	SWITCH 3	SWITCH 4
None	OFF (up)	Either ON or OFF
Odd	ON (down)	OFF (up)
Even	ON (down)	ON (down)

STOP BITS*	SWITCH 5
1	OFF (up)
2	ON (down)

* If parity is enabled (either odd or even) then only 1 stop bit is used and SW1 position 5 will be ignored

OTHER FUNCTIONS	SWITCH 6	SWITCH 7	SWITCH 8
ON (down)	Enable RS-485	Analog S.P. 0-5 VDC	Reserved
OFF (up)	RS-232	Analog S.P. 0-10 VDC	Reserved

TABLE 3.1.6 - (J6) "APC-X50-A"ANALOG / TTL CONNECTOR, DB-37 RECEPTACLE

PIN	FUNCTION
1	N/C
2	N/C
3	N/C
4	Digital GND / RS232 Common
5	\CDG2 Select In\
6	\Position Control Select In\
7	N/C
8	\Close Valve In\
9	\Control Active Out\
10	\Analog Div 10 Select In\
11	\Analog SP Control Select In\
12	Digital GND / RS232 Common
13	TTL Out Common
14	N/C
15	N/C
16	N/C
17	N/C
18	Analog Valve Out (0-5 VDC)
19	\Valve Open Out\
20	N/C
21	N/C
22	N/C
23	\Valve Closed Out\
24	Fault Out
25	\Zero Gauge Select In\
26	See NOTE below
27	\Open Valve In\
28	PLO #2 Status
29	PLO #1 Status
30	N/C
31	N/C
32	N/C
33	Analog SP+ In
34	Analog SP- In
35	Analog GND
36	Analog CDG Out
37	Analog Valve Out

NOTE: *For* **150-, 250-** *&* **350-** *series controllers, pin 26 is defined as \Hold Valve Select In*

NOTE: *For* **750-** *&* **850-** *series controllers, pin 26 is defined as \Valve Initialization Enable In*

NOTE: *Function* **\names** *with a backward slash indicate active low input or output signals*

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3.2 - A/C Powered Buried Box Controllers Interface

Refer to the following diagrams and tables when connecting to an A/C powered APC Buried Box Controller including models **APC-100-A**, **APC-200-A**, **APC-300-A**, **APC-700-A** and **APC-800-A**.

TABLE 3.2.1 - (J3 & J4) "APC-X00-A" GAUGE CONNECTOR DB-9 RECEPTACLE (IDENTICAL PINOUTS)

PIN	SIGNAL ASSIGNMENT
1	Signal input from gauge
2	N/C
3	N/C
4	+15VDC output to gauge
5	-15VDC output to gauge
6	N/C
7	N/C
8	Signal common from gauge
9	Power common output to gauge

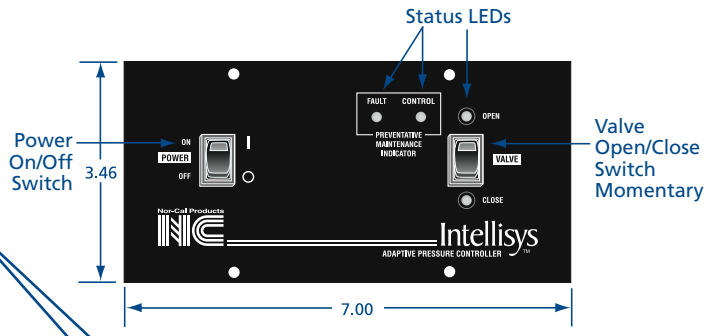
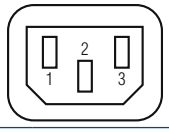


TABLE 3.2.2 - (J1) "APC-X00-A" A/C POWER CONNECTOR

PIN	FUNCTION
1	Neutral
2	Ground
3	Line in 100 to 240 VAC



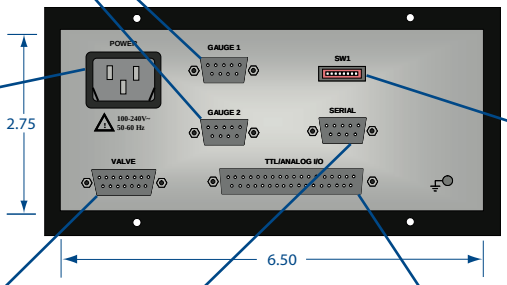


TABLE 3.2.3 - (J5) "APC-X00-A" VALVE CONNECTOR, DB-15 RECEPTACLE

PIN	SIGNAL ASSIGNMENT
1	Drive A+
2	Drive A-
3	Drive B-
4	Drive B+
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

TABLE 3.2.4 - (J2) "APC-X00-A" RS-232 SERIAL PORT, DB-9 RECEPTACLE

PIN	SIGNAL ASSIGNMENT
1	RS485 (B)
2	RS-232 TX (data from APC to host)
3	RS-232 RX (data from host to APC)
4	N/C
5	Signal Common
6	N/C
7	N/C
8	N/C
9	RS485 (A)

NOTE: *Function* **\names** *with a backward slash indicate active low input or output signals*

TABLES 3.2.5 - (SW1) "APC-X00-A" DIP SWITCH SETTINGS FOR SERIAL COMMUNICATIONS

BAUD RATE	SWITCH 1	SWITCH 2
19200	OFF (up)	OFF (up)
9600	ON (down)	OFF (up)
4800	OFF (up)	ON (down)
1200	ON (down)	ON (down)

PARITY	SWITCH 3	SWITCH 4
None	OFF (up)	Either ON or OFF
Odd	ON (down)	OFF (up)
Even	ON (down)	ON (down)

STOP BITS*	SWITCH 5
1	OFF (up)
2	ON (down)

* If parity is enabled (either odd or even) then only 1 stop bit is used and SW1 position 5 will be ignored

OTHER FUNCTIONS	SWITCH 6	SWITCH 7	SWITCH 8
ON (down)	Enable RS-485	Analog S.P. 0-5 VDC	Reserved
OFF (up)	RS-232	Analog S.P. 0-10 VDC	Reserved

TABLE 3.2.6 - (J6) "APC-X00-A"ANALOG / TTL CONNECTOR, DB-37 RECEPTACLE

PIN	FUNCTION
1	N/C
2	N/C
3	N/C
4	Digital GND / RS232 Common
5	\CDG2 Select In\
6	\Position Control Select In\
7	N/C
8	\Close Valve In\
9	\Control Active Out\
10	\Analog Div 10 Select In\
11	\Analog SP Control Select In\
12	Digital GND / RS232 Common
13	TTL Out Common
14	N/C
15	N/C
16	N/C
17	N/C
18	Analog Valve Out (0-5 VDC)
19	\Valve Open Out\
20	N/C
21	N/C
22	N/C
23	\Valve Closed Out\
24	Fault Out
25	\Zero Gauge Select In\
26	See NOTE below
27	\Open Valve In\
28	PLO #2 Status
29	PLO #1 Status
30	N/C
31	N/C
32	N/C
33	Analog SP+ In
34	Analog SP- In
35	Analog GND
36	Analog CDG Out
37	Analog Valve Out

NOTE: *For* **100-, 200-** *&* **300-** *series controllers, pin 26 is defined as \Hold Valve Select In*

NOTE: *For* **700-** *&* **800-** *series controllers, pin 26 is defined as \Valve Initialization Enable In*

3.3 - DC Powered Controllers with Serial I/O Interface

Refer to the following diagram and tables when connecting to a DC powered APC controller including model **APC-800L-A-S01**.

TABLE 3.3.1 - (J1) "APC-800L-A-S01" GAUGE CONNECTOR, DB-15 RECEPTACLE

PIN	FUNCTION
1	Chassis GND
2	Chassis GND
3	N/C
4	Signal common from gauge 2
5	Signal input from gauge 2
6	N/C
7	Signal common from gauge 1
8	Signal input from gauge 1
9	+15V supply to gauge
10	+15V supply to gauge
11	Power Supply Common
12	Power Supply Common
13	N/C
14	-15V supply to gauge
15	-15V supply to gauge

TABLE 3.3.2 - (J2) "APC-800L-A-S01" POWER CONNECTOR, DB-9 PLUG

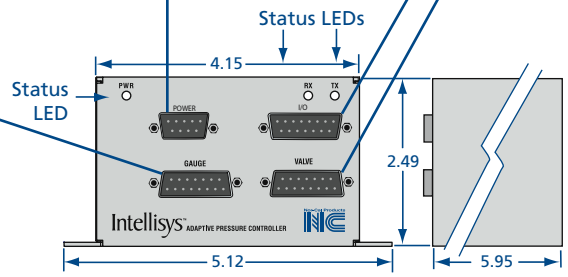
PIN	FUNCTION
1	Chassis GND
2	Power RTN
3	Power RTN
4	Power +24V IN
5	Power +24V IN
6	N/C
7	N/C
8	N/C
9	N/C

TABLE 3.3.3 - (J4) "APC-800L-A-S01" VALVE CONNECTOR, DB-15 PLUG

PIN	SIGNAL ASSIGNMENT
1	Drive A+
2	Drive A-
3	Drive B-
4	Drive B+
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

TABLE 3.3.4 - (J3) "APC-800L-A-S01" I/O CONNECTOR, DB-15 RECEPTACLE

PIN	FUNCTION
1	Chassis GND
2	RS-232 TX (data from APC to host), or 485A
3	RS-232 RX (data from host to APC), or 485B
4	N/C
5	N/C
6	N/C
7	Digital GND
8	N/C
9	N/C
10	N/C
11	N/C
12	Valve Closed input
13	Digital GND
14	\Valve Closed Output\
15	TTL Output Common



3.4 – DC Powered Controllers with Serial and Analog/TTL I/O Interface

Refer to the following diagram and tables when connecting to a DC powered APC controller including models **APC-100L-A**, **APC-200L-A**, **APC-300L-A, APC-700L-A** and **APC-800L-A**.

TABLE 3.4.2 - (SW1) "APC-X00L-A" DIP SWITCHES

	SWITCH 1	SWITCH 2	SWITCH 3	SWITCH 4
OFF (up)	9600 baud	8 bit, no parity	1 stop bit	0-10 V Analog in
ON (down)	19200 baud	7 bit, even parity (1 stop bit only)	2 stop bits	0 to 5V Analog in

TABLE 3.4.1 – (J4) "APC-X00L-A" ANALOG / TTL CONNECTOR, DB-25 RECEPTACLE

PIN	FUNCTION
1	Chassis GND
2	RS-232TX (data from IQ to host)
3	RS-232RX (data from host to IQ)
4	Analog CDG Out
5	Analog GND
6	Analog Valve Out
7	Digital GND
8	\Analog SP Control Select In\
9	Analog SP+ In
10	Analog SP- In
11	Power RTN
12	Power 24V in
13	\CDG2 Select In\
14	See NOTE below
15	\Position Control Select In\
16	N/C
17	Analog GND
18	\Close Valve In\
19	\Open Valve In\
20	Fault Out
21	N/C
22	\Valve Open Out\
23	\Valve Closed Out\
24	TTL Out Common
25	Chassis GND

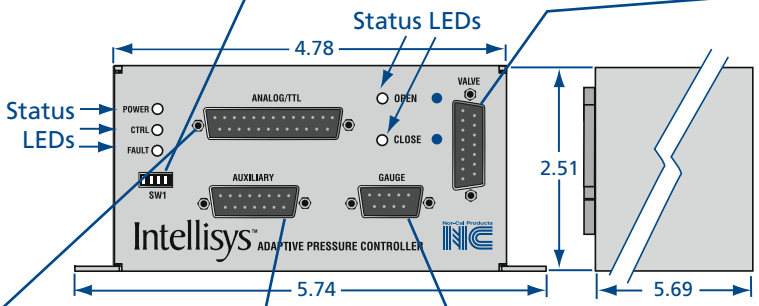


TABLE 3.4.3 - (J1) "APC-X00L-A" VALVE CONNECTOR, DB-15 RECEPTACLE

PIN	SIGNAL ASSIGNMENT
1	Drive A+
2	Drive A-
3	Drive B-
4	Drive B+
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

TABLE 3.4.4 - (J3) "APC-X00L-A" AUXILIARY CONNECTOR, DB-15 RECEPTACLE

PIN	FUNCTION
1	Not used
2	RS-232 TX (data from IQ to host)
3	RS-232 RX (data from host to IQ)
4	Digital GND
5	Power RTN
6	Not used
7	Power +24V in
8	Not used
9	Analog CDG Out
10	Analog Valve Out
11	Analog GND
12	TTL Out Common
13	\Valve Open Out\
14	\Valve Closed Out\
15	Chassis GND

TABLE 3.4.5 - (J2) "APC-X00L-A" GAUGE CONNECTOR, DB-9 RECEPTACLE

PIN	FUNCTION
1	Signal input from gauge 1
2	+15 V supply to gauge
3	-15 V supply to gauge
4	Not used
5	Signal input from gauge 2
6	Signal common from gauge 2
7	Not used
8	Signal common from gauge 1
9	Power supply common

NOTE: *For* **100L-A, 200L-A** *and* **300L-A** *series controllers, pin 14 is defined as \Hold Valve Select In*

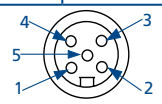
NOTE: *For* **700L-A** *and* **800L-A** *series controllers, pin 14 is defined as \Valve Initialization Enable In*

3.5 - DC Powered Controllers with Serial and DeviceNet I/O Interface

Refer to the following diagrams and tables when connecting to an D/C powered APC controller including models **APC-100L-D**, **APC-200L-D**, **APC-300L-D**, **APC-700L-D** and **APC-800L-D**.

TABLE 3.5.1 – (J1) "APC-X00L-D" DEVICENET NETWORK CONNECTOR

PIN	FUNCTION
1	Drain
2	Power In +
3	Power In -
4	CAN H
5	CAN L



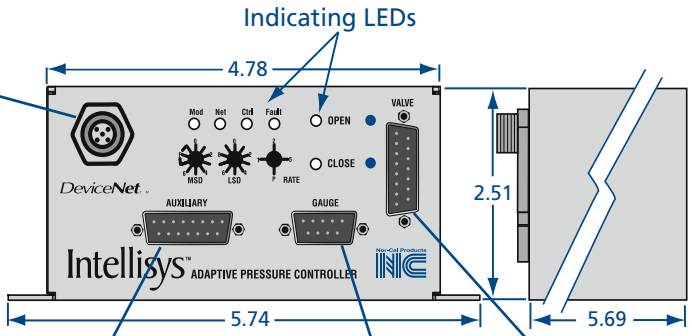


TABLE 3.5.2 – (J2) "APC-X00L-D" AUXILIARY CONNECTOR, DB-15 RECEPTACLE

PIN	FUNCTION
1	Not used
2	RS-232 TX (data from IQ to host)/485 (A)
3	RS-232 RX (data from host to IQ)/485 (B)
4	Digital GND
5	Power RTN
6	Not used
7	Power +24V in
8	Not used
9	Analog CDG Out
10	Analog Valve Out
11	Analog GND
12	TTL Out Common
13	\Valve Open Out\
14	\Valve Closed Out\
15	Chassis GND

TABLE 3.5.3 – (J3) "APC-X00L-D" GAUGE CONNECTOR, DB-9 RECEPTACLE

PIN #	FUNCTION
1	Signal input from gauge 1
2	+15 V supply to gauge
3	-15 V supply to gauge
4	Not used
5	Signal input from gauge 2
6	Signal common from gauge 2
7	Not used
8	Signal common from gauge 1
9	Power supply common

TABLE 3.5.4 - (J4) "APC-X00L-D" VALVE CONNECTOR, DB-15 RECEPTACLE

PIN	SIGNAL ASSIGNMENT
1	Drive A+
2	Drive A-
3	Drive B-
4	Drive B+
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

3.6 – DC Powered IQA Controlled Valve with Serial and Analog/TTL I/O Interface

Refer to the following diagram and tables when connecting to an IQA controller including models **TBV-IQA**, **TSS-IQA** and **TPV-IQA**.

TABLE 3.6.1 – (SW1) "IQA" DIP SWITCHES, DB-25 RECEPTACLE

	SWITCH 1	SWITCH 2	SWITCH 3	SWITCH 4
OFF (up)	9600 baud	8 bit, no parity	1 stop bit	0 to 10 V Analog In
ON (down)	19200 baud	7 bit, even parity (1 stop bit only)	2 stop bits	0 to 5 V Analog In

TABLE 3.6.2 – (J3) "IQA" AUXILIARY CONNECTOR, DB-15 RECEPTACLE

PIN	FUNCTION
1	Not used
2	RS-232 TX (data from IQ to host)
3	RS-232 RX (data from host to IQ)
4	Digital GND
5	Power RTN-
6	Not used
7	Power +24V in
8	Not used
9	Analog CDG Out
10	Analog Valve Out
11	Analog GND
12	TTL Out Common
13	\Valve Open Out\
14	\Valve Closed Out\
15	Chassis GND

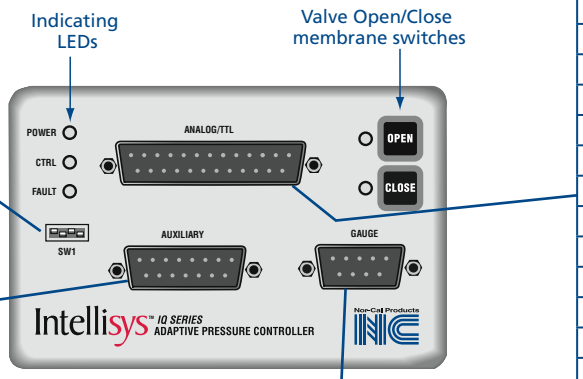


TABLE 3.6.3 – (J2) "IQA" GAUGE CONNECTOR, DB-9 RECEPTACLE

PIN #	FUNCTION
1	Signal input from gauge 1
2	+15 V supply to gauge
3	-15 V supply to gauge
4	Not used
5	Signal input from gauge 2
6	Signal common from gauge 2
7	N/C
8	Signal common from gauge 1
9	Power supply common

TABLE 3.6.4 – (J4) "IQA" ANALOG/TTL CONNECTOR, DB-25 RECEPTACLE

PIN	FUNCTION
1	Chassis GND
2	RS-232TX (data from IQ to host)
3	RS-232RX (data from host to IQ)
4	Analog CDG Out
5	Analog GND
6	Analog Valve Out
7	Digital GND
8	\Analog SP Control Select In\
9	Analog SP+ In
10	Analog SP- In
11	Power RTN
12	Power +24V in
13	\CDG2 Select In\
14	See NOTE below
15	\Position Control Select In\
16	N/C
17	Analog GND
18	\Close Valve In\
19	\Open Valve In\
20	Fault Out
21	N/C
22	\Valve Open Out\
23	\Valve Closed Out\
24	TTL Out Common
25	Chassis GND

NOTE: *When IQA is installed on a TBV valve, pin 14 is defined as \Hold Valve Select In*

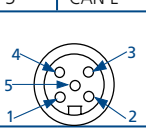
NOTE: *When IQA is installed on a TPV or TSS valve, pin 14 is defined as \Valve Initialization Enable In*

3.7 - DC Powered IQD Controlled Valve with Serial and DeviceNet I/O Interface

Refer to the following diagram and tables when connecting to an IQD controller including models **TBV-IQD**, **TSS-IQD** and **TPV-IQD**.

TABLE 3.7.1 – (J1) "IQD" DEVICENET NETWORK CONNECTOR

PIN	FUNCTION
1	Drain
2	Power In +
3	Power In -
4	CAN H
5	CAN L



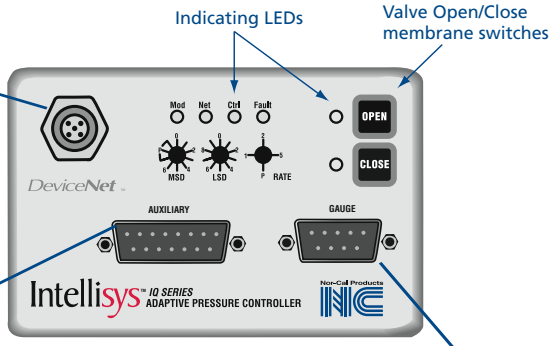


TABLE 3.7.2 – (J2) "IQD" AUXILIARY CONNECTOR, DB-15 RECEPTACLE

PIN	FUNCTION
1	Not used
2	RS-232 TX (data from IQ to host)/485 (A)
3	RS-232 RX (data from host to IQ)/485 (B)
4	Digital GND
5	Power RTN
6	Not used
7	Power +24V in
8	Not used
9	Analog CDG1 Out
10	Analog Valve Out
11	Analog GND
12	TTL Out Common
13	\Valve Open Out\
14	\Valve Closed Out\
15	Chassis GND

TABLE 3.7.3 – (J3) "IQD" GAUGE CONNECTOR, DB-9 RECEPTACLE

PIN #	FUNCTION
1	Signal input from gauge 1
2	+15 V supply to gauge
3	-15 V supply to gauge
4	Not used
5	Signal input from gauge 2
6	Signal common from gauge 2
7	Not used
8	Signal common from gauge 1
9	Power supply common

4.0 - Theory of Operation

All APC controllers are designed for downstream pressure control (see **Fig 4.1** and **4.2**). As such, it is one of four important components in a pressure control system. The other three essential components include a host system computer, a throttle valve and one or two vacuum gauges, such as a Capacitance Diaphragm Gauge (CDG). Most manufacturers' vacuum gauges can be used to provide the vacuum measurement signal, provided they have a voltage output proportional to pressure.

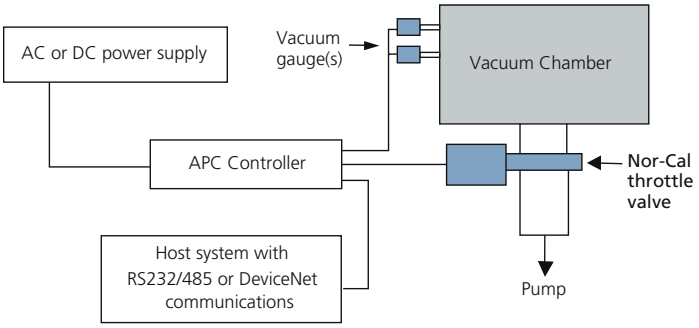


FIGURE 4.1 – TYPICAL INSTALLATION AND CONFIGURATION OF A BURIED BOX INTELLISYS DOWNSTREAM PRESSURE CONTROL SYSTEM

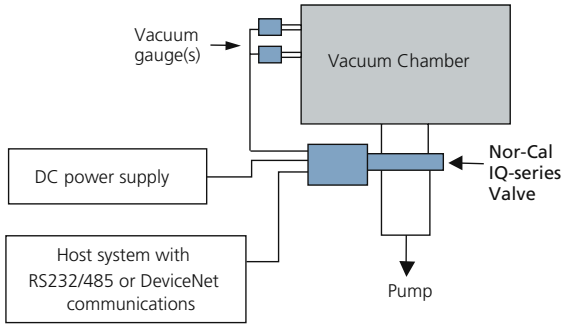


FIGURE 4.2 – TYPICAL INSTALLATION AND CONFIGURATION OF AN IQ PRESSURE CONTROL VALVE

Initialization Sequence

When first powered up, the APC 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 will blink in an alternating fashion. 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* **JC**. *Alternatively, the \Valve Initialization Enable In\ TTL pin can be pulled low to initiate this sequence.*

CAUTION: *Never attempt to initialize a throttle valve with differential pressure across the sealing gate. Make sure the pressure on both sides is equalized. 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 baffling or throttling is necessary.

Pressure control mode, on the other hand, is used whenever control to a specific system 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 set point value can be changed by the host at any time.

Tuning

The APC controller contains an Adaptive Pressure Control Algorithm that has been designed to work over a wide range of flow and pressure combinations. The APC controller therefore does not have a "learn mode" and there is no need for the user to set PID parameters. In some instances, however, vacuum system design may affect the closed loop pressure control time constants. As a result, pressure control performance may at times be affected. If satisfactory pressure control cannot be achieved with the Adaptive Pressure Control Algorithm, please contact Nor-Cal Products' Intellisys Customer Support.

5.0 - APC Controller Module Interfaces

APC 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 – 3.5** 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 APC controller module through the connector labeled GAUGE, or CDG1 and CDG2 depending on the model. In addition, ±15 VDC is available 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.*

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 steps:

1. The full scale range of the two gauges used must be at least one but no more than four decades (factors of ten) apart.
2. Only 1 gauge is active at a time.

Analog and TTL Interface *(not available on all models)*

For complete control and monitoring purposes using a PLC or A/D communications PC cards, several analog I/O signals as well as a host of discrete (TTL) I/O contacts are made available through the connectors labeled ANALOG/TTL or I/O, depending on model. The analog inputs and outputs are referenced to the analog output common, and are factory set as 0 to 10 Volt signals, though a 0 to 5 volt range can be selected via the dip-switch. All analog I/O is calibrated to within 10 mV.

All TTL outputs are active low signals except for the FAULT function, which is active high. TTL inputs are diode protected at –0.4 VDC. Maximum low input voltage is 0.6V and the minimum sink current is 1 mA. The minimum high input voltage is 2.5V, or open. TTL outputs are optically isolated and rated at 25V max and 10 mA. TTL inputs are referenced to the Digital Ground (pin #7), whereas the TTL outputs are referenced to TTL Out Common on pin #24.

On some controller models, certain functions and signals are available on more than one connector. This is to give the user a choice of how to connect the device, and also to offer the capability for in-situ monitoring without disconnecting the main interface cables

Serial interface

An RS-232 serial interface is available on all controller models, through one or more ports. 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 APC), Txd (data to the APC) 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 APC 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 APC-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 APC 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.

Indicating LEDs

There are a host of indicating LEDs on the APC 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 APC 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 APC device enters a fault state. Two LEDs usually are located adjacent to the OPEN and CLOSE switches or labels, and are illuminated whenever the valve position is within 2% of either limit.

Switches

Some controller models have a bank of four or eight dip switches labeled SW1. These are principally used for serial communications settings and selecting 0-5 VDC analog input. A switch in the "up position" (relative to the text) is OFF, and dip switch #1 is always in the left most position. Please refer to the tables in Section 3 for a complete listing of valid dip switch settings.

Primarily intended for operation during installation or troubleshooting, some APCs also feature two momentary switches that can be used to drive the valve fully open or closed. To prevent inadvertent valve operation, these switches cannot be used if the APC valve is in Control Mode (green Ctrl LED on).

6.0 - RS-232 Serial Interface and Commands

Interface basics

All APC controllers support RS-232 serial communications available though one or more interface ports. A full description of the communications protocol and a listing of all active serial commands follows in this section. But first, a three-wire connection needs to be completed to provide the communications lines, with Rxd (data from the APC), Txd (data to the APC) as well as signal common on.

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 on models with DIP switches, and changing the setting requires cycling APC 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 APC-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 APC 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 manitenance function.
L2	Control to and report CDG2 values only	Selects Gauge 2 for manitenance 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**
JC	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 APC 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 + xx.xx, where xx.xx is a number from 0.00 to 100.00
R5	Requests the current pressure	P+xx.xx, where xx.xx is a number from 0.00 to 100.00
R6	Requests the current valve position	V +xx.xx, where xx.xx is a number from 0.00 to 100.00
R38	Requests the software version	APC3-[version #] [version date]
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	Serial nb xxxxxx
RN1	Requests full scale range of CDG1	N1xx.xx, where xx.xx is the full scale range of CDG1
RN2	Requests full scale range of CDG2	N2xx.xx, where xx.xx is the full scale range of CDG2
RESET	Resets the device	Same as cycling power

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

Modifying the Setpoint

The APC 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 APC so that it controls to the correct type. The factory default setting is pressure control.

To assign the set point control type and source, send the following commands:

TØØ
Analog STPT input, position control

TØ1 (T02, T03, T04, T05)
Digital STPT 1 (2, 3, 4, or 5 if present), postion control

T1Ø
Analog STPT input, pressure control

T11 (T12, T13, T14, T15)
Digital STPT 1 (2, 3, 4, or 5 if present), pressure control

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

R25
Analog STPT

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

How to Control Valve Position

One of the two main functions of the APC controller is Valve Position Control. In this mode the APC 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 **T1Ø** 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:
Vxx.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 APC controller is to control system pressure. To accomplish this, the APC 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.

Reading System Pressure

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

The APC 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 a value.

The range of xx.xx is typically from 0.00 to 100.00 and represents the pressure as a percentage of the full scale of the pressure gauge. The value can be less than 0 if the vacuum gauge electronics have drifted or greater than 100 but limited to 101.5%. For example, it 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 APC controller 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 APC 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

The **L1** and **L2** command are 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 APC controller is then used alternatively control pressure in each chamber.

Dual range mode:
LØ 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 APC 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).

How to Configure Pressure Sensor Parameters

When two pressure gauges are used it is necessary to program the APC 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).

TABLE 6.3 – VALUES FOR 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: *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 N100 if CDG 1 is a 100 Torr 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.

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 APC 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 APC 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.

How to Set the PID Gain

NOTE: *The APC controller contains Nor-Cal's Adaptive Pressure Control Algorithm, with which the PID Gain should not be changed by the user. In the event that satisfactory pressure control cannot be achieved with the Adaptive Pressure Control Algorithm, please contact Nor-Cal Products.*

How to Set PID Phase

NOTE: *The APC controller contains Nor-Cal's Adaptive Pressure Control Algorithm, with which the PID Phase should not be changed by the user. In the event that satisfactory pressure control can not be achieved with the Adaptive Pressure Control Algorithm, please contact Nor-Cal Products.*

7.0 - Analog / TTL Interface

This section details the Analog/TTL interface. Each function is listed in alphabetical order for easy identification.

NOTE: *Not every function is available on all controller models – please refer to the connector and pin information in* ***Section 3.***

Analog CDG Out
The signal from the CDG input can be monitored on this pin. It should be referenced to Analog Ground. The Analog CDG output is not a direct pass through of the pressure signal; rather it is a digitized output with a finite resolution of about 5mV with an accuracy of 10mV with respect to the input signal. At crossover from one gauge to the next, this output changes to track the active gauge's signal.

Analog Div 10 Select In
This is an ACTIVE LOW TTL input that should be referenced to the Digital Ground Pin. Pulling this pin low causes the APC to interpret the analog set-point signal as $^{1}/_{10}$ of its actual value. In this state, a 1V differential input would result in control to 1% of full scale.

Analog Ground
Analog Ground should be used as a reference to all analog output signals (**i.e.** CDG1, CDG2, Valve Position). It should NOT be used as the reference for the analog set-point input, nor should it be used for the power common connection. Analog Ground and Digital Ground are directly tied together.

\Analog Set Point Control Select In
Analog Set Point Control Select is an ACTIVE LOW TTL input that should be referenced to Digital Ground. This input must be pulled low whenever analog pressure- or position control mode is desired. This does not, however, disable the RS-232 serial port. In other words, a serial command or inquiry will be acted upon irrespective of the status of this input. If a serial command is issued such that the operating state or condition of the APC controller is changed, then the Analog Set Point Control Select pin must be toggled for a minimum of 200 msec in order to switch the controller back to analog control mode.

Analog Set Point (+)Input
This is the positive terminal of the analog set point differential voltage input. When referenced to the negative terminal (Analog Set Point (-) Input), the differential voltage input should always be in the range from 0V to 10V. The voltage input across these terminals determines the analog set point value to which the APC controller will control, either in pressure or position mode.

Analog Set Point (-)Input
This is the negative terminal of the analog set point differential voltage input. Use this as a reference to Analog Set Point (+)Input.

Analog Valve Out
This signal should be referenced to the Analog Ground. This digitized output signal is normally a 0 to 10 VDC output, where **0** represents a fully closed valve and **10** represents a fully open valve. It has a finite resolution of about 5 mV with an accuracy of 25mV.

Analog Valve Out (0-5 VDC)
This signal should be referenced to the Analog Ground. This digitized output signal is normally a 0 to 5 VDC output, where **0** represents a fully closed valve and **5** represents a fully open valve. It has a finite resolution of about 5mV with an accuracy of 25mV.

\CDG2 Select In
CDG2 Select is an ACTIVE LOW TTL input that should be referenced to the Digital Ground. This input must be pulled low whenever pressure control using CDG2 is desired. If left high, then pressure control will, by default, always be performed using the input from CDG1.

Chassis Ground
This pin is directly connected to the controller chassis as well as to the A/C power Ground pin. Chassis Ground is decoupled from digital ground by a 100kΩ resistor and a 0.1µF capacitor in parallel with two 22µF capacitors in series.

\Close Valve In
This function is an ACTIVE LOW TTL input that should be referenced to Digital Ground. The valve will close when this pin is pulled low. However, the pin must be kept low during the entire valve stroke. If the pin is allowed to go high mid-stroke of the valve, then the valve will stop in that position.

\Control Active Out
This is an ACTIVE LOW TTL output that should be referenced to the TTL Output Common pin. This pin is low only when the APC controller is on Control Mode (same mode as when the Green Ctrl LED is illuminated).

Digital Ground
This pin should be used as the reference to TTL input signals (**i.e.** \Analog SP Control Select\, \CDG2 Select\, \Position Control Select\, etc..) DO NOT use this pin as reference to the TTL output signals.

Fault Status Out
Fault Status Output is an ACTIVE HIGH TTL output that should be referenced to the TTL Output Common pin. If the controller is powered off, or if a FAULT condition is present, then this pin will be high. When the controller is operating normally, this pin will be low.

Hold Valve Select In
This function is an ACTIVE LOW TTL input that should be referenced to Digital Ground. The valve will stop in its present position when this pin is pulled low. This is for butterfly valves.

N/C
This pin is not connected inside the controller.

\Open Valve In
This function is an ACTIVE LOW TTL input that should be referenced to Digital Ground. The valve will open when this pin is pulled low. However, the pin must be kept low during the entire valve stroke. If the pin is allowed to go high mid-stroke of the valve, then the valve will stop in that position.

7.0 - Analog / TTL Interface *(continued)*

\Position Control Select In
Position Control Select is an ACTIVE LOW TTL input that should be referenced to Digital Ground. Pulling this pin low will cause the APC controller to use the analog set-point value as a position command, provided that \Analog Set Point Control Select\ is also pulled low. Leaving it high will by default cause the controller to perform pressure control.

Power + 24V DC in
This is the positive terminal of the device power differential voltage input on DC powered controllers. When referenced to the negative terminal (Power RTN input), the differential voltage input should always be in the range of 24V ± 10%. The voltage input across these terminals provide the operating power for the device.

Power RTN
This is the negative terminal of the device power differential voltage input on DC powered controllers. Use this as a reference to the positive +24V DC power input.

Reserved
This pin is connected inside the controller, but its function is not assigned. Do not connect any external device or signal to this pin as APC damage may result.

RS232 RX
Used for data transmitted from the host to the APC controller, whenever RS-232 communications are used.

RS232 TX
Connect to this pin for data transmitted from the APC controller to the host computer, whenever RS-232 communications are used.

RS 485 (A) and RS 485 (B)
Used to transmit and receive RS485 data - half-duplex, multi-drop compatible.

TTL Output Common
This pin should be used as a reference to all TTL outputs (**i.e.** Fault, Valve Open and Valve Closed).

\Valve Closed Out
Valve Closed Output is an ACTIVE LOW TTL output that should be referenced to TTL Output Common pin. This pin will be low only when the valve is closed.

\Valve Initialization Enable In
This function is an ACTIVE LOW TTL input that should be referenced to Digital Ground. Used exclusively for sealing throttling valves (i.e. not for butterfly valves), it issues the "clear to initialize" command needed to cause the controller to exit out of the safe mode it enters upon power-up. Also required to remain low for normal TTL valve operation.

\Valve Open Out
Valve Open Output is an ACTIVE LOW TTL output that should be referenced to TTL Output Common pin. This pin will be low only when the valve is open.

\Zero Gauge Select In
This function is an ACTIVE LOW TTL input that should be referenced to Digital Ground. Pulling this pin low will "zero" the CDG output in software. This function can only be activated if the actual CDG signal is less than 500mV. If two gauges are used, then this function acts on both gauges.

7.0 - Analog / TTL Interface *(continued)*

User Examples

Below are examples of the most common modes of operation. Please contact Nor-Cal Products technical support for other types of uses.

Pressure Control

The following conditions must be true in order for the APC controller to perform pressure control.

1. The signal from a pressure gauge having a voltage output 0 to 10VDC must be connected to the connector labeled GAUGE.
2. There must be gas flow in to the chamber volume where pressure control is required.
3. An analog set-point signal in the 0 to 10 VDC must be applied across the analog set point input pins. The analog set-point signal is directly proportional to the pressure to which the APC will control – **i.e.** An ASP of 5 VDC will result in pressure control at a gauge output of 5VDC.
4. The **\Analog SP Control Select In** pin must be pulled low. Doing this will initiate pressure control.

Valve Position Control

Valve position (angle) control can be effected b y doing the following:

1. An analog set-point signal in the 0 to 10 VDC must be applied across the analog set point input pins. The analog setpoint signal is directly proportional to the target valve position, where 0 VDC is fully closed and 10 VDC is fully open.
2. The **\Position Control Select In** pin must be pulled low to ensure that the APC is in position control mode.
3. The **\Analog SP Control Select In** pin must be pulled low. Doing this will initiate position control.

Open Valve

There are two ways to command the valve fully open:

1. Analog valve position control can be used, as described immediately above, where an analog set-point value of 10 VDC is used.

OR

2. The **\Open Valve In** pin can be pulled low. Doing this at any time will cause the valve to open, even if it is in the middle of performing pressure control.

Close Valve

There are also two ways to command the valve fully closed:

1. Analog valve position control can be used, as described immediately above, where an analog set-point value of 0 VDC is used.

OR

2. The **\Close Valve In** pin can be pulled low. Doing this at any time will cause the valve to close, even if it is in the middle of performing pressure control.

Dual Gauge Operation

For applications where there is a wide range of control pressures, the use of two differently ranged gauges may be advantageous. All APCs support this functionality, with the exception that some controller models cannot power both gauges if they are both heated. Please refer to the ±15 VDC output specifications for your particular model. The following steps must be taken in order to perform dual gauge operation successfully:

1. The signals from two gauges of different full scale range, both with 0 to 10 VDC output, must be connected to the appropriate GAUGE connector(s).
2. The gauges' full scale must be set. See N1 and N2 serial command.
3. Then follow the instructions above for Pressure Control. The controller will use the signal from CDG1 as a default. If the use of CDG2 is desired for pressure control, then the **\CDG2 Select In** pin must be pulled low. The analog set point signal will be proportional to CDG2.

NOTE: *For normal operation of - 7x0 and 8x0 series APC/IQ controllers, the \Value Intialization Enable In\ pin must be pulled low.*

8.0 - DeviceNet Interface

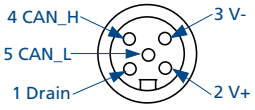
8.1. Overview and setup

DeviceNet is a network communication protocol that provides a cost-effective solution to low-level device networking for semiconductor equipment tools with power and signal in the same cable. 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 Process Control Valve (PCV) device profile. This device profile is available in the Volume II, Release 2.0, Errata 5 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 8.1**.

FIGURE 8.1 - IQD DEVICENET CONNECTOR PIN ASSIGNMENT

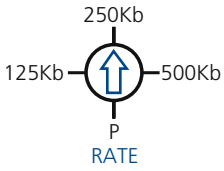


The controller unit requires a 24 VDC +/- 10% power source, which is typically provided through the auxiliary port - however, the controller can be configured to accept power via the DeviceNet connector. Please consult the factory for information on this option.

Baud Rate Selection:

The baud rate selector as shown in **Figure 8.2** is a 4 position rotary switch used to select the desired baud rate of the controller, respectively 125Kb, 250Kb, 500Kb and software programmable. The software programmable baud rate is kept in non-volatile memory and settable through the DeviceNet object.

FIGURE 8.2 - DEVICENET BAUD RATE SELECTION SWITCH



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 network master and should not be used by any slave 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.

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.

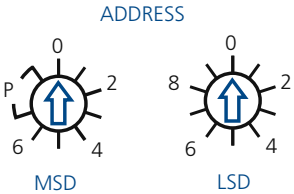


FIGURE 8.3 - DEVICENET ADDRESS SWITCHES

Module Status: A bicolor (red/green) Module status LED indicates the status of the communication module according to the logic in **Table 8.1**.

TABLE 8.1 - DEVICENET MODULE LED STATUS

LED	STATUS
Green	Module OK
Red	Fault condition
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 8.2.**

TABLE 8.2 - DEVICENET NETWORK LED STATUS

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

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 offline:

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 device online:

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 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.

Required Hardware:

A DeviceNet network is composed of a host controller, a bus and one or more slave devices. 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 8.4**.

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.

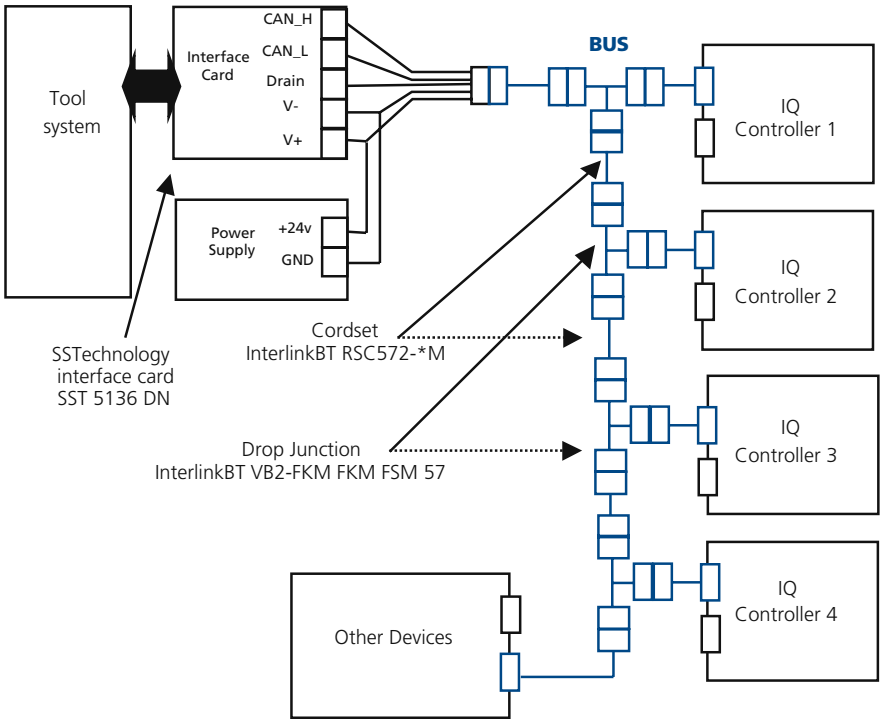
IQD controller devices can be plugged in and removed from the network live, however, if an inappropriate baud rate setting is selected it will bring the IQD controller to a network fault and possibly bring other installed devices on the bus to a fault. Upon connection the IQD controller will transmit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

Power Supply System and Typical Configuration:

The internal power converter of the IQD pressure controller is designed to provide power to its internal electronics, valve motor and up to two CDG gauges. Accordingly, the input power requirement is largely dependent on the type of valve and gauges attached to the controller. Additionally, while average power consumption is fairly low, the power supplied to the device has to be able to handle peak power requirements particularly as the valve motor performs accelerations. Insufficient power input will be detected by the IQD controller and will result in a fault during the initialization phase.

To be able to obtain optimal pressure control performance 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

FIGURE 8.4 - TYPICAL DEVICENET HARDWARE INSTALLATION



8.2 - Establishing a DeviceNet connection

This section describes how to communicate and control the IQD 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 8.3 - DEVICENET EXPLICIT MESSAGING

CLASS ID	INSTANCE ID	ATTRIBUTE ID	ACTION	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 (CDG1)
31	2	6	0E (get)	Process input (CDG2)
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

As a reminder, note that 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 12345678hex 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 264hex or 612dec, 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, **3A B1 02 00** meaning 2B13Ahex or 176442dec, which is the serial number of the device. (Nor-Cal device serial numbers are composed of 6 digits)

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 **5** (destination index) followed by the data **02**. This puts the destination index to the value **2** having for effect to select valve 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 **9** (source data value) followed by the setpoint **00 40**
- The device will move the valve to 50% of it's stroke(45° angle)
- Select attribute ID **9** (source data value) followed by the setpoint **00 00** The device will move the valve to 0% of its the stroke or closed

How to read the valve limit switch

- Select the service code **0E** (get attribute)
- Select class ID **8** (select the selection object)
- Select instance ID **1** (closed limit switch)
- Select attribute ID **3**
- The device will respond with data bytes **01** meaning that the closed 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

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 CDG1)
- 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 full open

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 IQD controller handles input assemblies and output assemblies in a poll connection. In an I/O poll connection the master periodically sends an output assembly and the slave responds with an input assembly. The IQD Controller supports one output assembly and 3 input assemblies format.

TABLE 8.4
OUTPUT ASSEMBLY FORMATS

INSTANCE$_{HEX}$	VARIABLES
7 (default)	Control setpoint Control instance

TABLE 8.5
INPUT ASSEMBLY FORMATS

INSTANCE$_{HEX}$	VARIABLES
2	Exception status Process variable
4	Exception status Process variable Control setpoint
5 (default)	Exception status Process variable Control setpoint Valve position

Example of I/O messaging transactions:

The following is an example format of a typical poll connection:

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

BYTE	DESCRIPTION	DATA RANGE
1	**setpoint (low byte)**	0 to 7FFFhex
2	**setpoint (high byte)**	
3	**setpoint destination**	01 pressure control high gauge 02 valve position control 03 pressure control low gauge

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

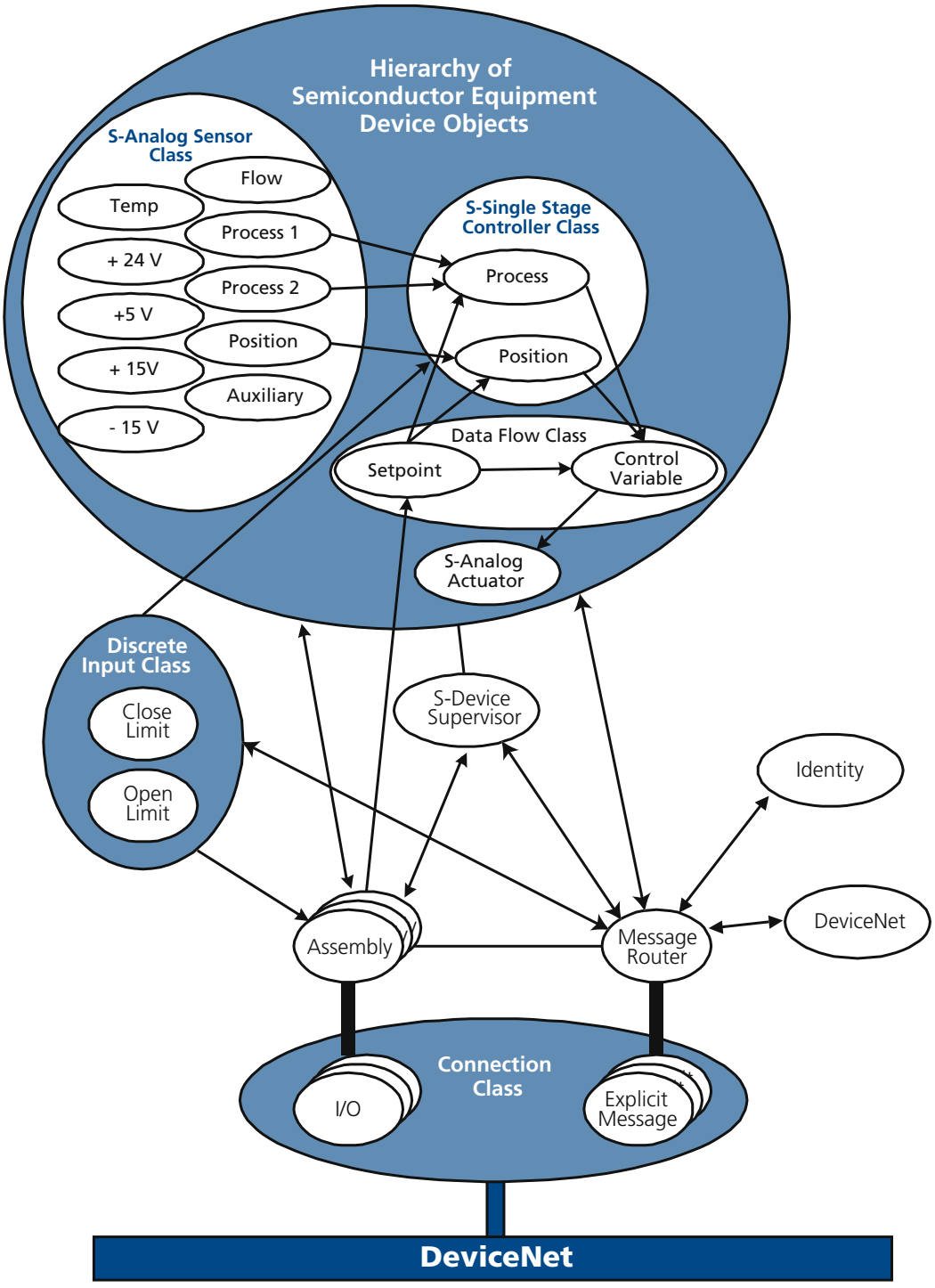
In valve position control mode, 7FFFhex represents full open stroke. Respectively, 0000hex setpoint corresponds to closing the valve and 7FFFhex corresponds to a full open the valve.

The controller response is formatted accordingly:

BYTE	DESCRIPTION	DATA RANGE
1	**exception status**	
2	**pressure (low byte)**	0 to 6000hex
3	**pressure (high byte)**	
4	**setpoint (low byte)**	0 to 7FFFhex
5	**setpoint (high byte)**	
6	**valve position (low byte)**	0 to 7FFFhex
7	**valve position (high byte)**	

9.0 - DeviceNet Device Profile

Figure 9.1 - Object Model for the Process Control Valve Device



9.1 - Identity Object

Class ID **1** hex
Instance ID **1**

- **Vendor ID:** Assigned number to Nor-Cal Products Inc. is 612
- **Device type:** The value of $1D_{hex}$ is used for process control valve (cf. specification volume II, page 3-153)
- **Product code:** Nor-Cal Products attributes a specific product code as a function of the valve size or type, Listed to the right in **Table 9.12** is the list of current product codes:

TABLE 9.1.1 – IDENTITY OBJECT ATTRIBUTES

ATTRIBUTE ID HEX	ACCESS CODE	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 (NVRAM)
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 = power cycle reset (default reset) 1 = out of box reset (NVRAM reset + power cycle)		

TABLE 9.1.2 – NOR-CAL PRODUCT TYPES

PORT ID	NOR-CAL VALVE TYPE	PRODUCT CODE
1"	Throttling Butterfly Valve (TBV1)	1
2"	Throttling Butterfly Valve (TBV2)	2
3"	Throttling Butterfly Valve (TBV3)	3
4"	Throttling Butterfly Valve (TBV4)	4
6"	Throttling Butterfly Valve (TBV6)	5
8"	Throttling Butterfly Valve (TBV8)	6
1"	Throttling Poppet Valve (TPV1)	41
2"	Throttling Poppet Valve (TPV2)	42
6"	Throttling Pendulum Valve (VTX6)	47
8"	Throttling Pendulum Valve (VTX8)	48
10"	Throttling Pendulum Valve (VTX10)	4A
12"	Throttling Pendulum Valve (VTX12)	4C
14"	Throttling Pendulum Valve (VTX14)	4E
6"	Throttling Butterfly Valve geared (TBV6G15)	C6
8"	Throttling Butterfly Valve geared (TBV8G15)	C8
*	Other special configuration valve	99

9.2 - Message Router Object

Class ID **2** hex
Instance ID **1**
No class attribute supported

9.3 - DeviceNet Object

Class ID **3** hex
Instance ID **1**

TABLE 9.3.1 – DEVICENET OBJECT ATTRIBUTES

ATTRIBUTE ID HEX	ACCESS CODE	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
None	4B	Allocate master/slave connection		
None	4C	Release master/slave connection		

- The values of attribute 1 and 2 are retrieved from NVRAM if the front panel switches are on 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, the device will then reset. Provided that the front panel switches are in program mode, the device will come back up with the new MACID and/or Baud rate value with all connection instances non-existent.
- The value of attribute 2 is decoded as follow: 0=125Kb, 1=250Kb, 2=500Kb

9.4 - Assembly Object

Class ID **4**$_{hex}$
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 9.4.1 – ASSEMBLY OBJECT ATTRIBUTES

ATTRIBUTE ID$_{HEX}$	ACCESS CODE	NAME	FORMAT	VALUE
3	0E (get) 10 (set)	Data	ARRAY	Static assembly

9.5 - I/O Assembly Instances

TABLE 9.5.1 - INPUT ASSEMBLY INSTANCES

INSTANCE$_{HEX}$	BYTE	VARIABLES	EPATH (HEX)
2	0 1-2	Exception status Process variable	20 04 24 02 30 03
4	0 1-2 3-4	Exception status Process variable Control setpoint	20 04 24 04 30 03
5 (factory setting)	0 1-2 3-4 5-6	Exception status Process variable Control setpoint Valve position	20 04 24 05 30 03

TABLE 9.5.2 - OUTPUT ASSEMBLY INSTANCES

INSTANCE$_{HEX}$	BYTE	VARIABLES	EPATH (HEX)
7 (factory setting)	0-1 2	Control setpoint Control instance	20 04 24 07 30 03

The control instance: indicates the significance of the control setpoint,
1 = pressure control high guage
2 = position control.
3 = pressure control low gauge

9.6 - Connection Object

Class ID **5**$_{hex}$

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

- Attribute E &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,
  1 = auto delete.
- Attribute 7 and 8: report 12 for explicit connection or the actual static assembly length in IO.

TABLE 9.6.1 – CONNECTION OBJECT ATTRIBUTES

ATTRIBUTE ID$_{HEX}$	ACCESS CODE	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
C	0E (get)	Watchdog time out action	UINT	1 for EC, 0 for IO
D	0E (get)	Produced connection length	UINT	0 in EC, 6 in IO
E	0E (get) 10 (set)	Produced connection path	EPATH	IO input assembly path
F	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

9.7 - Discrete Input Point Object

Class ID **8**$_{hex}$

Instance ID **1**

1 = closed
0 = not closed

Instance ID **2**

1 = open
0 = not open

TABLE 9.7.1 – DISCRETE INPUT POINT OBJECT ATTRIBUTE; INSTANCE ID 1

ATTRIBUTE ID$_{HEX}$	ACCESS CODE	NAME	FORMAT	VALUE
3	0E (get)	Close limit switch	BOOL	0-1 mirror close LED

TABLE 9.7.2 - DISCRETE INPUT POINT OBJECT ATTRIBUTE; INSTANCE ID 2

ATTRIBUTEID$_{HEX}$	ACCESS CODE	NAME	FORMAT	VALUE
3	0E (get)	Open limit switch	BOOL	0-1 mirror open LED

9.8 - S - Device Supervisor Object

Class ID **30** hex

Instance ID **1**

TABLE 9.8.1 – S-DEVICE SUPERVISOR OBJECT ATTRIBUTES

ATTRIBUTE ID HEX	ACCESS CODE	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)
B	0E (get)	Device status	USINT	See table 9.8.3
C	0E (get)	Exception status	BYTE	See table 9.8.2
None	06 (start)	Move the device to executing state		

TABLE 9.8.2 – 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*

FIGURE 9.2 - OBJECT STATE TRANSITION DIAGRAM

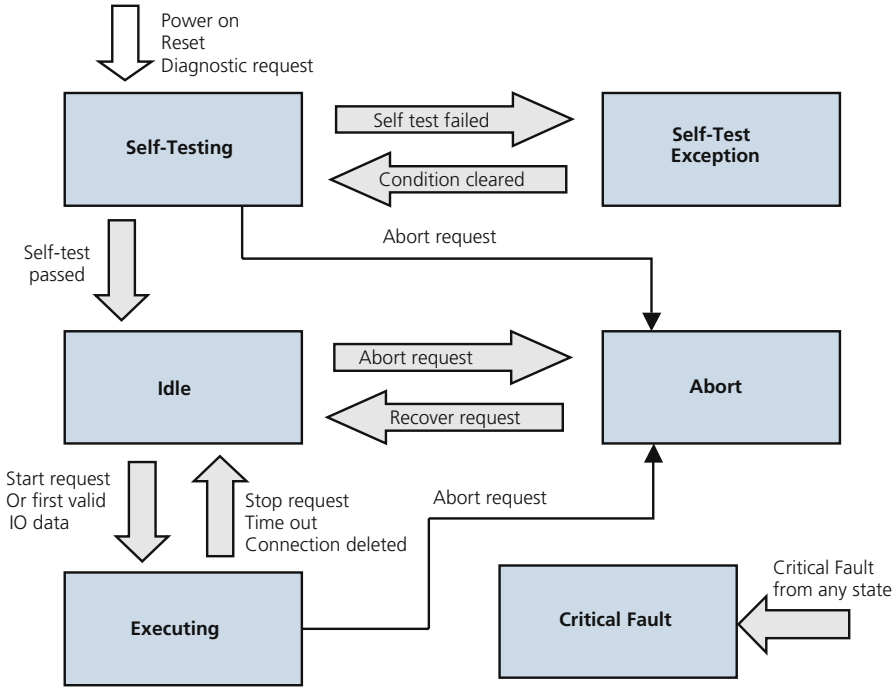


TABLE 9.8.3 - DEVICE STATUS ATTRIBUTE VALUE

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 executing state. Pendulum valves will rest at idle state until explicitly transitioned to executing state for safety purposes. (Access code 06 (Start))*

9.9 - S-Analog Sensor Object

Class ID **31**$_{hex}$

- 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 the bracket [–1.5% to 101.5%].

- 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 9.9.1 – S-ANALOG SENSOR INSTANCES

INSTANCE HEX	ACCESS CODE	NAME	FORMAT	VALUE
1	0E (get)	Process input (CDG1)	UINT	Pressure signal 0 to 100%
2	0E (get)	Process input (CDG2)	UINT	Pressure signal 0 to 100%
3	0E (get)	Valve position	UINT	(0% = close 100%=open)
5	0E (get)	Temperature Sensor	UINT	Temperature
6	0E (get)	24v power input	UINT	Input power voltage
7	0E (get)	Auxiliary input	UINT	Battery voltage
8	0E (get)	Logic 5v	UINT	5v internal feedback
9	0E (get)	Device +15v	UINT	+15v internal feedback
A	0E (get)	Device –15v	UINT	-15v internal feedback

TABLE 9.9.2 – S-ANALOG SENSOR OBJECT ATTRIBUTES

ATTRIBUTE ID HEX	ACCESS CODE	NAME	FORMAT	VALUE
6	0E (get)	Value	INT	Analog output value

9.10 - S-Analog Actuator Object

***Class ID* 32 hex**

***Instance ID* 1**

TABLE 9.10.1 – S-ANALOG ACTUATOR OBJECT ATTRIBUTES

ATTRIBUTE ID HEX	ACCESS CODE	NAME	FORMAT	VALUE
5	10 (set)	Override	UINT	Override for the valve 0 = closed; 7FFFh=open
6	0E (get)	Value	INT	Analog output value
7	0E (get)	Status	BYTE	Alarm & Warning, Default = 0

TABLE 9.10.2 –S-ANALOG ACTUATOR EXCEPTION STATUS BITMAP

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

9.11 - S-Single Stage Controller Object

***Class ID* 33 hex**

Instance ID* 1 *(process control)

PID and source select subclass 01 is used.

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

- *Changes to these attribute through the DeviceNet port is volatile (non recorded in NVRAM)*
- *Control optimization is done in real time and there is no learning calibration sequence*

TABLE 9.11.1 – S-SINGLE STAGE CONTROLLER OBJECT ATTRIBUTES

ATTRIBUTE ID HEX	ACCESS CODE	NAME	FORMAT	VALUE
06	10 (set)	Setpoint	UINT	0 to 7FFFh for 0 to 100%
0A	0E (get)	Status	BYTE	Alarm & Warning, Default = 0
63	0E (get)	Subclass	UINT	1 for PID and source select
5C	0E (get) 10 (set)	phase	UINT	Control Phase
5E	0E (get) 10 (set)	Gain	UINT	Proportional Gain
60	0E (get) 10 (set)	Process variable source	BYTE	0 network 1 if acquisition is from CDG1 2 if acquisition is from CDG2 3 automatic

Instance ID* 2 *(position control)

NOTE: *There is no subclass for instance 2*

TABLE 9.11.2 – S-SINGLE STAGE CONTROLLER OBJECT SUBCLASS ATTRIBUTES

ATTRIBUTE ID HEX	ACCESS CODE	NAME	FORMAT	VALUE
06	10 (set)	Setpoint	UINT	0 to 7FFFh for close to open
0A	0E (get)	Status	BYTE	Alarm & Warning, Default = 0

9.12 - Selection Object

***Class ID* 2E** hex

Instance ID* 1 *(setpoint)

- Attribute 5 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 5 only becomes effective once a new setpoint is sent (attribute 9)
- When in pressure control (destinationindex =1) writing a new setpoint is immediately tasking the controller to regulate to the designated pressure
- When in position control (destination index=2) writing a new setpoint will directly affect the valve position

TABLE 9.12.1 – SELECTION OBJECT ATTRIBUTES; INSTANCE 1

ATTRIBUTE ID HEX	ACCESS CODE	NAME	FORMAT	VALUE
1	0E (get)	Source index	USINT	0
2	0E (get)	Number of sources	USINT	0
3	0E (get)	Source path length	UINT	0
4	0E (get)	Source list	EPATH	0 (USINT)
5	0E (get) 10 (set)	Destination index	USINT	01 or 02 default to 1 after reset
6	0E (get)	Number of destinations	USINT	02
7	0E (get)	Destination path length	UINT	00 06
8	0E (get)	Destination list	EPATH	20/33/24/01/30/06 controller, process variable, SP 20/33/24/02/30/06 controller, valve position, SP
9	0E (get) 10 (set)	Source data value	Data type	0% = 0000h, 100%=7FFFh
B	0E (get)	Status	USINT	00

Instance ID* 2 *(control signal)

NOTE: *This object is static. The only changing variable is the value of attribute 4 that is linked to instance 1 attribute 5.*

TABLE 9.12.2 – SELECTION OBJECT ATTRIBUTES; INSTANCE 2

ATTRIBUTE ID HEX	ACCESS CODE	NAME	FORMAT	VALUE
1	0E (get)	Source index	USINT	Value of instance 1 attribute 5
2	0E (get)	Number of sources	USINT	02
3	0E (get)	Source path length	UINT	00 06
4	0E (get)	Source list	EPATH	20/33/24/01/30/09 controller, process variable, CV 20/33/24/02/30/09 controller, valve position, CV
5	0E (get)	Destination index	USINT	01
6	0E (get)	Number of destinations	USINT	01
7	0E (get)	Destination path length	UINT	00 06
8	0E (get)	Destination list	EPATH	20/32/24/01/30/06 analog act, value
9	0E (get)	Source data value	Data type	Control variable (TBD)
A	0E (get)	Destination data value	Data type	Control variable (TBD)
B	0E (get)	Status	USINT	00

10.0 - LCD Front Panel Interface

Controller models with a part number in the form APC-x50-A have a touch screen LCD front panel interface, in addition to a Serial and Analog/TTL port. On these models, the functionality of the Serial and Analog/TTL interfaces is identical to that previously described in sections 6.0 and 7.0 of the APC-OP Manual. This section is dedicated to describing the use and operation of the front panel touch screen.

The front panel touch screen interface has been designed with ease of use in mind. Every function is accessible with only a few keystrokes, and most pages are menu based. A top-level schematic of the interface is shown in Figure 10.1 below.

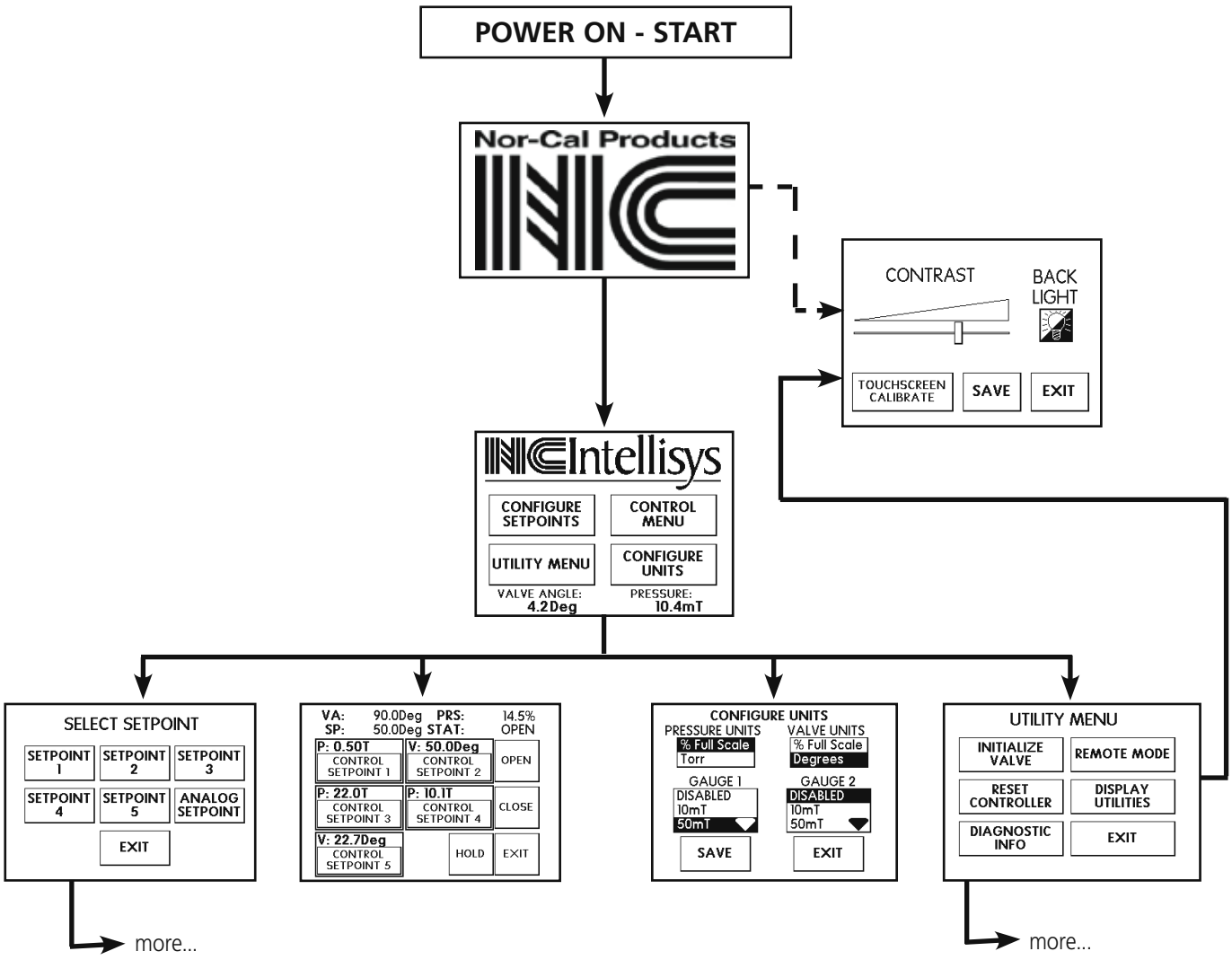


Figure 10.1 – Top Level Front Panel Screen Menu Tree

10.1 Commonly Used Function Buttons

Navigating through the various menus of the front panel LCD interface, the user will find that some functions and associated buttons are used in more than one place. This includes the **SAVE, SET VALUE, BACK SPACE, CLEAR, BACK** and **EXIT** functions.

The **SAVE** function is generally found on set-up type screens. This button must be pressed before exiting to another page allowing the set-up information to be stored in NVRAM. Exiting without pressing **SAVE** will result in the old information being used.

The **SET VALUE** function is used on pages where numerical information is entered. Similar to the **SAVE** function, the **SET VALUE** button has to be pressed in order for the new number to be stored in NVRAM.

The **BACK SPACE** button is also found on pages where numerical information is entered. Pressing the **BACK SPACE** button simply erases the last digit entered. For example, if the numbers 1 2 3 were entered and then the **BACK SPACE** button was pressed, then the numbers 1 2 remain on the command line.

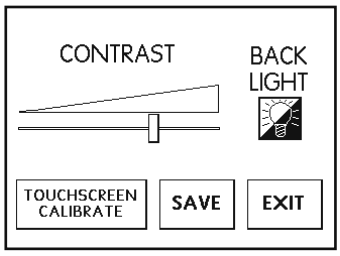
On a parallel path, the **CLEAR** function will erase the entire numerical entry on the screen. So, if the numbers 1 2 3 were entered followed by the **CLEAR** button being pressed, then no numbers would be left on the command line.

The **BACK** button is used to go back to the previous screen.

The **EXIT** button is used to go all the way back to the **MAIN MENU** screen.

10.2 Basic Operation

Once the APC is first powered on the **NOR-CAL LOGO** page will come on for approximately three seconds. At the same time, the valve initialization routine will commence if the controller is connected to a butterfly valve. Controllers that are connected to a gate- or pendulum valve will remain in a "safe mode" which effectively delays the valve initialization until the operator gives a "clear to proceed" command. If the **NOR-CAL LOGO** screen is touched during the first three seconds, an **LCD SET-UP** page will appear.



The **LCD SET-UP** page allows the user to:

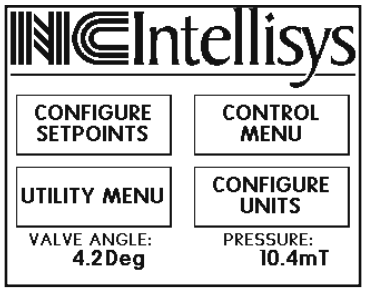
a) change the screen contrast by sliding the CONTRAST bar left or right. Be careful not to set too little or too much contrast, as screen legibility may be compromised to the point where no information can be seen.

b) turn on or off the BACK LIGHT.

c) perform an LCD screen X-Y calibration, as needed. This function essentially correlates the position of graphics information to physical position on the touch screen matrix. A calibration is done on each front panel display by Nor-Cal Products before shipment, and recalibration by the customer may seldom or never be required. If you must perform a calibration, please make sure you use a PDA - type stylus, not a pen, pencil, or other sharp object.

Once all LCD screen settings are adjusted appropriately, press SAVE to store the information in memory followed by EXIT to return to the **MAIN MENU** page.

10.2 Basic Operation *(continued)*



The **MAIN MENU** page simply serves as a central node used in navigation to the various sub menu pages. From this screen, the user can access sub-menus that are used:

a) to configure set-point parameters such as value, type and certain tuning parameters

b) to perform utility functions such as valve initialization, controller reset and LCD set-up

c) to configure engineering units for pressure and valve position, and

d) in the active control mode of the controller and valve system

The **MAIN MENU** also displays real time values for both pressure and valve position, and is therefore intended to be the page that is displayed whenever the controller is in normal operation mode.

10.3 CONFIGURE SETPOINTS

CONFIGURE SETPOINTS is the first sub-menu directly accessible from the **MAIN MENU** screen. Figure 10.2 shows a navigation tree detailing this part of the function software.

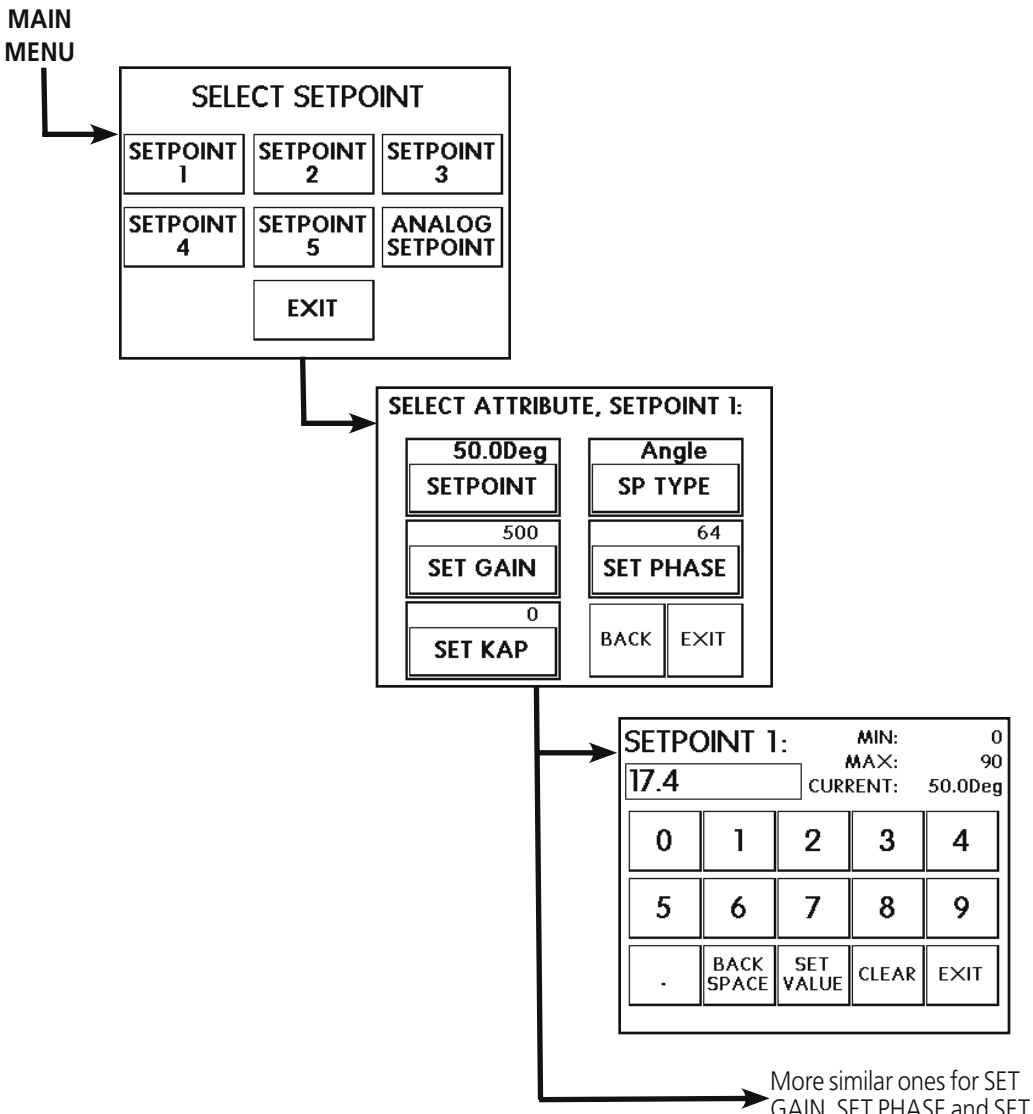
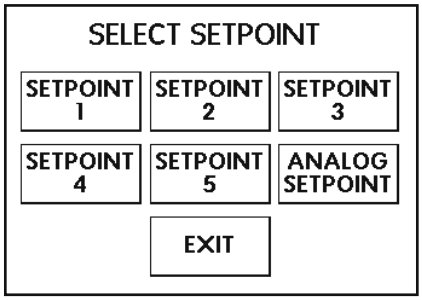
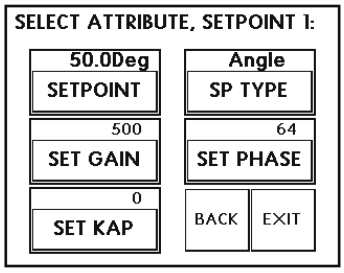


Figure 10.2 – CONFIGURE SETPOINTS Navigation Tree



The **SELECT SETPOINT** page allows the user to choose which set-point is to have its parameters manipulated. All parameters of setpoints 1 to 5 can be set from this screen. However, only the "tuning parameters" such as **GAIN, PHASE** and **KAP** can be set for the **ANALOG SETPOINT**. The latter's value and type are determined by what input is provided on the Analog/TTL port.

10.3 CONFIGURE SETPOINTS *(continued)*

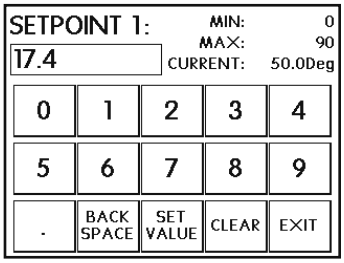


The **SELECT ATTRIBUTE** page for each setpoint allows the user to pick which attribute(s) to program. Pressing **SETPOINT** will bring up a number pad screen via which a numerical value can be given to the setpoint.

Pressing the **SP TYPE** button repeatedly causes the setpoint type to toggle between "valve" and "pressure" – in other words choosing a "valve" type here means that the setpoint, when activated, will drive the valve to a prescribed position as opposed to controlling to a particular pressure.

SET GAIN, SET PHASE and **SET KAP** are also functions that will bring up a number pad by which the value can be changed. However, the user is advised that these parameters do not normally need to be adjusted beyond the factory settings, because the controller contains an advanced adaptive pressure control algorithm that will work well under most conditions.

In all cases are the current values for **SETPOINT**, etc. displayed above each button. Pressing **BACK** or **EXIT** from the **SELECT ATTRIBUTE** page automatically stores the **SP TYPE** entry in NVRAM.



The number pad, in this case shown for the "setpoint 1" value entry provides the necessary interface to key in the desired numerical entry. Be sure to pay attention to the MIN and MAX values, as these limits provide the lower and upper range for the value in question. Pressing SET VALUE at the end saves the information to NVRAM. Pressing EXIT without pressing SET VALUE will return the user to the MAIN MENU without saving the entered information.

10.4 UTILITY MENU

The UTILITY MENU is another sub-menu directly accessible from the MAIN MENU screen. Figure 10.3 shows a navigation tree detailing this part of the function software.

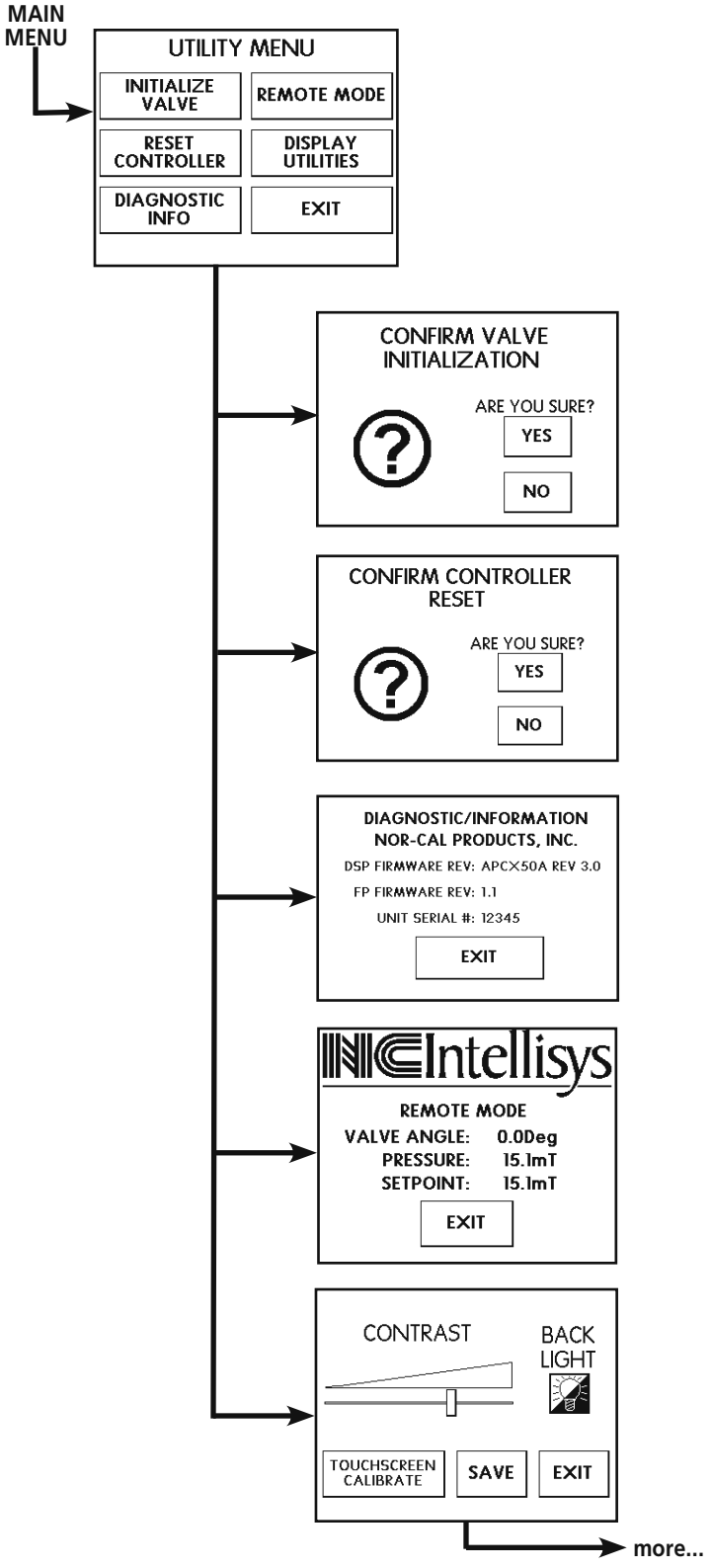
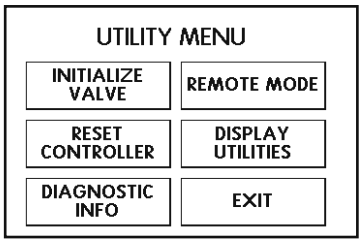
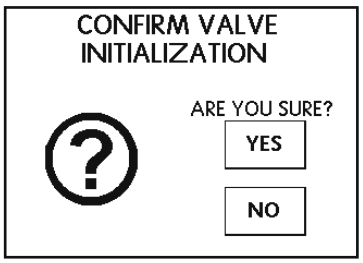


Figure 10.3 – UTILITY MENU Navigation Tree

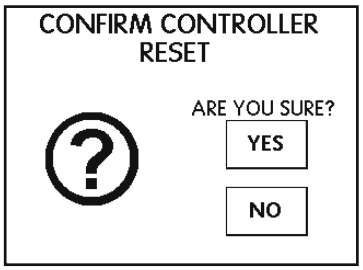
10.4 UTILITY MENU *(continued)*



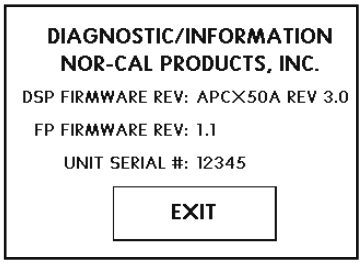
The **UTILITY MENU** page simply serves as the means to reach the five functions contained under this category, including **INITIALIZE VALVE, RESET CONTROLLER, DIAGNOSTIC INFORMATION, REMOTE MODE** and **DISPLAY UTILITIES.**



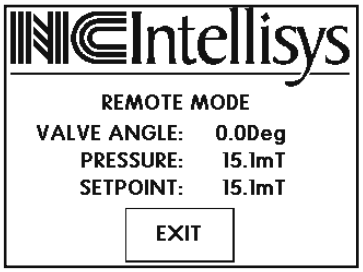
Pressing the **INITIALIZE VALVE** button on the **UTILITY MENU** page brings up the **CONFIRM VALVE INITIALIZATION** dialogue screen. By pressing **YES** here, the controller will initialize the valve, which means all other functions will cease to respond until initialization is complete. This is one of the ways a gate- or pendulum valve controller can be given the "clear to proceed" command after first being powered up. The first time that the controller initializes a gate- or pendulum valve, it will go through a full extensive routine lasting for about one minute. All subsequent times, a shorter initialization routine will be used. If a gate- or pendulum valve controller is used to control a different valve than it was first used to initialize, it is imperative that the controller be reset (see below) before initializing and operating. For butterfly valve controllers, the same initialization routine will be used at all times. Pressing **NO** on the **CONFIRM VALVE INITIALIZATION** screen will return the user to the **UTILITY MENU** page.



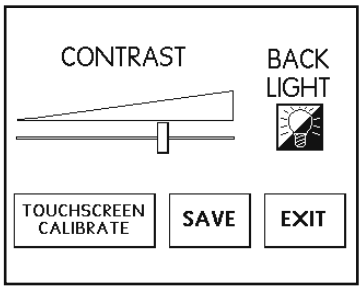
Pressing the **RESET CONTROLLER** button on the **UTILITY MENU** will bring up the **CONFIRM CONTROLLER RESET** dialogue screen. By pressing **YES** here, the controller will momentarily turn off power to the processor and clear all motor initialization data stored in NVRAM (other data in NVRAM such as set-point information will be retained). Once the processor comes back on line, the controller will initialize the valve if it is a butterfly type. If the valve is a gate- or pendulum type, the controller will stay in "safe mode" awaiting a "clear to proceed" command from the operator. Pressing **NO** on the **CONFIRM CONTROLLER RESET** screen will return the user to the **UTILITY MENU** page.



Pressing the **DIAGNOSTIC INFO** button on the **UTILITY MENU** makes certain controller information available. This screen will list firmware revision levels as well as the serial number of the finished product as it was produced by Nor-Cal Products. This information can be useful in diagnosing problems if/when they occur. **EXIT** will return the user to the **MAIN MENU** page.

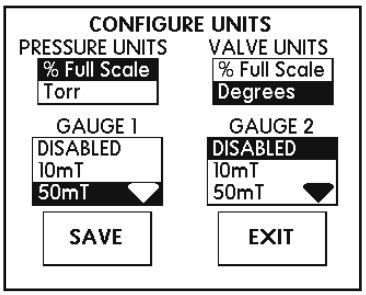


The **REMOTE MODE** button on the **UTILITY MENU** page currently only serves as a display screen for valve, pressure and setpoint information. It does NOT provide any lock-out or other safety features. With or without the **REMOTE MODE** screen displayed, the controller can be commanded via any of its three user interfaces using "whoever talks last" priority. Pressing **EXIT** will return the user to the **MAIN MENU** page.

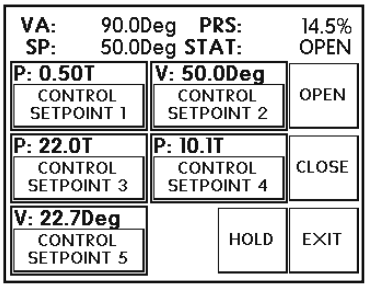


Pushing **DISPLAY UTILITIES** on the **UTILITY MENU** brings up the **LCD SET-UP** page. Please refer back to Section 10.2 for details about the functionality of this page.

10.5 CONFIGURE DISPLAY UNITS



The ability to **CONFIGURE DISPLAY UNITS** is directly accessible form the **MAIN MENU**. This screen allows the user to change engineering units for both pressure and valve position. Also, this page is used to set the full scale range of each gauge used. Please make sure to press the **SAVE** button prior to exiting back to the **MAIN MENU**.



The **CONTROL MENU** page, also directly accessible from the **MAIN MENU**, is the primary screen intended for manual operation. From this page, the push of a single button will cause the controller-and-valve system to act on either one of five preprogrammed (by the user) setpoints or on one of three discrete valve commands, including **OPEN, CLOSE** and **HOLD**. Current values for valve position as well as pressure are displayed at the top of the **CONTROL MENU** page. The value and type of each preprogrammed setpoint is also included at the top of each button. To change the value or type of setpoint, please refer to the **CONFIGURE SETPOINTS** instructions in Section 10.3. Pressing **EXIT** from the **CONTROL MENU** page will leave the controller-and-valve system controlling to the last instruction issued, but will return the display back to the **MAIN MENU**.

11.0 - Battery Back-Up

Some APC models 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 **GP**. The controller will respond with the internal Power Supply Module (PSM) output voltage, the battery voltage and the internal APC temperature 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 at least every 1 to 2 years 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 APC controller software continuously monitors the operating voltage delivered to it by the internal PSM. If that voltage drops below a certain threshold level for more than 50 msec, then the APC disconnects all external power outputs (such as ±15 VDC), exits its present operational state and drives the valve closed using battery power. Once the valve is closed, the APC 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 APC controller will reinitialize the valve and be ready for operation after about 30 seconds. However, if the APC controller is configured with the valve initialization safety lock function, then the **JC** serial command needs to be issued before valve initialization can occur. Alternatively, pull the appropriate **\Valve Initialization Enable In** TTL pin low to activate the initialization routine.

12.0 - 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 all 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' APC 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 APC 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 12.1 – POSSIBLE FAILURE MODES AND RECOMMENDED ACTIONS

SYMPTOM	POSSIBLE CAUSES	RECOMMENDED ACTION
The APC does not appear to turn on. No LEDs are illuminated	The APC is not receiving power properly	Check external power supply, cabling and pin assignments. Try to restart the APC by reconnecting power supply. Operate OPEN/CLOSE switches.
The APC 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.	Issue the JC command via the RS-232 serial port to execute the initialization sequence.
	The RS-232 serial or Analog/TTL 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 APC 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 APC to refresh dip switch settings.
	A communications timeout has occurred	Call for Intellisys Technical Support
The APC does not operate and only the amber FAULT LED is on.	The valve plate and/or actuator is jammed	Cycle power to attempt re-initialization. Or, with power OFF, try to move valve plate by hand. If stuck, call for Intellisys Technical Support.
	There is something wrong with the motor drive circuitry or the internal power supply circuitry.	Call to obtain an RMA#.
The valve plate position does not agree with the indicated position	The APC software has lost track of valve position	Cycle power and allow for re-initialization. If problem repeats or persists, call for Intellisys Technical Support.
Pressure control performance is unsatisfactory	The APC 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 mTorr (or similar) gauge is used.
	The APC is in valve position control mode	Put the APC in the correct mode by issuing the proper RS-232 or DeviceNet command
	System design or operating range may be outside the capabilities of the Adaptive Pressure Control Algorithm	Call for Intellisys Applications Support.
The controller / valve will not respond to a new set point value	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%. When using analog/TTL communications, the new set-point has to be at least 25 mV higher or lower than the old set-point.
	There is too much noise on the set-point signal (analog mode, only)	In order to not "chase moving targets" due to electrical noise, the APC will only accept a new set-point value if the stability of the signal is within a 50 mV band. Set-point signals with a high level of noise will therefore not be accepted and the controller / valve will remain in its present mode.
The LEDs are illuminated in an unknown fashion		Please refer to **Table 12.2** on the next page describing valid LED combinations.

TABLE 12.2 KEY

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

TABLE 12.2 – VALID STATUS LED COMBINATIONS

MOD	NET	CTRL	FAULT	OPEN/ CLOSE	COMMENTS
O	O	O	O	O / O	All LEDs off. IQD 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) IQD 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 IQD 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) IQD 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) IQD 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) IQD 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.

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 (APC)

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.

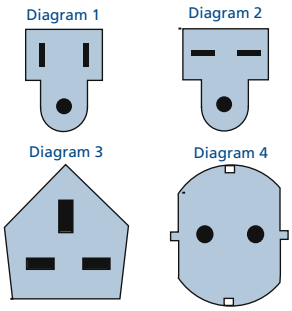
APC— [Valve Type] [User Interface] [Input Voltage] – [Comm. Type] [Battery Backup]

VALVE TYPE	USER INTERFACE	INPUT VOLTAGE	COMMUNICATIONS	OPTIONS
1 = Geared Throttling Buterfly Valve or Universal Valve Drive (TBV or UVD)	**00** = Standard. Buried Box *(limited switches & LEDs)*	**Blank** = 100-240 VAC, 50-60 Hz	**A** = RS-232 + Analog/TTL	**Blank** = None
2 = Direct Drive Throttling Buterfly Valve (TBV)	**50** = Graphic display / Touch screen. Front panel[1]	**L** = 24 VDC differential	**R** = RS-485 + Analog/TTL	**B** = Battery backup[2]
3 = Geared Drive Sealing Throttling Buterfly Valves (TBVS)			**D** = RS-232 + DeviceNet[2]	**Sxx** = Customer specific model, xx = 01, 02, etc.
7 = Throttling Soft-Shut Valve (TSS)				
8 = Throttling Pendulum Valve (TPV)				

[1] AC powered controllers only
[2] DC powered controllers only

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.



AC Power Cord Plug Configurations

APC -PSM-DB15 Power Supply

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

GAUGE CABLES	LENGTH	DESCRIPTION
CDG-CRD-10	10'	A/C powered APC-to-gauge cable, where gauge has 5-pole terminal block
CDG-CRD-DB9-10	10'	A/C powered APC-to-gauge cable, where gauge has DB-9 plug connector
CDG-CRD-DB15-10	10'	A/C powered APC-to-gauge cable, where gauge has DB-15 plug connector
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
APC-CRD-RS232-10	10'	Connects any A/C powered APC to a standard PC or laptop DB-9 serial port
IQ-CRD-RS232-10	10'	Connects any DC powered APC 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

POWER SUPPLY	
APC-PSM-DB15	For use with all DC powered APCs. 24 VDC, 2.5A power supply (100-240 VAC input). Includes one CRD-PWR-US1 power cord and 6' DC supply cable with DB15 D-sub receptacle connector

BATTERY BACK-UP SPARE	
APC-BAT-1518	Specially wrapped, 15-cell, 18 volt battery pack rated at 500 mA·H

APC-OP-LIT 1/12

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 it 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.