

PCC 100/200
SERVO OPERATED
PRESSURE CALIBRATOR/ CONTROLLER
INSTALLATION AND OPERATION

"LET US TAKE SOME OF THE PRESSURE OFF YOUR TESTING"

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Surface transportation charges covering any repaired or replacement product or component part shall be at Seller's expense; however, inspection, testing and return transportation charges covering any product or component part returned and redelivered, which proves not to be defective, shall be at the expense of Buyer or the end user, whichever has returned such product or component part.

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THIS WARRANTY IS IN LIEU OF AND EXCLUDES ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, ARISING BY OPERATION OF LAW OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND IN NO EVENT SHALL SELLER BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

In the event of a failure:

- 1) Notify Scanivalve Corporation, Technical Service Department. Include model number and serial number. On receipt of this information, service data or shipping instructions will be forwarded. This may be transacted by telephone. (800)935-5151 or (619)283-5851
- 2) On receipt of shipping instructions, forward the product, transportation prepaid. Repairs will be made and the product returned.
- 3) All shipments should be made via United Parcel Service or "Best Way". The product should be shipped in the original packing container or wrapped in protective material and surrounded by a minimum of four (4) inches of a shock absorbing material.

Scanivalve Corporation
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San Diego, CA 92108

INSTALLATION

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INTRODUCTION

The PCC 100/200 Pressure Calibrator/Controller is designed to generate and precisely measure pressures for the calibration of pneumatic pressure sensors. It is designed to be used in a stand-alone configuration in a laboratory environment, or as an automatic pressure system controlled via RS 232 or IEEE 488.



Figure 1 - PCC 100/200 Pressure Calibrator/Controller(Handle removed for clarity)

SYSTEM COMPONENTS

The PCC 100/200 is designed to be portable, thus supporting a wide range of customer requirements. The PCC 100/200 consists of the following major sub-assemblies:

- 1) Control Manifold - this manifold contains the valves required to port air to the secondary standard. It also contains a pressure relief valve to protect the secondary standard from overpressure inputs.
- 2) Servo Valve - This valve is mounted on the Control Manifold. It is used to control the pressure applied to the secondary standard from the supply air input.
- 3) Secondary Standard - The Secondary Standard is a Paroscientific Digiquartz® Transducer . It is mounted in an enclosure designed to provide shock mounting and stabilize temperature.
- 4) Power Supply - The power supply is a modular unit. It operates with AC inputs of 100 Vac to 240 Vac. The frequency may be 50 - 60 Hz. The mode of operation is selected automatically by the power supply.
- 5) Keypanel - The Keypanel is the front panel of the instrument. All commands may be entered from this panel.
- 6) Display Panel - The display panel is a vacuum fluorescent display unit. It can display two lines of information.
- 7) Board Set - The circuit board set used is the standard board set used in all Scanivalve Corporation Calibration Modules.
- 8) Handle - A multi-position handle is provided to improve portability.
- 9) Input/Output Fittings - All fittings are one-quarter inch stainless steel Swagelok type.
- 10) Accessory Kit - This kit contains adapters, cables and connectors required to operate the PCC 100/200.

NOTE: The PCC 200 contains two Secondary Pressure Standards. Each Standard has its own relief valve.

GETTING STARTED

The PCC 100/200 has been carefully packed to prevent damage. It is very important that the customer carefully inspect the instrument and immediately report any damage. It is also recommended that the customer save all packing material in the event that the instrument must be returned to the factory for repairs.

It is recommended that the user read and thoroughly understand this manual before operating the instrument.

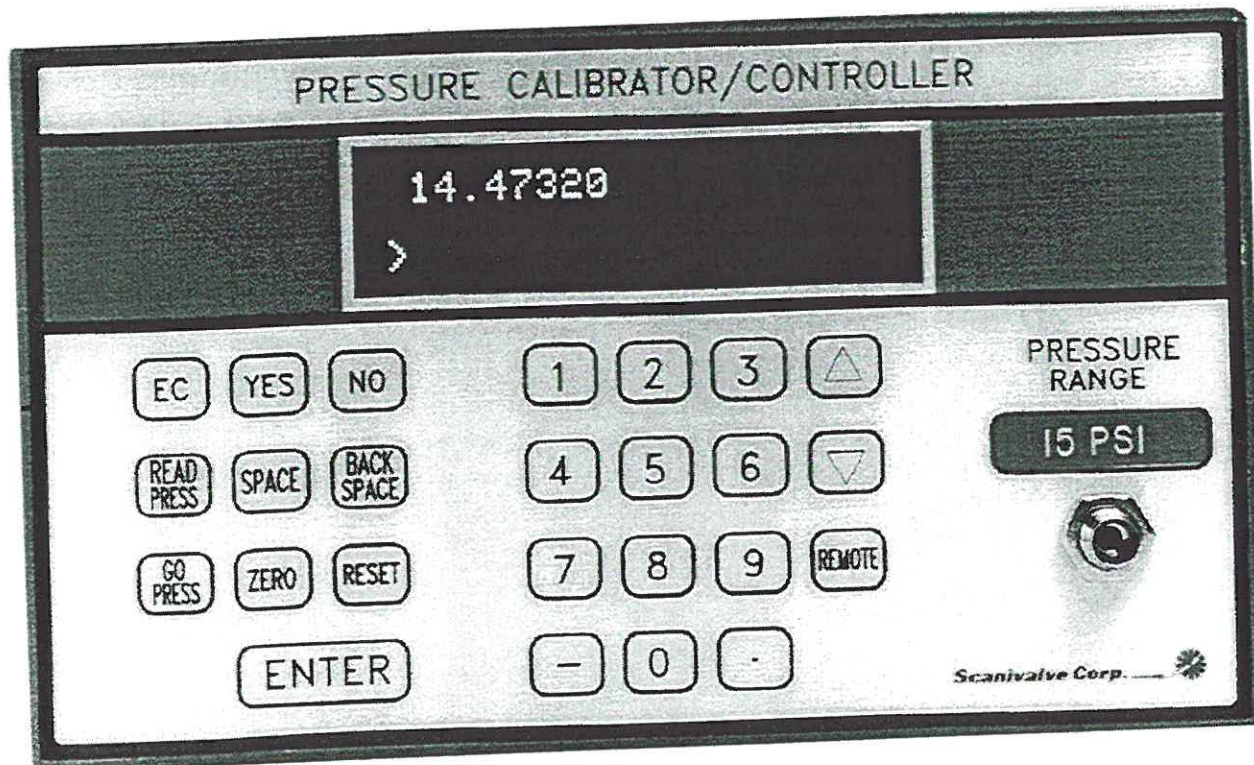


Figure 2 - PCC 100/200 Front View

PCC100 REAR PANEL

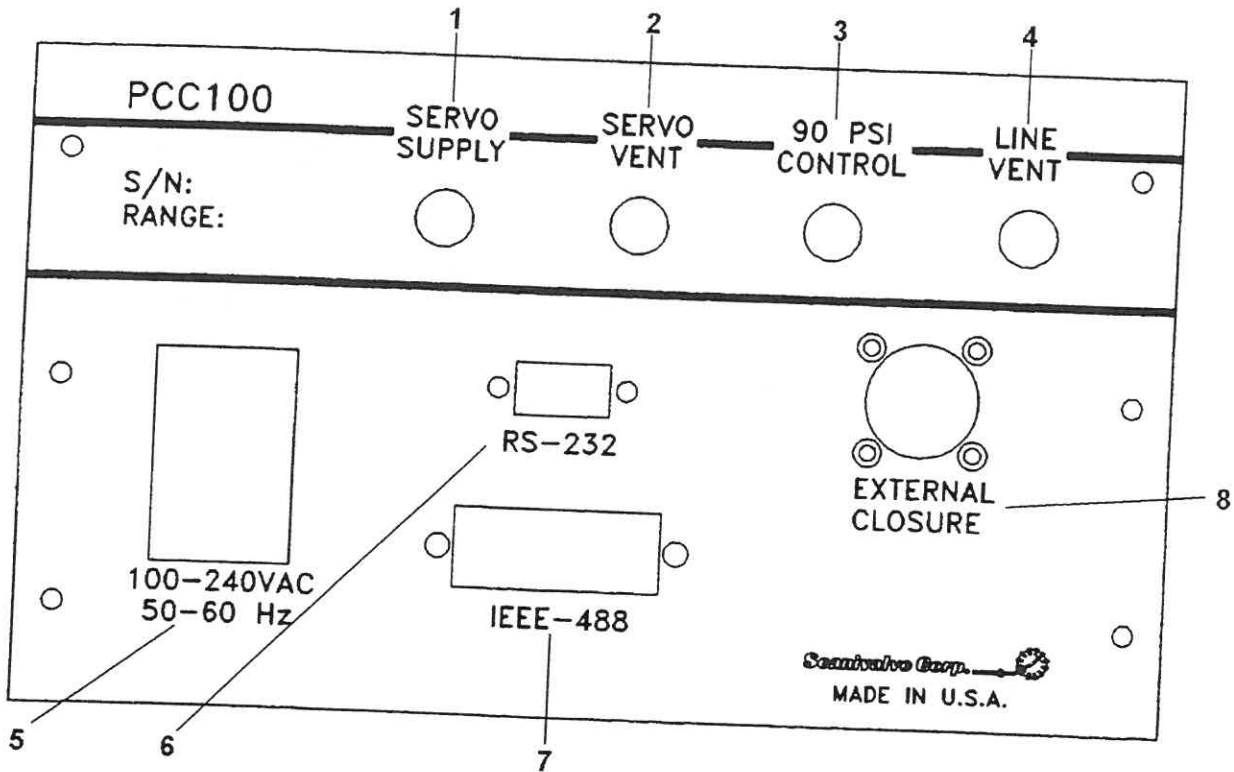


Figure 3 - PCC 100 Rear Panel

1) Servo Supply - Input for the supply air to the Servo Valve. It is recommended that this input be set according to the chart in the section on Pneumatic Connections on page 12. This pressure supply must be well regulated and capable of maintaining a flow that will not "starve" the servo valve. A chart giving the estimated flow for each pressure range may be found on page 11.

2) Servo Vent - This output must be vented to atmosphere or connected to a vacuum pump if pressure below atmospheric pressure will be required. Excess supply air will be vented through this vent during normal operation. If a vacuum pump is used to control absolute pressures, it must have sufficient capacity to draw all excess supply air when the PCC 100 is operating above ambient pressure.

3) 90 PSI Control - This input should be regulated. It provides the pilot air to switch the internal control valves. It must be set to 120 psi for pressure ranges greater than 250 psi.

4) Line Vent - This must be vented to atmosphere.

5) AC input - As marked

6) RS 232 - This input is used for remote control of the PCC 100. The controlling device must be set to communicate at 9600 BAUD, 1 start bit, 8 data bits, 1 stop bit, and no parity.

7) IEEE 488 - This is an optional input for remote control using a parallel bus.

8) External Closure - An output connector which may be used to control up to four external solenoids or other devices. The outputs are controlled by use of the EC commands on the front panel, or from a remote controlling device. The outputs are 12 Vdc at 100 ma into a resistive load. It should also be noted that the outputs do not have "kickback" diodes installed. The user is advised to provide diodes for these outputs.

PCC200 REAR PANEL

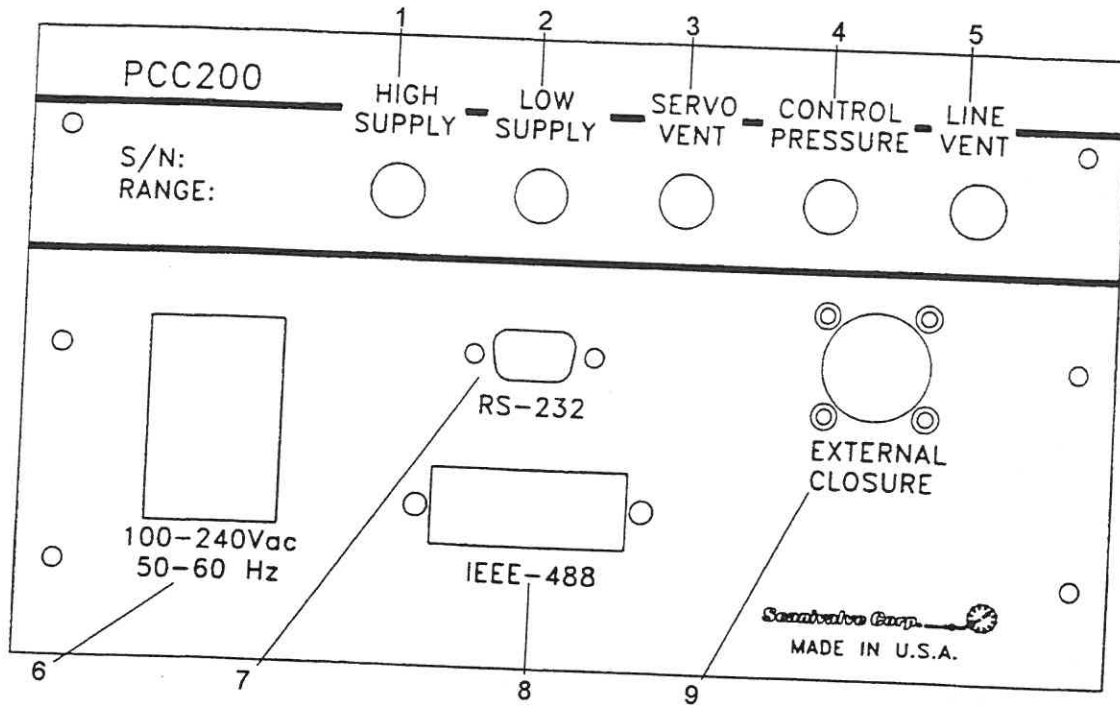


Figure 4 - PCC 200 Rear Panel

- 1) High Supply - Input for the high pressure supply air to the Servo Valve. This pressure is required for proper operation of the servo when the PCC 200 is operating in the high range. It is recommended that this input be set according to the chart in the section on Pneumatic Connections on page 12. This pressure supply must be well regulated and capable of maintaining a flow that will not "starve" the servo valve. A chart giving the estimated flow for each pressure range may be found on page 11.
- 2) Low Supply - Input for the low pressure supply air to the Servo Valve. This pressure is required for proper operation of the servo when the PCC 200 is operating in the low range. It is recommended that this input be set according to the chart in the section on Pneumatic Connections on page 12. This pressure supply must be well regulated and capable of maintaining a flow that will not "starve" the servo valve. A chart giving the estimated flow for each pressure range may be found on page 11.

- 3) Servo Vent - This output must be vented to atmosphere or connected to a vacuum pump if pressure below atmospheric pressure will be required. Excess supply air will be vented through this vent during normal operation. If a vacuum pump is used to control absolute pressures, it must have sufficient capacity to draw all excess supply air when the PCC 200 is operating above ambient pressure.
- 4) 90 PSI Control - This input should be regulated. It provides the pilot air to switch the internal control valves. It must be set to 120 psi for pressure ranges greater than 250 psi.
- 5) Line Vent - This must be vented to atmosphere.
- 6) AC input - As marked
- 7) RS 232 - This input is used for remote control of the PCC 200. The controlling device must be set to communicate at 9600 BAUD, 1 start bit, 8 data bits, 1 stop bit, and no parity.
- 8) IEEE 488 - This is an optional input for remote control using a parallel bus.
- 9) External Closure - An output connector which may be used to control up to four external solenoids or other devices. The outputs are controlled by use of the EC commands on the front panel, or from a remote controlling device. The outputs are 12 Vdc at 100 ma into a resistive load. It should also be noted that the outputs do not have "kickback" diodes installed. The user is advised to provide diodes for these outputs.

PCC 100/200 FRONT PANEL

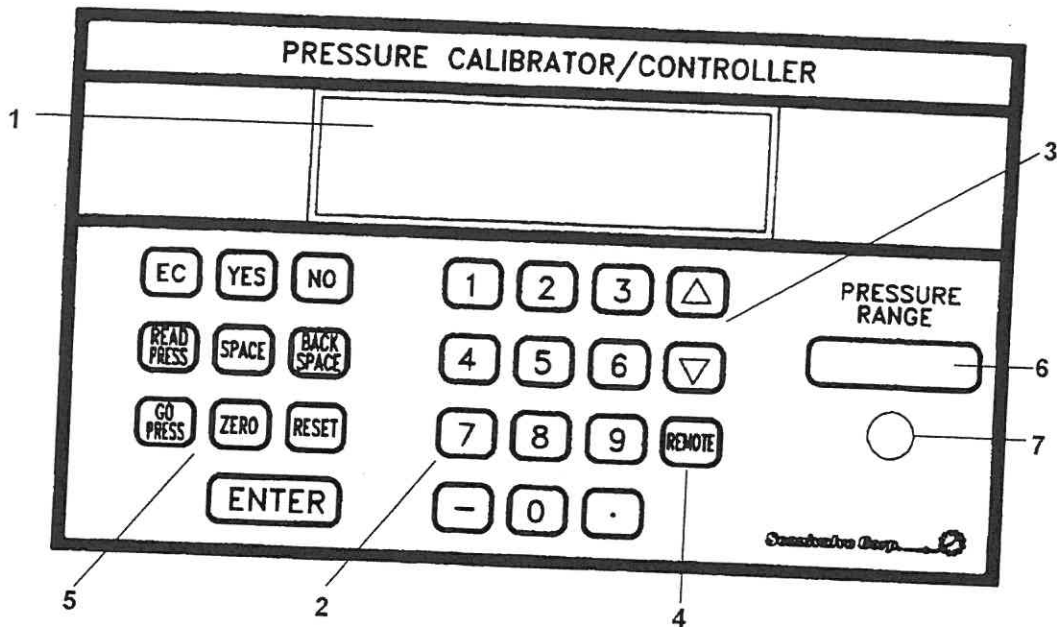


Figure 5 - PCC 100/200 Front Panel

- 1) Display - A vacuum fluorescent display. Two lines showing the command entered and the response of the PCC 100/200.
- 2) Numeric Keypad - used to enter numbers in the commands.
- 3) Up Arrow/Down Arrow - Used to make small increment changes in the command entries. Also used to scroll through the configuration entries.
- 4) Remote Key - used to switch between Local and Remote modes of operation.
- 5) Alpha Keypad - Used in conjunction with the numeric keypad to construct command entries.
- 6) Pressure Range - A label to indicate the full scale pressure range of the pressure standard installed in the PCC 100/200.
- 7) Output Connector - Pressure output port.

ELECTRICAL CONNECTIONS

This section describes the electrical connections required to operate the PCC 100/200

AC POWER

The PCC 100/200 requires AC voltages from 100 Vac to 240 Vac. Input frequency must be 50 to 60 Hz. An AC cord is supplied in the accessory kit.

COMMUNICATIONS

If the PCC 100/200 is to be used in the Remote Mode, a cable must be connected to the Serial or Parallel Communications Ports. Only one connection is required.

SERIAL

Serial Communication is via RS 232. The Serial connector is a DB9 connector. Connections should be made for DCE equipment. A drawing of the connections is shown in figure 14. The recommended cable wiring is shown in figure 15.

The communications software should be set up for the following configuration:

- 9600 Baud
- 1 start bit
- 8 data bits
- 1 stop bit
- no parity

PARALLEL

Parallel Communication is via IEEE 488. The Parallel connector is a standard IEEE 488 connector. This is an option installed only if ordered by the customer. When the IEEE 488 option is installed, the RS 232 output is blanked off.

PNEUMATIC CONNECTIONS

This section describes the supply air requirements for the PCC 100/200.

SUPPLY AIR QUALITY

The air supply to the PCC 100/200 must be of quality typical for sensitive instrumentation. Requirements can be found in the Instrument Society of America's "Quality Standard for Instrument Air" (ISA-S7.3). This standard calls for the following:

- Particle size The maximum particle size at the instruments should not be larger than 3 microns.
- Dew Point The dew point, at line pressure, should be at least 10°C below the minimum temperature to which any part of the instrument system is exposed at any season of the year. Dew point should never exceed 2°C (35°F) at line pressure.
- Oil Content The maximum total oil or hydrocarbon content, exclusive of non-condensing particulate should not exceed 1 PPM under normal operating conditions.

SUPPLY AIR CONSUMPTION

Actual air consumption will depend on supply air pressure, types and settings of regulators, and the volume of the sensors under test. The following table gives an indication of what may be anticipated.

PCC 100/200 Pressure Range (psi)	Instrument Air Consumption in SCFM Dead-End Service
1	0.5
5	0.5
15	0.5
50	0.5
100	0.5
200	0.8
500	0.9
750	1.4
	2.0

AIR PRESSURE REQUIREMENTS

CONTROL AIR SUPPLY

The PCC 100/200 solenoid valves require 90 to 120 psi for positive actuation. It is essential that the control air supply sources be pre-regulated with a good quality relieving regulator.

SERVO SUPPLY

The Servo valve requires a well regulated source. Optimum performance of the servo (stability and response) can only be obtained if this supply is stable. The following table must be followed in order to obtain optimum performance from the servo valve:

Calibration Module Range (psi)	Recommended Instrument Air Supply (psi)	Maximum Instrument Air Supply (psi)
0 - 1	2 - 5	5
0 - 2.5	3 - 5	5
0 - 5	7.5 - 10	10
0 - 15	18 - 25	25
0 - 30	35 - 45	45
0 - 50	55 - 65	65
0 - 100	105 - 125	125
0 - 200	205 - 225	225
0 - 300	305 - 325	325
0 - 500	505 - 550	550
0 - 750	755 - 775	775

SOFTWARE

LOCAL MODE

No special software is required to operate the PCC 100/200 in the Local Mode.

REMOTE MODE

SERIAL

Any communications software such as PROCOMM®, KERMIT®, or CROSSTALK® should be sufficient to operate in the Remote Mode.

PARALLEL

Any IEEE488 Communications package will interface directly with the PCC 100/200.

OPERATION PROCEDURE

The following procedure should be followed to operate the PCC 100/200:

- 1) Connect AC power to the unit.
- 2) Connect the Control Air Supply input.
- 3) Connect the Servo Supply input.
- 4) If the unit will be operated in the Remote Mode, connect the communications cable to the proper port.
- 5) Energize the instrument, the display will light up and display the software version installed after an approximate 5 second delay. For optimum performance the instrument should be allowed to warm up for at least 1 hour.
- 6) Operation of the instrument is explained in the Operation section of this manual.

CALIBRATION INTERVAL

It is recommended that the Secondary Standard be retested every six months until a trend can be established. It may be possible to extend this interval to 12 months after several calibration intervals. Recalibration of the secondary standard must be performed using an Air Dead Weight Tester with an accuracy of $\pm 0.01\%$ of reading. Scanivalve Corporation will recalibrate the secondary standards for a nominal charge. For more information, contact Scanivalve Corporation, Product Support Department.

MAINTENANCE

No special preventative maintenance procedures are required other than periodic recalibration of the secondary standard. The following drawings have been included in the event that the customer must perform some field repairs to the instrument.

Access to the internal components of the PCC 100/200 may be accomplished by the following:

- 1) Disconnect the AC cord and center the Handle.
- 2) Remove the 4 screws from the top cover and lift off the cover.
- 3) Loosen, but do not remove, the two screws holding the front circuit board mounting bracket.
- 4) Remove the two screws holding the rear circuit board mounting bracket.
- 5) Lift the rear of the circuit board and rotate it up toward the front panel.
- 6) Tighten the screws holding the front circuit board bracket.

All internal components are accessible with this method.

NOTE: DO NOT attempt to remove the bottom cover. Removal of the bottom cover may result in damage to the instrument.

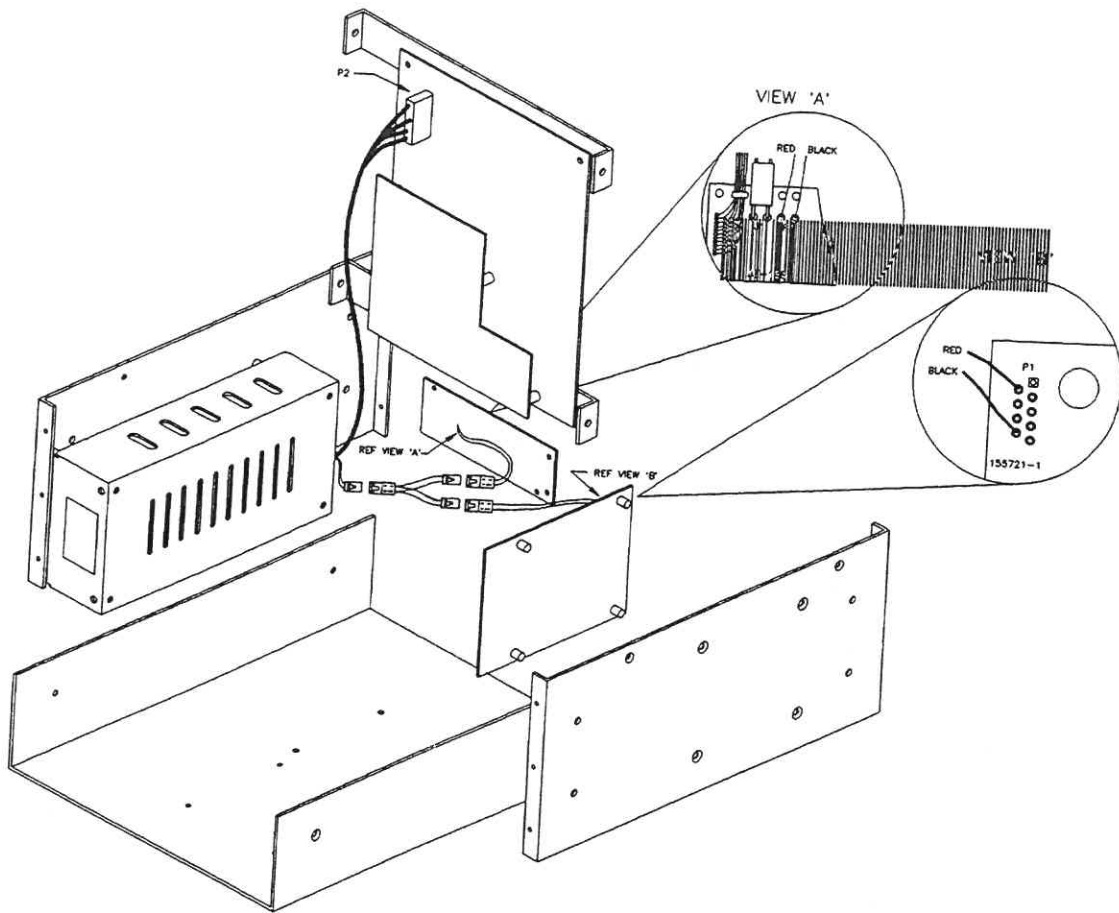


Figure 7 - PCC 100/200 Power Supply Installation

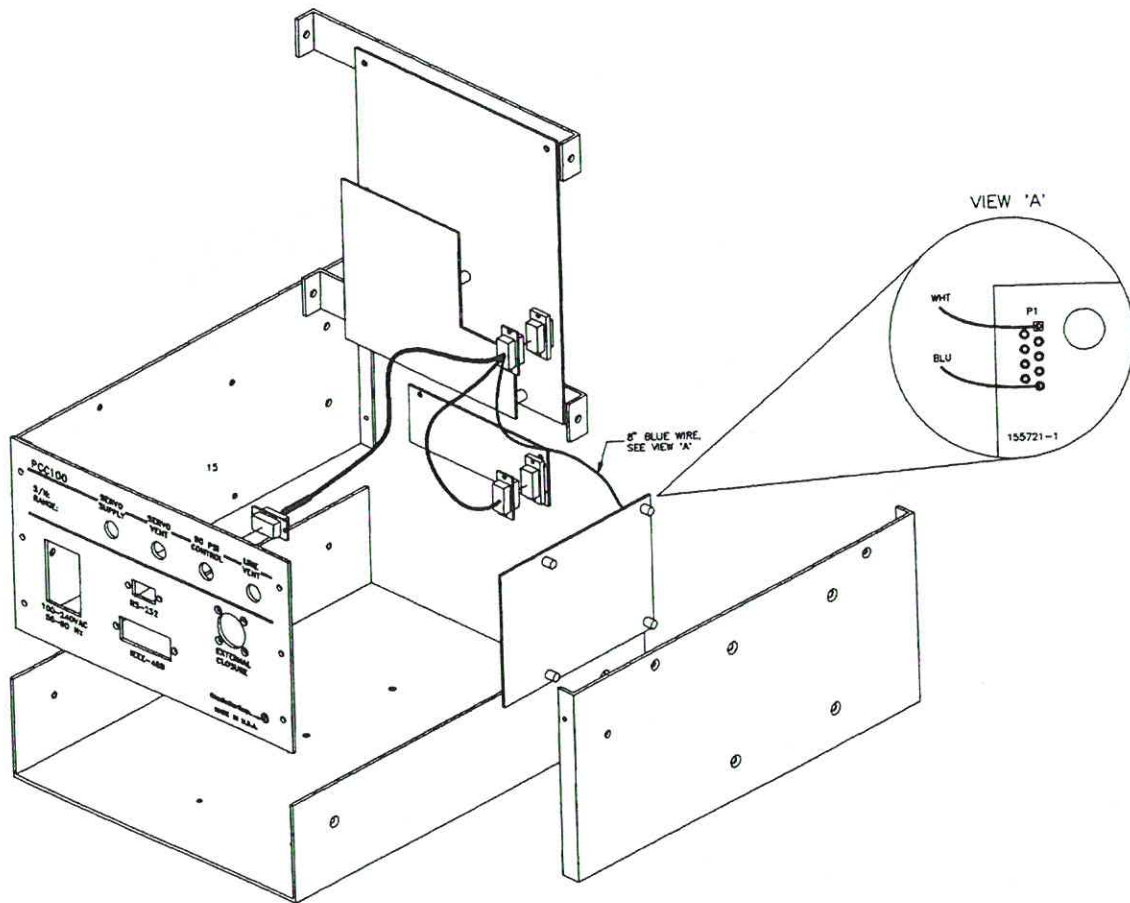


Figure 8 - PCC 100/200 Internal RS 232 Connections

1. NORMALLY CLOSED (NO PNEUMATIC FLOW)
2. NORMALLY OPEN VALVE (PNEUMATIC FLOW CONDITION)
3. BUBBLE NUMBERS REPRESENT ENERGIZED CIRCUIT CLOSURES (EC COMMANDS) REFER TO TRUTH TABLE BELOW.

CONFIG	EC CMDS	
	1	2
CALIBRATION OUTPUT	Y	N
CAL TRAP/OUTPUT READ	N	N
LINE VENT	N	Y

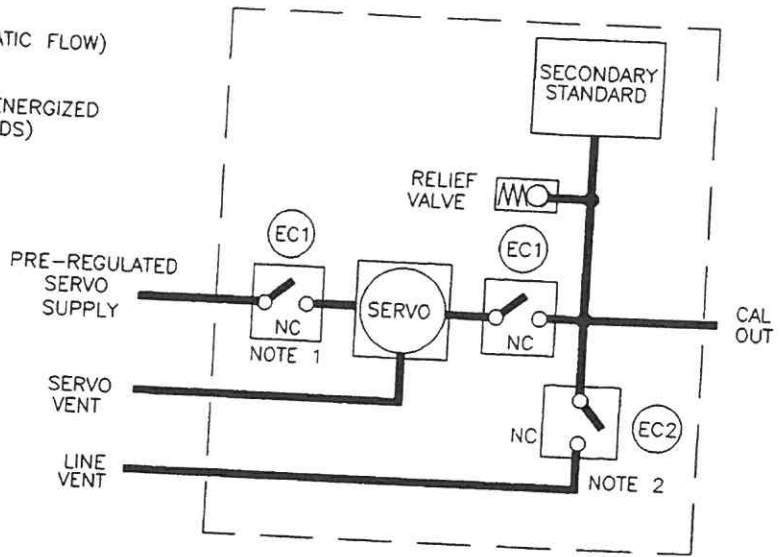


Figure 9 - PCC 100 Pneumatic Block Diagram

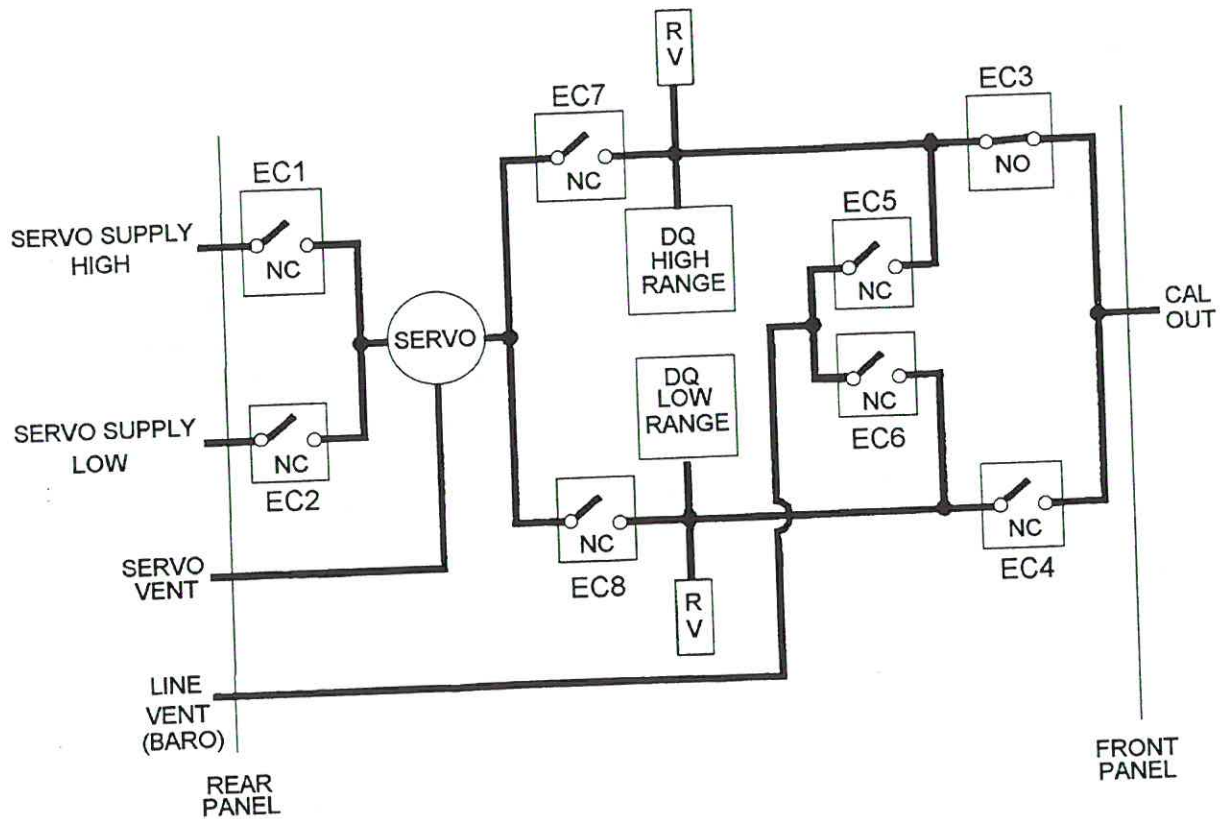


Figure 10 - PCC 200 Pneumatic Block Diagram

Configuration	Solenoid States							
	EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8
CAL High Range	Y	N	N	N	N	N	Y	N
CAL Low Range	N	Y	Y	Y	N	N	N	Y
Read High Range	N	N	N	N	N	N	N	N
Read Low Range	N	N	Y	Y	N	N	N	N
Read Baro	N	N	Y	N	N	Y	N	N
Vent High Range	N	N	N	N	Y	N	N	N
Vent Low Range	N	N	Y	Y	N	Y	N	N

Figure 11 - PCC 200 Pneumatic Truth Table

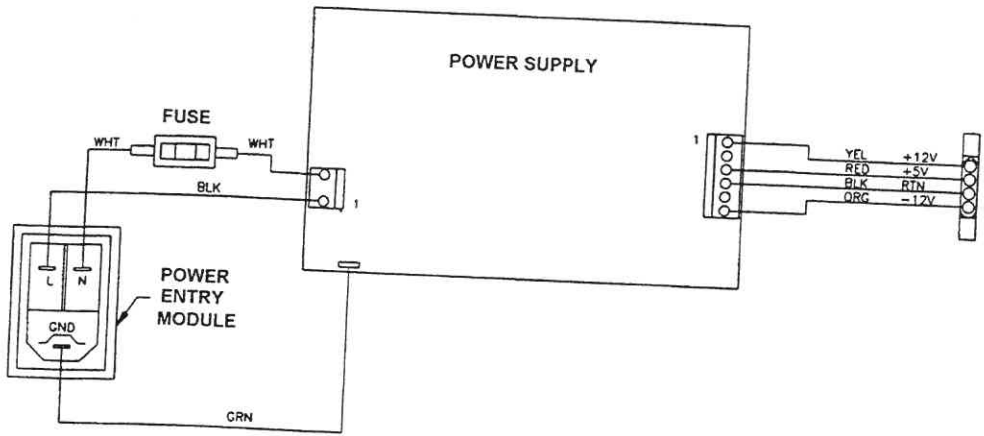


Figure 12 - PCC 100/200 Power Supply wiring

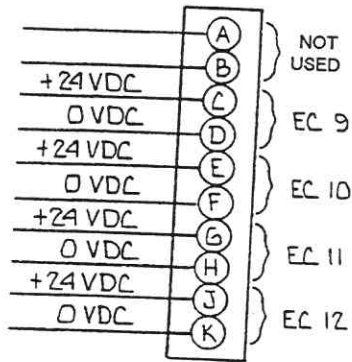


Figure 13 - PCC 100/200 External Closure Output Wiring

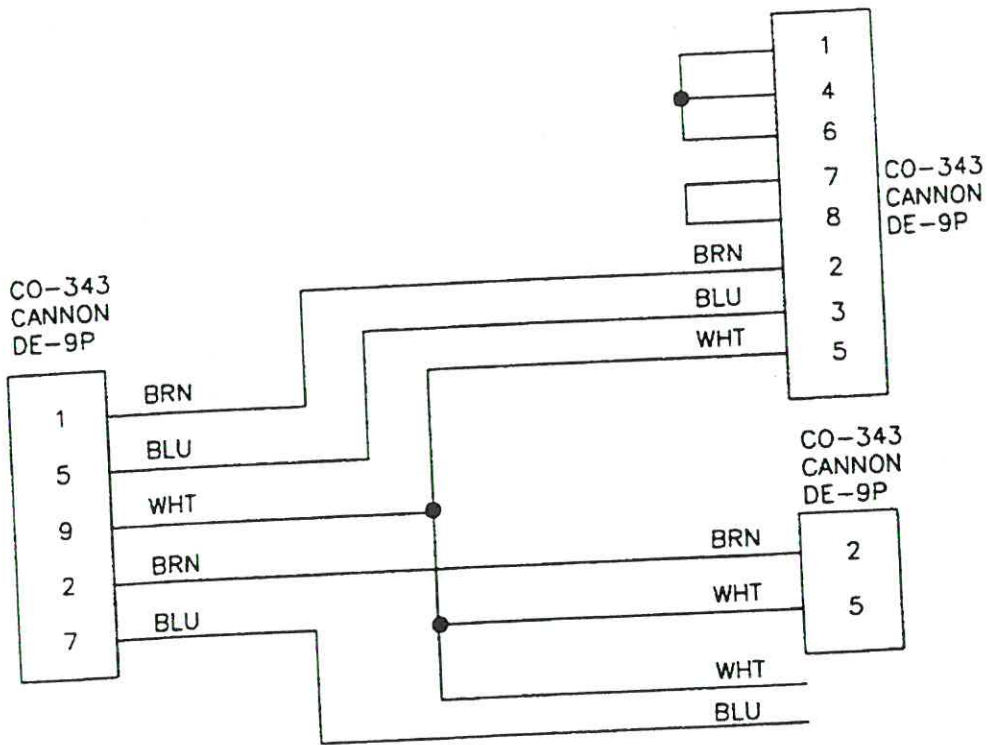


Figure 14 - PCC 100/200 Internal RS 232 wiring

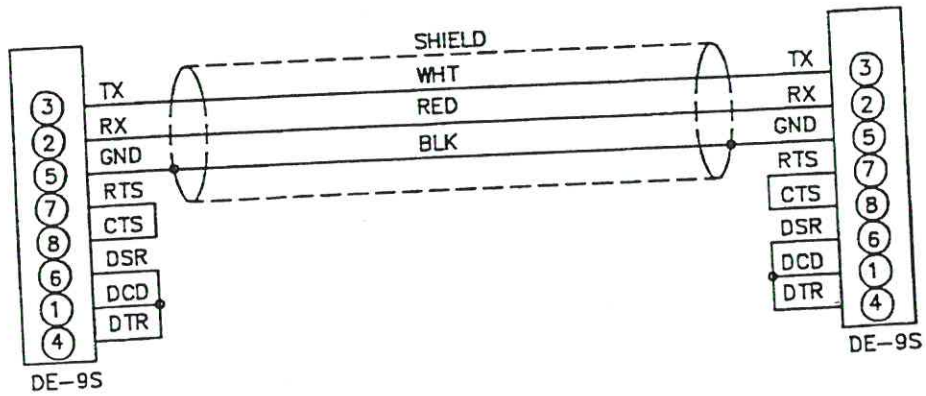


Figure 15 - Recommended External RS232 Cable Wiring

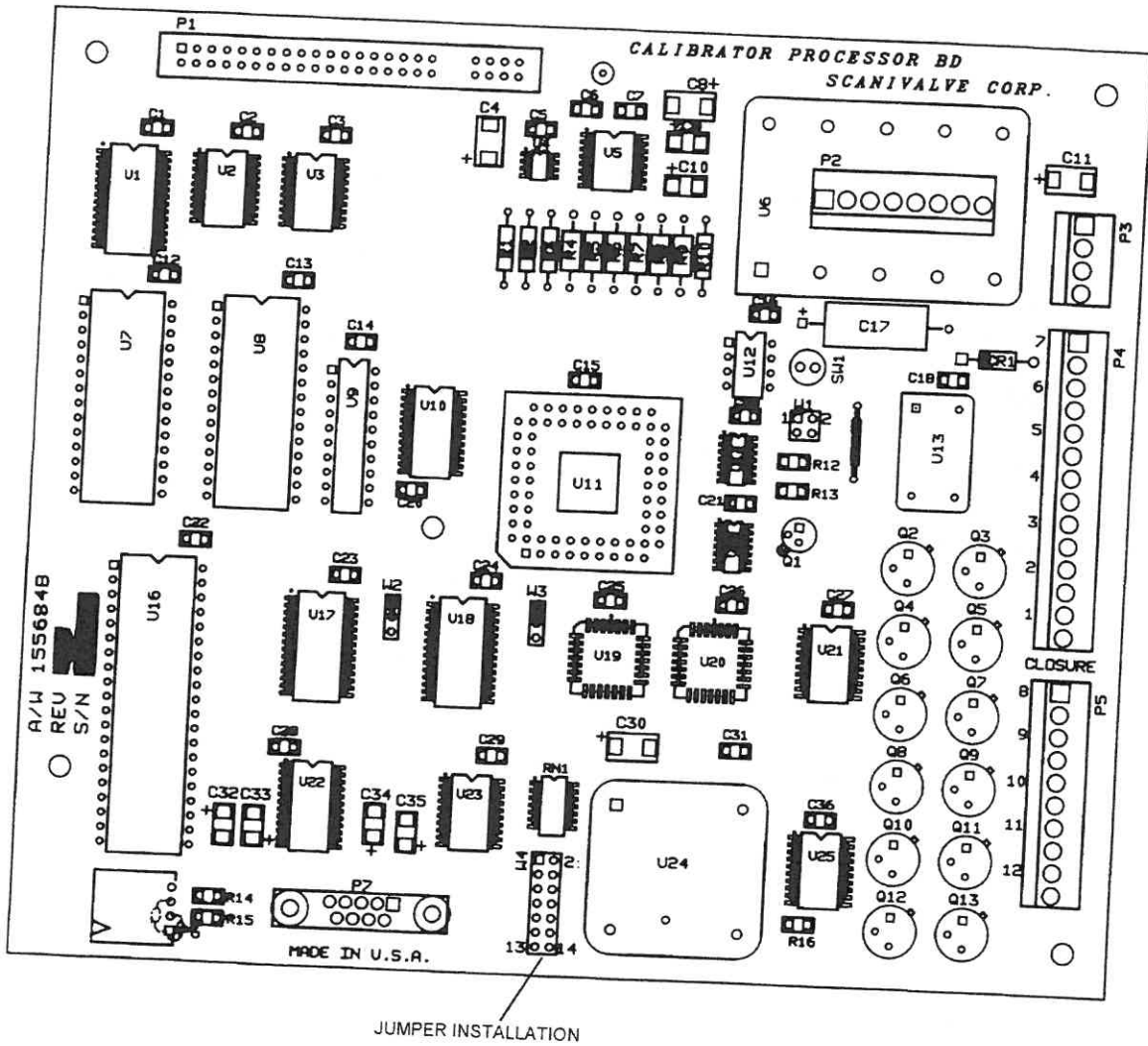


Figure 16 - PCC 100/200 Processor Board

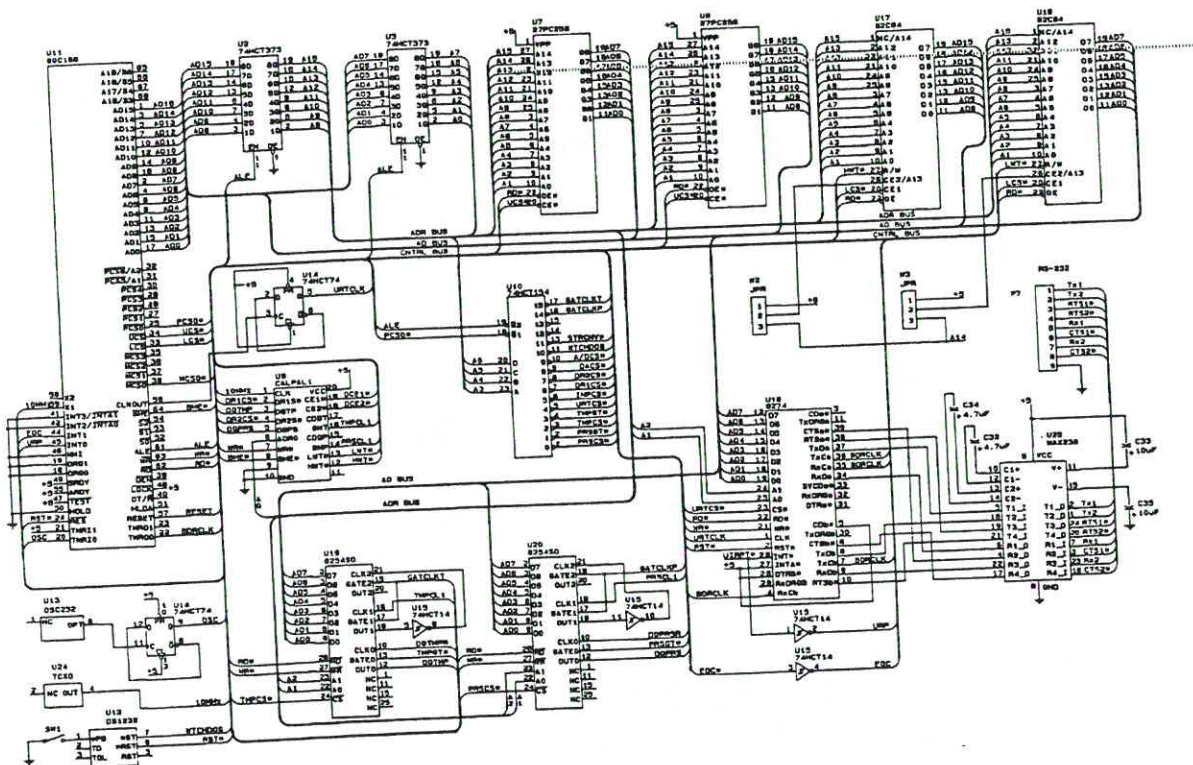


Figure 17 - PCC 100/200 Processor Board Schematic(page 1)

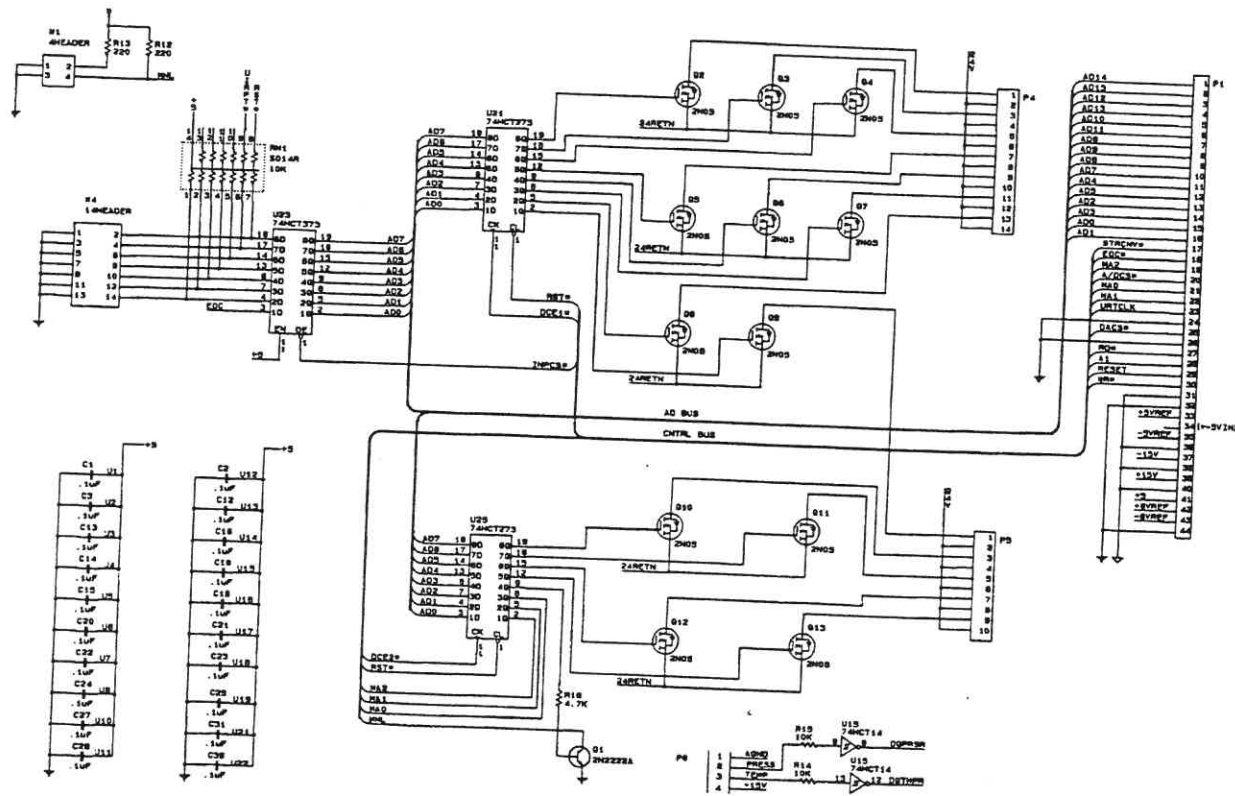
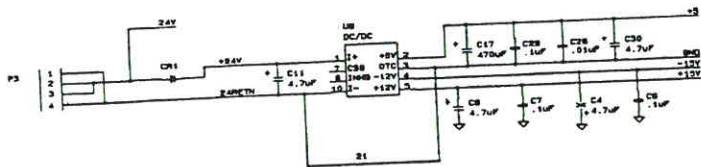


Figure 18 - PCC 100/200 Processor Board Schematic(page 2)



24V	1
5V5VETH	2
5V5V	3
5V	4
5V5V	5
5V5V	6
5V5V	7
5V5V	8

U1	28C84
A10	21A114
A11	21A112
A12	21A113
A13	21A110
A14	21A109
A15	21A108
A16	21A107
A17	21A106
A18	21A105
A19	21A104
A20	21A103
A21	21A102
A22	21A101
A23	21A100
A24	21A099
A25	21A098
A26	21A097
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A115	21A008
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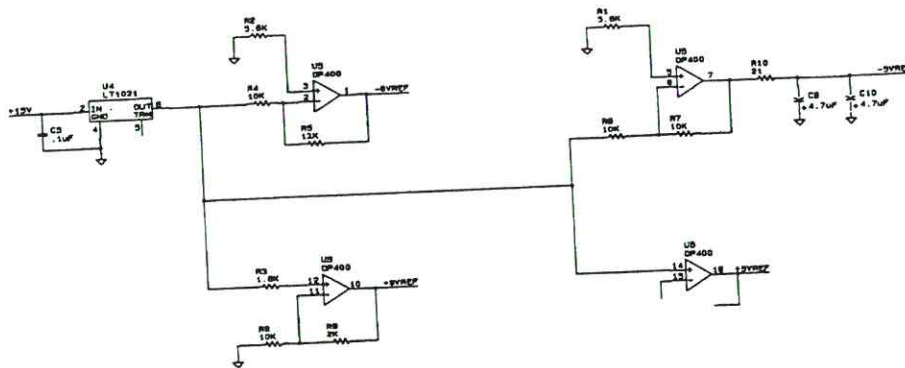


Figure 19 - PCC 100/200 Processor Board Schematic (page 3)

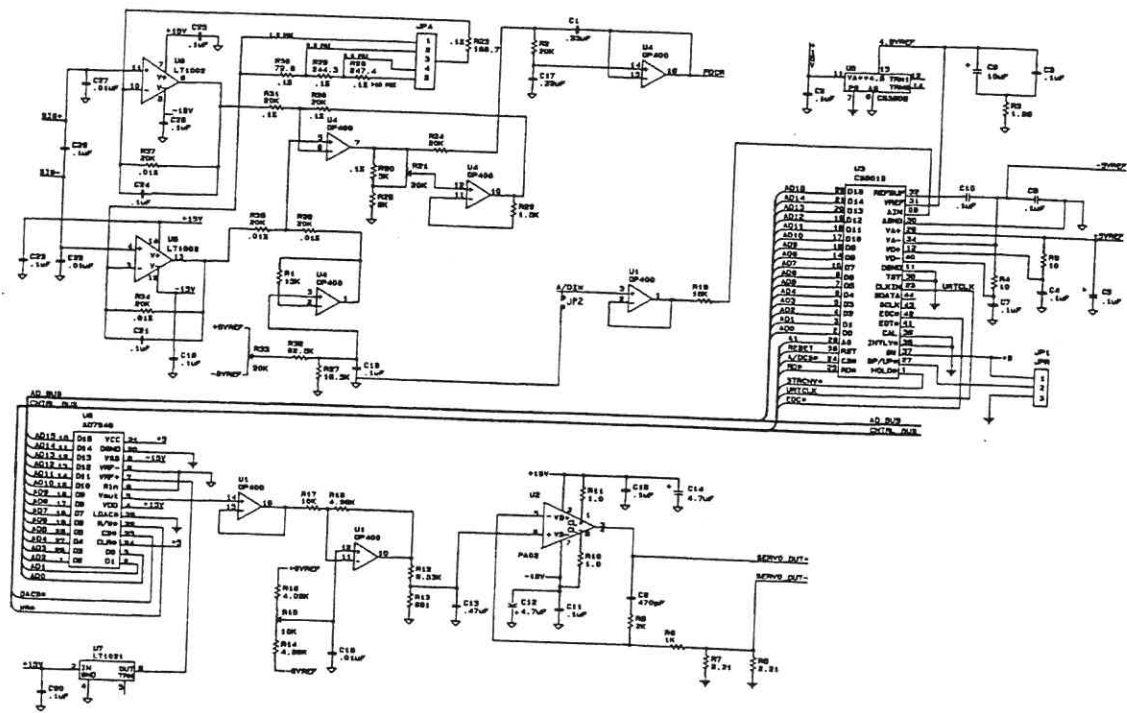


Figure 20 - PCC 100/200 Analog Board Schematic(page 1)

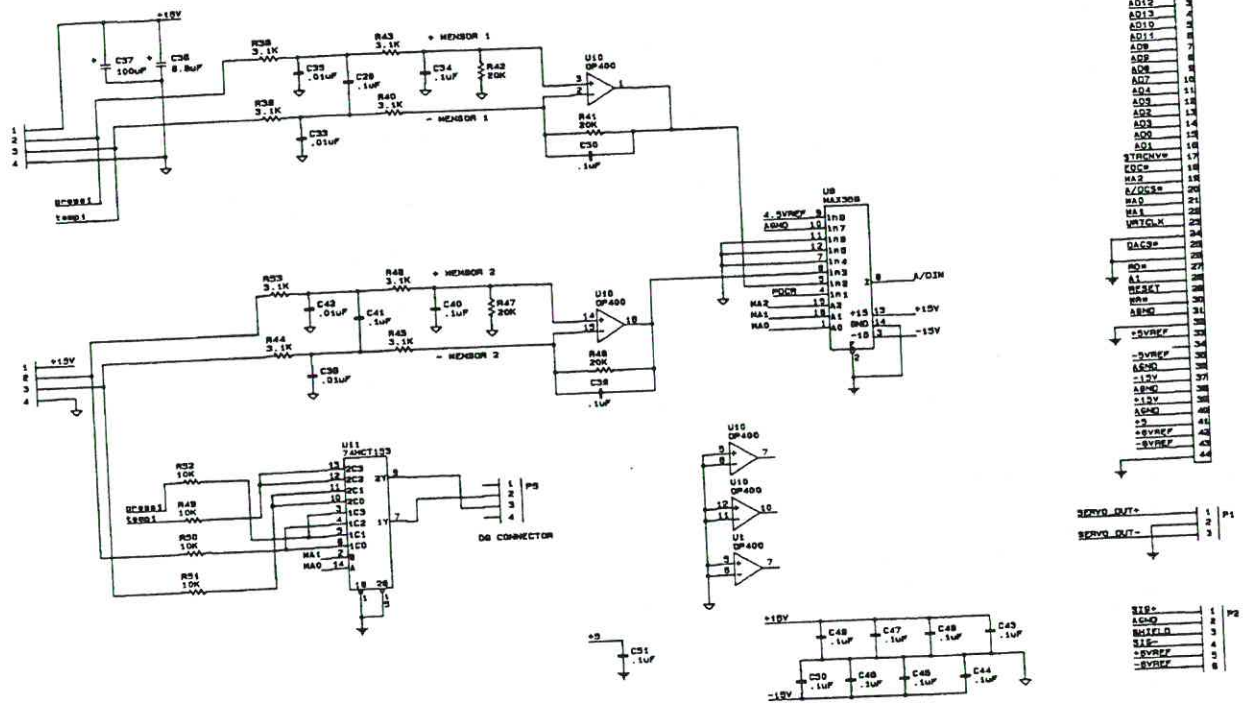


Figure 21 - PCC 100/200 Analog Board Schematic(page 2)

OPERATION

OPERATION

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INTRODUCTION

The PCC 100/200 Calibrator/Controller accepts commands from either the front panel, a serial link, or IEEE488 to measure or control pressures.

The calibrator operates in one of two major modes, Local and Remote. In the Local mode, the calibrator accepts commands from the front panel keypad and outputs data to the front panel display. In the Remote Mode, the calibrator accepts commands and outputs data over the RS-232 serial communication link or an optional IEEE488 connection. The front panel keypad is disabled while the PCC 100/200 is in the remote mode.

Switching between modes is performed locally by pressing the REMOTE key or remotely by issuing the LOCAL command. This is further discussed later in this chapter.

The PCC 100/200 Controller/Calibrator may only be configured while in remote mode operation. This is discussed later in the chapter.

LOCAL MODE

This section describes operation from the front panel. During Local Mode operation, no communication is possible over the serial or parallel links. The Local Mode supports most, but not all, of the commonly used commands.

DISPLAY

The front panel display consists of a 2 row by 20 column vacuum fluorescent display. Each row on the display performs certain functions.

The top row of the display:

- 1) Flashes the software version number upon power up.
- 2) Displays "REMOTE MODE" when in Remote Mode.
- 3) Displays the command either currently executing or just previously executed when in local mode.

The second line of the display:

- 1) Stages the command being entered prior to execution.
- 2) Continually displays pressure when commanded.
- 3) Displays error message(s) when required.

KEYPAD

The front panel keypad is used for entering commands for local operation and supports most commonly used commands. Each key function is described in the table below:

KEY NAME	KEY DESCRIPTION	NOTES
EC	Energize Closure command.	Only responds when cursor is in first column.
YES	Yes argument to EC command.	Only responds after EC button pushed.
NO	No argument to EC command.	Only responds after EC button pushed.
READ PRESS	Read Pressure command.	Only responds when cursor is in first column.
SPACE	Causes cursor to move one position to the right.	Only responds after EC or GO PRESS button pushed.
BACK SPACE	Causes cursor to move one position to the left.	Only responds after EC or GO PRESS button pushed.
GO PRESS	Go Pressure command.	Only responds when cursor is in first column.
ZERO	Zero command. Vents Pressure	Only responds when cursor is in first column.
RESET	Initialize Calibrator command.	Only responds when cursor is in first column.
ENTER	Executes the command displayed on the staging line.	Always active.
0 - 9 Function 1	Display one of 10 pre-programmed commands.	Only responds when cursor in first column.

0 - 9 Function 2	Argument data entry.	Only responds after EC or GO PRESS button pushed.
DECIMAL POINT	Argument data entry.	Only responds after GO PRESS button pushed.
UP ARROW Function 1	Scrolls up through pre-programmed commands.	Only responds when cursor in first column.
DOWN ARROW Function 1	Scrolls down through pre-programmed commands.	Only responds when cursor in first column.
UP ARROW Function 2	Increments the digit under the cursor.	Only responds after EC or GO PRESS button pushed.
DOWN ARROW Function 2	Decrements the digit under the cursor.	Only responds after EC or GO PRESS button pushed.
REMOTE Function 1	Remote command.	Switches to remote mode only if in local mode.
REMOTE Function 2	Local command.	Switches to local mode only if in remote mode.
MINUS SIGN	Clears staged command.	Always active.

LOCAL FUNCTIONS

This section describes the local mode functions and the steps necessary to perform these functions using the front panel keypad.

ENERGIZE CLOSURE

The PCC 100 contains 7 electronically switched circuits referred to as closure circuits. Two of these, 1 and 2, control internal solenoid valves. Four, numbered nine through twelve, are brought out through a back panel connector.

The PCC 200 contains 12 electronically switched circuits referred to as closure circuits. Eight of these, 1 through 8, control internal solenoid valves. Four, numbered Nine through twelve, are brought out through a back panel connector.

The user can manually control each of these closure circuits using the EC command. To execute this command:

- 1) Press the EC key.
- 2) Press any number key 0 through 12 to enter the closure number desired.
- 3) Press either the YES or NO key to energize or de-energize the closure.
- 4) Press the ENTER key to execute the command

READ PRESSURE

This command continuously displays the current pressure in the chosen pressure units.

To execute this command:

- 1) Press the READ PRESS key
- 2) Press the ENTER key to execute the command.
- 3) Pressing any key will stop the display of pressure and place the cursor in column one. This indicates that the calibrator is ready to accept another command.

GO PRESSURE

This command causes the calibrator to output and control the indicated pressure. The pressure is displayed continuously.

To execute this command:

- 1) Press the GO PRESS key.
- 2) The desired pressure value may be entered by one of two ways:
 - a) Use the number keys and decimal point to enter the pressure desired.
 - b) Press the UP ARROW or DOWN ARROW to increment or decrement the digit under the cursor. The cursor may be moved to the right or left by pressing the SPACE or BACK SPACE keys.
- 3) Press the ENTER key to execute the command.
- 4) Pressing any key will stop the display of pressure and place the cursor in column one. This indicates that the calibrator is ready to accept another command.

ZERO PRESSURE

This command causes the calibrator to vent the input/output pressure to the Line Vent fitting on the rear panel and continuously display the pressure. Barometric Pressure will be displayed if the Line Vent is connected to, or is open to, Atmospheric Pressure, and the calibrator is set to display absolute pressures.

To execute this command:

- 1) Press the ZERO key.
- 2) Press the ENTER key.
- 3) Pressing any key will stop the display of pressure and place the cursor in column one. This indicates that the calibrator is ready to accept another command.

RESET CALIBRATOR

This command resets the calibrator to its power up state.

To execute this command:

- 1) Press the RESET key.
- 2) Press the ENTER key.

NOTE: This command should not be used to obtain a zero reading. It is possible to trap some small pressure using this command if the output of the calibrator is not open to atmosphere.

REMOTE / LOCAL TOGGLE SWITCH

This command causes the calibrator to switch between Local Mode and Remote Mode.

To execute this command when the calibrator is in Local Mode:

- 1) Press the REMOTE key.
- 2) Press ENTER key.

The calibrator will display REMOTE MODE on line one of the display. No local cursor is displayed and a prompt is issued over the serial link indicating that it is ready to accept a command remotely.

To execute this command when the calibrator is in Remote Mode:

- 1) Press the REMOTE key.

The calibrator will display the cursor on line two indicating that the calibrator can accept commands locally.

PRE-PROGRAMMED COMMANDS

The calibrator can execute any one of ten pre-programmed commands. These commands are accessed by pressing one of the number keys (0 through 9) when the cursor is in the first column. Additionally, the user may scroll through the pre-programmed commands by pressing the UP ARROW or DOWN ARROW when the cursor is in the first column. Each command is displayed on the staging line.

After the command is displayed on the staging line, it is executed by pressing ENTER key or cleared by pressing the MINUS key.

Programming the pre-programmed commands is only possible through the Remote Mode and is covered in that section.

REMOTE MODE

In the Remote Mode, the calibrator can accept commands and transmit data via an RS-232 serial communications link or an IEEE-488 parallel communications link. All commands are transferred in 8 bit standard ASCII code with no parity. Commands are not case sensitive. The local display only shows REMOTE MODE on line one when in the Remote Mode. Typically, the serial link is connected to a terminal, computer running a communication software, such as Procomm, or a computer controlling a test or calibration.

The calibrator can execute all commands in the Remote Mode. The commands are grouped into the following three groups: 1) control, 2) configuration, and 3) diagnostics. The following section describes each command by these three groups.

In all cases the calibrator will transmit a prompt ">" indicating that it is ready to accept a new command.

NOTE: The calibrator cannot be switched to or from the remote mode using an external source. It may only be switched using the REMOTE key on the front panel keypad. For more information, refer to the REMOTE/LOCAL toggle switch section on page 2-6.

CONTROL COMMAND GROUP

The control command group specifies a pressure or pressures, reads a pressure, or sets closure circuits. Each command is defined below:

READ PRESSURE

SYNTAX: RP [/C] <ENTER>

C - causes continuous display of the pressure.

RETURNS: *pressure units*

pressure - is the current calibrator pressure.
units - is the chosen pressure units.

DESCRIPTION: Transmits the current pressure in the user chosen units. If the /C option is used the pressure is continuously displayed until an <ESC> character is received by the calibrator.

When pre-programmed, this command must be entered as:

READ PRESSURE

GO PRESSURE

SYNTAX: GP *pressure* <ENTER>

pressure - is the desired pressure in the user chosen units.

RETURNS: Nothing

DESCRIPTION: Causes the calibrator to produce the desired pressure. The solenoids are set according to the SCGP Configuration Variable. The rate of pressure change is determined by the setting of the RATE Configuration Variable.

For more information on Configuration Variables see the chapter on Configuration Commands.

When pre-programmed, this command must be entered as:

GO PRESS *pressure*

RESET CALIBRATOR

SYNTAX: IC <ENTER>

RETURNS: Nothing

DESCRIPTION: Places the calibrator in a power up state.

The pressure set point is set to zero and the solenoids are set according to the SCIC Configuration Variable. For more information on Configuration Variables see the chapter on Configuration Commands. This command may not vent the calibrator output pressure. Only the ZO command vents the calibrator.

When pre-programmed, this command must be entered as:

INITIALIZE CAL

ZERO PRESSURE

SYNTAX: ZO <ENTER>

RETURNS: Nothing

DESCRIPTION: The sensor is vented to Line Vent. The solenoids are set according to the SCZO Configuration Variable. For more information on Configuration Variables see the chapter on Configuration Commands.

When pre-programmed, this command must be entered as:

ZERO PRESSURE

ENERGIZE CLOSURE

SYNTAX: *EC channel state* <ENTER>

channel - is the closure number ranging from 1 to 12.
state - is either Y for on or N for off.

RETURNS: Nothing

DESCRIPTION: Sets the electronic switch channel specified, to either on or off.
No other channel is affected.

When pre-programmed, this command must be entered as:

EC channel state

CYCLE PRESSURE

SYNTAX: *CYC reference*

reference - is a cycle reference number from 0 to 4

RETURNS: *pressure units*

: : : :
pressure units

pressure - current pressure
units - pressure units

DESCRIPTION: The cycle command causes the output pressure to sequence through a series of predefined pressure values. The current pressure is continuously displayed. Sending <ESC> to the calibrator will abort the cycling. Between each pressure point the rate of pressure change is determined by the RATE Configuration Variable.

The pressure values, time at each pressure and number of cycles are defined for each cycle by Configuration Variables. See the section on Configuration Variables for more information.

When pre-programmed, this command must be entered as:

CYC reference

CONFIGURE COMMAND GROUP

The configure command group sets the calibrator to operate as desired by the user. These variables may only be set while in the remote mode. A list of these Configuration Variables is provided later in this section. After a Configuration Variable is set it can be saved, thus retaining the configuration after power is removed.

Two internal jumpers, accessible only by removing the main circuit board, control the saving and updating of Configuration Variables. When a jumper is installed between pins 13-14, the user may save Configuration Variables with the SAVE command. With this jumper removed, no changes are allowed. When a jumper is installed between pins 11-12, the Configuration Variable data is copied to RAM at power up and is usable. With this jumper removed, zeros are copied into RAM for all Configuration Variables. The location of the jumpers is shown in Figure 16 of the Installation Section.

There are only three configuration commands: SET, SHOW, and SAVE.

SET CONFIGURATION VARIABLE

SYNTAX: SET *name value* <ENTER>

name - is the name of the configuration variable
value - is the value of the configuration variable

RETURNS: Nothing

DESCRIPTION: The SET command sets the named Configuration Variable to the value specified.

When pre-programmed, this command must be entered as:

SET *name value*

SHOW CONFIGURATION VARIABLES

SYNTAX: SHOW *groupcode* <ENTER>

groupcode - is the name of the configuration group displayed.

RETURNS: *varname value*
 : : : : :
 varname value

varname - is the name of the variable
value - is the value assigned to that variable

DESCRIPTION: This command displays all of the Configuration Variables within the group specified. Valid groups are as follows:

GROUP CODE	GROUP FUNCTION
C	Configuration Group
D	Discrete Closure Group
S	Sensor Group
T	Tune Group
P	Pre-program Group
0	Cycle 0 Group
1	Cycle 1 Group
2	Cycle 2 Group
3	Cycle 3 Group
4	Cycle 4 Group

The list of Configuration Variables, shown below, are arranged by the above groups.

This command is NOT available for pre-programming.

SAVE CONFIGURATION VARIABLES

SYNTAX: SAVE <ENTER>

RETURNS: Nothing

DESCRIPTION: This command causes the calibrator to retain, after power down, all of the changed values entered by the SET command. Any changes not saved will be lost at power down.

When pre-programmed, this command must be entered as:

SAVE

CONFIGURATION VARIABLES

The following lists all of the Configuration Variables used by the calibrator. The left column gives the variable name and the right column supplies more detailed information.

CONFIGURE GROUP

The following Configuration Variables are members of the configure group. The C argument is used to display these variables via the SHOW command.

ECHO ECHO SERIAL LINK CHARACTERS

When set to 0, the calibrator DOES NOT echo characters received back over the serial link. When set to 1, the calibrator DOES echo characters received back over the serial link.

LOCAL LOCAL MODE ON POWER UP

When set to 0, the calibrator powers up in Remote Mode. When set to 1, the calibrator powers up in Local Mode.

SIGN SIGN ON OVER SERIAL LINK

When set to 0, a sign on message IS NOT sent over the serial link. When set to 1, a sign on message IS sent over the serial link. This only applies when Remote Mode is selected on power up. A prompt is always transmitted when powering up in Remote Mode.

UNITS PRESSURE UNITS

Sets the pressure units. The following lists the value entered and the corresponding units:

<u>VALUE</u>	<u>UNITS</u>
PSI	psi
ATM	atm
BAR	bar
CMHG	cm Hg
CMH2O	cm H ₂ O
DECIBAR	decibar
FTH2O	ft H ₂ O
GCM2	g/cm ²
INHG	in Hg @ 0°C
INH2O	in H ₂ O @ 4°C
KNM2	kN/m ²
KGM2	kg/m ²
KGCM2	kg/cm ²
KPA	kPa
KIPIN2	kip/in ²
MPA	MPa
MBAR	millibar
MH2O	mH ₂ O
MMHG	mm Hg
NM2	N/m ²
NCM2	N/cm ²
OZIN2	oz/in ²
OZFT2	oz/ft ²
PA	Pa
PSF	lb/ft ²
TORR	torr
USER	User chosen value (see USRCVT)

All PCC 100/200 Calibrator/Controllers are shipped with the UNITS value set for PSIA. The pressure UNITS selected is immediately applied. It may be entered as a pre-programmed command. It will not be made permanent unless a SAVE command is issued.

When the pressure units are changed, the following parameters are automatically updated to reflect the new pressure units: RANGEL, RANGEH, RATE, and CYCLE POINTS.

The following is **NOT** updated: All arguments of GO PRESSURE in pre-programmed commands.

CONFIG GENERAL CALIBRATOR CONFIGURATION

CONFIG must be set to a value of 1 to 4 to reflect the type(s) of secondary standard transducers installed by the following:

- 1 - a temperature compensated Digiquartz® transducer.
- 2 - a non-temperature compensated Digiquartz® transducer.
- 3 - a temperature compensated Digiquartz® transducer high range and a non-temperature compensated Digiquartz® transducer low range.
- 4 - a non-temperature compensated Digiquartz® transducer low range and a temperature compensated Digiquartz® transducer high range.

USRCVT USER CONVERSION FACTOR

If the user desires to work in a pressure unit other than the ones provided by the UNITS Configuration Variable, they may provide their own. The calibrator functions internally in psi. The conversion factor entered is the amount of user chosen units in one psi.

SSNL LOW RANGE SENSOR SERIAL NUMBER

The serial number of the low range sensor is stored in this variable for reference only. The entry may be up to 19 alpha-numeric characters.

SSNH HIGH RANGE SENSOR SERIAL NUMBER

The serial number of the high range sensor is stored in this variable for reference only. The entry may be up to 19 alpha-numeric characters.

CSN CALIBRATOR SERIAL NUMBER

The serial number of the calibrator is stored in this variable for reference only. The entry can be up to 19 alpha-numeric characters.

RANGEL MAXIMUM LOW RANGE SENSOR PRESSURE

The nominal maximum value of the low range sensor is stored in this variable. This value must be entered to prevent over pressure of the sensor and provides information for other tests. This value must be entered in the units specified in the UNITS Configuration Variable. It will be updated automatically when the UNITS configuration variable is modified.

RANGEH MAXIMUM HIGH RANGE SENSOR PRESSURE

The nominal maximum value of the high range sensor is stored in this variable. This value must be entered to prevent over pressure of the sensor and provides information for other tests. This value must be entered in the units specified in the UNITS Configuration Variable. It will be updated automatically when the UNITS configuration variable is modified.

MDATE MANUFACTURE DATE

The date the calibrator was manufactured is stored in this variable for reference only. The date can be up to 19 alpha-numeric characters.

RATE MAXIMUM ALLOWABLE PRESSURE RATE CHANGE

This variable is the maximum rate of change, in pressure units per second, in response to a pressure set point change. This variable should be adjusted to minimize overshoot. For example: if the UNITS Configuration Variable is set to psi and 2.5 was entered for rate, then the pressure would change at 2.5 psi per second in response to a set point change. This value should be set at no more than 10 percent of the maximum calibrator pressure. The smallest allowable value for RATE is 0.05 pressure units/second. It is recommended that the user make changes to this variable in small increments.

WARNING: The sensors may be damaged if RATE is set too high,

GAUGE DISPLAY PRESSURE UNITS IN GAUGE

When this variable is set to a non-zero value, the Calibrator will display the pressure units in gauge rather than absolute. A ZO command must be entered to establish a barometric pressure "baseline". The Calibrator will store the barometric pressure reading and subtract this value from all subsequent pressure readings before displaying the pressure value. A ZO command must be entered prior to all read pressure or go pressure commands in order to insure that the barometric pressure reading is not "stale".

XD SERIAL LINK TRANSMIT DELAY

When operating in Remote Mode, the calibrator can transmit data faster than some communication packages on the host computer can receive them. This causes the host computer's buffer to overflow. This variable inserts a delay between each output line transmitted. The value entered, must be an integer, and is multiplied by .02 to determine the actual delay. Typically a value of 3 provides sufficient delay.

DISCRETE GROUP

This group of Configuration Variables control the discrete closure circuits during each calibrator state. Each closure circuit could be either de-energized, not changed from previous state, or energized. By placing a 0, X or 1 respectively, each of the twelve closure circuits may be controlled. The discrete closures remain in the last state until a new state is entered. Closure circuit 1 is placed in the right most position and closure 12 to the left.

For example if solenoids 1 and 4 are to be on, 2 does not change and the remainder are to be off during the GO PRESS command the following would be the argument of the SCGP variable:

```
0000000010X1
```

The complete command entry is:

```
SET SCGP 0000000010X1
```

SCGPL SET CLOSURE FOR LOW RANGE GO PRESSURE

This variable controls the discrete closures during the GO PRESS command when a low pressure argument is used.

SCGPH SET CLOSURE FOR HIGH RANGE GO PRESSURE

This variable controls the discrete closures during the GO PRESS command when a high pressure argument is used..

SCLPO SET CLOSURE FOR LOW PRESSURE OVERRIDE

This variable controls the discrete closures during a low pressure override(LPO). An LPO occurs when a command is issued to use the low range sensor while the pressure is still too high. This setting overrides all other discrete settings.

SCIC SET CLOSURE FOR INITIALIZE CALIBRATOR

This variable controls the discrete closures during the INITIALIZE CALIBRATOR (RESET) command.

SCZO SET CLOSURE FOR ZERO PRESS

This variable controls the discrete closures during the ZERO command.

SCPU SET CLOSURE FOR POWER UP

This variable controls the discrete closures at power up.

SENSOR GROUP

This group of Configuration Variables set the sensor coefficients used by the calibrator to convert the frequency output from the sensor to a pressure reading.

The S argument is used to display these variables via the SHOW command.

TEMPERATURE COMPENSATED LOW RANGE DIGIQUARTZ® COEFFICIENTS

LU0,LY1,LY2,LY3,LC1,LC2,LC3,LD1,LD2,LT1,LT2,LT3,LT4,LT5

These coefficients are used by the temperature compensated low range Digiquartz® pressure standard. They are only used if the CONFIG variable is set to 1 or 4. The values are obtained from the Digiquartz calibration sheet. Please note that the U0 coefficient is referred to as X0 on the calibration sheet.

TEMPERATURE COMPENSATED HIGH RANGE DIGIQUARTZ® COEFFICIENTS

HU0,HY1,HY2,HY3,HC1,HC2,HC3,HD1,HD2,HT1,HT2,HT3,HT4,HT5

These coefficients are used by the temperature compensated high range Digiquartz® pressure standard. They are only used if the CONFIG variable is set to 1 or 3. The values are obtained from the Digiquartz calibration sheet. Please note that the U0 coefficient is referred to as X0 on the calibration sheet.

NON-TEMPERATURE COMPENSATED LOW RANGE DIGIQUARTZ® COEFFICIENTS

LT0,LCI,LDI

These coefficients are used by the non-temperature compensated low range Digiquartz® pressure standard. They are only used if the CONFIG variable is set to 2 or 3. The values are obtained from the Digiquartz calibration sheet. Please note that the LCI and LDI coefficients are referred to on the data sheets as C and D respectively.

NON-TEMPERATURE COMPENSATED HIGH RANGE DIGIQUARTZ® COEFFICIENTS

HTO,HCI,HDI

These coefficients are used by the non-temperature compensated high range Digiquartz® pressure standard. They are only used if the CONFIG variables is set to 2 or 4. The values are obtained from the Digiquartz calibration sheet. Please note that the HCI and HDI coefficients are referred to on the data sheets as C and D respectively.

TUNE GROUP

This group of Configuration Variables control the servo loop. These variables are factory set and normally do not require changing. Selecting values for these variables is beyond the scope of this manual.

The T argument is used to display these variables via the SHOW command.

- B SET POINT CHANGE GAIN MULTIPLIER
- N HIGH FREQUENCY TIME CONSTANT
- K PROPORTIONAL CONTROL LOOP GAIN
- TI INTEGRAL GAIN
- TD DERIVATIVE GAIN
- TT ANTI-WINDUP GAIN

PRE-PROGRAM GROUP

This group of Configuration Variables sets pre-programmed command 0 through 9.

- PP_n PRE-PROGRAMMED COMMAND (where n is 0 through 9)

The argument to this variable is any valid command available for pre-programming. Any of the 10 (0 through 9) possible pre-programmed variables may be set in this manner. For example if a GO PRESS 24.56 is desired to be assigned to button 1 on the front panel, the following would be entered:

```
SET PP1 GO PRESS 24.56 <ENTER>
```

CYCLE GROUP

This group of Configuration Variables sets the parameters for cycle commands 0 through 4. The n character is replaced by the numbers 0,1,2,3,or 4 corresponding to each of the cycle reference number 0 through 4. A total of 20 cycle pressures may be configured. This permits a full 10 point calibration from zero to full scale and back to zero. In all cases if the pressure value entered is negative that pressure point is skipped.

CnP0	First pressure point
CnP1	Second pressure point
CnP2	Third pressure point
CnP3	Fourth pressure point
CnP4	Fifth pressure point
CnP5	Sixth pressure point
CnP6	Seventh pressure point
CnP7	Eighth pressure point
CnP8	Ninth pressure point
CnP9	Tenth pressure point
CnP10	Eleventh pressure point
CnP11	Twelvth pressure point
CnP12	Thirteenth pressure point
CnP13	Fourteenth pressure point
CnP14	Fifteenth pressure point
CnP15	Sixteenth pressure point
CnP16	Seventeenth pressure point
CnP17	Eighteenth pressure point
CnP18	Ninteenth pressure point
CnP19	Twentieth pressure point
CnDT	Delay time between pressures in seconds. This is not a dwell time. If the user wishes to dwell at a point, this value must be zero. When this value is zero, the calibrator will dwell at each point until an ENTER command is issued
CnCY	Number of times to repeat the cycle - maximum number is 32767

DIAGNOSTIC COMMANDS

This group of command help the user evaluate system and calibrator problems.

DISPLAY MEMORY

SYNTAX: `DMEM seg offset [/B/W/U/S/I/L/F/C] <ENTER>`

seg - is the segment portion of the memory location. It must be a 16 bit hexadecimal value. Together the segment and offset specify the memory location.

offset - is the offset portion of the memory location. It must be a 16 bit hexadecimal value. Together with the segment and offset specify the memory location.

[/B/W/U/S/I/L/F/C] - is the option of the format of the displayed memory location.

B - hexadecimal byte
W - hexadecimal word
U - hexadecimal long
S - decimal byte
I - decimal integer
L - decimal long
F - float
C - character

RETURNS: `seg:offset = data`

seg - is the segment specified in the command
offset - is the offset specified in the command
data - is the data at the specified memory location

DESCRIPTION: This command continuously displays the data at the memory location specified. The data is displayed until an <ESC> character is received.

Knowledge of the 80186 memory structure is required to effectively use this command.

This command is not available for pre-programming.

SET MEMORY

SYNTAX: SMEM *seg offset* [/B/W/U/S/I/L/F/C] <ENTER>

seg - is the segment portion of the memory location. It must be a 16 bit hexadecimal value. The segment and offset specify the memory location.

offset - is the offset portion of the memory location. It must be a 16 bit hexadecimal value. The segment and offset specify the memory location.

data - is the data to be placed in the specified memory location. The format is determined by the option.

[/B/W/U/S/I/L/F/C] - is the option of the format of the displayed memory location.

- B - hexadecimal byte
- W - hexadecimal word
- U - hexadecimal long
- S - decimal byte
- I - decimal integer
- L - decimal long
- F - float
- C - character

RETURNS: Nothing

DESCRIPTION: This command sets the memory location to the data specified. Knowledge of the 80186 memory structure is required to effectively use this command.

This command is not available for pre-programming.

DISPLAY PORT

SYNTAX: DPORT *port* [/B/W] <ENTER>

port - is the port address entered in hexadecimal.

[/B/W] - is the optional size of the memory location.

B - hexadecimal byte
W - hexadecimal word

RETURNS: *port = data*

port - is the port address specified in the command
data - is the hexadecimal data at the port address specified

DESCRIPTION: This command continuously displays the data at the port addressed specified. The data continues to scroll until a <ESC> character is received.

This command is not available for pre-programming.

SET PORT

SYNTAX: SPORT *port data* [/B/W] <ENTER>

port - is the port address specified in the command
data - is the hexadecimal data at the port address specified

[/B/W] - is the optional size of the memory location.

B - hexadecimal byte
W - hexadecimal word

RETURNS: Nothing

DESCRIPTION: This command sets the data at the port address specified.

There is no guarantee that the data entered will remain unaltered. In some cases the program will immediately overwrite the data entered.

This command is not available for pre-programming.

ERASE FAULTS

SYNTAX: EFLT <ENTER>

RETURNS: Nothing

DESCRIPTION: This command erases any faults that have accumulated since power up or the last EFLT command.
This command is not available for pre-programming.

DISPLAY FAULTS

SYNTAX: DFLT <ENTER>

RETURNS: FAULT LIST
description LIMIT=*limit* COUNTS=*occurrences*
: : : : : : : : : : : :
description LIMIT=*limit* COUNTS=*occurrences*
END OF FAULT LIST

description - is a description of the fault
limit - is the number of times the fault may occur before being considered.
occurrences - is the number of times the fault has occurred.

DESCRIPTION: This command displays the list of current faults if any exist.
This command is not available for pre-programming.

READ DIGIQUARTZ FREQUENCY

SYNTAX: RF [/C] <ENTER>

C - causes continuous display

RETURNS: PRES PERIOD (μ sec) *freq* TEMP PERIOD (μ sec) *freq*

freq - is the frequency output of the Digiquartz® transducer

DESCRIPTION: This command displays the pressure and temperature period of the Digiquartz® transducer. When the /C option is used, the values are continuously displayed until an <ESC> character is received.
This command is not available for pre-programming.

SYSTEM LEAK TEST

SYNTAX: LEAK <ENTER>

RETURNS: *pressure units*
: : : : :
pressure units

pressure - is the current pressure
units - is the pressure units

DESCRIPTION: This command executes an automatic leak test on the system.
The test is executed as follows:

- 1) The pressure is set to 50% of full scale.
- 2) The pressure is trapped by closing solenoid 1
- 3) The pressure is continuously displayed on the screen.

If the pressure displayed falls at a fast rate the system has a leak.

To quit the test send an <ESC> character to the calibrator.

When pre-programmed this command must be entered as:

LEAK

TUNE

SYNTAX: TUNE [/Z/U]

Z - writes FFFF in hexadecimal to the servo D/A converter.
U - updates servo control variables

RETURNS: Nothing

DESCRIPTION: When the Z option is used, this command disengages the control loop and outputs FFFF to the servo D/A. This allows zero setting of the servo trim pot.

When the U option is used, this command updates various control parameters for the servo control loop. This is required after changing any of the Configuration Variables in the Tune Group.



FEATURES

- 0.01% Accuracy
- 1×10^{-8} Resolution
- Low Power Consumption
- High Stability and Reliability
- Quartz Crystal Frequency Outputs
- Fully Calibrated and Characterized
- NIST Traceable - ISO 9001 Quality System

APPLICATION AREAS

- Hydrology
- Meteorology
- Oceanography
- Air Data Computers
- Laboratory Standards
- Windtunnel Instrumentation
- Propulsion Control Systems
- Pressure Calibration Systems

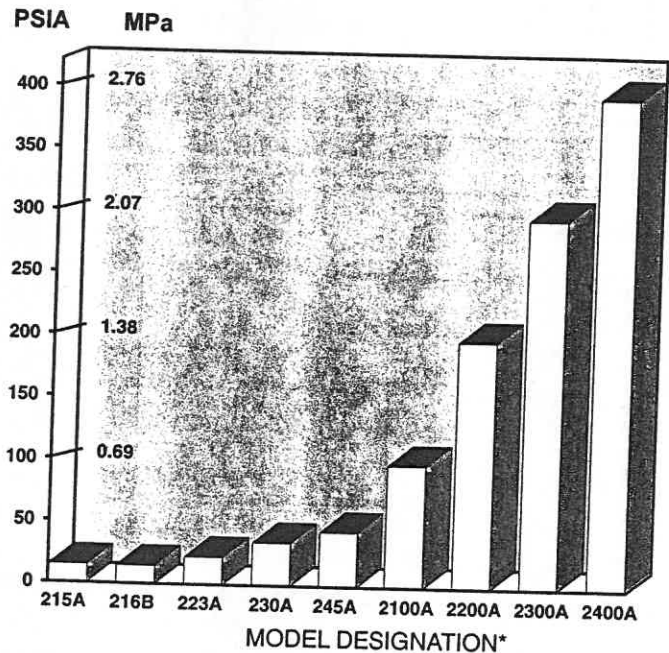
DIGIQUARTZ® PRESSURE TRANSDUCERS provide the ultimate in precision pressure measurements. Typical application accuracy of 0.01% is achieved even under difficult environmental conditions. Desirable characteristics include 1×10^{-8} resolution, low power consumption, and high reliability. The transducers are easy to interface with counters and digital computer systems.

The remarkable performance of these transducers is achieved through the use of a precision quartz crystal resonator whose frequency of oscillation varies with pressure induced stress. A quartz crystal temperature signal is provided to thermally compensate the calculated pressure and achieve high accuracy over a broad range of temperatures. The transducers include integral shock protection to withstand extremely high acceleration, shock, and vibrational loads.

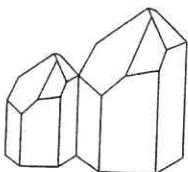
Excellent stability and low power consumption are mandatory for applications such as long term monitoring of barometric pressure. Superior resolution and accuracy comparable to the primary standards make DIGIQUARTZ® TRANSDUCERS ideal for high performance laboratory and calibration test systems.

All DIGIQUARTZ® products come with a limited five year warranty with the first two years covered at 100%.

SERIES 2000 PRESSURE RANGES

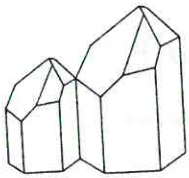


*See Series 3000 and Series 4000 absolute transducers for pressure ranges to 40,000 psia.



Paroscientific, Inc.
Digiquartz® Pressure Instrumentation





Digiquartz® Pressure Instrumentation

PERFORMANCE

Repeatability ±0.005% of Full Scale
 Hysteresis ±0.005% of Full Scale
 Acceleration Sensitivity ±0.0038% of Full Scale / g
 Max. Temp. Sensitivity Using Compensation Equation Provided ± 0.0008% of Full Scale/ °C

ENVIRONMENTAL

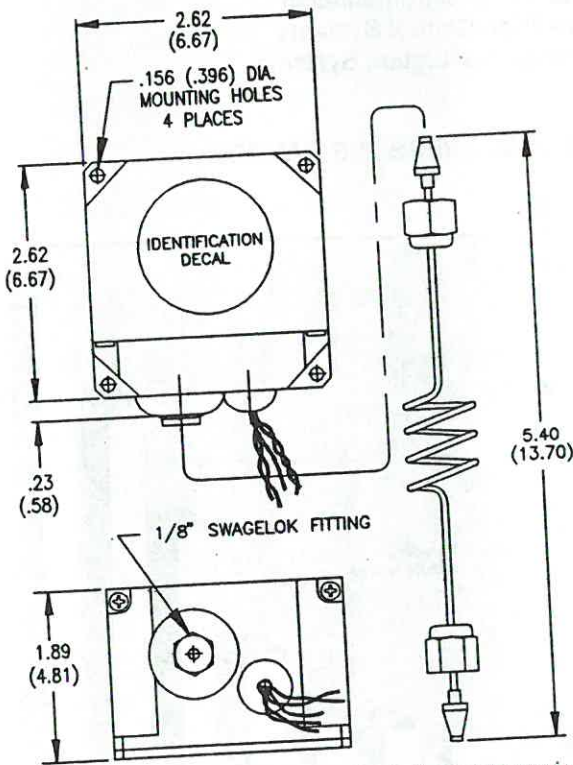
Overpressure 1.2 × Full Scale
 Calibrated Temperature Range -54°C to +107°C
 Power requirements +6 Volts DC @1.3mA
 (Operates from +25 V max to +6 min V.)
 Weight 15 ounces (430 grams)

CHARACTERISTICS

Pressure signal is a nominal 10% frequency change within the band 30KHz to 42KHz.
 Temperature signal is a nominal 45 ppm / °C sensitivity within the band 168KHz to 172KHz.
 Output signal is a nominal square wave of 4 volts amplitude peak to peak, capacitively coupled with source impedance less than 1000 ohms.
 Conformance and temperature compensation equations and calibration coefficients are provided with each transducer.

ORDERING INFORMATION

Listed below are standard model and part numbers. Please consult the factory for special configurations.



Dimensions are in inches - parenthesized dimensions are in centimeters.

PSIA	MPa	MODEL NO.	PART NO.
0-15	0-0.10	215A	1200-00X
11-16	0.08-0.11	216B*	1141-00X
0-23	0-0.16	223A	1201-00X
0-30	0-0.21	230A	1202-00X
0-45	0-0.31	245A	1203-00X
0-100	0-0.69	2100A	1204-00X
0-200	0-1.38	2200A	1205-00X
0-300	0-2.07	2300A	1206-00X
0-400	0-2.76	2400A	1207-00X

X = 1 For Stainless Steel Buffer Tube
 2 For Nylon Buffer Tube

Add -0 to the Part Number for Oil Filling (Liquid Applications)

* Barometer - 3 Year Stability Warranty
 0.01% of Reading Accuracy
 Temperature Range -54°C to +55°C

For more information on Paroscientific products, contact your local Digiquartz® representative or the application engineers at:

Paroscientific, Inc.
 4500 148th Ave. N.E.
 Redmond, WA 98052
 Tel: (206) 883-8700
 Fax: (206) 867-5407



Product defined by Specification Control Drawing. Specifications subject to change without prior notice. Manufactured under one or more of the following U.S. Patents: 4,089,058
 4,215,570 - 4,321,500 - 4,372,173 - 4,382,385 - 4,384,495 - 4,406,966 - 4,454,770 - 4,455,874 - 4,479,391 - 4,526,247 - 4,531,073 - 4,592,663 - 4,596,925 - 4,651,569 - 4,669,316 -
 4,706,259 - 4,713,540 - 4,717,240 - 4,724,351 - 4,727,752 - 4,733,561 - 4,743,752 - 4,751,849 - 4,757,228 - 4,764,244 - 4,831,252 - 4,872,343 - 4,912,990 - 4,929,860 - 5,113,698.
 Other patents pending. © Registered Trademark of Paroscientific, Inc. © Copyright 1994 by Paroscientific, Inc.