mensor®

Operation Manual PN 0014865001 H3

DUAL OUTPUT PRESSURE CONTROLLER

Model 8204

CODE _____

SN _____

VERSION _____

This Manual contains important information.
PLEASE READ PRIOR TO USE.

ISO 9001 BSI REGISTERED FM 59031

ACCREDITED 2066.01

WARRANTY

All products manufactured by Mensor® Corporation are warranted to be free of defects in workmanship and materials for a period of one year from the date of shipment. No other express warranty is given, and no affirmation of Seller, by words or actions, shall constitute a warranty. SELLER DISCLAIMS ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSES WHATSOEVER. If any defect in workmanship or material should develop under conditions of normal use and service within the warranty period, repairs will be made at no charge to the original purchaser, upon delivery of the product(s) to the factory, shipping charges prepaid. If inspection by Mensor Corporation or its authorized representative reveals that the product was damaged by accident, alteration, misuse, abuse, faulty installation or other causes beyond the control of Mensor Corporation, this warranty does not apply. The judgment of Mensor Corporation will be final as to all matters concerning condition of the product, the cause and nature of a defect, and the necessity or manner of repair. Service, repairs or disassembly of the product in any manner, performed without specific factory permission, voids this warranty.

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WARNINGS AND CAUTION NOTES

WARNING: NOT EXPLOSION PROOF!
Installation of this instrument in an area requiring devices rated as intrinsically safe is not recommended.

WARNING: POSSIBLE INJURY!
The tubing, valves and other apparatus attached to the gauge must be adequate for the maximum pressure which will be applied, otherwise physical injury to the operator or bystanders is possible.

CAUTION: USE THE PROPER PRESSURE MEDIUM.
USE ONLY CLEAN, DRY NON-CORROSIVE GASES UNLESS OTHERWISE SPECIFIED BY MENSOR. THIS INSTRUMENT IS NOT DESIGNED FOR OXYGEN USE.

ATTENTION
STATIC SENSITIVE DEVICES
HANDLING PRECAUTIONS REQUIRED

CAUTION: The proper use of grounded work surfaces and personnel are required when coming into contact with printed circuit boards in order to prevent static discharge damage to sensitive electronic components.

PLEASE NOTICE...

The product specifications and other information contained in this manual are subject to change without notice.

Mensor Corporation has made a concerted effort to provide complete and current information for the proper use of the equipment. If there are questions regarding this manual or the proper use of the equipment, contact Mensor Corporation at:

TEL	1.512.396.4200
TEL	1.800.984.4200 (USA only)
FAX	1.512.396.1820
WEB SITE	www.mensor.com
E-MAIL	sales@mensor.com
	tech.support@mensor.com

PACKAGING FOR SHIPMENT

If the product must be shipped to a different location or returned to Mensor for any reason through a common carrier it must be packaged properly to minimize the risk of damage.

The recommended method of packing is to place the instrument in a container, surrounded on all sides with at least four inches of shock attenuation material such as styrofoam peanuts.

TRADEMARKS

Mensor is a registered trademark of Mensor Corporation. All other brand and product names are trademarks or registered trademarks of their respective companies. The 8204 instrument contains software licensed from Microsoft Corporation.

SOFTWARE LICENSE AGREEMENT

This product contains intellectual property, i.e., software programs, that are licensed for use by the end user/customer (hereinafter “end user”).

This is not a sale of such intellectual property.

The end user shall not copy, disassemble or reverse compile the software program.

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FCC RADIO FREQUENCY EMISSION NOTICE

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his or her own expense.

USE SHIELDED CABLES TO CONNECT EXTERNAL DEVICES TO THIS INSTRUMENT TO MINIMIZE RF RADIATION.

MENSOR BACKGROUND

HISTORY: Mensor is an ISO-9001 certified manufacturer of precision pressure products. Mensor was established in 1969 in Houston, Texas as an independent spin-off from the Texas Instruments (TI) Pressure Instrument Group. As a private corporation, Mensor's objective was to design and produce high accuracy, high quality, easy to use pressure instruments. In 1978 Mensor moved to its present location in San Marcos, on Interstate 35 (the Austin-San Antonio corridor). Two and a half years after the move, the plant was destroyed by fire on Friday, February 13, 1981. Mensor resolved to come back, and almost before the ashes had cooled, construction of a new building began on the same site. Six months after the disaster Mensor moved into its present facility and began shipping products to customers who had waited patiently for the recovery.

PEOPLE: The key to Mensor's strength in the marketplace is the concentration of experienced people in the field of precision pressure measurement and control. The company's founders previously worked in various capacities in the Pressure Instrument Group of Texas Instruments, including engineering, production and marketing. These founders were involved in the design of the original quartz bourdon pressure gauge at TI. Mensor's CEO, Jerry Fruit, is co-holder of the patent on using a fused quartz bourdon tube to accurately measure pressure. The 50 current full time Mensor employees have an average longevity of fourteen years. That's a lot of pressure experience!

PRODUCTS: Mensor's portfolio of products consists of an extensive line of precision pressure instruments, including digital gauges, pressure controllers, transducers and pressure calibrations systems. All of these products feature computer interface capability. These products are used in metrology labs, calibration labs, research facilities, engineering offices, production test stands, and in other environments where high accuracy pressure measurement and/or control is required. Many of these products include customized features to meet a customer's specific requirement. Mensor products range from about $900 to $30,000.

CUSTOMERS: Typical Mensor customers are pressure sensor manufacturers, aerospace firms, jet engine manufacturers, electric utilities, nuclear power plants, pharmaceutical firms, calibration laboratories, government agencies and research organizations.

APPLICATIONS: In many facilities the highest accuracy pressure measuring or pressure controlling instrument is a Mensor product. A typical application for these Mensor instruments is the calibration of other pressure devices, such as sensors, transducers, transmitters, gauges and pressure switches. The Mensor product is used as the pressure standard to verify pressure calibrations or outputs of the device being produced, checked, tested or certified.

User's Notes:

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INTRODUCTION

DID YOU GET EVERYTHING?

In addition to this manual you should have:

- Model 8204 Dual Output Pressure Controller
- Power cord
- 1/8 inch NPT fitting adapters
- Any accessories ordered
- Envelope containing a Calibration Certificate

INITIAL INSPECTION

Your new instrument was subjected to many hours of functional testing before it left the factory. In addition to testing, the unit was inspected for appearance prior to being boxed. When your instrument is removed from the carton please examine it for shipping damage. Report any apparent damage to the carrier immediately.

MEET YOUR 8204

The Model 8204 Dual Output Pressure Controller is a special purpose instrument designed to test and calibrate two separate pressure devices simultaneously, or to test a differential pressure across a single device. The instrument consists of a self-contained, computerized, high accuracy two channel pressure management system integrated into a single, compact unit. The system is comprised of a front panel assembly, a rear panel, an electrical module, a pneumatic module, and a chassis to complete the package (see figure 1.10). The system functions either as a bench-top or a rack mounted instrument. It can operate in local mode to accept front panel input, or in remote mode to communicate with external devices.

Instrument Case

The instrument case is all aluminum construction with extruded aluminum frame members. The cover and side panels are vinyl clad. These panels, and the front and rear panel assemblies attach to the chassis frame. Each module is described separately below.

Front Panel

The 8204 front panel (figure 1.2) consists of the graphic display, a column of five function keys (F1 through F5), and the 20 key main keypad. A label in the upper right corner shows the model identity, and another label in the lower right corner shows the pressure ranges for the A and B channels, and the instrument serial number.

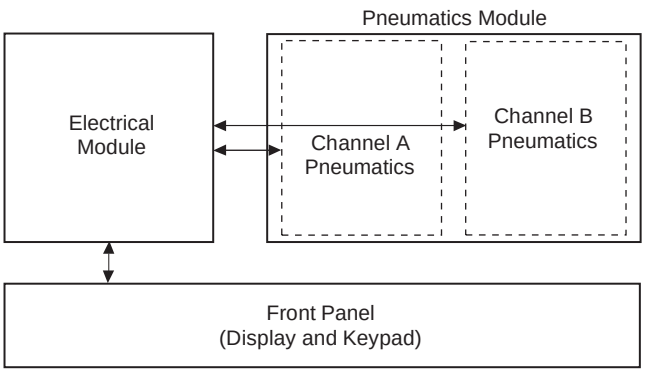


Figure 1.1 - System Block Diagram

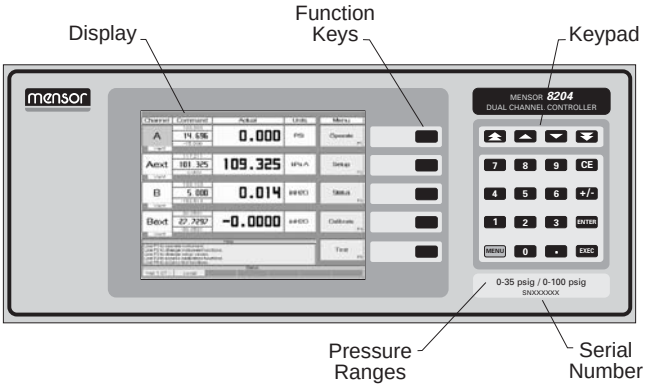


Figure 1.2 - Front Panel

Display

Several different display formats, or screens, are presented while operating the 8204. Each screen is arranged into blocks of information, generally organized into columns and rows.

When the 8204 is powered up it goes through an initialization process, then displays the Menu screen similar to figure 1.3. This screen is also displayed at any other time by pressing the blue MENU key on the main keypad.

Some of the screen elements of the Menu screen are described in figure 1.3. A header bar across the top of the screen uses labels to identify the type of data found in the column below the label. Starting at the left end of the header labels, 'Channel' refers to the A channel on the top data row, followed by the B channel on the lower data row. Two blank rows can be set up to display additional data, such as pressure rate, external transducers, or "virtual" channels. The next column, labeled 'Command', shows the last commanded control pressure values for the two channels. Moving right, the column under 'Actual' displays the currently measured numerical values for each channel. The forth column, 'Units', displays the measurement units associated with all of the values presented within that row. The far right label, 'Menu', indicates that this is the Menu screen.

A message area below the pressure data rows contains some screen sensitive Help information. At the very bottom a status bar contains labels for the installed software version number, the current 'Local' or 'Remote' operating mode, and to display 'Editing' and Pending' messages when new pressure values are being input, prior to execution.

The five rectangles below the 'Menu' label provide the functional descriptions or cues for each of the five function keys (F1 through F5). From the Menu pressing a function key will access one of the underlying screens shown in figure 1.4, per the following schedule:

F1 - OPERATE - Normal operation display
F2 - SETUP - Change some functional parameters
F3 - STATUS - Monitor current settings
F4 - CALIBRATE - Reset zero or span values, or change passwords
F5 - TEST - Perform internal tests on the 8204

Section 3 of the manual, *Local Operation*, explains the layout and use of the first three of these function screens; Operate, Setup, and Status. The Test screen is discussed in the *Maintenance* section, and the Calibrate screens are covered in the *Calibration* section of the manual.

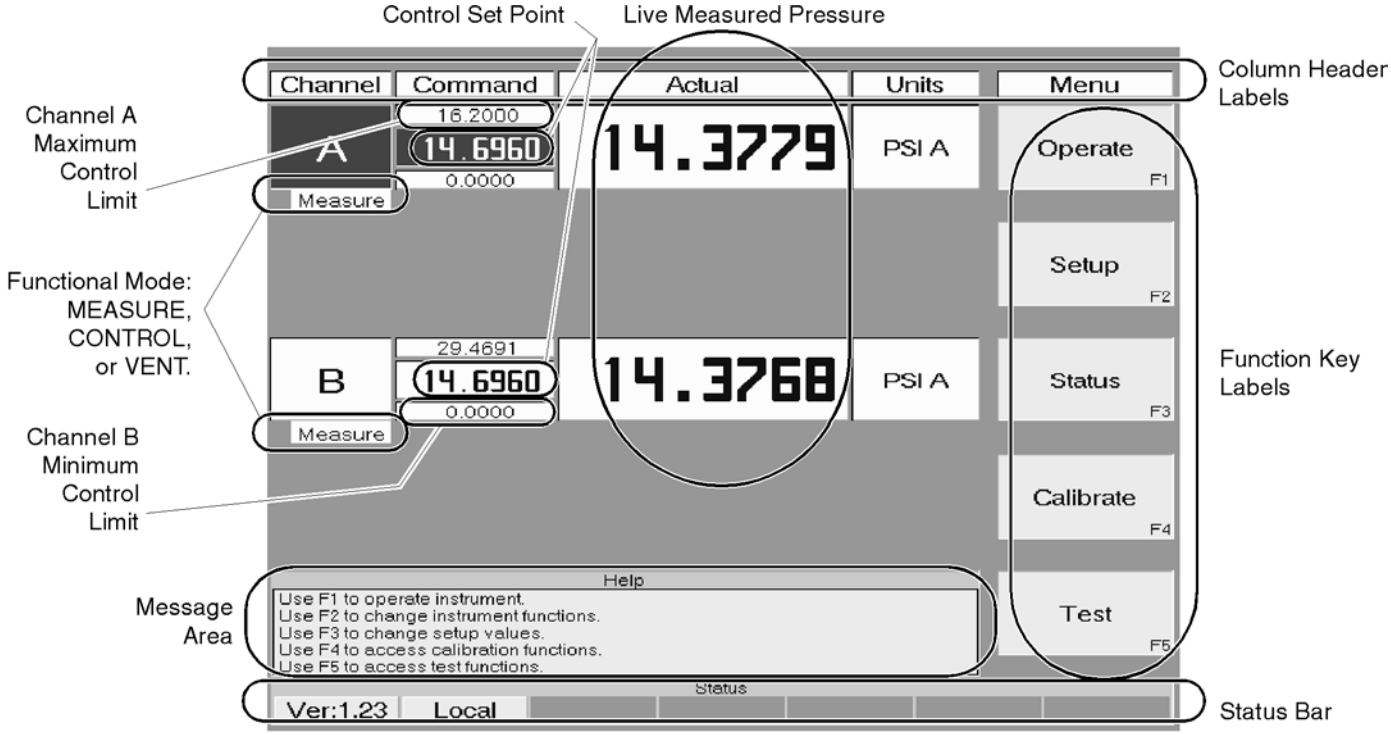


Figure 1.3 - Menu Screen Elements

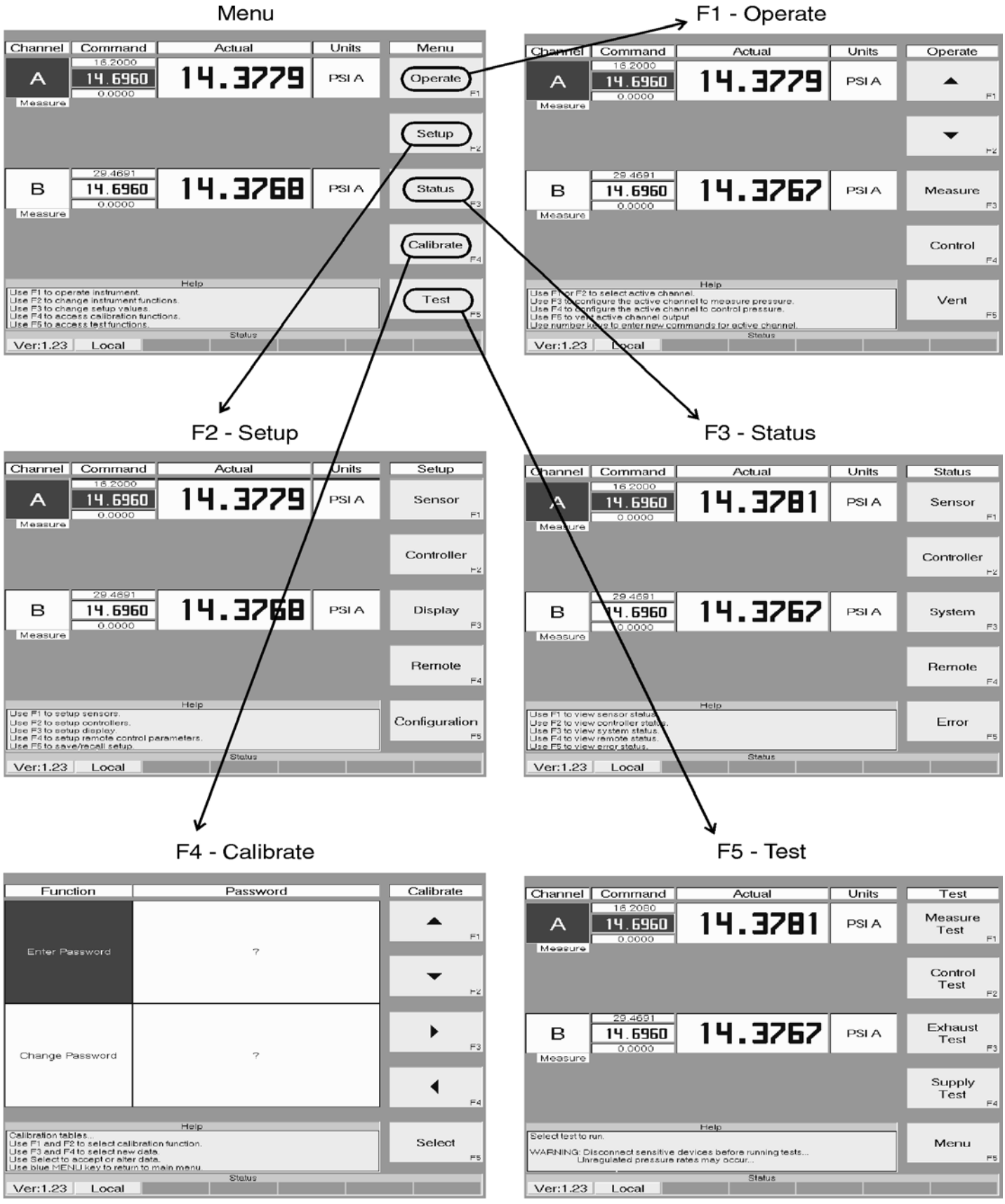


Figure 1.4 - Menu Screen and Five Function Screens

Function Keys

Located to the right of the display are the five Function Keys, F1 through F5 (figure 1.5). These keys change their operation according to which screen is visible. The far right column of each screen displays its own cues for these five keys.

Main Keypad

Twenty single function keys arranged in five rows of four columns make up the Main Keypad (figure 1.5). In addition to the numbered keys, the decimal point, the +/– polarity key there are the following:

1. The Up and Down arrow keys (top-center) are used to increment and decrement the Control mode values by a programmed step. To program the step, enter the step value then press either [▲] or [▼].

2. The Up and Down double arrow keys (top, outside) will step the command point by twice the step value.

3. The CE key is a backspace to clear numeric entries, one digit at a time, beginning with the most recently entered digit. This key is enabled only while in the Editing mode as seen on the Status label line (bottom line).

4. The +/– polarity key is used to assign polarity to numeric entries.

5. The ENTER key is used to store a newly edited value. The new value is immediately reflected on the operating screen, but does not yet take effect. This is indicated by the bottom right hand label showing the 'Pending' flag.

6. The EXEC key will execute the pending values into the system such that they immediately become the new CONTROL numbers.

7. The MENU key immediately returns the Menu screen (figure 1.3) to the display.

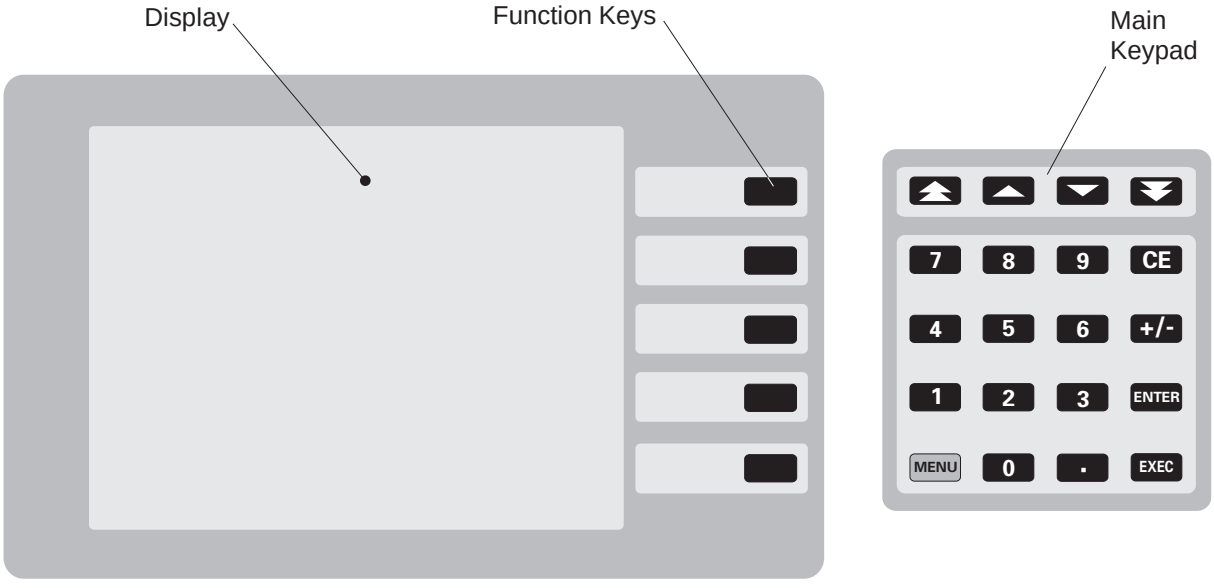


Figure 1.5 - Local Operation Features

Electrical Module

The internal electrical module (figure 1.6) consists of the input power module, a fan, a power supply, an AT compatible computer motherboard assembly, a 3.5 inch floppy disk drive, and a solid state disk drive. All program information to run the system is located on the solid state disk. The floppy disk drive is used for upgrades only.

Note that the plug-in printed circuit cards are not necessarily in the order illustrated.

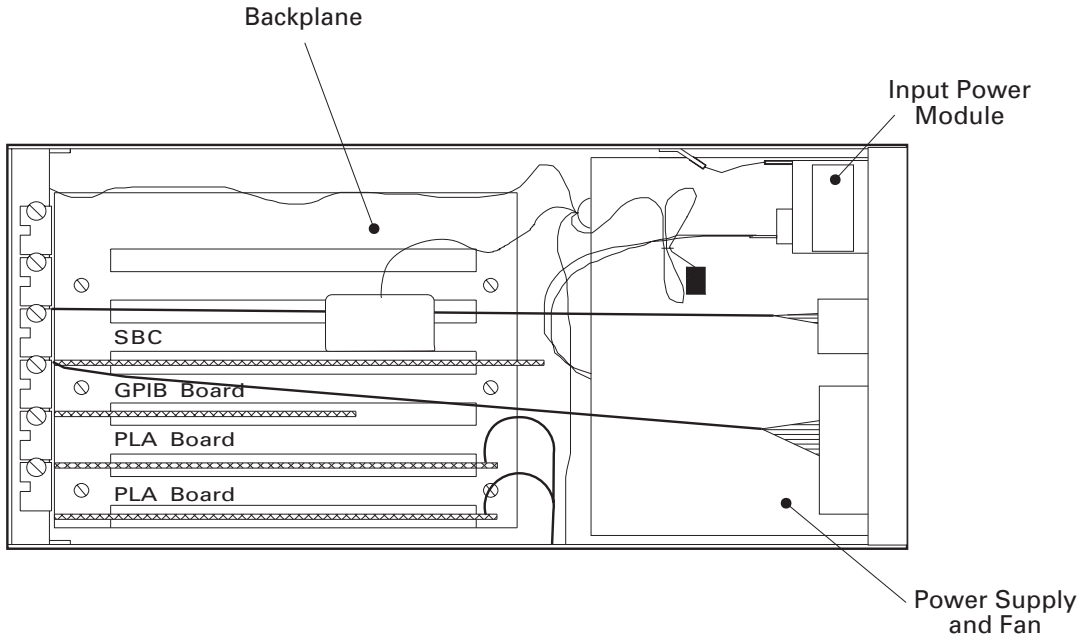


Figure 1.6 - Internal Electrical Module - Top View

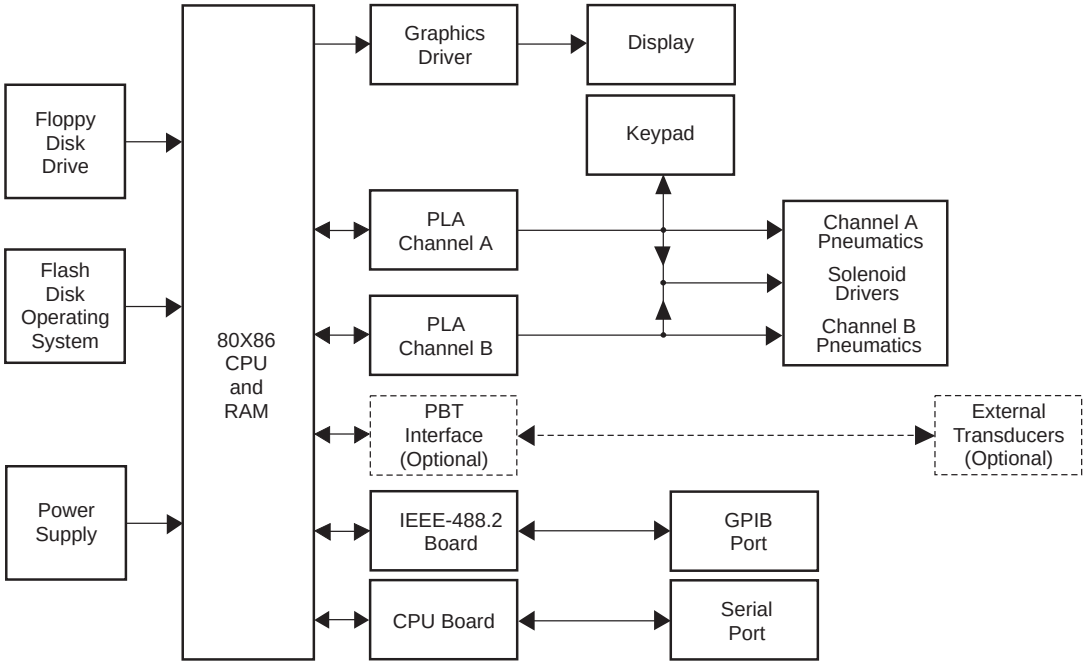


Figure 1.7 - Electrical Block Diagram

Pneumatic Module

The pneumatic module (figure 1.8) includes two high performance, low-drift, pressure transducers which are traceable to NIST standards. These transducers are used in conjunction with two independent, high stability pressure regulators to produce two precise pressure outputs, referred to as Channel A and Channel B.

The pneumatic module also contains all of the transducer compensation and calibration data for both internal channels. Because of this the pneumatic module can be replaced in the field without requiring a recalibration. The two internal pressure regulators can also be used in conjunction with one or two external transducers.

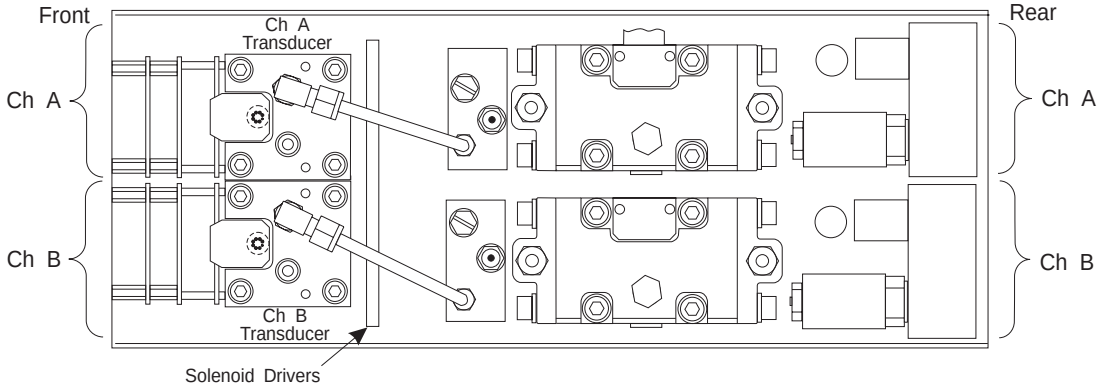
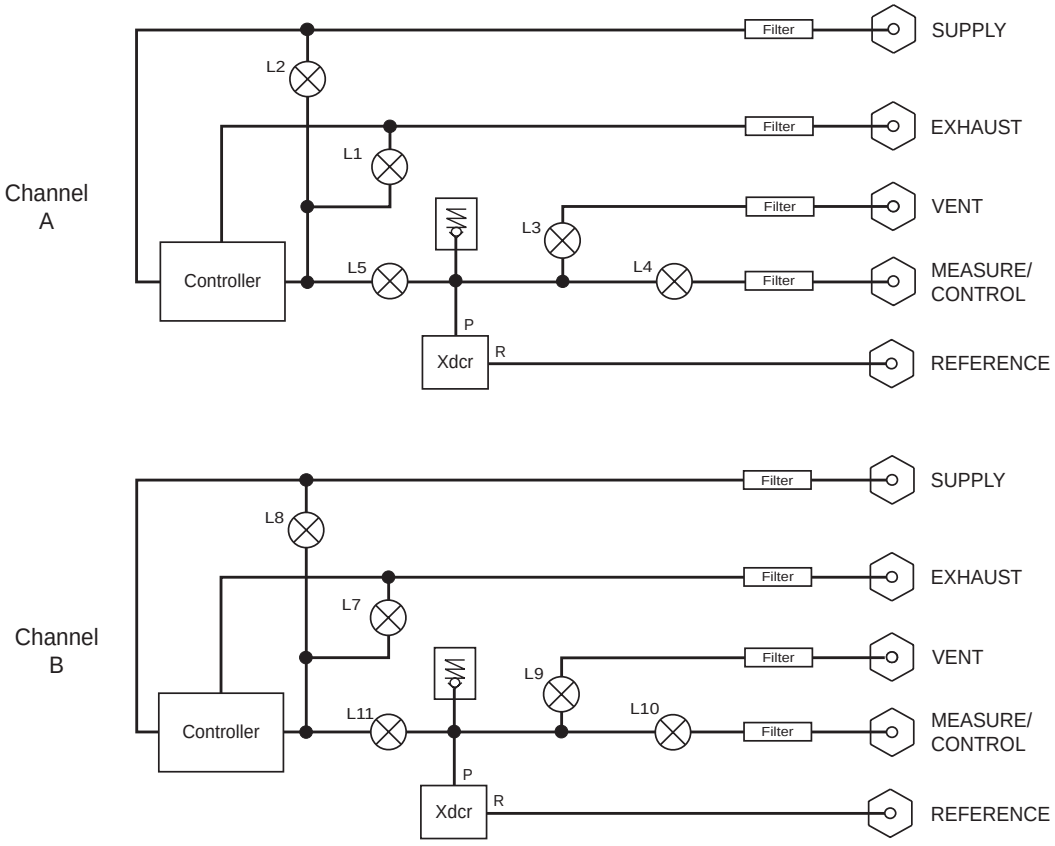


Figure 1.8 - Pneumatic Module, Top View



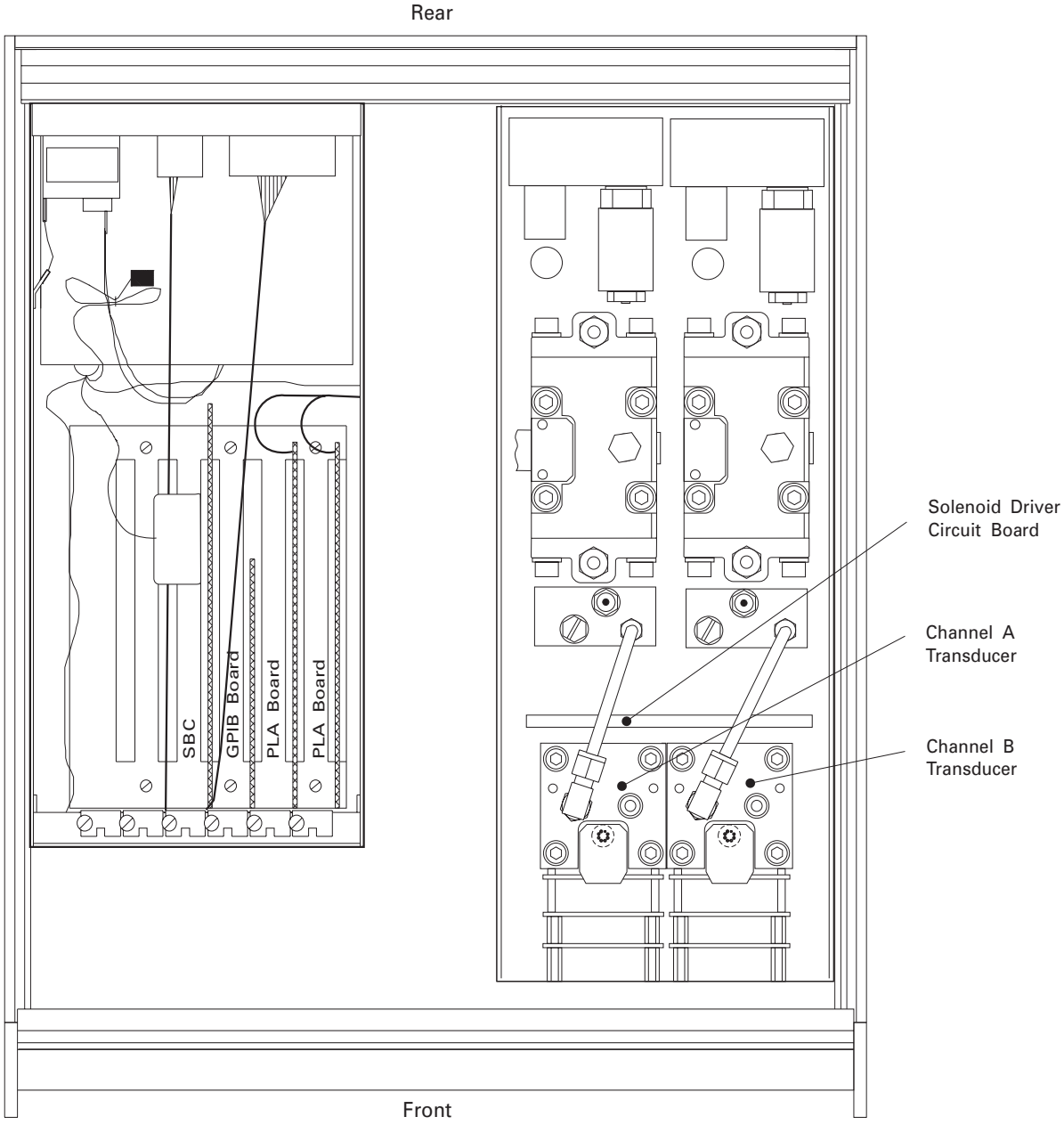
NOTE: All solenoid valves are 5 VDC, 1.5 w, normally closed.

Figure 1.9 - Gauge Pneumatic Schematic

Chassis Assembly

The chassis assembly acts as the housing for the system. The electrical and pneumatic modules are each self-contained and can be replaced individually using basic hand tools. Removal procedures are given in the *Maintenance* section (section 5).

The only moving parts in the 8204 are the fan, the disk drive mechanism, the pneumatic flow controller diaphragms and valves, and the solenoid valve plungers. There are no internal user adjustments or setup switches. The layout of the internal system is illustrated in figure 1.10.



NOTES:
1. The Electrical Module is shown with its cover removed.
2. The plug-in boards may be arranged in a different order than shown.

Figure 1.10 - Chassis Assembly - Top View

Rear Panel

All of the input/output connectors and pressure ports are on the rear panel (figure 1.11). The off/on switch and line fuses are also located on the rear panel.

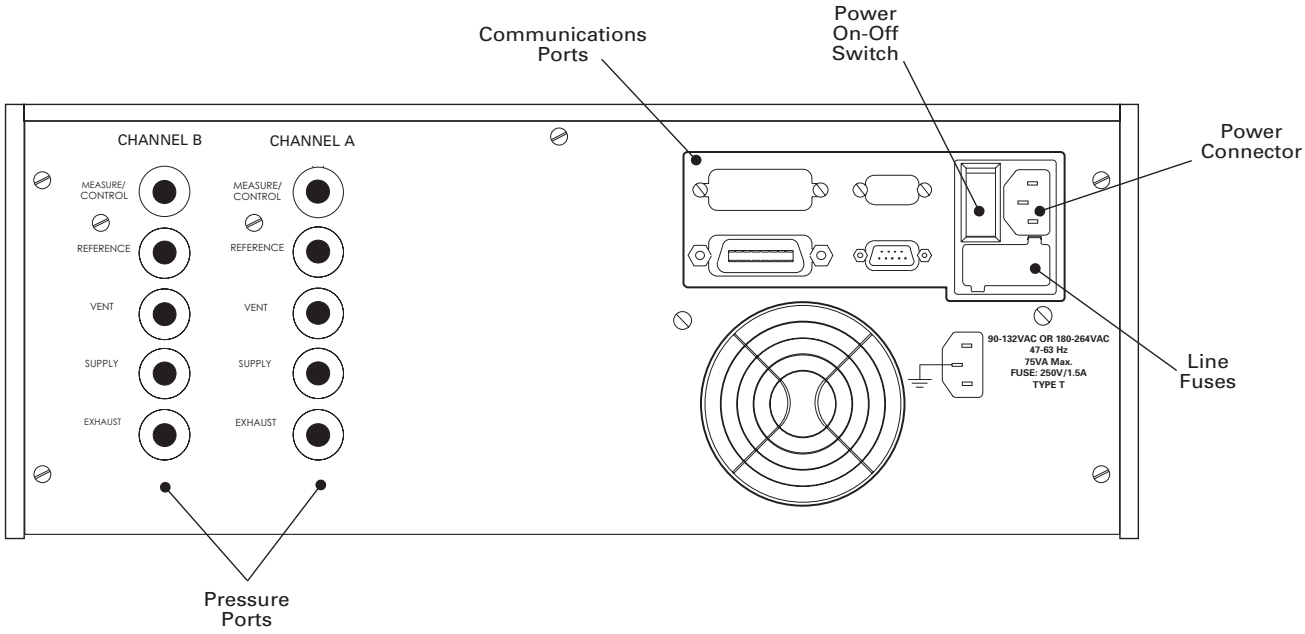


Figure 1.11 - Rear Panel

POWER UP!

You can confirm that your 8204 is operational right now. Simply apply power to the power connector on the rear of the instrument, remove any plastic plugs from the rear panel pressure ports and turn the power switch ON. The system will go through a brief initialization process and then the display should appear similar to the Menu screen shown in figure 1.3.

MENSOR SERVICE PLUS

If you have problems using your 8204 and you don't find the answer in your manual, contact Mensor at 1-800-984-4200 (U.S.A. only), or 1-512-396-4200 for personal assistance, or at any of the on-line addresses listed in the front of the manual. We are ready to help.

Mensor's concern with the welfare of this instrument is not limited to the warranty period. We provide complete repair, calibration and certification services after the warranty for a nominal fee as explained in Section 5, *Maintenance*.

Calibration Services

In addition to servicing our own products Mensor can perform a complete pressure calibration service, up to 20,000 psi, for all of your pressure instruments. This service includes a Certificate of Compliance and Calibration and a record of traceability to the pressure standards of the United States National Institute of Standards and Technology (NIST).

Accreditations

Mensor Corp. is registered to BS EN ISO 9001:2000. The calibration program at Mensor is accredited by A2LA, as complying with both the ISO/IEC FDIS 17025:1999 and the ANSI/NCSL Z540-1-1994 standards.

INSTALLATION

MOUNTING

The instrument can be set up on a table-top or it can be rack-mounted. See the rack mount kit instructions in Section 8, *Options*.

The special sensors used in the 8204 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.

PRESSURE CONNECTIONS

NOTE: *When making up a connection to an o-ring adapter port use a back-up wrench to prevent over-stressing the threads in the manifold block.*

All of the pressure ports on the rear are female 7/16-20 SAE/MS straight threads per MS16142 and SAE J514 table 14. They require a tube fitting boss seal with an o-ring per MS33656. Mensor provides female 1/8 NPT adapter fittings with the instrument. The pressure connections can be made to these adapters with the proper mating hardware. We recommend the use of either Loctite Hydraulic Sealant or fresh teflon tape on the threads of the male pipe fitting. Do not use sealants on fittings sealed with an o-ring. The integrity of the seal is particularly important since even microscopic leaks can cause errors in pressure measurements. Figure 1.9 is a pneumatic schematic of the internal plumbing. Requirements for connecting to the ports on the 8204 manifold are given in the following paragraphs.

SUPPLY Pressure Ports

Each channel of the 8204 has its own SUPPLY port. At each SUPPLY port connect a source pressure which is greater than the highest control pressure which will be commanded. See "Source Pressure" in the *Specifications* section for supply pressure requirements for different ranges.

EXHAUST Pressure Ports

If sub-atmospheric pressure is required from either channel, connect a vacuum pump to that channel's EXHAUST port. Connect separate vacuum pumps to each EXHAUST port if such pressure is required from both channels. Although a single vacuum pump can be common to both channels, this can create cross channel interference, and is not recommended.

MEASURE/CONTROL Pressure Ports

Devices to be tested are connected to the two MEASURE/CONTROL ports. In CONTROL mode these ports can output a precise, stable (static) pressure, or a pressure which climbs or falls in an orderly manner (pressure rate).

In MEASURE mode the 8204 will precisely measure the pressure at the MEASURE/CONTROL port up to the full scale range of the channel's sensor.

EXTERNAL TRANSDUCERS

If one or two external transducers (optional) are included with this system a DB-25F connector will be provided on the rear panel. This connector is identified by a "Special Features" label. For two external transducers use a 'T' or 'Y' adapter to double up the connections to the DB-25F connector. The Mensor part number for the 'T' adapter is 4050250013.

POWER ON

After the pressure connections are secure, apply power to the power connector on the rear of the instrument. Turn the power switch ON. The instrument will go through an initialization process and system check. As soon as the system check is completed the system will default to the MEASURE mode for both channels. The Menu screen (figure 2.1) will appear in the display at the end of the initialization. Allow at least 45 minutes of warm up before performing critical pressure measurements.

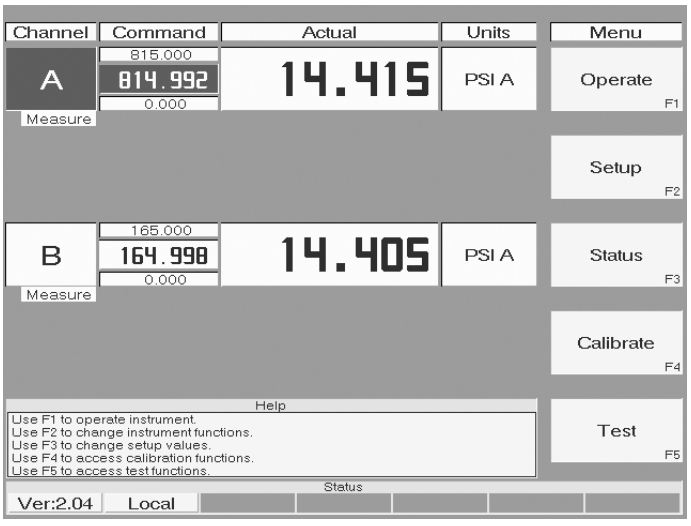


Figure 2.1 - Menu Screen

User's Notes:

LOCAL OPERATION

This section describes the procedures for operating the 8204 from the front panel. Instructions for operating the device remotely from an external computer are covered in the next section. By following the procedures provided in these two sections and Section 6, *Calibration*, you can expect your 8204 to deliver maximum accuracy and dependability for years of useful service.

This section of the manual opens with some explanatory text, followed by several pages of sample screens (figures 3.2 through 3.17), and ends with an alphabetical listing (table 3.1) of the more common terms and screen labels relating to the 8204. This table also shows the figure numbers for the related screens, and the keystrokes required to display the screens.

KEYPADS

Local operation is accomplished by observing the data presented in the display, then using the main keypad and the five function keys to modify the data or to change to another screen. Throughout this manual characters enclosed inside square brackets indicates the associated key. For example, [CE] refers to the key labeled CE on the main keypad, and [F4] indicates the fourth key down of the five function keys.

Main Keypad

Thirteen keys on the main keypad are used for numeric entry (keys [0] through [9], [CE], [+/–], and [.]. Use [ENTER] to enter the completed value into the system, however, the entered value does not take effect until [EXEC] is pressed to execute the command. Press [MENU] at any time to immediately return the display to the Menu screen.

At the top of the main keypad, the up and down arrow keys and the two double arrow keys act as incrementing or decrementing keys for the controlled pressure. A single arrow steps up or down by exactly the programmed step value each time it is pressed, while a double arrow key acts at twice the step value. To program a step value for the active channel enter the value, then press either [▲] or [▼] on the top row. Thereafter, pressing any of the four arrow keys will increase or decrease the controlled pressure value on that channel either by the new step value, or by double that value.

Function Keys

Notice that the five function keys are always identified as [F1] through [F5], but the operation performed by these keys is dependent upon which screen is displayed. Each screen includes its own labels for all five function keys. These labels appear in the right hand column of each screen.

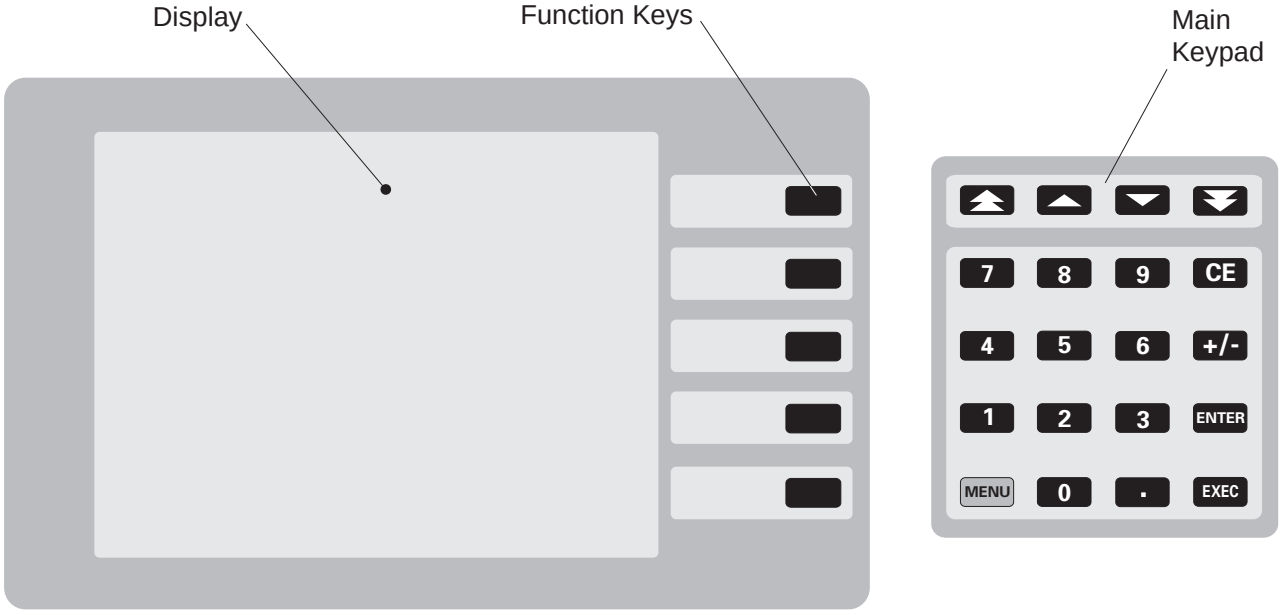


Figure 3.1 - Manual Operation Features

LOCAL MODE OPERATING SCREENS

The Menu, Operate, Setup, and Status screens are used during normal local mode operation of the 8204. All of these screens have sub-screens as depicted by the Menu Tree shown below (figure 3.2).

Blocks in the menu tree with bolded titles also include a listing of the manual illustration number for that screen (the figure number inside a parenthesis). To view any of these screens on the instrument, start with the Menu screen and press the F-keys listed within the menu tree. For example, from the Menu screen, to see the Remote Setup screen, press [F2] for the Main Setup screen, then press [F4] for the Remote Setup screen. Or, to see the Remote Status screen, from the Menu press [F3], and then [F4].

An illustration and brief discussion of each of the local mode operating screens are included in this section of the manual (figures 3.3 through 3.17). The screens used during calibration are illustrated and explained in the *Calibration* section of the manual (figures 6.2 through 6.5). The Test screen (figure 5.1), and the built-in diagnostics which run from it are discussed in the *Maintenance* section.

Pressure data in the operating display is normally configured with the Channel A information on the upper data row, and Channel B data below that, as illustrated in the figures in this manual. However, this arrangement can be changed by the operator using one of the 'Display' setup routines as explained later. Note that no matter how the channels are arranged on the screen, Channel A is always the left side channel within the pneumatic module as viewed from the front of the instrument.

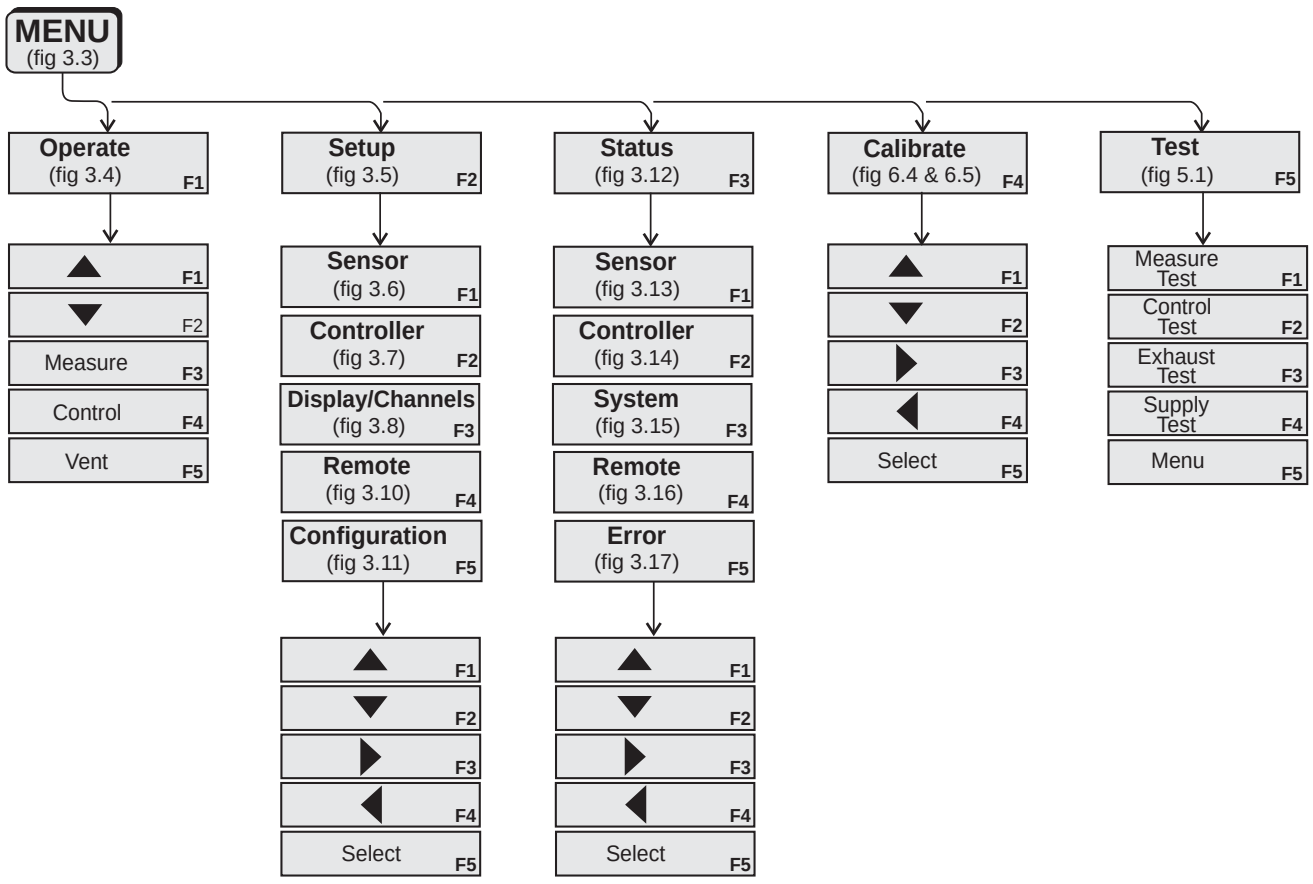


Figure 3.2 - Function Key Menu Tree

The 'Menu' Screen

Data Rows: Figure 3.3 shows a typical arrangement for the Menu screen. The dark field on the 'A' and the command value shows that Channel A is currently enabled. For this channel the figure shows that the current mode is 'Measure', the commanded control point value is '814.992' (within the limits of '815.000' and '0.0000' which have been entered as the maximum and minimum control points), and the current ('Actual') measured pressure is '14.415' psi, absolute pressure ('PSI A'). The equivalent data with some different values are shown for Channel B.

In figure 3.3 there are two blank data rows, one under each channel. These areas are used to display additional information if certain options are included with the system, such as pressure rate of change, or external transducers.

Help Window: Below the data rows is the 'Help' message area. This window displays some clues as to the available user actions while in the current screen.

Status Bar: Below the Help window the Status Bar is made up of several 'Status' labels. The left label always displays the version number of the loaded software. The next label to the right displays either 'Local' for front panel operation, or 'Remote' when the instrument is being controlled by a host computer.

If a number key is pressed the screen immediately changes to the 'Operate' screen, the Function key descriptors change, and a label near the right hand end of the status bar displays the word 'Editing'. This bar will also show 'Pending' and 'Error' labels at the appropriate times, as explained later.

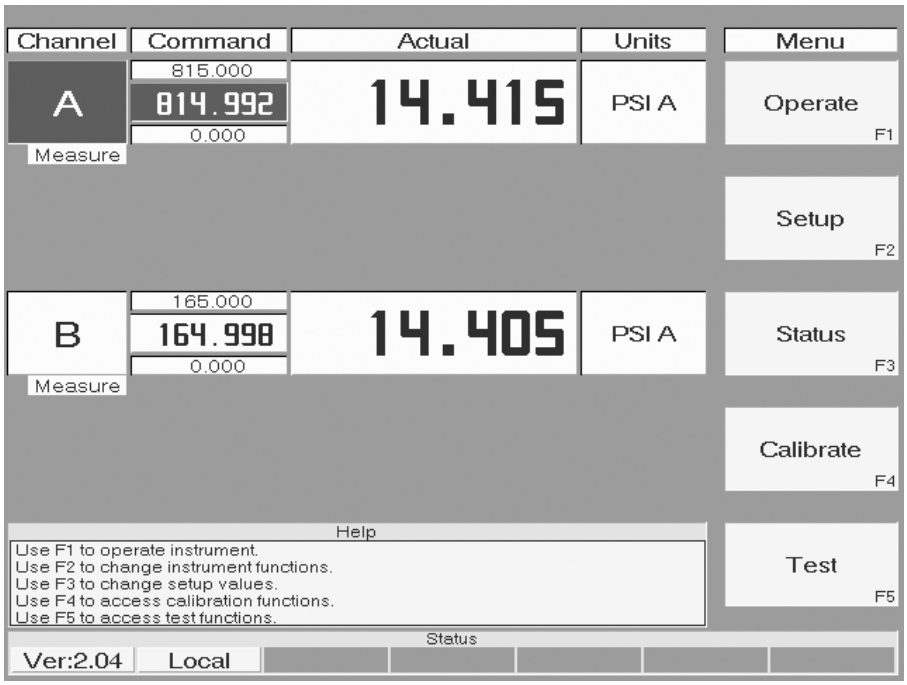


Figure 3.3 - The 'Menu' Screen

The 'Operate' Screen

The Operate screen (figure 3.4) is identical to the Menu screen except that all of the labels in the right hand column have changed. The right hand header label is now 'Operate', indicating that this is the main operating screen, and the five F-key labels have changed to describe different function assignments.

Channel A is currently the active channel as indicated by the dark field. The current pressure at the Channel A Measure/Control port is 14.417, shown in psi absolute units. Different measurement units may be selected from the 'Sensor Setup' screen.

F1 - ▲, and **F2 - ▼:** In this, *and all other screens,* up and down pointers for [F1] and [F2] will step the active row highlight up or down in the left column. Press either[F1] or [F2] to step the active function to the alternate channel. If more than two rows (channels) are displayed, each key press will move the highlight to the next higher or lower row.

F3 - Measure: The pneumatic functional modes are **Measure**, **Control,** and **Vent**. Press the F3 key to set the active channel to **Measure** mode. In this mode the screen displays the current pressure measured at the channel's Measure/Control port. This is the default mode for all channels.

F4 - Control: Press [F4] and the active channel goes into 'Control' mode. The channel immediately slews the output pressure at the Measure/Control port to the value shown in the highlighted 'Command' window. To change the 'Command' value for the active channel press the number keys to generate the desired value. When the first number key is pressed the 'Editing' label appears in the Status bar. Each number pressed is immediately reflected in the command value window. If a wrong number key is entered, press [CE] to erase it. [CE] can backspace through all of the entered numbers until either [ENTER] or [EXEC] is pressed. If an out of limits value is entered the system will default to the previous setting. When a newly entered value is correct, press [ENTER] for 'Pending', or [EXEC] to complete the entry.

The allowable upper and lower limits are shown above and below the current value. These upper and lower limits are settable within the 'Controller Setup' tables.

The method used to incrementally step the output pressure was explained under the heading 'Main Keypad' on page 3-1.

F5 - Vent: Press [F5] to open the Measure/Control port of the active channel to the Vent port.

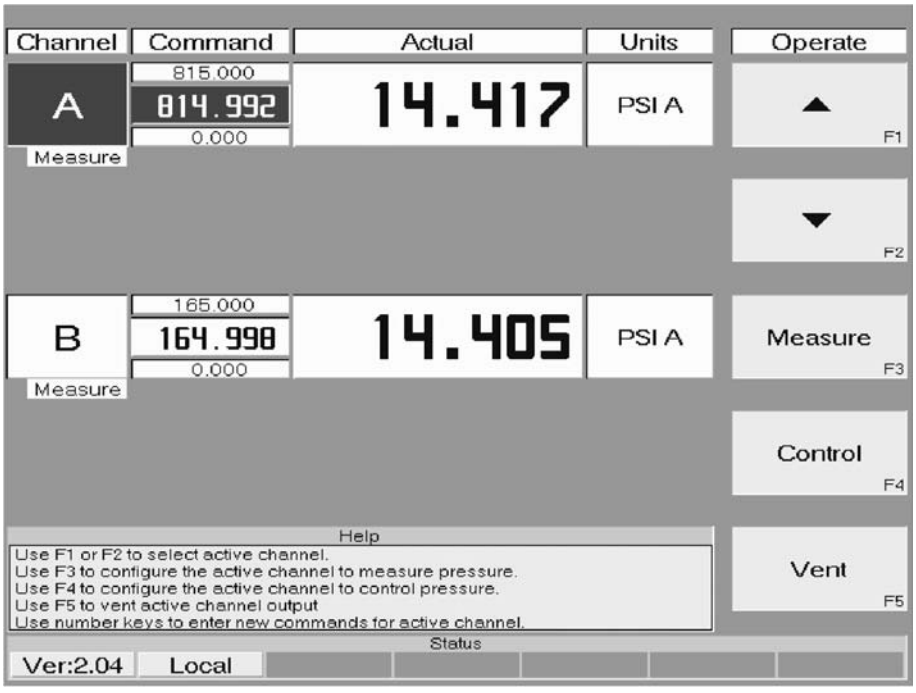


Figure 3.4 - The 'Operate' Screen

The 'Setup' Entry Screen

This screen (figure 3.5) is the gateway into any of the five separate setup table screens. Press the appropriate F-key to select a specific setup table. Then, the right-hand header label identifies the table, and [F1] through [F4] act as cursor control keys. [F5] is a 'Select' key which sets all of the highlighted values into the system.

Within the setup tables, the [F1] and [F2] cursor keys operate only in the left-most column to select the 'Function' (row) to be modified. The [F3] and [F4] cursor keys operate across the 'Data' columns to highlight an individual cell within the selected row.

When a setup table is displayed, all four cursor keys will wrap around in both directions. For example, with the highlight resting on the top line of any of the setup tables, pressing the up control, [F1], will cause the cursor to move to the bottom cell in the column. Likewise, the left and right pointers also wrap across the data rows.

While in a setup table screen move the cursor to 'Back to setup' at the bottom of the 'Function' column, and press [F5] to return to this, the Main 'Setup' screen. From this screen select any of the following:

[F1] - Sensor: Use this setup table for each channel's transducer, to select the Engineering Units, the reading filter rate, and to set the reference port condition.

[F2] - Controller: For each channel's regulator, select the control slew rate, the upper and lower limits for controlled pressure, the output pressure stable window and time, and the exhaust port condition.

[F3] - Display: Set the display contrast level (monochrome only), set from 1 to 4 fields (channels) to display, and assign the top to bottom order of the channels.

[F4] - Remote: Setup the parameters for serial (RS-232) operation, or assign a GPIB address.

[F5] - Configuration: Save, and later, recall up to four different instrument configurations as defined by the user in the setup tables. This allows the user to arrange up to four different test situations, each of which can be recalled later as the need arises. The factory defaults can be restored at any time.

Each of the five setup screens and tables are discussed in detail next (figures 3.6 through 3.11).

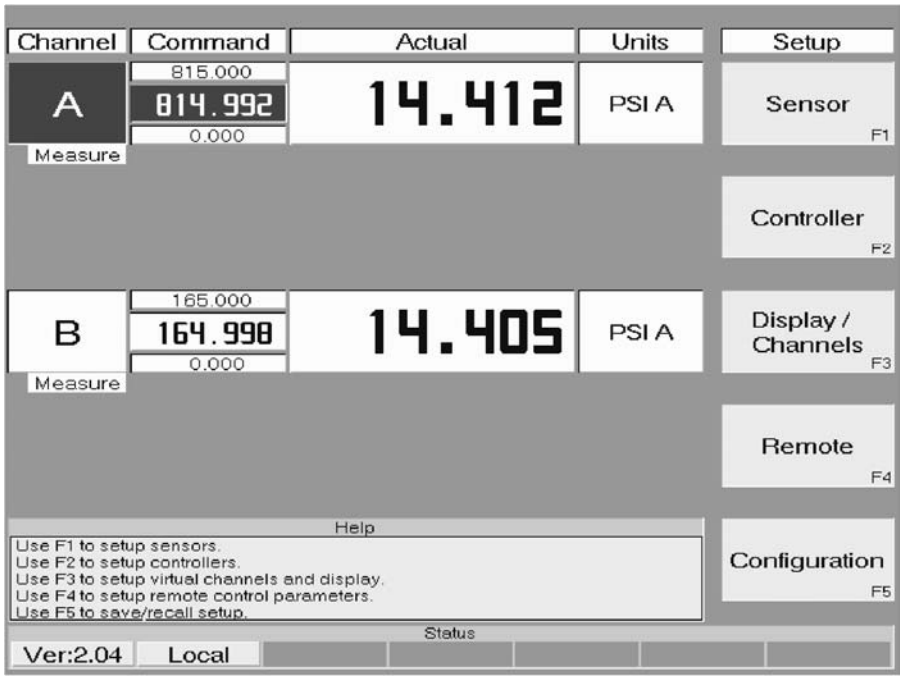


Figure 3.5 - The 'Setup' Entry Screen

The 'Sensor Setup' Screen

Figure 3.6 shows the Sensor Setup screen. In most cases the data columns will list Channel A and B, only. If one or two external transducers (optional) were ordered with the system, then 'External A' and 'External B' would also be exhibited.

Sensor setup for: This function is highlighted by default. The illustration indicates that Channel A is set to psi engineering units, its reading filter is set to Normal, and that if there is a reference port on Channel A, it should be open to atmosphere.

To see the current setup for the Channel B sensor press [F3] or [F4] to highlight the Channel B data column. Channels A and B usually have identical setups, but they can differ. The following functions can be selected for each sensor listed in this view.

Engineering Units: Press [F2] to move the 'Function' column highlight down one row, then [F5], 'Select' to see the units table. Find the desired units within the table, then press [F1] or [F2] to move the 'Function' cursor to that row. Next, press [F3] or [F4] to move the 'Data' cursor across to the target units. Finally, press [F5], 'Select' to enable this choice for the current channel. The process can now be repeated for the next channel. When the engineering units are changed, all of the pressure related values in the displays are automatically converted to values for the new pressure units.

Reading Filter: This is an electronic filter to smooth out the pressure readings. Because of the differences in resolution between engineering units, different filter settings may display a more or less stable reading. The more filtering applied, the less nervous the display. Use the cursor keys to select the best setting for the current pressure units, then press [F5], 'Select'.

Reference: This refers to the hookup on the Reference port on the rear of the instrument. If an incorrect setting is selected, the instrument will not control correctly, especially near the low end of the pressure range.

For a gauge pressure instrument choose the setting that agrees with the hookup, either vented or connected to a vacuum pump, then press [F5], 'Select'. The correct setting for an absolute instrument is VENT since there is no reference port.

Back to setup: Highlight this cell and press [F5] to return to the main Setup screen.

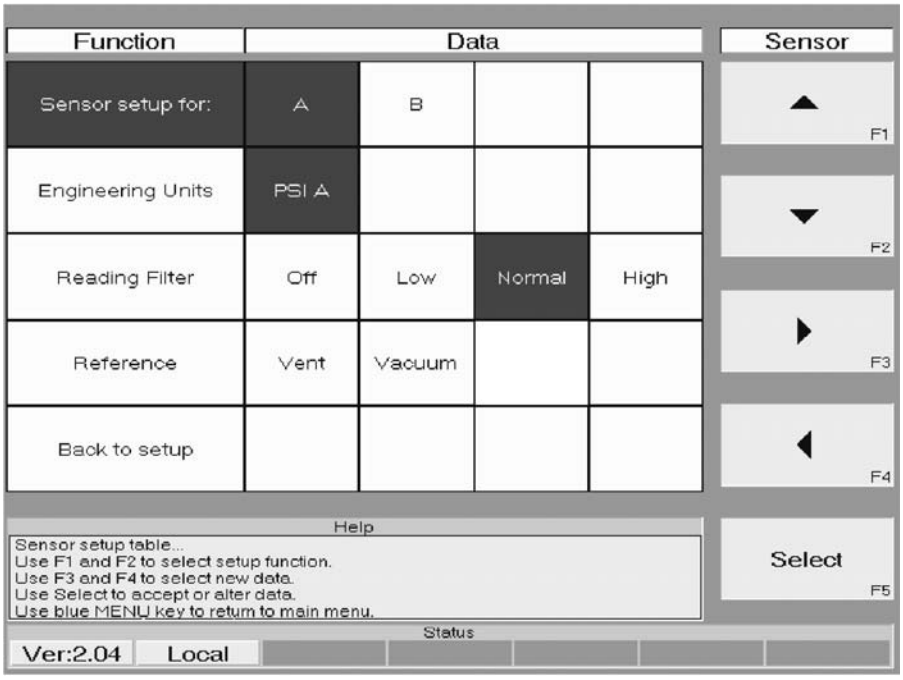


Figure 3.6 - The 'Sensor Setup' Screen

The 'Controller Setup' Screen

Using the function keys to navigate the Controller Setup screen shown in figure 3.7 is identical to getting around in the Sensor Setup screen. The top two keys move the 'Function' column cursor up and down, and the next two keys move right and left across the 'Data' rows. The bottom F-key is used to enable the highlighted options. The terms that may be selected for the pressure controllers are listed below.

Controller setup for: Use [F3] or [F4] to set up either channel A or B. If optional external transducers are included in the system there will also be either one or two external channels to choose from.

Control Rate: Control Rate is an optional feature that allows the user to command an output pressure that changes at a predetermined rate. The Rate settings in this screen have no effect unless the 8204 was ordered with this option. See the *Options* section for details on setting up and using the Rate function in both local and remote operating modes.

Lower Limit: Enter a value for the lowest acceptable controlled pressure point then press [F5]. The current pressure units are listed on the screen for informational purposes, and can be changed only in the 'Sensor Setup' table.

Upper Limit: Enter the highest acceptable control point value in this cell, then press [F5].

Stable Window: Enter a value for the pressure range within which a controlled pressure is considered to be stable, and [F5].

Stable Time: Enter the number of seconds the pressure must remain within the window for it to be considered stable, then [F5].

Exhaust Pressure: This refers to the hookup on the Exhaust port on the rear of the instrument. If an incorrect setting is selected, the instrument will not control correctly, especially near the low end of the pressure range.

Back to setup: Highlight this cell and press [F5] to return to the main Setup screen.

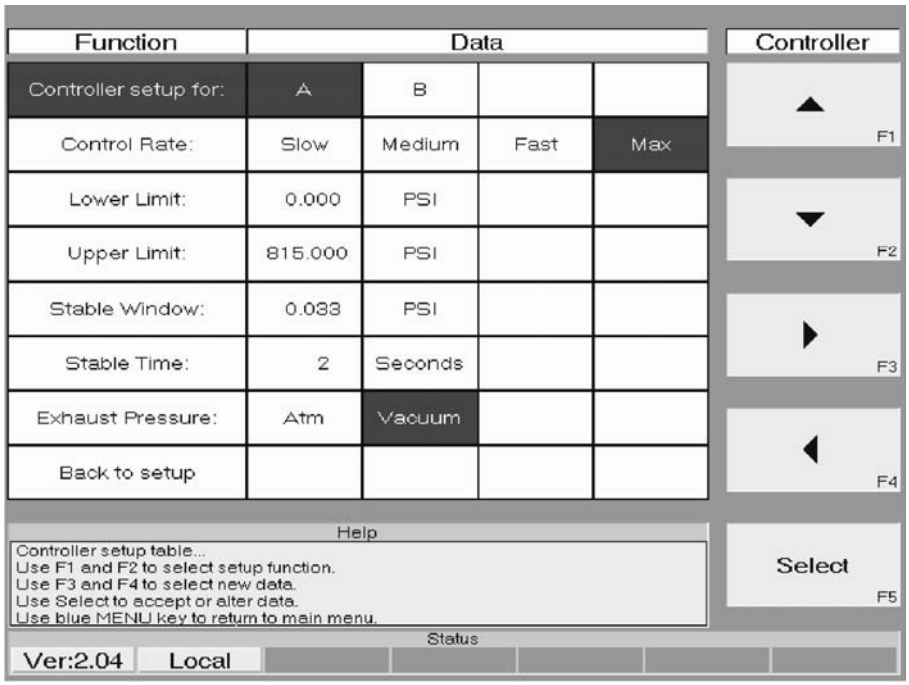


Figure 3.7 - The 'Controller Setup' Screen

The 'Display/Channels Setup' Screen

This setup table (figure 3.8) is used to format the 'Operate' screen layout. From here select how many channels to display (from one to four), and the position of each channel within the screen. In addition, the mathematical relationships for the two virtual channels (described below) are established in this table.

Virtual Channels: Choose the virtual channel(s) to display; None, Delta, Ratio, or Both. With the Display/Channels setup screen configured as shown in figure 3.8 the Menu and Operate screens would show the two virtual channels similar to figure 3.9.

Delta Function: Select the desired mathematical relationship between channels A and B which will represent the Delta virtual channel.

Ratio Function: Select the A and B channel formula to represent the Ratio virtual channel.

Dominant Channel: Set either Channel A or B as the dominant channel. This channel will remain unaffected by entering a new ratio value. The unselected pressure channel will alter its control setpoint to maintain the ratio setting between the two.

Dependency: A "Dependency" selection determines whether either the Ratio, or the Delta setting is locked in regardless of the changes to the pressure channels, or if both Ratio and Delta will react to changes to the primary channels.

Display Fields: A selection here determines how many of the available channels are displayed, and their position (field number) on the screen. To display all four channels requires that all of the following be enabled:

1. "Both" selected in the top row
2. "4 reading" selected in the "Display Fields" row
3. A unique channel selected for each of the 4 following fields.

Field 1: The top data row in the 'Operate' screen, normally assigned to display Channel A data.

Field 2: This is the next lower available data row. Channel B data is usually displayed here.

Field 3: Normally one of the virtual channels is assigned to the third field, or it is left blank.

Field 4: The bottom field usually displays the second virtual channel data, or it is left blank.

Back to setup: When all of the desired data cells are highlighted, use [F1] or [F2] to move to the 'Back to setup' function and press [F5] to return to the main Setup screen.

Instrument Variations: See the *Options* section for other 'Display/Channels Setup' screens which are specific to instruments that include either the Rate option, or the external transducer option. These two options and the standard 'Virtual Channels' capability are mutually exclusive. That is, an 8204 can be delivered with any one, but only one of these three functions installed. The other two will not be included.

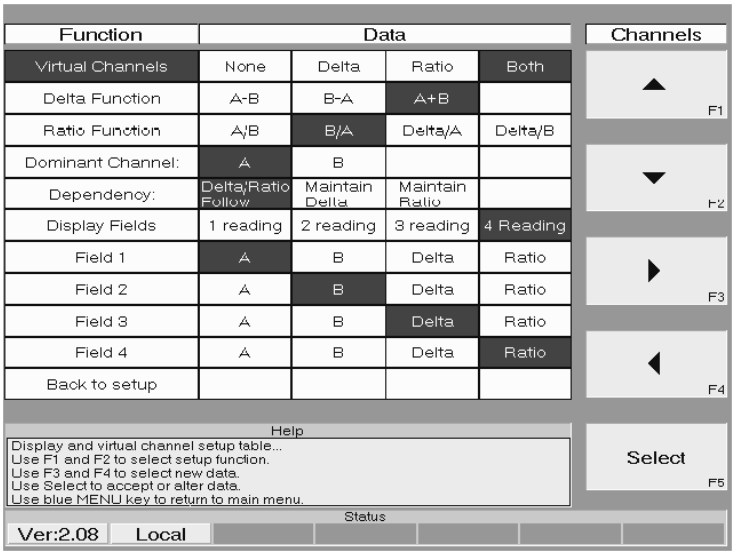


Figure 3.8 - The 'Display/Channels Setup' Screen

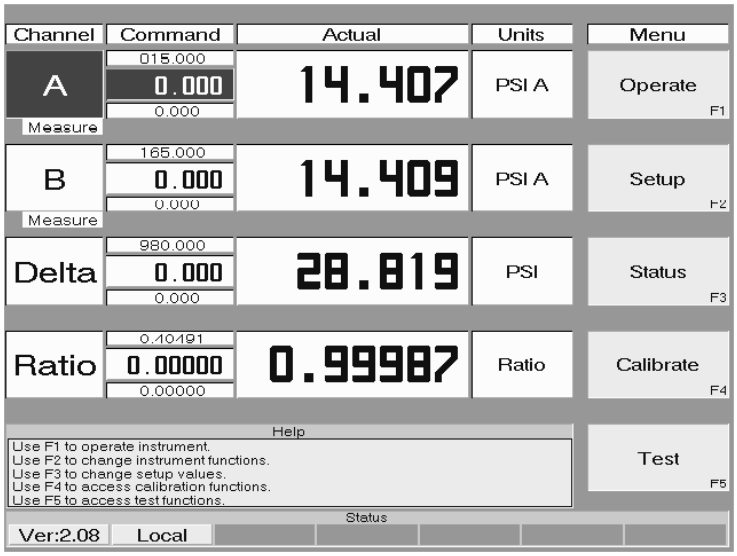


Figure 3.9 - Menu Screen with Two Virtual Channels

The 'Remote Setup' Screen

Use this screen to set the serial output (RS-232) operating parameters, and to assign the GPIB address.

Serial BAUD: Highlight the correct BAUD rate for the system from among those listed in the top two data rows, then press [F5].

Serial Data Bits: Choose either 7 or 8, then [F5].

Serial Stop Bits: Choose either 1 or 2, then [F5].

Serial Parity: Select either None, Odd or Even, then [F5].

GPIB Address: Set in a number from 0 to 15, then press [F5].

Back to setup: Highlight this cell and press [F5] to return to the main Setup screen.

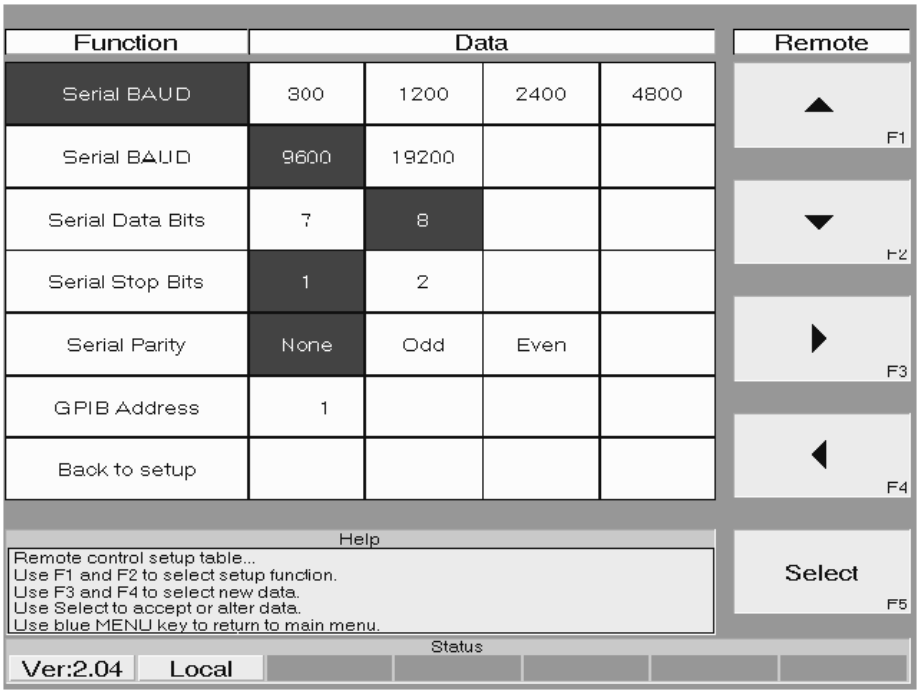


Figure 3.10 - The 'Remote Setup' Screen

The 'Configuration Setup' Screen

The 8204 includes the capability to save, and later, recall up to four different instrument configurations. These configurations are defined by the user in the Sensor and Controller setup tables. In figure 3.11 these four configurations are identified as CFG1 through CFG4. These are in addition to the Default setup which is stored in permanent memory.

Normally, all four of these CFG storage pockets are loaded with the Default setup when the instrument leaves the factory. To replace this with a custom setup:

1. First, make the desired changes in the Sensor and Controller setup tables;

2. Next, display the Configuration Setup screen shown below;

3. Next, move the 'Function' column cursor to the 'Save' function;

4. Then position the Data cursor to one of the four CFG# cells;

5. Finally, press [F5] to complete the sequence.

The current settings from the Sensor and Controller setup tables are now saved as the CFG# file, to be recalled sometime later.

To load a previously saved custom setup:

1. Move the 'Function' cursor to 'Recall';

2. Move the 'Data' cursor to the desired CFG# cell;

3. Press [F5] -Select.

The custom setup is now in place, and the 8204 is ready to run a pre-defined test.

To return the instrument to the factory default settings, highlight 'Load' in the Function column and press [F5]. the instrument is now loaded with the initial factory setup.

Back to setup: Highlight this cell and press [F5] to return to the main Setup screen.

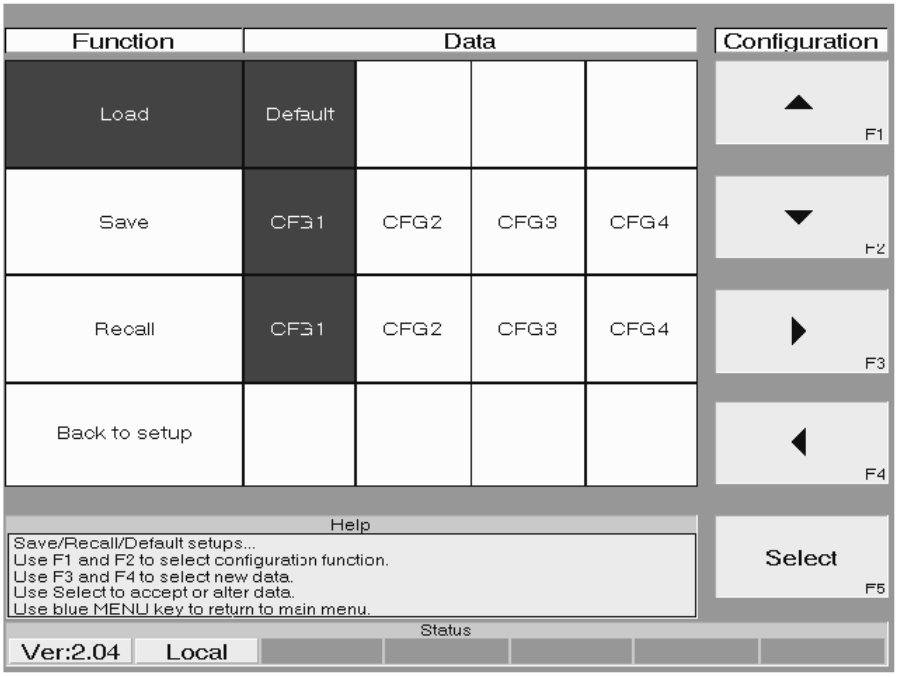


Figure 3.11 - The 'Configuration Setup' Screen

The 'Status' Entry Screen

This screen (figure 3.12) is the entry point into any of the five individual status screens. The status screens are informational displays, only. They do not require nor accept any user input. Press any of the five F-keys to view the corresponding 'Status' screen.

[F1] - Sensor: Both internal transducers (figure 3.13);

[F2] - Controller: This screen is reserved for future use (figure 3.14);

[F3] - System: Basic information about the system (figure 3.15);

[F4] - Remote: This screen is reserved for future use (figure 3.16);

[F5] - Error: Displays any detected errors (figure 3.17).

For each of the above five screens all of the function keys are disabled.

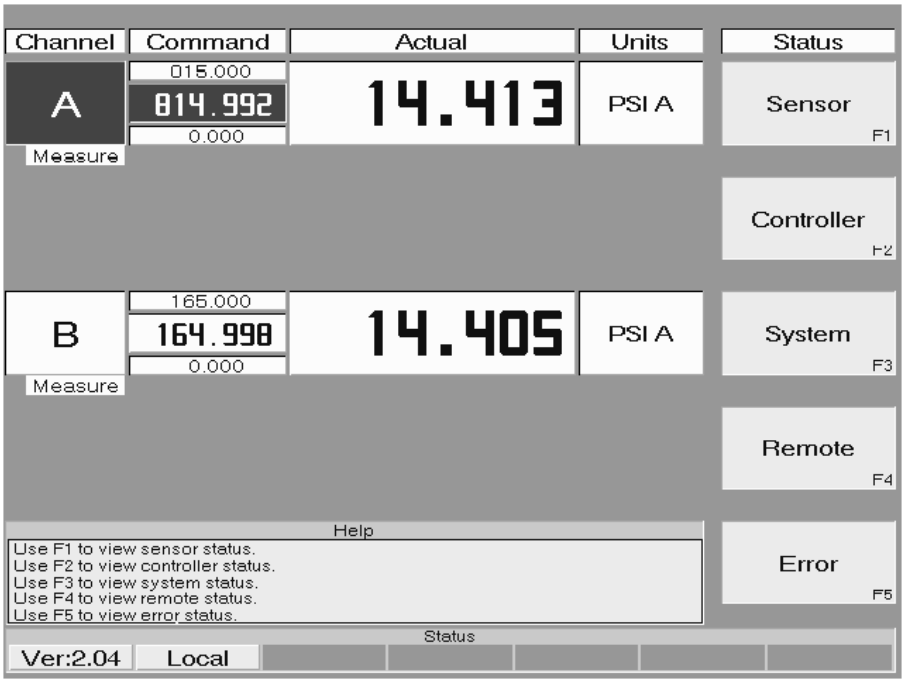


Figure 3.12 - The 'Status' Entry Screen

The 'Sensor Status' Screen

The 'Sensor' status screen (figure 3.13) displays the basic information for all included pressure transducers (normally A and B). Information seen in the first two rows are self-explanatory.

Minimum Range / Maximum Range: These are always stated in terms of psi regardless of the instrument settings.

Pressure count / Temperature count: Pressure and Temperature count data might be useful to a Mensor technician during troubleshooting (telephone or on-site).

No user action is required for this screen; all five function keys are disabled.

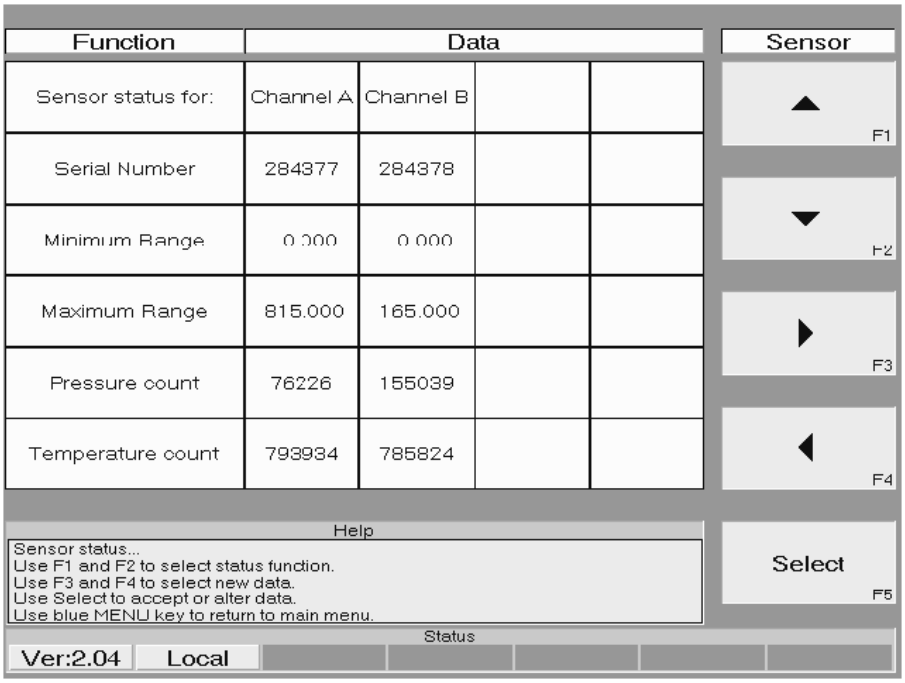


Figure 3.13 - The 'Sensor Status' Screen

The 'Controller Status' Screen

This screen (figure 3.14) is reserved for future use.

No user action is required for this screen; all five function keys are disabled.

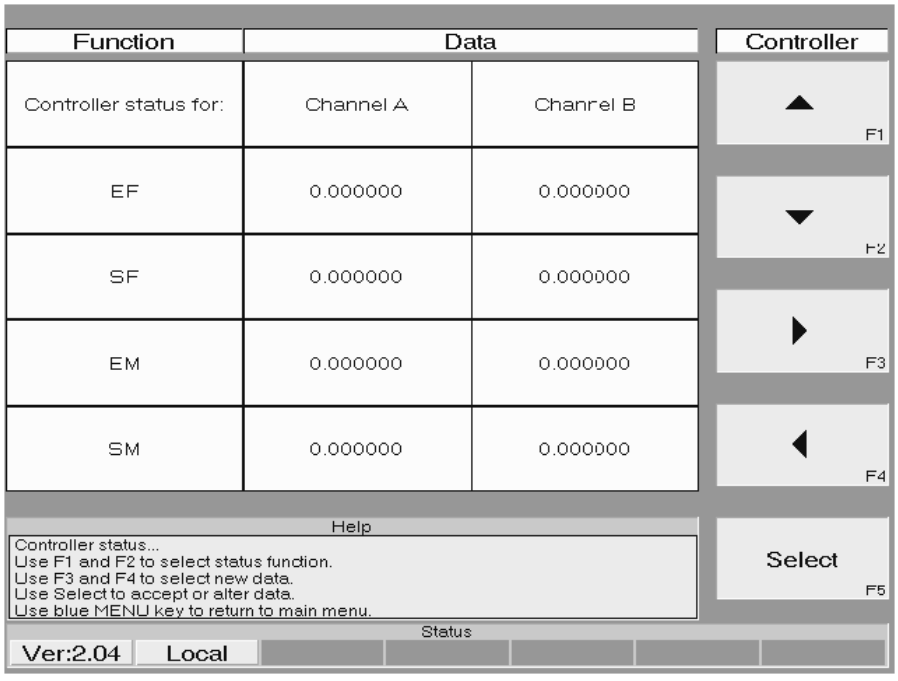


Figure 3.14 - The 'Controller Status' Screen

The 'System Status' Screen

The 'System' status screen (figure 3.15) displays the instrument model number, serial number, and the date of manufacture.

No user action is required for this screen; all five function keys are disabled.

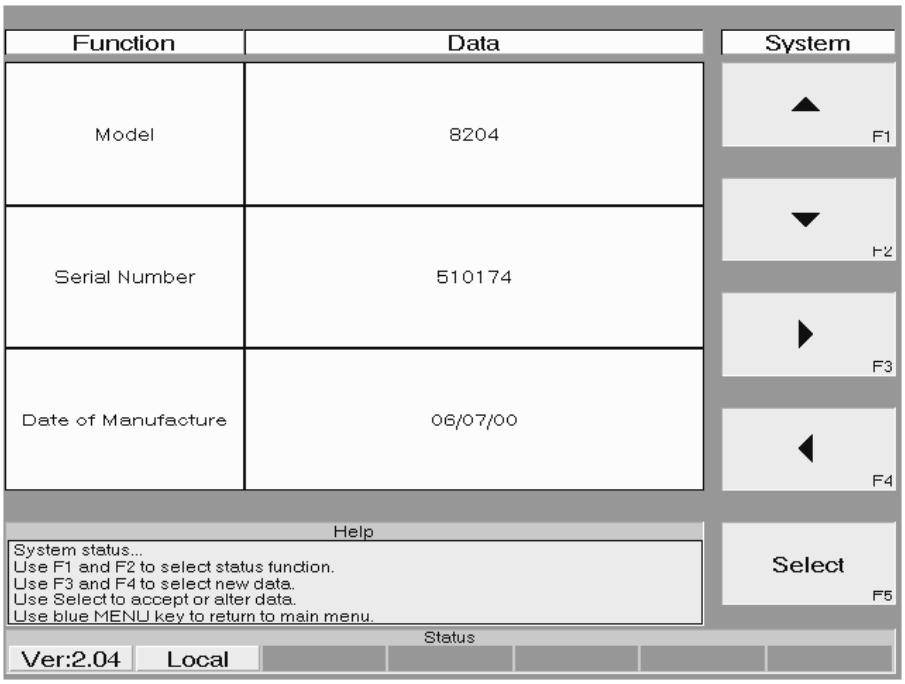


Figure 3.15 - The 'System Status' Screen

The 'Remote Status' Screen

The 'Remote' status screen (figure 3.16) is reserved for future use.

No user action is required for this screen; all five function keys are disabled.

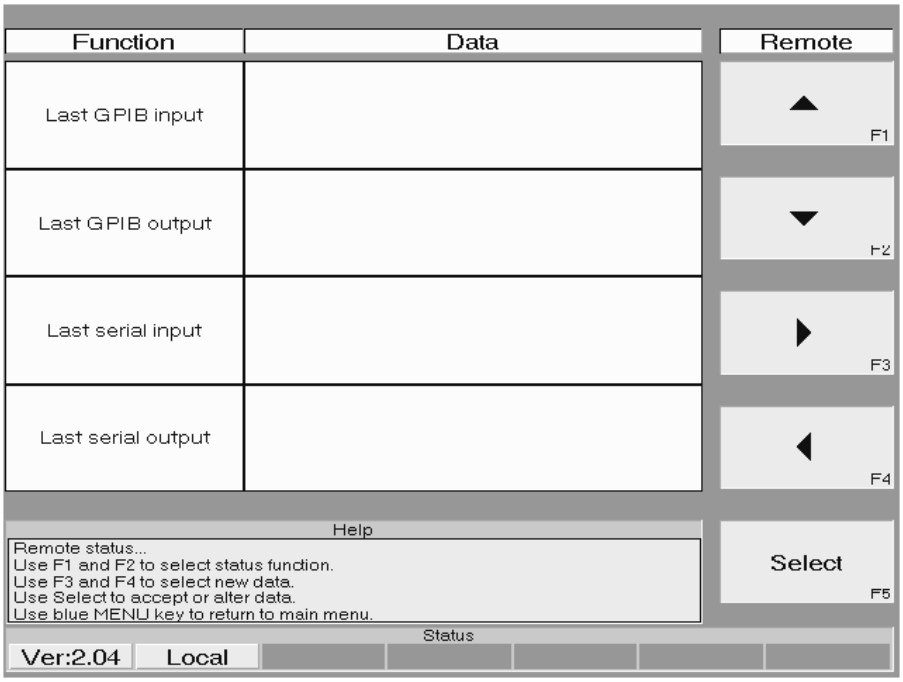


Figure 3.16 - The 'Remote Status' Screen

The 'Error Status' Screen

The 'Error' status screen (figure 3.17) shows a detected error condition.

No user action is required for this screen; all five function keys are disabled.

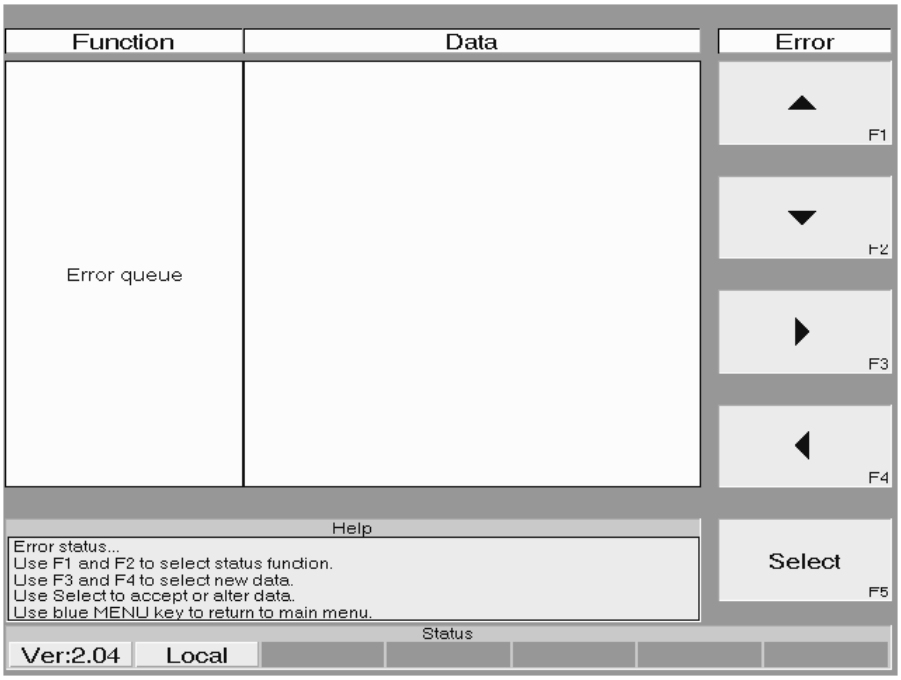


Figure 3.17 - The 'Error Status' Screen

DEFINITIONS

Table 3.1 is an alphabetical listing of many of the terms and labels used by the Model 8204. The first column names the term; the second column shows the specific keys to press to arrive at the relevant display; and the third column gives a brief description of the activity or meaning for the term. The Menu screen is the starting point to arrive at any of these. Of course, to see the Menu screen simply press the blue MENU key at any time.

Table 3.1 - Definitions of Terms

Term or Label	From Menu Screen Press Key(s):	Description
Active Channel Fig. 3.3	>F1>(F1 or F2)	The highlighted channel (dark background) selected from the 'Operate' screen. This makes the channel ready to accept changes to its primary mode, or to its control pressure or step pressure value, or to perform any of the various operations appropriate to a particular channel.
Calibrate Fig. 6.1	>F4	Displays: 1), 'Enter Password' which is required to make a change to a transducer zero or span calibration values; and 2), 'Change Password' which also requires the current password in order to make a change. See *Calibration*, Section 6, for further details.
Configuration Fig. 3.11	>F2>F5	Define, save and recall up to 4 different test configurations in addition to re-loading the default setup.
Control Fig. 3.3	>F1>F4	Outputs a precisely measured pressure to the MEASURE/CONTROL port when so commanded. This is one of three primary functional modes.
Control Test Fig. 5.1	>F5>F2	Pass/Fail determination is presented in the Help window.
Controller Fig. 3.7	>F2>F2	Setup these control parameters for a selected channel: 1), 'Rate' (Medium, Fast or Max); 2), 'Lower Limit'; 3), 'Upper Limit', or 4), 'Stable Window'; and D), 'Stable Time'.
Controller Status Fig. 3.14	>F3>F2	Inactive now; reserved for future use.
Display/Channels Fig. 3.8	>F2>F3	Setup the: 1), 'Display Contrast' (- or +); 2), 'Display Format' to show either 1, 2, 3 or 4 channels; 3), define which channel will show in 'Field 1' to 'Field 4'; and 4), 'Link...' the two internal channels, yes or no (On or Off).
Error Status Fig. 3.17	>F3>F5	Displays a detected error condition.
Exhaust Test Fig. 5.1	>F5>F3	Pass/Fail determination is presented in the Help window.
Measure Fig. 3.3	>F1>F3	Measures the pressure applied to a MEASURE/CONTROL port on the rear panel, or to an external transducer attached to the instrument. This is one of three primary functional modes.
Measure Test Fig. 5.1	>F5>F1	Pass/Fail determination is presented in the Help window.

Continued on next page...

Table 3.1 continued...

Term or Label	Press Key	Description
Operate Fig. 3.4	>F1	A screen entered directly from 'Menu' used to select a channel as the 'active' channel and perform some operations. See 'Active Channel'.
Primary Modes	>F1	The three primary functional modes are [F3] Measure, [F4] Control, and [F5] Vent. All other functions and operations revolve around these three functions.
Remote Control Fig. 3.10	>F2>F4	Setup the conditions for: 1), GPIB Address; or 2), Serial parameters including Baud, Data Bits, Stop Bits, and Parity.
Remote Status Fig. 3.16	F3>F4	Inactive now; reserved for future use.
Sensor Fig. 3.6	>F2>F1	Setup transducer variables for a selected channel: 1), 'Engineering Units' (from a table of 14); 2), 'Reading Filter' rate; or 3), 'Gauge' or 'Absolute' (native or emulated) type.
Sensor Status Fig. 3.13	>F3>F1	Displays transducer attributes for the selected channel: 1), 'Serial Number'; 2), 'Minimum Range'; 3), 'Maximum Range'; 4), 'Pressure count'; and 5), 'Temperature count'.
Setup Fig. 3.5	>F2	A screen entered directly from 'Menu' used to set up: [F1] for the 'Sensor' conditions for the 'Active Channel'; or [F2] for 'Controller' parameters for the 'Active Channel'; or [F3] for the 'Display' contrast, and the number and order of the channels to appear in the display; or [F4] for the 'Remote' bus operating parameters; or [F5] for operating configurations.
Status Fig. 3.12	>F3	Select the type of status to display: [F1] for 'Sensor'; [F2] for 'Controller'; [F3] for 'System; [F4] for 'Remote'; or [F5] for 'Error' status.
Supply Test Fig. 5.1	>F5>F4	Pass/Fail determination is presented in the Help window.
System Status Fig. 3.15	>F3>F3	Displays the system: A), Model (8204); B), 'Serial Number'; and C), 'Date of Manufacture'. 'Hours' is inactive for now.
Test Fig. 5.1	>F5	Automated tests of several internal functions include: [F1] for 'Measure Test'; [F2] for 'Control Test'; [F3] for 'Exhaust Test'; or [F4] for 'Supply Test'.
Vent Fig. 3.4	>F1>F5	Releases any trapped pressure within the active channel to the atmosphere. This is one of three primary functional modes.

REMOTE OPERATION

The Dual Channel Pressure Controller (8204) may be operated from a remote computer using either the IEEE-488 (GPIB) communication protocol or RS-232 serial communication. For IEEE-488 operation the host computer must contain an IEEE-488 Communications Board.

IEEE-488

The manufacturer of the host IEEE-488 interface board provides software to allow communication between the board and various programming languages. An interactive program for debugging is usually provided as well. Refer to the board manufacturer's documentation for more information.

8204 IEEE-488 Capability Codes:

SH1	Full source handshake capability
AH1	Full acceptor handshake capability
T6	Talker with serial poll and unaddress if MLA
L4	Listener with unaddress if MTA
SR1	Full service request capability
RL1	Full remote/local capability including LLO
PP0	No parallel poll capability
DC1	Full device clear capability
DT1	Full device trigger capability
C0	No controller capability
E2	Tri-state outputs

The 8204 also contains many features of IEEE-488.2, the latest version of this protocol.

The 8204 responds to the following IEEE-488 interface functions:

SRQ — Service Request
A service request is asserted whenever an error is encountered. When the bus controller issues a serial poll the error will be cleared. If the host IEEE board includes automatic serial polling capability, turn this feature off in order to view all errors (see ERROR? command).

LLO — Local Lockout
The front panel keyboard of the 8204 may be locked by sending LLO or the command LOCK ON.

GET — Group Execute Trigger
When this message is received, the 8204 will save the current readings until the next time it is addressed as a talker.

GTL — Go To Local
When this message is received, the 8204 will return to local operation and unlock the keyboard.

DCL — Device Clear
When this message is received, the 8204 will clear all errors and buffers and remain in the REMOTE mode.

SDC — Selected Device Clear
Responds as DCL.

EOI — End or Identify
May be used to terminate a command or query in the place of or concurrent with the transmission of the terminating linefeed.

Command and Query Format

All commands (messages sent to the 8204) and queries (requests for information from the 8204) follow a common format. The 8204 accepts commands and queries in the form of ASCII strings. The strings are divided into two or three fields. All strings must terminate with a linefeed (<lf>, 0a hex, 10 dec). All fields must be separated with at least one white space character (20 hex or less except 0a hex). Normally an ASCII space (20 hex, 32 dec) is used for the field separator. Lower and upper case letters are optional. Either may be used and mixed to improve readability.

Command/Query Field: Unless otherwise specified, commands are converted to queries by appending a question mark to the command. Detailed command and query keywords are listed in table 4.1.

Data Field: The data field is either in ASCII {*string*} or numeric {*value*} form. In the case of multiple data fields, commas are used 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
inHg

Examples of {*value*} data:

1
1.0
-5.678
25.68324e-5

8204 Remote 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.

The instrument is not case sensitive. Send any combination of upper or lower case text.

Command:
Any command or query listed in table 4.1.

Separator:
Space (SP) or any character code ≤ 0x20. Exception: 0x0a, (LF), which is used to terminate each command.

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 word(s) shown in the following examples.

Termination:
Linefeed (LF) is used to signal the end of a command statement. For IEEE-488 operation "EOI" is an acceptable alternative.

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, *"?"*, is the last character in the command. Queries have no data element.

When a valid query is received, the 8204 will return {*string*} or {*value*} data terminated by CR and LF.

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

Channels

The 8204 has two internal pneumatic channels identified as follows when viewed from the front of the instrument.

Channel A: Left internal pneumatic channel.
Channel B: Right internal pneumatic channel.

Additional channels (external only) are optional.

Output Formats

Pressure readings are returned in exponential notation in a format according to the OUTFORM command as follows:

Outform 1: A Ch pressure, B Ch pressure;
Outform 3: A Ch pressure, B Ch pressure, A Ch; rate, B Ch rate
Outform 4: PCS 400 format for the active channel.

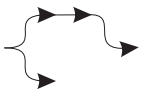
Syntax Diagrams

The command/query examples provided in this section are represented in flow diagrams to show the most common construction. The following symbols are used in these syntax diagrams.

This shape encloses the literal command or query keyword ("Command" from table 4.1) to begin each instruction. Enter the precise characters shown in the table, except that upper and lower case characters are interchangeable.

A circle contains either a required separator, usually a space (SP) between message elements, or a command terminator (LF) at the end of each instruction.

The rectangle positions the variable data, ({*value*} or {*string*}), that may be sent with the command. Queries do not include this symbol.

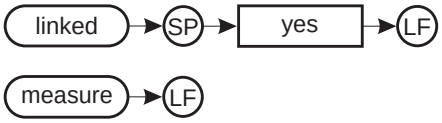


The lines and pointers link the command elements, showing the correct path. A branched path indicates optional command forms where the use of either form (either path) is acceptable.

Program Examples:

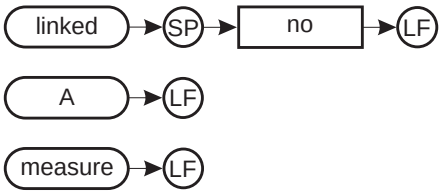
Example 1: LINKED & MEASURE
All pressure channels in this instrument can be linked (ganged) such that they respond simultaneously when switching to any of the four functional

modes, STANDBY, MEASURE, CONTROL or VENT. For example, to place all channels into the MEASURE mode simultaneously, send the following sequence:

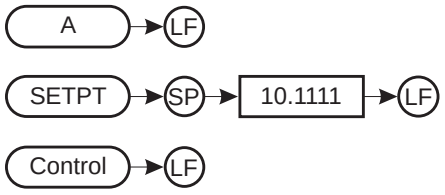


Example 2: VENT
With the link command still invoked, use the vent command to simultaneously place all pressure channels in VENT mode:

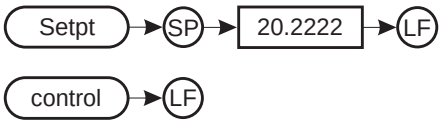
Example 3: MEASURE on Channel A
To switch channel A into MEASURE mode while leaving all other channels in VENT mode, first disable the link, then command Channel A as the active channel, and finally, switch Channel A to MEASURE mode:



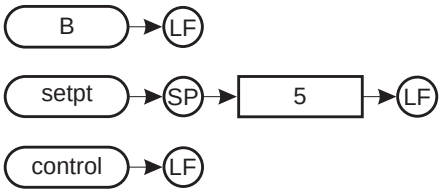
Example 4: CONTROL Setpoint on Channel A:
To command a new CONTROL pressure setpoint, first specify the channel, send the setpoint command, and the desired output pressure, and finally, send the CONTROL switch. For example, to set Channel A to control an output pressure at 10.1111 (in the current measurement units):



To change Channel A output to 20.2222 pressure units (Channel A is still the active channel):



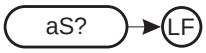
Example 5: Channel B CONTROL at 5.0000:



Example 6: Pressure Reading Query:
To get the measured pressure from Channel A:

The instrument returns the pressure reading in exponential format, followed by {*cr*}{*lf*}.

Example 7: Pressure Stable Query:
To check if the pressure is stable on channel A:

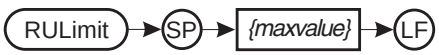


The return message is either 'YES" or "NO", followed by {*cr*}{*lf*}.

Example 8: Output a Pressure Rate on Ch B:
The following is a step-by-step example of programming a rate of pressure change to be output to the Channel B MEASURE/CONTROL port. First, Channel B is made the active channel (8a), then the upper and lower rate limits are set (8b & 8c), and the desired rate value is defined (8d). Next the units of time are selected for the Rate of change (8e), and finally, Channel B is commanded to go into CONTROL mode to execute the output pressure changing at the specified rate (8f). Example 8g is a query to get the current rate setting for Channel B.

8a: Assign Channel B as the active channel:

8b: Set the rate control upper limit for the active channel, which is now Channel B:



<maxvalue> cannot be greater than full scale of the target channel.

8c: Set the rate control lower limit for the active channel (Ch B):

{*minvalue*} will be less than {*maxvalue*}.

8d: Input the rate control setpoint, within the range of RU & RL, for the active channel (Ch B):

8e.: Provide the rate control period (units of time) for the active channel (Ch B):

{*string*} will be either Sec, Min, or Hour.

8f: Enable the control pressure rate at the MEASURE/CONTROL port of the active channel (Ch B) based on the settings in examples 8a through 8e:

8g: Query the 8204 for the current pressure rate setting for Channel B:

This query returns the value which was input at example 8d above, followed by {*lf*}{*cr*}.

Command/Query List

Table 4.1 is an alphabetical listing of all the native commands and queries currently available for the 8204. Following that, table 4.2 lists only the queries, showing typical responses for each.

At the end of this section, under the heading "PCS 400 REMOTE EMULATION", there are additional commands and queries specifically intended for remote operation of a Mensor PCS 400, a single channel pressure controller. This listing shows which of these commands the 8204 can recognize and respond to.

Table 4.1 - Command/Query Set

Ref	Command	Data Range	Response/Function
1	?		Returns the current output format.
2	A		Makes the A channel active.
3	A?		Returns the A channel reading.
4	As?		Returns the A channel stable indication (YES or NO).
5	B		Makes the B channel active.
6	B?		Returns the B channel reading.
7	Bs?		Returns the B stable indication (YES or NO).
8	Chan	A or B (w/o external xducers).	Sets the active channel.
9	Chan?		Returns the active channel name.
10	Control		If modes are linked, all channels are placed in the control mode, else the active channel is placed in control.
11	Control?		Returns Yes if active channel is in control, else No.
12	Default		Sets the default values.
13	DOM?		Returns the date of manufacture.
14	Error?		Returns the next error in the error queue.
15	Filter	0 to 99.	Sets the exponential filter % for the active channel's measured reading.
16	Filter?		Returns the exponential filter % for the active channel's measured reading.

Continued on next page...

Table 4.1 continued...

Ref	Command	Data Range	Response/Function
17	Id?		Returns MENSOR,8204,ssssss,v.vv (s=sn, v=version).
18	Keylock	Yes or No.	Locks or unlocks the keypad
19	Keylock?		Returns Yes or No.
20	Linked	Yes or No.	Links modes if Yes independent if No.
21	Linked?		Returns Yes or No.
22	List?		Returns a list of valid channel names.
23	LowerLimit	Less than Upper Limit and within the sensor range.	Sets the lower control limit for the active channel.
24	LowerLimit?		Returns lower control limit for the active channel.
25	Measure		With modes linked, all channels are placed in measure mode, else the active channel is placed in measure.
26	Measure?		Returns Yes if active channel is in measure, else No.
27	Outform	1, 3 or 4.	Sets the output format. See the text under “Output Formats”.
28	Outform?		Returns the output format as 1, 3 or 4.
29	Range?		Returns the maximum range of the active channel.
30	RangeMax?		Returns the maximum range of the active channel.
31	RangeMin?		Returns the minimum range of the active channel.
32	SBaud	300, 1200, 2400, 4800, 9600, or 19200.	Sets the serial baud.
33	SBaud?		Returns the serial baud.
34	SData	7 or 8	Sets the serial data bits.
35	SData?		Returns the serial data bits.
36	Setpt	Within lower and upper limits.	Sets the control setpoint for the active channel.
37	Setpt?		Returns the control setpoint for the active channel.
38	Span	Desired pressure or “?”.	Alters the span.
39	Span?		Returns span scale factor.
40	SParity	EVEN, ODD, or NONE	Sets the serial parity
41	SParity?		Returns the serial parity
42	SStop	1 or 2.	Sets the serial stop bits.
43	SStop?		Returns the serial stop bits.
44	Stable?		Returns Yes if current channel is stable, else No.
45	StableTime	0 to 65535.	Sets the stable time to the number of seconds specified.
46	StableTime?		Returns the stable time.
47	StableWin	Within lower and upper limits.	Sets the stable window.
48	StableWin?		Returns the stable window.

Continued on next page...

Table 4.1 continued...

Ref	Command	Data Range	Response/Function
49	Standby		If modes are linked, all channels are placed in standby mode, else the active channel is placed in standby.
50	Standby?		Returns Yes if active channel is in standby, else No.
51	Step	Within lower and upper limits.	Sets the control step for the active channel.
52	Step?		Returns the control step for the active channel.
53	Units	psi, inhg, inh2O, mbar, kpa, mmhg, or PCS 400 unit code.	Sets the instrument engineering units.
54	Units?		Returns the instrument units.
55	UpperLimit	Within sensor range and more than lower limit.	Sets the Upper control limit for the active channel.
56	UpperLimit?		Returns Upper control limit for the active channel.
57	Vent		If modes are linked, all channels are placed in vent mode, otherwise the active channel is placed in vent mode.
58	Vent?		Returns Yes if active channel is in the vent mode, else No.
59	Window	Value in current units.	Sets the filter window in current units.
60	Window?		Returns the current units.
61	Zero	Desired pressure or “?”.	Alters the zero value so that the instrument reads the values sent when at the current pressure; ? clears previous value.
62	Zero?		Returns zero offset.

Query Return Strings

Table 4.2 shows the 8204 queries with an example of the "as formatted" return string for each one.

Table 4.2 - Query and Return String

Query	Example Return String
?	+1.07549E-001, +1.07182E-001
chan?	A, B
control?	YES, NO
dom?	07/14/97
filter?	0-99
id?	MENSOR,8204,ssssss,v.vv
keylock?	NO
linked?	NO
lowerlimit?	-1.52513e+002
measure?	YES, NO
outform?	2
range?	1.00000e+002, 1.33103e+002
sbaud?	9600
sdata?	7
setpt?	1.44323e+001, 3.00000e_001
span?	1.00000e+000
sparity?	NONE
sstop?	1
stable?	YES, NO
stabletime?	2.00000e+000
stablewin?	4.60000e-003, 1.14246e+000
standby?	YES, NO
step?	1.00000e+000, 2.77297e+001
units?	PSI, INH2O 20c
upperlimit?	1.33103e+002
vent?	YES, NO
window?	1.22788e-002, 3.40487e-001
zero?	0.00000e+000

RS-232 SERIAL COMMUNICATION

The following applies to serial communication capability. Refer to the GPIB portion at the beginning of this section for additional information relating to commands and responses.

The serial communication port allows the Mensor instrument to communicate with computers, terminals and modems (referred to as the host) in RS-232 interface format. Communicating over the serial port does NOT disable the front panel keypad. However, in order to prevent conflicts, avoid front panel entry of commands while operating over the bus. See the KEYLOCK command.

Cable Requirements

RS-232 communications are transmitted over a three conductor, shielded cable terminated in a standard DB9S connector on the instrument end, and usually a DB25 connector on the host end. Figure 4.1 illustrates the proper pin-outs for the interconnect.

Setup

Before putting the RS-232 interface into operation the various serial parameters must be manually selected from the appropriate setup screen (either "System Setup" or "Remote Setup", depending on the software level). The serial parameters selected must match the host. Commands must be sent in ASCII format and terminated with either a line feed (<lf>) or a carriage return (<cr>). Commands are not case sensitive, and both upper and lower case characters are accepted. Each query returns a response after processing.

Parameters

Baud rate: Select the baud rate which matches that of the host. Available rates are from 200 to 19200.

Data Bits: Select either 7 or 8.
Stop Bits: Select either 1 or 2.
Serial Parity: Select None, Odd, or Even.

Command Format

The command format for RS-232 commands is the same as those given for IEEE-488 operation except that the termination character may be either <cr> or <lf>.

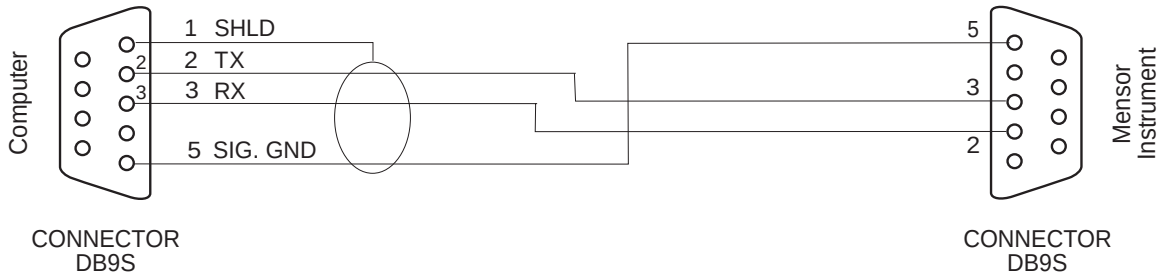


Figure 4.1 - RS-232 Cable

PCS 400 REMOTE EMULATION

The Mensor PCS 400 is the single channel equivalent to the 8204. There is some compatibility between the 8204 and a PCS 400 in that the 8204 will respond to some of the remote commands and queries (phrases) as if it were the single channel instrument.

The following is the list of the remote phrases taken from the PCS 400 manual. The 8204 will accept each command and query listed except as noted. Sending a remote phrase which is listed as "Not recognized" will be ignored by the 8204.

The commands and queries listed here include a "•" character between elements to represent a required delimiter. Use a space, comma or tab where a delimiter is indicated. A full description of the syntax and use for each of these commands and queries are presented in the PCS 400 manual.

> **NOTE:** *All pressure values will be in the currently active pressure units unless otherwise stated.*

PCS 400 Remote Commands

_PCS4•FUNC•MEAS<•unitno>
Do not send "•unitno".

_PCS4•FUNC•CTRL<•value•<unitno>>
Do not send "•unitno".

_PCS4•FUNC•STBY<•unitno>
Do not send "•unitno".

_PCS4•FUNC•VENT<•unitno>
Do not send "•unitno".

_PCS4•FUNC•F1
Not recognized.

_PCS4•FUNC•F2
Not recognized.

_PCS4•FUNC•F3
Not recognized.

_PCS4•UNIT•unitno
Unitno from 0-50 only.

_PCS4•CAL•A/D<•digit>
Not recognized.

_PCS4•CAL•ATM
Not recognized.

_PCS4•CAL•ZERO•value
OK.

PCS4•CAL•SPAN•value
OK.

_PCS4•CAL_DISABLE_ON
OK.

_PCS4•CAL_DISABLE•OFF
OK.

_PCS4•DEFAULT
OK.

_PCS4•CTRL•value
OK.

_PCS4•CTRLMAX•value
OK.

_PCS4•CTRLMIN•value
OK.

_PCS4•RATE•value
Slow, Med, Fast, Max or a number value.

_PCS4•RATEUNIT•digit
OK.

_PCS4•PEAKUNIT•digit
OK.

_PCS4•PEAKRESET
OK.

_PCS4•XDUCER•digits
OK.

_PCS4•AUTORANGE•1
Not recognized.

_PCS4•AUTORANGE•0
Not recognized.

_PCS4•DATE•yy-mm-dd
Not recognized.

_PCS4•TIME•hh:mm:ss
Not recognized.

_PCS4•FILTERWINDOW•value
OK.

_PCS4•FILTERSETTING•digits
OK.

_PCS4•OUTFORM•digit
Not recognized.

_PCS4•STABLEWINDOW•value
OK.

_PCS4•STABLEDELAY•digits
Change “digits” to
<=seconds>digits.

PCS 400 Queries

The 8204 will respond to all PCS 400 queries. These queries are listed below:

_PCS4•STAT?

_PCS4•ID?

_PCS4•ERR?

_PCS4•FILTERWINDOW?

_PCS4•FILTERSETTING?

_PCS4•CTRL?

_PCS4•CTRLMAX?

_PCS4•CTRLMIN?

_PCS4•RATE?

_PCS4•RATEUNIT?

_PCS4•PEAKUNIT?

_PCS4•XDUCER?

_PCS4•AUTORANGE?

_PCS4•SOURCEP?

_PCS4•EXHAUSTP?

_PCS4•RANGEMIN?

_PCS4•RANGEMAX?

_PCS4•OUTFORM?

_PCS4•STABLEWINDOW?

_PCS4•STABLEDELAY?

_PCS4•UNIT?

_PCS4•ZERO?

_PCS4•SPAN?

PCS 400 Tests

The 8204 will not recognize any of the “_PCS4•TEST• ...” commands.

MAINTENANCE

The 8204 was designed for maintenance-free operation. User maintenance is not recommended beyond replacement of parts listed in the 'Spare Parts List'. If you have questions not covered by this manual, call 1.800.984.4200 (USA only), or 1.512.396.4200 for assistance, or E-MAIL tech.support@mensor.com.

BEYOND THE WARRANTY

Take advantage of Mensor's expert product care. Mensor Corporation provides complete maintenance and calibration services, available for a nominal fee. Our service staff is knowledgeable in the innermost details of all of our instruments. We maintain units that are in operation in many different industries and in a variety of applications, and by users with a wide range of requirements. Many of these instruments have been in service for over twenty years, and continue to produce excellent results. Returning your instrument to Mensor for service benefits you in several ways:

a. Our intimate knowledge of the instrument assures you that it will receive expert care.
b. In many cases we can economically upgrade an older instrument to the latest enhancements.
c. Servicing our own instruments which are used in "real world" applications keeps us informed as to the most frequent services required. We use this knowledge in our continuing effort to design better and more robust instruments.

SELF-TESTS

There are four built-in diagnostic tests which can be run from the Test screen shown in figure 5.1. Each test will return a Pass or Fail indication. To see the test screen press [MENU], then [F5], then run any of the following tests:

[F1] - Measure Test: Vents the active channel to atmosphere and tests that the measured pressure is reasonable.

[F2] - Control Test: Opens and closes each of the four valves in the regulator of the channel and tests for an appropriate pressure change at each step.

[F3] - Exhaust Test: Opens the exhaust roughing solenoid valve, then checks that the exhaust pressure is less than 0.5 psi.

[F4] - Supply Test: Opens the supply roughing valve and tests for pressure greater than the range of the sensor in the active channel.

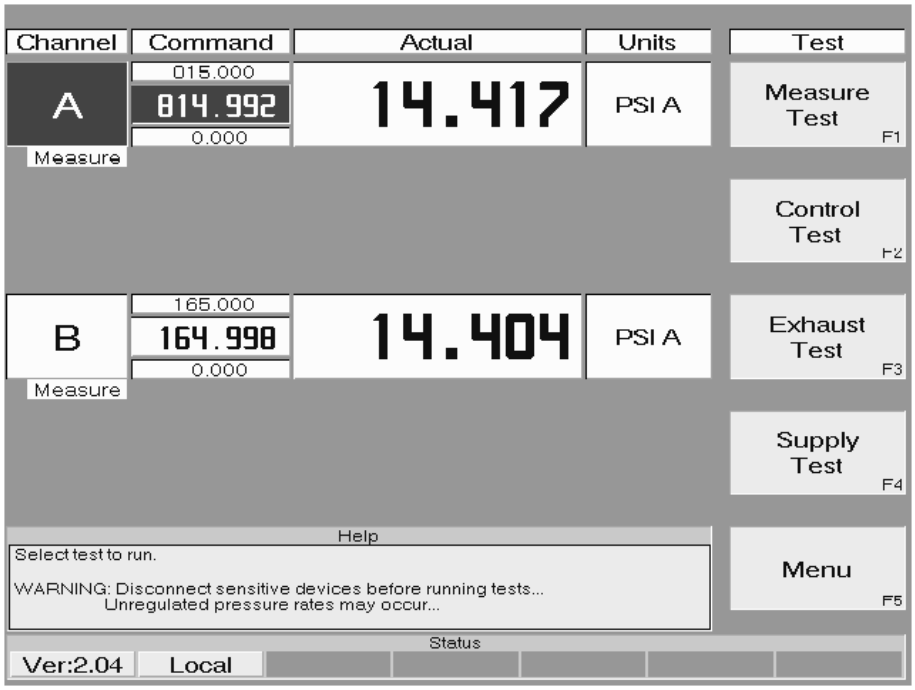


Figure 5.1 - The 'Test' Screen

PROGRAM UPGRADE DISK

In order to install a system upgrade floppy disk, first remove the power cord from the instrument. Then remove the rear panel by removing the nine screws holding it to the frame and the four screws near the pressure ports. The disk drive is located in the upper center at the rear of the instrument.

Push the upgrade disk into the disk slot until it locks in place. Boot up the unit and wait approximately two minutes, then remove the disk. Replace the rear panel and restore the instrument power. Turn on the instrument to reboot the 8204.

MODULE REPLACEMENT

To replace an electrical or a pneumatic module follow these steps:

1. Remove power cord.
2. Remove the top cover by removing the three screws on the top rear.
3. Remove the pressure fittings from the rear.
4. To remove the pneumatics module, remove the four screws on the rear panel that screw into the pressure manifold, and the two screws under the bottom plate that hold down the module. Disconnect all the pneumatic module cables from the electrical module. Then slide the pneumatic module forward slightly to disengage it from the key-hole slots in its base, and lift it out the top of the instrument.
5. To remove the electrical module, remove the cables to the pneumatic module and the front panel, and remove the two screws under the bottom plate that hold down the module. Slide the module forward slightly to disengage the key-hole slots in its base, and lift the module out the top.
6. Reverse the order to replace the module.

ATTENTION
STATIC SENSITIVE DEVICES
HANDLING PRECAUTIONS REQUIRED

CAUTION: The proper use of grounded work surfaces and personnel are required when coming into contact with printed circuit boards in order to prevent static discharge damage to sensitive electronic components.

Electrical Module Circuit Boards

To gain access to the circuit boards inside the electrical module without removing the module, remove the instrument top cover (3 screws), and the left side panel (2 screws). This allows access to the ten screws that secure the module cover to the module chassis; four screws at the top, and two screws each at the front, left and right sides. Remove these ten screws, then lift the module cover straight up to remove it.

All of the circuit boards in the module are compatible with IBM AT format Personal Computers (PC's). Most are purchased from outside vendors; they may differ in appearance, and also in position, from one unit to the next but their functionality remains the same. The exception is that the PLA boards are proprietary, designed and assembled by Mensor.

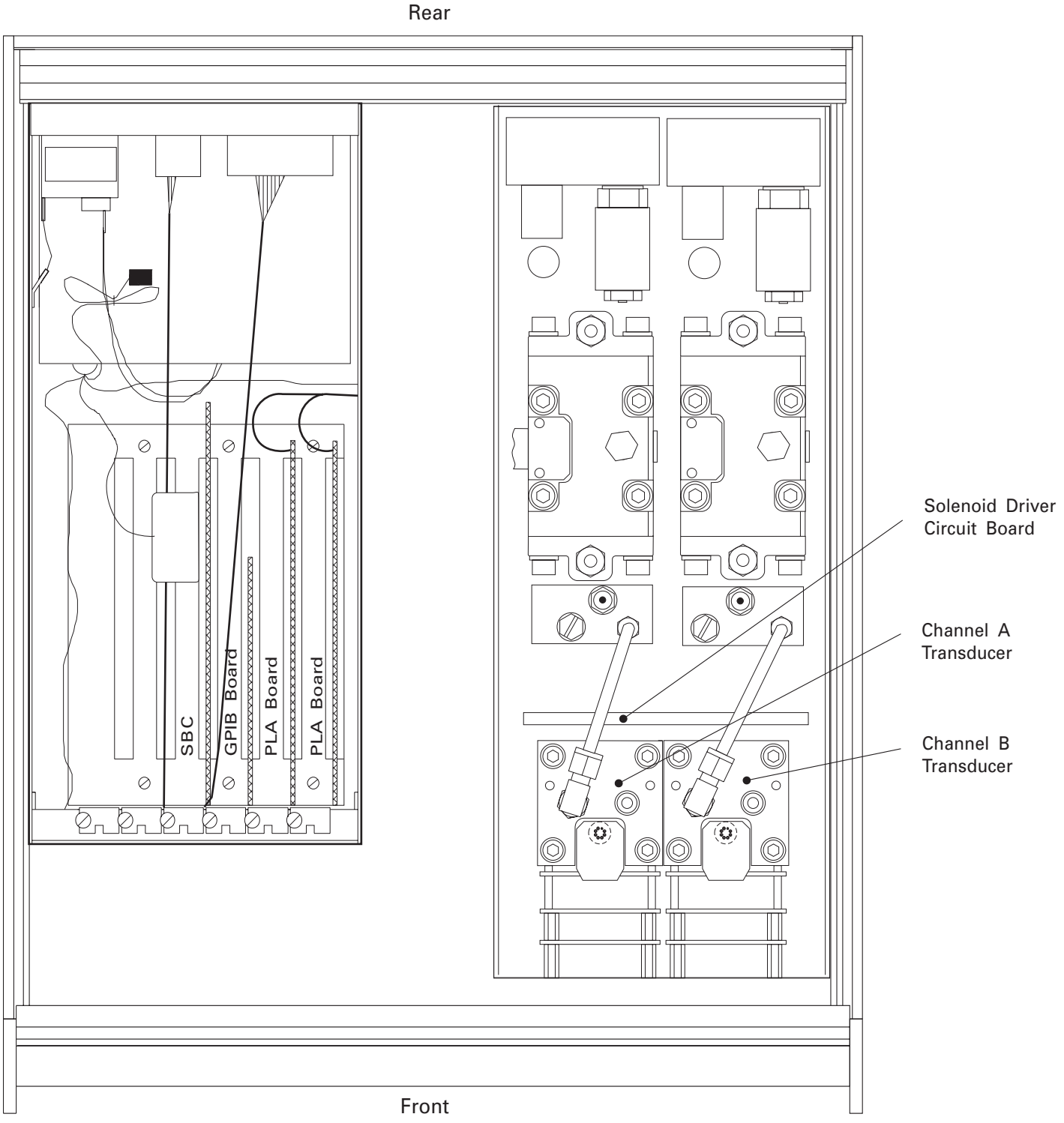
SPARE PARTS LIST

The following table lists 8204 spare parts that can be ordered from Mensor.

Table 5.1 – Spare Parts

Part Description	Part Number
Miscellaneous	
Manual	0014865001
Fuses	4100111150
Power Cord	4000400002
Rubber Feet	3201300001
Front Panel Assy - Color Display	0014940001
Electrical Module - Color Display	0017072001
GPIB Board	4904000015
Solenoid Driver Board (modified)	0014835001
PLA Board (specify channel)	0014293001
Power Supply (modified)	4901000024
Pneumatics Module	See Note
LP Regulator Top Cap Assembly (Std)	0014266002
Fitting Adapter - 7/16-20 to 1/8 NPT Female	4250010020
O-ring seals for 7/16-20 Fitting	4250010021

NOTE: *A replacement pneumatic module requires specific ranges and the software version number. Contact Mensor for exact replacement.*



NOTES:

1. The Electrical Module is shown with its cover removed.
2. The plug-in boards may be arranged in a different order than shown.

Figure 5.2 - Chassis, Top View with Covers Removed

User's Notes:

CALIBRATION

The 8204 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 8204 operated within its temperature band, and with proper zero and span adjustments, will provide accurate pressure measurements.

The 8204 should have the span verified periodically on both internal transducers (channels) to insure their stability. Initially, the recommended period between calibrations is 180 days, but this is usually extended as confidence is gained in the stability of these sensors.

ENVIRONMENT

For maximum accuracy, allow both channels of the 8204 to warm up in the MEASURE mode for a minimum of 45 minutes in an ambient temperature within the compensated range. In addition the instrument should be at rest on a stable platform which is free of excessive vibration and shock.

PRESSURE STANDARDS

Mensor 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 ANSI/NCSL *Z540*, or other applicable standards. The same requirement applies to the vacuum gauge used to set the zero offset. The recommended absolute pressure value for setting zero offset is 600 mTorr, or greater.

MEDIUM

The recommended calibration medium is dry nitrogen or clean dry instrument air. For pressure ranges below 20 psia head pressure height differences between the standard and the 8204 can cause errors. See 'Head Pressure Correction' in the *Appendix* for further information.

SETUP

Figure 6.1 (Calibration Setup) illustrates a typical setup for either local or remote calibration. In the figure the additional equipment required for remote calibration is shown as optional.

In the calibration setup illustration the 'Pressure Standard' is normally a deadweight test instrument, and the 'volume controller' refers to a hand operated variable-volume pressure vernier device. A diaphragm type vacuum gauge is recommended over the gauge tube type of vacuum sensor for calibrating sub-atmospheric pressures.

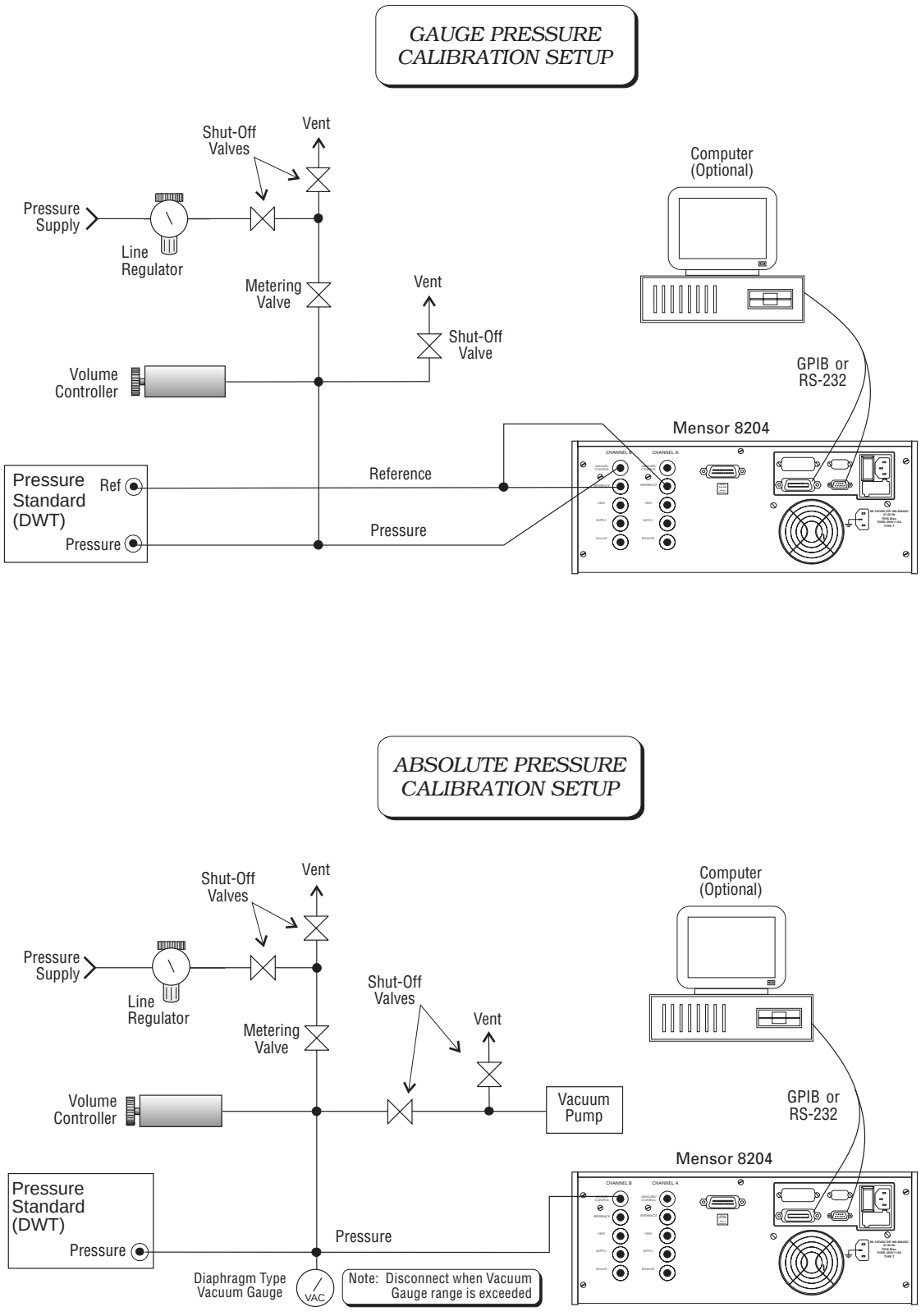


Figure 6.1 - Calibration Setup

PASSWORDS

Before changes can be made to either the zero or the span values that are recorded in the 8204 a protective password must be entered via the front panel keypad. The master password was set at the factory to 1 2 3 4 5 6. The user can replace this password with a new six digit password as explained further on. Also, a separate password can be defined which will authorize adjustments only to the zero setting. Separate zero and master passwords allow a facility to provide line personnel with the zero password for day-to-day zero adjustments, but limit access to the span adjustment to their calibration personnel. To assign or change either level of password requires entry of the current master password, whatever that is at the time.

Zero Password

In order to establish a zero password:

1. Press [MENU], [F4] to display the password screen as seen in figure 6.2;

2. Press [F1] to step to the Change Password line;

3. When the 8204 left the factory the master password was set to 1 2 3 4 5 6. Enter these six digits now, and as each number is pressed an '*' will be added in the Password cell;

4. With all six digits entered press either [F5], [ENTER], or [EXEC] to complete the entry, and the display will change to one similar to figure 6.3;

5. Again, press [F1] to move the highlight to the 'Enter Zero Password' function;

6. Assign the new zero password by pressing the desired six number keys. This time each number pressed is displayed on the screen so that the user can verify the entry. Use [CE] to backspace through erroneous numbers, and then enter the correction;

> **NOTE:** *Store a copy of this zero password where it can be recovered if forgotten.*

7. Finally, press [F5], [ENTER], or [EXEC]. The new zero password is immediately accepted and the '?' symbol displaces the new numbers in the display.

8. Confirm that the new zero password is valid by pressing [MENU], [F4], and key in the new six digit password. Then, press either [F5], [ENTER], or [EXEC]. The zero calibration screen for channel A and B (figure 6.4) should appear immediately. If it does not, return to step 1 and repeat the process.

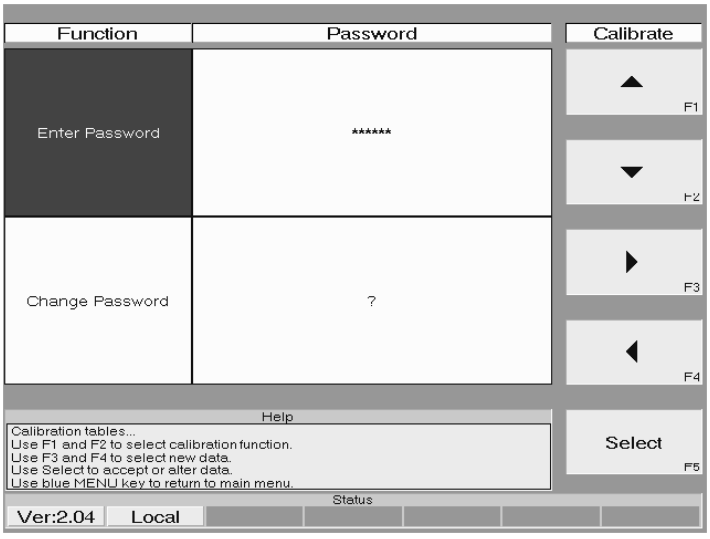


Figure 6.2 - The 'Enter/Change Password' Screen

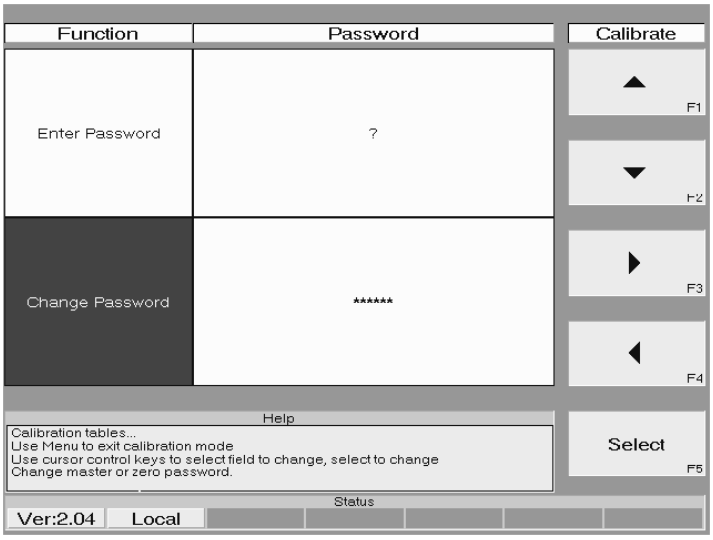


Figure 6.3 - The 'Change Passwords' Screen

Master Password

Use the master password to accomplish any of the following:

1. Change the master password;

2. Change the zero password;

3. Change the span calibration value;

4. Change the zero offset.

The master password is **required** for items 1, 2, and 3, and can be used to achieve item 4 in place of the zero password.

As previously mentioned, the master password was set at the factory to 1 2 3 4 5 6. To change this to a new set of six digits:

1. Press [MENU], [F4] to display the password screen as seen in figure 6.2;

2. Press [F1] to step down to the change password function;

3. Enter the current master password, and as each number key is pressed an '*' is added to the password window;

4. Press either [F5], [ENTER], or [EXEC] to complete the entry;

5. Enter a series of six numbers which become the new master password. The numbers are reflected on the screen as they are pressed.

6. Before proceeding, review the full six digits that are on the screen to insure that they are correct. A mistake here could preclude making future calibration adjustments to the system. Use [CE] to backspace through the numbers if they need to be corrected;

CAUTION: THE MASTER PASSWORD IS SELDOM USED, AND IS EASILY FORGOTTEN. WHEN MAKING A CHANGE WRITE DOWN AND SAVE THE NEW NUMBER. IF THE MASTER PASSWORD IS LOST CONTACT MENSOR.

7. When satisfied that the new password is correct, and a printed copy has been filed, press either [F5], [ENTER], or [EXEC] to complete the entry. The previous master password is immediately replaced by the new numbers and the '?' symbol returns to the display.

8. Confirm that the new master password is valid by pressing [MENU], [F4], then the new six digit password, and finally, either [F5], [ENTER], or [EXEC]. The Ps and Pt Master Calibration screen (figure 6.5) should appear immediately. If it does not appear, return to the password entry screen by pressing [MENU] and [F4], and carefully re-enter the master password, and [EXEC].

If the master calibration screen still does not appear contact Mensor.

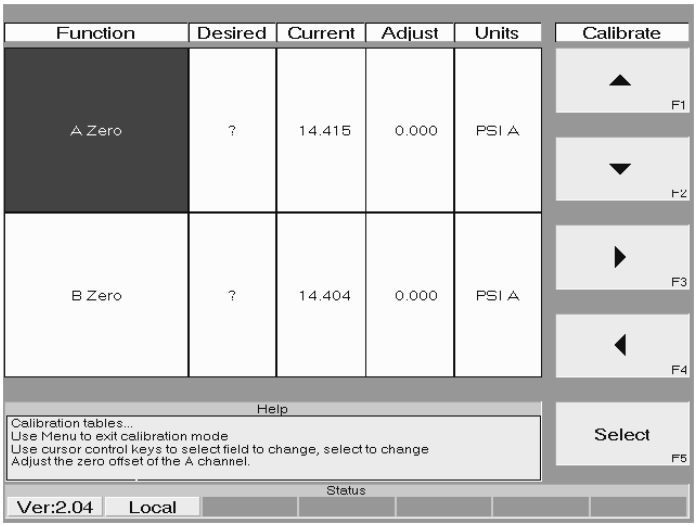


Figure 6.4 - The 'Zero Calibration' Screen

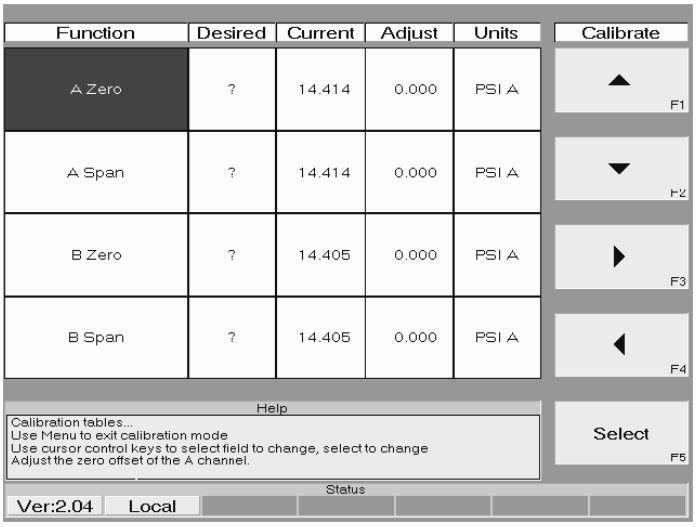


Figure 6.5 - The 'Master Calibration' Screen

LOCAL CALIBRATION

The 8204 contains two pressure transducers (channels A and B). Zero and span adjustments are available on both channels. Linearity is preset at the factory and is not adjustable. The zero and span adjustments are used to make a linear correction to the pressure readings of the active transducer according to the formula: ((uncorrected reading) x span) + zero. The 8204 automatically determines this value when the calibration function is executed either locally (front panel) or remotely (GPIB or RS-232).

At times the zero offset is adjusted without doing a span calibration, but always ensure that the zero is correct before adjusting the span. To begin a calibration connect the 8204 to either a gauge pressure or an absolute pressure calibration setup similar to figure 6.1. Close both vent shut-off valves, then set both channels to MEASURE mode and to psi pressure units.

> **NOTE:** *Psi are the recommended pressure units for making calibration adjustments. Other engineering units might add a small round-off error.*

The following procedures are for calibrating an absolute pressure instrument. For gauge pressure instruments the vacuum gauge and vacuum pump as illustrated in figure 6.1, would not be required.

Evacuate both the transducers to a low pressure that will still maintain a viscous flow, typically 600 millitorr. 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 (0.0116 psi). Table 9.2 in the Appendix lists millitorr conversion factors.

To enter the local calibration mode, press [MENU], then [F4] to display the password screen (figure 6.2). Enter the zero password to see or change just the zero offset (figure 6.4), or enter the master password to check or change both zero and span via the Master Calibration screen (figure 6.5).

Zero Offset

Each channel has a maximum zero offset of 10% of full scale. Zero values greater than 10% of FS will not be accepted.

The zero value which was entered at the factory can be restored to a selected channel at any time that a '?' is showing in the channel's 'Desired' field (see figures 6.4 and 6.5). Simply press [F5], [ENTER], or [EXEC] and the zero offset entered at the factory will displace any subsequent value.

To establish new zero values evacuate the output ports to about 600 millitorr (0.0116 psi), and place both channels in MEASURE mode. The 'Current' fields display the current pressure value in the active engineering units for both channels. The 'Adjust' fields display each channel's current zero offset. Use [F1] to highlight the desired channel, then use the number keys to enter the true zero pressure for that channel. The numbers replace the '?' in the 'Desired' column. When the displayed value is correct press [F5], [ENTER], or [EXEC] to enable the zero offset change for that channel. The display will now indicate the new 'zero' pressure reading for the active channel.

Press [F1] or [F2] to move to the alternate channel and repeat the above procedure for the second channel's new zero offset. When finished with setting the zero points press [MENU] to exit the calibration mode.

> **NOTE:** *As soon as a new value has been entered into the system the '?' symbol immediately returns to the 'Desired' field. If either [F5], [ENTER], or [EXEC] is pressed again, the new value will be deleted and the factory zero value will be restored. For the new value to remain in effect press any of the cursor keys to move to a different function, or press the [MENU] key to leave the Calibration screen with the new value intact.*

Span Offset

With an accurate zero offset established, the current calibration of the active sensor can be checked at several pressure points from zero to full scale. If recalibration is needed, proceed with the following.

To change either a span offset, or both zero and a span offset, enter the master password from the password screen and press [F5], [ENTER] or [EXEC]. The Calibration screen seen in figure 6.5 will appear. The 'Current' field displays the current pressure in the current engineering units. The 'Adjust' field shows the current zero and span offsets.

If both end points will be changed on one channel adjust the zero before adjusting the span. To reset zero proceed as above under 'Zero Offset'.

Span offset is the value of the span correction at the full scale range of the transducer. With a ? displayed in the 'Desired' field press [F5] to return the last factory offset value. Enter the true pressure using the numeric keys and then press [F5] or [ENTER] to change the offset. Span may only be set at 50% of the full scale range or greater.

With both channels warmed up and in MEASURE mode, apply a known absolute pressure equal to or near the span of the sensor. The value must be equal to or greater than 50% of the transducer range or the system will not accept the entry. The range of span adjustment available is ±10% of the transducer full scale value. Key in the true pressure and then [ENTER] to enter the reading. The display should now indicate the new true pressure for the active channel. Press [F1] to toggle to the alternate channel. Set the applied known pressure equal to or near the full scale value for this sensor. Key in the true pressure and [ENTER].

Both channels are now spanned to the new values. Press [MENU] to leave the calibration functions.

REMOTE CALIBRATION

To set zero over the remote bus apply a known pressure (less than 10% of the full scale span for the channel) and send the following command sequence:

1. A<lf> (or B<lf>)
2. Zero nn.nnnn<lf>

where nn.nnnn is the known applied zero pressure in the current engineering units.

To set span over the remote bus apply a known pressure (50% of full scale range or greater) and send the following command sequence:

1. As<lf> (or Bt<lf>)
2. Span nn.nnnn<lf>

where nn.nnnn is the known applied pressure in the current engineering units.

SPECIFICATIONS

Accuracy specifications presented herein are obtained by comparison with primary standards traceable to the National Institute of Standards and Technology (NIST). These specifications are obtained in accordance with the ISO *Guide to the Expression of Uncertainty in Measurement* (GUM). Mensor also adheres to ANSI/NCSL-*Z540*. If there is an exception to the requirements and recommendations of *Z540* during a calibration the exception is noted on the individual calibration certificate.

Mensor reserves the right to change specifications without notice.

MEASURE SPECIFICATIONS

Accuracy

0.010% FS including linearity, hysteresis, repeatability and temperature after zeroing at the operating temperature over the calibration interval. Optional 0.025% FS accuracy is available.

Precision

0.003% FS.

Calibration Stability

0.010% FS for 180 days after re-zeroing. Optional 0.025% FS accuracy instruments are 0.025% for 180 days after re-zeroing.

Pressure Ranges

Channel A & B: 10 inH_2O to 1500 psig, 5 to 1500 psia.

Measurement Units

The following are std: (32 press units, counts, %FS): In.Hg (at 0°C), In.Hg (at 60°F), mbar, Bar, psi, In.H2O (at 20°C), In.H2O (at 60°F), ft.H2O (at 4°C), ft.H2O (at 20°C), ft.H2O (at 60°F), mm H2O (at 4°C), cm H2O (at 4°C), m H2O (at 4°C), mm Hg (at 0°C), cm Hg (at 0°C), Kpa, Pa, mtorr (at 0°C), Torr, counts, & % Full Scale, in. Seawater (at 0°C), ft. Seawater (at 0°C), m Seawater (at 0°C), atm, Dynes/cm2, kg/cm2, oz/in.2, psf, tsf, g/cm2, tsi, microns Hg at 0°C, Mpa, Hpa. All seawater units are 3.5% salinity.

Measurement units are also referenced in table 9.1 in the *Appendix* section.

Resolution

Up to 1 ppm, dependent on FS range.

Calibration Adjustments

Zero Offset: Each channel has a maximum zero offset of 10% of full scale. Zero values geater than 10% of FS will not be accepted.

Span Offset: ±10% of span.

Calibration Interval

The recommended period between calibrations is 180 days.

Digital Filter

Off = 0, Low = 90, Norm = 95, High = 99

CONTROL SPECIFICATIONS

External Pressure Requirements

Reference Pressure: Atmosphere for gauge models. Permanent vacuum for absolute models.

Source Pressure: Instrument air or dry nitrogen that is 10% FS or 5 psi above the maximum range of the 8204, whichever is greater.

Exhaust Pressure: Atmospheric exhaust for gauge pressure control above 0.05 psig. Vacuum pump required for sub-atmospheric pressure control.

Stability of Controlled Pressure

±0.004% FS control stability.

Minimum Control Pressure

Gauge and Absolute Instruments (positive pressure): Exhaust pressure plus 0.05% FS, or exhaust pressure plus 0.025 psia, whichever is greater.

Pressure Control Rates

RATE Mode (optional): Typically less than 0.004% FS. This figure may be larger in low absolute pressure applications, and is somewhat dependent on the range, vacuum pump efficiency and overall system volume.

Control Time

When controlling: For the output pressure to be in the stable window, 55 seconds is typical between any two pressure points from 0.5% FS above the exhaust pressure to FS with a 1/2 liter volume. A larger volume can lengthen this time. The time will also be longer for absolute pressures below 0.5 psia.

Overshoot

NORMAL mode: 1% FS maximum with up to 1/2 liter volume.

GENERAL SPECIFICATIONS

Size

Width: . . . . . 17.05 inches (43.31 cm)
19.00 inches (48.26) with rack adapter
Height: . . . . . 6.97 inches (17.70 cm)
Depth: . . 20.00 inches (50.80 cm) without fittings

Weight

50.00 lbs (22.68 kg) . . . . . standard
54.00 lbs (24.49 kg) . . . . . with rack adapter
70.70 lbs. (32.07 kg) . . . . . shipping w/rack kit

Mounting

Standard: Table Model
Optional: Rack Mount Kit with slides is available for mounting in 19" rack.

Power Input Requirements

90-264 VAC, 50 to 60 Hz autoswitching. 175 VA max.
Power Cord: Detachable, 3-wire, 117V.

Pneumatic Interfaces

Fittings: 7/16" - 20 SAE/MS (female), 1/8" female NPT adapters provided

Particle Filters

Internal replaceable 20 micron filters are in line with all rear panel ports (8 total).

Pneumatic Overpressure Protection

Each Transducer is protected by relief valves.

Compensated Temperature Range

15°C to 45°C.

Operating Temperature Range

0°C to 50°C.
Note: This is not the compensated temperature range.

Storage Temperature Range

–25°C to +60°C.

Local User Interfaces

Graphic 6.5" (diagonal) color LCD.
20 single function main keypad.
5 special function keys.

Remote User Interfaces

IEEE-488.1 and RS-232.

Warm-up

Approximately 45 minutes to achieve full accuracy.

Response Time

Less than 0.2 seconds for FS step with no digital filtering.

Orientation Effects

Negligible effect on span, linearity and zero in any attitude.

Shock/Vibration

2 gravities max. for 10 minutes, per MIL-T-28800.

Pressure Media

Clean, dry, non-corrosive gases. No oxygen.

External Pneumatic Volume

Maximum: 1/2 liter
Minimum: 0.1 liter (100 cc)

Operating Environment

Humidity: 5% to 95% RH non-condensing humidity.

ADDITIONAL SPECIFICATIONS

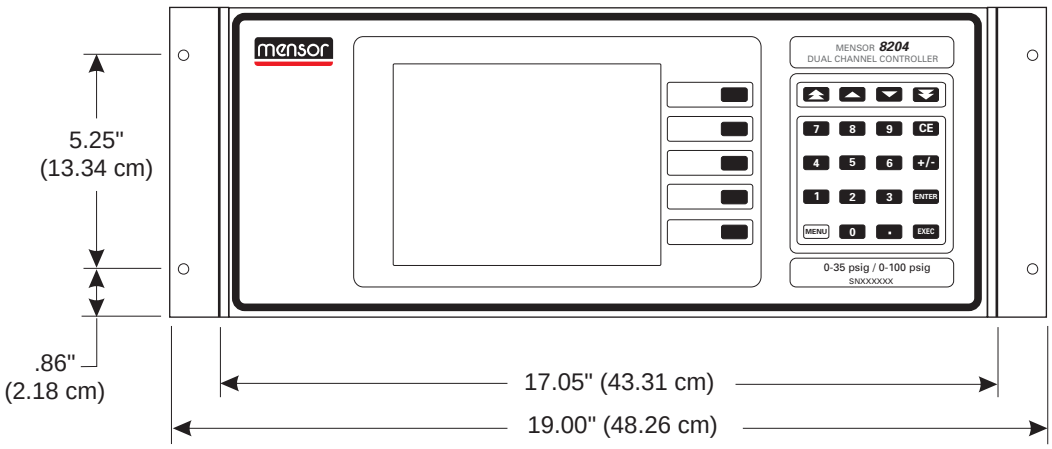
Options

Rack Mount Kit
Dual IEEE-488 Output
External Transducers
Barometric Reference Transducer
Control Rate

Software

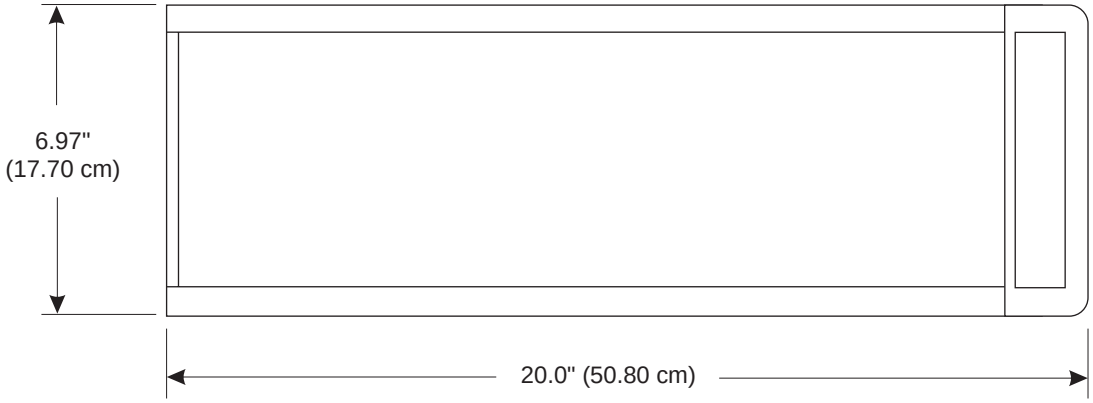
All program information to run the system is located on the solid state disk. The floppy disk drive is used for upgrades only.

Front View



Overall width with Rack Mount Flanges attached.

Side View



Add 0.40 inches (1.02 cm) to height with feet attached.

Figure 7.1 - Dimensional Outline

User's Notes:

OPTIONS

This section lists options available for the 8204. Users might consider letting the factory install a special feature not listed here. Mensor welcomes the opportunity to quote on such requests. The cost of adding an enhancement frequently will amortize itself in a very short time because of improved process efficiency.

TRANSPORT CASE (PN 0011159001)

A wheeled Transport Case is available suitable for moving the 8204 between sites, or as an air-freight (or other) shipping container. The case is constructed of a high impact plastic with a black exterior. It includes two keys, locks, a piano hinge, an anodized interlocking tongue and groove opening, various nickel-chrome and stainless steel fixtures, a vinyl satchel style handle and a retractable pull-out handle. The interior is filled with high density polyurethane foam with a die-cut cavity to cradle the instrument with fitting adapters in place, and an additional cavity to store related accessories. Rugged and weather resistant, the case makes an attractive, practical shipping and moving container. The case weighs approximately 29 pounds (13.15 kg) unloaded, and can support a load of up to 150 pounds (68.04 kg). Nominal dimensions are 15 inches by 24 inches by 26 inches (38.10 cm x 60.96 cm x 66.04). (See figure 8.1.)

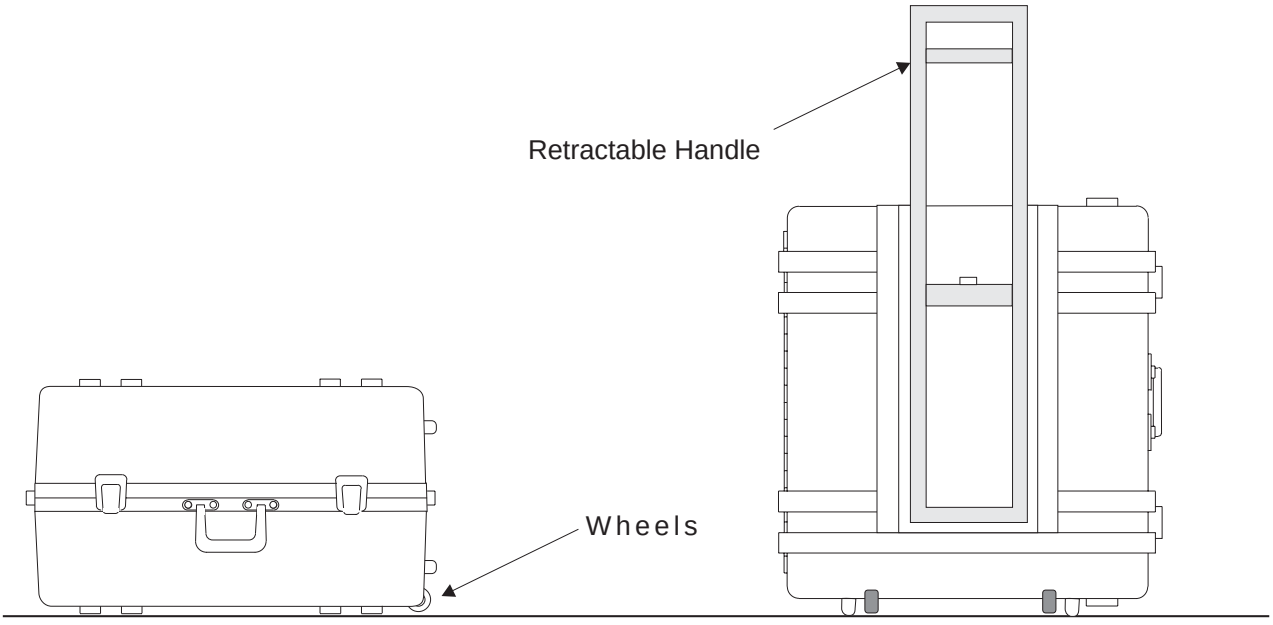


Figure 8.1 - Transport Case

RACK MOUNT KIT (PN 0012425004)

The 8204 is easily mounted into a 7 inch opening of a 19 inch wide rack. The rack used should satisfy the dimensional requirements shown below. It should be free of vibration and excessive heat, as noted below.

Install the chassis slide, being sure to allow the proper spacing above and below the 8204. An 8204 with the rack mount option is then installed from the front of the rack. Before installing the 8204, remove the four feet from the bottom of the instrument. Slide the 8204 all the way into position and secure the instrument to the rack before connecting power and pneumatic lines to the rear panel.

After all equipment is installed, check to see that the temperature inside the rack does not exceed 38°C. If it does, additional rack spacing and/or ventilation must be considered.

CAUTION: MOTORS OR VIBRATING DEVICES SHOULD BE MOUNTED SO AS TO MINIMIZE THE VIBRATIONS AT THE INSTRUMENT!

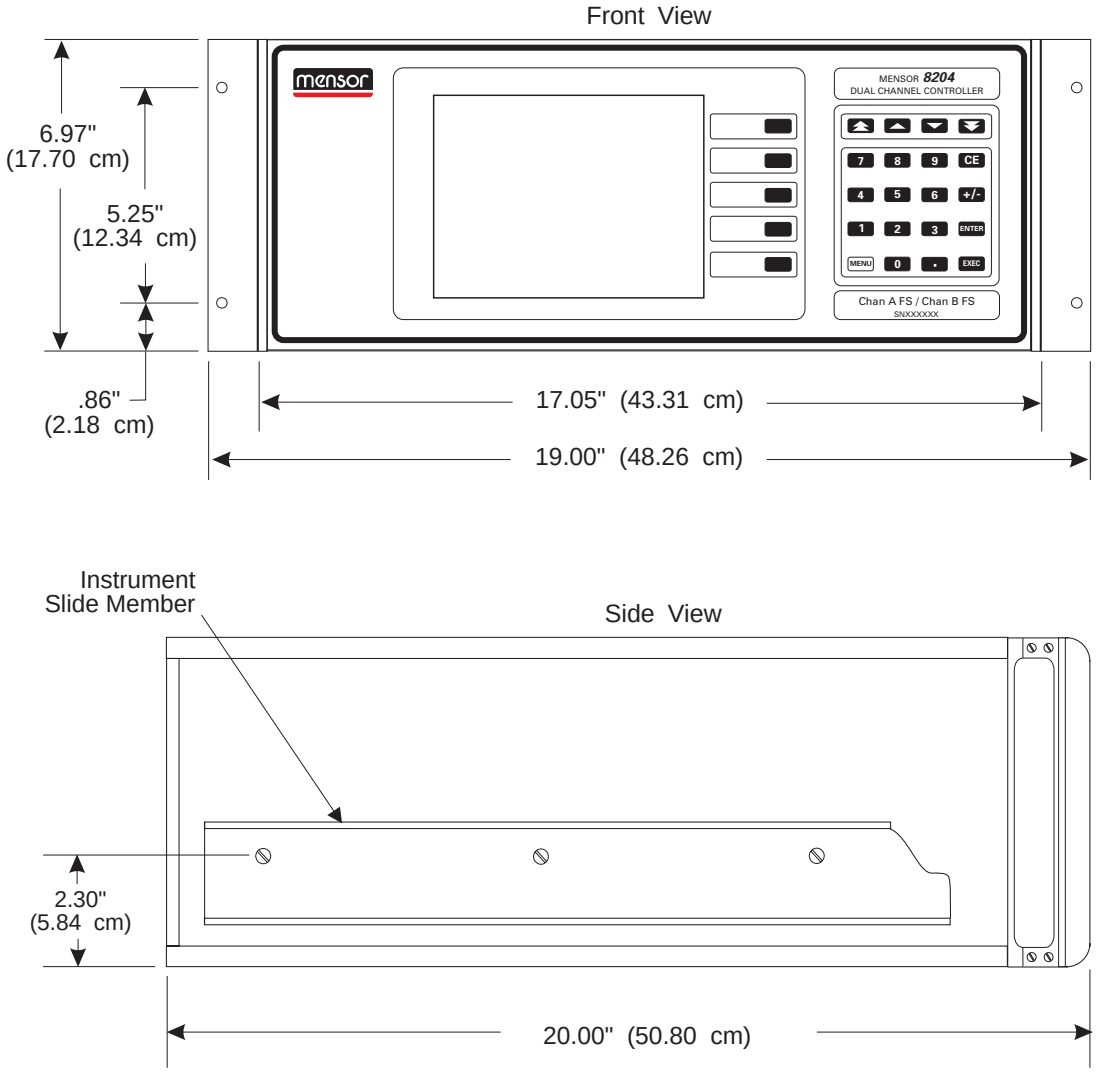


Figure 8.2 - Rack Mount Dimensions

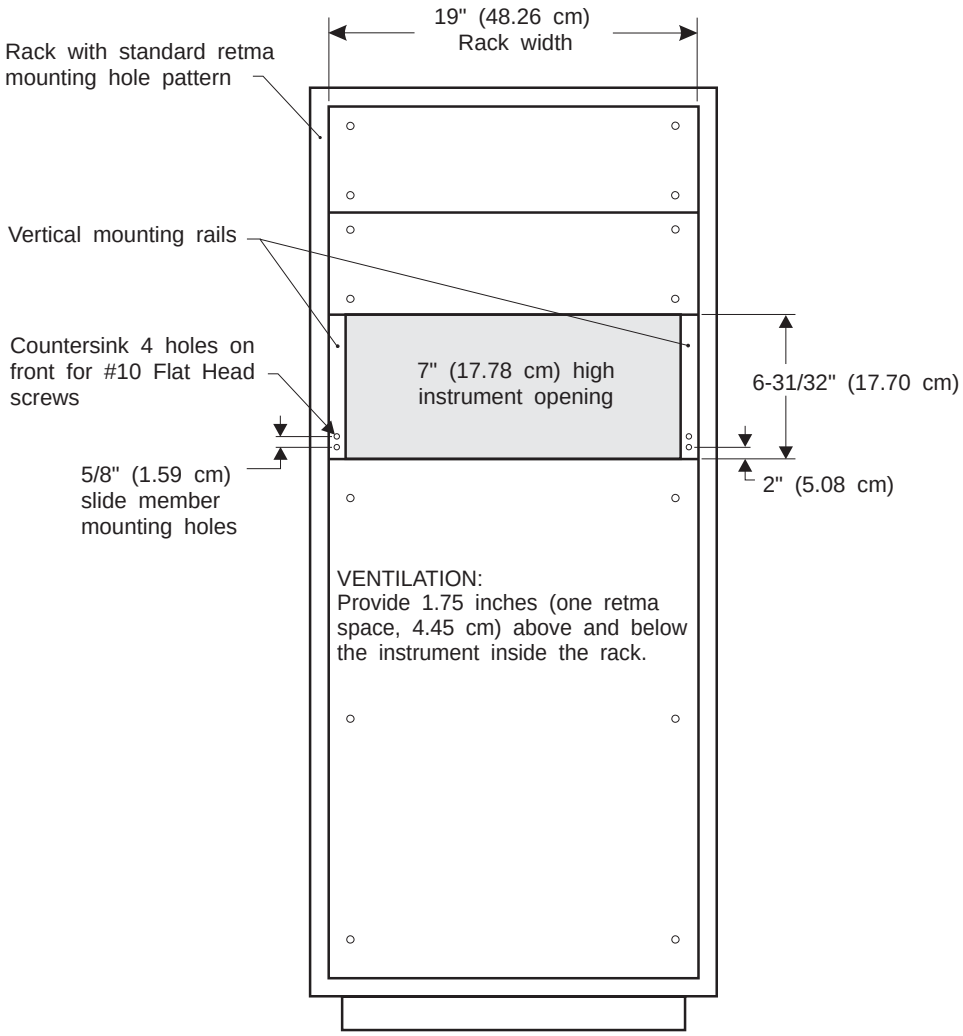


Figure 8.3 - Rack Specifications

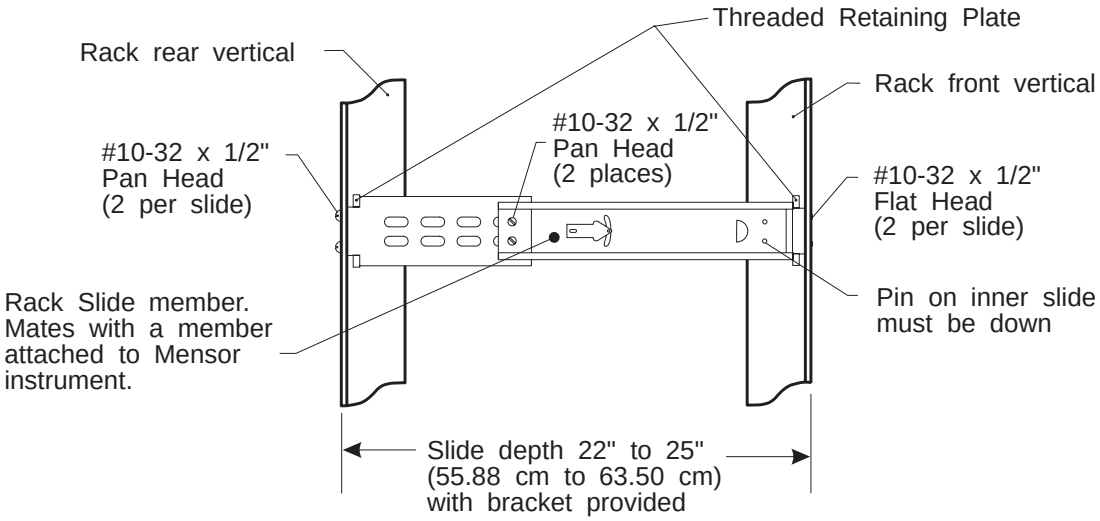


Figure 8.4 - Slide Specifications

DUAL IEEE-488 (GPIB) OUTPUT

The 8204 can be equipped with two independent GPIB controllers such that the one instrument will behave as two separate IEEE-488 devices. In this configuration (figure 8.6) each of two separate operators or work stations can communicate with an independent pneumatic channel of the 8204.

With this option the 'Remote Setup' screen provides for setting independent GPIB addresses as seen in figure 8.5. All channel selection commands in the remote command set are disabled. This option has no effect on local operation of the 8204 from the front panel.

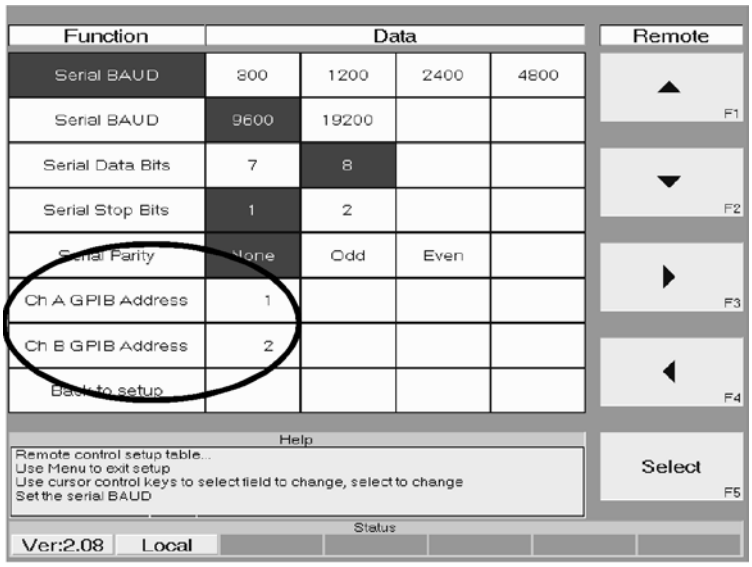


Figure 8.5 - 'Remote Setup' Screen for Two GPIBs

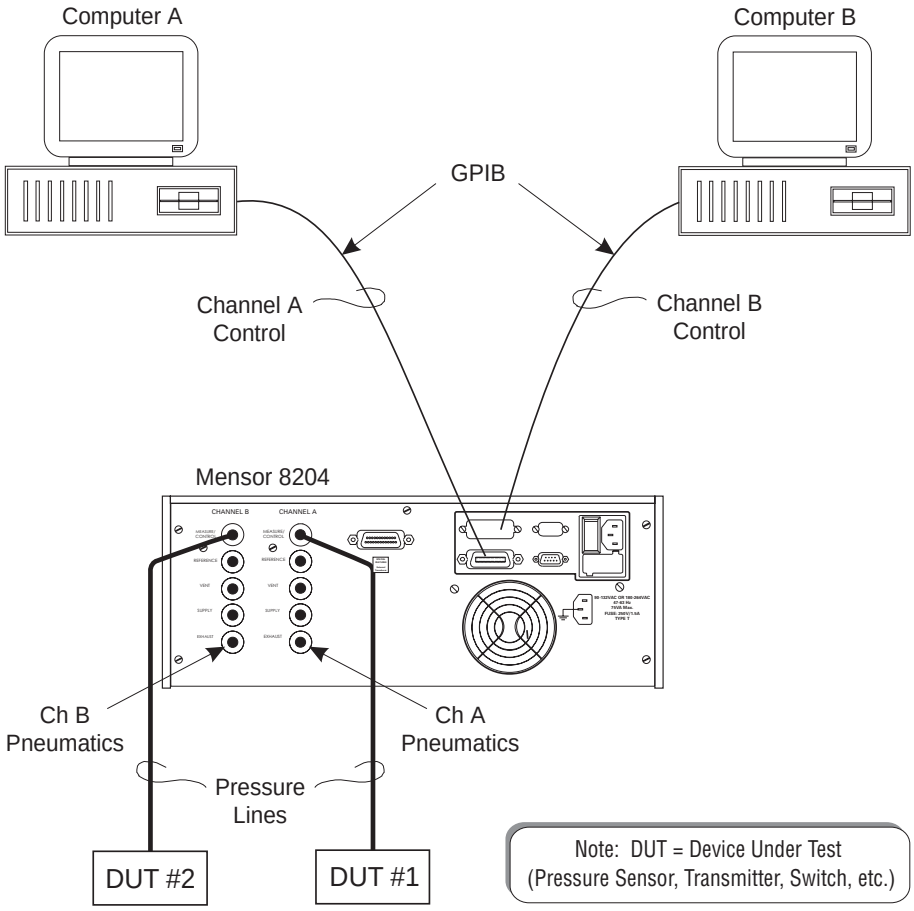


Figure 8.6 - Layout for Dual IEEE-488 Operation

EXTERNAL TRANSDUCERS

General

An 8204 can be supplied with either one or two external Parallel Bus Transducers (PBTs) in either absolute or gauge pressure type, or with a special purpose Barometric Reference Transducer (BRT). The distinguishing features of a BRT are discussed after the general discussion on external transducers. In either case, the external transducer is similar to figure 8.7 in appearance.

> **NOTE:** *The standard Virtual Channels feature (Delta & Ratio), and the options External Transducers, BRT, and Rate are all mutually exclusive. An 8204 may have any one of these, but not any two in combination.*

Installation

An 8204 ordered with either one or two external transducers will include a DB-25F connector on the rear panel (figure 8.8). This connector will be identified with a “Special Features" label which describes the connector’s purpose. For two external transducers a “T” connector is required between the transducers and the DB-25F. The Mensor part number for a “T” adaptor is 4050250013.

A Pressure line connects directly to the PBT pressure port. The pressure ports can be located on either the connector end or on the opposite end of the PBT.

Screens

There are several screen changes associated with the external transducer options. These changes affect the Menu, Operate, Setup and Calibrate screens.

Menu Screen: Figure 8.9 shows the Menu screen displaying two external sensors labeled as Aext and Bext. All of the measurement and control data normally displayed for the two internal channels are also shown for the external transducer(s).

Sensor Setup Screen: The Sensor Setup Screen is shown in figure 8.10. As above, all of the sensor settings available for the two internal sensors are also available for the external sensor(s). From this screen the engineering units and the reading filter settings for up to four sensors can be assigned.

Under the ‘Function’ label the ‘Sensor Type’ function has been added. By highlighting this function each of the two pressure channels (A and B) can be set for either gauge pressure operation, or absolute pressure operation.

Controller Setup Screen: Refer to figure 8.11. Just as with the Sensor Setup screen, this screen provides for setting control parameters for up to four channels. In this case the external transducers can be used as controlling devices by using the internal controllers up to the full pressure range of the controller. Obviously, there are only two controlling channels available at any time.

Figure 8.7 - External Transducer

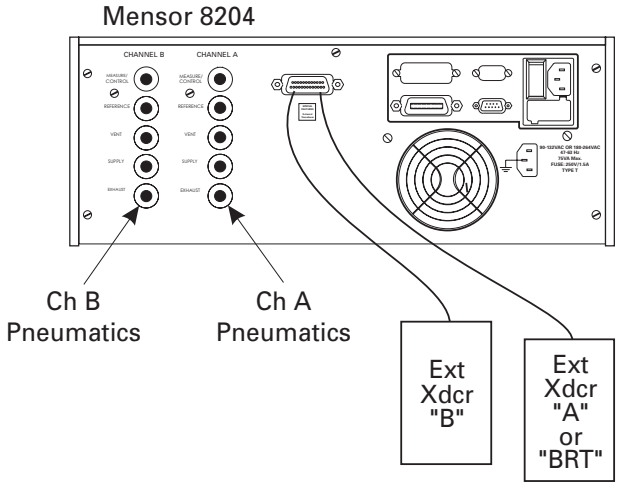


Figure 8.8 - External Transducer Installation

Display/Channels Setup Screen: With the External Transducer option the Display/Channels Setup screen (figure 8.12) provides for up to four channels to be displayed; Channel A, B, External A and External B. From this screen the channels can be arranged in any order, or channels can be suppressed from the display. The procedures for setting up the display are explained in the Local Operation section of the manual.

Calibration Screens: The Master Calibration and Zero Calibration screens will display the span and zero calibration data as appropriate for the additional sensors. The external sensor span and zero settings can be changed in the same manner as the internal sensors calibration values.

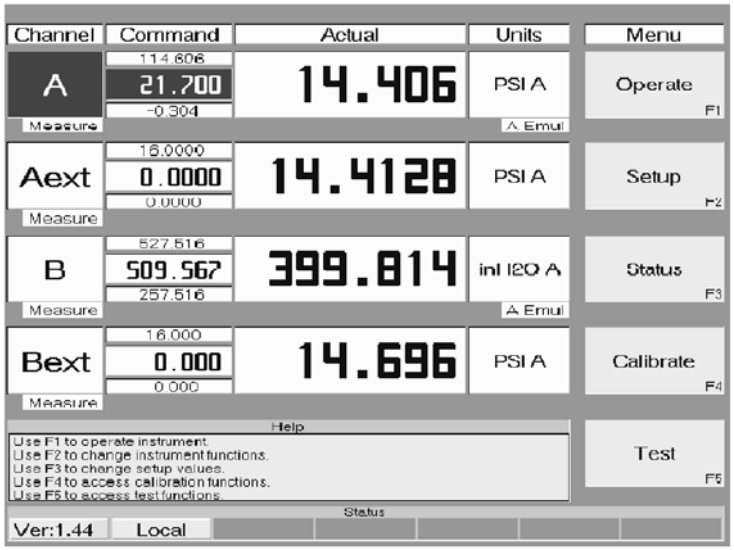


Figure 8.9 - Menu Screen

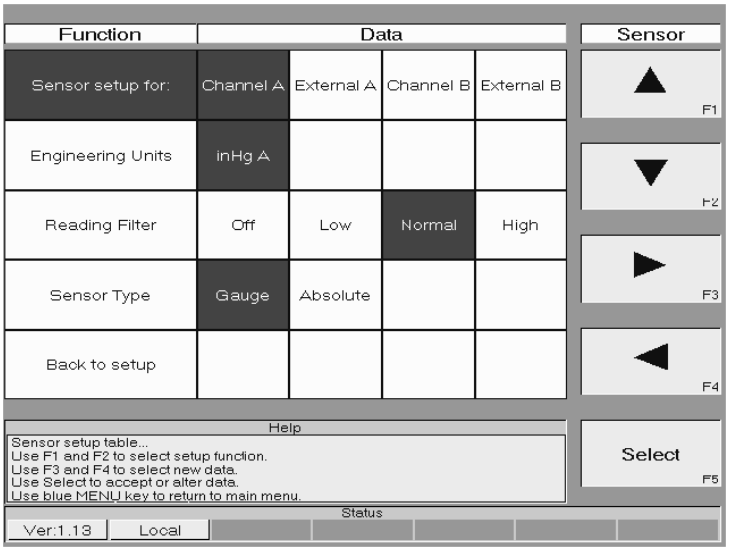


Figure 8.10 - The 'Sensor Setup' Screen

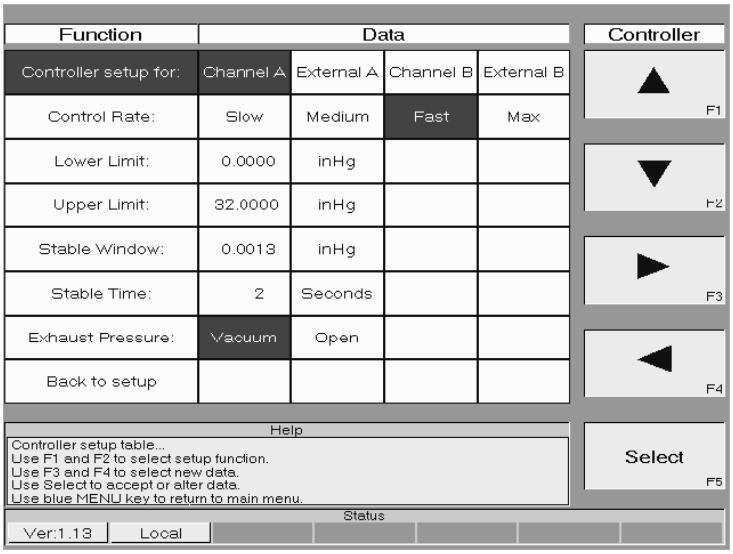


Figure 8.11 - The 'Controller Setup' Screen

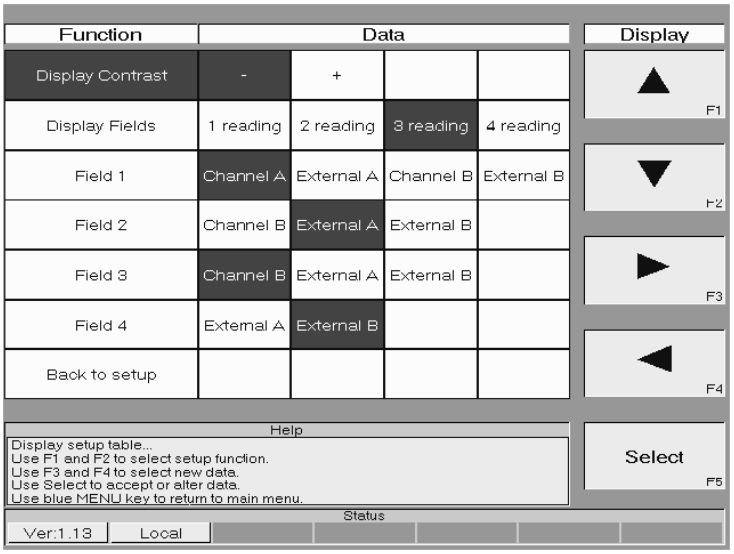


Figure 8.12 - The 'Display/Channels Setup' Screen

Barometric Reference Transducer

The BRT is a very stable, measure only, absolute pressure device used to accurately measure local atmospheric pressure. The BRT connects to the rear panel DB-25F described previously. With the BRT connected the 8204 can:

a. Calibrate the BRT.

b. Display the BRT output as atmospheric pressure.

c. Combine the BRT output with the output of an internal absolute pressure transducer in order to emulate gauge pressure measurement and control functions.

NOTE: *The standard Virtual Channels feature (Delta & Ratio), and the options External Transducers, BRT, and Rate are all mutually exclusive. An 8204 may have any one of these, but not any two in combination.*

Screens

Menu Screen: Figure 8.13 is a Menu display with the BRT option installed. Since the BRT is a measure only function, the 'Command' cell for the Baro channel is empty. There are no BRT control functions or settings to report.

Sensor Setup: With a BRT the 'Sensor Setup' screen is as seen in figure 8.14. Notice there are three sensors to configure, A, B, and Baro.

Display/Channels Setup: Refer to figure 8.15. As with the Sensor Setup screen, this screen has provisions to display up to three channels of data.

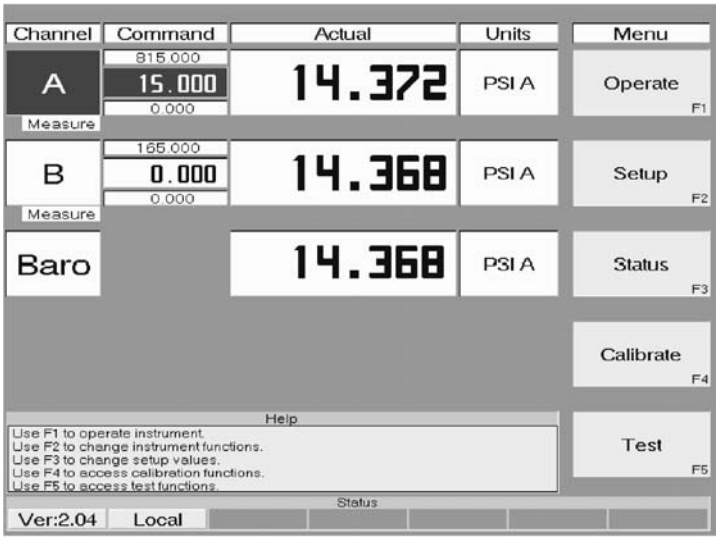


Figure 8.13 - Menu Screen with BRT

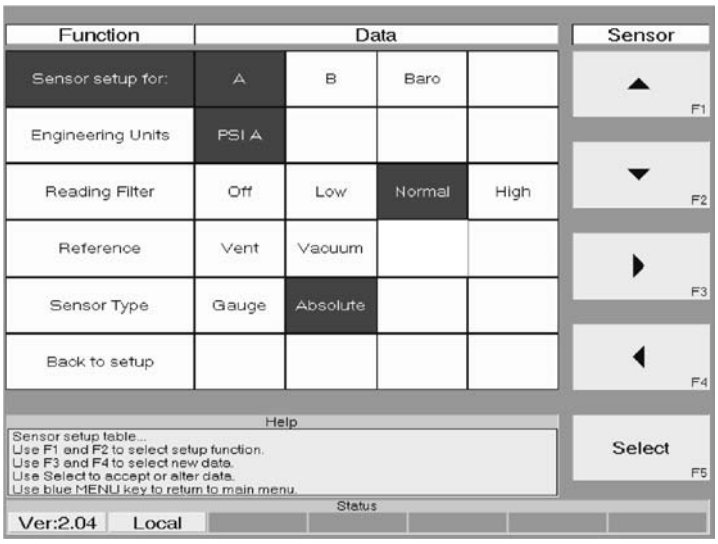


Figure 8.14 - 'Sensor Setup' Screen with BRT

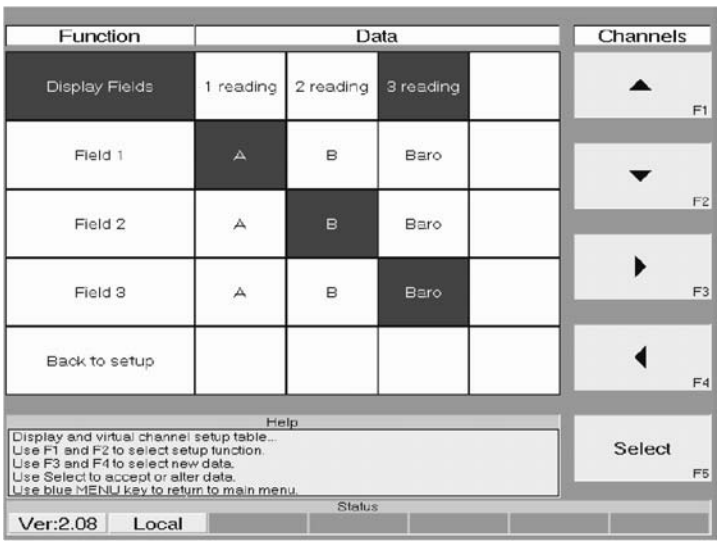


Figure 8.15 - 'Display/Channels Setup' Screen with BRT

Gauge Pressure Emulation

In addition to the operational instructions covered in the *Introduction* and *Local Operation* sections of the manual, with the addition of the BRT option absolute sensors in the A or B channels can be configured to emulate gauge pressure operations. When enabled, the emulation mode is consistent in both the Measure mode and the Control mode of operation.

To configure an absolute channel for gauge pressure emulation go to the Sensor Setup screen (figure 8.16). From there, select either the A or the B channel, cursor down to the 'Sensor Type' row, and set the highlight on 'Gauge'. Press F5, 'Select', then press the blue 'MENU' key, and a screen similar to figure 8.17 will appear. In this screen the 'A' (for absolute) has been removed from the PSI cell ('Units' column), and a small 'G Emul' label (circled in figure 8.17) has been added.

In the Gauge Emulation mode the atmospheric pressure reading from the BRT is subtracted from the absolute pressure reading of the subject channel to simulate a gauge pressure.

> **NOTE:** *Since the 'Gauge' pressure reading is a combination of the output from the BRT and either the A or B channel transducer, the error band in this mode is the sum of the errors from each transducer.*

Remote Operation

The BRT responds to the all of the standard 8204 commands and queries which are appropriate for the device. This option also adds the following BRT specific commands and queries to the 8204 command list:

Table 8.1 - BRT Commands and Queries

Command	Response/Function
Absolute	Sets the active channel (A or B only) to Absolute (Native) mode.
Baro	Makes the BRT the active channel (Measure or Calibrate only).
Baro?	Returns the atmospheric pressure as read by the BRT.
Gauge	Sets the active channel (A or B only) to Gauge (Emulation) mode.

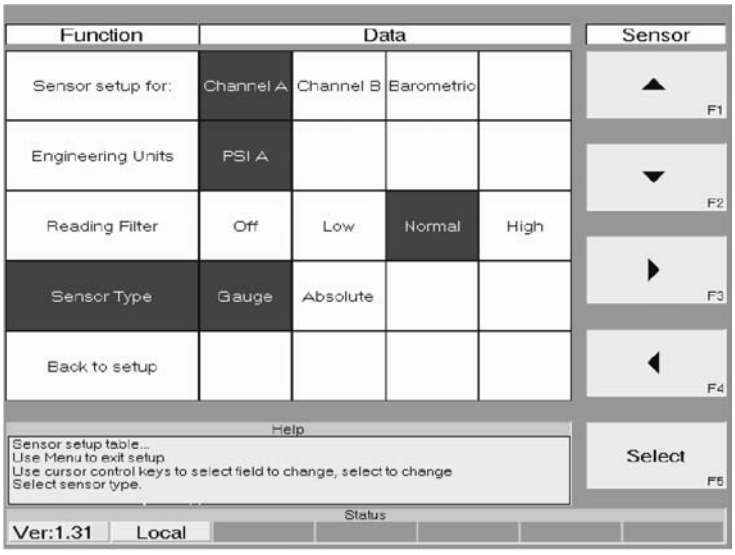


Figure 8.16 - Gauge Emulation Selection Screen

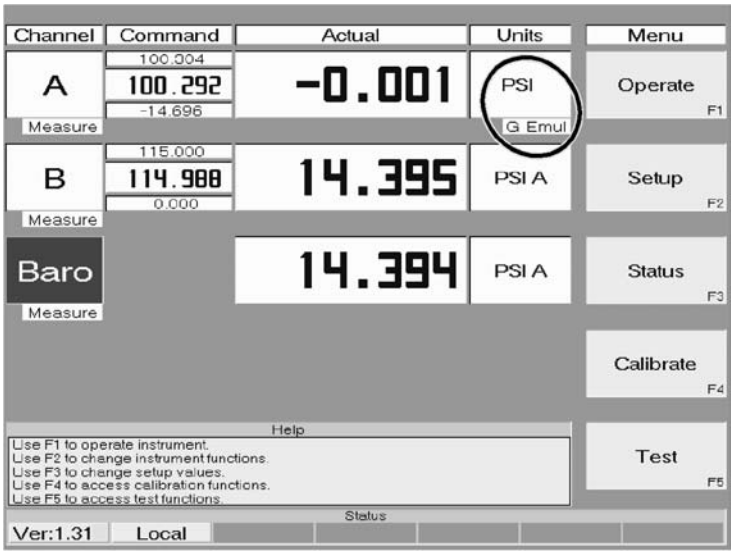


Figure 8.17 - Channel A in Gauge Mode

External Transducer Specifications

Physical:

Size
2.5" wide x 3.3 " high x 4.56" deep
(6.3 cm x 8.38 cm x 11.58 cm)

Weight
1.9 pounds (0.86 kg)

Power
Supplied from the 8204 via the interconnecting data cable

Warm-up
Approximately 5 minutes

Cable
6 foot multi-conductor, jacketed cable; DB-25M connector on each end

Mounting
An external transducer, including a BRT, may be mounted in any orientation. There are four 6-32 UNF threaded holes in the base, three 8-32 threaded holes on the pressure port end, and two 8-32 threaded holes on the opposite end. The transducer may be attached to a vibration free panel or surface using any of these threaded holes, or it may remain loose on a bench top. See figure 8.18 for mounting hole patterns. The BRT cover can be reversed such that the bus connector (*) can be on either end.

Functional:

Functional specifications for external transducers are the same as listed for the internal transducers in the *Specifications* section of the manual.

Exceptions to the specificiations for a Barometric Reference Transducer are as follows:

BRT Range
0 to 15.000 psia

Accuracy
0.010% FS

Resolution
One part in 150,000

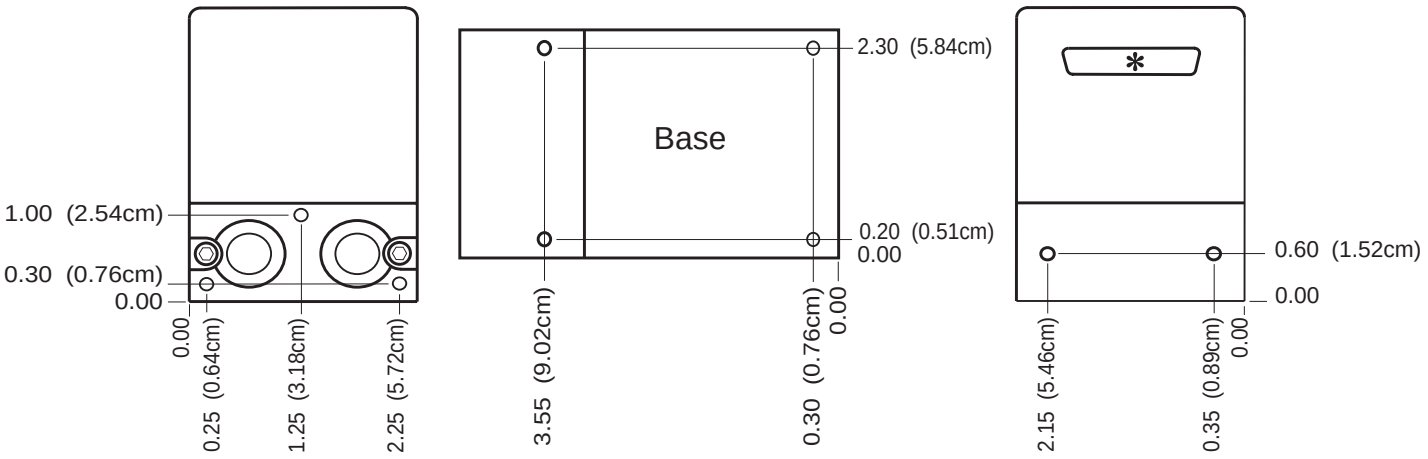


Figure 8.18 - External Transducer Mounting Layout

CONTROL RATE

Figure 8.19 is a Menu screen with the Rate option installed. This option provides the means to output a pressure that changes at a predetermined rate.

> **NOTE:** *The standard Virtual Channels feature (Delta & Ratio), and the options External Transducers, BRT, and Rate are all mutually exclusive. An 8204 may have any one of these, but not any two in combination.*

Local Operation

For Local Operation go to the Display/Channels Setup screen (figure 8.20) to set the Rate display. The Controller Setup screen (figure 3.7) is used to set the rate of change in general terms; Slow, Medium, Fast, or Max, and to set the upper and lower pressure limits for the Rate function.

Remote Operation

With remote commands the Rate of pressure change can be set to precise values of change in pressure units per second, per minute, or per hour. All of the Rate associated commands are listed in table 8.2 on the following page.

Overshoot Specification

RA*TE Mode:* Typically less than 0.004% FS. This figure may be larger in low absolute pressure applications, and is somewhat dependent on the range, vacuum pump efficiency and overall system volume.

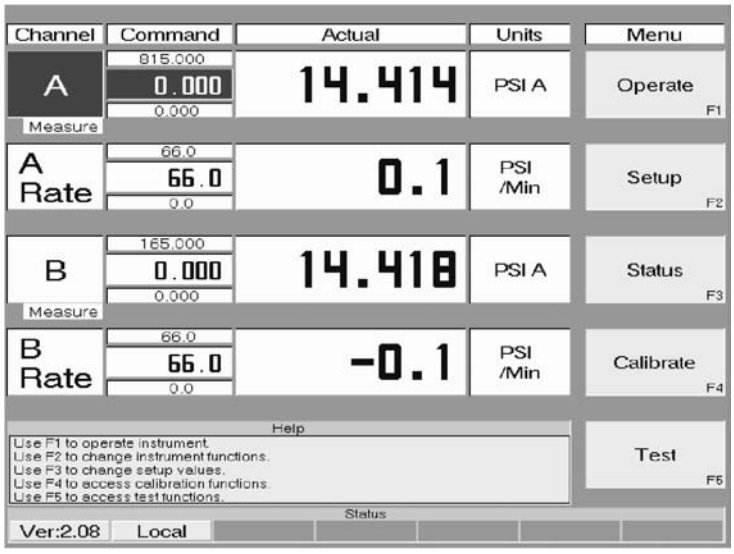


Figure 8.19 - Menu Screen with Rate

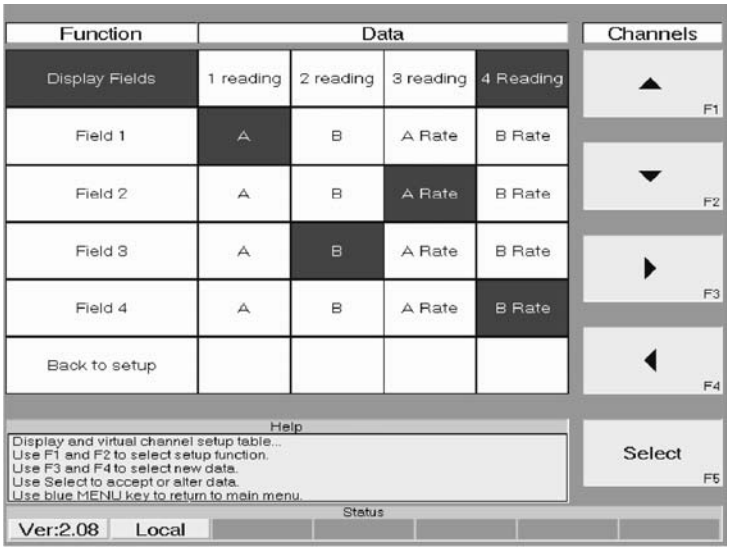


Figure 8.20 - Display/Channels Setup with Rate

Table 8.2 - Command/Query Set for Rate

Ref	Command	Data Range	Response/Function
1	Ar?		Returns the A channel rate.
2	Ars?		Returns the A rate stable indication (YES or NO).
3	Br?		Returns the B channel rate.
4	Brs?		Returns the rate stable indication (YES or NO).
5	rate?		Returns the rate reading of the active channel
6	RFilter	0 to 10.	Sets the corner frequency for the active channel rate reading.
7	RFilter?		Returns the rate filter corner frequency.
8	RLLimit	Within sensor range and less than upper limit.	Sets the lower rate control limit for the active channel.
9	RLLimit?		Returns lower rate control limit for the active channel.
10	RSetpt	Within lower and upper limits.	Sets the control rate setpoint for the active channel.
11	RSetpt?		Returns the control rate setpoint for the active channel.
12	RStable?		Returns Yes if current channel rate is stable.
13	RStableTime	0 to 65535	Sets the rate stable time to the number of seconds specified.
14	RStableTime?		Returns the rate stable time.
15	RStableWin	Within lower and upper limits.	Sets the rate stable window.
16	RStableWin?		Returns the rate stable window.
17	RULimit	Within sensor range and more than lower limit.	Sets the upper rate control limit for the active channel.
18	RULimit?		Returns upper rate control limit for the active channel.
19	Runits	Sec, Min or Hour.	Sets the rate units of time.
20	RUnits?		Returns the rate units of time.

User's Notes:

APPENDIX

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MEASUREMENT UNITS

Measurement units listed in table 9.1 are available to the user. Conversion factors for these units are listed in tables 9.2 and 9.3.

Table 9.1 – Measurement Units (unitno)

Description	Output Format
pounds per square inch	PSI
inches of mercury @ 0°C	INHG @ 0C
inches of mercury @ 60°F	INHG @ 60F
inches of water @ 4°C	INH2O @ 4C
inches of water @ 20°C	INH2O @ 20C
inches of water @ 60°F	INH2O @ 60F
feet of water @ 4°C	FTH2O @ 4C
feet of water @ 20°C	FTH2O @ 20C
feet of water @ 60°F	FTH2O @ 60F
millitorr	MTORR
inches of seawater @ 0°C (3.5% sal)	INSW @ 0C
feet of seawater @ 0°C (3.5% sal)	FTSW @ 0C
atmospheres	ATM
bars	BAR
millibars	MBAR
millimeters of water @ 4°C	MMH2O @ 4C
centimeters of water @ 4°C	CMH2O @ 4C
meters of water @ 4°C	MH2O @ 4C
millimeters of mercury @ 0°C	MMHG @ 0C
centimeters of mercury @ 0°C	CMHG @ 0C
torr	TORR
kilopascals	KPA
pascals	PA
dyne per square centimeter	DYNE/SQ CM
grams per square centimeter	G/SQ CM
kilograms per square centimeter	KG/SQ CM
meters of seawater @ 0°C (3.5% sal)	MSW @ 0C
ounce per square inch	OSI
pounds per square foot	PSF
tons per square foot	TSF
percent of full scale	%FS
micron HG @ 0°C	MICRON HG @ 0C
ton per square inch	TSI
n/a	n/a
hectopascals	HPA
megapascals	MPA

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 9.2 – Conversion Factors, PSI

Pressure Unit	To Convert From PSI	To Convert To PSI
PSI	1	1
INHG @ 0C	2.036020	0.4911544
INHG @ 60F	2.041772	0.4897707
INH2O @ 4C	27.68067	0.03612629
INH2O @ 20C	27.72977	0.03606233
INH2O @ 60F	27.70759	0.03609119
FTH2O @ 4C	2.306726	0.4335149
FTH2O @ 20C	2.310814	0.4327480
FTH2O @ 60F	2.308966	0.4330943
MTORR	51715.08	0.00001933672
INSW @ 0C (3.5% sal)	26.92334	0.03714250
FTSW @ 0C (3.5% sal)	2.243611	0.445710
ATM	0.06804596	14.69595
BAR	0.06894757	14.50377
MBAR	68.94757	0.01450377
MMH2O @ 4C	703.0890	0.001422295
CMH2O @ 4C	70.30890	0.01422295
MH2O @ 4C	0.7030890	1.422295
MMHG @ 0C	51.71508	0.01933672
CMHG @ 0C	5.171508	0.1933672
TORR	51.71508	0.01933672
KPA	6.894757	0.1450377
PA	6894.757	0.0001450377
DYNE/SQ CM	68947.57	0.00001450377
G/SQ CM	70.30697	0.01422334
KG/SQ CM	0.07030697	14.22334
MSW @ 0C (3.5% sal)	0.6838528	1.462303
OSI	16	0.06250
PSF	144	0.006944444
TSF	0.072	13.88889
% FS	(PSI / RANGE) x 100	(% FS x RANGE) / 100
MICRON HG @ 0C	51715.08	0.00001933672
TSI	0.0005	2000
HPA	68.94757	0.01450377
MPA	0.006894757	145.0377

CONVERSION FACTORS, MILLITORR

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

Table 9.3 – Conversion Factors, Millitorr

Pressure Unit	To Convert From Mi itorr	To Convert To Mi itorr
PSI	0.00001933672	51715.08
INHG @ 0C	0.000039316995	25400.08909
INHG @ 60F	0.00003948117	25328.53093
INH2O @ 4C	0.0005352534	1868.273977
INH2O @ 20C	0.0005362028	1864.966281
INH2O @ 60F	0.0005357739	1866.458778
FTH2O @ 4C	0.00004460451	22419.25773
FTH2O @ 20C	0.00004468356	22379.59744
FTH2O @ 60F	0.00004464783	22397.50637
MTORR	1.0	1.000000022
INSW @ 0C (3.5% sal)	0.0005206091	1920.827359
FTSW @ 0C (3.5% sal)	0.00004338408	23049.92831
ATM	0.000001315786	760002.2299
BAR	0.000001333220	750063.6259
MBAR	0.001333220	750.0636259
MMH2O @ 4C	0.01359544	73.55409971
CMH2O @ 4C	0.001359544	735.5409971
MH2O @ 4C	0.00001359544	73554.09971
MMHG @ 0C	0.001	1000.000022
CMHG @ 0C	0.0001	10000.00022
TORR	0.001	1000.000022
KPA	0.0001333220	7500.636259
PA	0.1333220	7.500636259
DYNE/SQ CM	1.333220	0.750063626
G/SQ CM	0.001359506	735.561166
KG/SQ CM	0.000001359506	735561.166
MSW @ 0C (3.5% sal)	0.00001322347	75623.11663
OSI	0.0003093875	3232.1925
PSF	0.002784488	359.132477
TSF	0.000001392244	718265.0575
MICRON HG @ 0C	1.0	1.000000022
TSI	n/a	n/a
HPA	0.001333220	750.0636259
MPA	0.0000001333220	7500636.259

TEMPERATURE CONVERSION

Table 9.4 - Temperature Conversion Chart

Find the known value in a center (shaded) column. If the known value is in °C, then the equivalent value is found in the °F column, or if the known value is in °F, then the conversion is found in the °C column.

°C		°F
-17.78	0	32.00
-17.22	1	33.80
-16.67	2	35.60
-16.11	3	37.40
-15.56	4	39.20
-15.00	5	41.00
-14.44	6	42.80
-13.89	7	44.60
-13.33	8	46.40
-12.78	9	48.20
-12.22	10	50.00
-11.67	11	51.80
-11.11	12	53.60
-10.56	13	55.40
-10.00	14	57.20
-9.44	15	59.00
-8.89	16	60.80
-8.33	17	62.60
-7.78	18	64.40
-7.22	19	66.20
-6.67	20	68.00
-6.11	21	69.80
-5.56	22	71.60
-5.00	23	73.40
-4.44	24	75.20
-3.89	25	77.00
-3.33	26	78.80
-2.78	27	80.60
-2.22	28	82.40
-1.67	29	84.20
-1.11	30	86.00
-0.56	31	87.80
0.00	32	89.60
0.56	33	91.40
1.11	34	93.20
1.67	35	95.00
2.22	36	96.80
2.78	37	98.60
3.33	38	100.40
3.89	39	102.20
4.44	40	104.00
5.00	41	105.80
5.56	42	107.60
6.11	43	109.40
6.67	44	111.20
7.22	45	113.00
7.78	46	114.80
8.33	47	116.60
8.89	48	118.40
9.44	49	120.20
10.00	50	122.00
10.56	51	123.80
11.11	52	125.60
11.67	53	127.40
12.22	54	129.20
12.78	55	131.00
13.33	56	132.80
13.89	57	134.60
14.44	58	136.40
15.00	59	138.20
15.56	60	140.00
16.11	61	141.80
16.67	62	143.60
17.22	63	145.40
17.78	64	147.20
18.33	65	149.00
18.89	66	150.80
19.44	67	152.60
20.00	68	154.40
20.56	69	156.20
21.11	70	158.00
21.67	71	159.80
22.22	72	161.60
22.78	73	163.40
23.33	74	165.20
23.89	75	167.00
24.44	76	168.80
25.00	77	170.60
25.56	78	172.40
26.11	79	174.20
26.67	80	176.00
27.22	81	177.80
27.78	82	179.60
28.33	83	181.40
28.89	84	183.20
29.44	85	185.00
30.00	86	186.80
30.56	87	188.60
31.11	88	190.40
31.67	89	192.20
32.22	90	194.00
32.78	91	295.80
33.33	92	197.60
33.89	93	199.40
34.44	94	201.20
35.00	95	203.00
35.56	96	204.80
36.11	97	206.60
36.67	98	208.40
37.22	99	210.20
37.78	100	212.00
38.33	101	213.80
38.89	102	215.60
39.44	103	217.40
40.00	104	219.20
40.56	105	221.00
41.11	106	222.80
41.67	107	224.60
42.22	108	226.40
42.78	109	228.20
43.33	110	230.00
43.89	111	231.80
44.44	112	233.60
45.00	113	235.40
45.56	114	237.20
46.11	115	239.00
46.67	116	240.80
47.22	117	242.60
47.78	118	244.40
48.33	119	246.20
48.89	120	248.00
49.44	121	249.80
50.00	122	251.60
50.56	123	253.40
51.11	124	255.20
51.67	125	257.00
52.22	126	258.80
52.78	127	260.60
53.33	128	262.40
53.89	129	264.20
54.44	130	266.00
55.00	131	267.80
55.56	132	269.60
56.11	133	271.40
56.67	134	273.20
57.22	135	275.00
57.78	136	276.80
58.33	137	278.60
58.89	138	280.40
59.44	139	282.20
60.00	140	284.00
60.56	141	285.80
61.11	142	287.60
61.67	143	289.40
62.22	144	291.20
62.78	145	293.00
63.33	146	294.80
63.89	147	296.60
64.44	148	298.40
65.00	149	300.20
65.56	150	302.00
66.11	151	303.80
66.67	152	305.60
67.22	153	307.40
67.78	154	309.20
68.33	155	311.00
68.89	156	312.80
69.44	157	314.60
70.00	158	316.40
70.56	159	318.20
71.11	160	320.00
71.67	161	321.80
72.22	162	323.60
72.78	163	325.40
73.33	164	327.20
73.89	165	329.00
74.44	166	330.80
75.00	167	332.60
75.56	168	334.40
76.11	169	336.20
76.67	170	338.00
77.22	171	339.80
77.78	172	341.60
78.33	173	343.40
78.99	174	345.20
79.44	175	347.00
80.00	176	348.80
80.56	177	350.60
81.11	178	352.40
81.67	179	354.20
82.22	180	356.00
82.78	181	357.80
83.33	182	359.60
83.89	183	361.40
84.44	184	363.20
85.00	185	365.00
85.56	186	366.80
86.11	187	368.60
86.67	188	370.40
87.22	189	372.20
87.78	190	374.00
88.33	191	375.80
88.89	192	377.60
89.44	193	379.40
90.00	194	381.20
90.56	195	383.00
91.11	196	384.80
91.67	197	386.60
92.22	198	388.40
92.78	199	390.20

HEAD PRESSURE CORRECTION

The accuracy of pressure measurement depends on several factors, one of which is the consideration of the head pressure in the system. The pressure medium, whether a gas or liquid, can cause an error in the measurement if not considered. In some cases the offset may be insignificant, and it may be ignored. The following information provides instructions for determining the density of the pressure medium and how to calculate the head pressure effect.

Gas Density

Liquids and gases have mass and are affected by gravity. The extent of the effect is dependent upon the density of the pressure medium. Liquids normally have a constant density that does not change with pressure. Gases, however, increase in density as the pressure increases. To determine the density of a gas at a specific pressure multiply the absolute pressure by the density from the following table. For gas the head pressure difference due to temperature changes within the compensated temperature range will be insignificant.

Table 9.5 – Gas Density

Gas @ 23°C		Density per psi in pounds/in^3 (D_{psi})
Air, Dry		2.9315×10^{-6}
Argon	(A)	4.0443×10^{-6}
Carbon Dioxide	(CO_2)	4.4824×10^{-6}
Helium	(He)	4.0466×10^{-7}
Hydrogen	(H_2)	2.0379×10^{-7}
Nitrogen	(N_2)	2.8355×10^{-6}

Head Pressure Calculation

The pressure input port (P2 in figure 9.1) of the Device Under Test (DUT) will be a positive number if the Pressure Standard is positioned higher than the DUT. If the standard is lower than the DUT the head pressure correction will be a negative value. The equation used to calculate the head pressure for a gas medium is:

$$P2 = P1 (1 + h \times Dpsi)$$

h = Difference in vertical height between the center lines of the two pressure ports.

Dpsi = Gas density (refer to the "Gas Density" table).

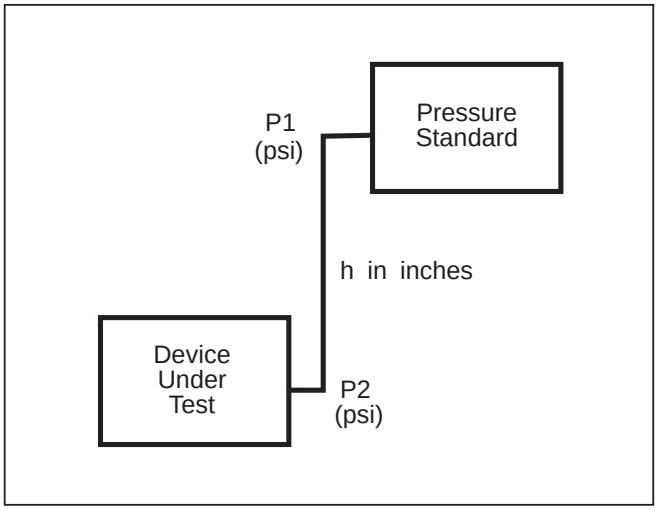

Figure 9.1 - Head Pressure Calculation

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