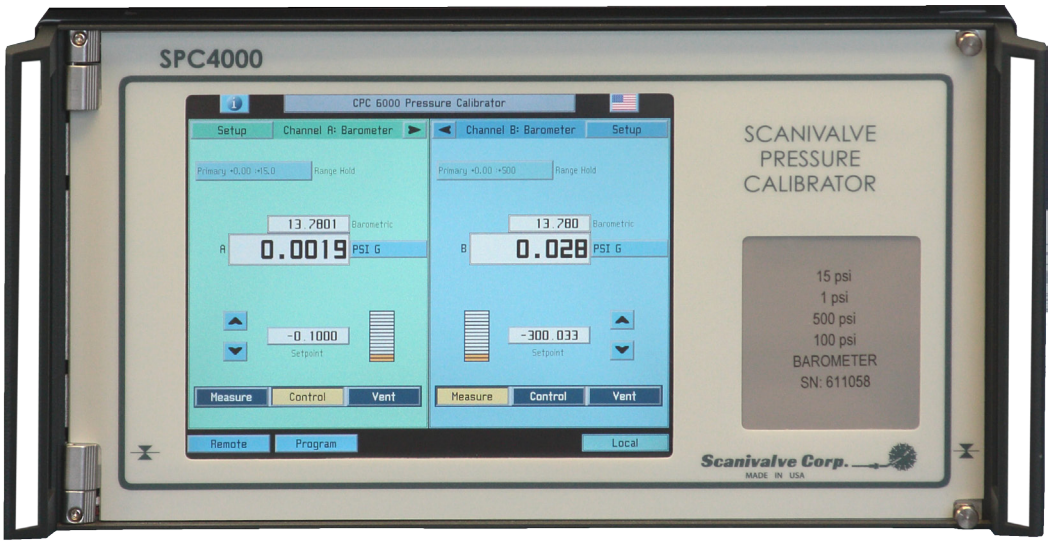
SPC4000
PRESSURE CALIBRATOR

OPERATION MANUAL

(REVISION B)



Scanivalve

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SECTION 1: INTRODUCTION

System Overview

The SPC4000 calibration system consists of three components; the SPC4000 calibrator, the Pneumatic Logic Unit (SPCPLU) and PressCal, Scanivalve's free calibration software.

The Scanivalve SPC4000 Pressure Calibrator is a multi-channel, multi-range pressure system based off of Mensor's CPC6000. It is designed to test and calibrate all of Scanivalve's pressure measurement equipment. The SPC4000 can have two independent control channels, each with its own pressure regulator. Each control channel can have up to two transducers.

Scanivalve's Pneumatic Logic Unit (SPCPLU) is a compliment to the SPC4000 Pressure Calibrator and allows the SPC4000 to perform automated calibrations on any DSA or ZOC modules.

Scanivalve's PressCal calibration software is included with the purchase of every SPC4000 and is capable of controlling the SPC4000, the SPCPLU and communicating with the Scanivalve module being calibrated.

The SPC4000 system (SPC4000 calibrator and SPCPLU) is capable of calibrating multiple modules of different ranges during the same automated calibration without any operator intervention.

Unpacking The SPC4000 System

Upon receiving your SPC4000 system, the first thing you should do is to unpack, inventory and inspect all of the included components of the SPC4000 system. Before it left the Scanivalve factory, the SPC4000 system was subjected to many hours of testing and inspection. Please look over all included components and inspect for any damage that might have occurred during shipping. Report any visible damages to the shipper and to Scanivalve immediately. Once you have inspected all included components for any signs of damage, it is important that you do an inventory check and ensure that all components and accessories were included in the shipment. The shipment should include:

1) SPC4000 Calibrator
2) Pneumatic Logic Unit (SPCPLU)
3) Rack Mount Fixture
- Main rack mount assembly
- Foam padding
- Mounting hardware (6 #10x1/4" screws)

4) Certificate of calibration
5) Digital Out cable 155662-01 (1 or 2)
6) Power Cord
7) Swagelok® to bulge-tube adaptors (1/8" & 1/16")
8) Helical spring-clamps (1/8" & 1/16")
9) Nylon tubing (25' - 1/8"; 25' - 1/16")
10) PressCal installation CD
11) SPC4000 Resource CD

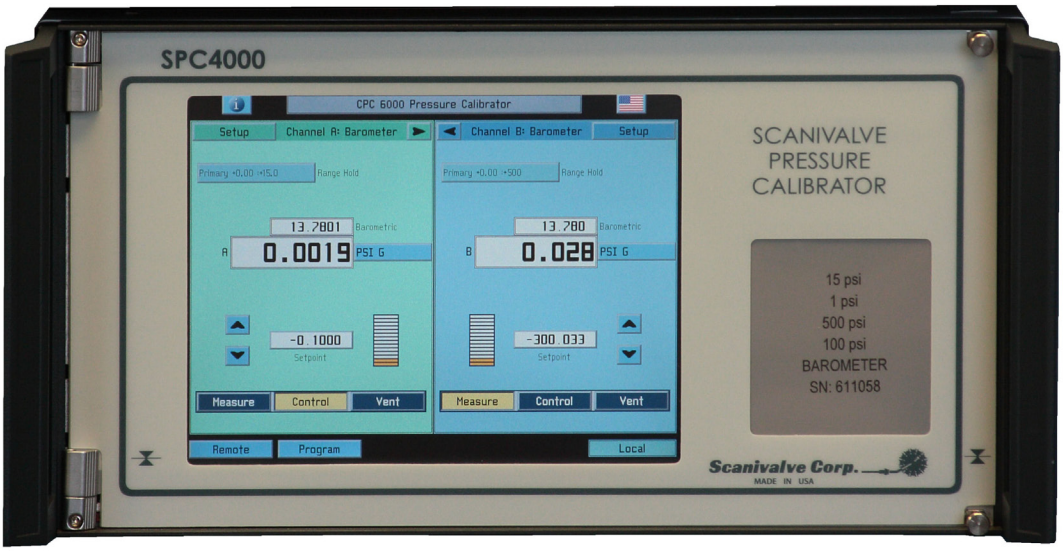


FIGURE 1.1 - SCANIVALVE SPC4000 FRONT PANEL

SPC4000 FRONT PANEL

The SPC4000 front panel includes and 8.4 inch color SVGA display featuring touch screen technology. Operator input is accomplished by pressing the words or symbols presented on the display. There are no discrete keypads or switched on the front panel. On the right hand side of the front panel there is a clear window which shows the calibrated pressure ranges of the internal transducers and the calibrator serial number.

To gain access to the internal modules simply loosen the two thumb screws on the right hand edge of the front panel and swing it open (Figure 1.2). In the front of the instrument directly below the electrical module are slots to accommodate two pressure transducer modules on each control channel. Each transducer can be removed and reinstalled through the front panel opening. See Section 6: ***Maintenance***, for additional information on module removal and replacement.

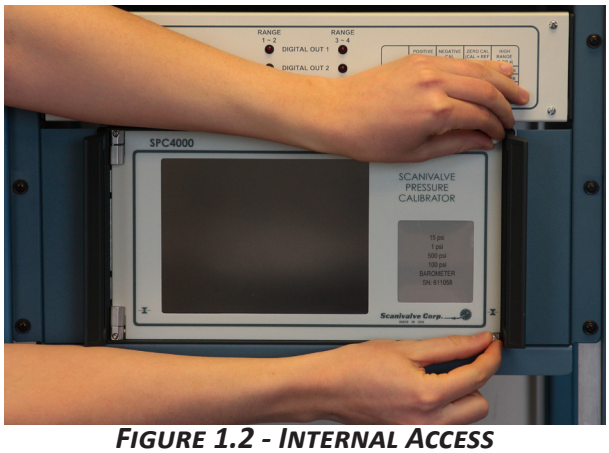


FIGURE 1.2 - INTERNAL ACCESS

SPC4000 REAR PANEL

Up to eight pneumatic pressure ports are located horizontally across the rear panel (Figure 1.3). Positioned to the right of the pressure ports are the Ethernet and RS-232 connectors, the off/on switch, the line fuses, and a protective grill covering the ventilating fan.

Figure 1.3 shows a rear panel containing two solenoid valve regulator pneumatic modules. Rear panels may differ slightly depending on what modules are installed.

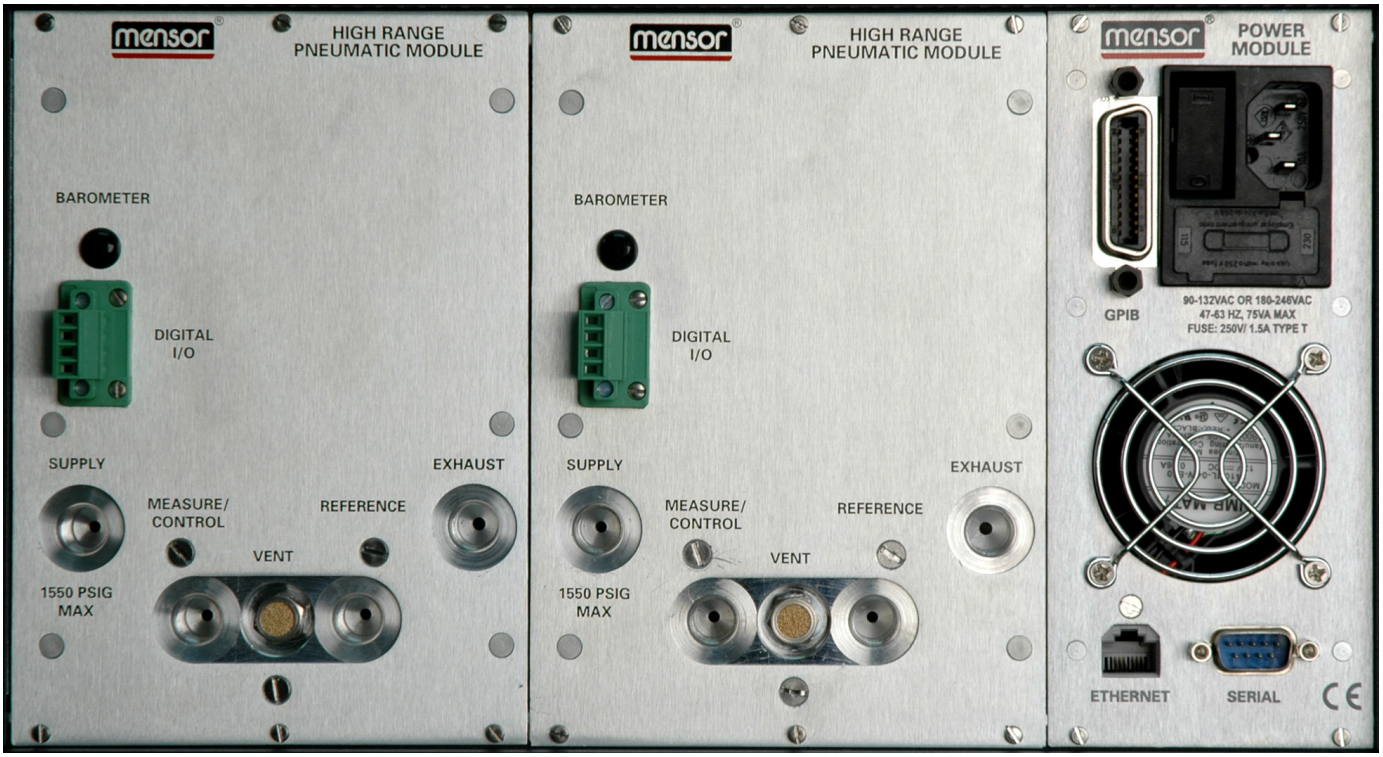


FIGURE 1.3 -REAR PANEL

SPC4000 DISPLAY

When the SPC4000 is powered up it takes about one minute for initialization, then it displays a screen similar to Figure 1.4. The display is made up of rectangles which display text or symbols.

Keys, Tabs, Labels and Windows: In this manual a key is a small rectangle which acts as a switch when pressed. Keys have borders with a three dimensional, shadowed effect. Tabs are a group of touch points, each of which will overlay most of the screen with one page related to its title subject. Small rectangles with solid borders that display information, but do not respond to being touched, are called Labels or Windows.

Keys: Keys cause something to change when they are touched. Throughout this manual keys are represented with the displayed characters enclosed in brackets such as [PSI A]. Each key has a characteristic response when actuated; either an instant, single step response when the key is pressed, or continuously repeating steps while the key is held down, or a delayed response when released. Operators will quickly become accustomed to the particular characteristics of the frequently used keys. Some keys become labels under certain conditions, then resume their key function in other circumstances.

Header Bar: The bar across the top of the screen which displays the Mensor Logo, a title frame, and a national flag is stationary and remains displayed at all times. All of the number formats and text displayed on the SPC4000 screens will be in the language appropriate to the national flag displayed here such as American English for the USA flag, etc. Touch the flag to access a drop-down window showing all of the languages programmed into the SPC4000. Touch any flag to change the display to the corresponding language.

Optional Display: The optional display is a window near the pressure label. This window can be set up to be blank, or to display any one of the following:

- Peak Pressure – minimum and maximum
- Rate of change of a measured pressure
- Barometer reading

Footer Keys: Like the top bar, the [Remote] and [Program] keys on the bottom left corner of the display remain permanently on-screen. Touching either of these keys will cause that subject page to appear in the display.

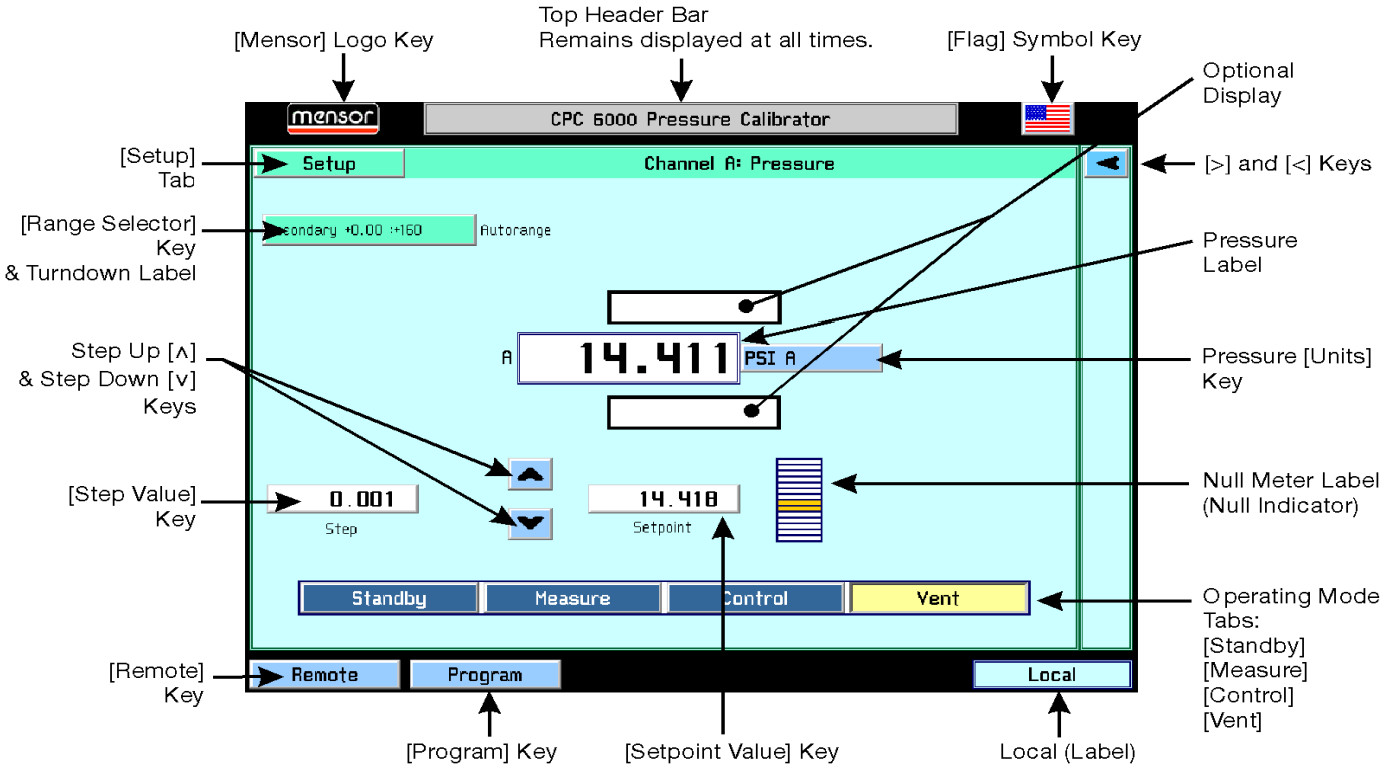


FIGURE 1.4 - TERMINOLOGY OF SCREEN ELEMENTS

SPC4000 ELECTRICAL MODULE

The electrical module is illustrated below with the instrument lid removed (Figure 1.5). All program information to run the system resides on a solid state disk module located on this module. The power switch and line fuses are situated on the rear of the electrical module such that they are accessible on the rear of the fully assembled SPC4000.

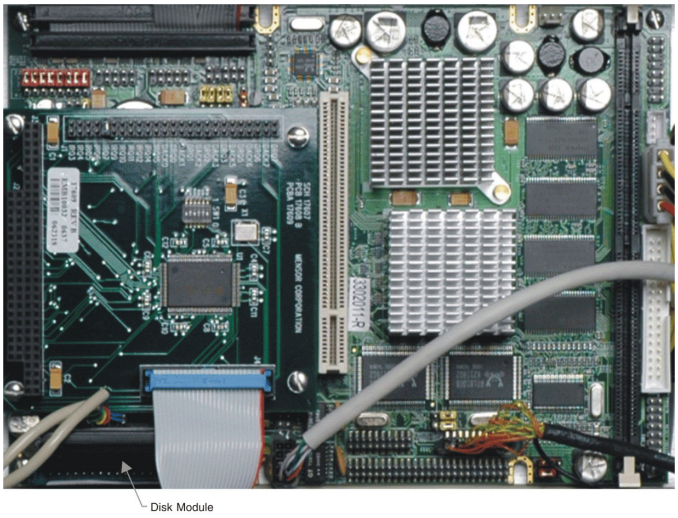


FIGURE 1.5 - ELECTRICAL MODULE

SPC4000 PNEUMATIC MODULE

Pneumatic modules come in two types and are referred to in this manual as the "Pump Regulator" or the "Solenoid Valve Regulator". The pump regulator is used with low pressure sensors specified in Section 2: ***Specifications***. The solenoid valve regulator is used with higher pressure sensors and comes in three varieties:

High Pressure Solenoid Valve Regulator (HPSVR)
Medium Pressure Solenoid Valve Regulator (MPSVR)
Low Pressure Solenoid Valve Regulator (LPSVR)

Pressure limits for all of these are specified in Section 2: ***Specifications***.

Each pneumatic module (Figure 1.6) includes platforms for up to two high performance pressure transducers which are traceable to NIST standards. Both of these transducers can be used in conjunction with the highly stable pressure regulator to produce a precise pressure output. Each transducer includes its own on-board compensation and calibration data so that any transducer can be replaced in the instrument without requiring a recalibration.

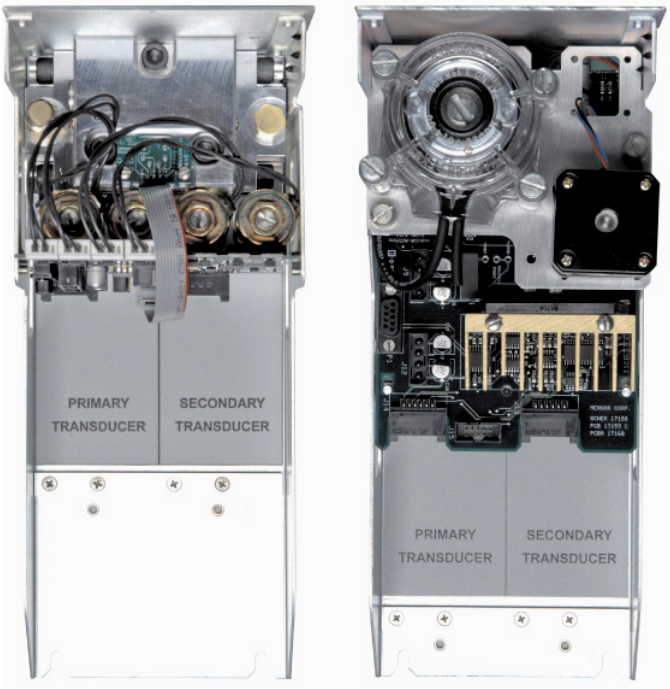


FIGURE 1.6 - PNEUMATIC MODULE

SPC4000 Chassis Assembly

The chassis assembly acts as the housing for the system. The electrical and pneumatic modules are each self-contained inside the chassis, and either can be replaced using basic hand tools. In addition, each pressure transducer is individually removable without tools. Instructions for transducer and module removal are provided in Section 6: ***Maintenance***.

The only moving parts in the SPC4000 are the fan, the pneumatic flow controller diaphragms and valves, the pump/motor, and the solenoid valve plungers. There are no internal user adjustments or setup switches.

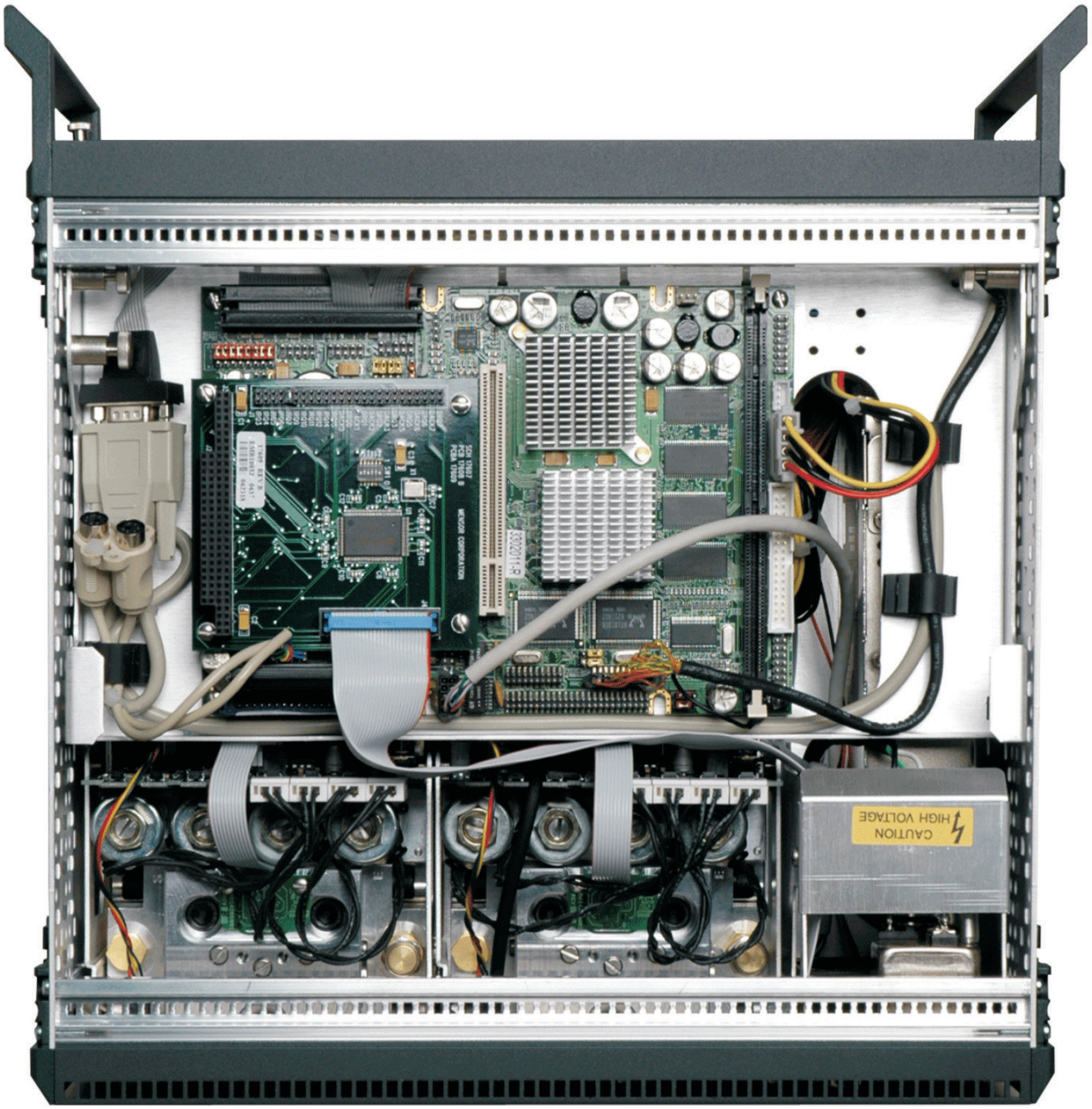


FIGURE 1.7 - CHASSIS ASSEMBLY

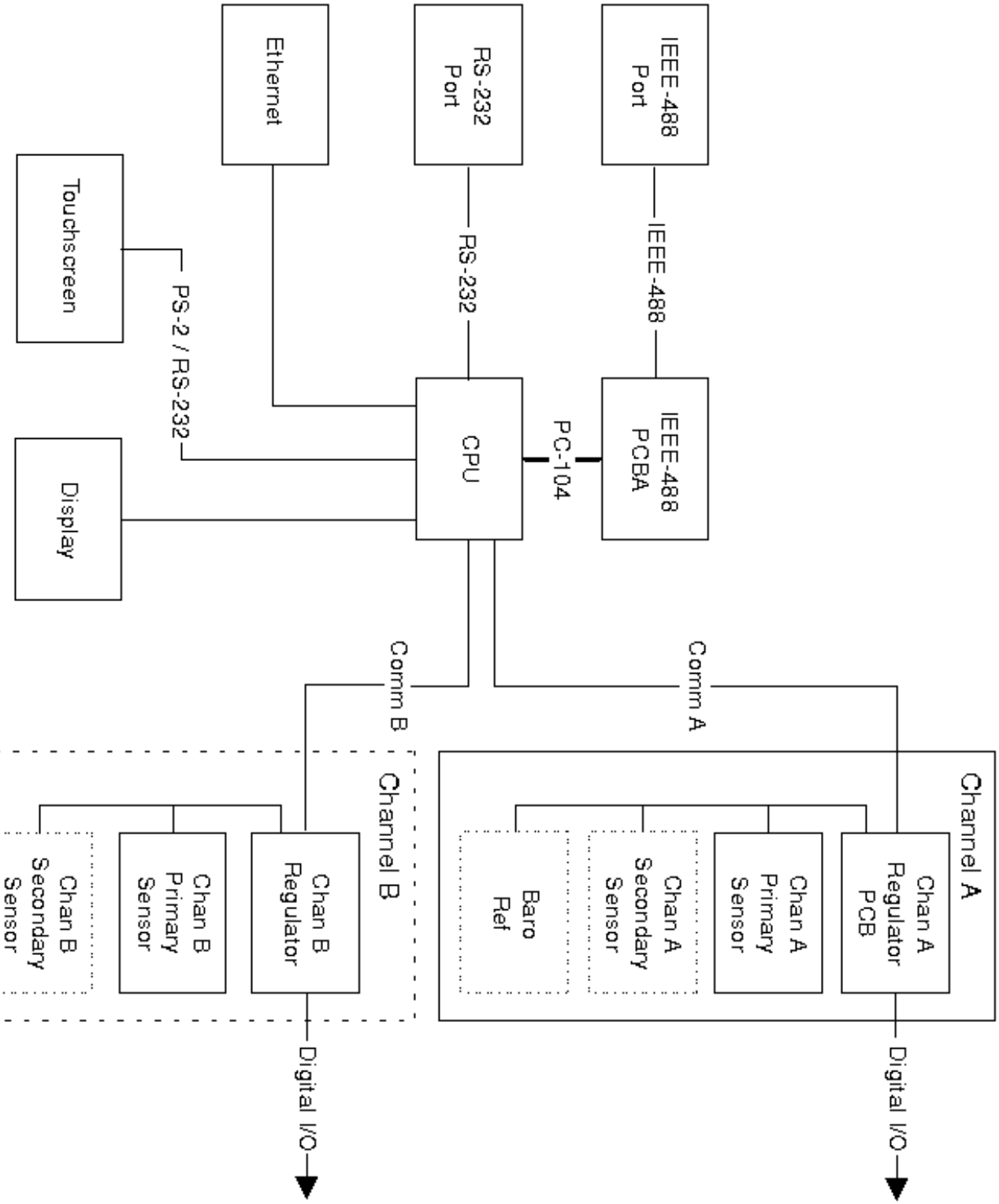


FIGURE 1.8 - SPC4000 ELECTRICAL BLOCK DIAGRAM

SPCPLU Overview

The Pneumatic Logic Unit (SPCPLU) is required for automated calibrations of DSA and ZOC modules. The SPCPLU is designed to orchestrate all of the pneumatic switching required during the calibration. It contains all required pneumatic solenoid valves and manifolds required to perform both single and multi-range calibrations as well as zero offset corrections. The SPCPLU is dependant on the SPC4000 for configuration and is controlled by 3 digital outputs per channel from the SPC4000.

The SPCPLU is capable of segregating four individual calibration pressure ranges to allow modules of varying pressure ranges to be calibrated together during a single automated calibration procedure. Figure 1.9 depicts the internal pneumatic logic of the SPCPLU as well as how it interacts with the SPC4000 calibrator and the module being calibrated

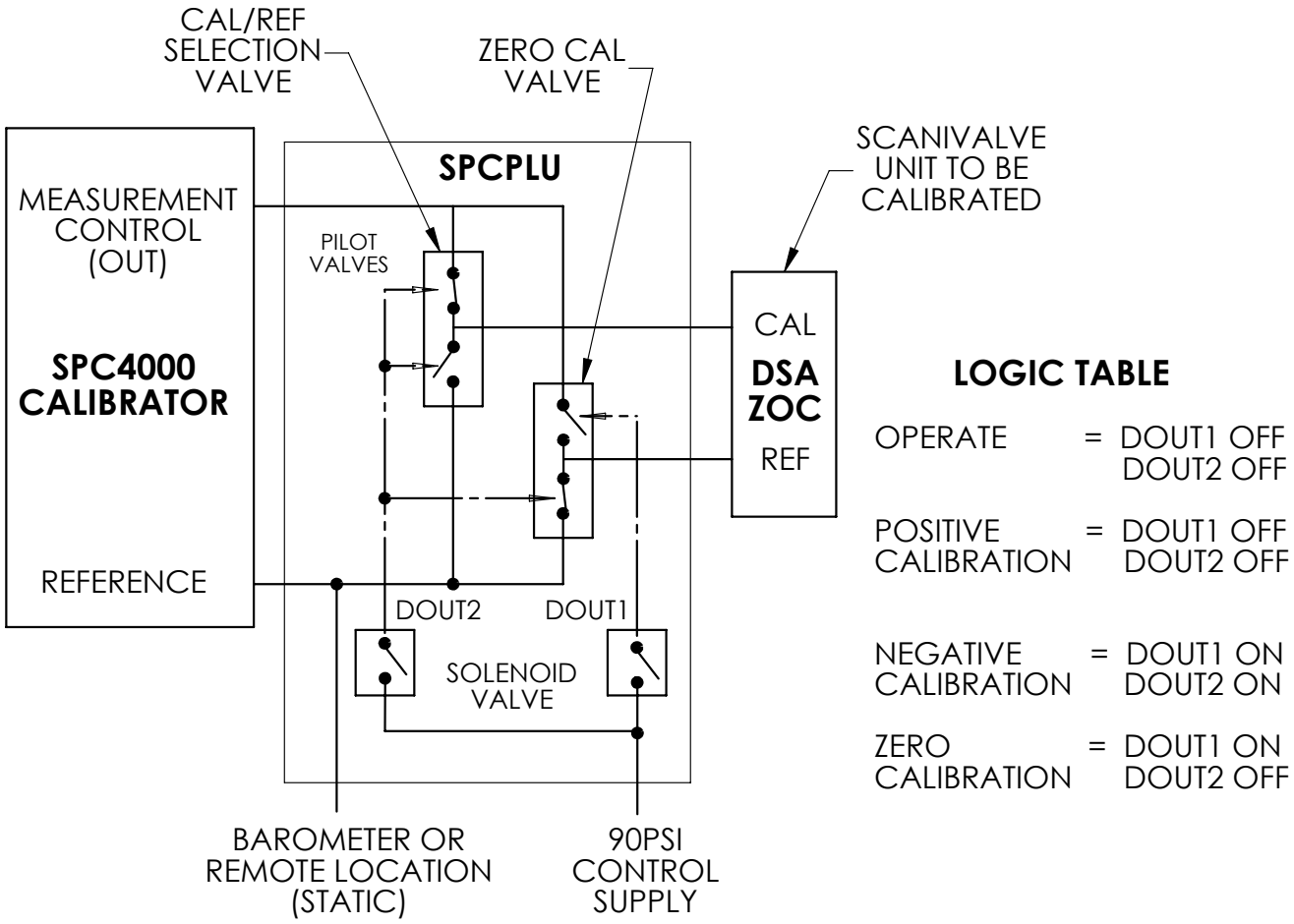


FIGURE 1.9 - SPCPLU PNEUMATIC LOGIC

SPCPLU FRONT PANEL

The front panel of the SPCPLU (Figure 1.10) displays its current configuration using 6 LEDs. Each of the LEDs represent the current state of each one of the internal solenoid valves. Included on the front panel of the SPCPLU is a truth table explaining each of the SPCPLU's configurations and the digital outputs associated with each.

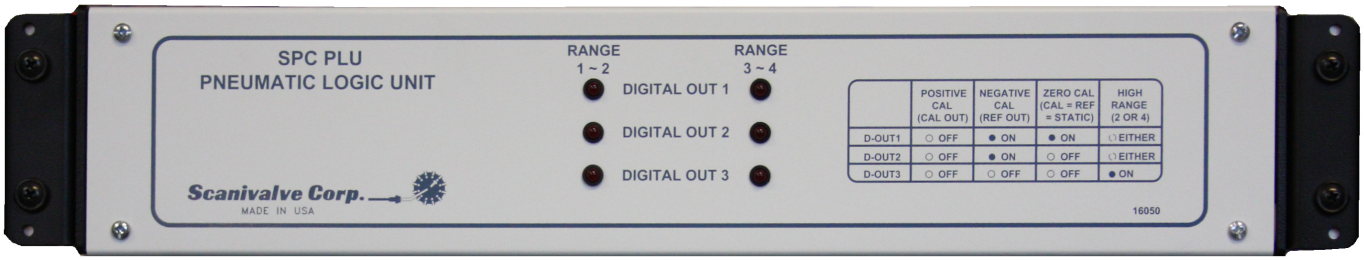


FIGURE 1.10 - SPCPLU FRONT PANEL

SPCPLU REAR PANEL

All of the pneumatic interfaces for the SPCPLU are located on the rear panel of the SPCPLU (Figure 1.11). These include input pressures, control pressure inputs, reference output and calibration output. Also located on the rear panel of the SPCPLU are the digital input/output connections. Each of the pneumatic fittings on the rear of the SPCPLU are 1/4" Swagelok® fittings. It is important that any pneumatic input or output not being used should be plugged.

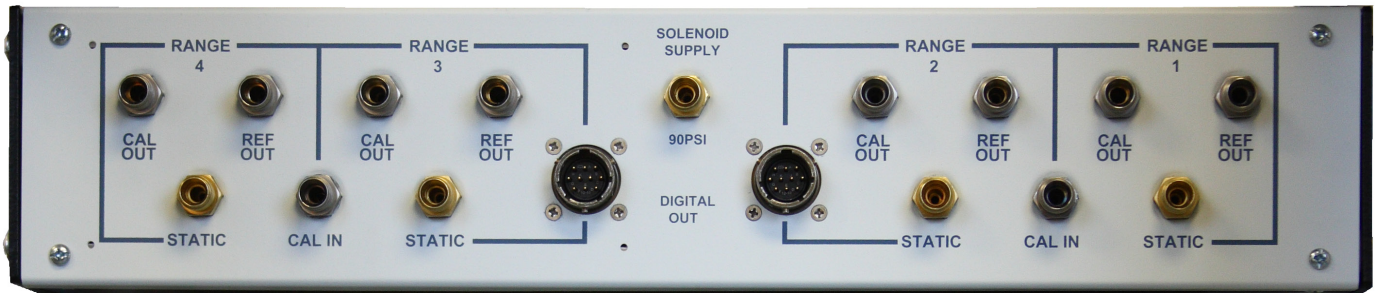


FIGURE 1.11 - SPCPLU REAR PANEL

SPC4000 SYSTEM OVERVIEW

In order to fully exploit the capabilities of the SPC4000 calibrator, it must be used in the SPC4000 system which includes the SPCPLU and PressCal software. Figure 1.12 shows the SPC4000 mounted in a standard 19" rack with the SPCPLU. This configuration allows fully automated, multiple range calibrations to be performed.

FIGURE 1.12 - SPC4000 SYSTEM

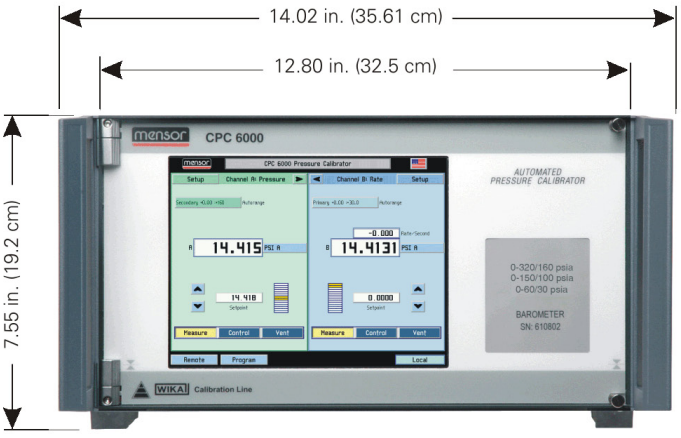
SECTION 2: SPECIFICATIONS

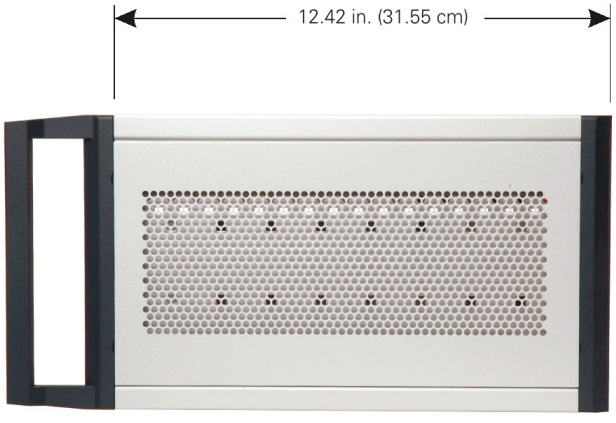
GENERAL SPECIFICATIONS- SPC4000

Size (WxHxD)	14.02” x 7.55” x 14.42” (35.61 cm x 19.2 cm x 31.55 cm)
Weight	36lbs - with all internal options (16.33 kg)
Power Requirements	100-240 VSC, 47-63 Hz, 75VA max
Digital I/O	
Pneumatic Interfaces	1/4” Swagelok®
Particle Filters	The instrument has 20-micron filters on all pressure ports through the manifold. The baro metric transducer has no filters.
Overpressure Protection	Protected by relief valves.
Compensated Temperature Range	15°C to 45°C
Operating Temperature Range	0°C to 50°C
Storage Temperature Range	0°C to 70°C
Local User Interface	8.4” color LCD display with 8 wire resistive touch screen.
Remote User Interface	Serial RS-232, Ethernet
Warm-up Period	Approximately 30 minutes for full accuracy
Orientation Effects	Negligible
Operating Environment	5 to 95% RH non-condensing

GENERAL SPECIFICATIONS - SPCPLU

Size (WxHxD)	19” x 3.5” x 13” (48.3 cm x 8.9 cm x 33 cm)
Weight	6.9 lbs - SPCPLU-1 (3.13 kg) 11.5 lbs - SPCPLU-2 (5.22 kg)
Pneumatic Interfaces	1/4” Swagelok®
Control Pressure	
SPCPLU-1 & -2	90-120 psi - user supplied
SPCPLU-3 & -4	60-70 psi - user supplied





CONTROL SPECIFICATIONS FOR PUMP REGULATOR

Source Requirements	
Fast Mode	110% of highest pressure
Slow Mode	None
Stability of Controlled Pressure	0.003% of span, typically better than 0.001% of span 10 seconds after displaying stable flag.
Available Sensor Range	0-.36 psig to 0-15 psig
Minimum Controlled Pressure	0.05% FS or 0.5 psi over exhaust pressure, whichever is greater
Control Time	
Fast Mode	10 seconds to stable flag for 10% FS step pressure change into 50cc volume. Larger volumes can lengthen this time.
Slow Mode	15 seconds to stable flag for 10% FS step pressure change into 50cc volume. Larger volumes can lengthen this time.
Supply Consumption	
Fast Mode	Zero after set point is reached. All supply gas is used for upscale pressure sample filling.
Slow Mode	Zero
Measure to Control Offset	<0.0005% Span
Overshoot	<1% of active range

CONTROL SPECIFICATIONS FOR SOLENOID VALVE REGULATOR

Source Requirements	110% of highest pressure or 20 psi over highest pressure transducer, whichever is less
Stability of Controlled Pressure	0.003% of span, typically better than 0.001% of span 10 seconds after displaying stable flag.
Available Sensor Range	
LPSVR	0-1 psig to 0-50 psig
MPSVR	0-10 psig to 0-150 psig
HPSVR	0-75 psig to 0-850 psig
Minimum Controlled Pressure	0.05% FS or 0.25 psi over exhaust pressure, whichever is greater
Control Time	10 seconds to stable flag for 10% FS step pressure change into 50cc volume. Larger volumes can lengthen this time.
Supply Consumption	<2.5 scfh in steady-state mode
Overshoot	
Low overshoot mode	<0.005%
High speed mode	<1.00%

MEASURE SPECIFICATIONS

Accuracy	±0.01% FS
Calibration Period	365 days (15 psi +) 180 days (0-14.9 psi)
Precision	0.003% of span
Pressure Ranges***	0.36 psig 1 psig 5 psig 15 psig 50 psig 100 psig 200 psig 500 psig 750 psig 850 psig
Resolution	4 to 6 significant digits, user selectable
Optional Barometer Range	11 to 17 psia
Optional Barometer Uncertainty	±0.01% FS
Optional Barometer Calibration Period	180 days
Pressure Media	Clean, dry, non-corrosive, non-combustible, non-oxidizing gases. Not for oxygen use.

*** Nominal pressure ranges listed. Actual transducer pressure range will be 10-20% greater.

SECTION 3: INSTALLATION

MOUNTING

The SPC4000 system is intended to be mounted in a standard 19" rack. If desired however, it can be used in a bench top application. Installing the SPC4000 system into a rack requires the rack mount (included). The SPC4000 and the SPCPLU must be installed in the rack mount before being installed in a 19" rack.

The special sensors used in the SPC4000 are relatively insensitive to tilt and vibration. However to further assure stability and accuracy, avoid mounting the instrument on surfaces subject to excessive motor or machinery vibration.

CAUTION! Improperly installing the SPC4000 calibrator or the SPCPLU could result in damage to the components.

PNEUMATIC CONNECTIONS

All pneumatic connections on the SPC4000 and the SPCPLU are 1/4" Swagelok® fittings. A variety of 0.125" and 0.063" Swagelok® to bulge-tube adaptors are provided with the SPC4000 to provide a means of connecting smaller tubing to the 1/4" Swagelok® fittings. If desired, either Swagelok® nut and ferrule or a Scanivalve X-lok adaptor fittings can be used in place of the Swagelok® to bulge-tube adaptors. When making the pneumatic connections, it is important to not use any form of sealant on the O-ring sealed connections. Take great care when making the connections, as even a microscopic leak can cause errors in the pressure measurements.

Refer to Figure 3.1 and Figure 3.3 for a layout of all connections of the SPC4000 and the SPCPLU.

SUPPLY PORT

Connect a source pressure to the SUPPLY port of each channel. A source pressure is not required if using a Pump Regulator, however if the SPC4000 will be required to supply pressures to large volumes (300cc +) it is recommended that a source pressure is provided. See "Source Pressure" in Section 2: Specifications, for supply pressure requirements for various pressure ranges. Keep in mind, a well regulated supply pressure will aid in providing more stable, accurate output from the calibrator.

CAUTION! Separate supply pressures should be applied to each of the independent control channels based on the maximum pressure range of each channel. Applying source pressure higher than the recommended pressure can cause permanent damage to the control channel.

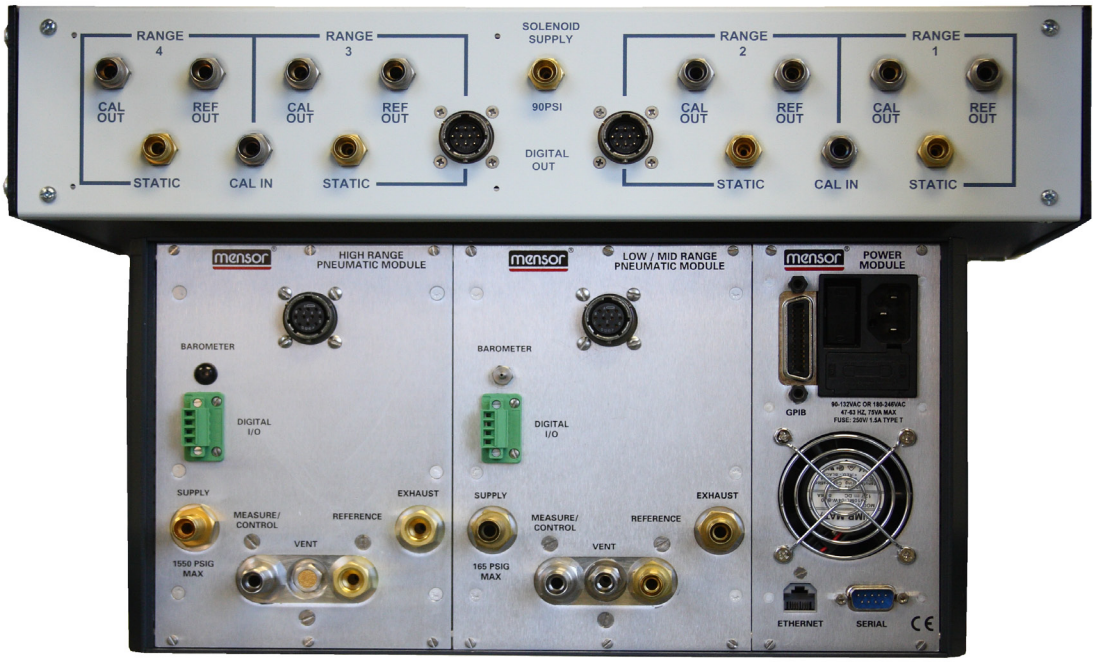


FIGURE 3.1 - SPC4000 SYSTEM REAR VIEW

MEASURE/CONTROL/CAL PORT

The Measure/Control/Cal port is the output pressure from the SPC4000 calibrator. Connect this port to the 'Cal In' port on the SPCPLU for the related channel. In addition to outputting a precisely controlled pressure out of this port, when the SPC4000 is in 'Measure' mode, the calibrator will measure and display the pressure at this port.

A pressure value can be selected using the on-screen keypad. That pressure will then be output to the MEASURE/CONTROL/CAL port by switching to the CONTROL mode of operation.

EXHAUST PORT

If sub-atmospheric control pressure is required a vacuum pump must be connected to the EXHAUST port. Otherwise, this port may be left open to atmosphere.

CAUTION! Improper use of this equipment may impair protection provided by this instrument.

REFERENCE/STATIC PORT

This port is connected to the reference side of the transducer. This port is normally left open to atmosphere but should be connected to a known reference or static source for low pressure calibrations.

WARNING! HIGH NOISE LEVELS! As pressure decreases compressed gas will escape out the exhaust port. For ranges above 500 psi high noise levels may result during such pressure releases. To overcome objectionable exhaust noise either install a muffler or route the port to a remote location.

VENT PORT

Built up calibration pressure is vented through this port. It can be left open to local atmosphere, or it can be routed to a remote venting location.

SPCPLU STATIC PORT

The SPCPLU has an individual static port for each range. This port is used when a zero calibration is performed on the Scanivalve module being calibrated. It should be plumbed to the same location as the reference/static port on the SPC4000 calibrator is plumbed to. That is, for low pressure modules, to some form of stable static reference location and for higher pressure modules left open to local atmosphere. Either case, it is very important that the SPCPLU static port and the SPC4000 reference/static port are tied to the same location. If any of the Static Ports are not being used, ensure that the fitting is plugged.

SPCPLU SOLENOID SUPPLY PORT

There is one solenoid supply port on the SPCPLU. This is the supply pressure for the pneumatic solenoids within the SPCPLU. It is very important that adequate control pressure is supplied to the SPCPLU (90psi for SPCPLU-1&-1, 60psi for SPCPLU-3&-4 minimum). Anything less than this may not be sufficient for proper function and switching of the internal pneumatic solenoids.

SPCPLU CAL OUT PORT

Each range on the SPCPLU has a dedicated Cal Out port. This is the calibration port that needs to be connected to the positive calibration port on the module being calibrated. If any of the Cal Out ports are not being used, ensure that the fitting is plugged.

SPCPLU REF OUT PORT

Each range on the SPCPLU also has a dedicated Ref Out Port. This needs to be connected to the negative, or reference calibration port on the module being calibrated. If any of the Ref Out ports are not being used, ensure that the fitting is plugged.

DIGITAL I/O CONNECTIONS

After all pneumatic connections have been made, connect the Digital Output(s) from the SPC4000 calibrator to the Digital Input(s) on the SPCPLU. These Digital I/O's allow the SPC4000 calibrator to communicate with and control the SPCPLU. Make sure that the Digital I/O's are connected to the correct output channel from the SPC4000. Range 1 & 2 on the SPCPLU must be connected to Digital I/O's of Channel A on the SPC4000, and range 3 & 4 on the SPCPLU must be connected to Channel B.

COMMUNICATIONS CONNECTIONS

If the SPC4000 system is to be operate remotely, communications connections must be made to the SPC4000. Connect either an Ethernet cable to the Ethernet port, or a serial cable to the RS-232 port. For more information on remote communications with the SPC4000, see Section 4: ***Remote Operations***.

POWER UP!

After the pressure connections are secure and the communication connection is made, connect the power cord first to the SPC4000. After the power cord is securely connected to the SPC4000, apply power to the calibrator. Turn on the power switch, located on the back of the power supply module immediately beside the power connector to power the system up.

The calibrator will go through an initialization process and system check during the power up cycle. As soon as the system check is completed the system will default to an operating screen similar to Figure 3.2. Before performing any critical calibrations or pressure measurements, allow the system to warm up for at least 30 minutes.

WARNING! EARTH GROUND!
Any power adaptors or surge protection devices that negate the protective earth ground should not be used.

SYSTEM OPERATION AND LEAK CHECK

After they SPC4000 has warmed up (minimum 30 minutes) and before any calibrations are attempted, ensure that the system is leak tight. The 'Cal' and 'Ref' ports on the SPCPLU either need to be plumbed to a Scanivalve pressure module or plugged for this test. Apply a positive pressure (reference Section 5: ***Local Operations*** for instructions on controlling the calibrator's output locally), allow the pressure to stabilize and then put the SPC4000 into 'measure' mode. This traps the system. Monitor the pressure to see if any leaks are present. Repeat the test with a negative pressure applied. Also verify that the DOUT indicator LED's on the front of the SPCPLU match the configurations shown in the truth table on the front panel of the SPCPLU. If any problems or leaks are detected, reference Section 6: ***Maintenance*** for troubleshooting information or contact Scanivalve.

WARNING! VENTILATION!
Do not block airflow to ventilation fan located on the rear of the instrument.

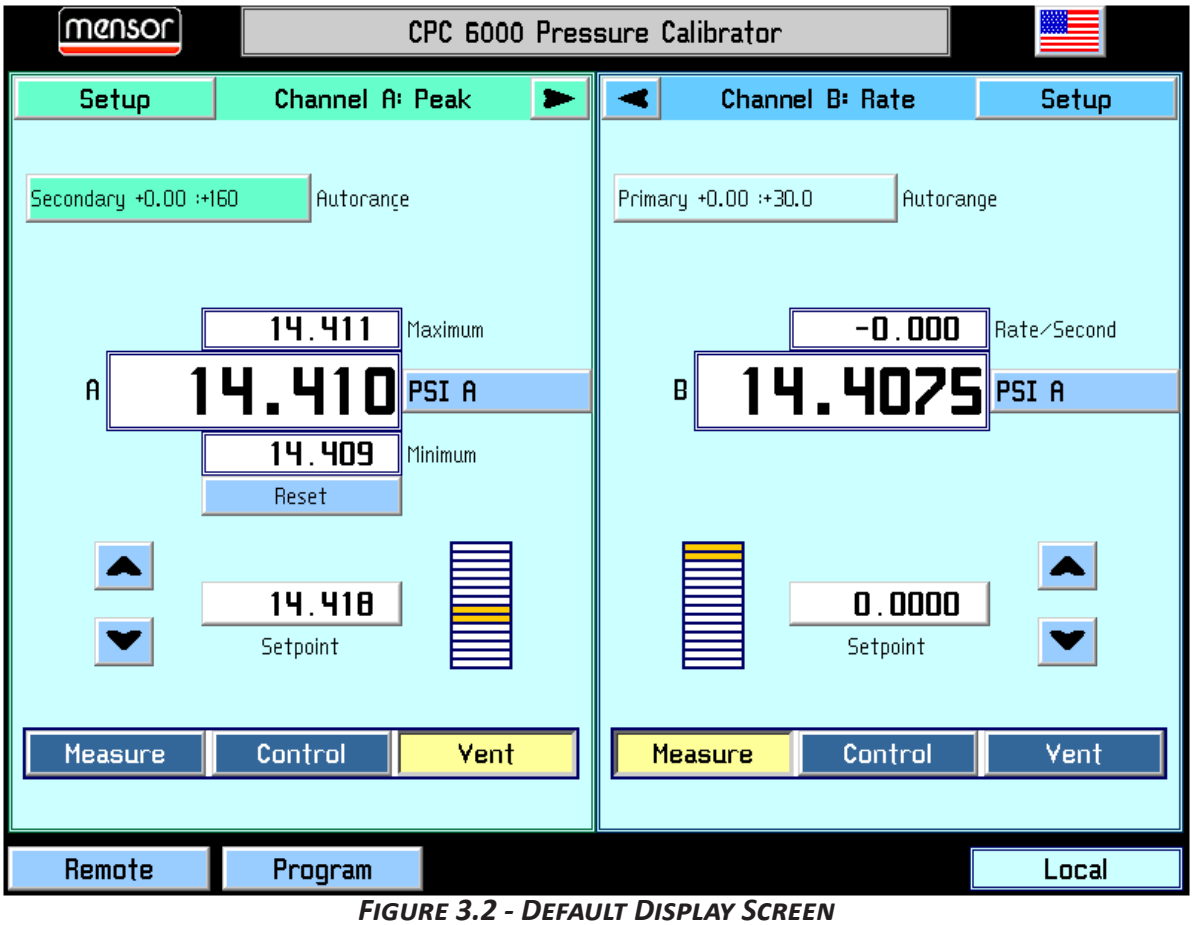


FIGURE 3.2 - DEFAULT DISPLAY SCREEN

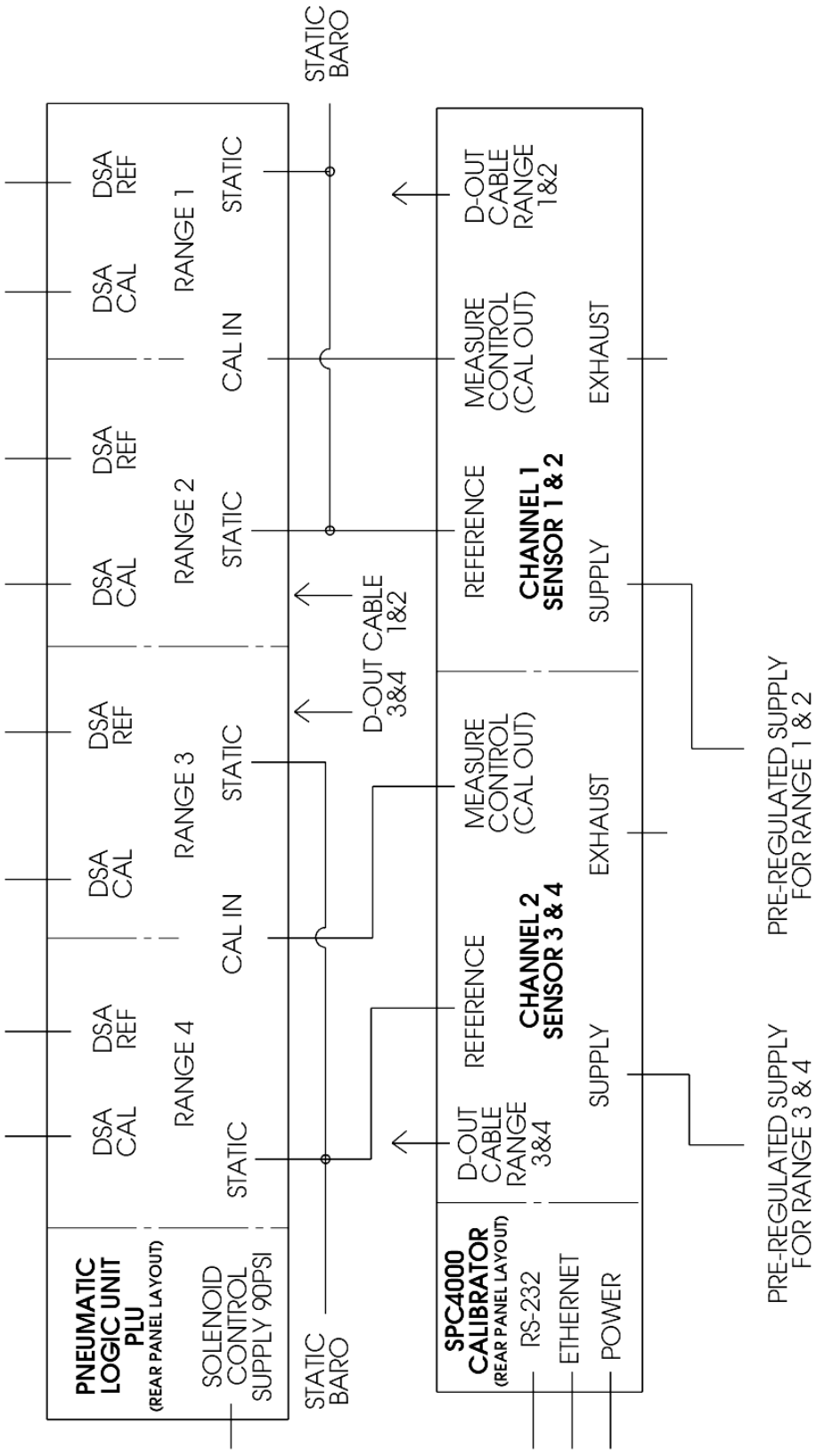


FIGURE 3.3 - SPC4000 / SPCPLU CONNECTIONS

SECTION 4: REMOTE OPERATIONS

REMOTE SETUP

Use the following screens to set the operating parameters for the Ethernet and RS-232 serial ports.

Press the [Remote] key located on the bottom left corner of the screen, and a new display appears with another set of tabs across the top as shown in Figure 4.1.

INSTRUMENT SETUP SCREEN

Press the [Instrument] tab to set up available emulation modes. The default command set is Mensor.

[A] [B] (channel selection): This channel selection sets the active remote channel to A or B and is useful for customers using an SPC4000 to replace two single channel controllers. The user can simply select the channel here first and then begin their normal program.

[Monitor] key: Press the [Monitor] key to bring up the remote monitor window (Figure 4.2) which displays current remote activity and syntax errors. This is helpful when troubleshooting programs.

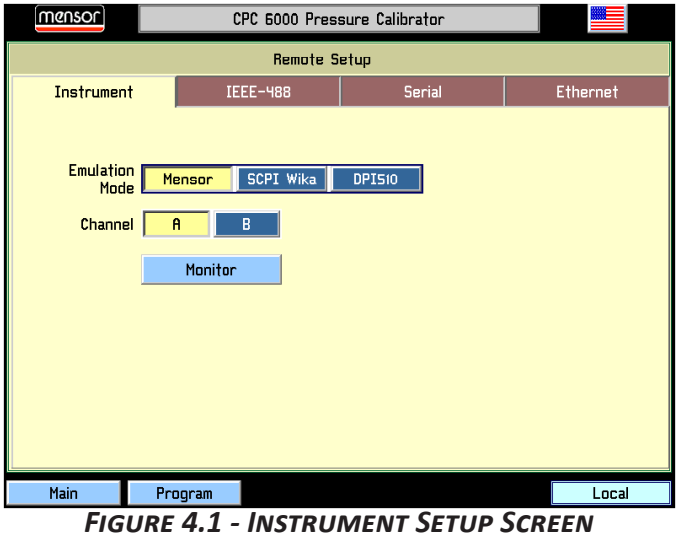


FIGURE 4.1 - INSTRUMENT SETUP SCREEN

IEEE-488 SETUP SCREEN

The IEEE-488 function is not available on the SPC4000 calibrator so this screen is extraneous and can be ignored.

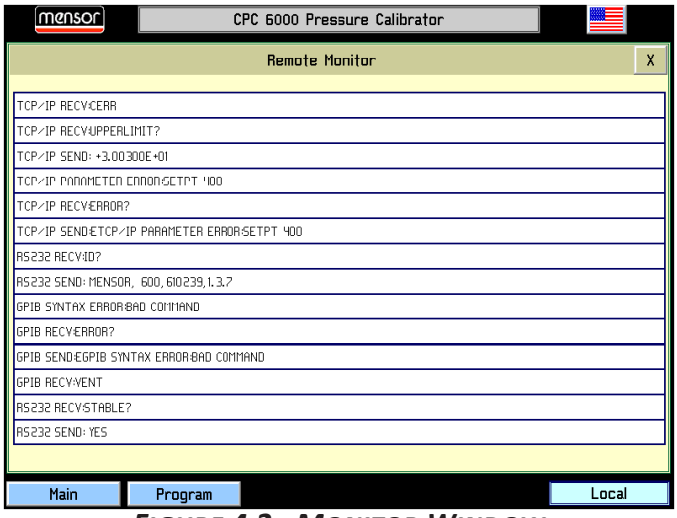


FIGURE 4.2 - MONITOR WINDOW

SERIAL SETUP SCREEN

Press the [Serial] tab to set up the serial port parameters (Figure 4.3). These parameters should be set up to match your host computer. Default settings are: 57600, 8,1, none parity, and no echo.

If the Echo check box is checked, the SPC4000 will immediately echo back characters sent over the serial port.

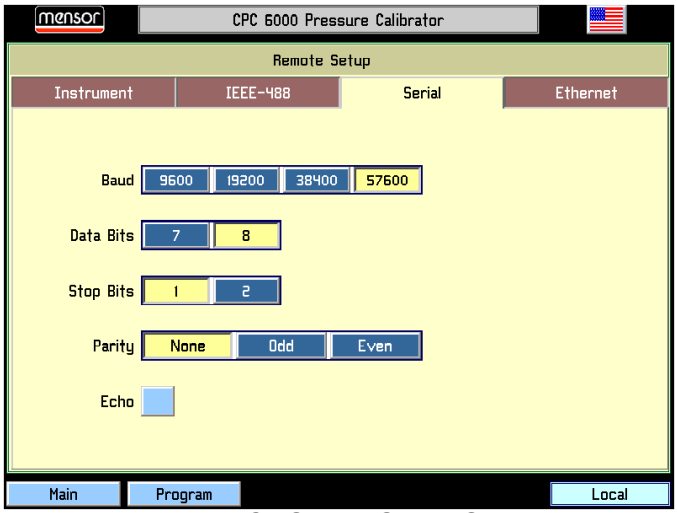


FIGURE 4.3 - SERIAL SETUP SCREEN

ETHERNET SETUP SCREEN

Press the [Ethernet] tab to set up the Ethernet parameters (Figure 4.4). These parameters should be set up to match your host computer.

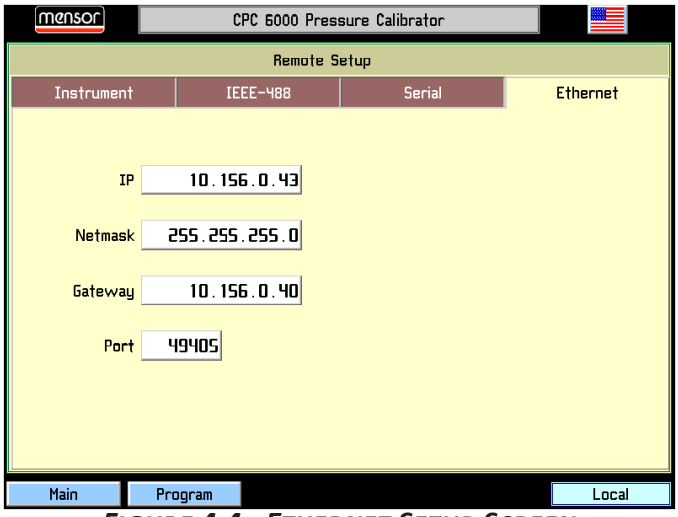


FIGURE 4.4 - ETHERNET SETUP SCREEN

When the correct values have been selected for all four parameters simply touch any of the keys across the top or the bottom of the screen to move on to another function.

ETHERNET COMMUNICATIONS

The Ethernet communication port allows the SPC4000 to communicate with computers using 10/100Based-T specifications. Ethernet communications are transmitted over a standard RJ-45 cable.

Connecting directly to a PC requires a crossover Ethernet cable. Hub connection requires a straight Ethernet cable.

Prior to first time use of Ethernet communication, the four parameters, IP, Netmask, Gateway, and Port must be setup.

CAUTION! Please consult your Computer Resources Department prior to connecting this instrument to your network to verify there are no conflicts with existing IP addresses.

RS-232 SERIAL COMMUNICATIONS

The serial communication port allows the SPC4000 to communicate in RS-232 format with computers, terminals, or similar hosts.
RS-232 communications are transmitted over a three conductor, shielded cable terminated in a standard DB9S connector on the instrument end, and typically the same connector on the host end. Figure 4.5 illustrates the proper pin-outs. Notice that each pin 2 is connected to pin 3 on the opposite end. This configuration is commonly referred to as a 9-pin null modem cable.

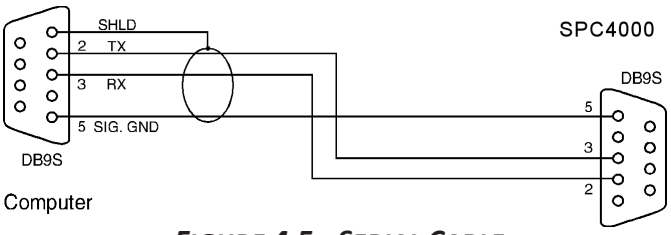


FIGURE 4.5 - SERIAL CABLE

COMMAND/QUERY FORMAT

Commands must be sent in ASCII format and terminated with either a carriage return (<cr>), linefeed (<lf>) or both. Commands are not case sensitive. Each query returns a response. If an error is detected the response will include an error flag.

One of the first commands issued when starting remote communications should be “Keylock Yes”. This will disable the on-screen keys and tabs, and place the “Keylock” label on the screen. Turning keylock on prevents the potential conflicts that could occur if someone pressed an on-screen key, either intentionally or by accident.

Command/Query Field: Unless otherwise specified, commands are typically converted to queries by appending a question mark to the command. Table 4.1 lists all of the SPC4000 command/query keywords.

Data Field: The data field is either in ASCII {string} or numeric {value} form. In the case of multiple data fields, commas are required to separate the fields. Queries do not have a data field. String (text) or value (numeric) data are acceptable in any of the following formats:

Examples of {string} data:	ON	OFF	mBar
Examples of {value} data: 1	1.0	-5.678	

COMMAND SET DEFINITIONS

In this manual a data entry made up of alpha characters is defined as a string, as opposed to data containing only numbers, such as “Enter 1 for ON or 0 for OFF” where 1 and 0 are defined as values.

Command: Any command or query listed in Table 4.1.

Separator: Space <SP>.

Data: ASCII representations of numbers, {value}, or alpha characters, {string}, data as defined above. When sending code a literal variable replaces the braces and the enclosed character(s) shown in the following examples.

Termination: Linefeed (LF) or carriage return (CR) is used to signal the end of a command statement.

Always send commands in one of the following formats:

1. [Command] [Termination];
2. [Command] [Separator] [Data] [Termination];
3. Queries are special instructions in the form: [Command?] [Termination] where the question mark, “?”, immediately precedes the terminator.

When a valid query is received, the SPC4000 will return {data} terminated by CR and LF.

Floating point data is returned in the current engineering units in exponential format.

Channel specific commands are sent to only the active channel. See ‘CHANNEL’ command. Exceptions are GP, GN, RP, RP/C, IC and ZO commands when preceded by a specific range/transducer number.

Commands that are included in the “Scanivalve” command set are specific to the SPC4000 and are indicated in the following table in bold font. When any of these commands are received, the SPC4000 will return a prompt as defined by the current setting of the “SM” command.

Table 4.1 - SPC4000 Commands and Queries		
Command	**Data**	**Function / Response**
Autozero	none	Re-zero all ranges that can measure the vented pressure. These adjustments are not password protected and are not saved through power cycles. This command takes approximately 60 seconds.
Autozero?	S,T,X,X	Returns autozero data where S represents state (responses can be 0 = complete, 1 = local autozero, or 2 = remote autozero), T represents the estimated remaining time to complete in seconds, and X is a (0) character since this data location is not used at this time.
Autozero-abort	none	Aborts autozero.
Baro?	<sp>{value}<cr><lf>	Returns reading from barometric sensor.
Channel	**{A or B}**	**Sets the active channel on the instrument.**
Chan?	<sp>{A or B}<cr><lf>	Returns which channel is active.
Decpt	<sp>{4, 5 or 6}<cr><lf>	Sets the number of significant digits displayed.
Decpt?	<sp>{value}<cr><lf>	Returns the number of significant digits displayed for the active channel.
Default	none	Sets the default values. This command takes approximately 20 seconds.
Error?	<sp>{string}<cr><lf>	Returns a description of an error.
Errorno?	<sp>{string}<cr><lf>	Returns SPC4000 error code and text.
Filter	{Off, Low, Normal, High}	Sets the reading filter.
Filter?	<sp>{string}<cr><lf>	Returns the reading filter.
GN	**<sp>{value}**	**Sends the SPC4000 to control mode and a desired negative pressure (value). Precede with a 1, 2, 3 or 4 for a specific range.** **EX: 2gn 10**
GP	**<sp>{value}**	**Sends the SPC4000 to control mode and a desired positive pressure (value). Precede with a 1, 2, 3 or 4 for a specific range.** **EX: 3gp 53.47**
IC	**none**	**Places the specified channel in a "trap" mode closing all valves internally in the SPC4000 including the supply, vent measure/output solenoids. This leaves the module being calibrated in a no-flow condition.** **Precede with a 1, 2, 3 or 4 for a specific range.** **EX: 1ic**
ID?	<sp>MENSOR,600,{ssssss},{v.vv}<cr><lf>	Returns the instrument identity where {ssssss} is the serial number, and {v.vv} is the software version number.
IP	{string e.g. nnn.nnn.nnn.nnn}	Sets the IP address of the instrument.
IP?	<sp>{string}<cr><lf>	Returns the IP address of the instrument.
Keylock	{Yes or No}	YES to lock, or NO to unlock the on-screen keys.
Keylock?	<sp>{Yes or No}<cr><lf>	Returns current keylock status as YES or NO.

Table 4.1 - SPC4000 Commands and Queries		
Command	**Data**	**Function / Response**
Listcal?	<sp>PRI,{sn},{td},{mm/dd/yyyy},{td},{mm/dd/yyyy};SEC,{td},{mm/dd/yyyy},{td},{mm/dd/yyyy}<cr> <lf>	Returns the serial number of each installed transducer and calibration dates for each range.
Listrange?	<sp>PRI,{td},{min},{max},{td},{min},{max};SEC,{td},{min},{max},{td},{min},{max}<cr><lf>	Returns the minimum and maximum ranges of all installed sensors for the active channel.
Locale?	<sp>{string}<cr><lf>	Returns current language and Country locale.
Meas	**none**	**Instrument placed in Measure or trap mode.**
Measure?	<sp>{Yes or No}<cr><lf>	Returns YES if active channel is in Measure mode; NO if otherwise.
Mode?	<sp>{string}<cr><lf>	Returns the operation mode of the active channel.
Netmask	{nnn.nnn.nnn.nnn}	Sets the Ethernet network mask.
Netmask?	<sp>{nnn.nnn.nnn.nnn}<cr><lf>	Returns the Ethernet network mask.
Peakmax?	<sp>{value}<cr><lf>	Returns the maximum pressure since peakreset was sent.
Peakmin?	<sp>{value}<cr><lf>	Returns the minimum pressure since peakreset was sent.
Peakreset	none	Resets the peak values.
Port	{value}	Sets the Ethernet port of the instrument.
Port?	<sp>{value}<cr><lf>	Returns the Ethernet port of the instrument.
RangeMax?	<sp>{value}<cr><lf>	Returns the maximum range of the active transducer and turndown in the current units.
RangeMin?	<sp>{value}<cr><lf>	Returns the minimum range of the active transducer and turndown in the current units.
Rdecpt?	<sp>{value}<cr><lf>	Returns the number of rate decimal points for the active channel. See: Resolution
Repeat	None	Repeats output continually over serial port only.
Resolution	{4 to 6}	Sets the number of significant digits. See: decpt
Resolution?	<sp>{value}<cr><lf>	Returns the number of significant digits.
RP	**None**	**Returns the current pressure read by a transducer. Precede with a 1, 2, 3 or 4 to specify the transducer being measured. EX: 1RP**
RP/C	**None**	**Continuously returns the current pressure read by a transducer. Precede with a 1, 2, 3 or 4 to specify the transducer being measured. EX: 4RP/C <esc><cr> to terminate**
Rsetpt	{value}	Sets the rate setpoint of the active channel in current units per second. Must be a value inside the current sensor range.
Sbaud	{9600, 19200, 38400, 57600}	Sets the serial baud rate.
Sbaud?	<sp>{value}<cr><lf>	Returns the serial baud rate.
Sdata	{7 or 8}	Sets the serial data bits.
Sdata?	<sp>{value}<cr><lf>	Returns the serial data bits number.

Table 4.1 - SPC4000 Commands and Queries		
Command	**Data**	**Function / Response**
Sensorid?	<sp>{Address}<sp>MENSOR ,<sp>600SNSR,<sp>{Serial No.},V{V.VV}<cr><lf>	Returns the active sensor's serial number and firmware version.
SM	**{pcode}N**	**Sets the type of prompt returned after each "Scanivalve" command sent. It signals the user that the calibrator is ready to accept a new command. It also determines if the incoming characters are echoed back to the host.** **{pcode} - 2 = <CR><LF>;** **3 = <CR><LF> >** **EX: To set the SPC4000 to return a ">" prompt after a command is received, send the command:** **1SM3N**
Sparity	{Even, ODD , NONE}	Sets the serial parity.
Sparity?	{<sp>{string}<cr><lf>	Returns the serial parity.
Sstop	{1 or 2}	Sets the serial stop bits.
Sstop?	<sp>{value}<cr><lf>	Returns the serial stop bits.
Stabledelay	{0 to 65535}	Sets the stable time to the number of seconds specified.
Stabledelay?	<sp>{value}<cr><lf>	Returns the stable time.
Stabletime	{0 to 65535}	Sets the stable time to the number of seconds specified.
Stabletime?	<sp>{value}<cr><lf>	Returns the stable time.
StableWin	{%fs value}	Sets the stable window as a %FS.
StableWin?	<sp>{value}<cr><lf>	Returns the stable window in % of Span.
Units	{units code, or output format text from Measurement Units Table 11.1 in the Appendix Section}	Sets the instrument engineering units.
Units?	<sp>{string}<cr><lf>	Returns the instrument units in a text string.
Versions?	<sp>{string}<cr><lf>	Returns the versions of the firmware for the instrument, gpib driver, gate array, installer, and the graphics library.
Volume	{value in cc}	Sets the system volume in cc's – only applicable if the active channel is a low pressure regulator.
Volume?	<sp>{value}<cr><lf>	Retuns the current system volume in cc's – only applicable if the active channel is a low pressure regulator.
ZO	**None**	**Vents any pressure in the system and pneumatically shorts the positive and negative side of any transducers together within the module being calibrated.** **Precede with a 1, 2, 3 or 4 for a specific range.** **EX: 1zo**

SECTION 5: LOCAL OPERATIONS

GENERAL

This section describes the procedures for operating the SPC4000 from the font panel. Instructions for operating the calibrator remotely can be found in Section 6: ***Remote Operations***. The SPC4000 features a full color 8.4" touch screen that allows for intuitive local operations.

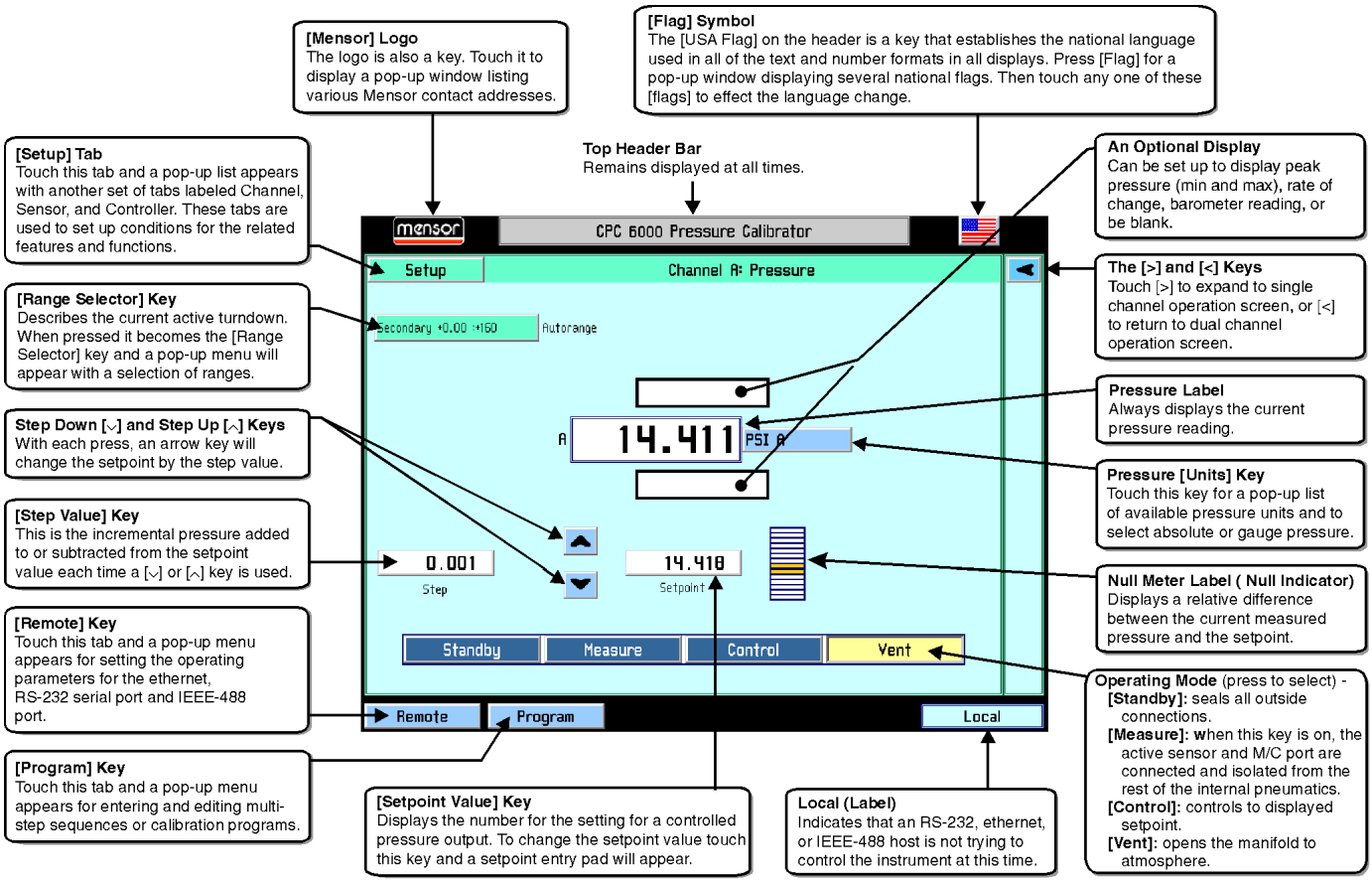


FIGURE 5.1 - DISPLAY SCREEN FEATURES

KEYS AND TABS

Local operation is accomplished by observing the data presented in the display, then pressing the on-screen [key] or [tab] for the desired function. Throughout this manual characters enclosed inside square brackets [ ] represent the associated on-screen touch point.

DISPLAY SCREEN FEATURES

Figure 5.1 provides a brief description of the features shown on a single channel display.

Figure 5.2 is an example of a typical display after initialization. To expand the selected channel to a single channel operation screen as shown in Figure 5.1, press the [>] key. The [Standby] key appears on the screen when expanded. To expand or return to a dual channel operation screen press the [<] or [>] key.

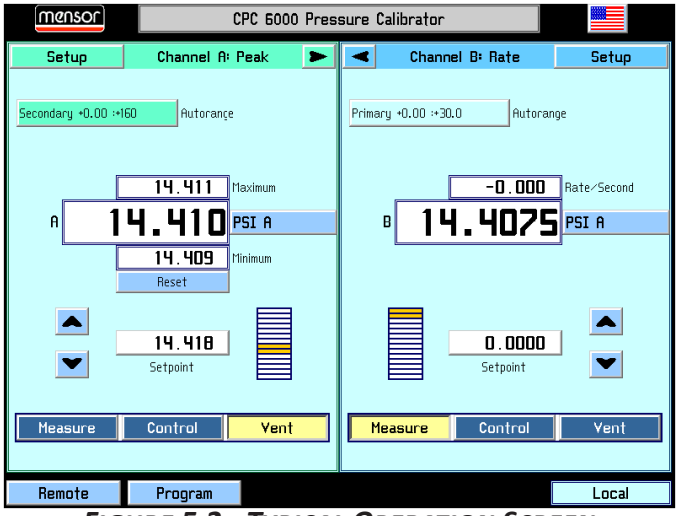


FIGURE 5.2 - TYPICAL OPERATION SCREEN

All of the SPC4000 screen features are described in more detail in the rest of this section.

CONTACT INFORMATION BUTTON

The logo is also a key. Touch it (Figure 5.3) to display a pop-up window listing various Scanivalve contact information and SPC4000 serial number and version information. Touch [Close] to close the window.

FIGURE 5.3 - CONTACT INFORMATION BUTTON

FLAG SYMBOL

The [USA Flag] on the header is a key that establishes the national language used in all of the text and number formats in all displays. Press the [Flag] for a pop-up window displaying several national flags (Figure 5.4). Touch any one of these [Flags] to effect the language change.

The current language selections available are:

Language	Country Flags
English	USA
German	Germany
German	Switzerland
English	Great Britain
Chinese	China
English	Canada
French	France
French	Switzerland
English	Ireland
Korean	Korea
French	Canada
Italian	Italy
Russian	Russia
Polish	Poland
Japanese	Japan
Spanish	Mexico
Spanish	Spain

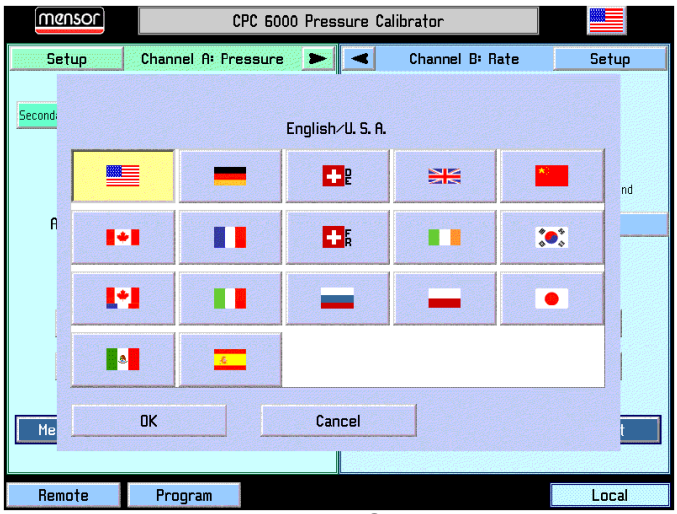


FIGURE 5.4 - LANGUAGE SELECTION WINDOW

[>] AND [<] KEYS

The [>] and [<] keys will expand the selected channel to single channel operation screen, or return to dual channel operation screen.

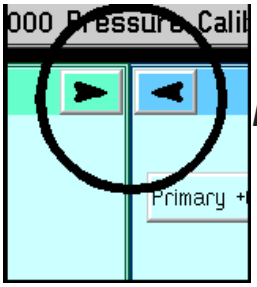


FIGURE 5.5 - CHANNEL SCREEN SELECTION BUTTONS

RANGE SELECTOR KEY

The label in the upper left portion of Figure 5.6 describes the current active range as “Secondary +0.00 :+160”. The label , when touched, becomes the [Range Selector] key. Different colors are used to distinguish primary and secondary transducers. The currently active range is highlighted with a yellow background. Touch any range other than the yellow one to select a different range as shown in Figure 5.7. The last selection in this range selector is [Autorange], which will automatically switch to the most accurate range in the system capable of measuring the current pressure. Each change is immediately reflected in the turndown label. There is also a label beside the current active range to show if you are in range hold or autorange.

Some pressure units can cause a number to be too long for the value window. In those cases the value will be abbreviated with an “m” (milli), “k” (kilo), or “M” (mega) multiplier appended to the range in the range drop list.

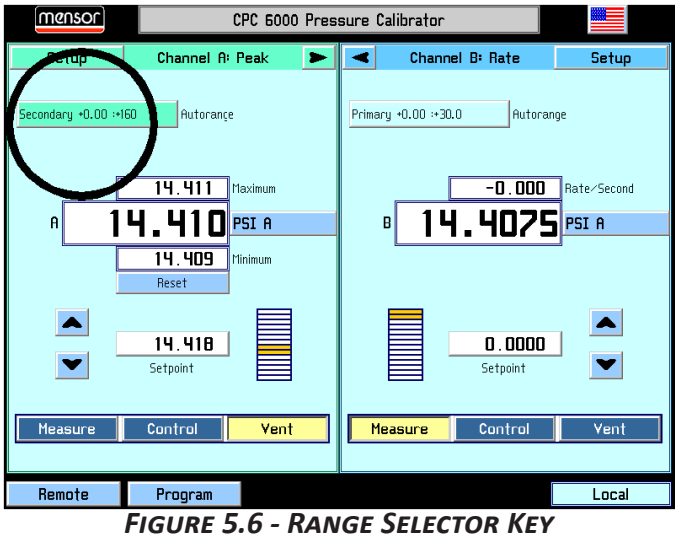


FIGURE 5.6 - RANGE SELECTOR KEY

An important feature of the SPC4000 is that transducers can easily be changed. A transducer can be replaced in the SPC4000 in less than 30 seconds, with no tools required. Each installed transducer identifies itself to the system using its on-board stored data. Among the items stored in this data are the transducer serial number, curve characterizations and calibrations for each turndown, the dates of calibration, and the transducer’s software version.

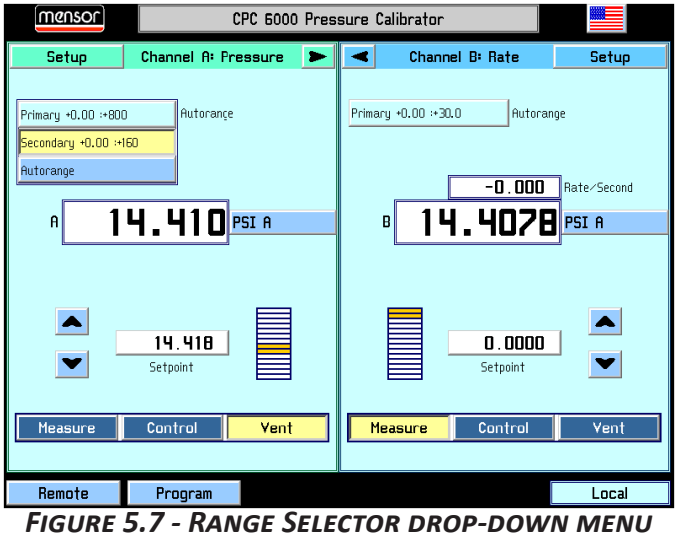


FIGURE 5.7 - RANGE SELECTOR DROP-DOWN MENU

PRESSURE LABEL

Below the turndown label shown in Figure 5.6 is a larger label showing the measured pressure value of “14.410”. This large label always displays the current pressure reading.

PRESSURE UNITS KEY

To the right of the pressure label is the [Units] key, shown in Figure 5.6 as [PSI]. Touch [PSI] and a pop-up menu of pressure units will appear as in Figure 5.8. This menu includes [User 1] and [User 2] keys allowing the user to enter customized pressure units. Touch [PSI] and it will toggle to Pascal. Press a [Value] key to enter a custom multiplier to equal either one PSI, or one Pascal, whichever is showing in the user multiplier base units key.

The upper right [absolute] or [gauge] key allows emulation mode if an optional barometric sensor is installed.

The current units are highlighted by a yellow background. Touch any other [Pressure Units] key, and press [OK] to enable change and return to previous operation screen. All of the displayed pressure values will have changed to correspond to the newly selected units at the correct conversion ratio.

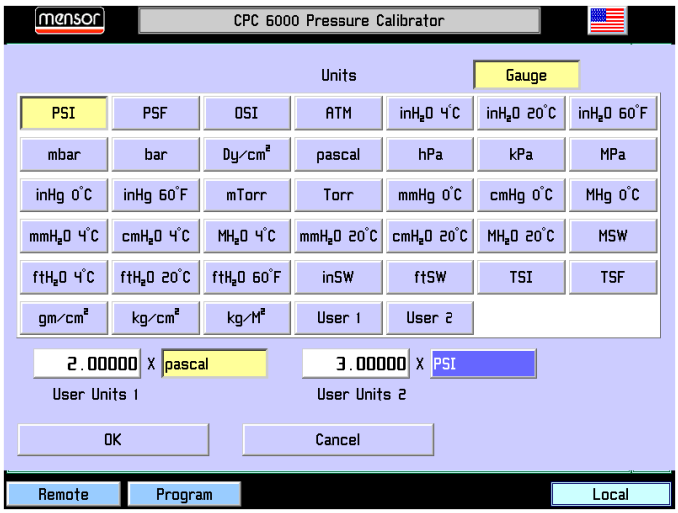


FIGURE 5.8 - UNITS SELECTION WINDOW

STEP VALUE KEY

On the left side of the screen as seen in Figure 5.1 is the [Step Value] key. The step value displayed is 0.001. This is the incremental pressure added to or subtracted from the setpoint value each time a [\/] or [/\] key is used on the main screen. To change the step value touch the [Step Value] key and the step entry pad as shown in Figure 5.9 will appear.

This number pad shows the maximum and minimum values applicable to the active turndown. There is also a Current Value and a New Value window. Enter a new step number and then press [OK], or else touch [Cancel] to return to the operate screen without changing the step value. Press CE to backspace.

STEP DOWN [\/] AND STEP UP [/\] KEYS

As shown in Figure 5.1, the [\/] and [/\] keys are located to the side (different for A and B Channels) of the [Setpoint Value] key; one for Step Down [\/], and another for Step Up [/\]. Pressing an arrow key will change the setpoint by the step value until the control limits of the channel are reached.

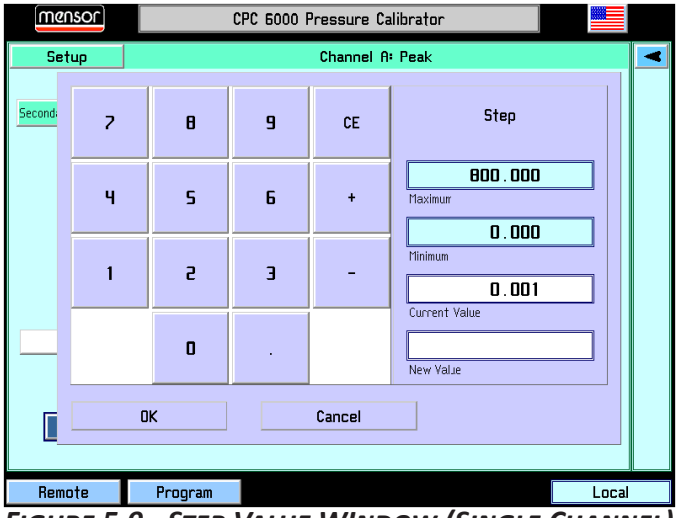


FIGURE 5.9 - STEP VALUE WINDOW (SINGLE CHANNEL)

CONTROL PRESSURE / SETPOINT VALUE

The number displayed inside the [Setpoint Value] key is the setting for a controlled pressure output. When the [Control] key at the bottom of the active channel screen is switched to [On] the regulator will attempt to present that precise pressure to the Measure/Control port on the rear panel. The setpoint number is changed either by using the [\/] and [/\] keys, or by touching the [Setpoint Value] key to input a new number. It should be noted that when negative pressures are commanded, a positive pressure is supplied from the SPC4000 to the SPCPLU, which is then directed to the appropriate reference outlet port to the module.

If the displayed number is beyond the range of a selected turndown in range hold mode, the number will change to a control value within the limits of the turndown. The setpoint will change in value automatically, but it will not be restored automatically if the previous turndown is re-selected.

[Standby] key: When this key is ON all internal solenoid valves are closed.

[Measure] key: When this key is ON the active sensor and the Measure/Control port are connected and isolated from the rest of the internal pneumatics.

[Control] key: When this key is ON the unit will attempt to control to the setpoint displayed.

[Vent] key: When this key is ON the internal pneumatics are open to atmosphere.

REMOTE BUTTON

Refer to Section 4: ***Remote Operations*** for more details on the [Remote] button.

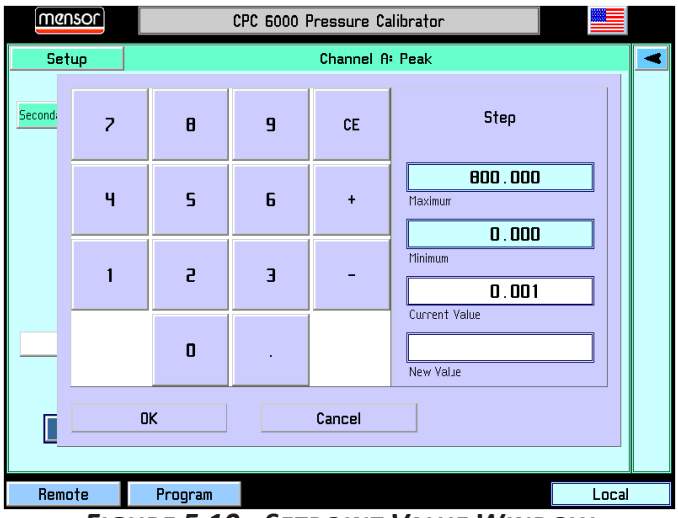


FIGURE 5.10 - SETPOINT VALUE WINDOW

PROGRAM KEY

The SPC4000 is capable of creating and storing multi-step, pre-programmed sequences. This feature is of limited functionality compared to the capability of the included calibration software, PressCal. However, if a program is to be used, it is access through the [Program] key. The [Program] key on the bottom left of the operation screen (see Figure 5.1) enters the main program creation/edit screen shown in Figure 5.11. Programs can be entered and edited from this screen. There are sample programs available in the instrument that can be edited and renamed. A saved program can be executed by entering the setup channel screen and selecting the [Program] key. The SPC4000 can store up to 64 programs with up to 100 steps in each program.

The large key at the top of this screen contains the program name of the currently active program that can be run or edited. If this key is pressed, a list of saved programs will be displayed as shown in Figure 5.12. The up and down arrow keys display additional pages of programs. To select a program to run or edit, simply press the name of the program. To create a new program sequence, select a blank line and press [OK]. To copy an existing program, select the program to be copied, press [Copy], select a new line (or an existing program to overwrite) and press [Paste]. The [Delete] key erases a program from memory.

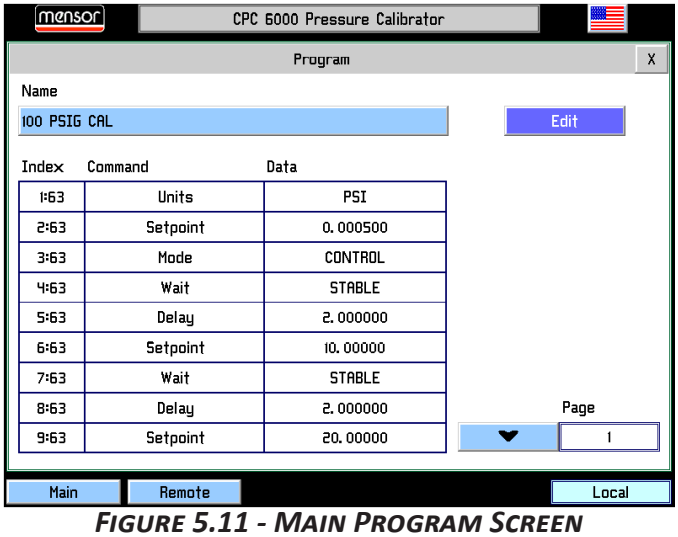


FIGURE 5.11 - MAIN PROGRAM SCREEN

EDITING OR CREATING A PROGRAM

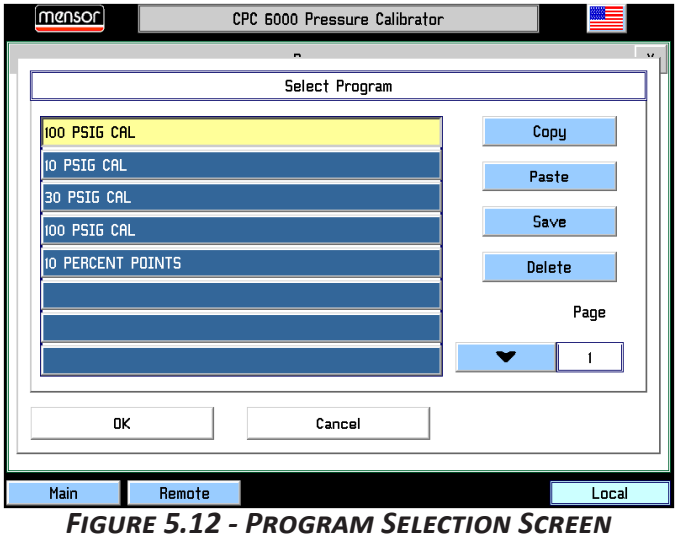


FIGURE 5.12 - PROGRAM SELECTION SCREEN

To edit or create a program, select a program name from the Program Selection Screen and press [OK]. This brings up the main program screen. Below the [Name] key is a table that shows a synopsis of the program steps. There are also up and down arrow keys to display additional pages of program steps.

To edit the selected program press the [Edit] key. This displays the program editing screen shown in Figure 5-13. Each program line shown in Figure 5.13 only executes

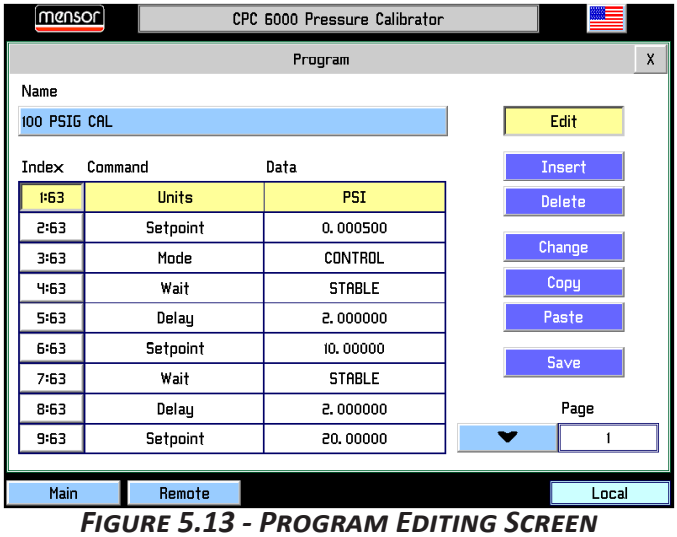


FIGURE 5.13 - PROGRAM EDITING SCREEN

one function or command. Each line has an index number associated with it. For example, if a program has 30 commands, the first command index is 1:30 to represent that it is command 1 of 30 to be executed.

To edit individual program lines, select the index number of the program line to edit.

[Insert] key: inserts a new program line before the selected one. This also re-scales the index numbers accordingly.

[Delete] key: deletes the selected program line and re-scales the index numbers accordingly.

[Change] key: displays the program line edit screen as shown in Figure 5.15 . Its functionality is described in the following text.

[Copy] key: copies the selected program line.

[Paste] key: To paste a copied program line over an existing line, select the program line to be overwritten and press the [Paste] key.

[Save] key: saves the individual program lines to the program and the program to memory. If program lines are edited and the main program screen is exited without pressing the [Save] key, a warning dialog box is displayed prompting the user to save program changes or cancel.

To change the name of the program, press the [Name] key. This displays a keyboard screen shown in Figure 5.14. Enter the name of the program and press [OK] to return to edit the program steps.

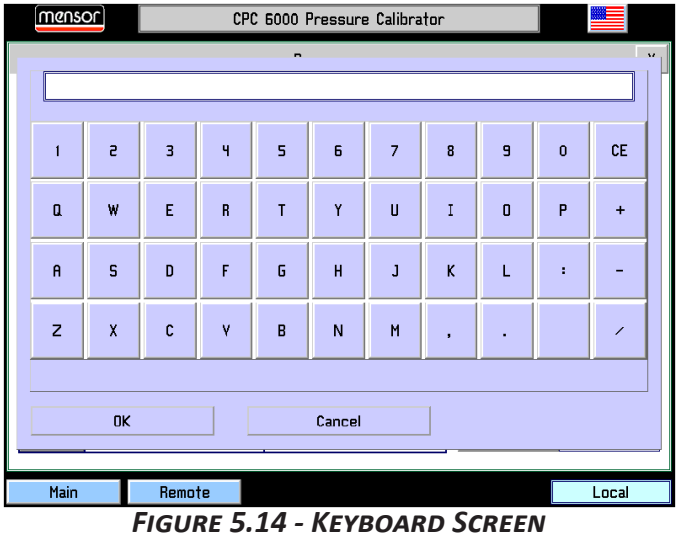


FIGURE 5.14 - KEYBOARD SCREEN

The Program Line Edit Screen (Figure 5.15) sets the function of each program line. Each program line performs the function selected from the ones displayed in the left-most column.

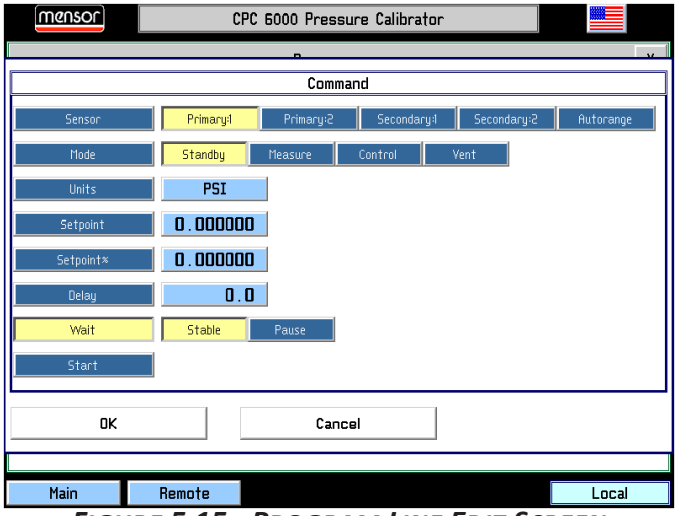


FIGURE 5.15 - PROGRAM LINE EDIT SCREEN

[Sensor] key: This key selects which sensor and turndown to use for the program.
[Mode] key: The [Mode] key selects the operation mode of the SPC4000.

[Units] key: This key selects the pressure units.

[Setpoint] key: This key allows the control pressure to be set with the key just to its right. Because of the flexibility of the SPC4000, it should be noted that to make the SPC4000 control at this setpoint there needs to be another program line that puts the SPC4000 into the control mode.

[Setpoint%] key: The [Setpoint%] key sets the control pressure at the entered percentage of the range of the currently active transducer.

[Delay] key: The [Delay] key delays the execution of the program for the entered number of seconds.

[Wait] key: The [Wait] key delays the execution of the program until the instrument measures a stable pressure, or the control pressure stabilizes within the control parameters or pauses until the operator presses a key to continue the program execution.

[Start] key: The [Start] key causes execution of the program to begin at the first program line. This is useful for running a program repeatedly until the stop key (the key with the black filled square) is pressed by the operator.

RUNNING A PROGRAM

To run a stored program, select the program mode from the channel setup screen. The main operation screen looks like Figure 5.16.

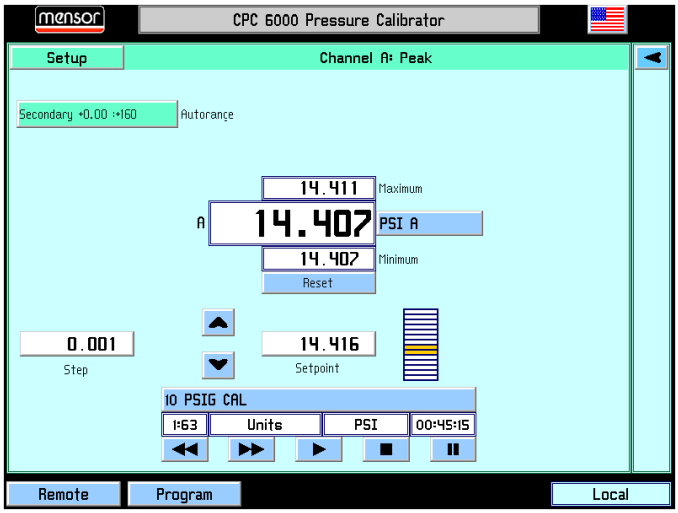


FIGURE 5.16 - MAIN OPERATION SCREEN IN PROGRAM MODE

At the bottom of the screen, the function tabs (Measure, Control and Vent) are replaced by information and tabs pertaining to the selected program. The large key at the top of this section is the program name. Any saved program may be selected directly from this screen by pressing this key and selecting the program to run.

When a program has been selected, the line below the program name key shows the current program line that is or will be executed. The right-most box on this line shows the time at which the program has been on the current program line.
The five keys below this control the operation of the program.

The [<<] key steps one command line back.

The [>>] key steps one command line forward.

The [>] key begins execution of the program at the first program line. It is also used to re-start a program at the current line after a wait/pause program line.
The next key shows a black square. Pressing this key stops execution of the program and resets the program to the first program line.

The [II] key pauses program execution at the current program line. If the [>] key is subsequently pressed, the program begins execution at the next program line.

LOCAL LABEL

On the bottom right of the operation screen (Figure 5.1) is a 'Local' label to indicate that an RS-232 or Ethernet host is not trying to control the instrument at this time. The text of this label will change to "Serial" or the IP address of the controller when the SPC4000 receives a remote command.

SETUP KEY

Touch the [Setup] tab on the top left or top right corner of the Operation screen (Figure 5.1) and a new display appears with another set of tabs across the top as shown in Figure 5.17. These tabs are labeled [Channel], [Sensor], and [Controller]. The tab and screen that was last accessed is active by default. The top tabs are used to set up conditions for the related feature/ function as explained in the following text.

CHANNEL SETUP

Press the [Channel] tab to access the Channel Setup page as shown in Figure 5.17. From there the user can select the optional display function to be [Pressure], which will show only the current reading, or have it show [Peak], [Rate], or [Barometer] readings.

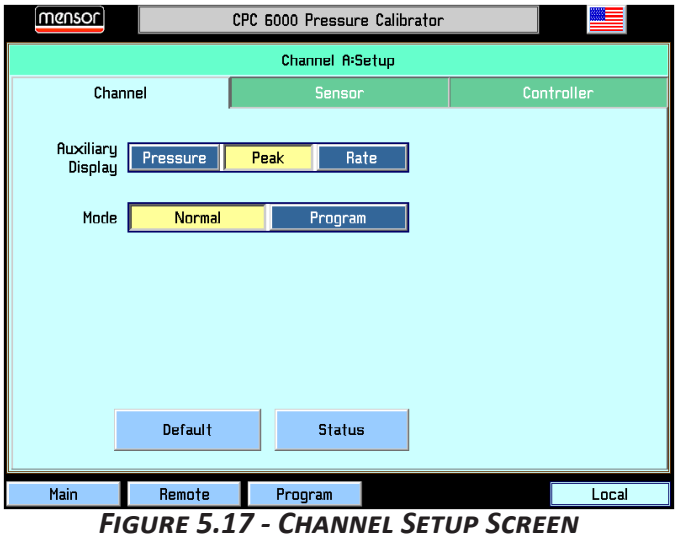


FIGURE 5.17 - CHANNEL SETUP SCREEN

The content of the three active displays are:

[Pressure]: Shows no alternate readings on the screen, only the measured pressure reading.

[Peak]: Displays the highest and lowest pressure points since the last [Reset], or power up. Figure 5.2 shows an example of the Peak feature displayed in this window.

[Rate]: Reports the rate at which the measured pressure is changing in units/second.

[Barometer]: If this optional feature was ordered with your SPC4000, press this key to display the atmospheric pressure reading.

[Normal] (mode selection): This mode will allow the user to command the instrument to individual setpoints manually or remotely.

[Program] (mode selection): This mode will allow the user to define and run user entered program sequences (Figure 5.12).

[Default]: Touch this key to immediately reset the instrument to the following conditions:

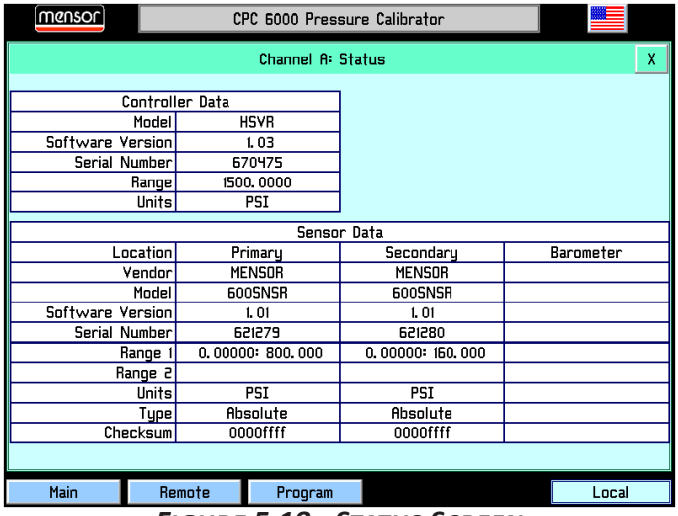


FIGURE 5.18 - STATUS SCREEN

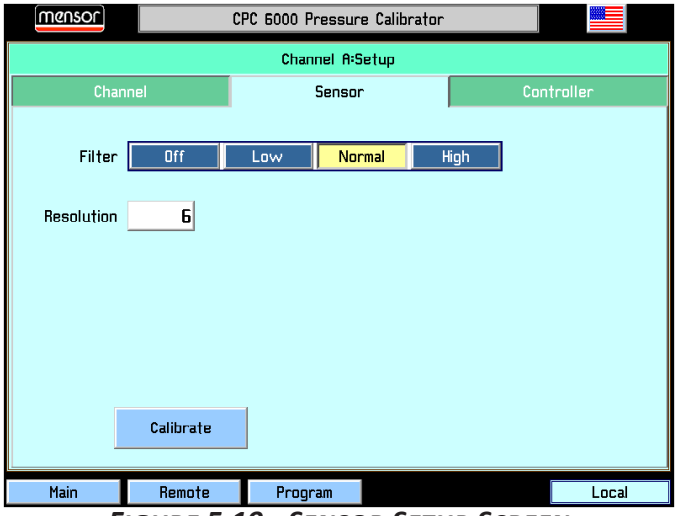


FIGURE 5.19 - SENSOR SETUP SCREEN

Autorange ON; a solenoid valve regulator module defaults to low overshoot mode (see “Sensor Setup”).
Step value: Ignore if valid; Set to 1 if out of range
Setpoint: Ignore if valid; Set to 0 if out of range
Restart peak maximum and peak minimum
Set sensor filter to Normal
Set control rate to Maximum
Set maximum allowable control point to match the highest maximum turndown in the instrument
Set minimum allowable control point equal the lowest minimum turndown in the instrument
Set the stable window to 0.003% FS
Set the stable delay to 4 seconds.
Any existing conditions not covered above will be unaffected.

[Status]: Touch this key to display all current channel information including: Model, Software Version, Serial Number, Range, and Units. See Figure 5.18.

SENSOR SETUP

Touch the [Sensor] tab and Figure 5.19 will appear.

Filter: The Filter is an electronic filter to smooth out the pressure readings. Because of the differences in resolution, more filtering may display a more stable reading for some pressure units. Select the best filter for the current units. [Off], [Low], [Normal], [High].

Resolution: The Resolution [value] key allows the user to enter the number of significant digits that will be displayed on the operate screen. See Figure 5.20.

[Calibrate] Setup key: Details for the [Calibrate] key are given in Section 7: ***Calibration***.

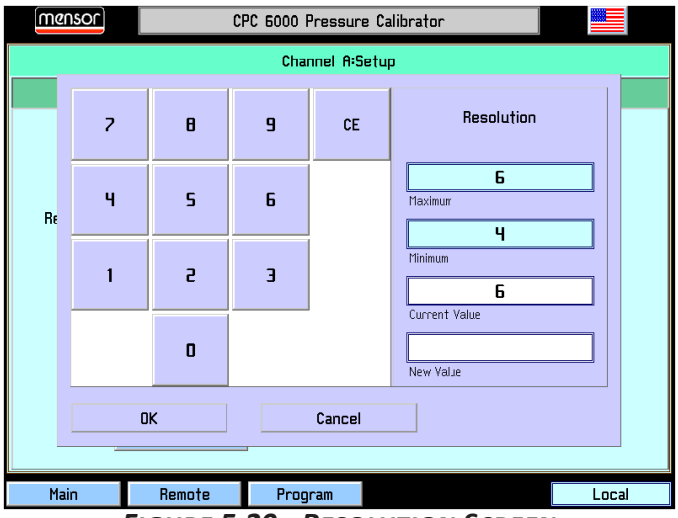


FIGURE 5.20 - RESOLUTION SCREEN

CONTROLLER SETUP

The controller setup screen (Figure 5.21 for the pump regulator or Figure 5.25 for the solenoid valve regulator) is used to set the control parameters for the selected pressure control channel.

The controller test screens are an interactive diagnostic display used for troubleshooting the overall pneumatic system of the SPC4000. Proper use of these features are described in Section 6: ***Maintenance***.

PUMP REGULATOR

Control Limits: The control limits cannot be set outside the maximum or minimum ranges of the transducers installed on the active channel. To change a limit touch either of the [Limit Value] keys and enter the new value.

Stable Limits: The stable limit is the percent of span of the active range that the current pressure can deviate from the setpoint and still display a stable flag.

To change the stable limit or stable delay press the appropriate key. The pop-up number pad will show the upper and lower limits for the item being edited.

Stable Delay: The stable delay is the number of seconds that the instrument must remain within the stable window before the stable flag is displayed.

Rate: A rate (slewing speed) which best suits the user's test requirements is selected here. The [Slow] rate will use internal pressure generation without the use of the roughing supply and exhaust valves. Use this mode if no external supply or exhaust pressures are applied to the selected pressure control channel. The [Fast] rate utilizes the roughing supply and exhaust valves.

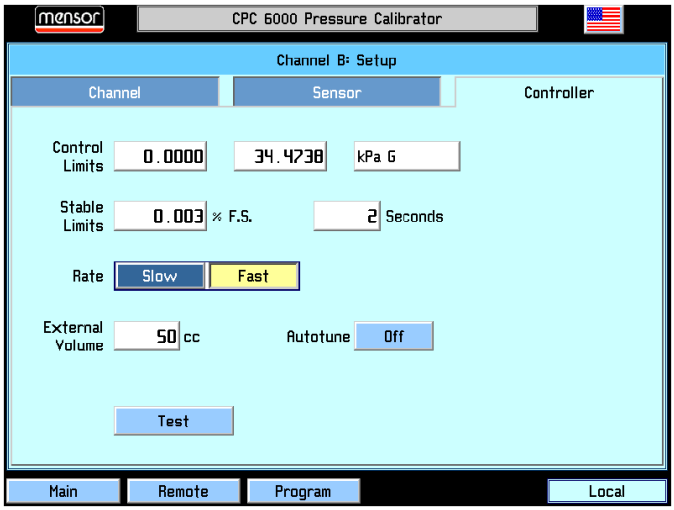


FIGURE 5.21 - CONTROLLER SETUP - PUMP REGULATOR

External Volume: If the autotune is turned on, the external volume of the controlled system is calculated automatically for optimum control performance. If the external volume is known, the user can press the external volume key and enter the volume. Subsequently, if [Autotune] is turned off, the control channel will not re-calculate the external volume on each control setpoint change which will decrease the control times.

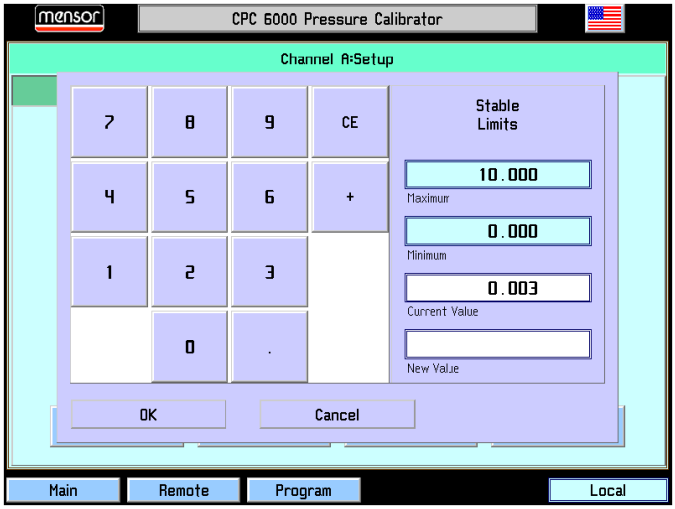


FIGURE 5.22 - STABLE LIMIT SCREEN

Autotune: If the autotune key is turned on, the control channel automatically calculates the external system volume for optimum performance on each control setpoint change.

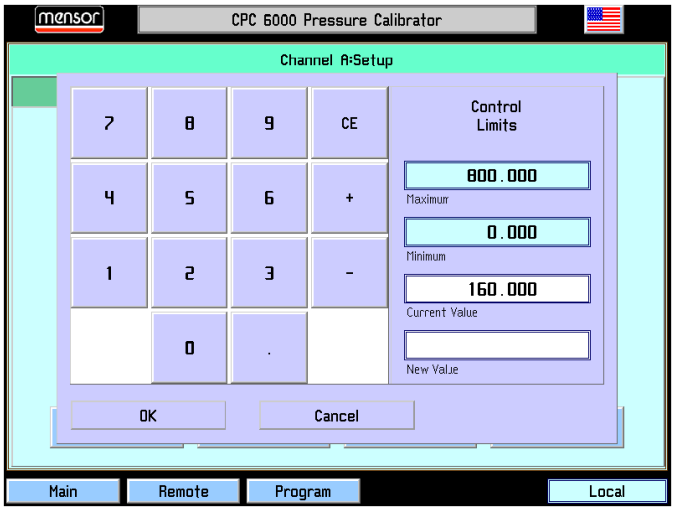


FIGURE 5.23 - CONTROL LIMITS SCREEN

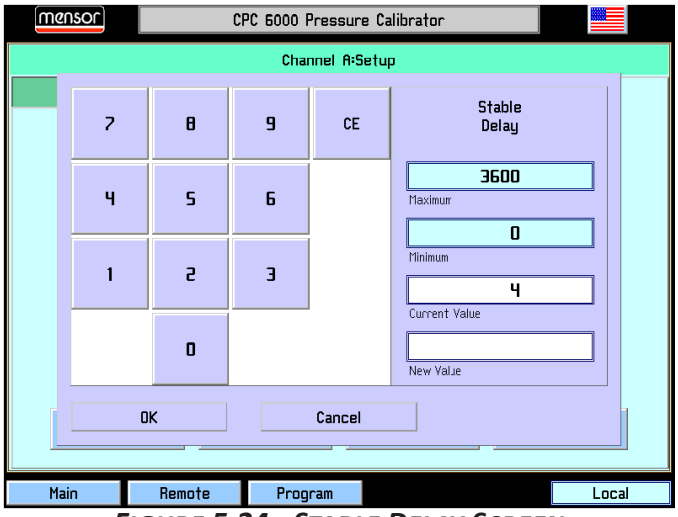


FIGURE 5.24 - STABLE DELAY SCREEN

[Test] key: is used to enter a test mode that gives the user individual control of all solenoids. This is further described in Section 6: ***Maintenance***.

SOLENOID VALVE REGULATOR

Control Limits: The control limits cannot be set outside the maximum or minimum ranges of the transducers installed on the active channel. To change a limit touch either of the [Limit Value] keys and enter the new value.

Stable Limits: The stable limit is the percent of span of the active range that the instrument can deviate from the setpoint and still display a stable flag. To change the stable limit or stable delay press the appropriate key. The pop-up number pad will show the upper and lower limits for the item being edited.

Stable Delay: The stable delay is the number of seconds that the instrument must remain within the stable window before the stable flag is displayed.

Rate: A rate (slewing speed) which best suits the user's test requirements are selected here. The rates vary the pressure slew rate while driving to a pressure setpoint. The [Slow] rate will target approximately .1% of the highest installed range/second. The [Medium] rate will target approximately 1% of the highest installed range/second. The [Fast] rate will target approximately 10% of the highest installed range/second.

Variable rate allows the customer to enter the desired rate that the controller will approximate in the current units/second.

Low Overshoot check: If this is checked, the control channel will minimize pressure overshoot when driving to a new control setpoint.

[Precision] key: If this key is selected, parameters are loaded into the active channel so that it will operate with minimum overshoot and maximum stability. This changes the control stable window to 0.003% of the active sensor turndown and the stable delay to 4 seconds.

High Speed] key: If this key is selected, parameters are loaded into the active channel so that it will operate in a high control speed mode. This changes the control stable window to 0.006% of the active sensor turndown and the stable delay to 1 second. It also changes the way the controlled pressure approaches the setpoint to minimize the time to stable.

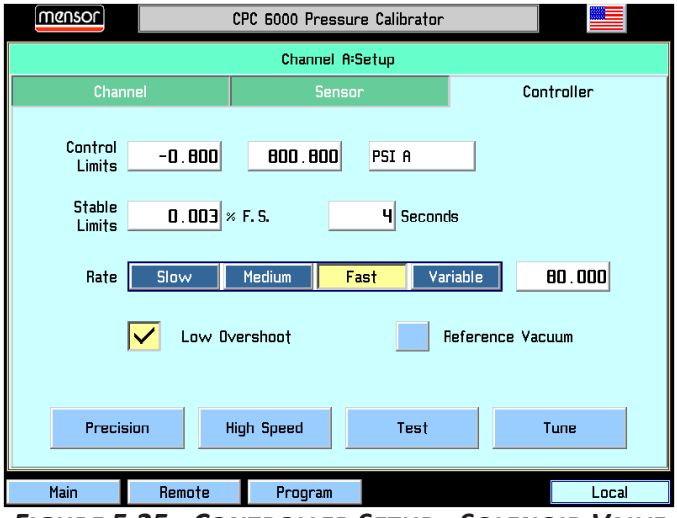


FIGURE 5.25 - CONTROLLER SETUP - SOLENOID VALVE REGULATOR

[Test] key: This key is used to enter a test mode that gives the user individual control of all solenoids. This is further described in Section 6: ***Maintenance***.

[Tune] key: This key is used to tune the regulator. This is described further in Section 6: ***Maintenance***.

SECTION 6: MAINTENANCE

Any maintenance outside of the information provide in this section is not recommended by the customer. Contact Scanivalve customer support if further maintenance or support is required.

CAUTION

CAUTION! The following test feature is a powerful troubleshooting tool, but it incurs a dangerous potential for misdirecting high pressures. Study the pneumatic schematics (Figure 6.3) to understand the possible consequences of various pressure routings.

TROUBLESHOOTING THE SPC4000 - PUMP REGULATOR

The SPC4000 has two Controller test screens; one is for the Pump Regulator (see Figure 6.1) and the other is for the Solenoid Valve Regulator (see Figure 6.4).

To get to the test screen press [Setup], [Controller], and [Test]. The pump regulator test screen allows control of the solenoid valves directly by the operator. Pressing the key labeled [Closed] or [Open] will toggle the associated solenoid between the open and closed states. As each key is pressed the key will change text and color, and the target solenoid will make an audible “click”. If a key changes color without the accompanying click it is an indication of a defective solenoid or a bad connection. Pressing the [+] or [-] key will actuate the pump and increase or decrease the system pressure respectively. The [speed] key allows adjustment of the relative rate at which the pump operates to increase or decrease pressure. The [%] key allows an adjustment of the duty cycle of the supply and exhaust valves. The Primary and Secondary labels show the pressure sensed at the respective transducers. The Rate [psi/sec.] label indicated the rate of change of the system pressure. See Figure 6.2 for the pump regulator pneumatic module. See Figure 6.3 for the pneumatic schematic for the pump regulator.

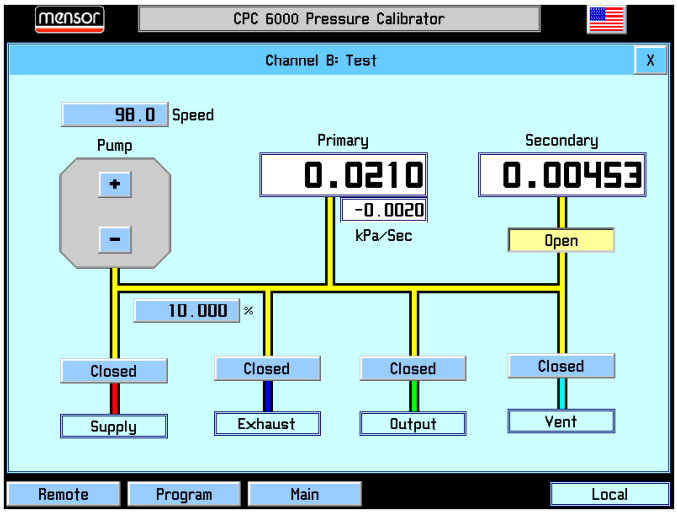


FIGURE 6.1 - TEST SCREEN, PUMP REGULATOR

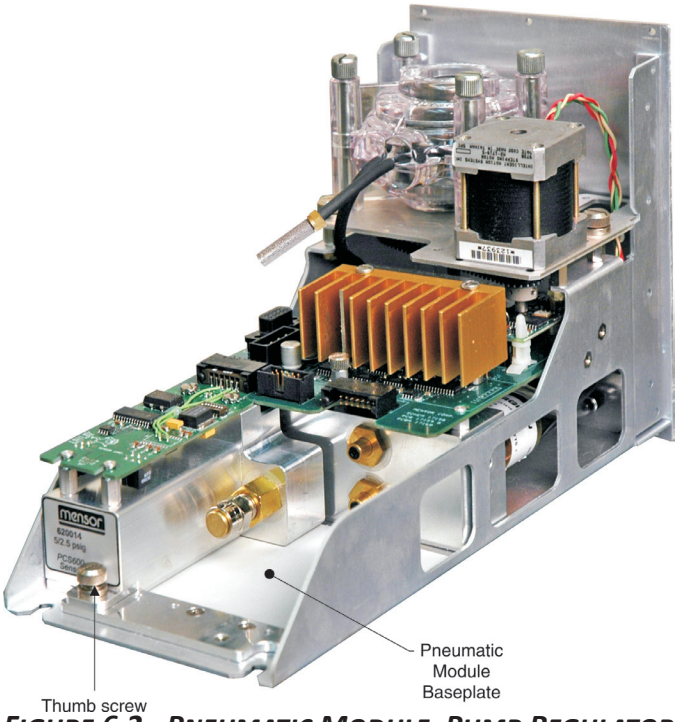


FIGURE 6.2 - PNEUMATIC MODULE, PUMP REGULATOR

CAUTION

CAUTION! System pressure should not be drive above the range of the primary transducer. The valve isolating the secondary transducer should be closed before the system pressure is driven above the range of the range of the secondary transducer.

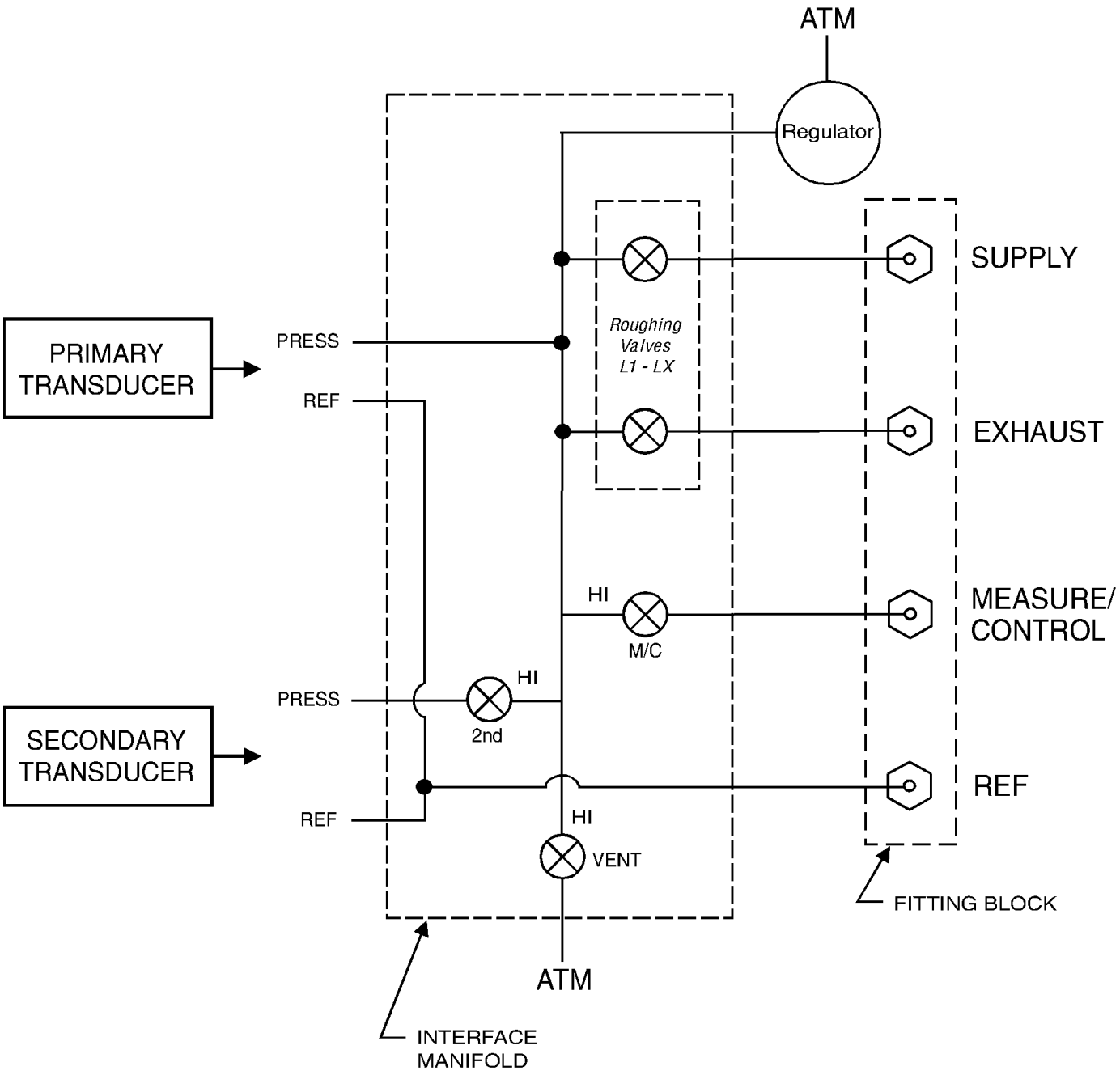


FIGURE 6.3 - PNEUMATIC SCHEMATIC - PUMP REGULATOR

TROUBLESHOOTING THE SPC4000 - SOLENOID VALVE REGULATOR

CAUTION! The following test feature is a powerful troubleshooting tool, but it incurs a dangerous potential for misdirecting high pressures. Study the pneumatic schematics (Figure 6.6) to understand the possible consequences of various pressure routings.

The Solenoid Valve Regulator test screen (Figure 6.4) allows control of the solenoid valves directly by the operator. Pressing [Closed] or [Open] key will toggle the associated solenoid between the open and closed states. As each key is pressed the key will change text and color, and the target solenoid will make an audible "click". If a key changes color without the accompanying click it is an indication of a defective solenoid or a bad connection. The [+], [++], and [+++] represent the fine, medium and course regulator supply valves respectively. The [-], [--], [---] keys represent the fine, medium and course regulator exhaust valves respectively. Applying a continuous touch to any of these keys will open the respective regulator valve and increase or decrease the system pressure. The [%] key (top left) allows a collective adjustment of the duty cycle of the regulator valves to adjust the flow rate through the regulator. The Primary and Secondary labels show the pressure sensed at the respective transducers. The Rate [psi/sec.] label indicated the rate of change of the system pressure. See Figure 6.6 for the pneumatic schematic for the solenoid valve regulator.

CAUTION! System pressure should not be drive above the range of the primary transducer. The valve isolating the secondary transducer should be closed before the system pressure is driven above the range of the range of the secondary transducer.

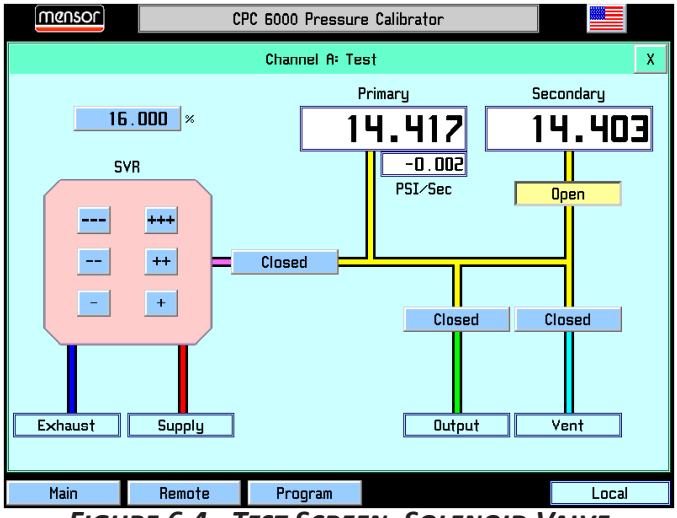


FIGURE 6.4 - TEST SCREEN, SOLENOID VALVE REGULATOR

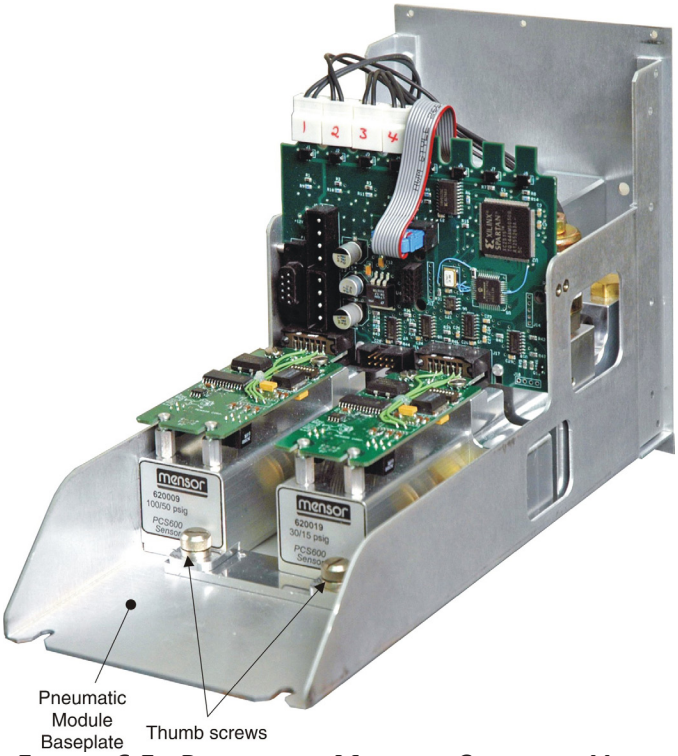


FIGURE 6.5 - PNEUMATIC MODULE, SOLENOID VALVE REGULATOR

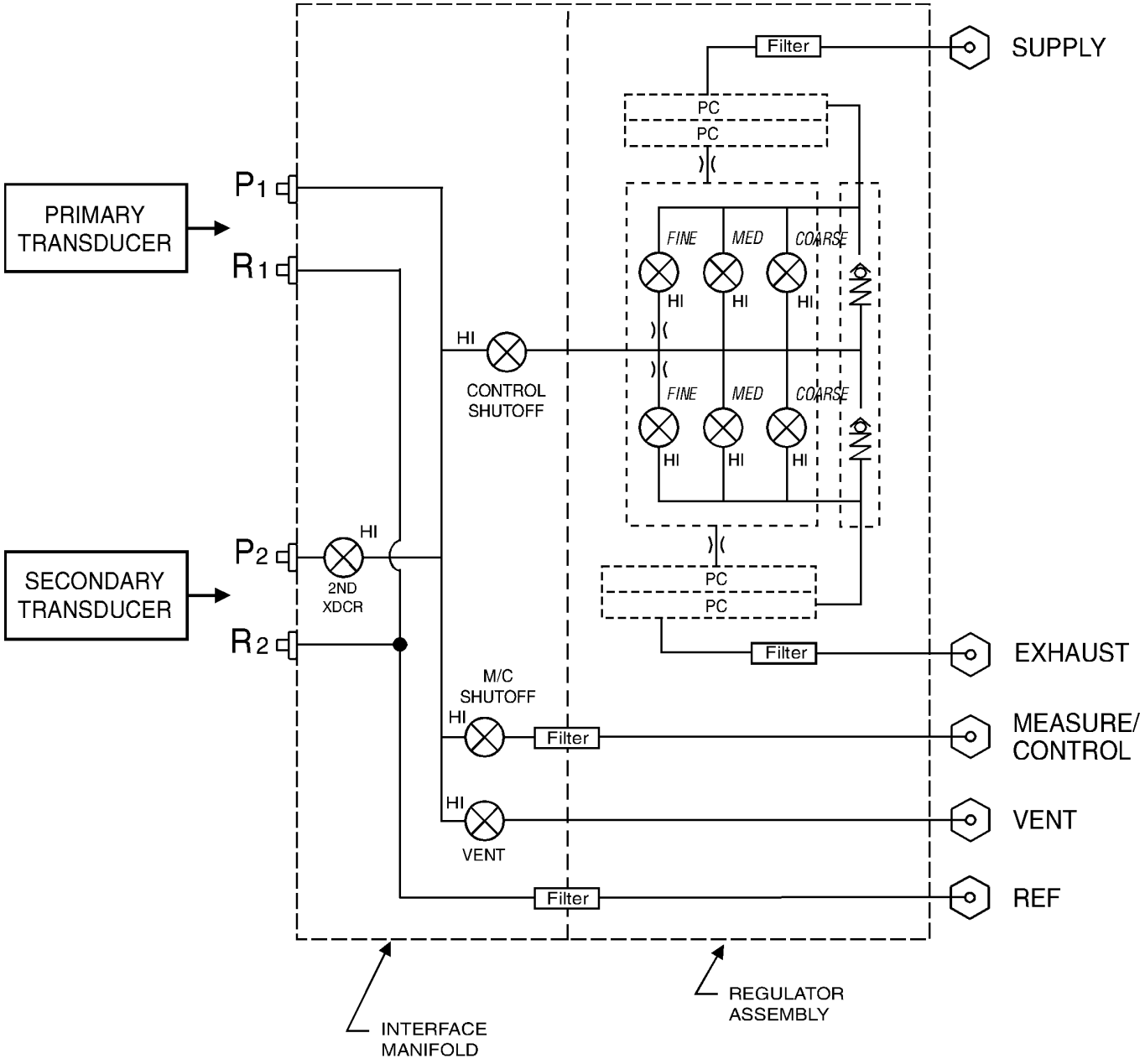


FIGURE 6.6 - PNEUMATIC SCHEMATIC - SOLENOID VALVE REGULATOR

TUNING A SOLENOID VALVE REGULATOR

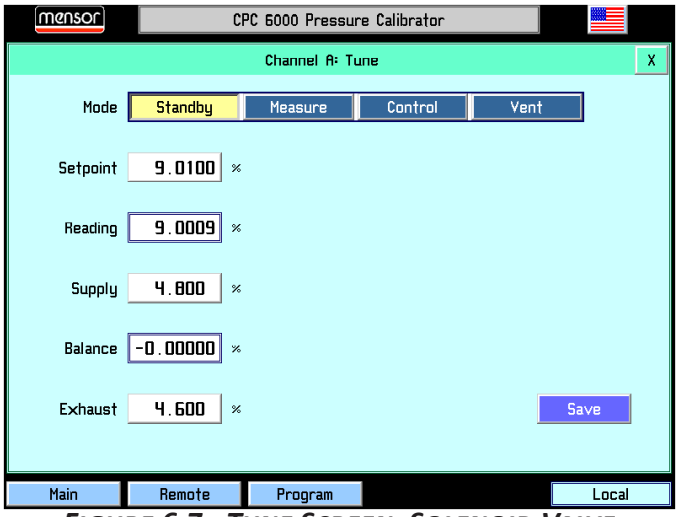


FIGURE 6.7 - TUNE SCREEN, SOLENOID VALVE REGULATOR

Tuning Modes:
[Standby]: Seals all outside connections.
[Measure]: Isolates the active sensor and measure/control port.
[Control]: Controls to displayed setpoint in % F.S.
[Vent]: Opens manifold to atmosphere.
Setpoint = Desired pressure in % F.S.
Reading = Measured pressure in % F.S.
Supply = Supply fine bleed valve.
Balance = Balance between supply and exhaust fine valves.
Exhaust = Exhaust fine bleed valve.
[SAVE]: Saves the supply and exhaust fine bleed valves to the regulator.
Typical supply and exhaust values will be 3.00 to 6.00.

Tuning Procedure:

1. Plug Measure/Control port.
2. Connect supply pressure equal to 110% of the maximum range for that channel and a vacuum pump if necessary.
3. Press [Setup] [Controller] [Tune] on the channel you wish to tune.
4. Press the box to the right of the Setpoint and enter 50.00 and [OK].
5. |Push the [Control] button and watch the value in the box to the right of Reading climb towards the setpoint.
6. If the Reading stays below the Setpoint increase the Supply value by .1 until the setpoint is reached.
7. Again press the box to the right of Setpoint and enter 25.00 and [OK].
8. If the Reading stays above the Setpoint increase the Exhaust value by .1 until the setpoint is reached.
9. Return again to the Setpoint of 50 by repeating step 4.
10. Evaluate the way the reading reacts when approaching the setpoint and repeat steps 6 and 8 until the desired result is reached.
11. When you are satisfied with the performance of the regulator, press the [Save] button to store the changes you have made to the regulator. These values are stored in nonvolatile memory on the regulator and they will be saved through power cycles.

TRANSDUCER REMOVAL

CAUTION: ESD PROTECTION REQUIRED. The proper use of grounded work surfaces and personal wrist straps are required when coming into contact with exposed circuits (printed circuit boards) to prevent static discharge damage to sensitive electronic components.

1. **VENT THE SYSTEM!** Then turn off the power.
2. Loosen the two captive screws on the front panel (Figure 1.2), and swing the panel open.
3. Unscrew the thumb screw holding in the transducer (Figures 6.2 and 6.7).
4. Apply a light inward pressure against the bottom of the transducer case, just below the range label, while tilting the case upward to clear the clamp plate and screw head.
5. Pull the transducer module outward, through the front opening.

   NOTE: Always store loose transducers and PC boards in static protective bags or containers.

Removing a transducer disengages the electrical and pneumatic connections and seals off the pressure on the pneumatic module. This permits the SPC4000 to be turned on with the supply pressure connected even with no transducers installed.

CAUTION! There must be a transducer installed in the “Primary Transducer” berth for the system to function properly. If the system is operated with the primary berth empty the results will be unpredictable.

Each control channel has pressure control limits. Typically, the pump regulator modules have a maximum limit of 15 psig and the solenoid valve regulator modules have limits

of 50-150 or 1500 psig. If a sensor is placed into a control channel where the sensor has a higher upper pressure range than the control module, the maximum control limit will be limited to the maximum range of the control module.

While any sensor can be installed in any control channel, the results may not always be optimum. It is not recommended to install a low pressure transducer in a high pressure channel. A high pressure transducer should not be installed in a low pressure channel.

TRANSDUCER INSTALLATION

To replace a transducer first make sure that it is going into the proper transducer berth in the pneumatic module. Each

CAUTION: ESD PROTECTION REQUIRED. The proper use of grounded work surfaces and personal wrist straps are required when coming into contact with exposed circuits (printed circuit boards) to prevent static discharge damage to sensitive electronic components.

berth is clearly marked on the pneumatic module baseplate (see Figure 1.6). **The "PRIMARY TRANSDUCER" must be the transducer with the highest pressure range.**

To install a transducer with the front panel already open:

1. Rest the transducer on the baseplate and the retention bar. The transducer will be tilted down slightly.
2. Slide the transducer inward until resistance is felt. Then apply enough pressure against the transducer for it to clear the clamp so that it clears the retention bar and is fully seated and level on the baseplate.
3. Tighten the thumb screw to secure the transducer.
4. Swing the front panel closed and secure it by tightening the two captive screws.

CAUTION! When transducers are replaced and the unit is rebooted, the default parameters will be loaded. If you are using custom settings they must be reloaded after transducer installation.

CAUTION! Do not install a high pressure transducer into a low pressure SPC4000. It is acceptable to install a low pressure transducer in a high pressure instrument, but control stability will be degraded.

PNEUMATIC MODULE REMOVAL

CAUTION: ESD PROTECTION REQUIRED. The proper use of grounded work surfaces and personal wrist straps are required when coming into contact with exposed circuits (printed circuit boards) to prevent static discharge damage to sensitive electronic components.

1. **VENT THE SYSTEM!** Then turn off the power.
2. Remove top cover.
3. Remove all external pressure connections.
4. Remove the 6 slotted 2.5mm screws that fasten the pneumatic module rear panel to the chassis.
5. Inside the pneumatic module disconnect one 9-pin D-sub connector at the regulator, and the two connectors on the power cable.
6. Slide the pneumatic module out through the rear and clear of the chassis.

NOTE: Pneumatic modules have EMI containment strips that may necessitate some force to remove modules.

PNEUMATIC MODULE INSTALLATION

To install or replace the pneumatic module, simply reverse the steps taken for its removal.

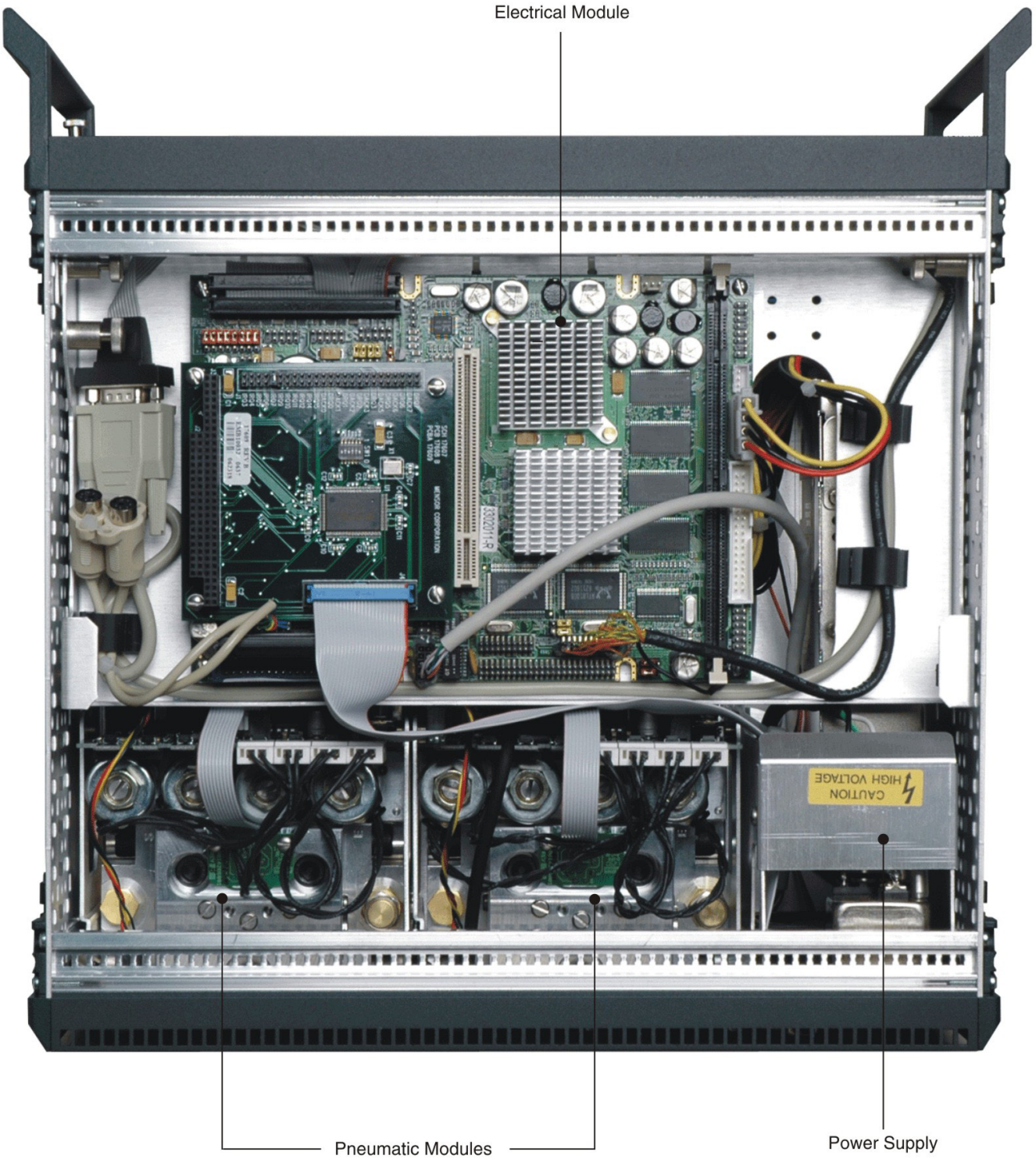


FIGURE 6.8 - CHASSIS INTERIOR, TOP VIEW

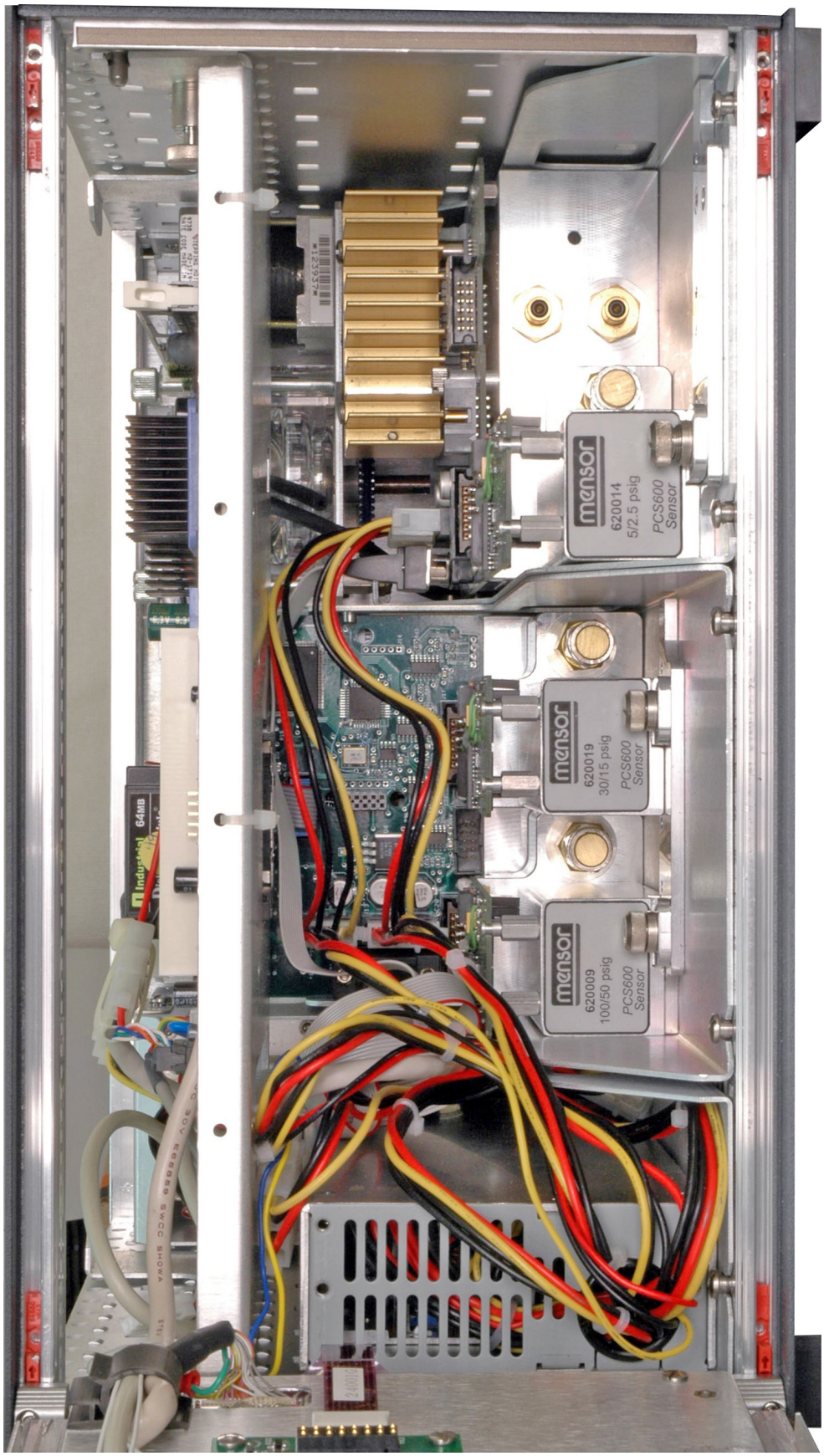


FIGURE 6.9 - CHASSIS INTERIOR, FRONT VIEW

SPCPLU DIAGNOSTICS

Figure 6.10 depicts the internal pneumatic schematic of the SPCPLU. This can be used to diagnose and locate any pneumatic logic errors or pressure leaks.

The best technique for diagnosing problems with the SPCPLU is to use pressure generated by the SPC4000 calibrator and cap off the pressure outputs (CAL OUT and REF OUT) from the SPCPLU. By systematically capping off and opening the various pressure outlets while working through the various pneumatic logic states of the SPCPLU one can determine where a leak is or determine if a solenoid is faulty.

The LED's on the front panel of the SPCPLU (Figure 1.10) also serve as a useful diagnostic tool. Confirming the LED's logic matches the expected logic confirms that the digital out signals are being properly sent from the SPC4000 calibrator.

One of the most common causes of problems with the SPCPLU is due to insufficient solenoid supply pressure. For SPCPLU-1&-2, a minimum of 90psi is required, 120psi maximum. For SPCPLU-3&-4 60psi minimum is required, 70psi maximum.

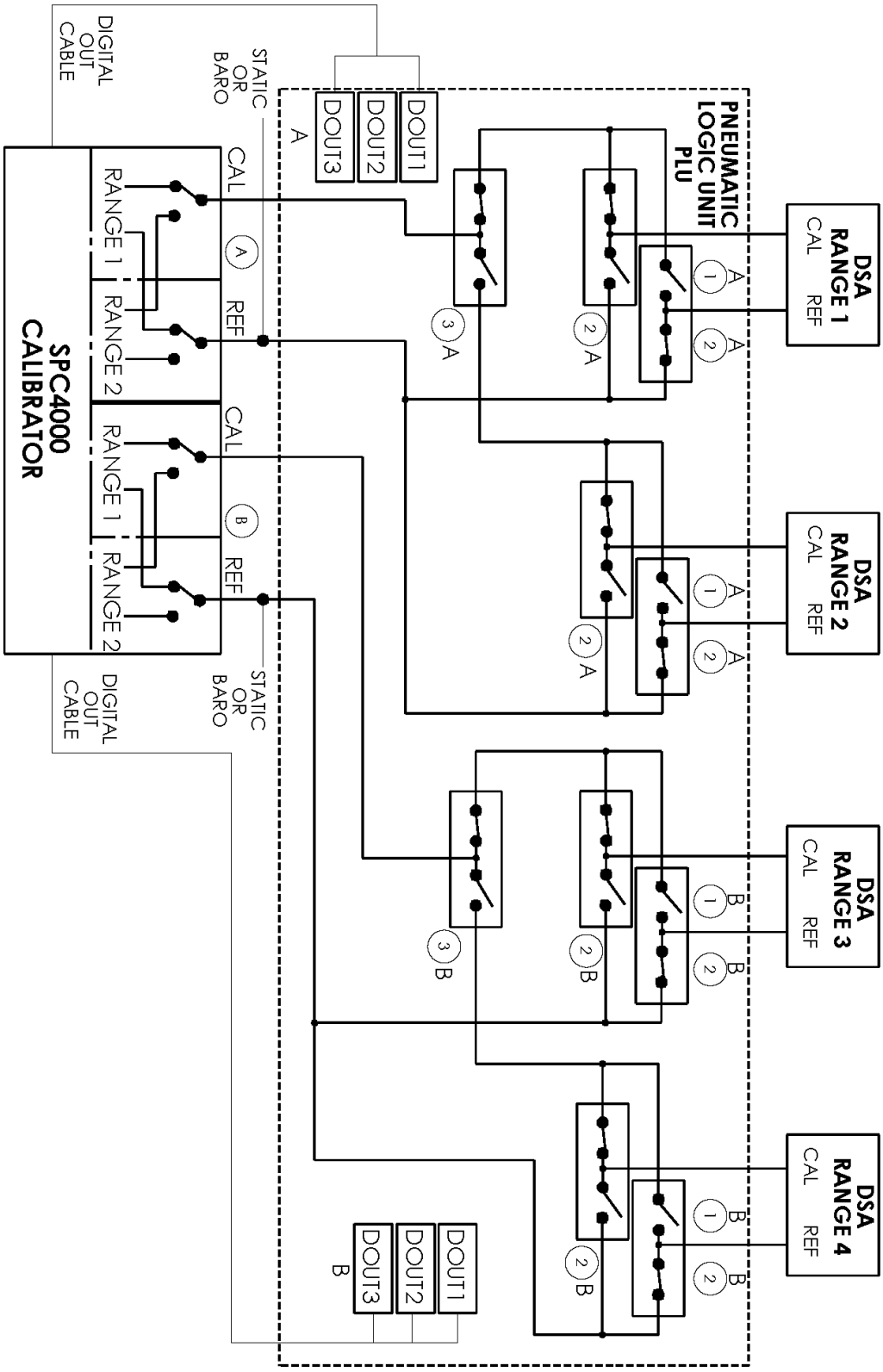


FIGURE 6.10 - SPCPLU PNEUMATIC SCHEMATIC

SECTION 7: CALIBRATION

General

The SPC4000 automatically adjusts the pressure reading for the effects of temperature and non-linearity within the calibrated temperature range of 15-45°C. The process is referred to as dynamic compensation because each reading is so adjusted before it is output to the display or to a communication bus. Thus, a calibrated SPC4000 operated within its temperature band, and with proper zero and span adjustments, will provide accurate pressure measurements.

Environment

For maximum accuracy, allow the SPC4000 to warm up for a minimum of 30 minutes in an ambient temperature within the compensated range prior to commencing a calibration. In addition the instrument should be at rest on a stable platform that is free of excessive vibration and shock.

Pressure Standards

Scanivalve recommends the use of appropriately accurate primary pressure standards when calibrating this instrument. Such standards should be sufficient so that when the techniques of the ISO Guide to the Expression of Uncertainty in Measurement (GUM) are applied, the instrument meets its accuracy statements as required by ISO/IEC 17025:2005, or other applicable standards.

Media

The recommended calibration medium is dry nitrogen or clean dry instrument air. A height variation between the standard and the SPC4000 can cause significant errors. See “Head Pressure Correction” for further information.

Setup

Figure 7.1 - Calibration Setup illustrates a typical setup for either local or remote calibration for a gauge pressure instrument. In the illustration the ‘Optional Computer’ is required only for performing a remote calibration.
The ‘Pressure Standard’ is normally a deadweight test instrument, and the ‘Volume Controller’ refers to a hand operated variable-volume pressure vernier device.

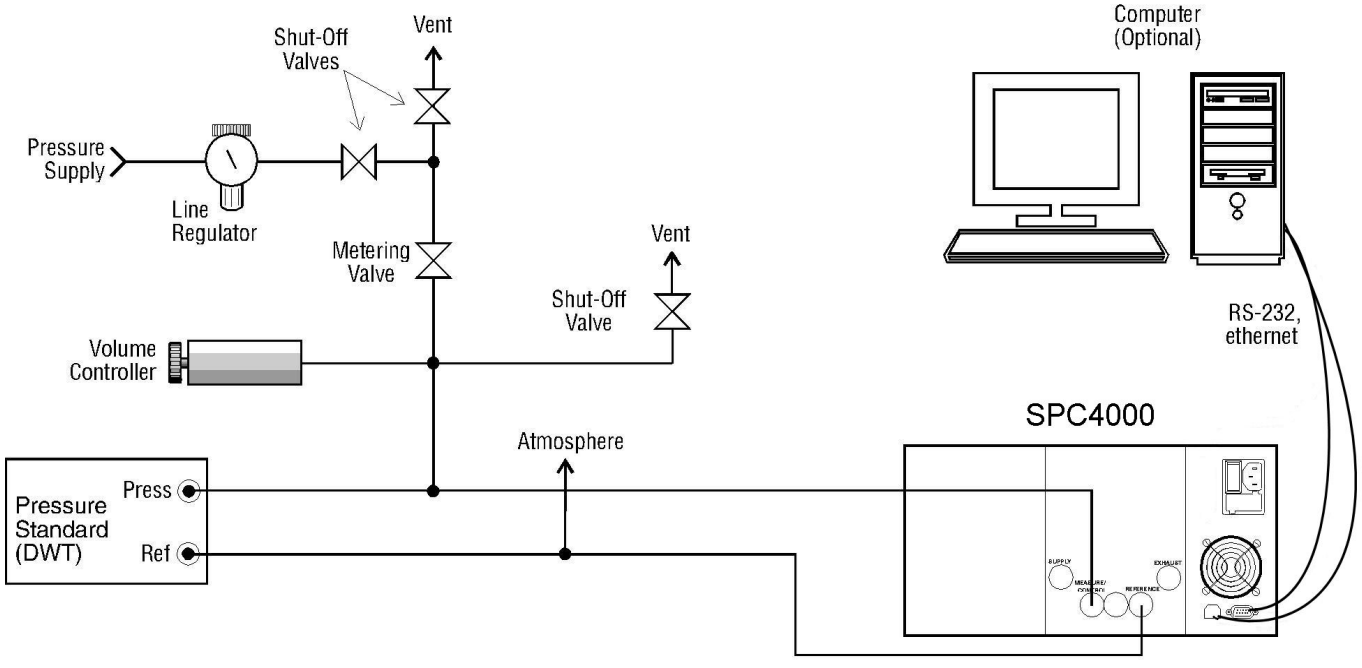


Figure 7.1 - Calibration Setup

PASSWORD

Autozero does not require a password, however one is needed to change any date of calibration, Zero, Span, or to change the system password. The password installed at the factory was 1 2 3 4 5 6, but the user can change this as described below.

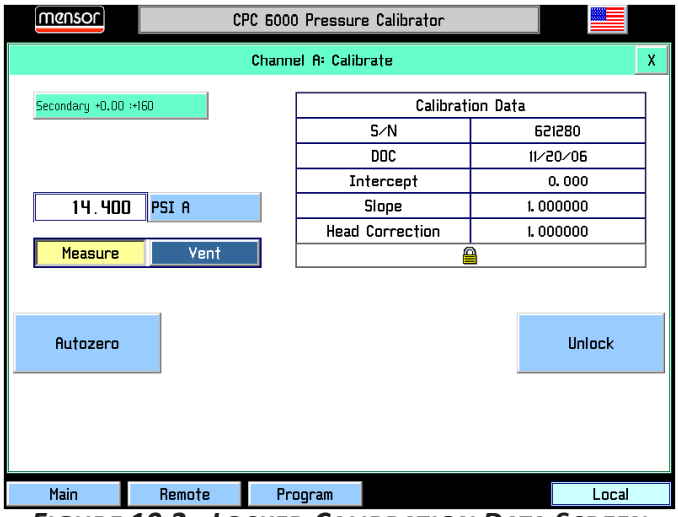


FIGURE 10.2 - LOCKED CALIBRATION DATA SCREEN

To Change the password:

1. Press the [Calibrate] key to see the Calibration Data screen similar to Figure 10.2. Notice the padlock.
2. Touch the [Unlock] key to display the Enter Password window as shown in Figure 10.3.

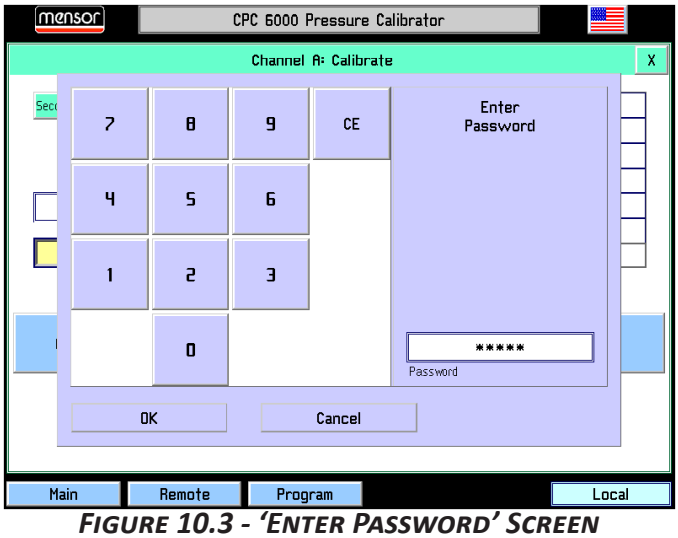


FIGURE 10.3 - 'ENTER PASSWORD' SCREEN

3. Enter the current password. As each number is pressed an '*' appears in the 'Password' window. When completed touch [OK] to unlock the calibration data screen.

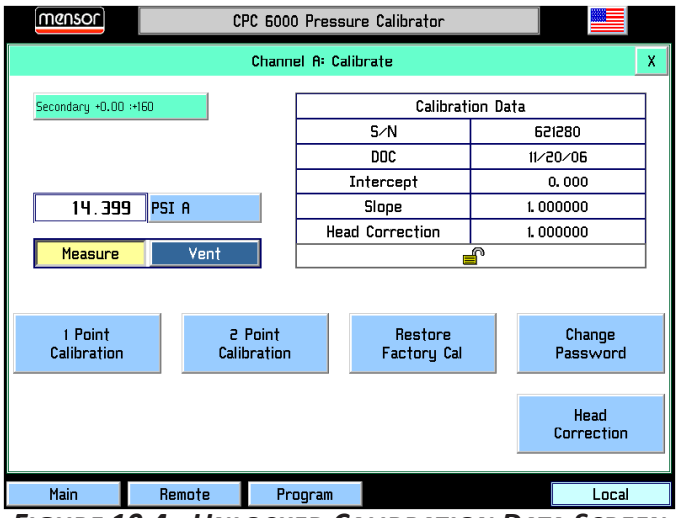


FIGURE 10.4 - UNLOCKED CALIBRATION DATA SCREEN

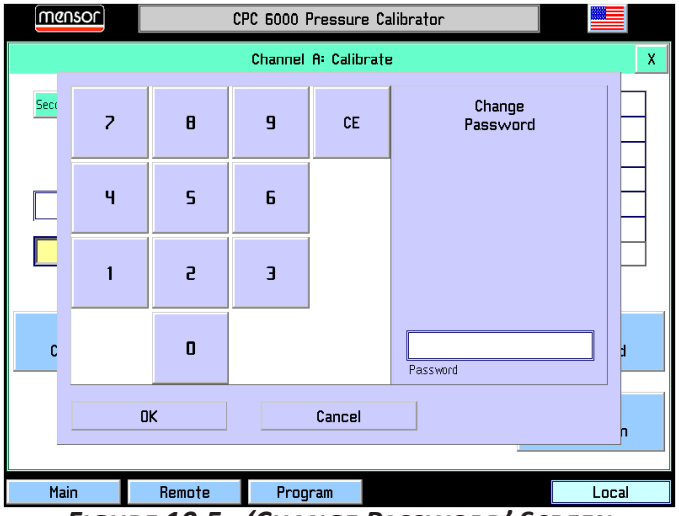


FIGURE 10.5 - 'CHANGE PASSWORD' SCREEN

4. The Calibration Data screen of Figure 10.4 is displayed. Use this screen to change the password to perform functions for 1 point calibration, 2 point calibration, restore factory cal, and head correction. Touch [Change Password] and the Change Password window appears as in Figure 10.5.

5. At the Change Password screen enter from one to six digits for a new password. As each number is pressed it appears in the Password window.

6. Before proceeding, review the displayed digits for accuracy. A mistake here could prevent future access to this screen. To make a correction use [CE] to backspace through the entries and then immediately re-enter the correct numbers.

7. When satisfied that the new password is correct, and a written copy has been stored, press [OK] to complete the entry. The previous password is immediately replaced by the new one.
8. Confirm that the new password is valid by pressing [Main], then repeat steps 1 through 3 to return to the Calibration Data screen (Figure 10.4). If this screen can't be accessed using either the old or the new password contact Scanivalve.

CAUTION! The password is seldom used and is easily forgotten. After a change write down and save the new number. If the password is lost, contact Scanivalve.

Restoring Factory Calibration

The offset and slope values established for each turndown during the final factory calibration are stored in permanent memory within each transducer. These factory values can be restored at any time regardless of the number of subsequent calibrations. To restore the factory calibration to the active turndown, press [Restore Factory Cal] on the unlocked Data Entry screen seen in Figure 10.4. This will restore both the factory zero offset and slope calibration values to the active turndown. The [Restore Factory Cal] function can be repeated for each turndown as desired.

On-Site Calibration

The SPC4000 can contain one primary transducer and barometric reference and may have an additional, secondary transducer. Each transducer (except the Barometric Reference Transducer) can have up to two separately calibrated ranges (two turndowns). Zero and span adjustments are available for each of these turndowns.

Linearity is preset at the factory and is not adjustable. One and two point calibrations are used to make a linear correction to the pressure readings using the formula: (uncorrected reading) X (slope) + offset. The one point calibration adjusts the offset, the two point calibration adjusts both the offset and the slope.

To perform an on-site calibration, follow the step-by-step procedure for calibrating a transducer.

SPC4000 Preparation

Evacuate the pressure transducer(s) to a low pressure that will still maintain a viscous flow, typically 600 millitorr (0.0116 psi). At pressures lower than this the pressure at any particular point in the system is questionable. Allow from five to ten minutes for the target pressure to stabilize, then convert the millitorr reading to an equivalent instrument reading in the active measurement units. Table 3 in the Appendix lists millitorr conversion factors.

To begin a calibration, press the [Calibrate] tab and unlock the calibration screen as described in the previous section. Select the turndown to calibrate from the drop list and the units in which to perform the calibration on the unlocked calibration data screen.

Calibrate Setup Key

The Calibration screen shown in Figure 10.6 is the first of several screens relating to the calibration functions. This screen allows the user to perform the following tasks:

1. Calibrate zero and span values on any turndown open of all installed sensors.
2. Establish a new Date of Calibration (DOC) for any turndown;
3. Change the system password;
4. Autozero all turndowns at one time.

Notice the padlock icon on the display. This signifies that the indicated values on the screen are not able to be modified until the password has been entered.

[Unlock] Key: Touch [Unlock] (Figure 10.6) to move on to the password screen. This function is password protected. Details on this function are included in Section 7: ***Calibration***.

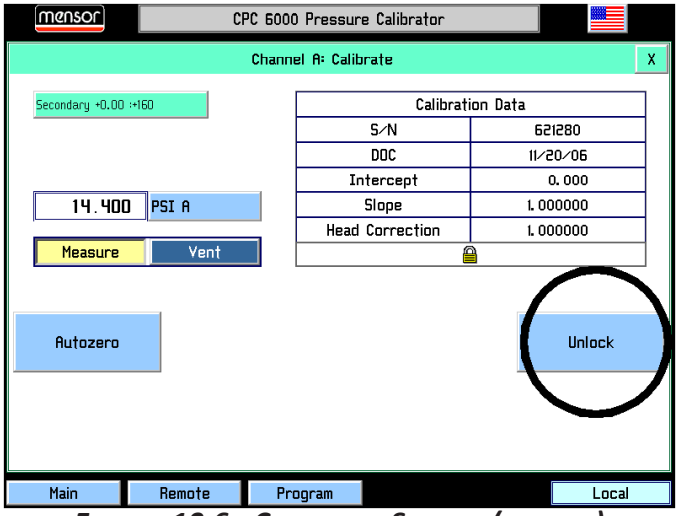


FIGURE 10.6 - CALIBRATE SCREEN (LOCKED)

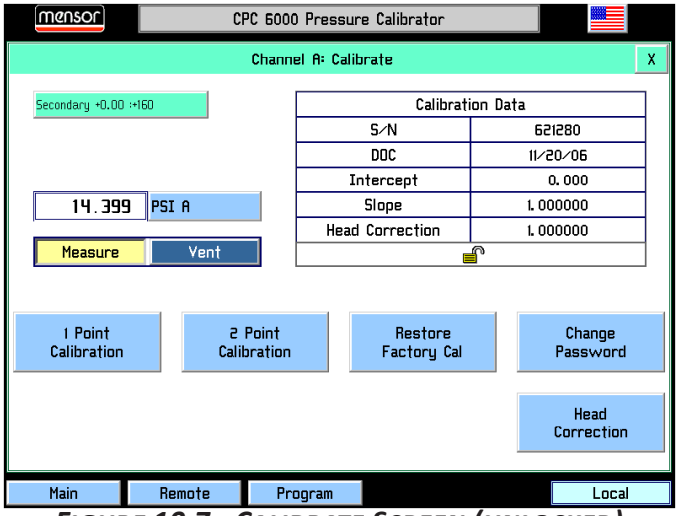


FIGURE 10.7 - CALIBRATE SCREEN (UNLOCKED)

[Autozero] Key: Press this key to have the SPC4000 automatically re-zero all turndowns that can measure the vented pressure (Figure 10.8).

This automatic function will:

1. Vent the system.
2. Adjust the zero offset of each turndown that can measure the vented pressure so the turndown's output is equal to zero.

NOTE: The autozero function re-zeros sensors without storing the zero offsets through power cycling.

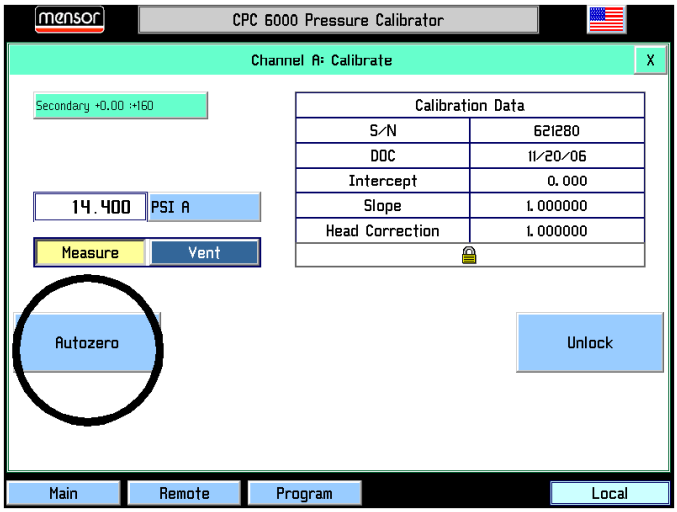


FIGURE 10.8 - AUTOZERO KEY

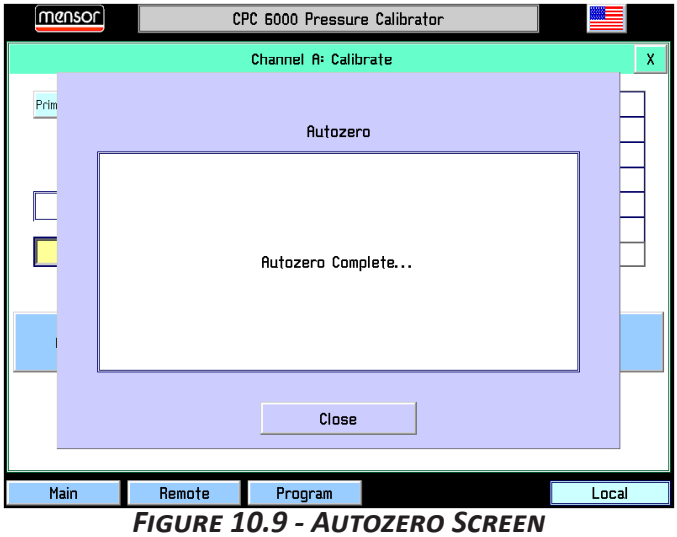


FIGURE 10.9 - AUTOZERO SCREEN

1 POINT CALIBRATION

A one-point calibration adjusts only the offset of the active turndown. From the unlocked calibration data screen, press the [1 Point Calibration] key shown in Figure 10.10. The '1 Point Cal' window shown in Figure 10.11 will appear. This window shows the maximum and minimum acceptable values and the current reading. The [?] key pops up a help dialog with instructions on how to use this screen. Enter the current known pressure in the 'Desired Reading' data window. Values entered that are outside of the displayed Maximum/Minimum limits will not be accepted. When the desired reading is displayed in the data window press the [OK] key and the offset will be stored. The [Cancel] key will exit this window and not make any adjustments to the calibration of the active turndown.

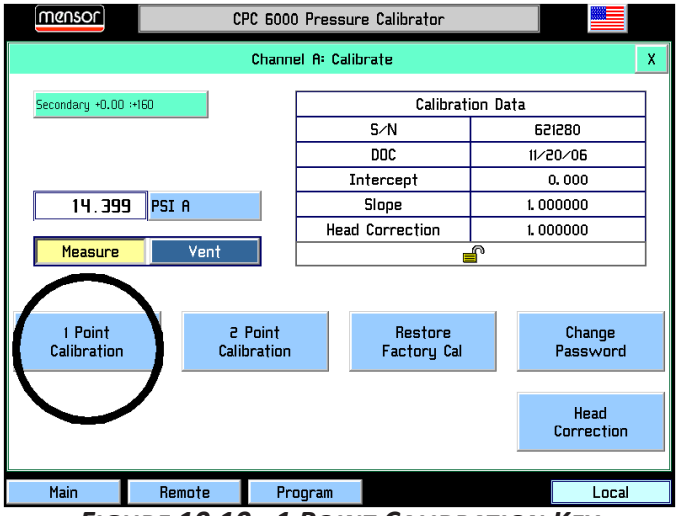


FIGURE 10.10 - 1 POINT CALIBRATION KEY

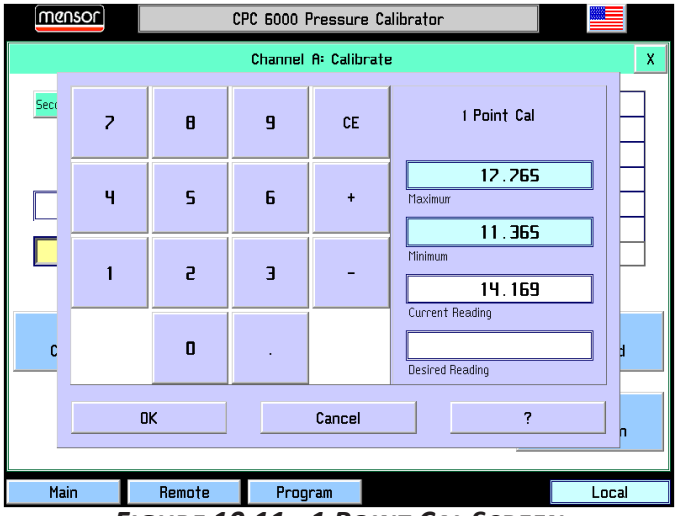


FIGURE 10.11 - 1 POINT CAL SCREEN

2 POINT CALIBRATION

A two-point calibration adjusts both the offset and the slope of the active turndown. The low point must be within 20% of the minimum range of the active turndown and the high point must be within 20% of the maximum range of the active turndown. Insure that the head correction is adjusted properly, see 'Head Pressure Correction.' From the unlocked calibration data screen, press the [2 Point Calibration] key as shown in Figure 10.12. The 'Low Point Cal' window illustrated in Figure 10.13 will appear. This window shows the maximum and minimum acceptable values and the current reading. The [?] key pops up a help dialog with instructions on how to use this window. Enter the current known pressure in the 'Desired Reading' data window and press the [OK] key.

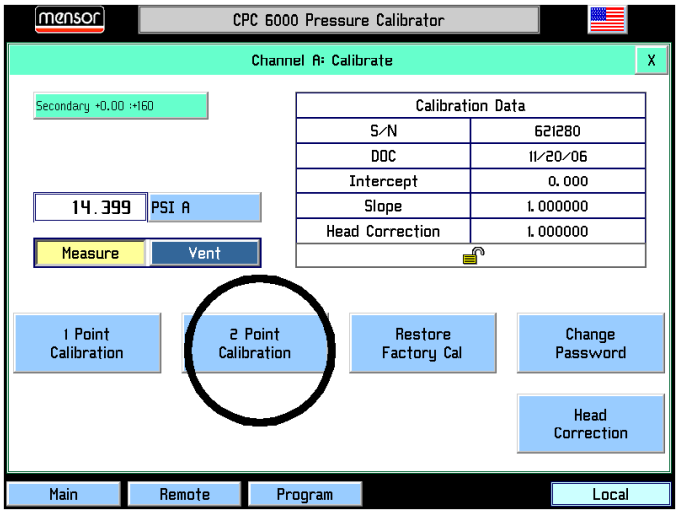


FIGURE 10.12 - 2 POINT CALIBRATION KEY

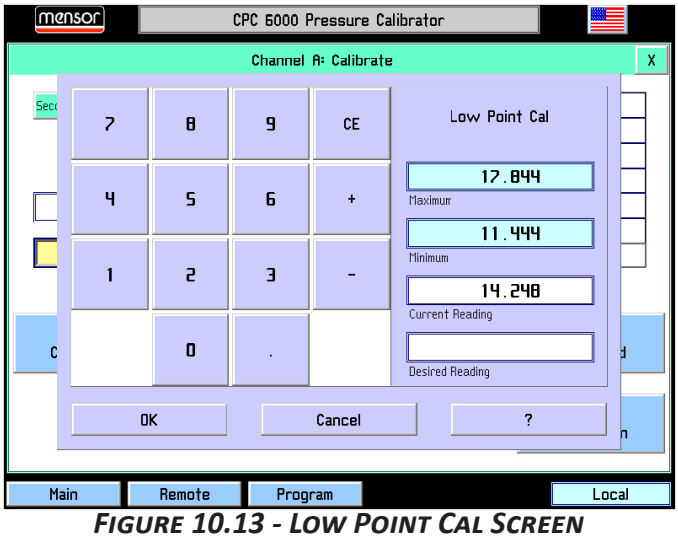


FIGURE 10.13 - LOW POINT CAL SCREEN

The 'High Point Cal' window illustrated in Figure 10.14 will appear. It's function is identical to the 'Low Point Cal' window. Enter the new known pressure and press the [OK] key.

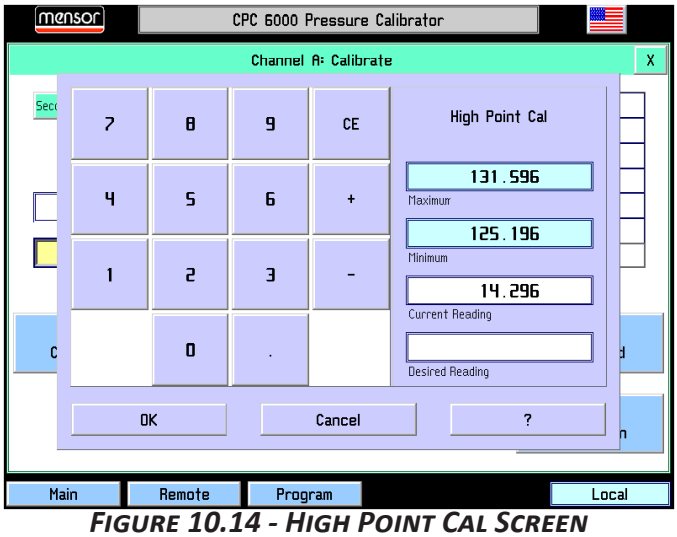


FIGURE 10.14 - HIGH POINT CAL SCREEN

The [Cancel] key will exit either window and not make any adjustments to the calibration of the active turndown.

The 'Date of Calibration' window illustrated in Figure 10.15 will appear. Enter the date of calibration in a mm/dd/yyyy format exactly, including the '/' separation marks. Press the [OK] key and the new data of calibration will be saved to the turndown.

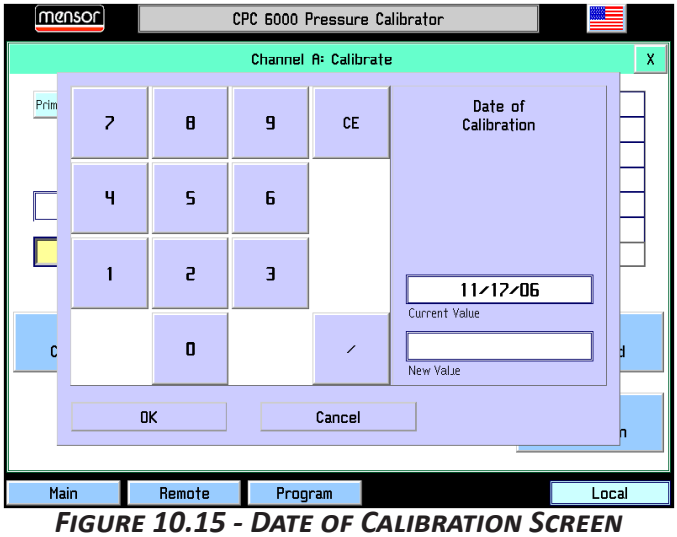


FIGURE 10.15 - DATE OF CALIBRATION SCREEN

HEAD PRESSURE CORRECTION

The correction is accessed from the calibration menu. Four parameters may be set to reflect conditions at the operator's site. Press either [English] or [Metric] units for entering head pressure correction information into the SPC4000. See Figure 10.16.

NOTE: Head correction parameters are stored separately for each channel.

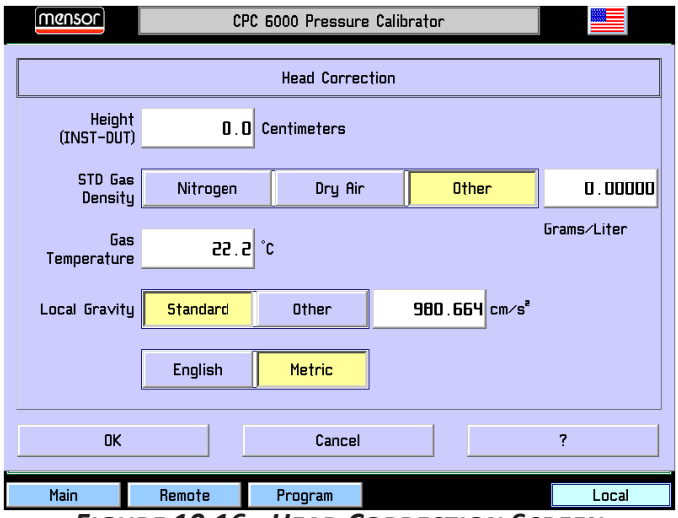


FIGURE 10.16 - HEAD CORRECTION SCREEN

Height: Enter the difference in height between the center of the measure/control port of the SPC4000 and the reference level of the Device Under Test (DUT). If the reference level of the DUT is lower than the center of the measure/control port of the SPC4000, enter a positive height. If it is higher, enter a negative height. See Figure 10.17.

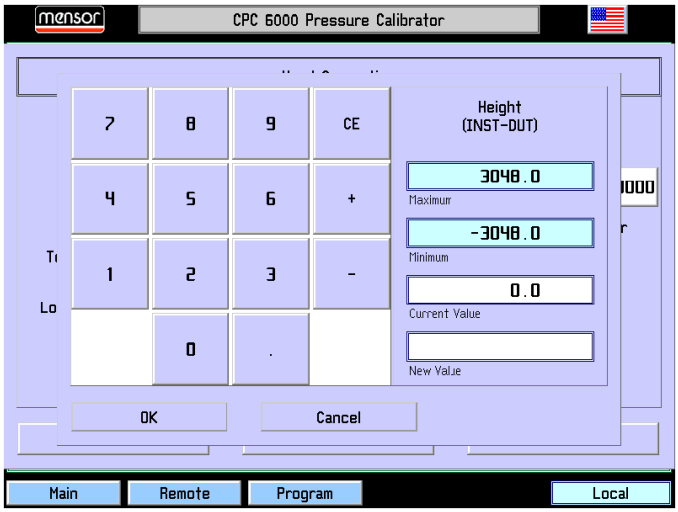


FIGURE 10.17 - HEIGHT SCREEN

Gas Density: If nitrogen (N2) or dry air are being used as a pressure media, press the appropriate selection. If another gas is being used, enter the density for the gas at standard pressure and temperature in either lb/cubic foot (english) or kg/liter (metric) units. See Figure 10.18.

Gas Temperature: Enter the average gas temperature in degrees F or C. If unsure of the gas temperature, use 68 F. See Figure 10.19.

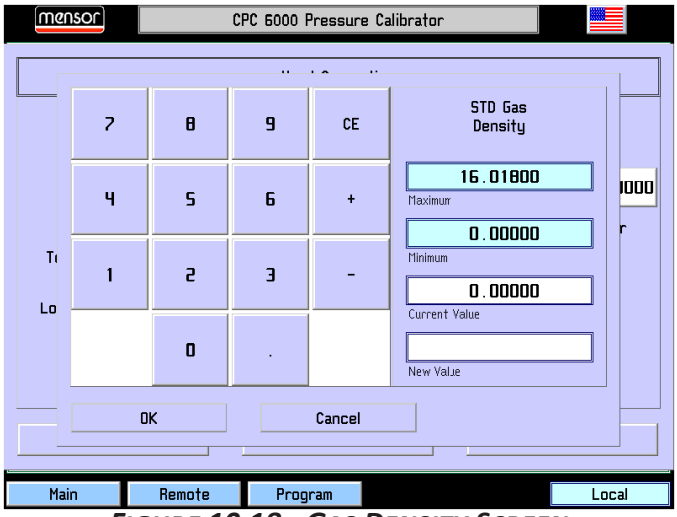


FIGURE 10.18 - GAS DENSITY SCREEN

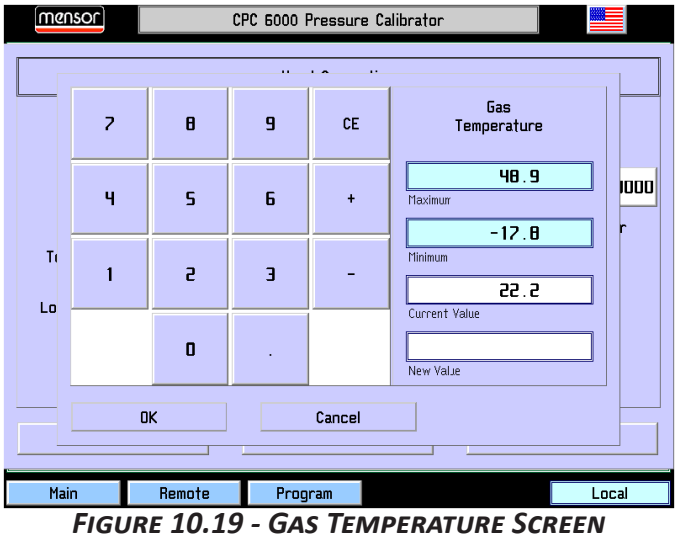


FIGURE 10.19 - GAS TEMPERATURE SCREEN

Local Gravity: Enter the local gravity acceleration value. If unsure, use the standard gravity radio button. See Figure 10.20.

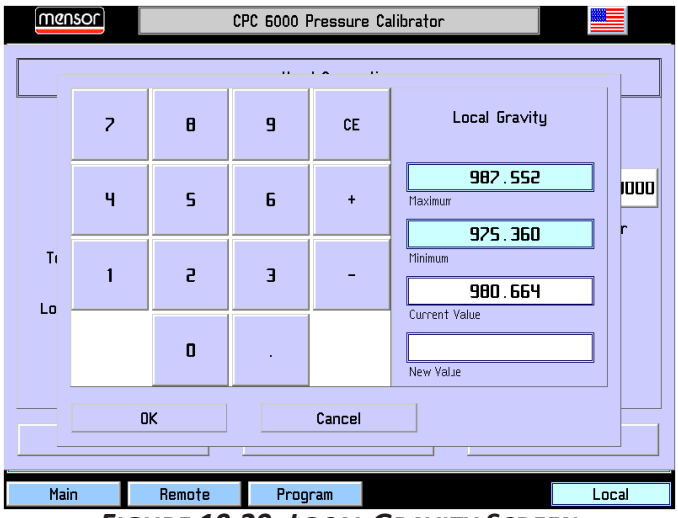


FIGURE 10.20- LOCAL GRAVITY SCREEN

Head Pressure Correction Limits	
Height	±1200 inches
Density	0 to 1 lb/cu ft
Temperature	0 to 120 °F
Gravity	32 to 32.4 ft/sec²

APPENDIX

MEASUREMENT UNITS

The Units command selects the measurement units to be output on the bus and the display.

Table 1 - Measurement Units		
Code	**Description**	**Output Format**
1	pounds per square inch	PSI
2	inches of mercury @ 0°C	inHg 0°C
3	inches of mercury @ 60°F	inHg 60°F
4	inches of water @ 4°C	inH_2O 4°C
5	inches of water @ 20°C	inH_2O 20°C
6	inches of water @ 60°F	inH_2O 60°F
7	feet of water @ 4°C	ftH_2O 4°C
8	feet of water @ 20°C	ftH_2O 20°C
9	feet of water @ 60°F	ftH_2O 60°F
10	millitorr	mTorr
11	inches of seawater @ 0°C 3.5% salinity	inSW
12	feet of seawater @ 0°C 3.5% salinity	ftSW
13	atmospheres	ATM
14	bars	Bar
15	millibars	mBar
16	millimeters of water @ 4°C	mmH_2O 4°C
17	centimeters of water @ 4°C	cmH_2O 4°C
18	meters of water @ 4°C	MH_2O 4°C
19	millimeters of mercury @ 0°C	mmHg 0°C
20	centimeters of mercury @ 0°C	cmHg 0°C
21	torr	Torr
22	kilopascals	kPa
23	pascals	PA
24	dyne per square centimeter	Dy/cm^2
25	grams per square centimeter	gm/cm^2
26	kilograms per square centimeter	kg/cm^2
27	meters of seawater @ 0°C 3.5% salinity	MSW
28	ounce per square inch	OSI
29	pounds per square foot	PSF
30	tons per square foot	TSF
31	percent of full scale	%FS
32	micron HG @ 0°C	µHg 0°C
33	ton per square inch	TSI

Table 1 - Measurement Units		
Code	**Description**	**Output Format**
34	n/a	n/a
35	hectopascals	hPa
36	megapascals	MPa
37	millimeters of water @ 20°C	mmH_2O 20°C
38	centimeter of water @ 20°C	cmH_2O 20°C
39	meters of water @ 20°C	MH_2O 20°C
n/a	User Units 1	User defined
n/a	User Units 2	User defined

CONVERSION FACTORS, PSI

The values listed in the column "To convert from PSI" are the values imbedded in the instrument program. The values listed under "To convert to PSI" are internally calculated approximations based on the imbedded values.

Table 2 - Conversion Factors, PSI			
Code	**Pressure Unit**	**To convert from PSI**	**To convert to PSI**
1	PSI	1	1
2	inHg 0°C	2.036020	0.4911544
3	inHg 60°F	2.041772	0.4897707
4	inH_2O 4°C	27.68067	0.03612629
5	inH_2O 20°C	27.72977	0.03606233
6	inH_2O 60°F	27.70759	0.03609119
7	ftH_2O 4°C	2.306726	0.4335149
8	ftH_2O 20°C	2.310814	0.4327480
9	ftH_2O 60°F	2.308966	0.4330943
10	mTorr	51715.08	0.00001933672
11	inSW 0°C 3.5% salinity	26.92334	0.03714250
12	ftSW 0°C 3.5% salinity	2.243611	0.445710
13	ATM	0.06804596	14.69595
14	Bar	0.06894757	14.50377
15	mBar	68.94757	0.01450377
16	mmH_2O 4°C	703.0890	0.001422295
17	cmH_2O 4°C	70.30890	0.01422295
18	MH_2O 4°C	0.7030890	1.422295
19	mmHg 0°C	51.71508	0.01933672
20	cmHg 0°C	5.171508	0.1933672
21	Torr	51.71508	0.01933672
22	kPa	6.894757	0.1450377
23	PA	6894.757	0.0001450377
24	Dy/cm^2	68947.57	0.00001450377

Table 2 - Conversion Factors, PSI			
Code	**Pressure Unit**	**To convert from PSI**	**To convert to PSI**
25	gm/cm^2	70.30697	0.01422334
26	kg/cm^2	0.07030697	14.22334
27	MSW 0°C 3.5% salinity	0.6838528	1.462303
28	OSI	16	0.0625
29	PSF	144	0.006944444
30	TSF	0.072	13.88889
31	%FS	(PSI / RANGE) x 100	(% FS x RANGE) / 100
32	µHg 0°C	51715.08	0.00001933672
33	TSI	0.0005	2000
35	hPa	68.94757	0.01450377
36	MPa	0.006894757	145.0377
37	mmH_2O 20°C	704.336	0.001419777
38	cmH_2O 20°C	70.4336	0.01419777
39	MH_2O 20°C	0.704336	1.419777

CONVERSION FACTORS, MILLITORR

The following table lists factors which should be used as multipliers when converting other pressure units to or from millitorr.

Table 3 - Conversion Factors, Millitorr			
Code	**Pressure Unit**	**To convert to from millitorr**	**To convert to millitorr**
1	PSI	0.00001933672	51715.08
2	inHg 0°C	0.00003936995	25400.08909
3	inHg 60°F	0.00003948117	25328.53093
4	inH_2O 4°C	0.0005352534	1868.273977
5	inH_2O 20°C	0.0005362028	1864.966281
6	inH_2O 60°F	0.0005357739	1866.458778
7	ftH_2O 4°C	0.00004460451	22419.25773
8	ftH_2O 20°C	0.00004468356	22379.59744
9	ftH_2O 60°F	0.00004464783	22397.50637
10	mTorr	1.0	1.000000022
11	inSW 0°C 3.5% salinity	0.0005206091	1920.827359
12	ftSW 0°C 3.5% salinity	0.00004338408	23049.92831
13	ATM	0.000001315786	760002.2299
14	Bar	0.000001333220	750063.6259
15	mBar	0.001333220	750.0636259
16	mmH_2O 4°C	0.0135954	73.5540997
17	cmH_2O 4°C	0.001359544	735.5409971
18	MH_2O 4°C	0.00001359544	73554.09971
19	mmHg 0°C	0.001	1000.000022

Table 3 - Conversion Factors, Millitorr			
Code	**Pressure Unit**	**To convert to from millitorr**	**To convert to millitorr**
20	cmHg 0°C	0.0001	10000.00022
21	Torr	0.001	1000.000022
22	kPa	0.0001333220	7500.636259
23	PA	0.1333220	7.500636259
24	Dy/cm^2	1.333220	0.750063626
25	gm/cm^2	0.001359506	735.561166
26	kg/cm^2	0.000001359506	735561.166
27	MSW 0°C 3.5% salinity	0.00001322347	75623.11663
28	OSI	0.0003093875	3232.1992
29	PSF	0.002784488	359.132477
30	TSF	0.000001392244	718265.0575
32	µHg 0°C	1.0	1.000000022
33	TSI	n/a	n/a
35	hPa	0.001333220	750.0636259
36	MPa	0.0000001333220	7500636.259
37	mmH_2O 20°C	0.01361955	73.42388114
38	cmH_2O 20°C	0.001361955	734.2388114
39	MH_2O 20°C	0.00001361955	73423.88114

CONVERSION FACTORS, PASCAL

The following table lists factors which should be used as multipliers when converting other pressure units to or from Pascal.

Table 4 - Conversion Factors, Pascal			
Code	**Pressure Unit**	**To convert from Pascal**	**To convert to Pascal**
1	PSI	1.450377E-04	6.894757E+03
2	inHg 0°C	2.952997E-04	3.386390E+03
3	inHg 60°F	2.961339E-04	3.376850E+03
4	inH_2O 4°C	4.014741E-03	2.490820E+02
5	inH_2O 20°C	4.021862E-03	2.486410E+02
6	inH_2O 60°F	4.018645E-03	2.488400E+02
7	ftH_2O 4°C	3.345622E-04	2.988980E+03
8	ftH_2O 20°C	3.351551E-04	2.983692E+03
9	ftH_2O 60°F	3.348871E-04	2.986080E+03
10	mTorr	7.500636E+00	1.333220E-01
11	inSW 0°C 3.5% sal	3.904899E-03	2.560885E+02
12	ftSW 0°C 3.5% sal	3.254082E-04	3.073062E+03
13	ATM	9.869230E-06	1.013250E+05
14	Bar	1.00000E-05	1.00000E+05
15	mBar	1.00000E-02	1.00000E+02

Table 4 - Conversion Factors, Pascal			
Code	**Pressure Unit**	**To convert from Pascal**	**To convert to Pascal**
16	mmH_2O 4°C	1.019744E-01	9.806378E+00
17	cmH_2O 4°C	1.019744E-02	9.806378E+01
18	MH_2O 4°C	1.019744E-04	9.806378E+03
19	mmHg 0°C	7.500636E-03	1.333220E+02
20	cmHg 0°C	7.500636E-04	1.333220E+03
21	Torr	7.500636E-03	1.333220E+02
22	kPa	1.00000E-03	1.00000E+03
23	PA	1.00000E+00	1.00000E+00
24	Dy/cm^2	1.00000E+01	1.00000E-01
25	gm/cm^2	1.019716E-02	9.806647E+01
26	kg/cm^2	1.019716E-05	9.806647E+04
27	MSW 0°C 3.5% sal	9.918444E-05	1.008222E+04
28	OSI	2.320603E-03	4.309223E+02
29	PSF	2.088543E-02	4.788025E+01
30	TSF	1.044271E-05	9.576052E+04
32	µHg 0°C	7.500636E+00	1.333220E-01
33	TSI	7.251885E-08	1.378951E+07
35	hPa	1.00000E-02	1.00000E+02
36	MPa	1.00000E-06	1.00000E+06
37	mmH_2O 20°C	1.021553E-01	9.789017E+00
38	cmH_2O 20°C	1.021553E-02	9.789017E+01
39	MH_2O 20°C	1.021553E-04	9.789017E+03