Operation Manual

AIR DATA TEST SET
Manual PN 0014785001 C4

Model 8201

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

ISO 9001
428797

ACCREDITED
Calibration 2066.01

mensor®
WIKA Calibration Line

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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. THIS INSTRUMENT IS NOT DESIGNED FOR OXYGEN USE.

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

IMPORTANT NOTICE

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

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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.

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DID YOU GET EVERYTHING?

In addition to this manual you should have:

- Model 8201 ADTS
- Power cord
- 1/8 inch NPT fitting adapters
- Any accessories ordered
- Envelope containing a Calibration Certificate

INITIAL INSPECTION

In addition to the many hours of functional testing, your new instrument was inspected at the factory for dings, dents and scratches. Please examine it now for signs of shipping damage. Report any apparent damage to the carrier immediately.

MEET YOUR ADTS

The Model 8201 Air Data Test Set (ADTS) is a special purpose instrument designed to test and calibrate air data instrumentation for altitude and airspeed, and their rates of change. An ADTS 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 and vinyl clad cover and side panels. Front and rear panel assemblies attach to the case. These are described separately below.

Front Panel

An ADTS 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 Ps and Pt pressure ranges.

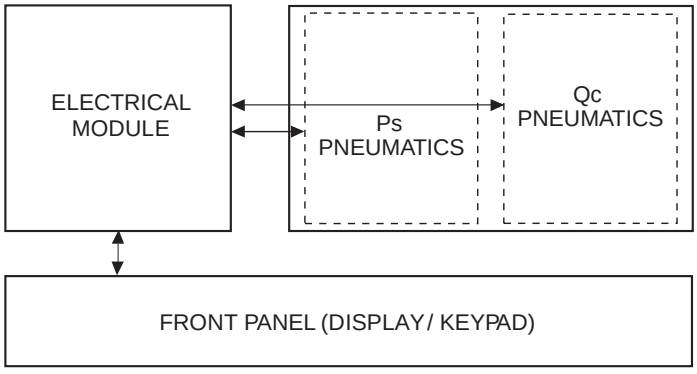


Figure 1.1 - System Block Diagram

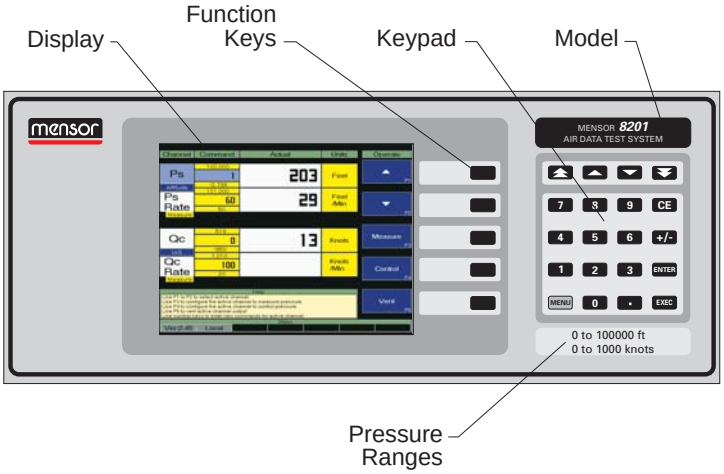


Figure 1.2 - Front Panel

Display

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

When the 8201 is powered up it goes through an initialization process, then displays the Menu screen (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 directly below the label. Starting at the left end of the header labels, 'Channel' refers to the Ps channel on top, and Qc (or Pt) channel below that. The next column, labeled 'Command', shows the last commanded values for Altitude, Altitude Rate, Airspeed and Airspeed Rate. Moving right, the column under 'Actual' displays the currently measured numerical values for each of the above four air data parameters. The fourth column, 'Units', displays the measurement units associated with each of the four values. The far right label, 'Menu', indicates that this is the Menu screen.

A message area below the two channels 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 will show 'Editing' and 'Pending' messages when new air data values are being input, but not yet executed.

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 screen any of the five function screens (see figure 1.4) are accessed by using the function keys as shown in the following schedule:

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

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.

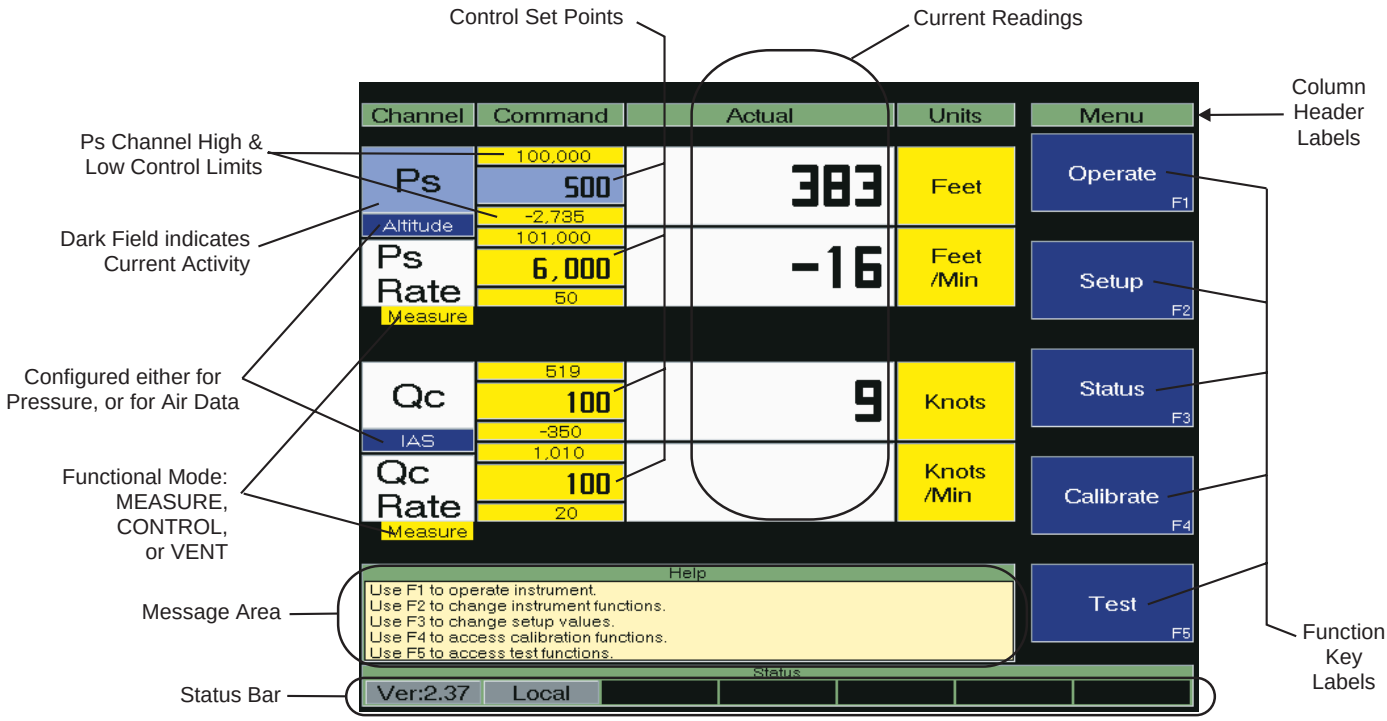


Figure 1.3 - Screen Elements (Menu Screen)

Figure 1.4 - Menu Screen and Five Function Screens

Main Keypad

Twenty single function keys, arranged in five rows of four columns, make up the keypad (figure 1.5). In addition to the numbered keys and the decimal point, 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 available only while in the Editing mode as seen on the bottom status bar.

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 the Control mode will immediately use the commanded numbers.

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

Figure 1.5 - Main Keypad

Rear Panel

The rear panel (figure 1.6) includes access to the line-fuse holder, the power cord socket, the system power switch, a ventilator fan opening, and several communication connectors. All of these items are grouped on the electrical module side of the rear panel.

The pneumatic side exposes the pressure ports for the two pneumatic channels. This side may also have additional electrical or pneumatic connectors to support any installed options.

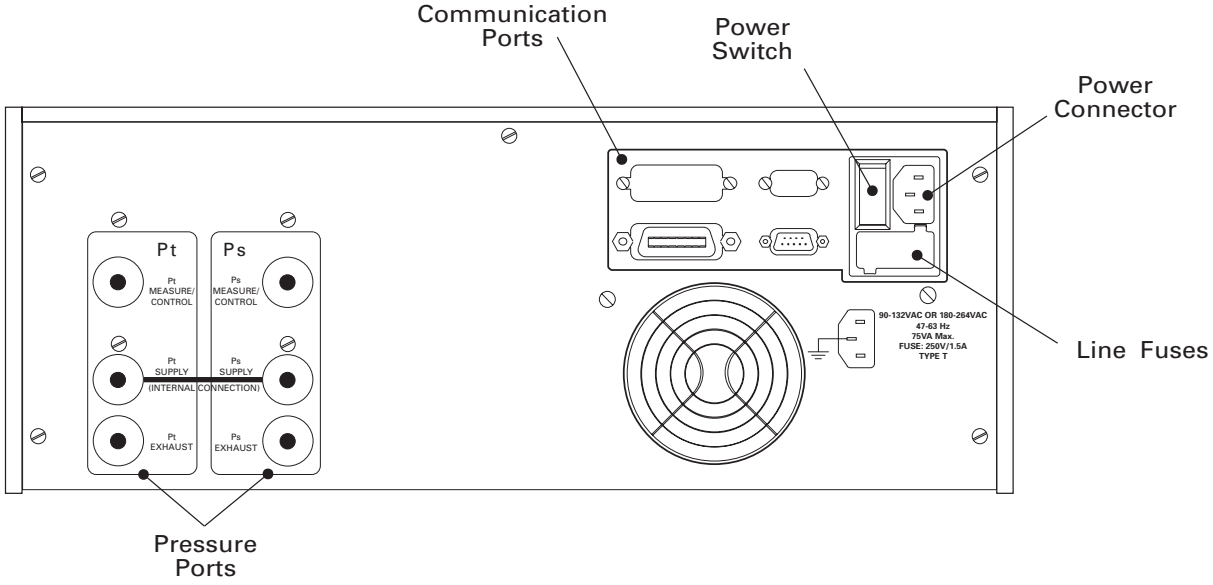


Figure 1.6 - Rear View

Electrical Module

The internal electrical module (figure 1.7) consists of the input power module, a fan, a power supply, an AT compatible single board computer, a 3.5 inch disk drive and a solid state disk drive. The solid state disk drive contains the program information to run the system. Note that the plug-in printed circuit cards are not necessarily in the order illustrated.

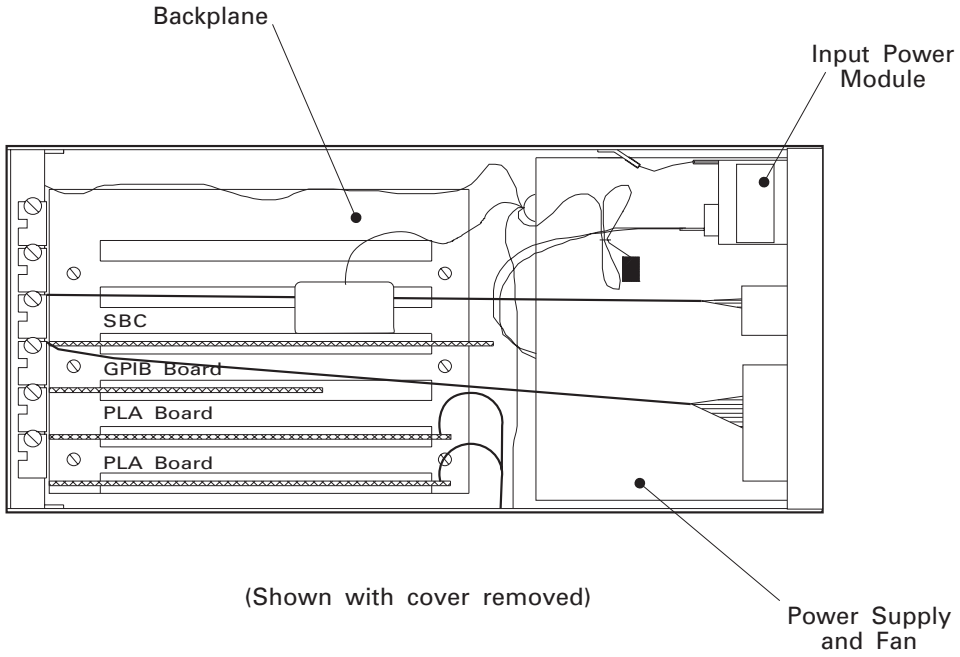


Figure 1.7 - Electrical Module

Pneumatic Module

The pneumatic module (figure 1.8) includes two high performance, low-drift, pressure transducers which are traceable to NIST as secondary standards. These transducers are used in conjunction with two independent, high stability pressure regulators to produce two precise pressure outputs. The outputs are commonly referred to as Static Pressure (Ps) and Total Pressure (Pt). The Ps output has a range of 1.0 to 32 inHg A and is normally used to calibrate static pressure transducers. The Pt output is derived by adding the Qc and Ps pressures. Qc is a differential pressure with a span from -0.5 in Hg to 10 inHg, up to -0.5 to 100 inHg, which is used for airspeed computations. The second pressure channel can function and display either the actual Qc data or the derived Pt data.

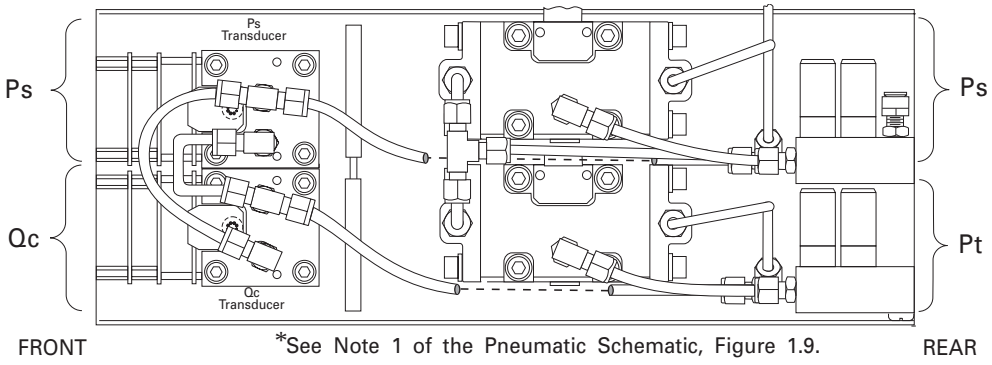
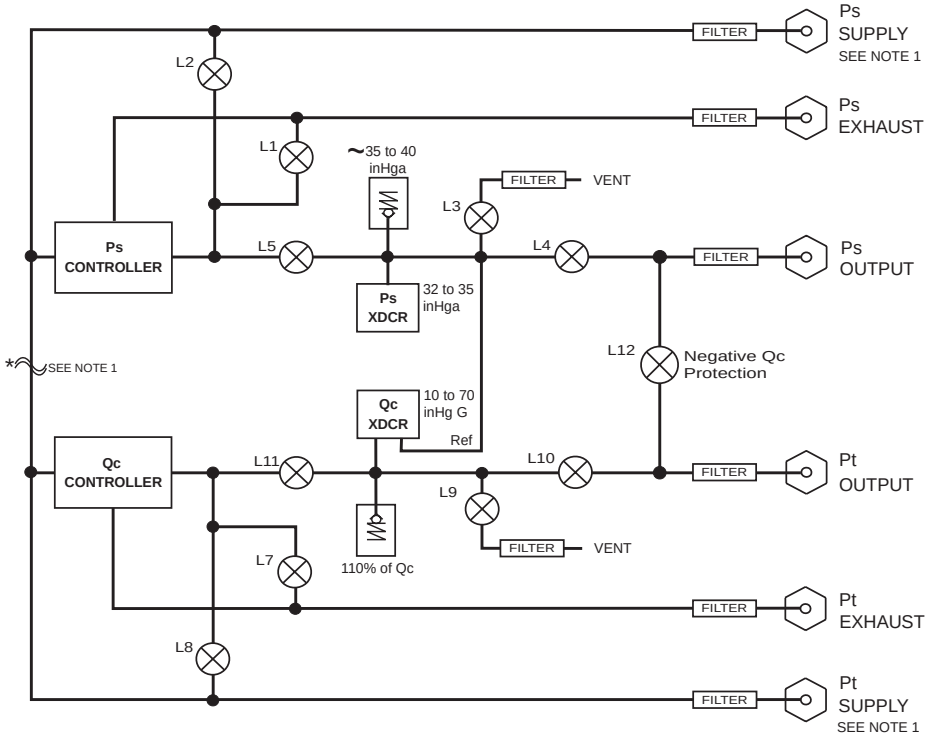


Figure 1.8 - Pneumatic Module



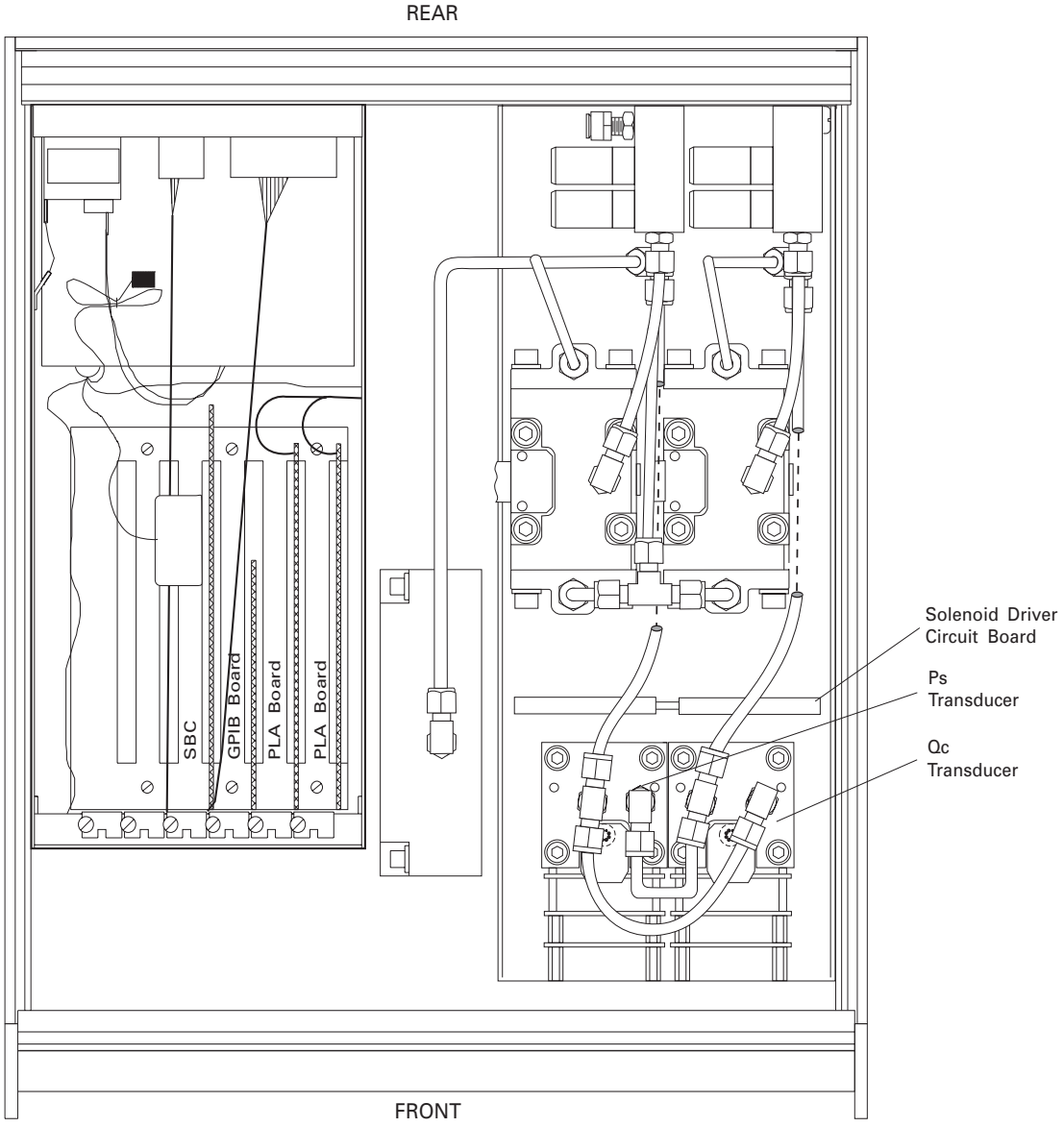
NOTES: 1. For single source pressure plug one of the two external SUPPLY ports, or for independent sources disconnect the internal tube marked "~" which joins the two controllers.
2. Solenoid valves L1 through L12 are 5 vdc, 1.5 w, normally closed.
3. Solenoid valve L6 is omitted.

Figure 1.9 - Pneumatic Schematic

Chassis Assembly

The chassis assembly acts as the housing for the system. The layout of the internal system is illustrated in figure 1.10. The electrical and pneumatic modules are each self-contained and can be replaced individually using basic hand tools.

The only moving parts in the ADTS 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.



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

POWER UP!

You can confirm that your ADTS 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 Main Operating screen shown in figure 1.3.

MENSOR SERVICE PLUS

If you have problems using your ADTS 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 *Preface* Section or rear cover page of the manual. We are ready to help.

After the Warranty

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 meets the requirements of ANSI/NCSL Z540, and includes a Certificate of Compliance and Calibration and the record of traceability to the pressure standards of the National Institute of Standards and Technology (NIST).

Accreditations

Mensor Corp. is registered to ISO 9001:2008. The calibration program at Mensor is accredited by A2LA, as complying with both the ISO/IEC 17025:2005 and the ANSI/NCSL Z540-1-1994 standards. All Mensor primary standards are traceable to NIST.

User's Notes:

INSTALLATION

MOUNTING

The ADTS can be set up on a table-top or it can be rack-mounted. For rack-mount installation refer to the rack mount kit in Section 8, *Options*.

The special sensors used in the ADTS are relatively insensitive to tilt and vibration. However to further assure stability and accuracy, excessive motor or machinery vibration of the mounting surface should be avoided.

PRESSURE CONNECTIONS

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

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. Adhere to the manufacturers tightening instructions for all fittings and hoses to minimize errors caused by leaks. Mensor provides female 1/8 NPT adapter fittings with the instrument. Pressure connections can be made to these adapters with the proper mating hardware. Use either Loctite Hydraulic Sealant or fresh teflon tape on the threads of the male pipe fittings. 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 various ports on the ADTS manifold are provided in the following paragraphs.

SUPPLY Pressure Port

Each channel of the ADTS has its own SUPPLY port. However, one of these is plugged on the rear panel since they are connected together inside the pneumatics module. Connect a source as shown in table 2.1 to the open SUPPLY.

EXHAUST Pressure Ports

Connect a separate vacuum pump to each of the two EXHAUST ports. These ports must be evacuated in order to control at sub-atmospheric pressures. Although both channels can be connected to a single vacuum pump, doing so can create cross channel interference under some conditions, and is not recommended.

Table 2.1 - Supply Pressure Requirement

~Qc Range	~Pt Range	~Supply Pressure
10 inHg	45 inHgA	20 inHg or 10 psi
20 inHg	55 inHgA	30 inHg or 15 psi
30 inHg	65 inHgA	40 inHg or 20 psi
40 inHg	75 inHgA	60 inHg or 30 psi
50 inHg	85 inHgA	80 inHg or 40 psi

MEASURE/CONTROL Pressure Ports

Devices to be tested are connected to one or two of the 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 ADTS will precisely measure the pressure at the MEASURE/CONTROL port up to the full scale range of the sensor.

POWER ON

After the pressure connections are secure apply power to the power connector on the rear of the instrument and turn the power switch ON. The instrument will perform an initialization and system check, then default to MEASURE mode and display the Menu screen (figure 2.1). The system is now ready for use, but a warm-up period of at least 45 minutes is advised for greatest accuracy.

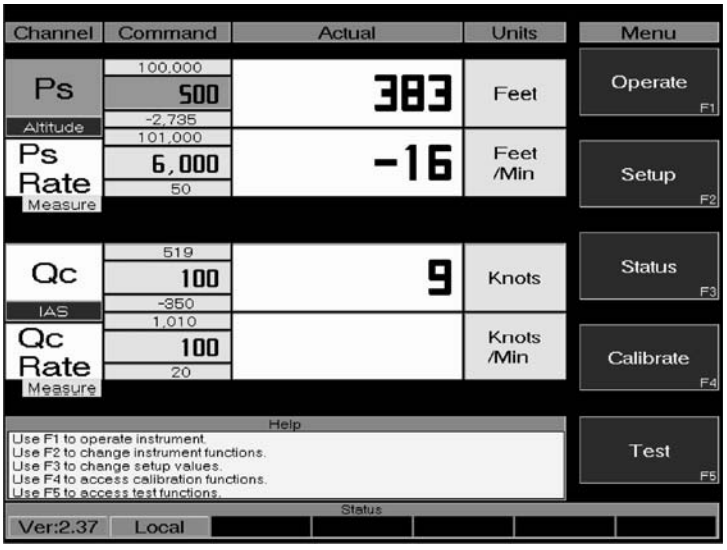


Figure 2.1 - Menu Screen

User's Notes:

LOCAL OPERATION

This section describes the procedures for operating the ADTS from the front panel. The instructions for operating the instrument remotely from a computer are covered in the next section. By following the procedures provided in these two sections, and Section 6, *Calibration,* you can expect maximum accuracy and dependability from your instrument. In addition to operating and calibration instructions several self-test routines are built into the ADTS. Information relating to these tests are presented in Section 5, *Maintenance.*

This section of the manual begins with some explanatory text, followed by several pages of sample screens. Figure 3.1 illustrates the ADTS features used during manual operation. Table 3.1 lists some common terms and labels relating to the instrument.

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 indicate the associated key. For example, [CE] indicates 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. Pressing [MENU] at any time will immediately return the display to the Menu screen.

The up and down arrow keys and the two double arrow keys at the top of the keypad act as incrementing or decrementing keys for the controlled pressure relating to altitude, airspeed, altitude rate, or airspeed rate. A single arrow steps up or down by exactly the programmed step value each time it is pressed, while the double arrow keys act at twice the step value. To program a step value enter the value, then press either the [▲] or [▼] key.

Function Keys

Notice that the five function keys are always identified as F1 through F5, but the operation performed by these keys changes according to which screen is currently displayed. Each screen includes its own labels for all five function keys. These labels appear in the right hand column of each screen. Figure 3.2 is a menu tree depicting the relationship of the various function key labels.

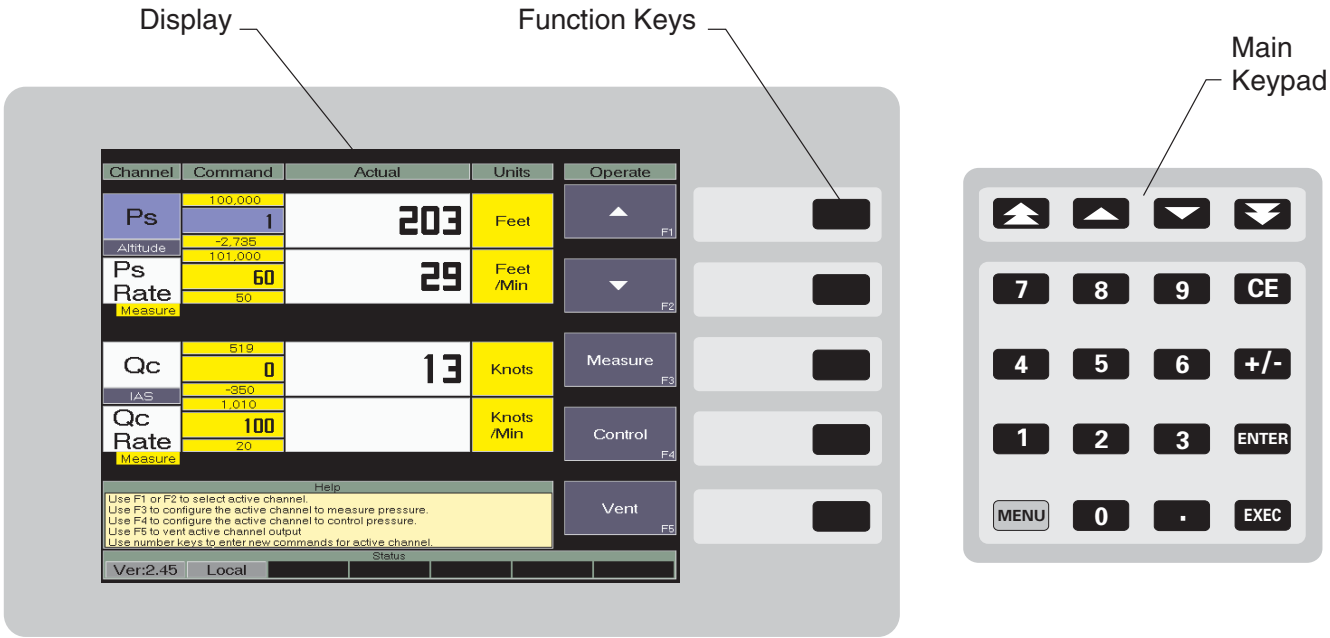


Figure 3.1 - Manual Operation Features

LOCAL OPERATION SCREENS

The Menu and Operate screens, and all of the Setup and Status screens may be used during normal operation of the ADTS. Each of these screens have sub-screens as depicted by the Menu Tree of figure 3.2. A brief discussion and accompanying illustrations (figures 3.3 through 3.16) for most of these screens follow in this section of the manual.

The screens used during calibration are explained in the *Calibration* section, and the functions available for running the built-in diagnostics from the Test screen are discussed in the *Maintenance section* of the manual.

The arrangement of the primary data display lists the static pressure information (Ps and Ps Rate) on the top half, and either the airspeed data (Qc and Qc Rate), or the total pressure data (Pt and Pt Rate) on the bottom half of the data display.

The Ps pressure and Ps Rate relate to the left channel of the pneumatics module as viewed from the front of the instrument. The Pt and Qc pressures and Rates relate to the right pneumatic channel. Table 3.1 defines the main pressure terms used by the ADTS.

Table 3.1 - Air Data Pressure Terms

TERM	AIR DATA	PARAMETER
Ps	Static Pressure	Altitude
Ps Rate	Static Pressure Rate of Change	Altitude Change Rate (Climb or Descend)
Qc	Ram Pressure (Pt – Ps)	Indicated Airspeed
Qc Rate	Airspeed Rate of Change	Acceleration or deceleration
Pt	Total Pressure (Ps + Qc)	Static Pressure + Ram Pressure
Pt Rate	Total Pressure Rate of Change	Leak Rate, etc.

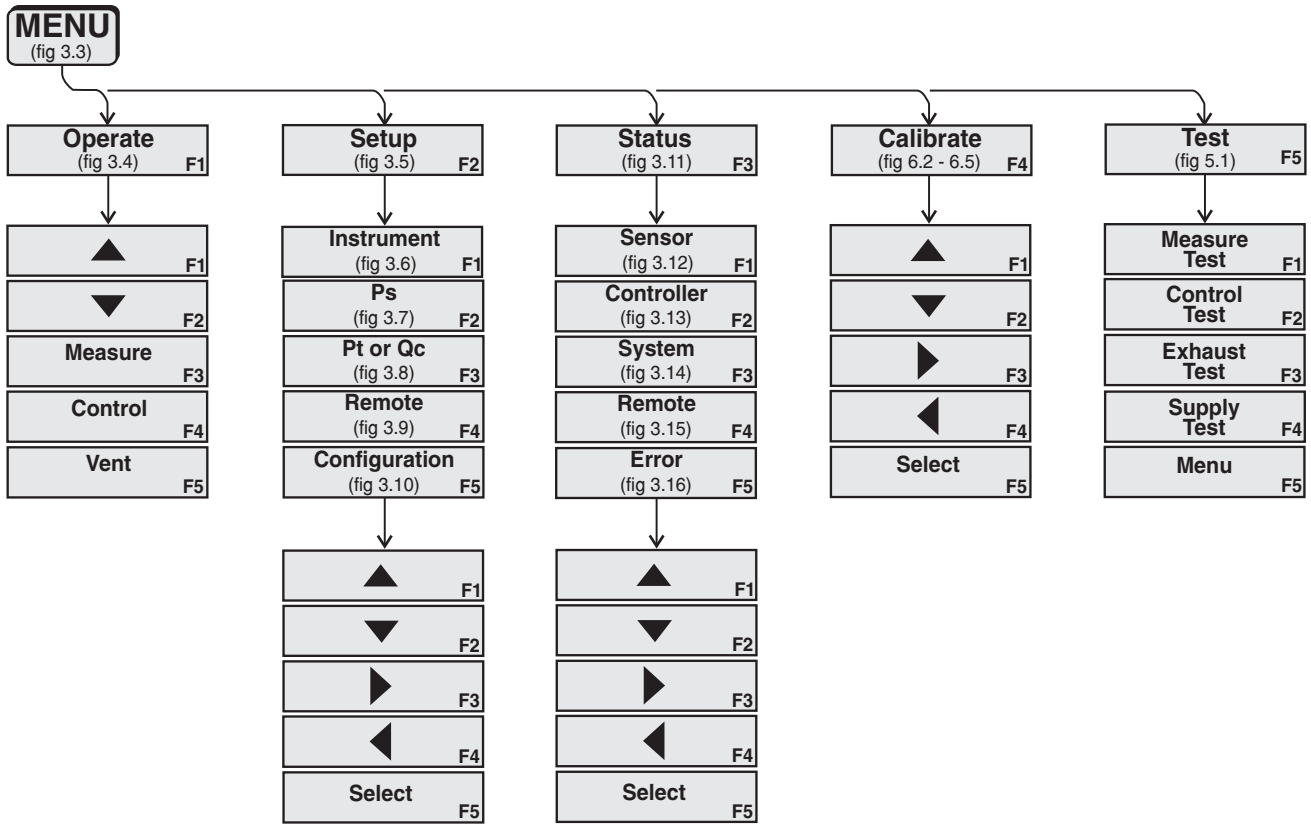


Figure 3.2 - Function Key Menu Tree

The 'Menu' Screen

The Menu screen in figure 3.3 shows the ADTS currently configured for air data (Altitude and Airspeed readings) with the Ps channel enabled. The Ps and Qc channels are shown in Measure mode. The Ps channel pressure control point is set for 1,000 feet, and the control point limits are set to 101,000 ft maximum and -1,870 feet minimum. The current altitude reading is 585 feet. The setup control values for the Ps Rate function (second row) are somewhat different than those seen in the top (Ps) row. (The actual valves depend on the internal sensor ranges).

The data for the Qc channel (the lower half of the data display) is shown in terms of Airspeed. This channel can be configured to show either Qc and Qc Rate, or Pt and Pt Rate as explained later under the 'Setup' procedures.

A 'Help' message area immediately below the data display contains some clues as to the available user actions while in the current screen.

Below the Help window are several 'Status' labels. The left status label always displays the version number for the loaded software. The next window to the right displays either 'Local' for front panel operation and serial port, or 'Remote' when the ADTS is being controlled through the GPIB communications port.

When numbers are entered from the main keypad the far right bottom labels will display 'Editing' until [ENTER] is pressed, and 'Pending' until [EXEC] is completed.

From the Menu screen, the only options available to the user are to press one of the five function keys to display a different screen, or press any numeric key to go directly to the Operate screen. If a number, or a series of numbers are pressed which are within the control limits established for the active channel in the Command column, then that number value appears as the new control command number.

For normal operations press [F1] to display the Operate screen, which is discussed next.

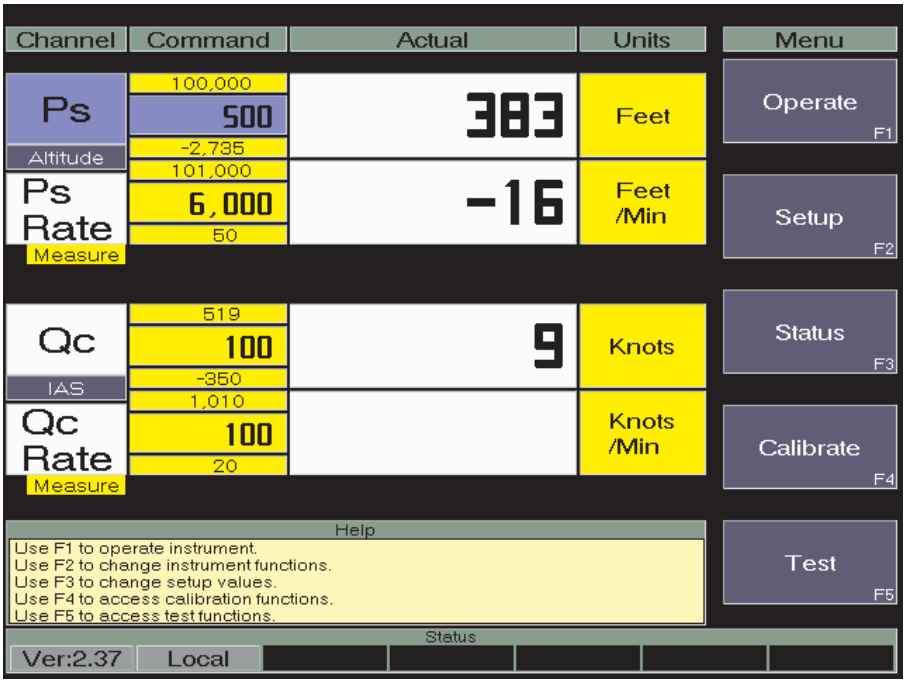


Figure 3.3 - The 'Menu' Screen

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 header label is now 'Operate', indicating that this is the main operating screen. The five F-key labels have changed to describe different functions.

Ps is the current activity, indicated by the dark field in the 'Channel' column. The channel is displaying pressure in feet of altitude, but it can show meters of altitude, or pressure units.

In this and all other screens, an up and down pointer for [F1] and [F2] will step the active function highlight up and down in the left (Channel) column. Press either [F1] or [F2] to step the active function through Ps, Ps Rate, Qc, and Qc Rate.

The data cells just below the Ps data row display the Ps Rate information. This is the altitude rate-of-change function (rate of climb or descent). Pressure data for both Ps and Ps Rate are developed in the left hand pneumatics channel.

The next item down is Qc which is the indicated airspeed. Below this is the Qc Rate for the rate of change in airspeed. The lower portion of the screen that shows Qc and Qc Rate can be configured to display Pt (total pressure), and Pt Rate (rate of change of total pressure). The means to accomplish this change is described later in this section in the discussion on Instrument Setup. The pressure data for the Pt function is the sum of pressure in the Ps and the Qc transducers.

Press [F4] and both channels immediately go into 'Control' mode. The channels change simultaneously because they are 'linked'. They can be made independent, as explained under Instrument Setup (figure 3.6). Press [F5] and both channels switch to Vent mode. Press [F3] to return both channels to Measure mode. Initial setup and use of the Vent mode is explained in detail at the end of this section.

To edit any of the four air data 'Command' values shown in the display, first use [F1] or [F2] to select the specific Altitude or Airspeed function to edit. Next, press the appropriate number keys to generate the desired value. Each press of a number key is reflected in the command value box for the selected function. If an erroneous number key is pressed, press [CE] to erase it. [CE] can backspace through all of the entered numbers until [ENTER] or [EXEC] is pressed. If an out of limits value is attempted the system will default to the previous setting. The allowable upper and lower limits are shown above and below the current value. These upper and lower limits are settable within the Setup screens. When a newly entered value is correct, press [ENTER] for 'Pending', or [EXEC] to complete the entry. With an adequate supply pressure attached to the system, the new value is the pressure output that the ADTS will slew to as soon as [F4]-Control is pressed.

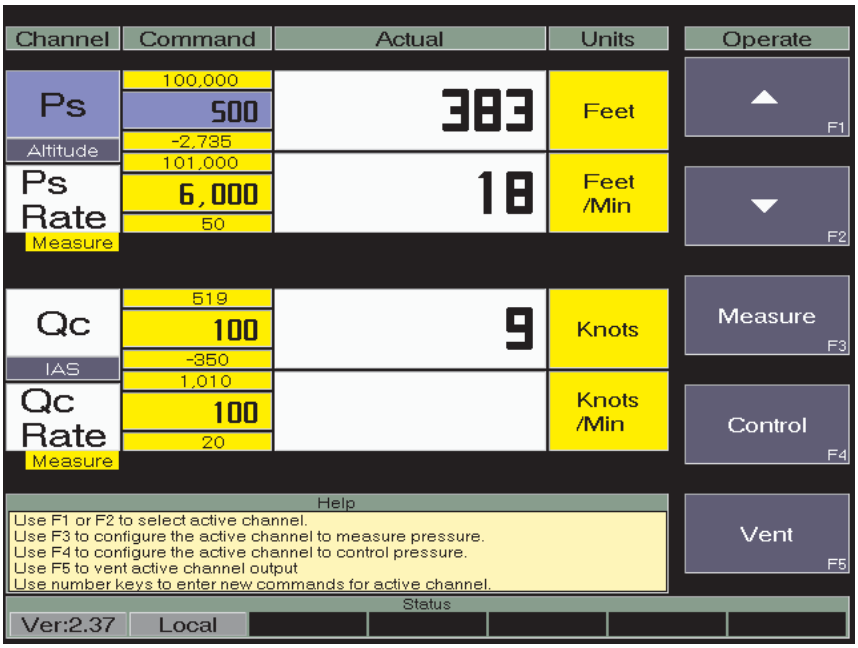


Figure 3.4 - The 'Operate' Screen

The Main 'Setup' Screen

This screen (figure 3.5) provides entry into any of the various setup tables by pressing the appropriate F-key. Upon selecting a specific setup table the right hand header label identifies the table, and [F1] through [F4] will display triangular pointers which act as cursor control keys. [F5] is a 'Select' key. Press this key to set all of the highlighted values into the system.

The [F1] and [F2] up/down cursor controls operate only in the left-most column to select the 'Function' to be modified. The [F3] and [F4] left/right cursor keys operate across the 'Data' columns to highlight an individual cell within the selected row.

All four cursor controls will wrap around in both directions. For example, with the highlight resting on the top 'Function' line in any setup table, pressing the up control, [F1], will cause the cursor to travel down to the bottom function in the column. The left and right pointers also wrap across the data rows in a similar manner.

From the main setup screen select one of the following:

[F1] - Instrument (figure 3.6)**:** Used to set various instrument parameters to be displayed, such as: Select either Ps/Qc or Ps/Pt pressure mode or air data mode for display; set the display contrast level on a monochrome screen; link or separate the two displayed channels; select the measurement units for pressure, altitude, or airspeed; and set several other instrument variables.

[F2] and **[F3] - Ps, Pt/Qc:** Each of these channels has its own setup table screen. The three tables, which are almost identical, are used to set the various pneumatic and electronic parameters for their respective channels.

[F4] - Remote: This setup table assigns the GPIB address, and the serial port operating parameters.

[F5] - Configuration: Provides the capability to save, and later, recall up to four different instrument configurations as defined by the user in the Instrument and Channels setup tables. This allows the user to set up four different test situations such that any one of them can be recalled as the need arises. Later, the factory defaults can be restored.

Each of the above screens and tables are discussed next.

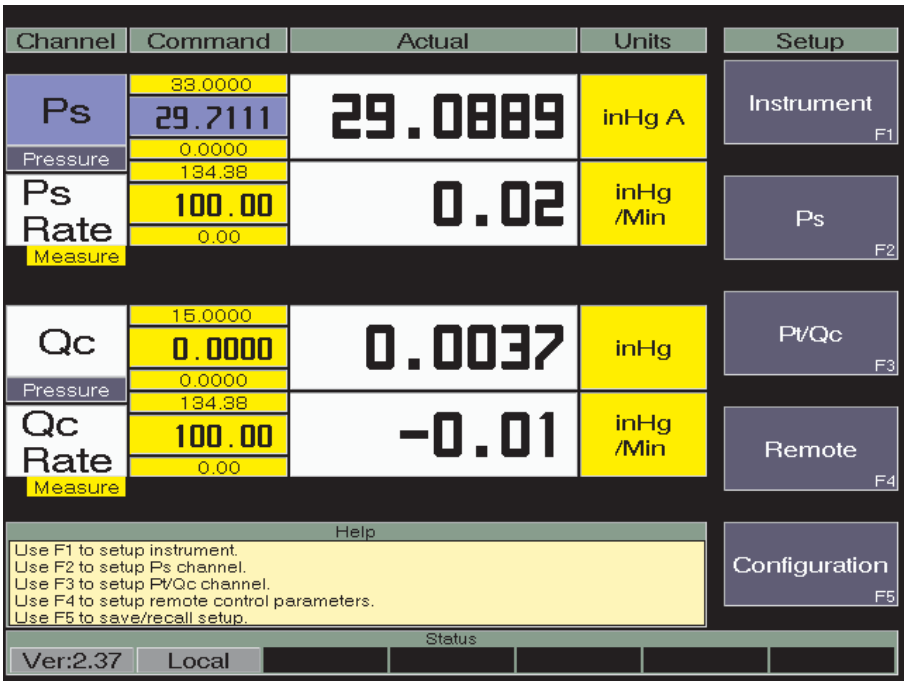


Figure 3.5 - The Main 'Setup' Screen

The 'Instrument' Setup Screen

Use this screen (figure 3.6) to set the conditions listed below for the active channel. Use [F1] and [F2] cursor keys to move the highlight vertically to select an item from the Function column. Then use [F3] and [F4] to move the row highlight horizontally to the desired Data cell. Press [F5] to enable the selected cell, then select another row (Function) if desired. All of the cells that are highlighted when [F5] is last pressed will be enabled.

Display Format: The three choices, shown on the top Data row are: Air Data; Ps/Pt; or Ps/Qc. Choose Air Data to display altitude units (feet, meters, etc) on the Ps channel, and airspeed (knots, MPH, etc) units on the Qc channel. Selecting either Ps/Pt, or Ps/Qc will display pressure units (PSI, kPa, mmHg, etc) on the respective channels. Note that Ps is always active (displayed), but the second active channel might be either Qc or Pt.

To make changes to the Ps channel parameters go to the Ps Channel Setup screen (figure 3.7). To modify parameters for either the Pt or Qc channel, select the desired channel for display from here, then go to the Qc - Pt Setup Screen (figure 3.8).

Display Contrast: No effect on a color display.

Channel Link: Either link or separate the two displayed channels for Measure and Control modes. Vent mode is always linked.

–Qc Protection: Select On to prevent Qc from going below negative 100 knots. Select Off for no negative Qc protection.

Local Altitude: Controls the vent rate to this altitude before venting the system. This should be set to the local elevation.

Vent Rates: Separate settings are provided for Altitude and Pressure vent rates. For details, see the text under 'Vent Mode' at the end of this section.

Measurement Units: Separate settings for Pressure, Rate, Altitude and Airspeed units. Select one from each category. (See *Mach Units* box, below.) Notice that the Display Format selection determines whether units of measure are displayed as air data units or pressure units.

Reading Filter: This is an electronic filter to smooth out the pressure readings. The more filtering applied, the less nervous are the displayed readings.

Back to setup: With the cursor on this function press either function key [F5], or [ENTER] or [EXEC] on the main keypad to enable all of the highlighted settings for the instrument and return to the main Setup screen.

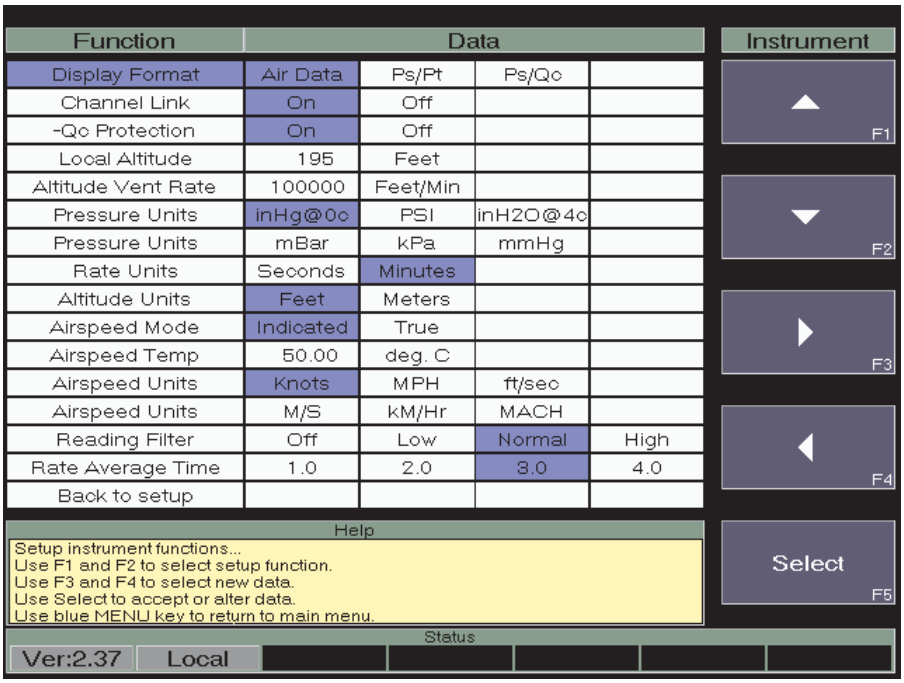


Figure 3.6 - The 'Instrument' Setup Screen

Mach Units: Mach in this instrument is calculated for subsonic flight only (< 1.0 Mach).

The following equation is used to calculate the Mach value:

$$\text{Mach} = \sqrt{5\left[\left(\frac{Pt}{Ps}\right)^{2/7} - 1\right]}$$

Where:
Ps = static pressure in inHg
Pt = total pressure in inHg

The 'Ps' Channel Setup Screen

Unlike the Pt and Qc channels, the Ps channel is always active, and these parameters can be changed at any time. Simply press [MENU], [F2], [F2], and the screen shown in figure 3.7 will appear.

Notice that there is no highlight showing in the data cells. For this screen the left and right cursor controls, [F3] and [F4] are disabled. Use [F1] or [F2] to select any function in the left column, and the value in the next column immediately changes to a '?' prompt. Press the number keys to enter a new value for the function. Again, if an erroneous number is entered, press [CE] to clear it. Continue pressing [CE] to backspace through any previously entered digits. When the new data value appears to be correct press [ENTER] on the main keypad to complete the activity.

The right hand data column lists the units of measure assigned to each function in this channel. These units can be changed only in the 'Instrument' setup routine as previously explained; they cannot be changed in this screen. Values can be changed here for the following functions:

Lower Limit: Enter a new value as the low limit for Altitude, Altitude Rate, Ps pressure, and Ps pressure Rate. Press [F5] - Select when the displayed value is correct.

Upper Limit: Set the top end limit for the same four functions, then press [F5].

Stable Window: Enter a new value for the range within which a controlled output is considered stable. Individual settings are provided for each of the four functions; Altitude, Altitude Rate, Ps, and Ps Rate.

Stable Time: As above, enter the minimum time that an output pressure must remain within the window to be considered stable. Separate settings are available for all four functions.

Notice that the old value will remain in effect if the cursor is moved away from a function that has been edited without pressing [F5], [ENTER], or [EXEC]. Also, if the new value is beyond the instrument's limits the old value will remain in effect.

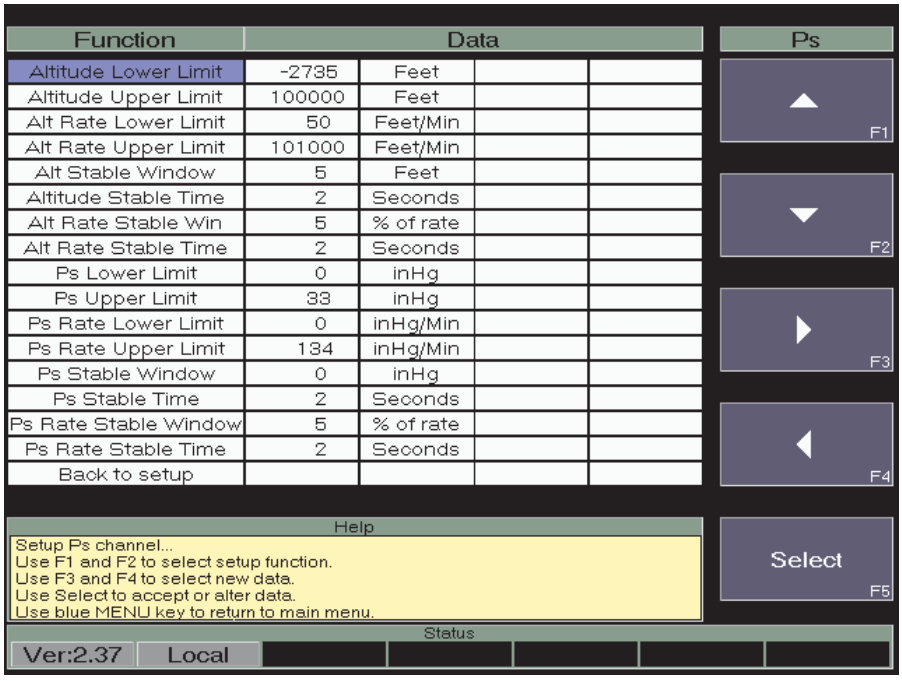


Figure 3.7 - The 'Ps' Channel Setup Screen

The 'Qc' and 'Pt' Channel Setup Screen

The Ps channel (left pneumatics channel) is a dedicated channel which is always displayed on the Menu and Operate screens. The second displayed channel can be either Qc which is the right pneumatics channel, or Pt which is the sum of the pressure in the left and right channels.

Whether the Qc or the Pt channel appears in the Menu, Operate, and in this Setup display, is determined by selection of the 'Display Format' in the Instrument Setup table (figure 3.6). The setup screen is equivalent to the Ps setup screen discussed on the previous page (figure 3.7), except substituting 'Airspeed' in place of 'Altitude'.

Set each parameter to its desired value, then press [F5]-Select.

To then change to the other channel (the one which is not displayed), return to the Instrument Setup table and select the alternate from the Display Format function. That is, press [MENU], [F2], [F1], and then either [F3] or [F4] to highlight the other channel (either Ps/Pt or Ps/Qc). Finally, press Select [F5], [MENU], [F2], [F3], and the alternate channel will now appear (figure 3.8) available for setup changes.

Again, after all parameters are set to their desired values, press [F5]-Select before exiting this display.

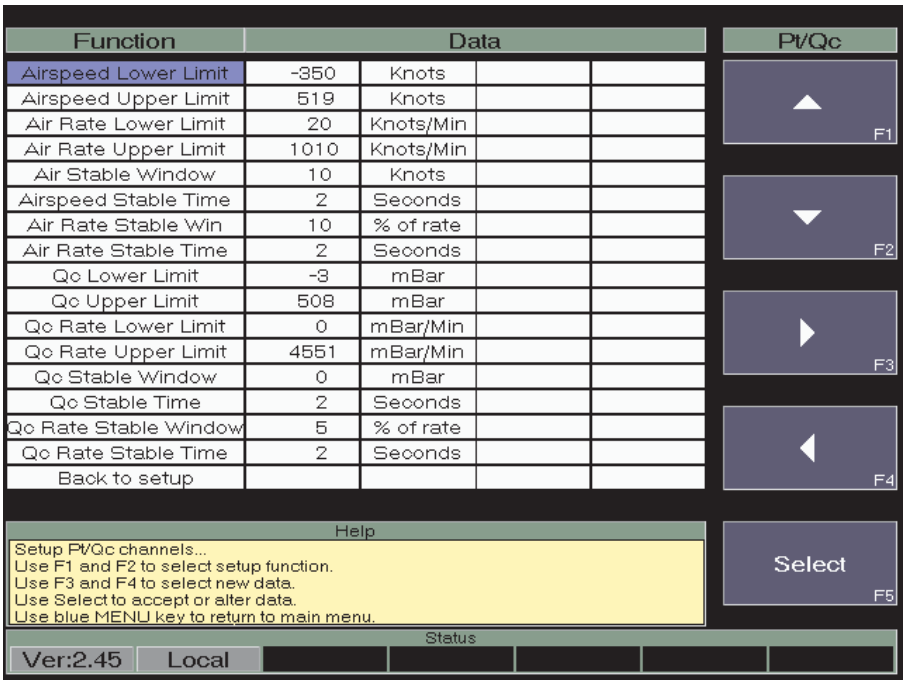


Figure 3.8 - The 'Qc' and 'Pt' Channel Setup Screen

The 'Remote' Operation Setup Screen

This screen (figure 3.9) is used to set the system parameters for remote operation. As with the preceding setup screens, the [F1] and [F2] up/down pointers operate only on the Function column. First, select a function, then traverse across the data row to the desired value, press [F5]-Select, then step to the next function to modify.

The first five functions pertain to serial bus settings, while the sixth item sets the GPIB address. The address is the only menu item available for GPIB operation.

When all of the desired values are highlighted, and the GPIB address is correct, press [F5]-Select. Finally, either return to setup by selecting that function on the bottom line of the table entry, or press [MENU] to return to the main menu screen.

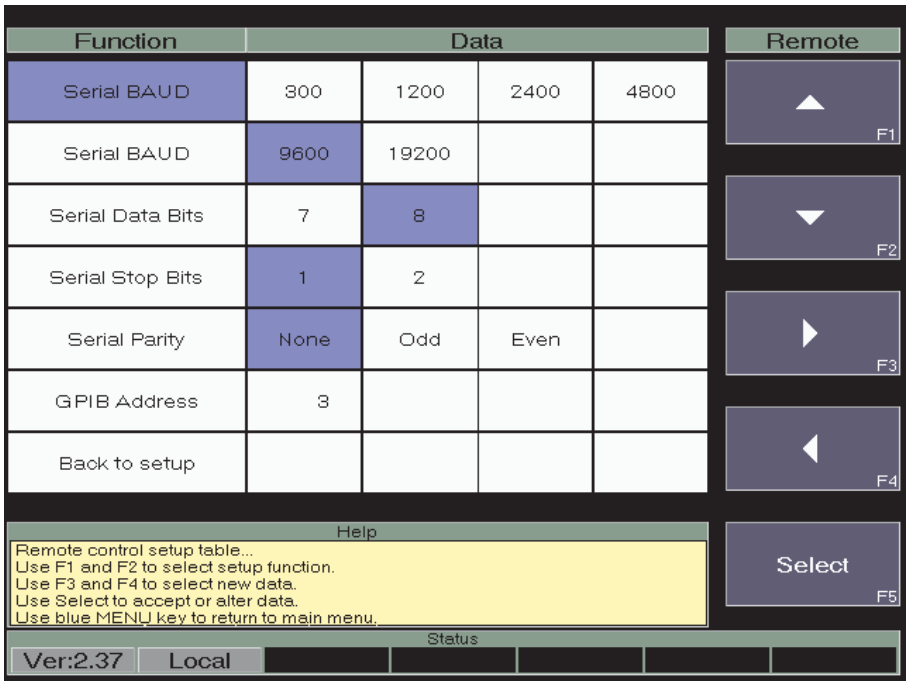


Figure 3.9 - The 'Remote' Operation Setup Screen

The 'Configuration' Setup Screen

The ADTS includes the capability to save, and later, recall up to four different instrument configurations. These configurations are defined by the user in the Instrument and Channels setup tables. In figure 3.10 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 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 to the Instrument, Ps, Pt and Qc Setup tables;

2. Next, display the Configuration Setup screen shown below (figure 3.10);

3. Next, move the Function cursor to Save, and the data cursor to one of the four CFG# cells;

4. Finally, press [F5]-Select.

The current settings from the Instrument Ps, Pt and Qc 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 appropriate CFG# cell;

3. Press [F5]-Select.

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

To return the ADTS to the factory default settings highlight Load in the function column and press [F5]-Select. The instrument is now loaded with the initial factory setup.

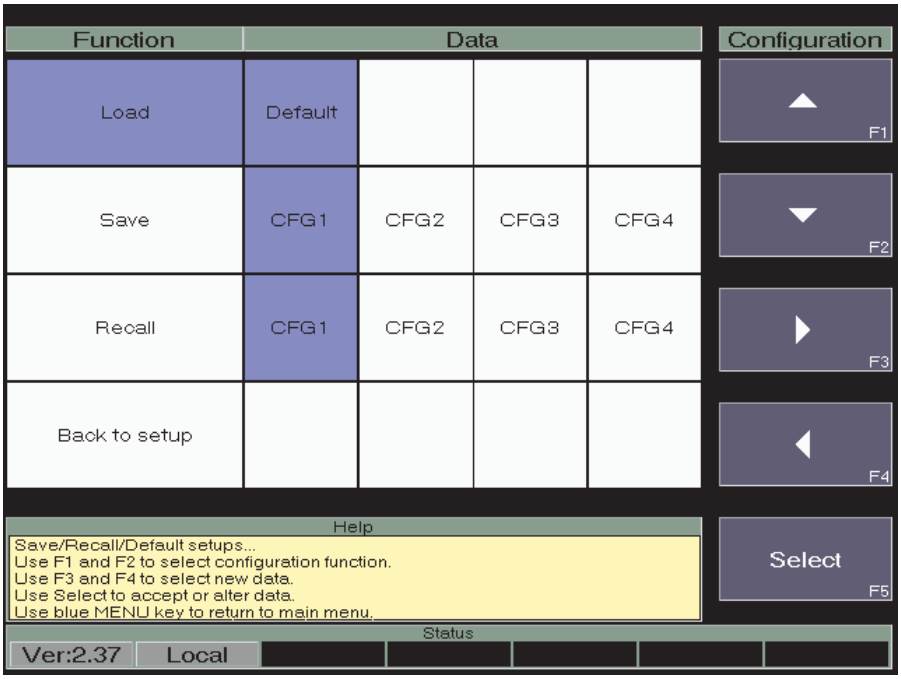


Figure 3.10 - The 'Configuration' Setup Screen

The Opening 'Status' Screen

This screen (figure 3.11) is the entry point to the five individual status screens. The status screens display certain data pertaining to:

F1 - Sensor: Both internal pressure transducers;

F2 - Controller: Reserved for future use;

F3 - System: Basic data for the instrument;

F4 - Remote: GPIB and Serial communications;

F5 - Error: Any detected errors.

These five displays are informational, only, and require no user interaction. All of the function keys are disabled in these five screens.

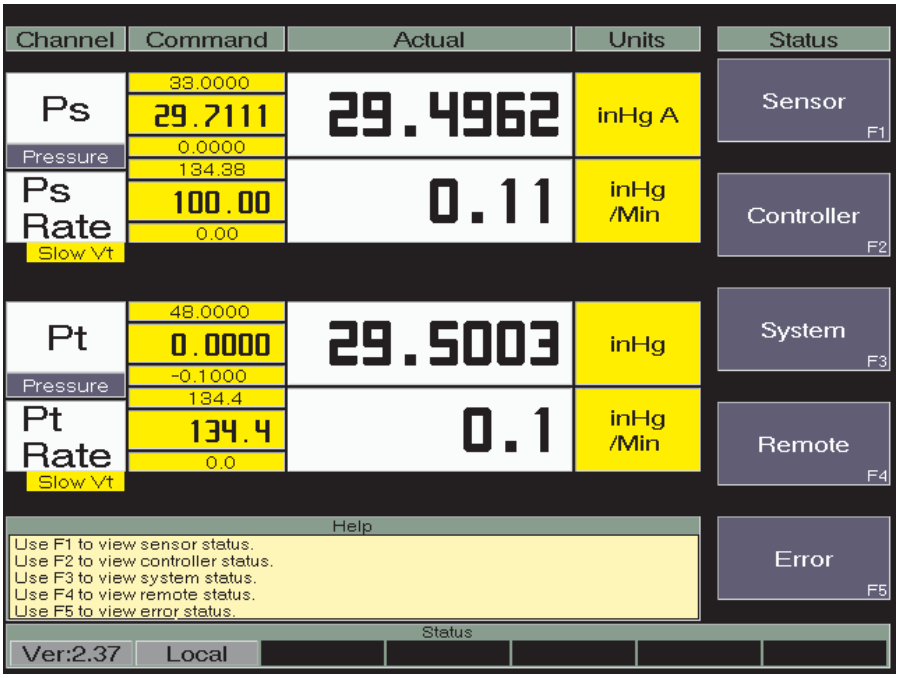


Figure 3.11 - The Opening 'Status' Screen

The 'Sensor' Status Screen

The Sensor status screen (figure 3.12) displays the basic information for the two transducers (channels A and B) that are standard equipment in the ADTS. There is additional data space to display information on two external transducers (External A and External B), but the ADTS does not use external transducers.

The Minimum Range and Maximum Range are given in psi units.

Data displayed for Pressure count and Temperature count might be useful to a Mensor technician during a telephone troubleshooting session.

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

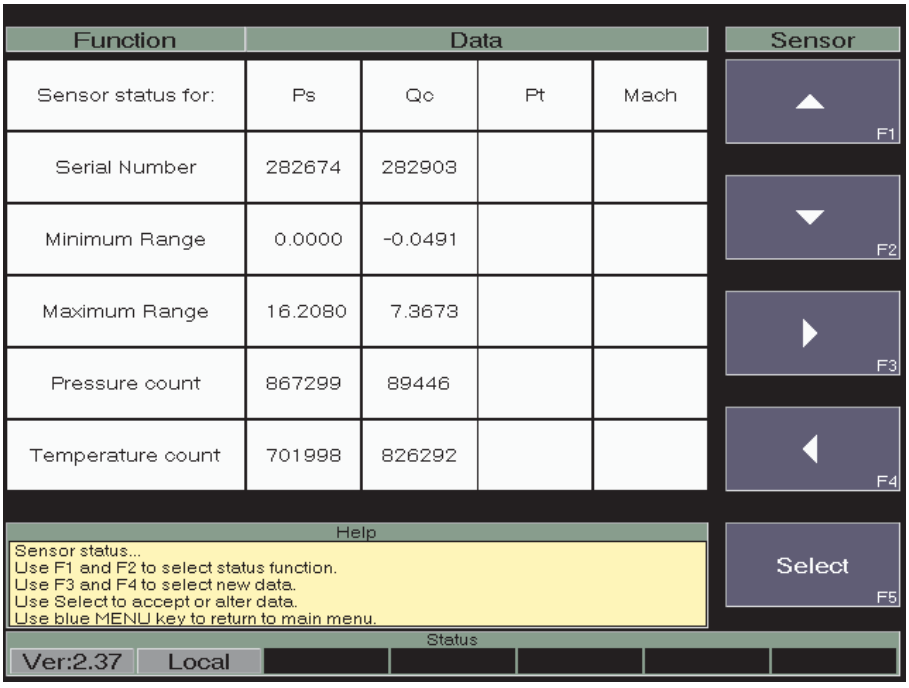


Figure 3.12 - The 'Sensor' Status Screen

The 'Controller' Status Screen

This screen (figure 3.13) is reserved for future use.

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

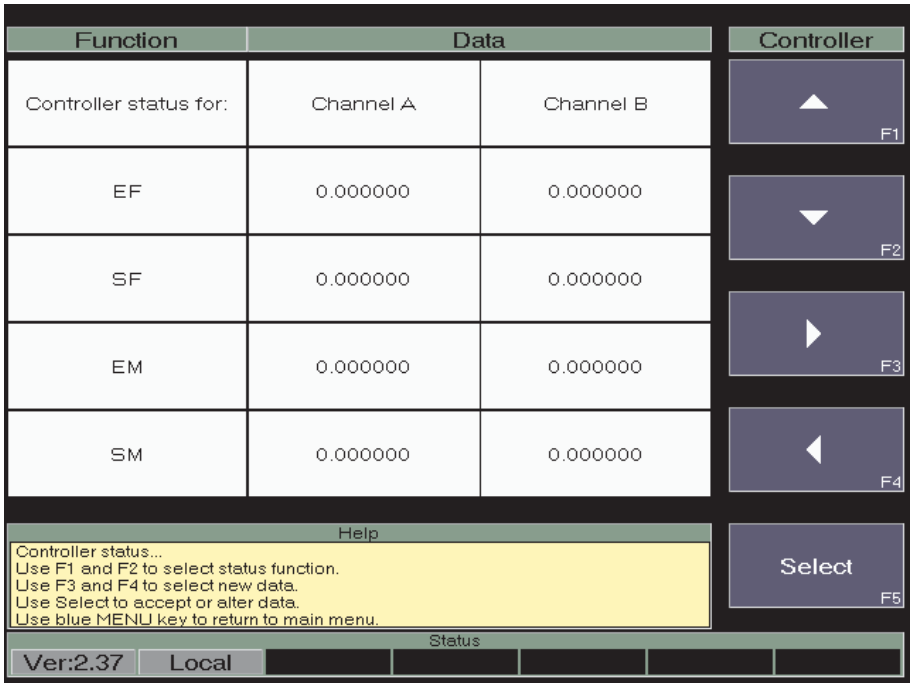


Figure 3.13 - The 'Controller' Status Screen

The 'System' Status Screen

The System status screen (figure 3.14) displays the instrument model number, serial number and date of manufacture.

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

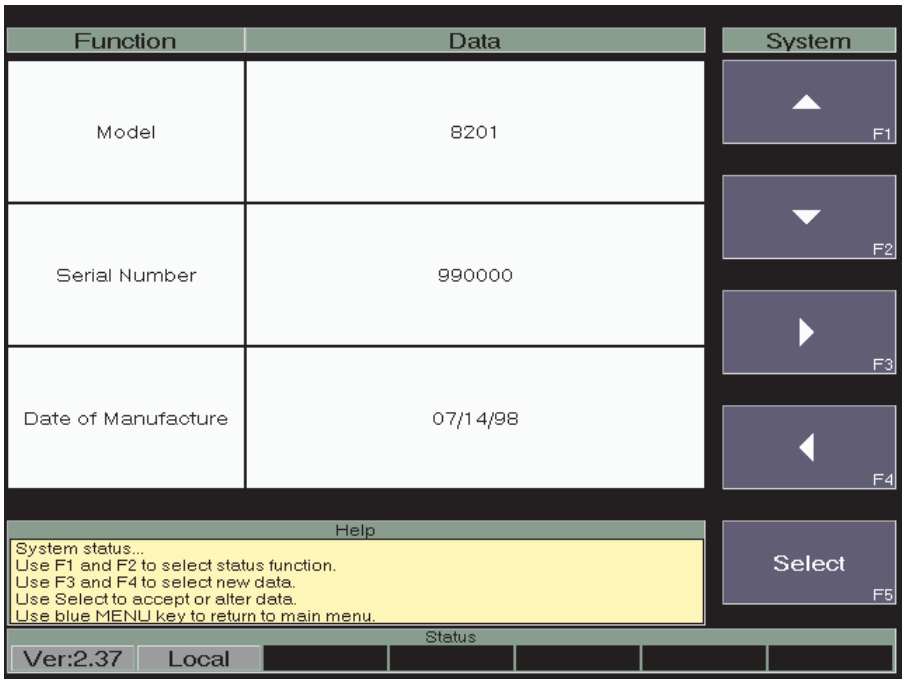


Figure 3.14 - The 'System' Status Screen

The ‘Remote’ Communication Status Screen

The Remote status screen (figure 3.15) is reserved for future use.

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

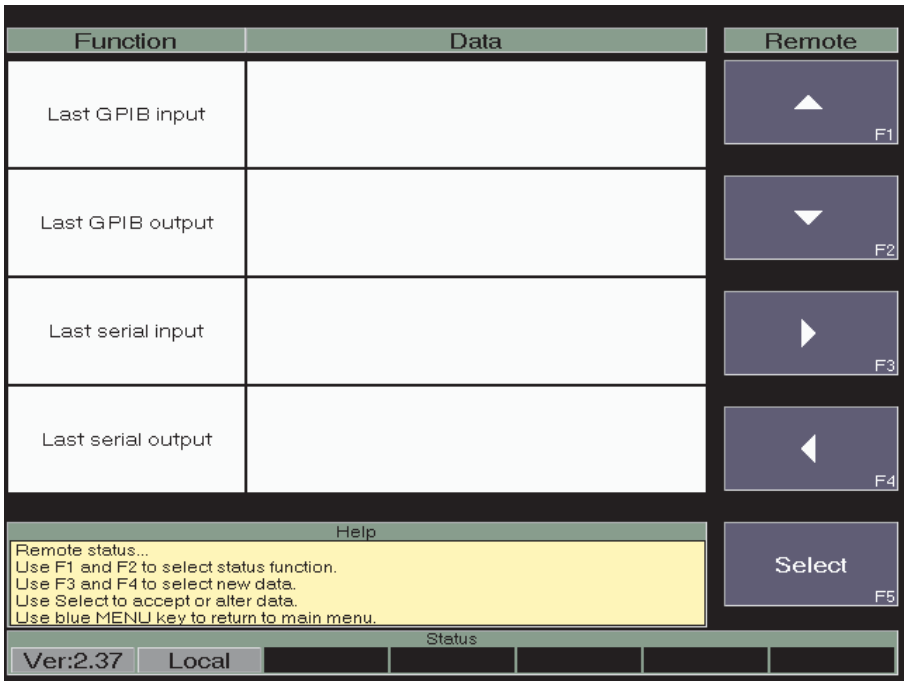


Figure 3.15 - The ’Remote’ Communication Status Screen

The ‘Error’ Status Screen

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

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

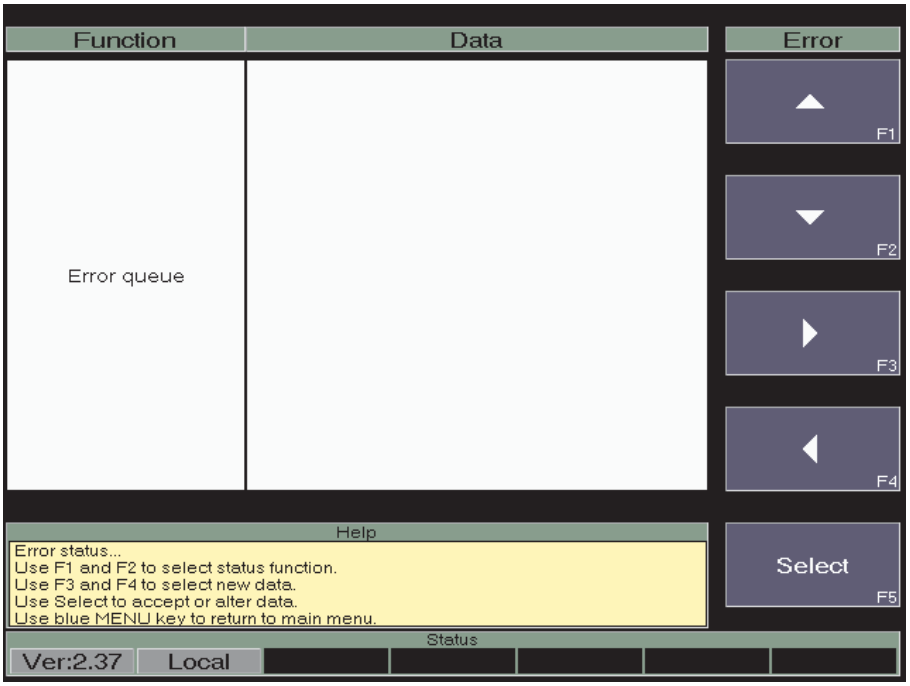


Figure 3.16 - The ’Error’ Status Screen

VENT MODE

Initial Setup

To initially set up the vent mode, go to the Instrument Setup screen (figure 3.6) by pressing [MENU] [F2] [F1]. Set the 'Local Altitude' to the approximate station elevation. Obtain the elevation either through survey maps or by placing the unit in the measure mode with the Ps MEASURE/CONTROL port open to atmosphere and reading the altitude in feet off of the front panel. This reading will fluctuate with changing barometric pressure.

Set the 'Altitude Vent Rate' to a vent rate in feet/minute or meters/minute that is within the capability of the devices to be tested. This is the rate at which the instrument will control the vent process when in the Air Data Configuration mode. Six thousand feet per minute (6,000 f/m) is the default value for the ADTS.

Set the 'Pressure Vent Rate' to a vent rate in pressure units (inHg/minute, psi/minute, mBar/min, etc.; NOT feet or meters) that is an acceptable rate for measuring and controlling pressure. The default value is 30 psi/minute or 61.08 inHg/minute.

Vent Operation in Air Data Mode

When Vent key [F5] is pressed, the control system will set the Ps Altitude to the Local Altitude setting which was entered during the Instrument Setup step, above. It will also set the Ps Rate to the Altitude Vent Rate setting, set the Qc value to zero, and leave the Qc rate at its current setting. The pressure regulator will drive to the setpoints as if it were in the control mode. This will require an operational pressure source and vacuum source. During the process the display will identify the mode as 'Slow Vt' (Slow Vent). When the altitude is within 10 feet of the setpoint the unit will vent to atmosphere. The mode will then change to 'Vent' and pressure will be released to atmosphere. It is important that the 'Local Altitude' and the 'Altitude Vent Rate' settings are correct to prevent rapid rate changes from damaging sensitive external devices.

Vent Operation in the Pressure Mode

In the pressure modes of Ps/Qc and Ps/Pt, press [F5]-Vent and the ADTS will convert the 'Local Altitude' setting to an equivalent pressure, then apply this to the Ps and Pt channel setpoints, and apply zero to the Qc pressure channel setpoint. The pressure rate of change on the Ps and Pt/Qc channels is set to the 'Pressure Vent Rate' setting. The pressure is controlled at the rate setting until both channels get close to the setpoints, then the unit will vent to atmosphere. This mode usually requires both a pressure source and a vacuum source to reach the setpoints.

On units with software versions prior to V2.09: During the process of driving to the setpoints, the display will indicate a mode of 'Slow Vt' (Slow Vent). When the setpoints are achieved, the mode will change to 'Vent'.

Problems Exiting 'Slow Vent' Mode

Leaving the unit in the 'Slow Vent' mode will consume gas at an accelerated rate, adding to the wear and tear on the ADTS, and the connected compressors and pumps. If the unit will not achieve the vent setpoints within a reasonable time, and if any attached devices under test can tolerate a pressure rate change, reset the control setpoint of one or both channels to the current reading. This will force the ADTS into the Vent mode.

To achieve this use the [F1] and [F2] (up and down) cursor keys to highlight the affected channel, enter the current reading value using the main keypad, and finally, press the [ENTER] or [EXEC] key.

User's Notes:

REMOTE OPERATION

The Air Data Test Set (ADTS) 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

Before IEEE-488 communications can be established between the ADTS and a host, the GPIB address in the ADTS and the host must be set into agreement. The ADTS is shipped with the GPIB address set to 1. To change the address go to the Remote Setup screen by pressing [MENU], [F2], and [F4] to see the Remote setup table shown in figure 3.9. Go to the GPIB Address function in that table and enter a number from 1 to 15, to agree with the host computer.

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.

ADTS 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 ADTS also contains many features of IEEE-488.2, which is a later version of this protocol.

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

SRQ Service Request
The ADTS asserts service request whenever an error is encountered. When the bus controller issues a serial poll the error will be cleared. If automatic serial polling is available with your IEEE-488 board, turn this feature off if you do not want to ignore errors. (see ERROR? command).

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

GET Group Execute Trigger
When this message is received, the ADTS 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 ADTS will return to local operation and unlock the keyboard.

DCL Device Clear
When this message is received, the ADTS 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 ADTS) and queries (requests for messages from the ADTS) follow a common format. The ADTS 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 whitespace character (20 hex or less except 0a hex). Normally an ASCII space (20 hex, 32 dec) is used for the field separator. Lower case letters are converted to uppercase by the ADTS and may be used 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 functions are listed in table 4.1.

Data Field: The data field is either an ASCII string or numeric value. The data field is only used with commands, not with queries. In the case of multiple data fields, commas are used to separate the fields. String or numeric data are acceptable in any of the following formats:

Example ASCII string data:

ON
OFF
mBar
inHg

Example ASCII numeric data:

1
1.0
-5.678
25.68324e-5

ADTS Remote Command Set

Definitions:

[White Space]:
any character code <= 0x20 (space) except 0x0a (<lf>)

[Command]:
any valid command (listed below)

[Data]:
ASCII representations of numeric or string data

[Termination]:
0x0a (<lf>)

Commands are always sent in one of the following formats:

[Command] [Termination]
[Command] [White Space] [Data] [Termination]

Queries are special commands that contain the character '?'

Queries always return an ASCII data string terminated with <cr><lf>

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

Command/Query Set

Table 4.1 - Command/Query Set

Command	Data	Response / Function
?		Returns the current output format.
A		Makes the A channel active.
A?		Returns the A channel reading.
Address	0-30	Sets the GPIB Address.
Address?		Returns the GPIB Address.
AirData		Changes the control mode to Air Data control.
AirData?		Return YES or NO.
Airmode		Accepts parameters TRUE or INDICTED and changes the airspeed mode appropriately.
Airmode?		Returns TRUE or INDICATED.
Airtemp		Sets the Total Temperature (T_t), in degrees C, that is used for the true airspeed calculation. Limit: ±100 °C.
Airtemp?		Returns the Total Temperature in degrees C.
Ar?		Returns the A channel rate.
Ars?		Returns the A rate stable indication (YES or NO).
As?		Returns the A channel stable indication (YES or NO).
B		Makes the B channel active.
B?		Returns the B channel reading.
Br?		Returns the B channel rate.
Brs?		Returns the B rate stable indication (YES or NO).
Bs?		Returns the B channel stable indication (YES or NO).
Chan	A,B,P3 or Ratio	Sets the active channel.
Chan?		Returns the active channel name.
CheckValve	Yes or No	Enables or Disables check valve protection.
CheckValve?		Returns YES or NO.
Control		Active or linked channels placed in Control Mode.
Control?		Returns YES if active channel is in Control Mode. NO if otherwise.
Default		Sets the default values.
DOM?		Returns the date of manufacture.
Error?		Returns the next error in the error queue.
Filter	0 to 10	Sets the corner frequency for the active channel's measured reading.
Filter?		Returns the filter corner frequency.
Id?		Returns MENSOR,8201,ssssss,v.vv.
Keylock	Yes or No	Locks or unlocks keyboard.
Keylock?		Returns YES or NO.
Linked	Yes or No	Links modes of both channels if YES, independent if NO.
Linked?		Returns YES or NO.
List?		Returns a list of valid channel names.
LowerLimit	Value inside xducr Range	Sets the control limit for the active channel.
LowerLimit?		Returns the lower control limit for the active channel.
Measure		Active or linked channels placed in Measure Mode.
Measure?		Returns YES if active channel is in Measure Mode, NO if otherwise.
Outform	1, 2, or 3	Sets the output format. Outform 2 is the default.
Outform?		Returns the output format.
Pressure		Change the control mode to pressure control.

Continued on next page...

Table 4.1 continued...

Command	Data	Response / Function
Pressure?		Returns YES or NO.
PressurePt		Puts the ADTS in the pressure Ps/Pt mode.
PressurePt?		Returns YES if in pressure Ps/Pt mode, No otherwise.
Ps		Makes the left channel active.
Ps?		Returns the left channel reading.
Pt		Makes the right channel active.
Pt?		Returns the right channel reading.
Qc		Makes the right channel active.
Qc?		Returns the right channel reading.
Range?		Returns the range of the active channel.
RangeMax?		Returns the maximum range of the active channel.
RangeMin?		Returns the minimum range of the active channel.
Rateavg		Sets the number of seconds for the rate filter.
Rateavg?		Returns current number of seconds of the filter.
Rfilter	0 to 10	Sets the corner frequency for the active channel rate reading.
Rfilter?		Returns the rate filter corner frequency.
RLLimit	in sensor range	Sets the lower rate control limit for the active channel.
RLLimit?		Returns the lower rate control limit for the active channel.
RULimit	in sensor range	Sets the upper rate control limit for the active channel.
RULimit?		Returns the upper rate control limit for the active channel.
Rsetpt	in sensor range	Sets the control rate setpoint for the active channel.
Rsetpt?		Returns the control rate setpoint for the active channel.
Rstable?		Returns Yes if current channel rate is stable.
RstableTime	0 to 65535	Sets the rate stable time to the number of seconds specified.
RstableTime?		Returns the rate stable time.
RStableWin	in sensor range	Sets the rate stable window.
RstableWin?		Returns the rate stable window.
Runits	Sec, Min, or Hour	Sets the rate time base units.
Runits?		Returns the rate units.
Sbaud	300, 1200, 2400, 4800, 9600, 19200	Sets the serial baud.
Sbaud?		Returns the serial baud rate.
Sdata	7 or 8	Sets the serial data bits.
Sdata?		Returns the serial data bits number.
Setpt	value inside limits	Sets the control setpoint for the active channel.
Setpt?		Returns the control setpoint for the active channel.
Span	desired pressure or ?	Sets span to sent pressure or for ?, clears previous value. RESTRICTION: Must be >50% of range and has a 1% limit.
Span?		Returns span scale factor.
Sparity	EVEN,ODD, or NONE	Sets the serial parity.

Continued on next page...

Table 4.1 continued...

Command	Data	Response / Function
Sparity?		Returns the serial parity.
Sstop	1 or 2	Sets the serial stop bits.
Sstop?		Returns the serial stop bits.
Stable?		Returns YES if current channel is stable.
StableTime	0 to 65535	Sets the stable time to the number of seconds specified.
StableTime?		Returns the stable time.
StableWin	in sensor range	Sets the stable window.
StableWin?		Returns the stable window.
Standby		Active or linked channels placed in Standby Mode.
Standby?		Returns YES if active channel is in the Standby Mode, NO if otherwise.
Step	value inside limits	Sets the control step for the active channel.
Step?		Returns the control step for the active channel.
Units	psi, inHg, inH2O, mbar, kpa, mmhg, or units code	Sets the instrument engineering units.
Units?		Returns the instrument units.
UpperLimit	in sensor range	Sets the upper control limit for the active channel.
UpperLimit?		Returns the upper control limit for the active channel.
Vent		Active or linked channels placed in Vent Mode.
Vent?		Returns YES if active channel is in the Vent mode, NO if otherwise.
VentAltRate		Sets vent rate in air data mode.
VentAltRate?		Returns vent rate.
VentPRate		Sets vent rate in pressure mode.
VentPRate?		Returns vent rate in pressure mode.
Zero	desired pressure or ?	Sets zero to sent pressure or for ?, clears previous value.
Zero?		Returns zero offset.

Outform Formats

The "Outform" command sets the output format that will be returned by a subsequent outform query. The formats are:

Outform Command	Outform Query Returns
1	Ps Pressure, Pt Pressure
2 (Default)	Ps Pressure, Qc Pressure (Pt-Ps)
3	Ps Pressure, Pt Pressure, Ps Rate, Pt Rate

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.

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 similar 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 <cr> or <lf>.

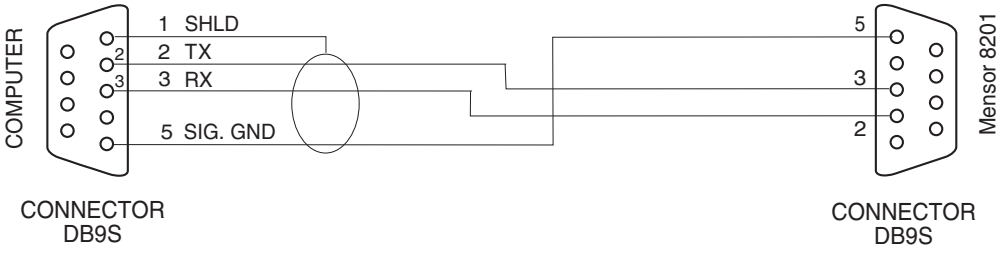


Figure 4.1 - RS-232 Cable

MAINTENANCE

The ADTS 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.

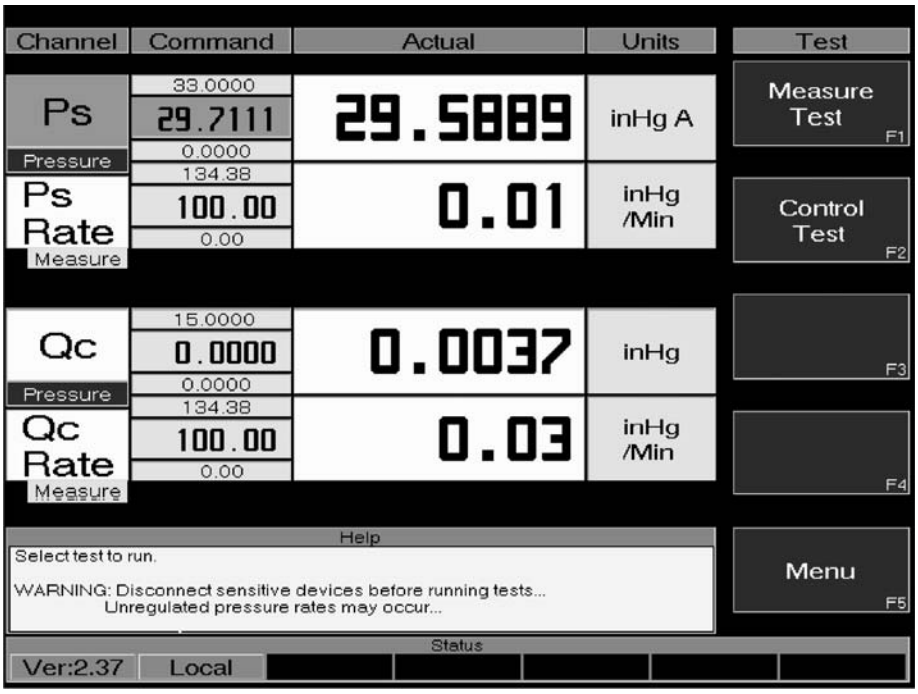


Figure 5.1 - The 'Test' Screen

PROGRAM DISK REPLACEMENT

In order to replace the system program disk, first remove the power cord from the instrument. Then remove the rear panel by removing the five 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. The disk is ejected by pressing the eject button.

Push the new disk into the disk slot until it locks in place. Replace the rear panel and restore the instrument power. Turning on the instrument will reboot the ADTS and load the new program.

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.

Electrical Module Circuit Boards

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

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 2 screws each at the front, left and right sides. Remove these ten screws, then lift the module cover straight up to remove it.

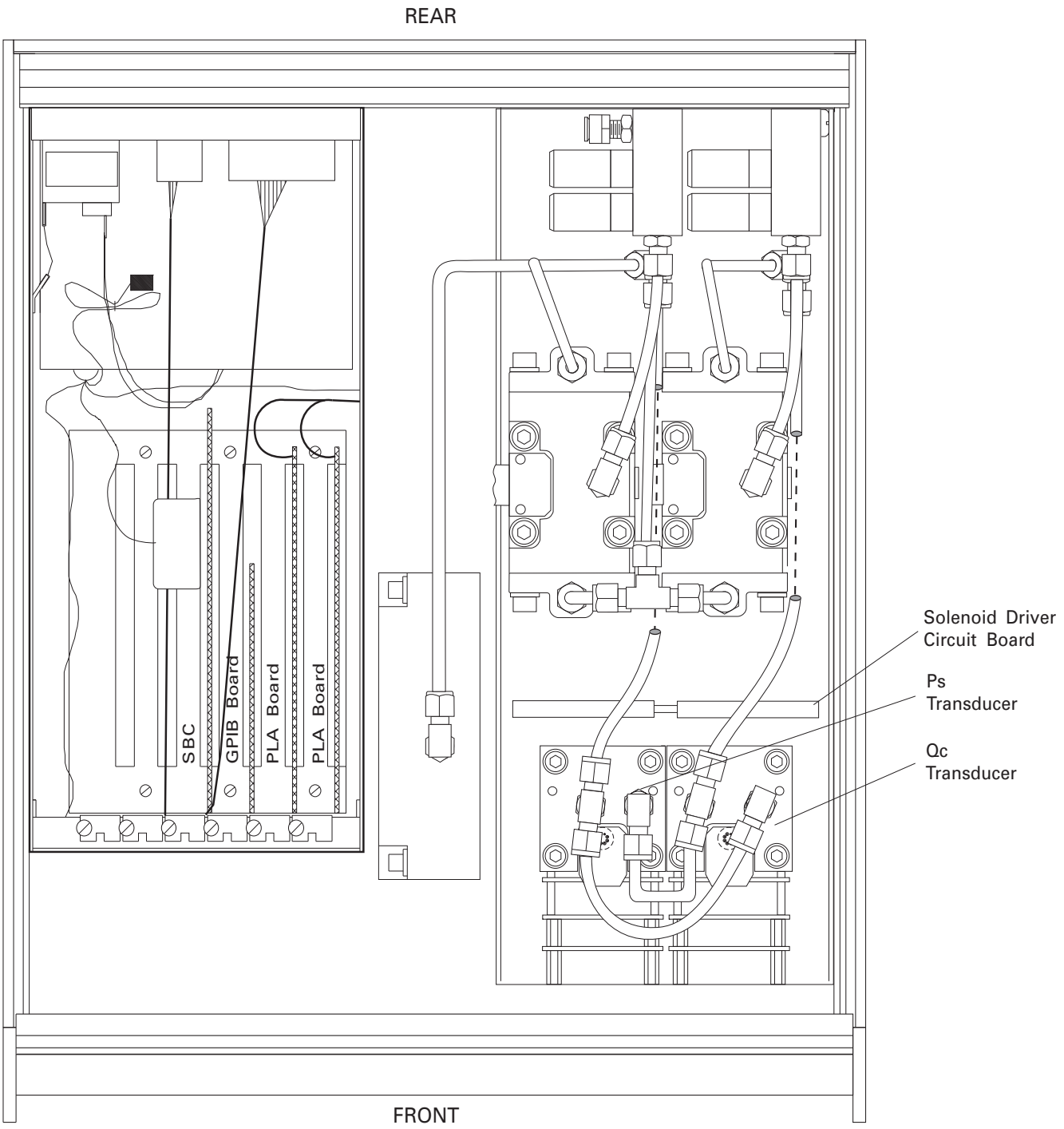
All of the circuit boards in the module are compatible with IBM AT format Personal Computers (PC's). Most are purchased from outside vendors; they may differ in appearance, and also in position, from one unit to the next but their functionality remains the same. The exception is that the PLA boards are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

SPARE PARTS LIST

Below is a table showing ADTS spare parts that can be ordered from Mensor.

Table 5.1 – Spare Parts

Part Description	Part Number
Miscellaneous	
Manual	0014785001
Fuses	4100111150
Power Cord	4000400002
Rubber Feet	3201300001
Front Panel Assembly	0014940001
Electrical Module	0014812002
GPIB Board	4904000015
Solenoid Driver Board (modified)	0014835001
PLA Board (specify whether for Ps or Pt)	0014293001
Power Supply (modified)	4901000024
Pneumatics	
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



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

The ADTS 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 period may be extended as confidence is gained in the stability of these sensors.

ENVIRONMENT

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

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.

MEDIUM

The recommended calibration medium is dry nitrogen or clean dry instrument air. For pressure ranges below 20 psia (~40 mHgA) head pressure height differences between the standard and the ADTS 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. A vacuum source with a minimum capacity of 21 liters per minute is recommended.

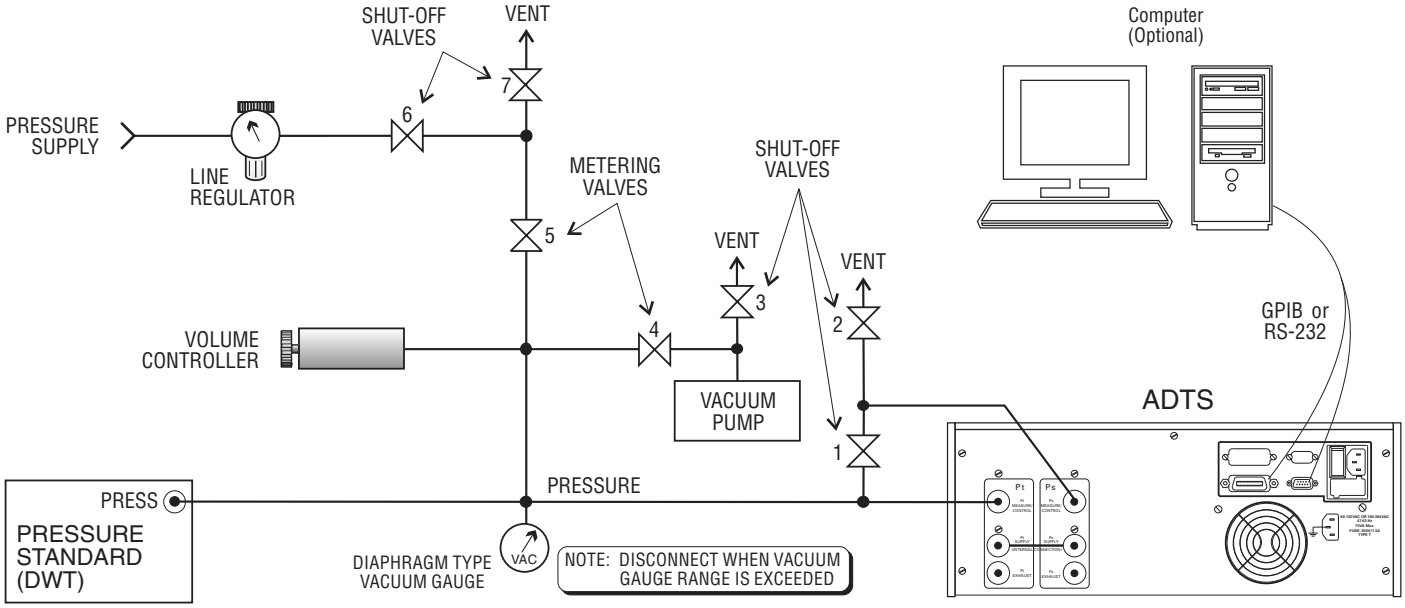


Figure 6.1 - Calibration Setup

PASSWORDS

Before changes can be made to either the zero or the span values that are recorded in the ADTS 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 ADTS 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 from one to six number keys. Each number pressed is displayed on the screen so that the user can verify the entry is as desired. Use [CE] to backspace through erroneous numbers, and then enter the correction;

> **NOTE:** *Store a copy of the new number where it can be recovered if forgotten.*

7. 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], then enter the new password, and finally, press either [F5], [ENTER], or [EXEC]. The Ps and Qc zero calibration screen (figure 6.4) should appear immediately. If it does not, return to step 1 and repeat the process.

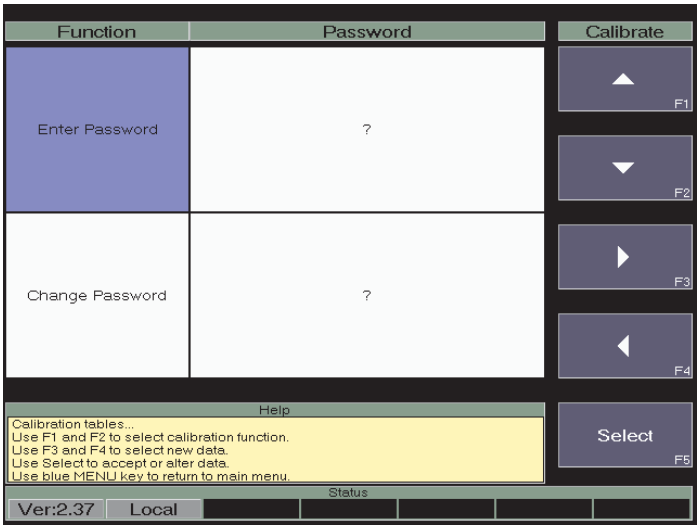


Figure 6.2 - The 'Enter/Change Password' Screen

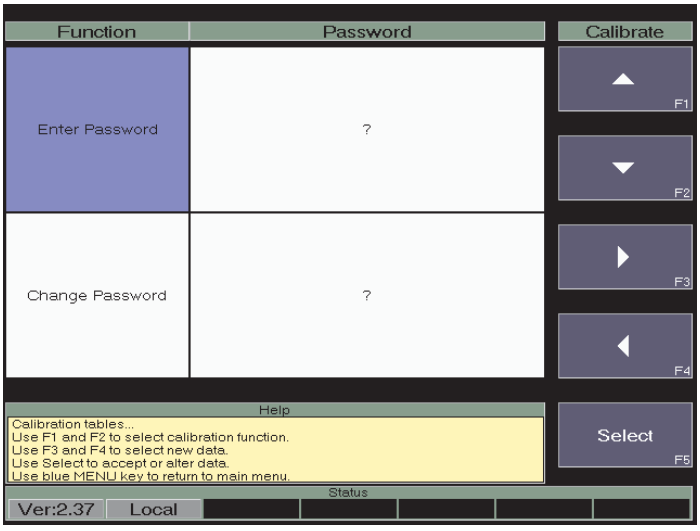


Figure 6.3 - The 'Change Passwords' Screen

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 Qc 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.

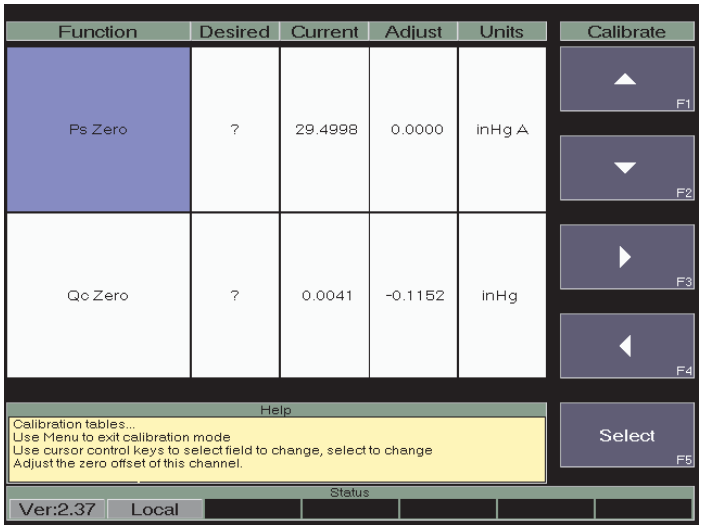


Figure 6.4 - The 'Zero Calibration' Screen

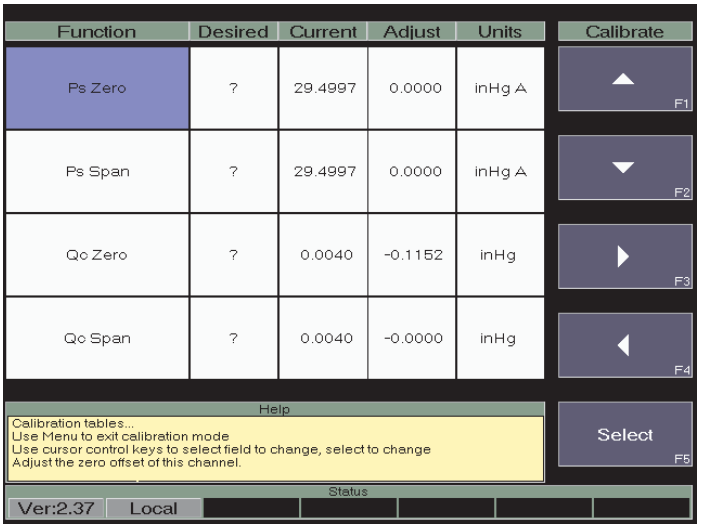


Figure 6.5 - The 'Master Calibration' Screen

CALIBRATION SEQUENCE

The ADTS contains an absolute pressure transducer (Ps) and a differential transducer (Qc). Zero and span adjustments are available on both channels. Linearity is preset at the factory and is not adjustable. Pt has no calibration adjustment since it is merely derived as the sum of Ps and Qc. (Ps + Qc = Pt). The Ps and Qc zero and span adjustments are used to make a linear correction to the pressure readings of the active transducer according to the formula:

Reading = ((uncorrected reading) x span correction) + zero offset

The ADTS automatically applies the correction value when the calibration function is executed either locally from the front panel or remotely via the RS-232 or the GPIB bus.

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 ADTS to a calibration setup similar to figure 6.1. Both pressure channels of the ADTS should be placed in the measure mode. The ADTS should be set to read in the Ps and Qc display mode. (Menu/Setup/Instrument and the display format of Ps/Qc selected.) Open valves 1 and 2 (ref: figure 6.1) until the calibration is started.

Absolute Sensor Calibration (Ps Channel)

Since the Qc channel is referenced to the Ps channel pressure, shut-off valve 1 must be left open throughout the test to apply the pressures to both the Ps and Qc channels. Close vent valve 2 for now. To calibrate from the front panel, press [MENU] and then press [F4]-Calibrate to display the calibration menu. Enter the zero password to monitor or change just the zero offset (figure 6.4) or enter the master password to also monitor or change the span corrections via the Master Calibration screen (figure 6.5). The 'Current' fields display the current pressure value in the current engineering units. The 'Adjust' fields display the current zero offsets and span multipliers. The 'Units' fields display the current units of measure settings.

Absolute sensor (Ps channel) zero offset correction using a vacuum pump: Evacuate the transducers to a low absolute 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 two to five minutes for the target pressure to stabilize, then convert the millitorr reading to an equivalent instrument reading in the active measurement units (600 millitorr = 0.0116 psi or 0.0236 inHg):

PSI value = millitorr value x 0.0000193367
inHg @ 0 C value = millitorr value x 0.0000393701

Table 9.2 in the Appendix lists millitorr conversion factors.

With the actual pressure of the standard convert to the units of measure on the ADTS, highlight the Ps Zero field using the [F1] or [F2] arrow keys, enter the true pressure using the numeric keys and then press [F5], [ENTER] or [EXEC] to effect the zero offset change. Press [MENU] to return to the main menu, and then press [F1]-Operate to return to the normal operation.

Or over the bus, send PS <lf> to set the channel to Ps, followed by a linefeed termination character.

Next, send ZERO dd.dddd<lf> to enter the desired zero pressure, where dd.dddd is the true pressure in the current engineering units, followed by a linefeed termination character.

Absolute sensor (Ps channel) zero offset correction using a barometric standard: An alternate approach to correcting the zero offset in the transducer is to use a high quality barometric reference. This approach is applicable when accurate vacuum standards are not available, a method of maintaining viscous flow of the gas media are not available and span corrections are not necessary or have already been made. It also has an advantage of having a known good calibration point within the more commonly used range of an altimeter or air data computer.

For this method the barometric reference should have an accuracy of 0.01% of reading or better. To begin, vent both the Ps port and the barometric reference to atmosphere. From the front panel of the ADTS, press [MENU], [F4]-Calibrate to display the calibration menu. Enter the zero password or the master password to enable changes to the calibration (figure 6.4 or 6.5). The 'Current' fields display the current pressure values in the current engineering units. The 'Adjust' fields display the current zero offsets and span multipliers. The 'Units' fields display the current units of measure. Press the [F1] or [F2] cursor keys to highlight the Ps Zero field. Use the main keypad to enter the true pressure from the barometer, then press [F5], [ENTER] or [EXEC] to effect the zero offset change. Press [MENU] to return to the main menu, and then

press [F1]-Operate to return to the normal operation.

Or over the bus, send PS <lf> to set the active channel to Ps followed by a linefeed termination character.

Next, send ZERO dd.dddd<lf>to enter the desired zero pressure, where dd.dddd is the true pressure in the current engineering units followed by a linefeed termination character.

Absolute sensor (Ps channel) span correction: After the zero offset has been checked and corrected if necessary, the calibration can be checked at span or a number of pressure points from zero to full scale. If recalibration is needed, press [MENU], [F4]-Calibrate to display the calibration menu. Enter the master password to monitor or change the span corrections via the Master Calibration screen (figure 6.5). The 'Current' fields display the current pressure values in the current engineering units. The 'Adjust' fields display the current zero offsets and span multipliers. The 'Units' fields display the current units of measure.

Apply a pressure of at least 50 percent of full scale or higher. To minimize errors, bring this pressure as close to the full scale as practical, rather than at mid scale. If a calibration setup configuration similar to figure 6.1 is used, close vent valves 2, 3 and 7, and open shut-off valve 1. Apply pressure to the pressure supply line and a vacuum to the vacuum line. Use metering valves 4 and 5 to adjust the pressure to the approximate target pressure, and then use the volume controller to fine tune the reading to float the DWT.

Convert the actual pressure of the standard to the units of measure of the ADTS. Press cursor key [F1] or [F2] to highlight the Ps Span field, enter the true pressure using the numeric keys, and then press [F5], [ENTER] or [EXEC] to effect the span multiplier correction. Press [MENU] to return to the main menu, then press [F1]-Operate to return to the normal operation.

To do this over the bus, send, send PS <lf> to set the channel to Ps followed by a linefeed termination character.

Send SPAN dd.dddd<lf> to enter the desired zero pressure, where dd.dddd is the true pressure from the standard in the current engineering units followed by a linefeed terminator.

Span corrections can only be made between 50 and 100 percent of span and the maximum allowed change is plus or minus 10 percent of the transducer range.

Differential Sensor Calibration (Qc Channel)

Since the Qc channel is referenced to the Ps channel pressure, shut-off valve 1 must be closed and vent valve 2 should be left open throughout the test. To calibrate from the front panel, press [MENU], then [F4]-Calibrate to display the calibration menu. Enter the zero password to monitor or change just the zero offset (figure 6.4) or enter the master password to monitor or change span, or both zero and span correction via the Master Calibration screen (figure 6.5). The 'Current' fields display the current pressure values in the current engineering units. The 'Adjust' fields display the current zero offsets and span multipliers. The 'Units' fields display the current units of measure.

Differential sensor (Qc channel) zero offset correction: The simplest way to set the zero offset on the Qc differential sensor is to vent both the pressure port (Pt Measure/Control) and its reference port (Ps Measure/Control) on the ADTS. Next, press [F1] or [F2] cursor key to highlight the Qc Zero field, then enter the true pressure (0.000) from the main keypad, and finally press [F5], [ENTER] or [EXEC] to effect the zero offset change. Press the [MENU] key to return to the main menu, and then press [F1]-Operate to return to the normal operation.

To do this over the bus, send QC <lf>to set the channel to Qc, followed by a linefeed termination character.

Send ZERO 00.0000<lf> to enter the desired zero pressure, where dd.dddd is the true pressure in the current engineering units, followed by a linefeed termination character.

Differential sensor (Qc channel) span correction: After the zero offset has been checked and corrected if necessary, the calibration can be checked at span or a number of pressure points from zero to full scale. If recalibration is needed, press [MENU] and then [F4]-Calibrate to display the calibration menu. Enter the master password to monitor or change the span corrections via the Master Calibration screen (figure 6.5). The 'Current' fields display the current pressure values in the current engineering units. The 'Adjust' fields display the current zero offsets and span multipliers. The 'Units' fields display the current units of measure.

Apply a pressure of at least 50 percent of full scale or higher. To minimize errors, bring this pressure as close to the full scale as practical, rather than at mid scale. If a calibration setup configuration similar to figure 6.1 is used, close shut-off valve 1, and vent valves 3 and 7, and open vent valve 2. Apply pressure on the pressure supply line. Use metering valves 4 and 5 to adjust the pressure to approximately the target pressure, and then use the volume controller to fine tune the reading to float the DWT.

Convert the actual pressure of the standard to the units of measure on the ADTS. Press cursor [F1] or [F2] to highlight the Qc Span field, enter the true pressure using the numeric keys, and then press [F5], [ENTER] or [EXEC] to effect the span multiplier correction. Press [MENU] to return to the main menu, then press [F1]-Operate to return to the normal operation.

To do this over the bus, send QC <lf> to set the channel to Qc, followed by a linefeed termination character.

Send SPAN dd.dddd<lf> to enter the desired zero pressure, where dd.dddd is the true pressure from the standard in the current engineering units, followed by a linefeed termination character.

Span corrections can only be made between 50 and 100 percent of span and the maximum allowed change is plus or minus 10 percent of the transducer range.

To Restore Factory Calibrations by Clearing Existing Offsets

To return a pressure channel's calibration to the factory setting, from the front panel, press [MENU], [F4]-Calibrate to display the calibration menu. Enter the zero password to change just the zero offset (figure 6.4) or enter the master password to monitor or change both zero or span corrections via the Master Calibration screen (figure 6.5). The 'Current' fields display the current pressure values in the current engineering units. The 'Adjust' fields display the current zero offsets and span multipliers. The 'Units' fields display the current units of measure. With the appropriate field highlighted (Ps Zero, Ps Span, Qc Zero, Qc Span) and a '?' showing in the 'Desired' field, press [F5] or [ENTER]. Press [MENU] to return to the main menu, and then press [F1]-Operate to return to the normal operation.

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 these specifications without notice.

MEASURE SPECIFICATIONS

Accuracy
Ps: 0.010% FS pressure.
Qc: 0.010% FS pressure referenced to sea level. Additional error <5 knots at altitudes below 4,000 ft.

Calibration Stability
0.010% FS for 180 days after re-zeroing. Optional 0.025% FS accuracy instrments are 0.025% for 180 days.

Pressure Ranges (nominal)
Ps: 0 - 32 inHg or 0 - 35 inHgA.
Qc: -0.5 to + 10 inHg up to -2 to +100 inHg.

Measurement Units
(See table in the Appendix).

Resolution
Ps: 0.0001 inHga.
Qc: 0.001 or 0.0001 inHg.

Calibration Adjustments
Zero and Span

Calibration Interval
The recommended period between calibrations is 180 days.

CONTROL SPECIFICATIONS

External Pressure Requirements
Reference Pressure: Permanent vacuum on Ps (absolute) sensor.
Qc (gauge) sensor referenced to Ps pressure.

Source Pressure: Instrument air or dry nitrogen. Recommended pressure at the supply port: 5 psi or greater above the channel's range, but less than 100 psi. Accurate external regulation is not required.

> **NOTE:** *Ps and Pt Supply ports are internally connected at the factory.*

Exhaust Pressure: Vacuum pump required for absolute pressure control around and below local barometric pressures.

Stability of Controlled Pressure
0.002% FS pressure

Minimum Control Pressure
0.1 inHga

Pressure
200 inHg max. (atmosphere to any port without damage to instrument) with power off.

Dynamic Response (slew time for Fast Response mode)
40 seconds maximum between any two pressure points from 0.5% FS above the EXHAUST pressure to FS, to within 0.1% FS of the set point into a 1/2 liter volume. A larger volume will lengthen the stated time.

Settling Time
15 seconds after the slew time as indicated above (for pressure to remain within ± 0.01% FS of the set control point). External volume will lengthen the stated time.

Control Offset (Ps and Qc channels)
<0.010 inHg at any pressure above 1 inHg.

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

RATE 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.

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 (51.0 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 inch rack.

Power Input Requirements
90-132 or 180-264 VAC, 47-63 Hz. Autoswitching.
175 VA max.
Power Cord: Retractable, 3-wire, 117V.

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

Particle Filters
8 internal replaceable 20 micron filters are in line with the rear panel ports and the VENT ports.

Pneumatic Overpressure Protection
Protected by Relief Valves

Compensated Temperature Range
15°C to 45°C.

Operating Temperature Range
0°C to 50°C.
Humidity: 5% to 95% RH non-condensing.

Storage Temperature Range
–25°C to 60°C. Minimal vibration,
Non-condensing humidity.

Local User Interfaces
6.4" (diagonal) active matrix color LCD.
20 key main keypad.
5 special function keys.

Remote User Interfaces
IEEE-488.1.

Warmup
Approximately 45 minutes to achieve full accuracy.

Response Time
33 milliseconds.

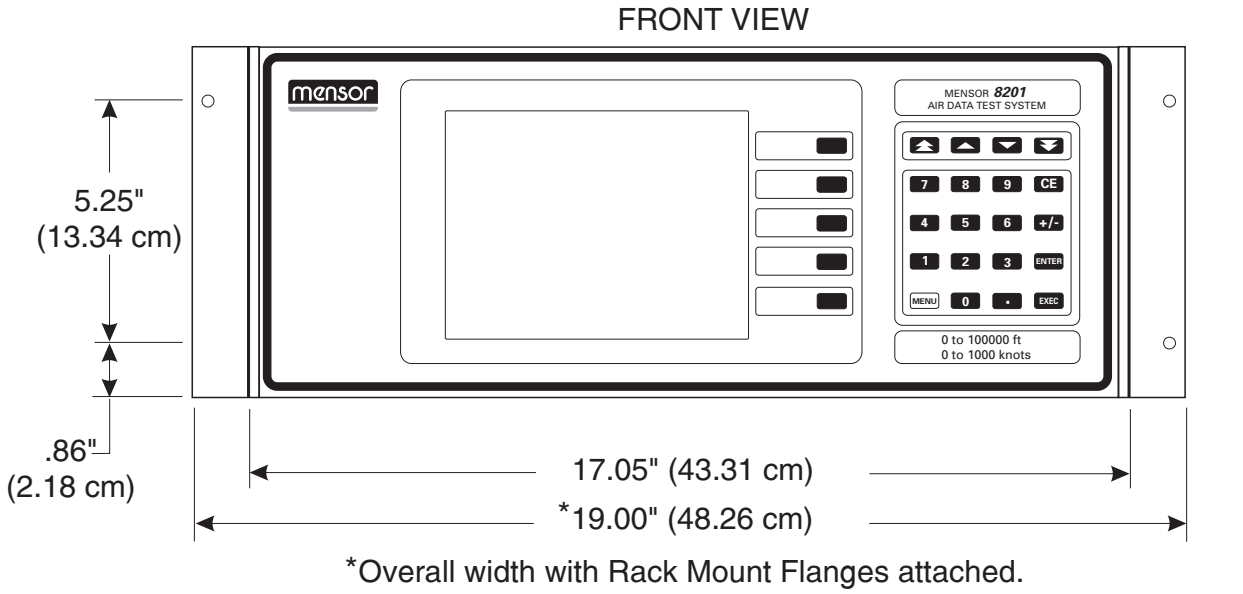
Orientation Effects
Negligible effect on span, linearity and zero in any attitude.

Shock/Vibration
2 gravities max for 10 minutes per MIL-T-28800.

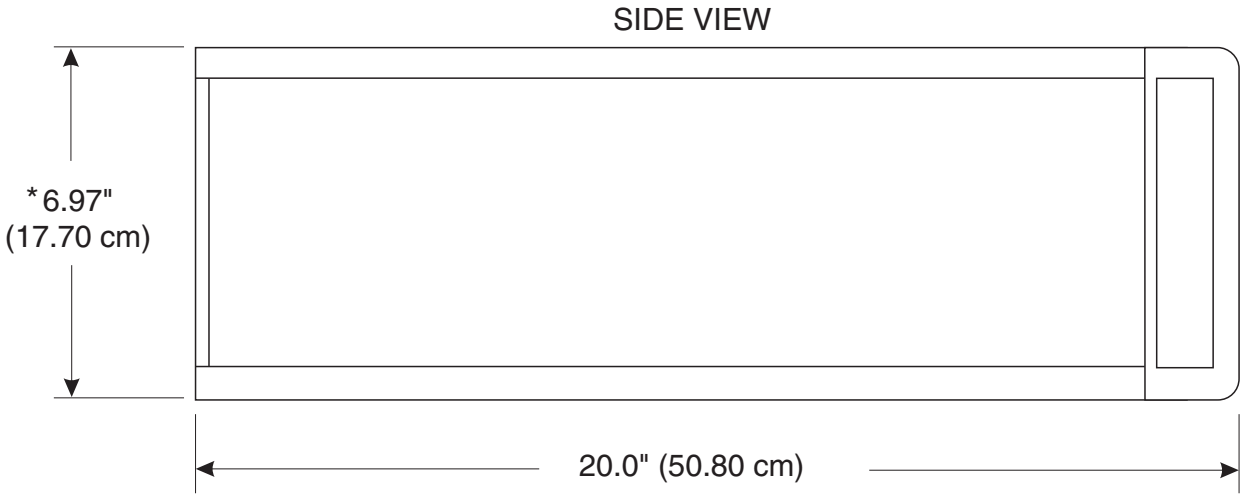
Pressure Media
Clean, dry non-corrosive gases.

Internal Pneumatic Volume (Measure/Control Ports):
Measure Mode: 357 cc.
Control Mode: 565 cc.

External Pneumatic Volume
Maximum: 1 liter.
Minimum: 0.1 liter (100 cc).



*Overall width with Rack Mount Flanges attached.



*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 ADTS. 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.

RELIEF VALVES

There are several types of relief valves available:

- One-way differential
- Two-way differential
- One-way absolute
- One-way absolute with vacuum gauge tube

Relief valves are available for pressure ranges from 0.5 psi to 1020 psi. Over time, contaminants in the system may enter the valves and prevent proper operations. Servicing the valves by the user is not recommended.

TRANSPORT CASE (PN 0011159001)

A wheeled Transport Case is available suitable for moving the ADTS 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.)

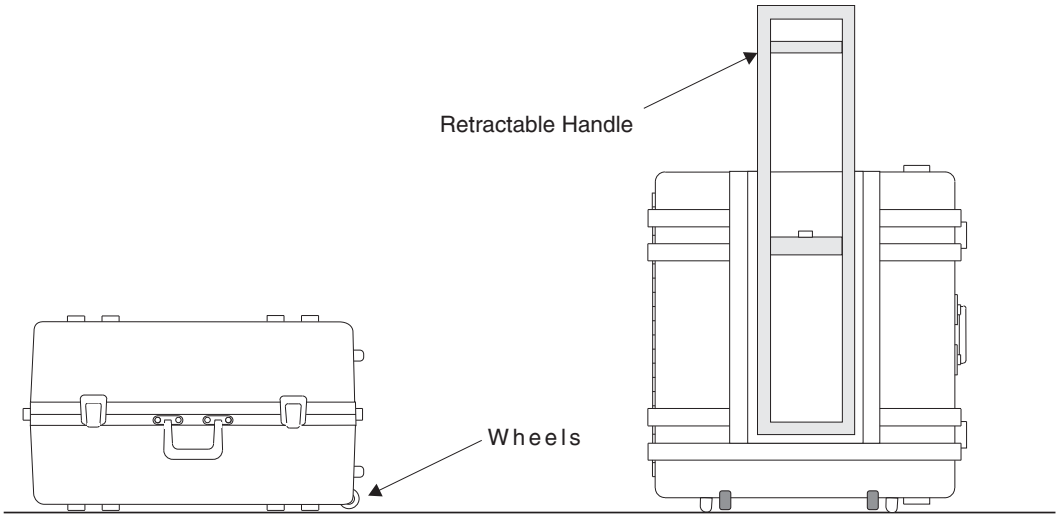


Figure 8.1 - Transport Case

RACK MOUNT KIT (PN 0012425004)

The ADTS 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 ADTS. An ADTS with the rack mount option is then installed from the front of the rack. Before installing the ADTS, remove the four feet from the bottom of the instrument. Slide the ADTS 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 vibration devices should be mounted so as to minimize the vibrations at the instrument!

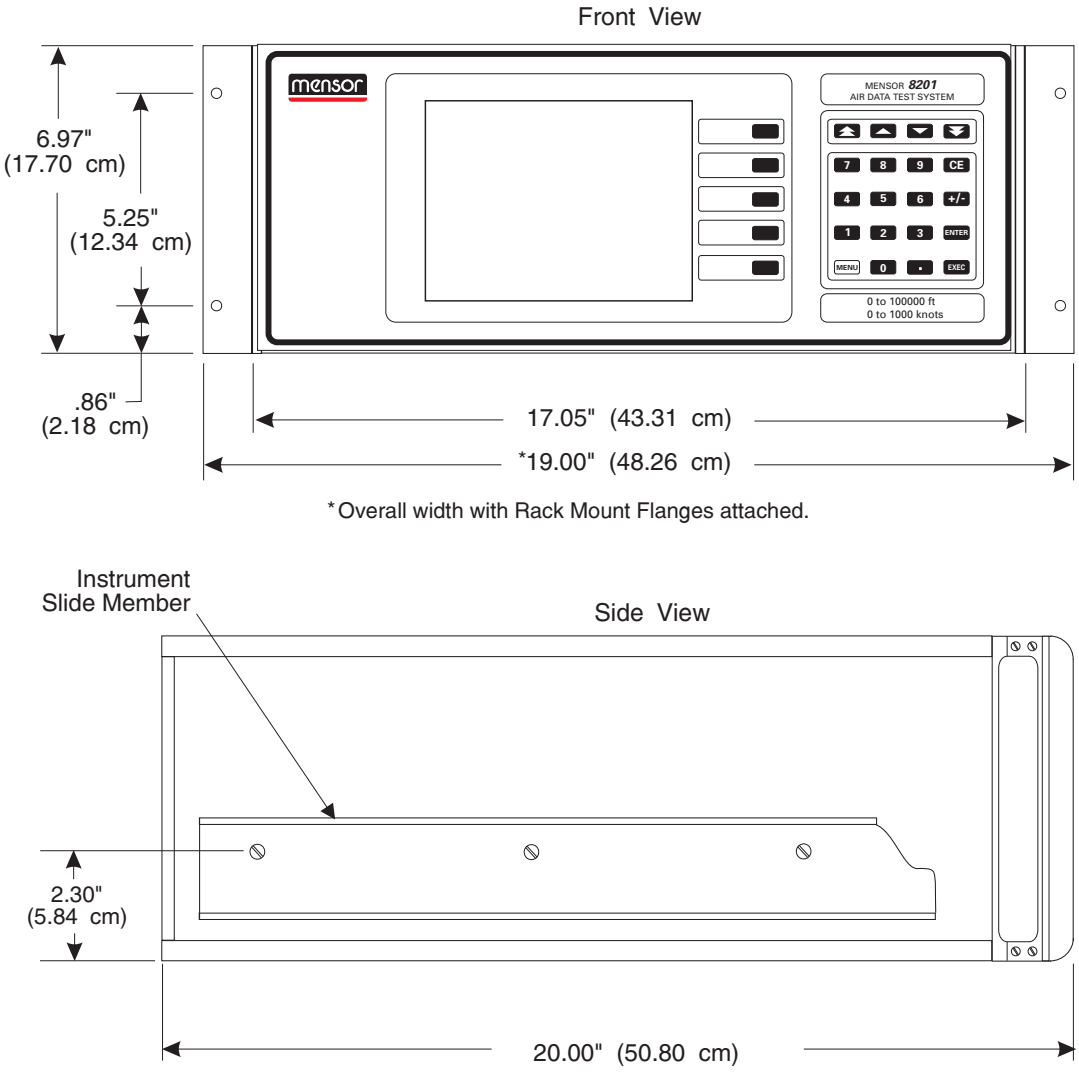


Figure 8.2 - Rack Mount Dimensions

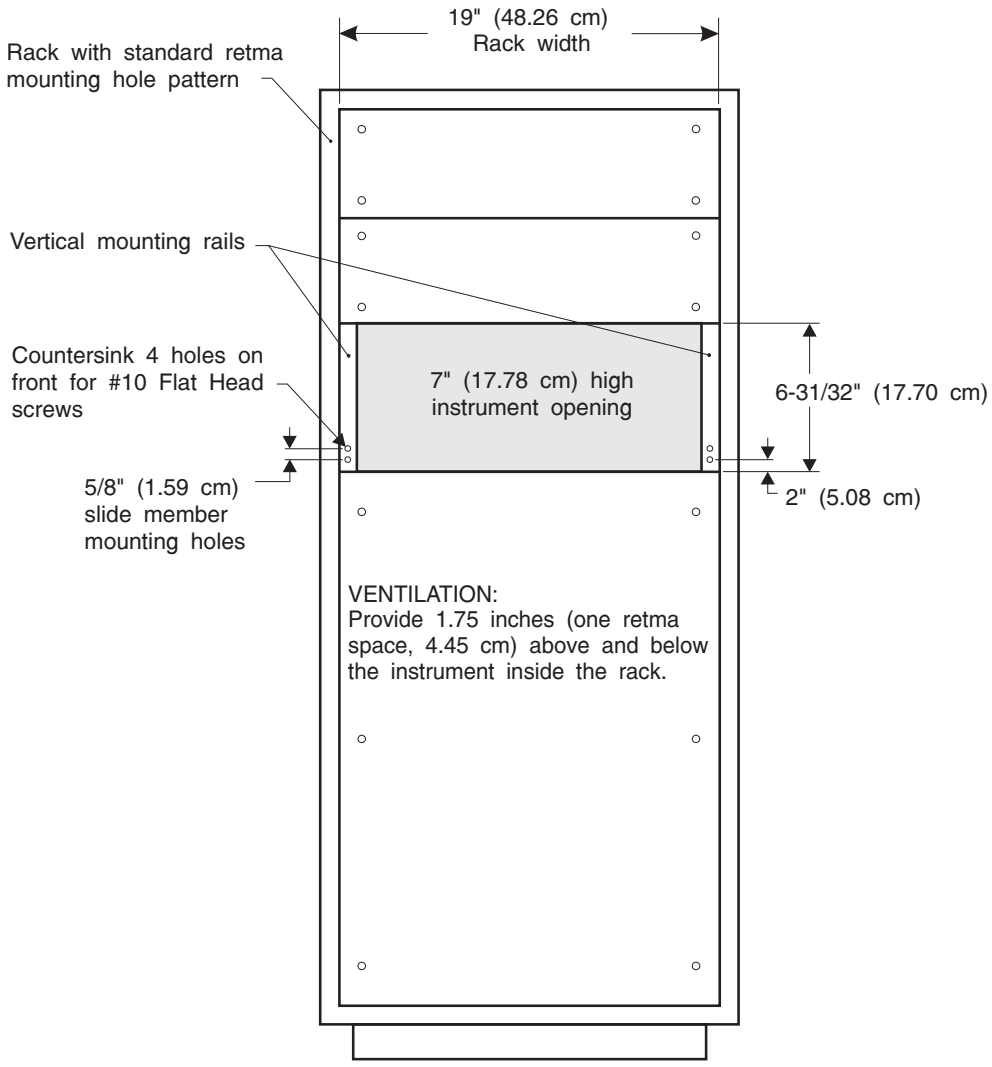


Figure 8.3 - Rack Specifications

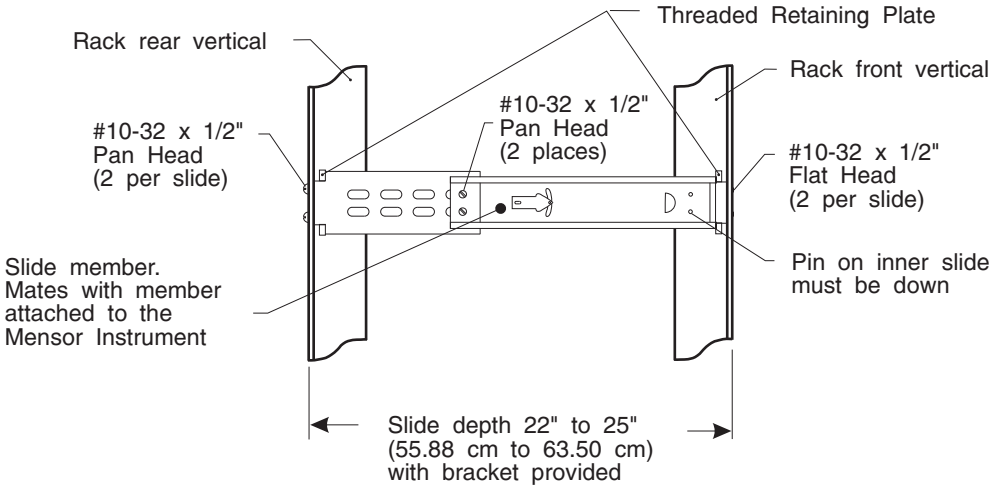


Figure 8.4 - Slide Specifications

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MEASUREMENT UNITS (Number)

The unitno command selects the measurement units to be output on the bus and the display. The syntax for the unitno command is **UNITS N** where **N** is a number from the 'Unitno' column in the following table.

Table 9.1 – Measurement Units

Unitno	Units	Output Format
1	pounds per square inch	PSI
2	inches of mercury @ 0°C	INHG @ 0C
4	inches of water @ 4°C	INH2O@ 4C
15	millibar	MBAR
19	millimeters of mercury @ 0°C	MMHG @ 0C
22	kilopascals	KPA

PRESSURE CONVERSION TABLES

Table 9.2 – Conversion Factors, psi

Units	Pressure Unit	To convert from Psi	To convert to Psi
1	PSI	1	1
2	INHG @ 0C	2.03603	0.491152
4	INH2O @ 4C	27.6807	0.0361262
15	MBAR	68.94757	0.01450377
19	MMHG @ 0C	51.7150733	0.0193367
22	KPA	6.894757	0.1450377

Table 9.3 – Conversion Factors, millitorr

Units	Pressure Unit	To convert from Millitorr	To convert to Millitorr
1	PSI	0.0000193367	51715.1
2	INHG @ 0C	0.0000393701	25400.0
4	INH2O @4C	0.000535253	1868.27
15	MBAR	0.00133322	750.064
19	MMHG @ 0C	0.001	1000.00
22	KPA	0.000133322	7500.64

Table 9.4 – Altitude to Pressure Conversion

Altitude		Ps Pressure		
Feet	Meters	inHgA	mmHg	Millibars
-3,000	-914	33.311	846.09	1,128.03
-2,000	-610	32.148	816.56	1,088.66
-1,000	-305	31.018	787.87	1,050.41
0	0	29.921	760.00	1,013.25
1,000	305	28.856	732.94	977.17
2,000	610	27.821	706.66	942.13
3,000	914	26.817	681.15	908.12
4,000	1,219	25.842	656.38	875.10
5,000	1,524	24.896	632.36	843.07
6,000	1,829	23.978	609.05	812.00
7,000	2,134	23.088	586.44	781.85
8,000	2,438	22.225	564.51	752.62
9,000	2,743	21.388	543.26	724.28
10,000	3,048	20.577	522.66	696.82
12,000	3,658	19.029	483.35	644.41
14,000	4,267	17.577	446.47	595.24
16,000	4,877	16.216	411.90	549.15
18,000	5,486	14.942	379.53	506.00
20,000	6,096	13.750	349.25	465.63
22,000	6,706	12.636	320.96	427.91
24,000	7,315	11.597	294.56	392.71
26,000	7,925	10.627	269.94	359.89
28,000	8,534	9.725	247.01	329.32
30,000	9,144	8.885	225.69	300.90
32,000	9,754	8.106	205.88	274.49
34,000	10,363	7.382	187.51	249.99
36,000	10,973	6.712	170.48	227.29
38,000	11,582	6.097	154.86	206.46
40,000	12,192	5.538	140.67	187.54
45,000	13,716	4.355	110.62	147.48
50,000	15,240	3.425	86.99	115.97
55,000	16,764	2.693	68.40	91.20
60,000	18,288	2.118	53.79	71.72
65,000	19,812	1.665	42.30	56.40
70,000	21,336	1.310	33.29	44.38
75,000	22,860	1.033	26.24	34.98
80,000	24,384	0.815	20.71	27.61
85,000	25,908	0.645	16.38	21.84
90,000	27,432	0.511	12.97	17.30
95,000	28,956	0.405	10.29	13.72
100,000	30,480	0.322	8.18	10.90

Table 9.5 – Airspeed to Pressure Conversion

Airspeed	Qc Pressure	
Knots	inHg	mmHg
0	0.0000	0.00
10	0.0048	0.12
20	0.0192	0.49
30	0.0431	1.09
40	0.0767	1.95
50	0.1198	3.04
60	0.1727	4.39
70	0.2352	5.97
80	0.3075	7.81
90	0.3895	9.89
100	0.4814	12.23
120	0.6950	17.65
140	0.9488	24.10
160	1.2435	31.58
180	1.5799	40.13
200	1.9589	49.76
220	2.3816	60.49
240	2.8492	0.00
260	3.3628	85.42
280	3.9240	99.67
300	4.5343	115.17
320	5.1953	131.96
340	5.9088	150.08
360	6.6769	169.59
380	7.5015	190.54
400	8.3850	212.98
450	10.8674	276.03
500	13.7756	349.90
550	17.1590	435.84
600	21.0749	535.30
650	25.5893	649.97
700	30.7780	781.76
750	36.7274	932.88
800	43.5356	1105.81
850	51.3141	1303.38
900	60.1887	1528.80
950	70.3016	1785.67
1,000	81.8124	2078.04

TEMPERATURE CONVERSION

Table 9.6 – Temperature Conversion

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

°C		°F
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

°C		°F
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

°C		°F
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 is 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 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 media the head pressure difference due to temperature changes within the compensated temperature range will be insignificant.

Table 9.7 – 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 at the input port (P_2 in figure 9.1) of the Device Under Test (DUT) will be a positive number if the 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 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).

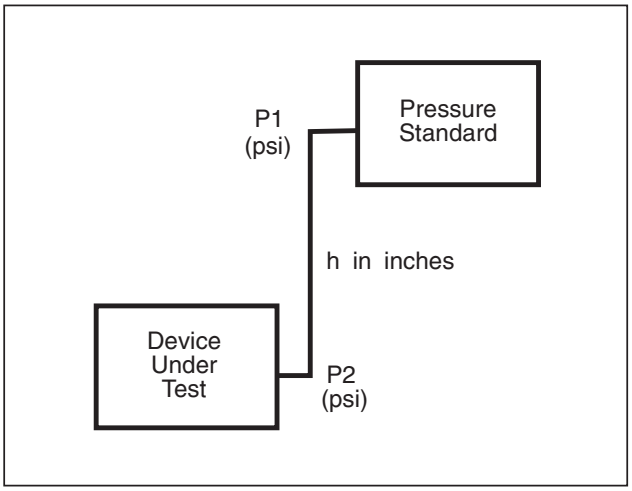

Figure 9.1 - Head Pressure Calculation

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User's Notes:

MENSOR CORPORATION
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Operation Manual
PN 0014785001 C4
December, 2009