



User Manual

Model T400

Photometric Ozone Analyzer

with NumaView™ software

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TRADEMARKS

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SAFETY MESSAGES

Important safety messages are provided throughout this manual for the purpose of avoiding personal injury or instrument damage. Please read these messages carefully. Each safety message is associated with a safety alert symbol and is placed throughout this manual; the safety symbols are also located inside the instrument. It is imperative that you pay close attention to these messages, the descriptions of which are as follows:



WARNING: Electrical Shock Hazard



HAZARD: Strong oxidizer



GENERAL WARNING/CAUTION: Read the accompanying message for specific information.



CAUTION: Hot Surface Warning



Do Not Touch: Touching some parts of the instrument without protection or proper tools could result in damage to the part(s) and/or the instrument.



Technician Symbol: All operations marked with this symbol are to be performed by qualified maintenance personnel only.



Electrical Ground: This symbol inside the instrument marks the central safety grounding point for the instrument.

CAUTION

This product should only be installed, commissioned, and used strictly for the purpose and in the manner described in this manual. If you improperly install, commission, or use this instrument in any manner other than as instructed in this manual or by our Technical Support team, unpredictable behavior could ensue with possible hazardous consequences.

Such risks, whether during installation and commission or caused by improper installation/commissioning/use, and their possible hazardous outcomes include but are not limited to:



RISK	HAZARD
Liquid or dust/debris ingress	Electrical shock hazard
Improper or worn power cable	Electrical shock or fire hazard
Excessive pressure from improper gas bottle connections	Explosion and projectile hazard
Sampling combustible gas(es)	Explosion and fire hazard
Improper lift & carry techniques	Personal injury

Note that the safety of a system that may incorporate this product is the end user's responsibility.

For Technical Assistance regarding the use and maintenance of this instrument or any other Teledyne API product, contact Teledyne API's Technical Support Department:

Telephone: +1 800-324-5190 (toll free) or +1 858-657-9800

Email: api-techsupport@teledyne.com

or access any of the service options on our website at <http://www.teledyne-api.com/>

CONSIGNES DE SÉCURITÉ

Des consignes de sécurité importantes sont fournies tout au long du présent manuel dans le but d'éviter des blessures corporelles ou d'endommager les instruments. Veuillez lire attentivement ces consignes. Chaque consigne de sécurité est représentée par un pictogramme d'alerte de sécurité; ces pictogrammes se retrouvent dans ce manuel et à l'intérieur des instruments. Les symboles correspondent aux consignes suivantes :



AVERTISSEMENT : Risque de choc électrique



DANGER : Oxydant puissant



AVERTISSEMENT GÉNÉRAL / MISE EN GARDE : Lire la consigne complémentaire pour des renseignements spécifiques



MISE EN GARDE : Surface chaude



Ne pas toucher : Toucher à certaines parties de l'instrument sans protection ou sans les outils appropriés pourrait entraîner des dommages aux pièces ou à l'instrument.



Pictogramme « technicien » : Toutes les opérations portant ce symbole doivent être effectuées uniquement par du personnel de maintenance qualifié.



Mise à la terre : Ce symbole à l'intérieur de l'instrument détermine le point central de la mise à la terre sécuritaire de l'instrument.

MISE EN GARDE

Ce produit ne doit être installé, mis en service et utilisé qu'aux fins et de la manière décrites dans le présent manuel. Si vous installez, mettez en service ou utilisez cet instrument de manière incorrecte autre que celle indiquée dans ce manuel ou sous la direction de notre équipe de soutien technique, un comportement imprévisible pourrait entraîner des conséquences potentiellement dangereuses.

Ce qui suit est une liste, non exhaustive, des risques et résultats dangereux possibles associés avec une mauvaise utilisation, une mise en service incorrecte, ou causés mauvaise commission.



RISQUE	DANGER
Pénétration de liquide ou de poussière/débris	Risque de choc électrique
Câble d'alimentation incorrect, endommagés ou usé	Choc électrique ou risque d'incendie
Pression excessive due à des connexions de bouteilles de gaz incorrectes	Risque d'explosion et d'émission de projectile
Échantillonnage de gaz combustibles	Risque d'explosion et d'incendie
Techniques de manutention, soulevage et de transport inappropriées	Blessure corporelle

Notez que la sécurité d'un système qui peut incorporer ce produit est la responsabilité de l'utilisateur final.

WARRANTY

WARRANTY POLICY (02024J)

Teledyne API (TAPI), a business unit of Teledyne Instruments, Inc., provides that:

Prior to shipment, TAPI equipment is thoroughly inspected and tested. Should equipment failure occur, TAPI assures its customers that prompt service and support will be available. (For the instrument-specific warranty period, please refer to the “Limited Warranty” Section in the Terms and Conditions of Sale on our website at <http://www.teledyne-api.com>).

COVERAGE

After the warranty period and throughout the equipment lifetime, TAPI stands ready to provide on-site or in-plant service at reasonable rates similar to those of other manufacturers in the industry. All maintenance and the first level of field troubleshooting are to be performed by the customer.

NON-TAPI MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by TAPI is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturer’s warranty.

PRODUCT RETURN

All units or components returned to Teledyne API should be properly packed for handling and returned freight prepaid to the nearest designated Service Center. After the repair, the equipment will be returned, freight prepaid.

The complete Terms and Conditions of Sale can be reviewed on our website.

CAUTION – Avoid Warranty Invalidation



Failure to comply with proper anti-Electro-Static Discharge (ESD) handling and packing instructions and Return Merchandise Authorization (RMA) procedures when returning parts for repair or calibration may void your warranty. For anti-ESD handling and packing instructions please refer to the manual, Fundamentals of ESD, PN 04786, in its “Packing Components for Return to Teledyne API’s Customer Service” section. The manual can be downloaded from our website at <http://www.teledyne-api.com>. RMA procedures can also be found on our website.

ABOUT THIS MANUAL

This manual is comprised of multiple documents, in PDF format, as listed below.

Part No.	Name/Description
083730400	T400 Photometric Ozone Analyzer User Manual with NumaView™ Software (this manual)
n/a	MODBUS Registers, Appendix A
069130000	T400 Interconnect Diagram, Appendix B

Support manuals that are available on the CD of Instrument User Manuals and on the TAPI website <http://www.teledyne-api.com> include:

- NumaView™ Remote Software User Guide, part number 08492
- Hessen Protocol Manual, part number 04585
- Fundamentals of ESD Manual, part number 04786 (to prevent Electro-Static Discharge and consequent damage to instrument)
- Pump Pack Manual, part number 07900 (if option installed)

NOTE

We recommend that all users read this manual in its entirety before operating the instrument.

CONVENTIONS USED

In addition to the safety symbols as presented in the *Safety Messages* page, this manual provides *special notices* related to the careful and effective use of the instrument and related, pertinent information.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

This special notice provides information to avoid damage to your instrument and possibly invalidate the warranty.

IMPORTANT

IMPACT ON READINGS OR DATA

Provides information about that which could either affect accuracy of instrument readings or cause loss of data.

NOTE

Provides information pertinent to the proper care, operation or maintenance of the instrument or its parts.

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1. INTRODUCTION, SPECIFICATIONS, APPROVALS, & COMPLIANCE

Teledyne API's microprocessor-controlled Model T400 measures low ranges of ozone in ambient air using a method based on the Beer-Lambert law that relates the absorption of light to the properties of the material through which the light is traveling over a defined distance. In the T400 the intensity of an ultra violet light is measured after it passes through a chamber, called the sample cell, where it is absorbed in proportion to the amount of ozone present. Every three seconds, a switching valve alternates measurement between a gas stream containing ozone and a stream that has been scrubbed of ozone. These measurements are calculated along with the ambient sample gas pressure and temperature to provide a true, stable ozone measurement.

The T400 tracks operational parameters and issues warnings if they fall outside diagnostic limits, as well as stores easily retrievable data. Proprietary software allows configurable data acquisition capability that can be triggered conditionally or periodically, enabling operators to perform predictive diagnostics and enhanced data analysis by tracking parameter trends. Reports can be downloaded onto a USB flash drive or via the I/O ports. Operators can also view real-time graphing with one touch of the interface screen.

1.1 SPECIFICATIONS

Table 1-1. T400 Basic Unit Specifications

PARAMETER	SPECIFICATION	
Ranges	Min: 0-100 ppb Full scale Max: 0-10 ppm Full scale (selectable, dual ranges and auto-ranging supported)	
Measurement Units	ppb, ppm, $\mu\text{g}/\text{m}^3$, mg/m^3 (selectable)	
Zero Noise	< 0.2 ppb (RMS) (with 80 Sample Digital Filter)	
Span Noise	< 0.5% of reading (RMS) above 100 ppb	
Lower Detectable Limit	< 0.4 ppb (with 80 Sample Digital Filter)	
Zero Drift	< 1.0 ppb/24 hours	
Span Drift	< 1% of reading/24 hours	
Lag Time	< 10 sec	
Rise/Fall Time	< 20 sec to 95%	
Linearity	1% of full scale	
Precision	< 0.5% of reading above 100 ppb	
Sample Flow Rate	800 cc/min \pm 10%	
Power Requirements	Rating	Typical Power Consumption
	110 - 120 V~ 60 Hz 3.0 A	110 W
	220 - 240 V~ 50 Hz 3.0 A	112 W
	220 - 240 V~ 60 Hz 3.0 A	112 W
Analog Output Ranges	10V, 5V, 1V, 0.1V (selectable)	
Recorder Offset	\pm 10%	
Standard I/O	1 Ethernet: 10/100Base-T 2 RS-232 (300 – 115,200 baud) 2 USB device ports 8 opto-isolated digital outputs 6 opto-isolated digital inputs (3 defined, 3 spare) 4 analog outputs	
Optional I/O	1 USB com port 1 RS485 4 digital alarm outputs Multidrop RS232 3 4-20mA current outputs	
Operating Temperature Range	5 - 40°C (with EPA Equivalency)	
Humidity Range	0-90% RH, Non-Condensing	
Pressure Range	25 – 31 "Hg-A	
Temp Coefficient	< 0.05% per deg C	
Voltage Coefficient	< 0.05% per Volt AC (RMS) over range of nominal \pm 10%	
Dimensions (H x W x D)	7" x 17" x 23.5" (178 x 432 x 597 mm)	
Weight	28 lbs (12.7 kg) 30.6lbs. (13.8kg) with IZS Option	
Environmental Conditions	Installation Category (Over voltage Category) II Pollution Degree 2 Intended for indoor use only at altitudes \leq 2000m	

Table 1-2. IZS Generator Specifications *with* Reference Feedback Option

PARAMETER	SPECIFICATION
Maximum Concentration	1.0 ppm
Minimum Concentration	0.050 ppm
Resolution	0.5 ppb
Repeatability (7 days)	1% of reading
Initial Accuracy	+/- 5% of target concentration
Response Time	< 5 min to 95%

Table 1-3. IZS Generator Specifications *without* Reference Feedback Option

PARAMETER	SPECIFICATION
Maximum Concentration	1.0 ppm
Minimum Concentration	0.050 ppm
Resolution	0.5 ppb
Repeatability (7 days)	2% of reading
Initial Accuracy	+/- 10% of target concentration
Response Time	< 5 min to 95%

1.2 EPA DESIGNATION

Teledyne API’s Model T400 photometric ozone analyzer is officially designated as US EPA Federal Equivalent Method (FEM), Designation Number EQOA-0992-087. The official “List of Designated Reference and Equivalent Methods” is published in the U.S. Federal Register: <http://www3.epa.gov/ttn/amtic/criteria.html>, and specifies the instrument’s settings and configurations.

1.3 COMPLIANCE AND CERTIFICATIONS

This product is CE compliant and adheres to the Low Voltage and ElectroMagnetic Compatibility directives.

For any other certifications, please refer to this product’s specifications sheet on our website

2. GETTING STARTED

This Section addresses unpacking, connecting, and initializing the instrument, getting an overview of the menu system, and setting up/configuring the functions.

2.1 UNPACKING



CAUTION - GENERAL SAFETY HAZARD

To avoid personal injury, always use two persons and proper lift and carry techniques to move/relocate the analyzer.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Printed Circuit Assemblies (PCAs) are sensitive to electro-static discharges too small to be felt by the human nervous system. Failure to use Electro-Static Discharge (ESD) protection when working with electronic assemblies will void the instrument warranty. Refer to the manual, Fundamentals of ESD, PN 04786, which can be downloaded from our website at <http://www.teledyne-api.com>.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Do not operate this instrument without first removing dust plugs from SAMPLE and EXHAUST ports on the rear panel.

Note

Teledyne API recommends that you store shipping containers and materials for future use if/when the instrument should be returned to the factory for repair and/or calibration service. See Warranty statement in this manual and Return Merchandise Authorization (RMA) on our Website at <http://www.teledyne-api.com>.

Verify that there is no apparent external shipping damage. If damage has occurred, please advise the shipper first, then Teledyne API.

Included with your instrument is a printed record of the final performance characterization performed on your instrument at the factory. This record, titled Final Test and Validation Data Sheet, is an important quality assurance and calibration record and should be placed in the quality records file for this instrument.

With no power to the unit, carefully remove the top cover of the instrument and check for internal shipping damage by carrying out the following steps:

1. Carefully remove the top cover and check for internal shipping damage.
 - a. Remove the screws located on the instrument's sides.
 - b. Slide cover backward until it clears the instrument's front bezel.
 - c. Lift cover straight up.
2. Inspect instrument interior to ensure all circuit boards and other components are intact and securely seated.
3. Check the connectors of the various internal wiring harnesses and pneumatic hoses to ensure they are firmly and securely seated.
4. Verify that all of the optional hardware ordered with the unit has been installed. These are listed on the paperwork accompanying the instrument.



WARNING – ELECTRICAL SHOCK HAZARD

Never disconnect or reconnect PCAs, wiring harnesses or electronic subassemblies while instrument is under power.

2.1.1 VENTILATION CLEARANCE

Whether the analyzer is set up on a bench or installed into an instrument rack, be sure to leave sufficient ventilation clearance.

Table 2-1. Ventilation Clearance

AREA	MINIMUM REQUIRED CLEARANCE
Back of the instrument	10 cm / 4 in
Sides of the instrument	2.5 cm / 1 in
Above and below the instrument	2.5 cm / 1 in

Various rack mount kits are available for this analyzer. Contact Sales for more information.

2.2 INSTRUMENT LAYOUT

Instrument layout includes front panel, rear panel connectors, and internal chassis layout.

2.2.1 FRONT PANEL

The front panel (Figure 2-1) includes two USB ports for peripheral device connections, which can be used with mouse and keyboard as alternatives to the touchscreen interface, or with flash drive for uploads/downloads (devices not included).

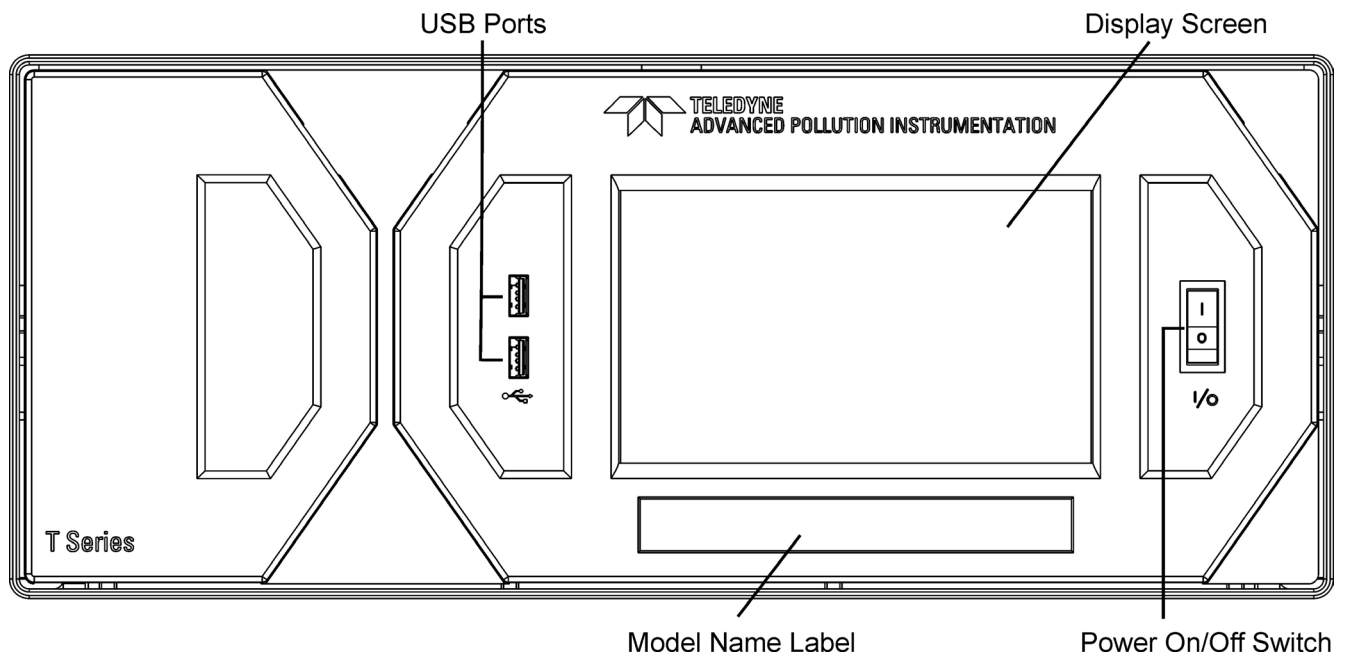


Figure 2-1. Front Panel Layout

2.2.2 REAR PANEL

Figure 2-2 shows the layout of the rear panel.

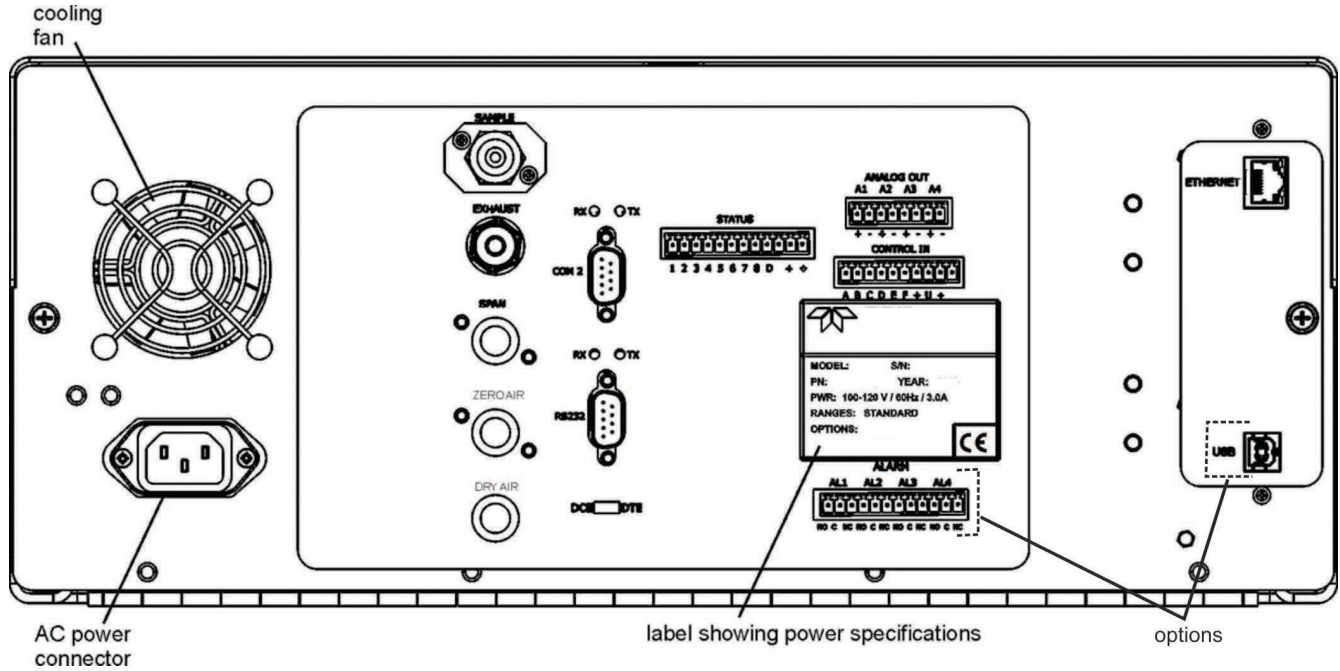



Figure 2-2. Rear Panel Layout

Table 2-2 provides a description of each component on the rear panel.

Table 2-2. Rear Panel Description

COMPONENT	FUNCTION
cooling fan	Pulls ambient air into chassis through side vents and exhausts through rear.
 AC power connector	Connector for three-prong cord to apply AC power to the analyzer. CAUTION! The cord's power specifications (specs) MUST comply with the power specs on the analyzer's rear panel model number label.
Model/specs label	Identifies the analyzer model number and provides power specs
SAMPLE	Connect a gas line from the source of sample gas here. Calibration gases are also inlet here on units with the zero/span valve option installed.
EXHAUST	Connect an exhaust gas line of not more than 10 meters long here that leads outside the shelter or immediate area surrounding the instrument.
(option) SPAN	On units with zero/span valve option installed, connect a gas line to the source of calibrated span gas here.
(option) ZERO AIR	Internal Zero Air: On units with zero/span valve option installed connect the source of zero air here.
(option) DRY AIR	On units with zero/span valve option installed connect the source of dry air here (- <20°C dew point).
RX TX	LEDs indicate receive (RX) and transmit (TX) activity on the when blinking.
COM 2	Serial communications port for RS-232 or RS-485.
RS-232	Serial communications port for RS-232 only
DCE DTE	Switch to select either data terminal equipment or data communication equipment during RS-232 communication.
STATUS	For outputs to devices such as Programmable Logic Controllers (PLCs).
ANALOG OUT	For voltage or current loop outputs to a strip chart recorder and/or a data logger.
CONTROL IN	For remotely activating the zero and span calibration modes.
(option) ALARM	Option for concentration alarms and system warnings.
ETHERNET	Connector for network or Internet remote communication, using Ethernet cable.
(option) USB	Connector for direct connection to laptop computer, using USB cable.
Information Label	Includes voltage and frequency specifications

2.2.3 INTERNAL CHASSIS

 **CAUTION – UV RADIATION RISK**
 Do not look directly at the light of the UV lamp. Use proper UV-protective lenses.

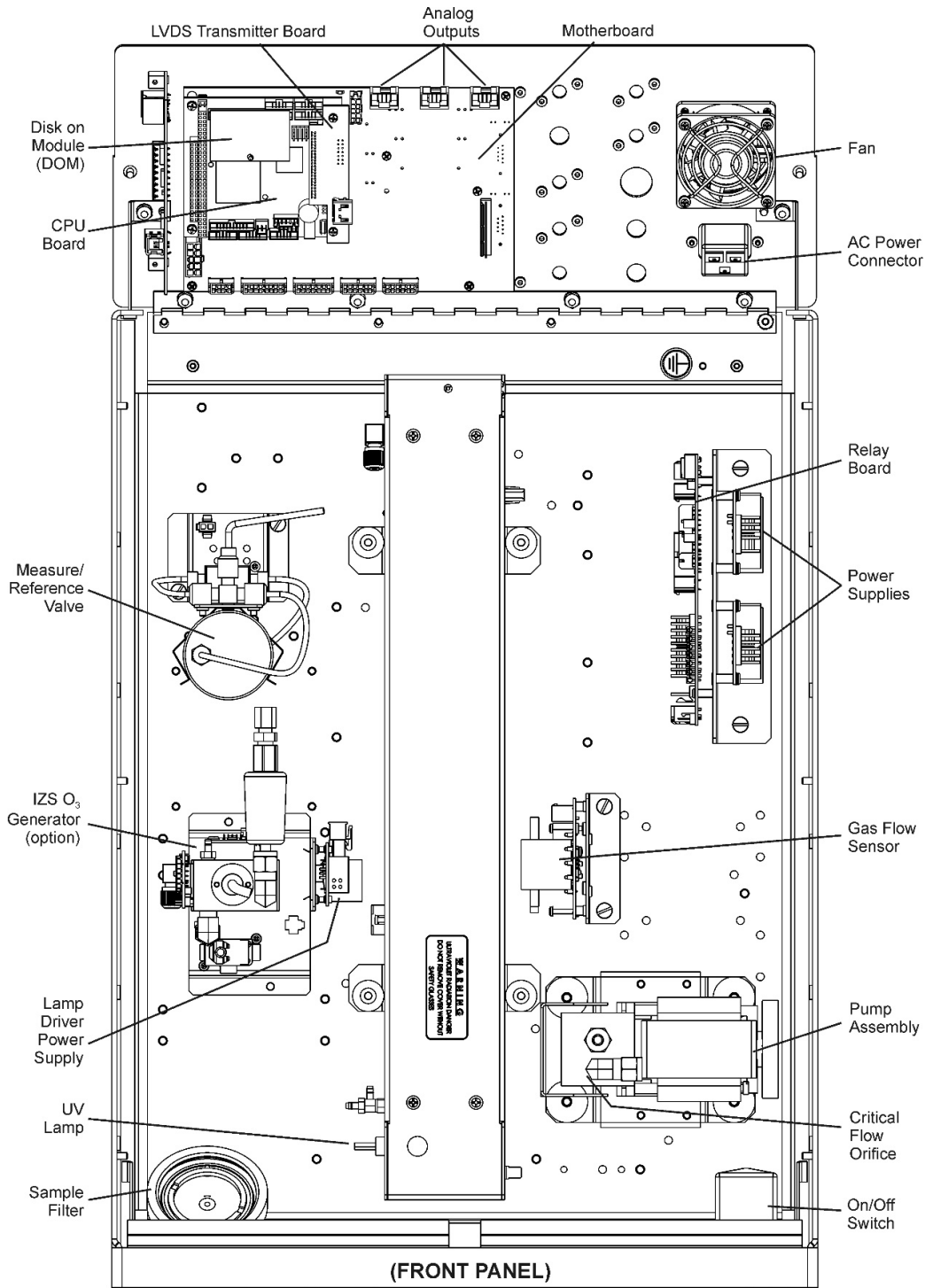


Figure 2-3. T400 Internal Layout – Top View with IZS Option

2.3 CONNECTIONS AND STARTUP

This Section presents the electrical (Section 2.3.1) and pneumatic (Section 2.3.2) connections for setup and preparing for instrument operation.

2.3.1 ELECTRICAL CONNECTIONS

Note To maintain compliance with EMC standards, cables must be no longer than 3 meters for all I/O connections.



WARNING – ELECTRICAL SHOCK HAZARD

- High Voltages are present inside the instrument's case.
- Power connection must have functioning ground connection.
- Do not defeat the ground wire on power plug.
- Turn off instrument power before disconnecting or connecting electrical subassemblies.
- Do not operate with cover off.
- Ensure that installation provides access to disconnect power from the instrument



CAUTION – AVOID DAMAGE TO THE INSTRUMENT

Ensure that the AC power voltage matches the voltage indicated on the instrument's model/specs label before plugging it into line power.

2.3.1.1 CONNECTING POWER

Attach the power cord between the instrument's AC power connector and a power outlet capable of carrying at least the rated current at your AC voltage range and ensure that it is equipped with a functioning earth ground. It is important to adhere to all safety and cautionary messages.

2.3.1.2 CONNECTING ANALOG OUTPUTS

The rear panel Analog Output channels A1 through A4 can be mapped to reflect various operating values in the analyzer, including concentration values, temperatures, pressures, etc. These mappings are not configured by default and must be set by the user.

An optional Current Loop output (Section 2.3.1.3) is available for A1, A2 and A3 only.

To access these signals attach a strip chart recorder and/or data-logger to the appropriate analog output connections on the rear panel of the analyzer.

ConFigure through the Setup>Analog Outputs menu (Section 2.5.8).

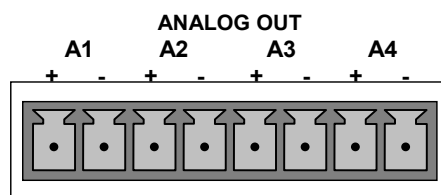


Figure 2-4. Analog Output Connector

Table 2-3. Analog Output Pin-Outs

PIN	ANALOG OUTPUT	SIGNAL OUT	STANDARD VOLTAGE OUTPUT	CURRENT LOOP OPTION
1	A1	User-selected through the Setup>Analog Outputs menu.	V Out	I Out +
2			Ground	I Out -
3	A2		V Out	I Out +
4			Ground	I Out -
5	A3		V Out	I Out +
6			Ground	I Out -
7	A4		V Out	I Out +
8			Ground	I Out -

2.3.1.3 CURRENT LOOP ANALOG OUTPUTS (OPTION 41) SETUP

If your analyzer had this option installed at the factory, there are no further connections to be made. Otherwise, it can be installed as a retrofit for each of the analog outputs. This option converts the DC voltage analog output to a current signal with 0-20 mA output current, which can be scaled to any set of limits within that 0-20 mA range. However, most current loop applications call for either 2-20 mA or 4-20 mA range. All current loop outputs have a +5% over-range. Ranges with the lower limit set to more than 1 mA (e.g., 2-20 or 4-20 mA) also have a -5% under-range.

Figure 2-5 provides installation instructions and illustrates a sample configuration of one current output and two voltage outputs. Following Figure 2-5 are instructions for converting current loop analog outputs to standard 0-to-5 VDC outputs. To calibrate or adjust these outputs use the Setup>Analog Outputs menu (Section **Error! Reference source not found.**).



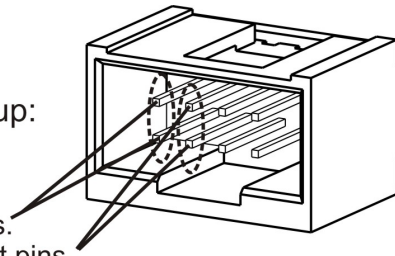
CAUTION – AVOID INVALIDATING WARRANTY

Servicing or handling of circuit components requires electrostatic discharge protection, i.e. ESD grounding straps, mats and containers. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty. For information on preventing ESD damage, refer to the manual, Fundamentals of ESD, PN 04786, which can be downloaded from our website at <http://www.teledyne-api.com>.

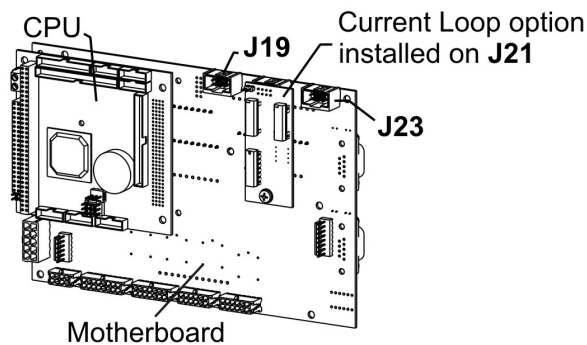
J19, J21, J23 Analog Output Setup:

- For **voltage** output of any one, two, or all:
 1. Jumper two leftmost pins.
 2. Jumper next two leftmost pins.
 3. Calibrate per Analog I/O Configuration menu.

- For **current** output of any one, two, or all:
 1. Remove jumper shunts.
 2. Install Current Loop option.
 3. Calibrate per Analog I/O Configuration menu.



J19, J21, J23



Example setup: install jumper shunts for voltage output on J19 and J23; remove jumper shunts and install Current Loop option for current output on J21.

Figure 2-5. Current Loop Option Installed on Motherboard

CONVERTING CURRENT LOOP ANALOG OUTPUTS TO STANDARD VOLTAGE OUTPUTS

To convert an output configured for current loop operation to the standard 0 to 5 VDC output operation:

1. Turn off power to the analyzer.
2. If a recording device was connected to the output being modified, disconnect it.
3. Remove the top cover.
 - Remove the screws fastening the top cover to the unit (both sides).
 - Slide the cover back and lift straight up.
4. Remove the screw holding the current loop option to the motherboard.
5. Disconnect the current loop option PCA from the appropriate connector on the motherboard (see Figure 2-5).
6. Each connector, J19 and J23, requires two shunts. Place one shunt on the two left-most pins and the second shunt on the two pins next to it (see Figure 2-5).
7. Reattach the top case to the analyzer.
 - The analyzer is now ready to have a voltage-sensing, recording device attached to that output.
8. Calibrate the analog output in the Setup>Analog Outputs>Analog Output Cal menu.

2.3.1.4 CONNECTING THE STATUS OUTPUTS (DIGITAL OUTPUTS)

The 12-pin STATUS connector allows the digital status outputs to report analyzer conditions (configured through the Setup>Digital Outputs menu) via optically isolated NPN transistors, which sink up to 50 mA of DC current. These outputs can be used to interface with devices that accept logic-level digital inputs, such as Programmable Logic Controllers (PLCs). Each status bit is an open collector output that can withstand up to 40 VDC. All of the emitters of these transistors are tied together and available at pin D (see Figure 2-6).

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Most PLCs have internal provisions for limiting the current that the input will draw from an external device. When connecting to a unit that does not have this feature, an external dropping resistor must be used to limit the current through the transistor output to less than 50 mA. At 50 mA, the transistor will drop approximately 1.2V from its collector to emitter.

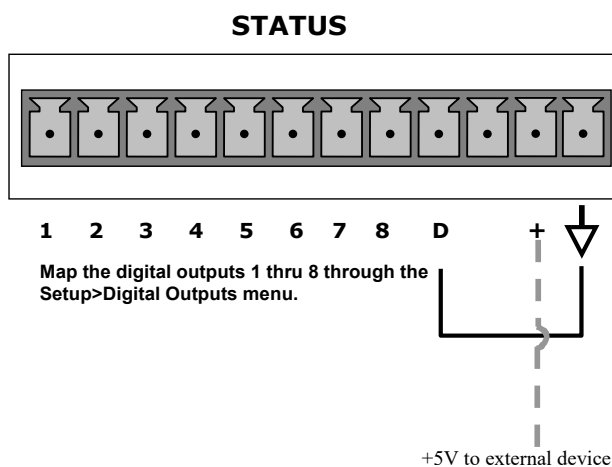


Figure 2-6. Status Output Connector for Digital Outputs

Table 2-4. Status Output Pin Assignments

PIN	STATUS DEFINITION	CONDITION
1-8	Configurable through the Setup>Digital Outputs menu	Collector side of individual status output opto-isolators.
D	Emitter BUS	The emitters of the transistors on pins 1 to 8 are bussed together.
Blank	NO CONNECTION	
+	DC Power	+ 5 VDC, 300 mA source maximum
↓	Digital Ground	The ground level from the analyzer's internal DC power supplies. This connection should be used as the ground return when +5VDC power is used.

2.3.1.5 CONNECTING THE CONTROL INPUTS (DIGITAL INPUTS)

With zero and span valves option installed, their digital control inputs are provided through the rear panel 10-pin **CONTROL IN** connector to remotely activate the zero and span calibration modes.

Energize the Control Inputs either by the internal +5V available from the pin labeled “+” (more convenient), or by a separate external 5 VDC power supply (ensures that these inputs are truly isolated). Refer to Figure 2-7

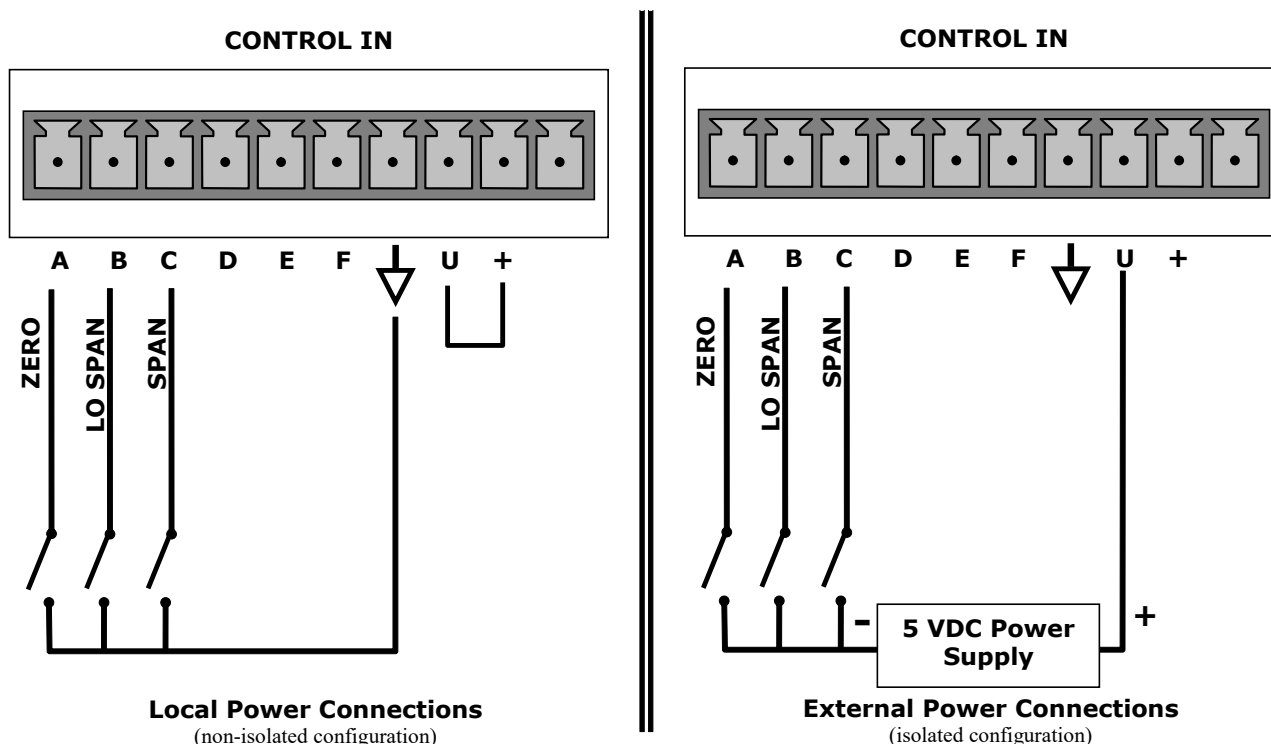



Figure 2-7. Control Input Connector

Table 2-5. Control Input Signals

INPUT #	STATUS DEFINITION	ON CONDITION
A	REMOTE ZERO CAL	The analyzer is placed in zero calibration mode.
B	REMOTE LOW SPAN CAL	The analyzer is placed in low span calibration mode.
C	REMOTE SPAN CAL	The analyzer is placed in span calibration mode.
D, E & F	SPARE	
	Digital Ground	The ground level from the analyzer's internal DC power supplies (same as chassis ground).
U	External Power input	Input pin for +5 VDC required to activate pins A – F.
+	5 VDC output	Internally generated 5V DC power. To activate inputs A – F, place a jumper between this pin and the “U” pin. The maximum amperage through this port is 300 mA (combined with the analog output supply, if used).

2.3.1.6 CONNECTING THE CONCENTRATION ALARM RELAY (OPTION 61)

The concentration alarm option provides four (4) “dry contact” relays on the rear panel (Figure 2-8) , each with 3 pins: Common (C), Normally Open (NO), and Normally Closed (NC). The Relays can be mapped to reflect various internal instrument conditions and states. ConFigure these outputs through the Setup>Digital Outputs menu (Section 2.5.7) under MB Relay [1 thru 4].

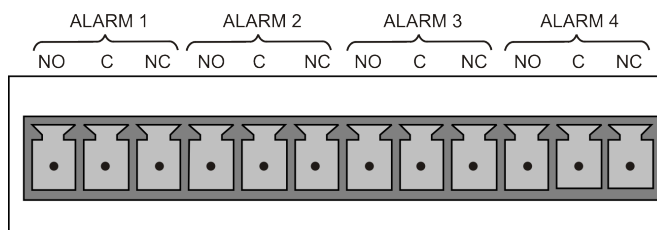


Figure 2-8. Concentration Alarm Relay

2.3.1.7 CONNECTING THE COMMUNICATION INTERFACES

For remote communications, the rear panel provides **Ethernet**, **USB**, **RS-232**, optional **RS-232 Multidrop**, and optional **RS-485** connectors. In addition to using the appropriate cables, each type of communication method must be configured using the SETUP>COMM menu, Section 2.5.10).

ETHERNET CONNECTION

For network or Internet communication with the analyzer, connect an Ethernet cable from the analyzer’s rear panel Ethernet interface connector to an Ethernet access port. Although Ethernet is DHCP-enabled by default, it should be manually configured (Section 2.5.10.5) with a static IP address.

USB (OPTION) CONNECTION

The rear panel USB option is for direct communication between the analyzer and a PC. Connect a USB cable between the analyzer and computer USB ports. The baud rate for the analyzer and the computer must match; see Section 3.2.

Note

If this option is installed, the COM2 port cannot be used for anything other than Multidrop communication.

RS-232 CONNECTION

For **RS-232** communications with data terminal equipment (**DTE**) or with data communication equipment (**DCE**) connect either a DB9-female-to-DB9-female cable) or a DB9-female-to-DB25-male cable, as applicable, from the analyzer's rear panel RS-232 port to the device. Adjust the rear panel DCE-DTE switch (Figure 2-2) to select DTE or DCE as appropriate.

Configuration: Section Section 3.2.1 and/or Section 3.4.2 (for Hessen protocol).

IMPORTANT

IMPACT ON READINGS OR DATA

Cables can appear to be compatible due to matching connectors, but their internal wiring can make the link inoperable. Check cables acquired from sources not from Teledyne API for pin assignments (Figure 2-9) before using.

Electronically, the difference between the DCE and DTE is the pin assignment of the Data Receive and Data Transmit functions.

- DTE devices receive data on pin 2 and transmit data on pin 3.
- DCE devices receive data on pin 3 and transmit data on pin 2.

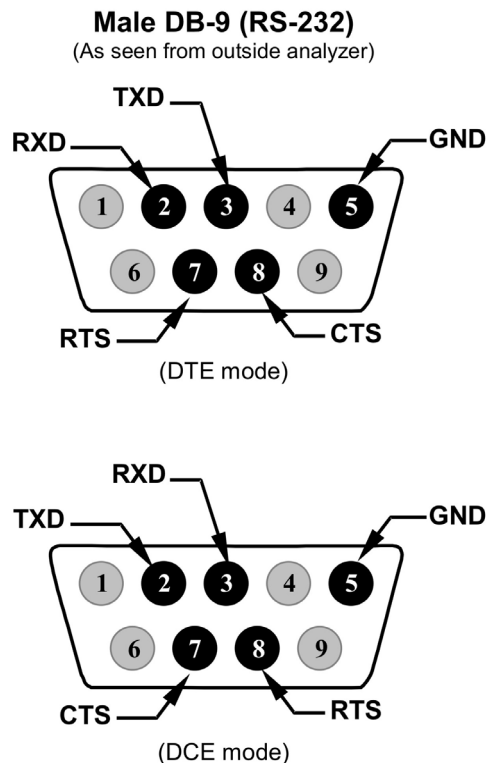


Figure 2-9. Rear Panel Connector Pin-Outs for RS-232 Mode

The signals from these two connectors are routed from the motherboard via a wiring harness to two 10-pin connectors on the CPU card, J11 (COM1) and J12 (COM2) (Figure 2-10).

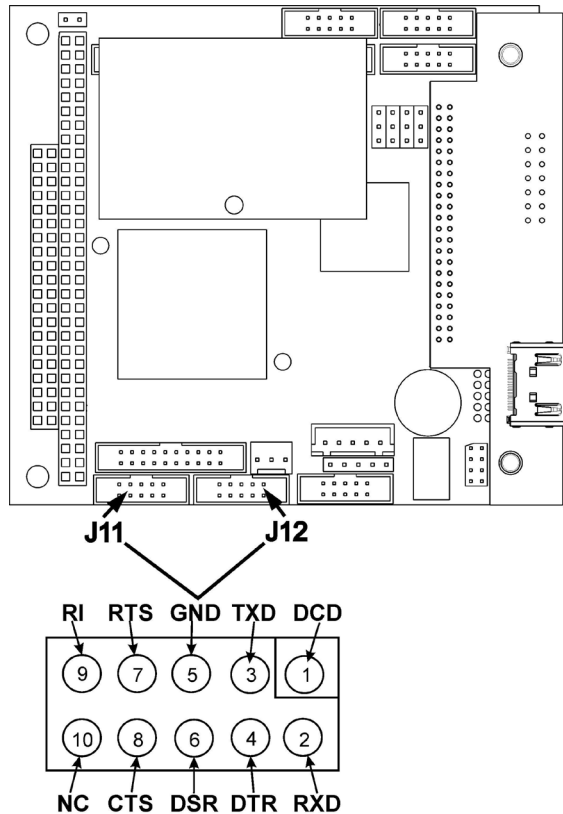


Figure 2-10. Default Pin Assignments for CPU COM Port connector (RS-232)

Received from the factory, the analyzer is set up to emulate an RS-232 DCE device, with Pin 3 of the DB-9 connector designated for receiving data and Pin 2 designated for sending data. (View these parameters in the Setup>Comm>COM1[COM2] menu).

- **RS-232 (COM1):** RS-232 (fixed) DB-9 male connector.
 - **Baud rate:** 115200 bits per second (baud)
 - **Data Bits:** 8 data bits with 1 stop bit
 - **Parity:** None
- **COM2:** RS-232 (configurable to RS-485), DB-9 female connector.
 - **Baud rate:** 19200 bits per second (baud)
 - **Data Bits:** 8 data bits with 1 stop bit
 - **Parity:** None

RS-232 MULTIDROP OPTION CONNECTION

When the RS-232 Multidrop option is installed, connection adjustments and configuration through the menu system are required. This Section provides instructions for adjusting the internal connections, then for making the external connections, and ends with instructions for menu-driven configuration.

Note Because the RS-232 Multidrop option uses both the RS232 and COM2 DB9 connectors on the analyzer's rear panel to connect the chain of instruments, COM2 port is no longer available for separate RS-232 or RS-485 operation.

ATTENTION **COULD DAMAGE INSTRUMENT AND VOID WARRANTY**
Printed Circuit Assemblies (PCAs) are sensitive to electrostatic discharges too small to be felt by the human nervous system. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty. Refer to the manual, Fundamentals of ESD, PN 04786, which can be downloaded from our website at <http://www.teledyne-api.com> under Help Center > Product Manuals in the Special Manuals section.

In each instrument with the Multidrop option there is a shunt jumpering two pins on the serial Multidrop and LVDS printed circuit assembly (PCA), as shown in Figure 2-11. This shunt must be removed from all instruments except that designated as last in the multidrop chain, which must remain terminated. This requires powering off and opening each instrument and making the following adjustments:

1. With **NO power** to the instrument, remove its top cover and lay the rear panel open for access to the Multidrop/LVDS PCA, which is seated on the CPU.
2. On the Multidrop/LVDS PCA's JP2 connector, remove the shunt that jumpers Pins 21 ↔ 22 as indicated in. (Do this for all but the last instrument in the chain where the shunt should remain at Pins 21 ↔ 22).
3. Check that the following cable connections are made in *all* instruments (again refer to Figure 2-11):
 - J3 on the Multidrop/LVDS PCA to the CPU's COM1 connector
(Note that the CPU's COM2 connector is not used in Multidrop)
 - J4 on the Multidrop/LVDS PCA to J12 on the motherboard
 - J1 on the Multidrop/LVDS PCS to the front panel LCD

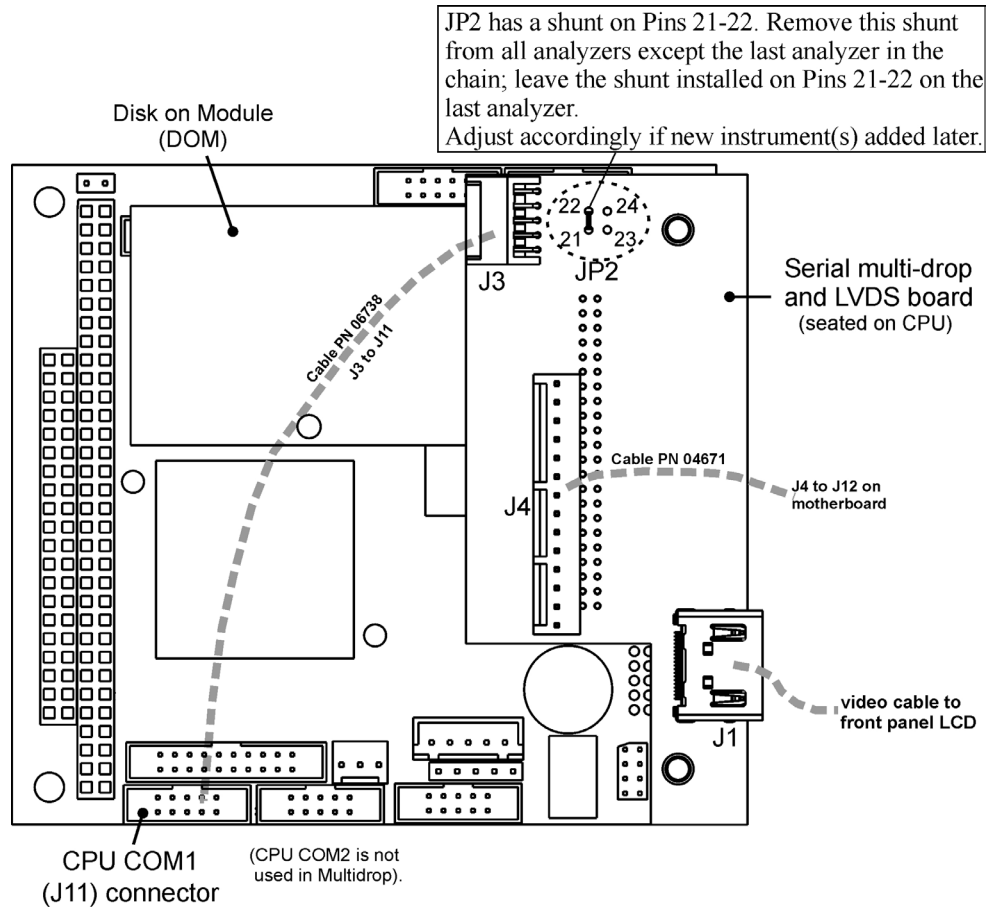


Figure 2-11. Jumper and Cables for Multidrop Mode

Note

If you are adding an instrument to the end of a previously configured chain, remove the shunt between Pins 21 ↔ 22 of JP2 on the Multidrop/LVDS PCA in the instrument that was previously the last instrument in the chain.

4. Close the instrument.
5. Referring to Figure 2-12 use straight-through DB9 male → DB9 female cables to interconnect the host RS232 port to the first analyzer's RS232 port; then from the first analyzer's COM2 port to the second analyzer's RS232 port; from the second analyzer's COM2 port to the third analyzer's RS232 port, etc., connecting in this fashion up to eight analyzers, subject to the distance limitations of the RS-232 standard.
6. On the rear panel of each analyzer, adjust the DCE DTE switch so that the green and the red LEDs (RX and TX) of the COM1 connector (labeled RS232) are both lit. (Ensure you are using the correct RS-232 cables internally wired specifically for RS-232 communication; see **Error! Reference source not found.**, "Communication Cables" and Section 2.3.1.7: Connecting the Communications Interfaces, "RS-232 Connection").

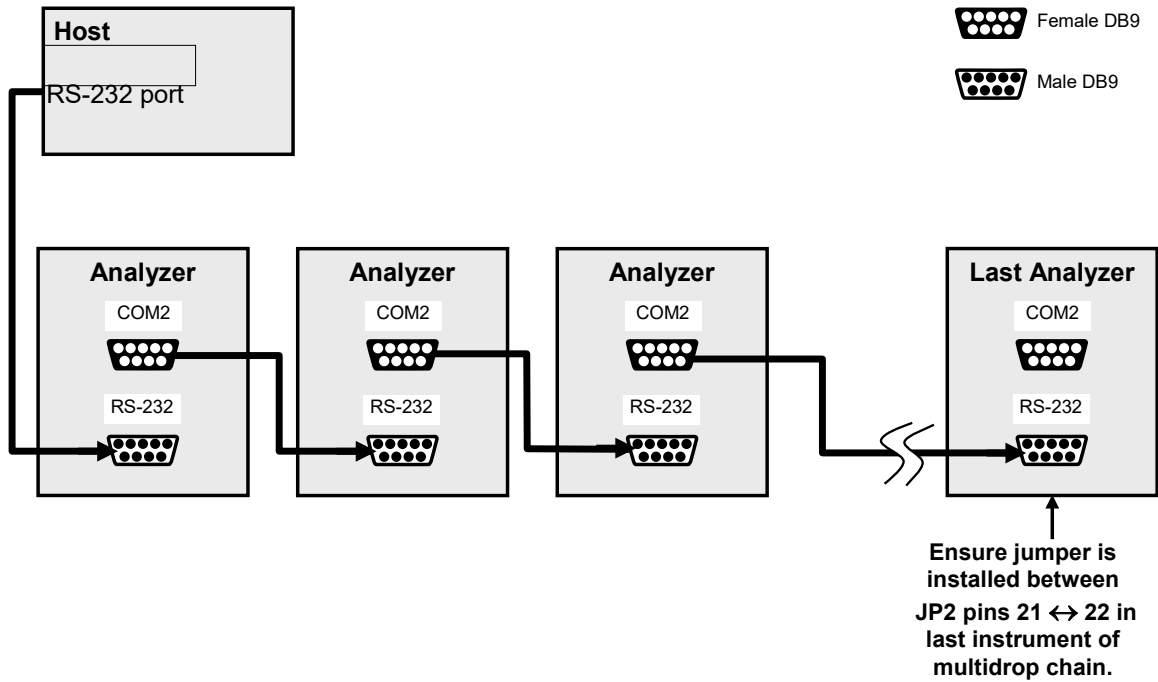


Figure 2-12. RS-232-Multidrop PCA Host/Analyzer Interconnect Diagram

7. BEFORE communicating from the host, power on the instruments and check that the Machine ID code is unique for each. In the Setup>Vars menu, check Instrument ID in the list of variables. To change, select the variable and press the Edit button; once changed, press the Enter button.
8. Next, in the Setup>Comm>COM1 menu (do not use the COM2 menu for multidrop), use the Edit button to set COM1 Quiet Mode and COM1 Multidrop to ENABLED; then press the Accept button.
9. Also check the COM1 Baud Rate to ensure it reads the same for all instruments (edit if needed and press the Accept button).

Note

- Instrument ID's must not be duplicated.
- The (communication) Host instrument can only address one instrument at a time.
- Teledyne API recommends setting up the first link, between the Host and the first analyzer, and testing it before setting up the rest of the chain.

2.3.2 PNEUMATIC CONNECTIONS

This Section provides not only pneumatic connection information, but also important information about the gases required for accurate calibration. Pneumatic flow diagrams are shown in Section 2.3.3. Calibration instructions are provided in Section 4.

Before making the pneumatic connections, carefully note the following cautionary and special messages:

CAUTION – General Safety Hazard



- Ozone (O₃) is a toxic gas. Do not vent calibration gas or sample gas into enclosed areas.
- Obtain a Safety Data Sheet (SDS) for this material. Read and rigorously follow the safety guidelines described there.
- Sample and calibration gases should only come into contact with PTFE (Teflon), FEP, or glass
- Venting should be outside the shelter or immediate area surrounding the instrument.
- It is important to conform to all safety requirements regarding exposure to O₃.

ATTENTION**COULD DAMAGE INSTRUMENT AND VOID WARRANTY****Maximum Pressure:**

Ideally the maximum pressure of any gas at the sample inlet should equal ambient atmospheric pressure and should **NEVER** exceed 1.5 in-hg above ambient pressure.

Venting Pressurized Gas:

In applications where any gas (span gas, zero air supply, sample gas is) received from a pressurized manifold, a vent must be provided to equalize the gas with ambient atmospheric pressure before it enters the analyzer to ensure that the gases input do not exceed the maximum inlet pressure of the analyzer, as well as to prevent back diffusion and pressure effects. These vents should be:

- at least 0.2m long
- no more than 2m long
- vented outside the shelter or immediate area surrounding the instrument.

Dust Plugs:

Remove dust plugs from rear panel exhaust and supply line fittings before powering on/operating instrument. These plugs should be kept for reuse in the event of future storage or shipping to prevent debris from entering the pneumatics.

IMPORTANT**LEAK CHECK**

Run a leak check once the appropriate pneumatic connections have been made; check all pneumatic fittings for leaks using the procedures defined in Section 5.6.3.

See Figure 2-2 and Table 2-2 for the location and descriptions of the various pneumatic inlets/outlets referenced in this section.

2.4.1.1 IMPORTANT INFORMATION ABOUT CALIBRATION GASES

Zero air and span gas are required for accurate calibration.

ZERO AIR

Zero air is a gas that is similar in chemical composition to the earth's atmosphere but scrubbed of all components that might affect the analyzer's readings. If your analyzer is equipped with an Internal Zero Span (IZS) or an external zero air scrubber option, it is capable of creating zero air. For analyzers without an IZS or external zero air scrubber option, a zero air generator such as the Teledyne API Model T701 can be used.

CALIBRATION (SPAN) GAS

Span gas is specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the desired measurement range. Because ozone (O_3) quickly breaks down into molecular oxygen (O_2), this calibration gas cannot be supplied in precisely calibrated bottles like other gases.

- If the T400 analyzer is not equipped with the optional internal zero air generator (IZS), an external O_3 generator capable of supplying accurate O_3 calibration mixtures must be used.
- Also, some applications, such as EPA monitoring, require multipoint calibration checks where Span gas of several different concentrations is needed.
- In either case, we recommend using a Gas Dilution Calibrator such as a TAPI Model T700 with internal photometer option.

In the case of O_3 measurements made with the Model T400 photometric ozone analyzer, it is recommended that you use a span gas with an O_3 concentration equal to 90% of the reporting range for your application.

EXAMPLE:

- If the application is to measure between 0 ppm and 500 ppb, an appropriate span gas would be 450 ppb.
- If the application is to measure between 0 ppb and 1000 ppb, an appropriate span gas would be 800 ppb.

2.3.2.1 PNEUMATIC CONNECTIONS: BASIC CONFIGURATION

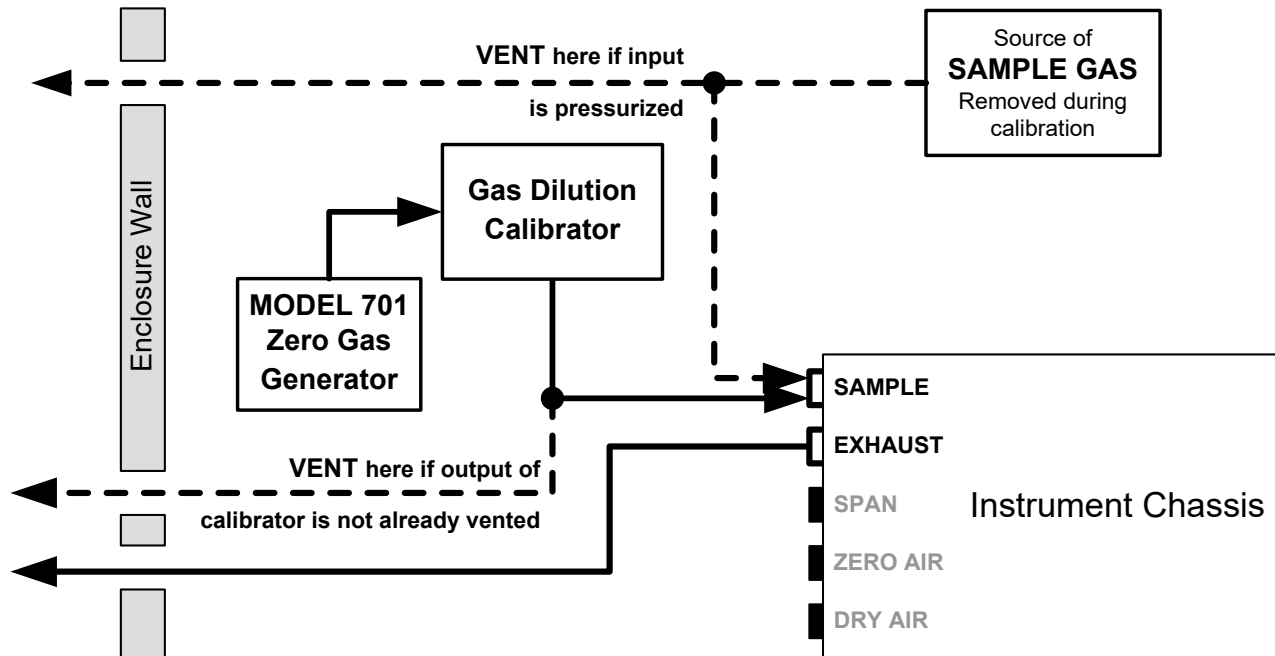


Figure 2-13. Gas Line Connections for the T400 Analyzer – Basic Configuration

For the Model T400 photometric ozone analyzer in its basic configuration (i.e. without the optional internal zero air source or valves), attach the following pneumatic lines:

SAMPLE GAS SOURCE

Attach a sample inlet line to the **SAMPLE** inlet port.

- Sample Gas pressure must equal ambient atmospheric pressure (1.0 psig)
- In applications where the sample gas is received from a pressurized manifold, a vent must be placed on the sample gas line. This vent line must be:
 - At least 0.2m long
 - No more than 2m long
 - Vented outside the shelter or immediate area surrounding the instrument

CALIBRATION GAS SOURCES

The source of calibration gas is also attached to the **SAMPLE** inlet, but only when a calibration operation is actually being performed.

EXHAUST OUTLET

Attach an exhaust line to the analyzer's **EXHAUST** outlet fitting. The exhaust line should be:

- PTFE tubing; minimum O.D $\frac{1}{4}$ ";
- A maximum of 10 meters long;
- Vented outside the analyzer's enclosure.

LEAK CHECK

Once the appropriate pneumatic connections have been made, check all pneumatic fittings for leaks using the procedures defined in Section 5.6.3.

2.3.2.2 PNEUMATIC CONNECTIONS: ZERO/SPAN (Z/S) OPTION

For a Model T400 photometric ozone analyzer with the optional zero/span valves, attach the pneumatic lines as described in this section.

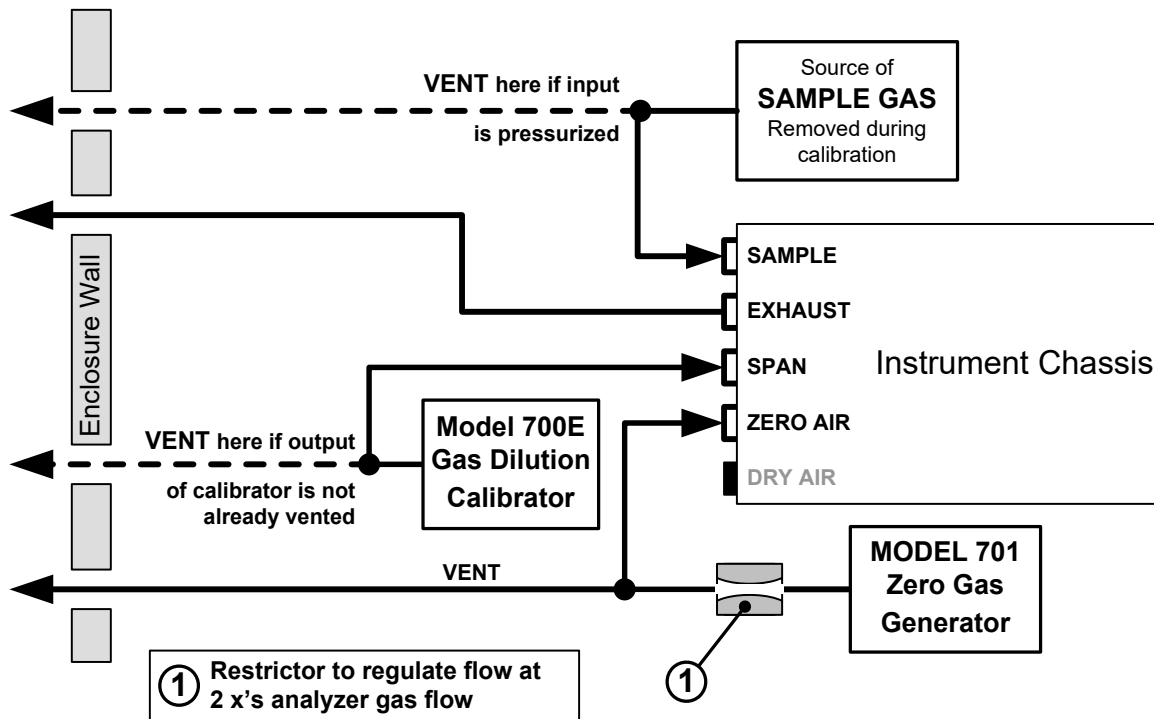


Figure 2-14. Gas Line Connections for the T400 Analyzer with Zero/Span Valve Option (OPT 50A)

The instrument's zero air and span gas flow rate required for this option is 800 cc/min, however, the US EPA recommends that the cal gas flow rate be at least 1600 cc/min.

SAMPLE GAS SOURCE

Attach a sample inlet line to the **SAMPLE** inlet fitting.

- Sample Gas pressure must equal ambient atmospheric pressure (1.0 psig)
- In applications where the sample gas is received from a pressurized manifold, a vent must be placed on the sample gas line. This vent line must be:
 - At least 0.2m long
 - No more than 2m long
 - Vented outside the shelter or immediate area surrounding the instrument

CALIBRATION (SPAN) GAS SOURCE

Attach a gas line from the source of calibration gas (e.g. a Teledyne API T700 Dynamic Dilution Calibrator) to the **SPAN** inlet.

- Span gas can be generated by a M700E Mass Flow Calibrator equipped with a Photometer Option or an M703E UV Photometric Ozone Calibrator.

ZERO AIR

Attach a gas line from the source of zero air (e.g. a Teledyne API M701 zero air Generator) to the **ZERO AIR** inlet.

- Zero air can be supplied by the API M701 zero air generator.
- A restrictor is required to regulate the gas flow at 2x the gas flow of the analyzer.

VENTING

In order to prevent back diffusion and pressure effects, both the span gas and zero air supply lines should be:

- Vented outside the enclosure
- Not less than 2 meters in length
- Not greater than 10 meters in length

EXHAUST OUTLET

Attach an exhaust line to the **EXHAUST** outlet fitting. The exhaust line should be:

- ¼" PTFE tubing
- A maximum of 10 meters long
- Vented outside the T400 analyzer's enclosure



CAUTION – Ozone Exposure Risk

Venting should be outside the shelter or immediate area surrounding the instrument and conform to all safety requirements regarding exposure to O₃.

Once the appropriate pneumatic connections have been made, check all pneumatic fittings for leaks using the procedures defined in Section 5.6.5).

2.3.2.3 PNEUMATIC CONNECTIONS: INTERNAL ZERO/SPAN (IZS) OPTION

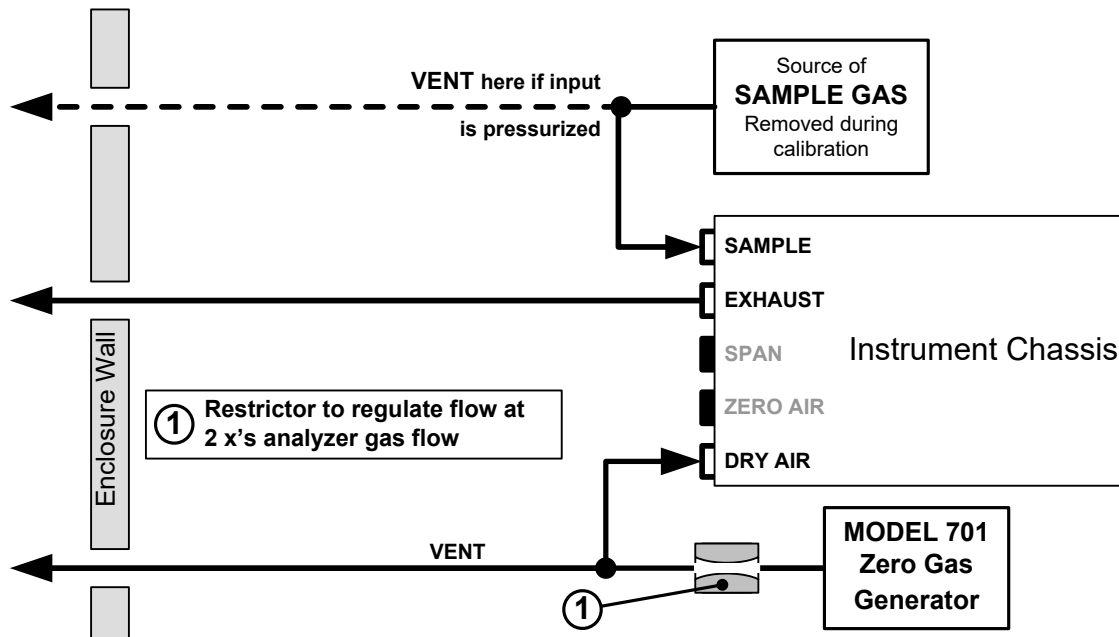


Figure 2-15. Gas Line Connections for the T400 Analyzer with IZS Option (OPT 50G)

SAMPLE GAS SOURCE

Attach a sample inlet line to the SAMPLE inlet port.

- Sample Gas pressure must equal ambient atmospheric pressure (1.0 psig)
- In applications where the sample gas is received from a pressurized manifold, a vent must be placed on the sample gas line. This vent line must be:
 - At least 0.2m long
 - No more than 2m long
 - Vented outside the shelter or immediate area surrounding the instrument

ZERO AIR SOURCE

Attach a gas line from the source of zero air (e.g., a Teledyne API M701 zero air Generator) to the **DRY AIR** inlet.

- The gas from this line will be used internally as zero air and as source air for the internal O₃ generator

EXHAUST OUTLET

Attach an exhaust line to the EXHAUST outlet fitting. The exhaust line should be:

- PTFE tubing; minimum O.D ¼”;
- A maximum of 10 meters long;
- Vented outside the analyzer’s enclosure.

LEAK CHECK

Once the appropriate pneumatic connections have been made, check all pneumatic fittings for leaks using the procedures defined in Section 5.6.3.

2.3.2.4 PNEUMATIC CONNECTIONS: AMBIENT AIR MONITORING IN SAME ROOM

In this application it is often preferred that the sample gas and the source gas for the O₃ generator and internal zero air be the same chemical composition.

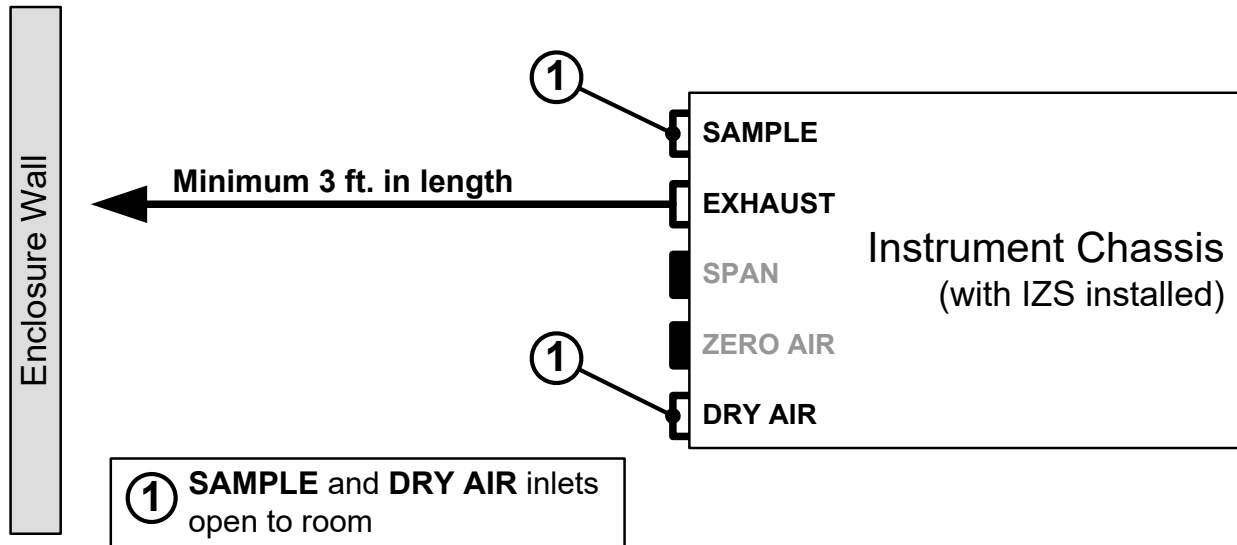


Figure 2-16. Gas Line Connections when the T400 Analyzer is Located in the Room Being Monitored

SAMPLE GAS AND DRY AIR SOURCES

For instruments located in the same room being monitored, there is no need to attach the gas inlet lines to the **SAMPLE** inlet or the **DRY AIR** inlet.

EXHAUST OUTLET

Attach an exhaust line to the **EXHAUST** outlet fitting. The end of the exhaust line should be at least 2 feet from the rear panel of the instrument in order to prevent sampling its own exhaust (resulting in low readings).

LEAK CHECK

Once the appropriate pneumatic connections have been made, check all pneumatic fittings for leaks using the procedures defined in Section 5.6.3.

2.3.2.5 PNEUMATIC CONNECTIONS: AMBIENT AIR MONITORING IN REMOTE LOCATIONS

In this application it is often preferred that the Sample gas and the source gas for the O₃ generator and internal zero air be the same chemical composition.

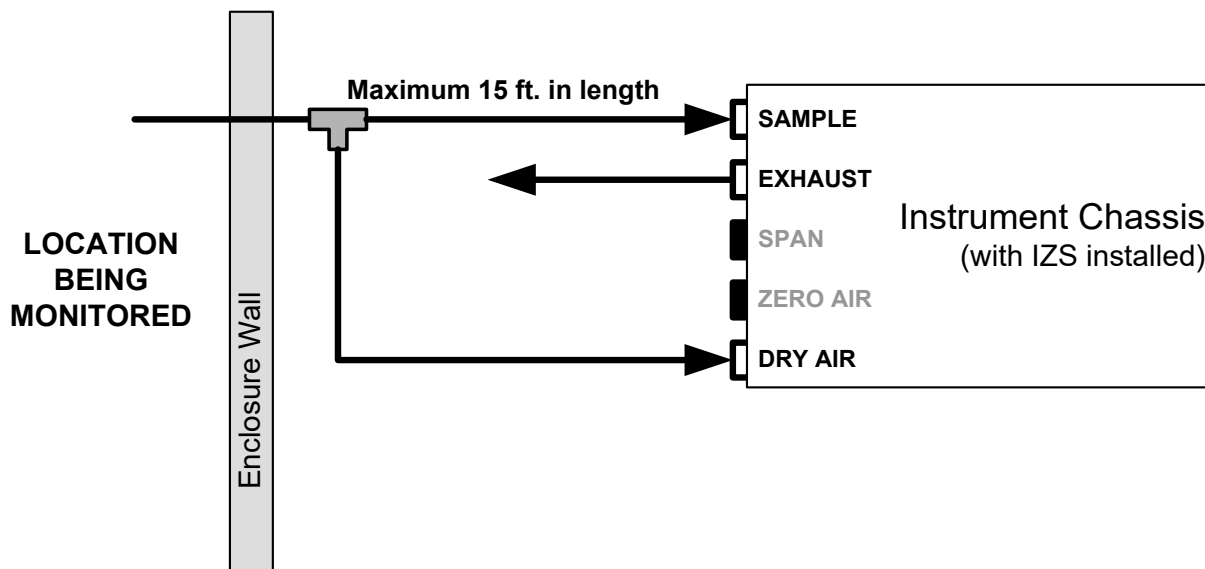


Figure 2-17. Gas Line Connections when the T400 Analyzer is Monitoring a Remote Location

SAMPLE GAS SOURCE

Attach a sample inlet line leading from the room being monitored to the **SAMPLE** inlet fitting.

DRY AIR SOURCE

Attach a gas line leading from the room being monitored to the **DRY AIR** inlet port. This can be a separate line or, as shown above (Figure 2-17) in the same line with a T-fitting.

EXHAUST OUTLET

No outlet line is required for the exhaust port of the instrument.

LEAK CHECK

Once the appropriate pneumatic connections have been made, check all pneumatic fittings for leaks using the procedures defined in Section 5.6.3.

2.3.3 PNEUMATIC FLOW DIAGRAMS

This Section shows the pneumatic flow diagrams for basic and Internal Zero Span (IZS) configurations.

2.3.3.1 PNEUMATIC FLOW: BASIC CONFIGURATION

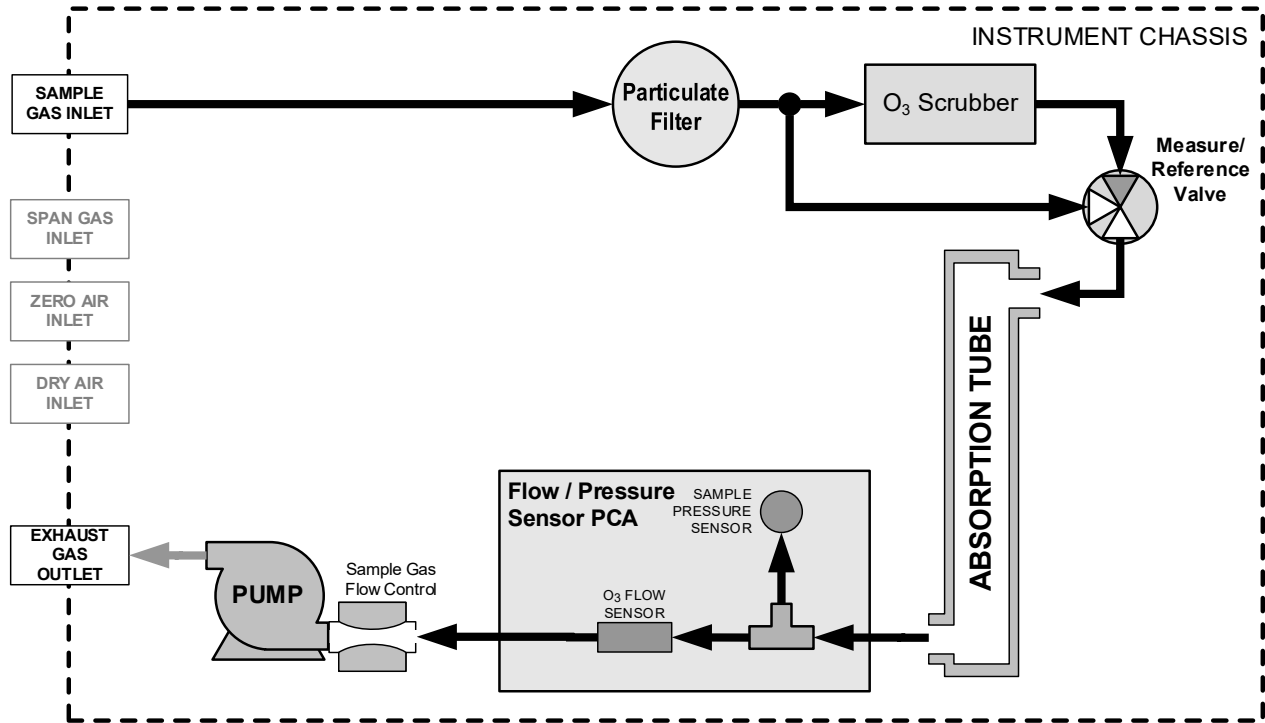


Figure 2-18. T400 Pneumatic Diagram – Basic Unit

2.3.3.2 PNEUMATIC FLOW: ZERO/SPAN (ZS) VALVE OPTION

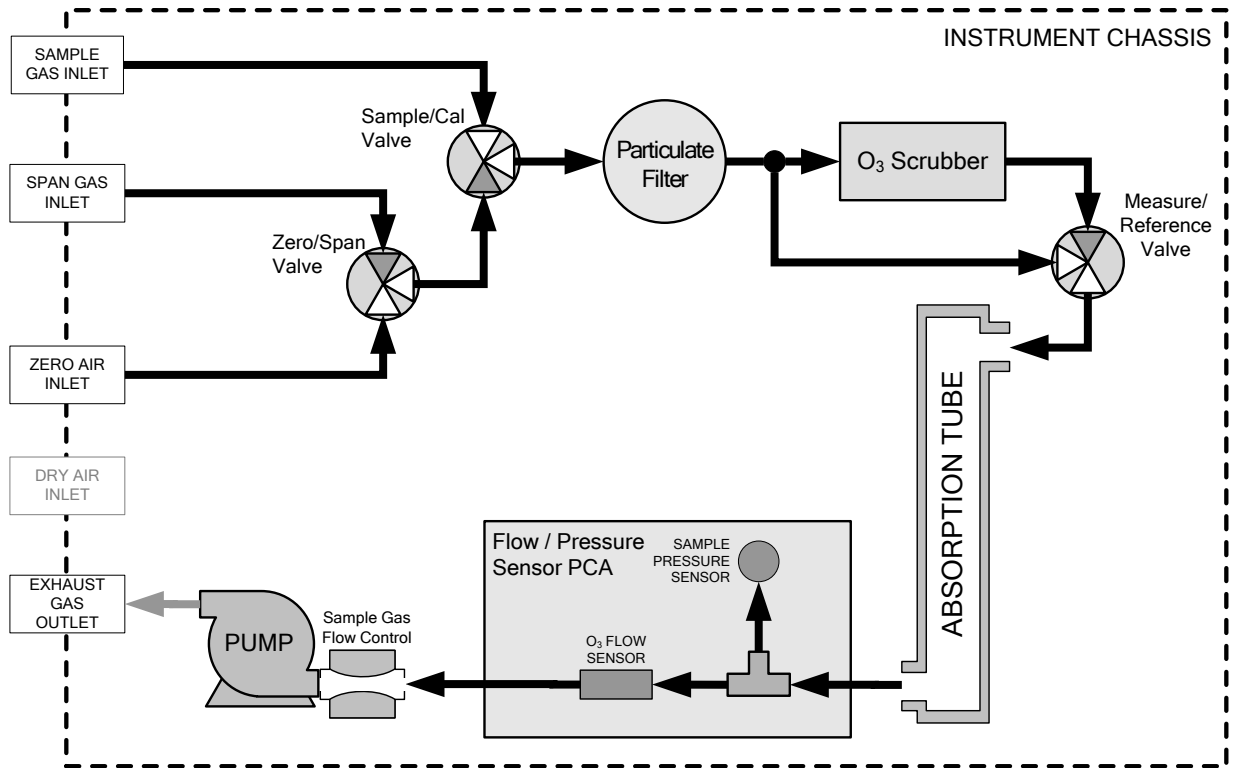


Figure 2-19. T400 Pneumatic Diagram with Zero/Span (ZS) Option (OPT50A)

Table 2-6. Zero/Span Valve Operating States for Option 50A

Mode	Valve	Condition
SAMPLE	Sample/Cal	Open to SAMPLE inlet
	Zero/Span	Open to ZERO AIR inlet
ZERO CAL	Sample/Cal	Open to ZERO/SPAN valve
	Zero/Span	Open to ZERO AIR inlet
SPAN CAL	Sample/Cal	Open to ZERO/SPAN valve
	Zero/Span	Open to SPAN GAS inlet

The state of the Sample/Cal valves can be controlled:

- Manually via the analyzer's front panel;
- By activating the instrument's AutoCal feature (See Section 4.3);
- Remotely by using the External Digital I/O Control Inputs (See Section 4.2.2.1)

2.3.3.3 PNEUMATIC FLOW: INTERNAL ZERO/SPAN (IZS) VALVE OPTION

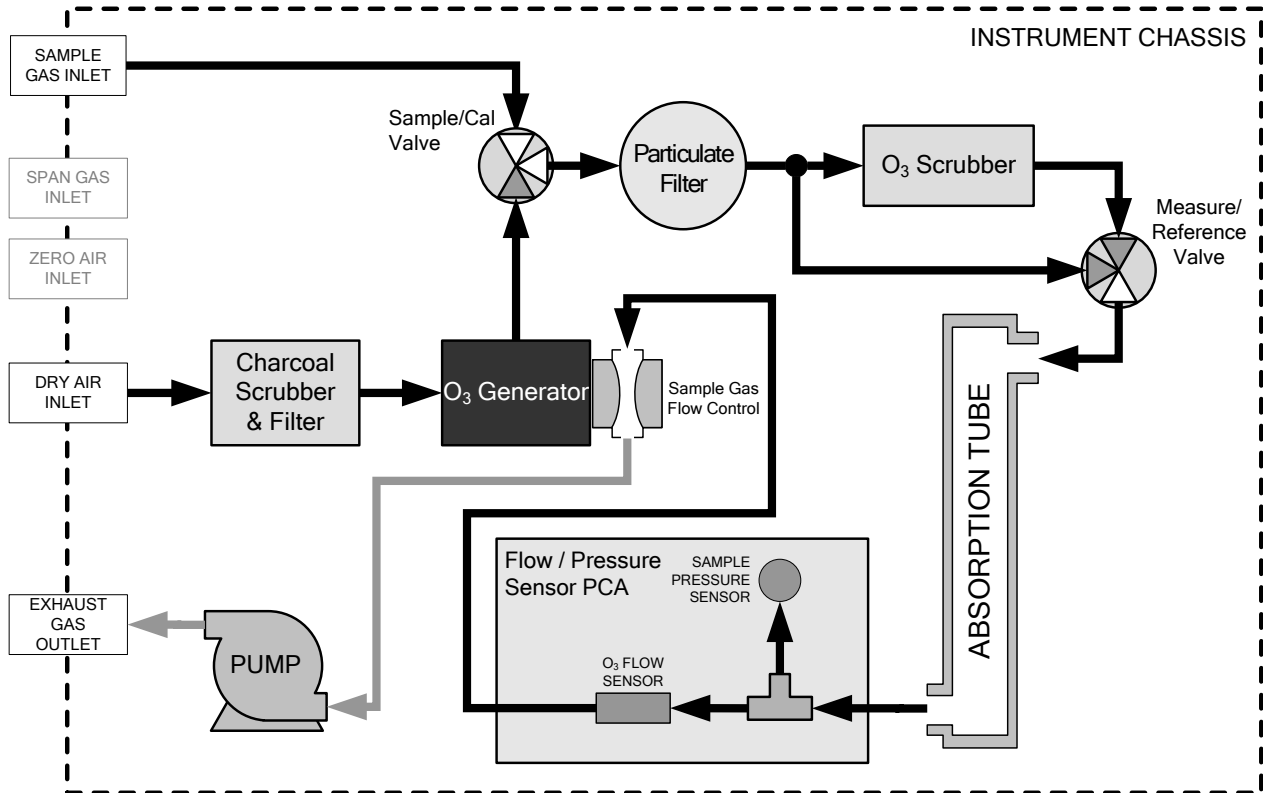


Figure 2-20. T400 Pneumatic Diagram with Internal Zero/Span (IZS) Option (OPT50G)

Table 2-7. Internal Zero/Span Valve Operating States for Option 50G

Mode	Valve	Condition
SAMPLE	Sample/Cal Valve	Open to SAMPLE inlet
	Ozone Generator	OFF
ZERO CAL	Sample/Cal Valve	Open to Ozone Generator
	Ozone Generator	OFF
SPAN CAL	Sample/Cal Valve	Open to Ozone Generator
	Ozone Generator	ON at intensity level set by user

The state of the Sample/Cal valves can be controlled:

- Manually via the analyzer's front panel;
- By activating the instrument's AutoCal feature (See Section 4.3);
- Remotely by using the External Digital I/O Control Inputs (See Section 4.2.2.1)

2.3.4 STARTUP, FUNCTIONAL CHECKS, AND INITIAL CALIBRATION

We recommend reading Section 6 to become familiar with the principles of operation.

When the instrument is first started (Section 2.3.4.1, check its functionality (Section 2.3.4.3) and run an initial calibration (Section 4). Section 2.4 introduces the menu system, and Section 2.5 provides setup/customization instructions.

2.3.4.1 STARTUP

Upon initial startup, a sequence of status screens (Figure 2-21) appear prior to the Home page (Figure 2-22).

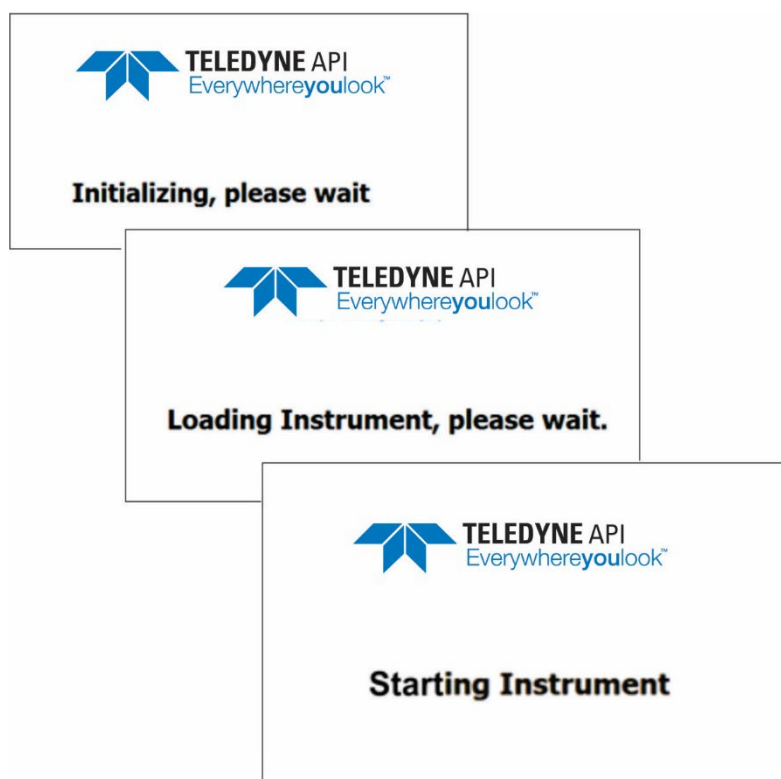


Figure 2-21. Status Screens at Startup

Upon any startup, this instrument should warm up for approximately one hour before reliable measurements can be taken.

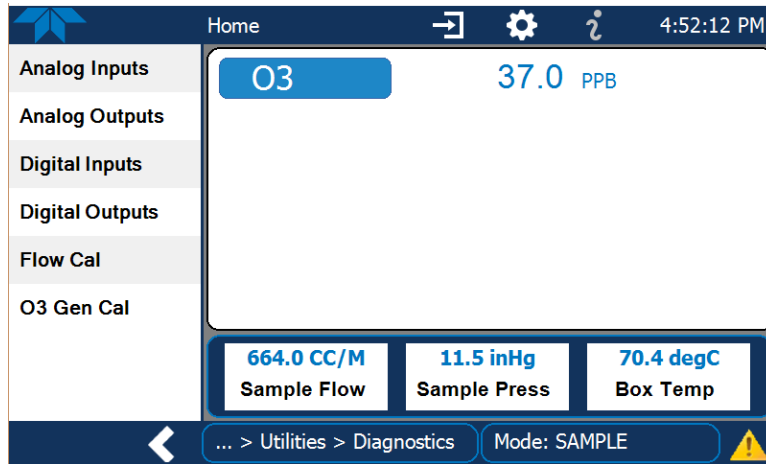


Figure 2-22. Home Page Example

2.3.4.2 ALERTS: WARNINGS AND OTHER MESSAGES

Because internal temperatures and other conditions may be outside the specified limits during the analyzer’s warm-up period, the software will suppress most Alerts for 30 minutes after power up. The Alerts page (Figure 2-23) shows the status of any active warning conditions or user-configured Events. (Section 2.4.3 provides more detailed information about Alerts, and Section 2.5.2 addresses Events).

Alerts can be viewed and cleared via either the Alerts menu or the Alerts shortcut (Caution symbol, bottom right corner of the screen). Although these alerts can be cleared from the Active Alerts page, a history of all alerts remains in the Utilities>Alerts Log page.

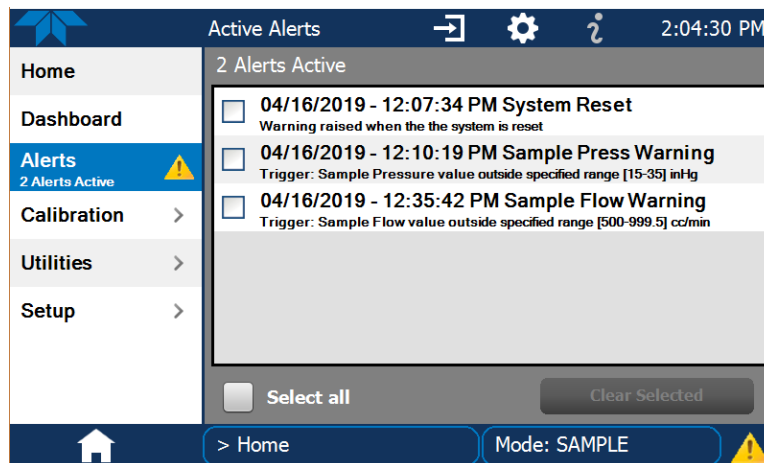


Figure 2-23. Viewing Active Alerts Page

If Alerts about warning conditions persist after the warm up period or after being cleared, investigate their cause using the troubleshooting guidelines in Section 5.7.

2.3.4.3 FUNCTIONAL CHECKS

After warm-up, verify that the software properly supports any hardware options that are installed (Setup>Instrument menu), and that the instrument is functioning within allowable operating parameters. Check the Dashboard page against the instrument’s Final Test and Validation Data sheet, which lists these values as they appeared before the instrument left the factory. (If any functional parameters are not displayed, configure the Dashboard through the Setup>Dashboard menu to add them; see Section 2.4.2).

These functions are also useful tools for diagnosing problems (information provided in Section 5.7.2).

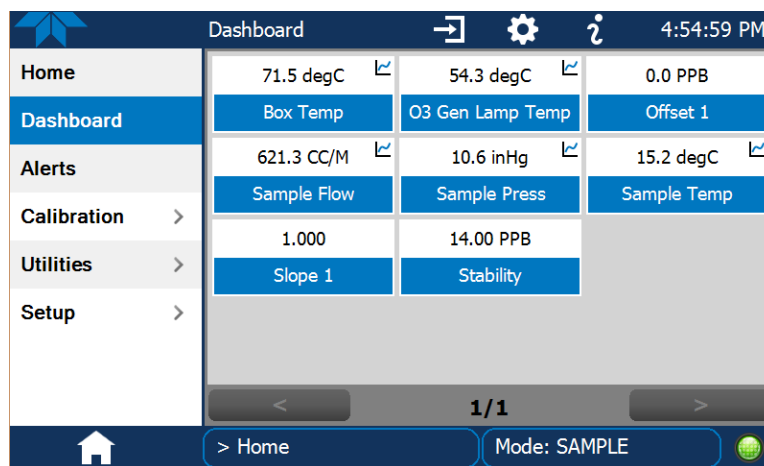


Figure 2-24. Sample Dashboard Page

2.3.4.4 INITIAL CALIBRATION

Before operation begins, the analyzer requires initial calibrations for the location in which it will perform any of the gas analyses. Also, any time an analyzer is moved or its configuration changed, it must be calibrated. The method for performing a calibration differs slightly depending on whether or not any of the available internal zero air or valve options are installed. Follow the appropriate calibration instructions in Section 4.

2.4 MENU OVERVIEW

Table 2-8 describes the main menus and provides cross-references to the respective sections with configuration details.

Table 2-8. Menu Overview

MENU	DESCRIPTION	LOCATION
Home	View and plot concentration readings and other selectable parameter values (Figure 2-26).	Section 2.4.1
Dashboard	View user-selected parameters and their values, some of which can be displayed in a live-plot graph (Figure 2-27).	Section 2.4.2
Alerts	View and clear active Alerts that were triggered by factory-defined Events as well as user-defined Events. (Active and past Alerts are recorded in the Utilities>Alerts Log).	Section 2.4.3
Calibration	Run a multipoint calibration on the gas (or additional gas if 2 nd sensor option installed), and span and zero calibrations (if valve option installed).	Section 4
Utilities	View logs, download data and firmware updates, copy configurations between instruments, and run diagnostics.	Section 2.4.5
Setup	Configure a variety of features and functions through these submenus for customized operation.	Section 2.5
Datalogging	Track and record concentration and calibration data and selectable diagnostic parameters, the reports for which can be viewed in the Utilities>Datalog View menu (Section 2.4.5) and downloaded to a flash drive via the Utilities>USB Utilities menu (Section 2.4.5). Also, select configured Events (Section 2.5.2) and create customized triggers for data logging functions.	Section 2.5.1
Events	Select parameters and define the conditions by which they are to be flagged and recorded in the Alerts log (Section 2.4.3) when they are triggered. Once configured, Events can be used to trigger Datalogs. (Section 2.5.1). Note that some Events are predefined and are not editable.	Section 2.5.2
Dashboard	Monitor instrument functionality (Figure 2-24) via selectable parameters.	Section 2.5.3
Auto Cal (with valve options)	When zero/span valve options installed, configure sequences for automatic calibration functions.	Section 4.3
Vars	Manually adjust several software variables that define specific operational parameters.	Section 2.5.5
Homescreen	Select up to three parameters to be displayed in the meters (Figure 2-25).	Section 2.5.6
Digital Outputs	Map the rear-panel digital outputs to a variety of signals present in the instrument to monitor the status of operating conditions or custom Events.	Section 2.5.7
Analog Outputs	Send user-selected parameter readings in the form of user-defined voltage or current loop signals as outputs to a strip chart recorder and/or the data logger.	Section 2.5.8
Instrument	View product and system information, including list of options, if any; view network settings; view/adjust Date and Time settings*; and check for firmware updates when connected to a network that is connected to the Internet. *Time Zone change requires special procedures (Section 5.5).	Section 2.5.9
Comm	View and configure network and serial communications.	Section 2.5.10

2.4.1 HOME PAGE

Figure 2-25 presents an orientation to the main display screen; Figure 2-26 shows that pressing the gas name or its concentration value or a meter below displays a live plot of their respective readings. Section 2.5.6 provides configuration instructions.

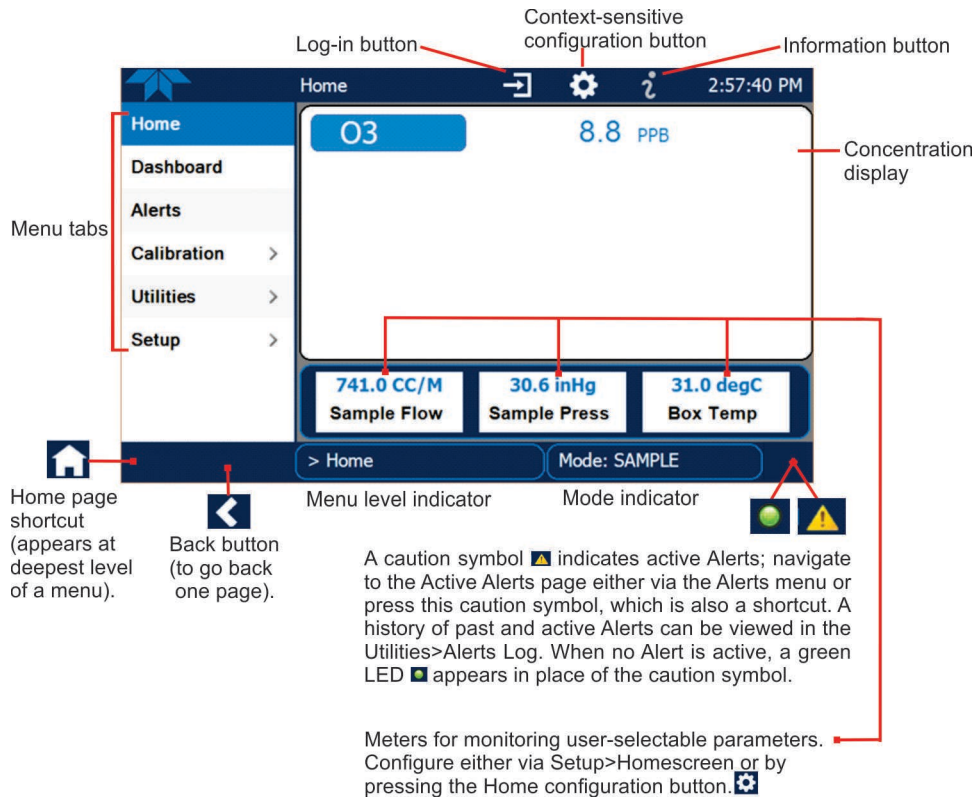


Figure 2-25. User Interface Orientation

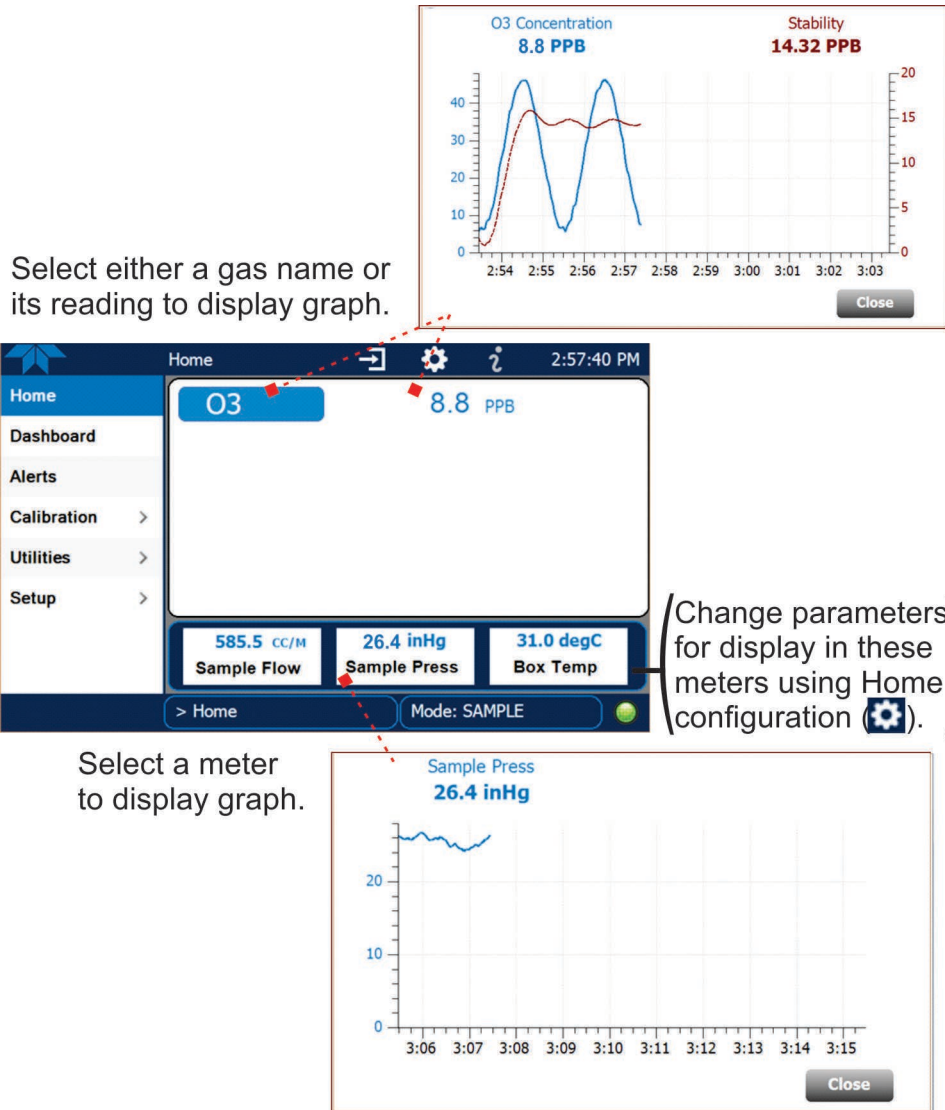
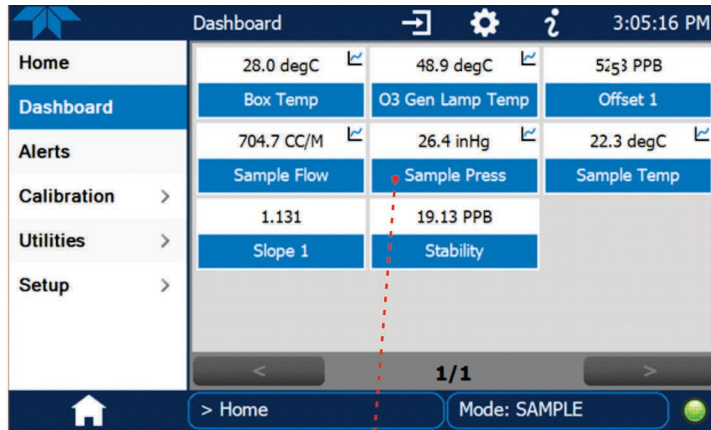


Figure 2-26. Concentration and Stability Graph (top) and Meter Graph (bottom)

2.4.2 DASHBOARD

The Dashboard displays an array of user-selectable parameters and their values (Section 2.5.3 provides configuration instructions). If there is a graphing icon in the upper right corner of a parameter, pressing that parameter displays a live plot of its readings as in Figure 2-27.



Select a graphable parameter in the Dashboard page to view a live plot.

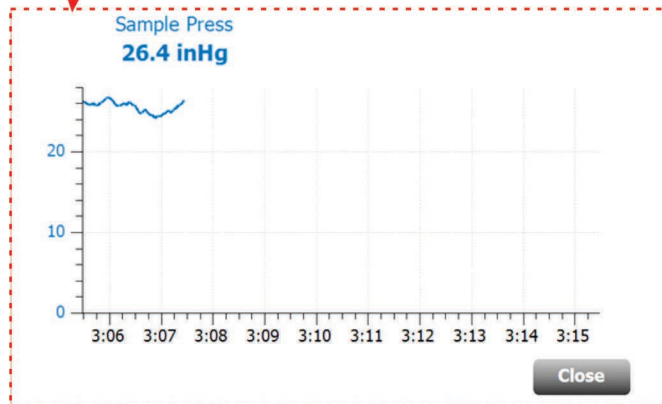


Figure 2-27. Dashboard Page

Several of the common parameters and their descriptions are presented in Table 2-9.

Table 2-9. Common Dashboard Parameters

PARAMETER	UNITS	DESCRIPTION
Box Temp	°C	The temperature inside the analyzer chassis.
Offset	PPB	The Offset of the instrument as calculated during the last calibration activity.
Photo Lamp Temp	°C	The temperature of the UV Lamp in the Optical Bench.
Photo Meas	MV	The average UV Detector output during the MEASURE portion of the analyzer's measurement cycle.
Photo Ref	MV	The average UV Detector output during the REFERENCE portion of the analyzer's measurement cycle.
Sample Flow	CC/MIN	Sample Gas mass flow rate as measured by the Flow Sensor located between the Optical Bench and the Sample Pump.
Sample Press	IN-HG-A	The absolute pressure of the Sample Gas as measured by a solid-state pressure sensor.
Sample Temp	°C	The temperature of the gas inside the Sample Chamber.
Slope	--	The Slope of the instrument as calculated during the last calibration activity.
Stability	MV	Standard deviation of O ₃ Concentration readings. Data points are recorded every ten seconds. The calculation uses the last 25 data points.

2.4.3 ALERTS

Alerts are notifications triggered by specific criteria having been met by either factory-defined conditions (standard and not editable) or user-defined Events (Section 2.5.2). The Active Alerts page shows the status of any active warning conditions or Events that have been triggered.

When Alerts are triggered, a caution symbol appears in both the Alerts menu tab and in the bottom right corner of the software interface, which serves as a shortcut to the Alerts page from any other page. View a list of currently active Alerts by pressing either the Alerts menu on the Home screen or by pressing the Alerts shortcut (Figure 2-28).

While Alerts can be cleared from the Active Alerts page, they remain recorded in the Utilities>Alerts Log menu.

Navigate to the Active Alert page via the Alerts menu on Home screen.

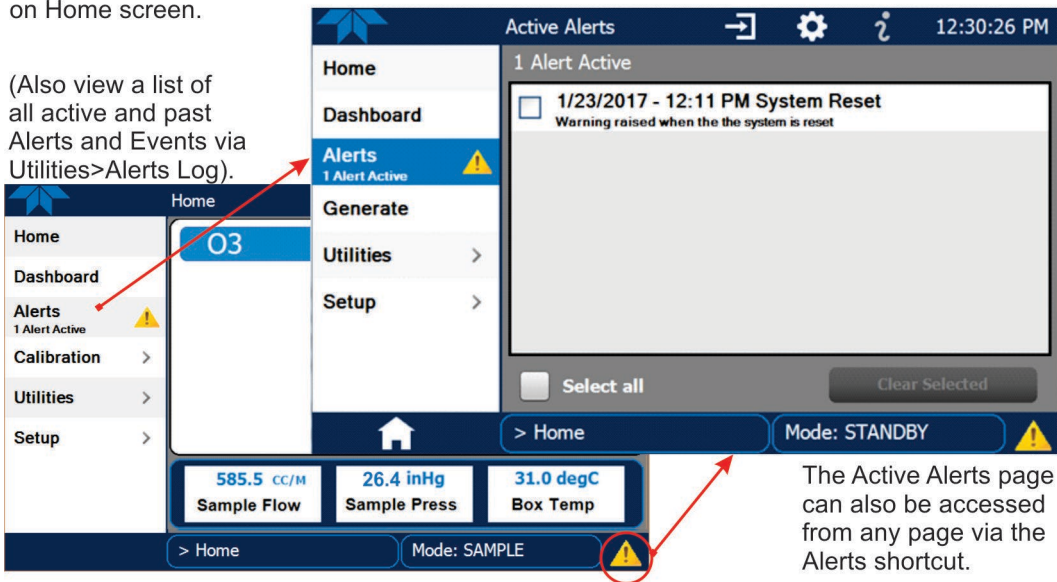


Figure 2-28. Navigating to the Active Alerts Page

Alerts can be configured as either latching (appears in Active Alerts screen when Event is triggered and must be cleared by the user) or non-latching (Active Alerts screen continuously updates based on the Event criteria, clearing on its own). See Section 2.5.2.

To clear Alerts from the Active Alerts page, either check individual boxes to choose specific Alerts, or check the Select All box to choose all Alerts, then press the Clear Selected button.

When all Alerts are cleared, the Alerts menu tab no longer shows the caution symbol, and a green LED replaces the caution symbol in the bottom right corner of the interface (Figure 2-29). However, Alerts can reappear if the conditions causing them are not resolved. For troubleshooting guidance, refer to Section 5.7.

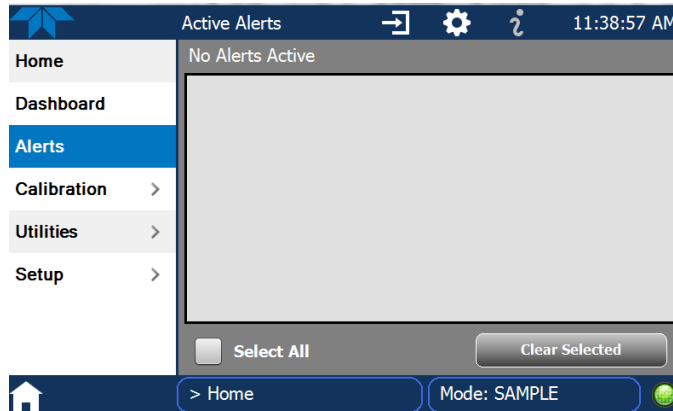


Figure 2-29. Active Alerts Cleared

Alerts and Events remain recorded in the Utilities>Alerts Log (Figure 2-30).

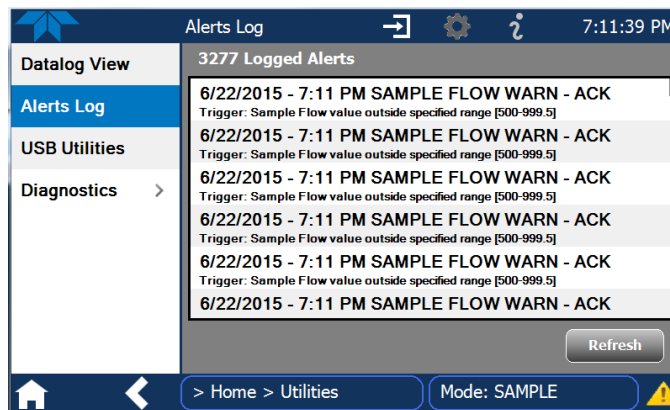


Figure 2-30. Utilities>Alerts Log of Active and Past Alerts and Events

2.4.4 CALIBRATION

The Calibration menu is used for multipoint calibrations as well as calibrations for zero and span with valve options, and for external calibration with valve options installed. Calibration procedures are presented in Section 4.

2.4.5 UTILITIES

The Utilities menu has a variety of functions as described next in Table 2-10.

Table 2-10. Utilities Submenu Descriptions

UTILITIES MENU	DESCRIPTION	
Datalog View	Displays the data logs that were configured via the Setup>Data Logging menu. From this list a log can be selected and filters applied to view the desired data. (For details on setting up and running the Data Logger, see Section 2.5.1).	
Alerts Log	Displays a history of alerts that are triggered by factory-defined and user-defined Events, such as warnings and alarms (See Section 2.5.2 for Events configuration).	
USB Utilities	Serves multiple purposes using a flash drive connected to the instrument's front panel USB port: <ul style="list-style-type: none"> • download data from the instrument's Data Acquisition System (DAS), the Data Logger, to a flash drive (Section 2.5.1.3) • update firmware (Section 5.3) • download a basic operation functionality report (Section 5.3). 	
Diagnostics	Provides access to various pages that facilitate troubleshooting.	
	Analog Outputs	Show the voltage signals for the functions selected and configured in the Setup>Analog Outputs menu (Section 2.5.8).
	Digital Inputs	Show whether specific available features are turned ON or OFF; for example, whether or not Maintenance Mode input or Language selection can be controlled through the front panel, or whether a zero or span calibration can be activated remotely when an external source is connected to the rear panel Control In connector.
	Digital Outputs	Show the function of user-specified parameters configured in the Setup>Digital Outputs menu (Section 2.5.7).
	Flow Cal	Use to calibrate the sample gas flow reading with actual flow measured by an external device. (See Section 4.5.2).
	O3 Gen Cal	Use to calibrate the O3 Generator option
	Pressure Cal	Use for compensating for changes in atmospheric pressure (Section 4.5.1).
	Config Transfer	Use to transfer instrument configuration from/to other same-model instruments (Section 2.6)

2.4.6 SETUP

The Setup menu is for configuring the instrument's various programmable features and functions. Section 2.5 provides details for the menus under Setup.

2.5 SETUP MENU: FEATURES/FUNCTIONS CONFIGURATION

Use the Setup menu to configure the instrument's software features, to gather information on the instrument's performance, and to configure and access data from the Datalogger, the instrument's internal data acquisition system (DAS). Once the setups are complete, the saved configurations can be downloaded to a USB drive through the Utilities>USB Utilities menu and uploaded to other instruments of the same model (Section 2.6).

2.5.1 SETUP>DATA LOGGING (DATA ACQUISITION SYSTEM, DAS)

The Datalogger can be configured to capture and store user-defined data, which then can be viewed in the Alerts page, if elected, as well as downloaded from the instrument to a USB flash drive or using NumaView™ Remote software for examination and analysis.

Figure 2-31 shows a new log; Figure 2-32 shows a sample existing log, which can be edited or deleted, and Figure 2-33 provides illustrated instructions for setting up a new log, with Sections 2.5.1.1 and 2.5.1.2 providing additional details.

To transfer captured instrument data to a flash drive see Section 2.5.1.3.

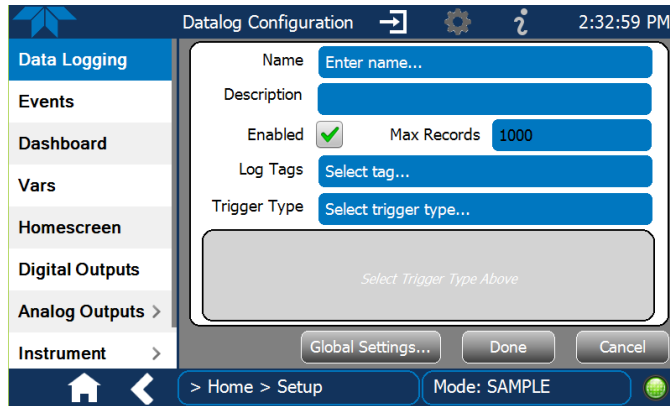


Figure 2-31. Datalog Configuration, New Log Page

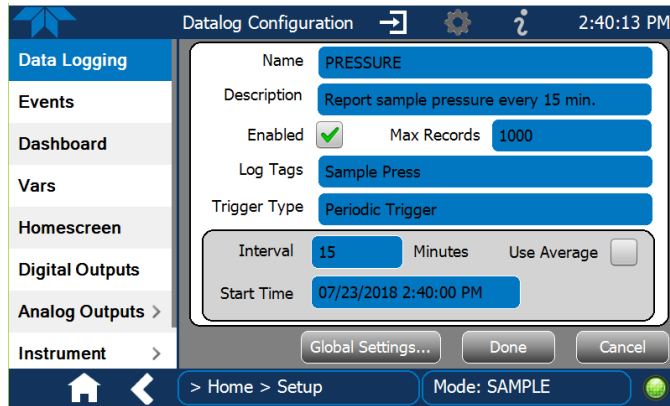


Figure 2-32. Datalog Configuration, Existing Log

Press the Name field and use the keyboard pop-up to label the new log.

Press the Description field and use the keyboard pop-up to describe the log.

Press the Max Records field and use the keypad pop-up to set a maximum.

Leave the Enabled box checked to allow data capture of this log, or press to uncheck and suspend data capture.

Press the Log Tag field to select the parameters to be tracked.

Press the Trigger Type field to select either Periodic or Conditional.

Press Global Settings to set time format.

Datalog Global Settings
Time Format 12 hour 24 hour
12 hour

When **Periodic** is selected as the Trigger Type, the field below it is populated with the Interval and Date/Time windows.

When **Conditional** is selected as the Trigger Type, the field below it is populated with the Trigger Tag and Condition definition windows.

Interval 15 minutes
Start Time 6/30/2015 6:33:56 AM

Trigger Tag Select tag here...
Condition Select trigger here...

(Please refer to the section on Configuring Trigger Types for details).

Figure 2-33. Creating a New Data Log

The parameters available in the list of Log Tags include the names of Events configured in the Events page (Section 2.5.2).

2.5.1.1 CONFIGURING TRIGGER TYPES: PERIODIC

The Periodic trigger is a timer-based trigger that is used to log data at a specific time interval. Periodic Trigger requires an interval that is set to number of minutes and a start time that is set to date and clock time.

Press the Interval field and use the keypad pop-up to edit the amount of time in seconds (default 60) between capturing data for the selected Log Tags.

Press the Start Time field and use the Time and Date pop-ups to select the time and the date to start capturing data for the parameters that were selected in the Log Tags field.

(toggle)

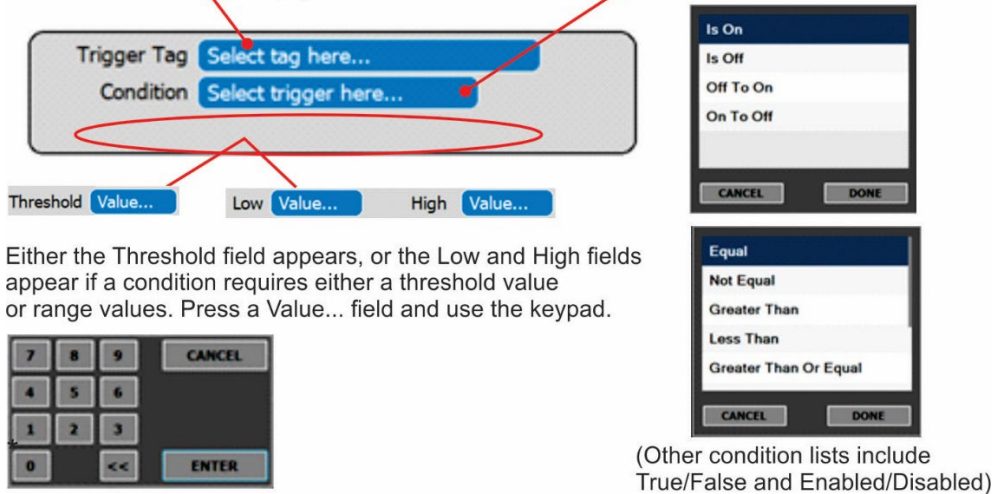
Figure 2-34. Datalog Periodic Trigger Configuration

2.5.1.2 CONFIGURING TRIGGER TYPES: CONDITIONAL

Conditional Trigger tracks/records data for user-selected parameters that meet specified conditions.

Press the Trigger Tag field and select a parameter to be tracked/logged. A default Condition associated with the selected Tag will populate the Condition field.

Press the Condition field to select a different choice from the condition list.



Either the Threshold field appears, or the Low and High fields appear if a condition requires either a threshold value or range values. Press a Value... field and use the keypad.

Figure 2-35. Datalog - Conditional Trigger Configuration

2.5.1.3 DOWNLOADING DAS (DATA ACQUISITION SYSTEM) DATA

To download DAS data collected by the Datalogger from the instrument to a flash drive, navigate to the Utilities>USB Utilities>DAS Download menu.

1. Insert a flash drive into a front panel USB port and wait for the Status field to indicate that the drive has been detected; available buttons will be enabled.

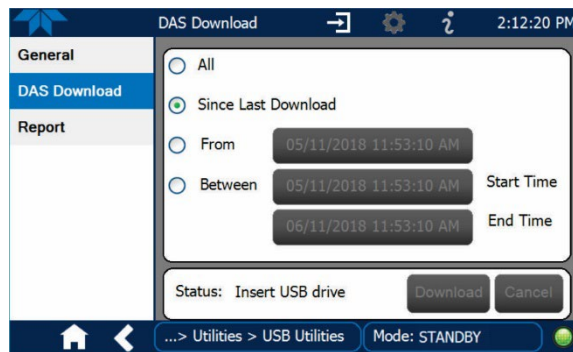


Figure 2-36. DAS Download Page

2. Select all or define a period from which to download the collected data.
3. Press the Download button, and when complete, as indicated in the Status field, press the Done button (changed from “Cancel”) and remove the flash drive.

2.5.2 SETUP>EVENTS

Events are occurrences that relate to any operating function, and are used to define the conditions that can be set to trigger Alerts (Section 2.4.3). Events can provide diagnostic information about the instrument, typically referred to as “Warnings”, or they can provide other information on instrument functionality, such as concentration alarms. Some Events are standard and not editable while others are user-configurable, described here. Existing Events are listed in the Events page (Figure 2-37) under the Setup menu.

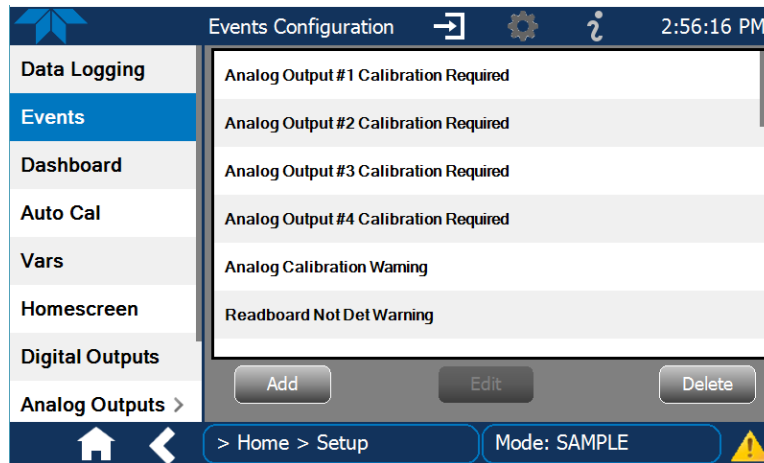


Figure 2-37. Events List

Access the Events Configuration page either from the Active Alerts page (Alerts Menu) by pressing the configuration button, or through the Home>Setup>Events menu (Figure 2-37). Press ADD to create a new Event (refer to Figure 2-38 for details), or select an existing Event to either Edit or Delete it (Figure 2-40).

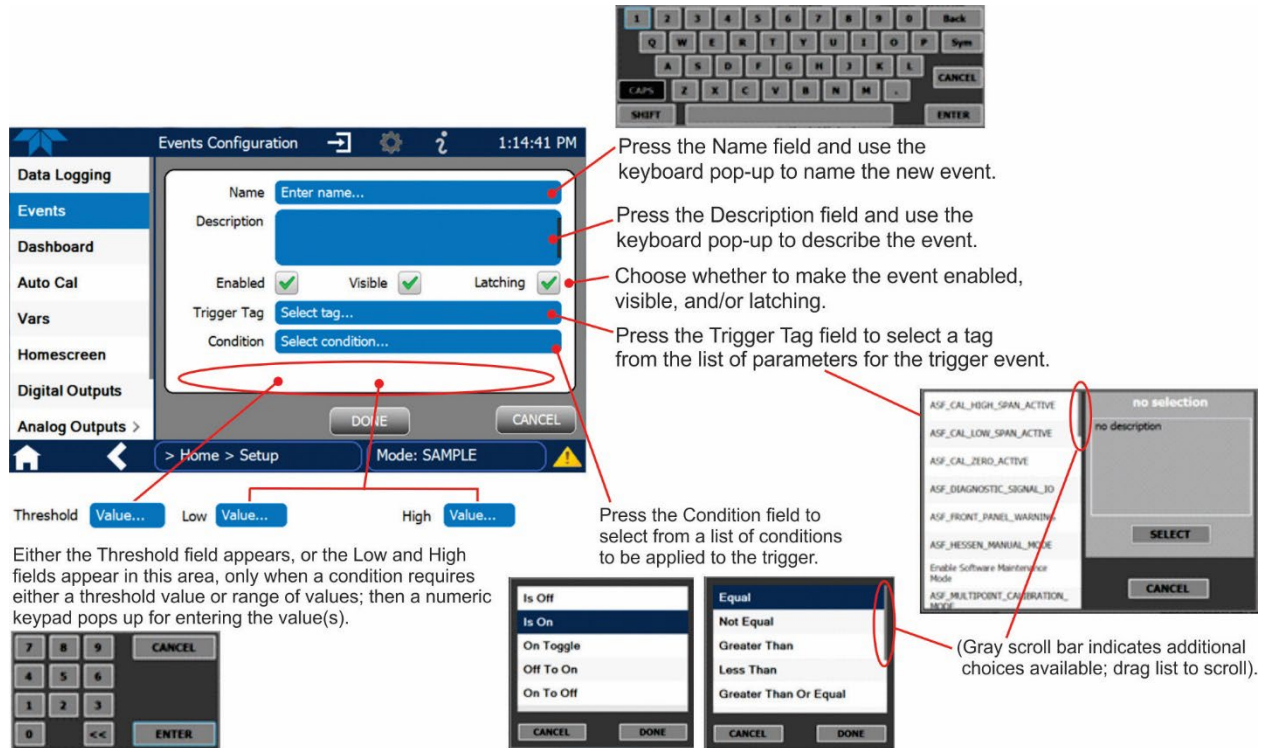


Figure 2-38. Event Configuration

- Enabled allows the choice of whether to track and record the Event (uncheck this box to “turn off” or deactivate the Event without deleting it). An Event must be enabled in order to use the Visible and the Latching options.
- Visible allows the choice of whether or not to display the Event in the Alerts page when it is triggered (it will still be recorded and can be viewed in the Utilities>Alerts Log). To use this option, the Event must be enabled.
- Latching allows the choice of whether or not to keep an Event visible even if the conditions that triggered it were to correct themselves. (Latching requires that the user interact with the Active Alerts screen to manually clear the Alert and internal Event state. Non-latching allows the entry in the Active Alerts screen and the internal Event state to continuously update based on the Event criteria, requiring no user interaction to clear the Alert or Event state).

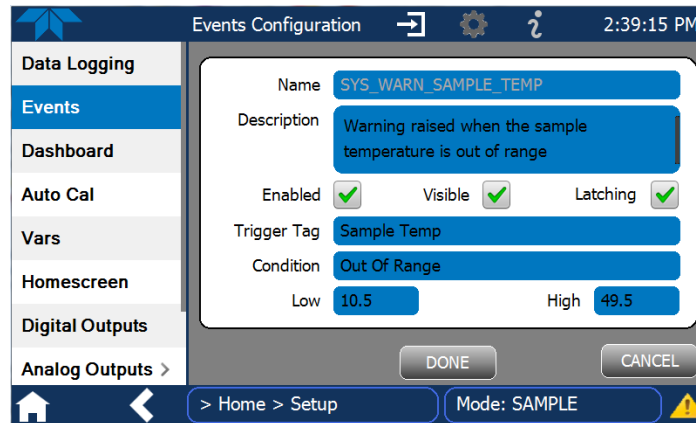


Figure 2-39. Configured Event Sample

2.5.2.1 EDITING OR DELETING EVENTS

Select an Event from the list (Figure 2-37) and press the Edit button to view or edit the details (Figure 2-39), or press the Delete button to delete the Event.

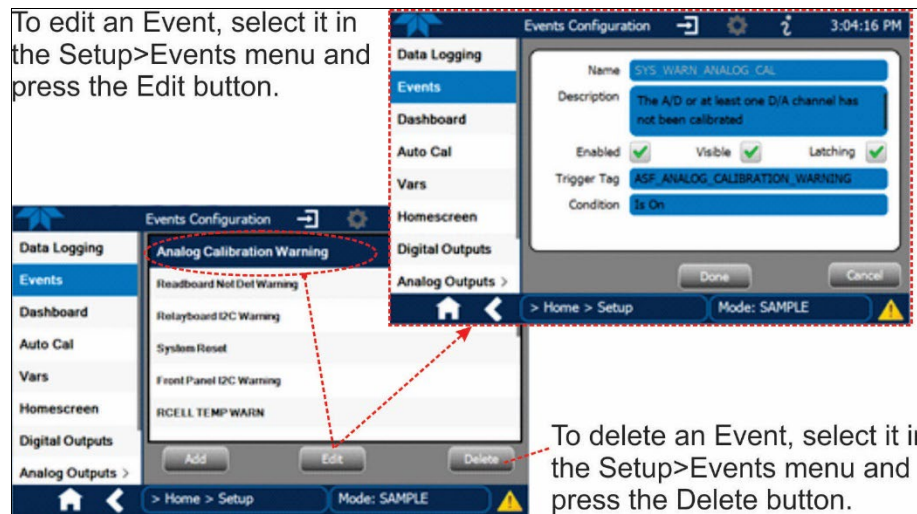



Figure 2-40. Edit or Delete an Event

2.5.2.2 USING EVENTS AS TRIGGERS FOR DATA LOGGING

Events can also be used to create customized triggers for data logging functions. The name entered in the Name field of the Events Configuration page will appear in the list of Log Tags of the Datalog Configuration page. The Data Logger is presented in Section 2.5.1.

2.5.3 SETUP>DASHBOARD

Configuration Shortcut



To navigate to Dashboard Configuration, either press the configuration shortcut in the Dashboard page, or use the Setup>Dashboard menu.

Configuration editing:

To add a parameter to the Dashboard, select it in the “Available Tags” list and press the right-pointing arrows button. (Checkmarks in the “Available Tags” list indicate parameters that are currently in the Dashboard).

To remove a parameter from the Dashboard, select it from the “Dashboard” list and press the left-pointing arrows button.

Figure 2-41. Dashboard Display and Configuration

2.5.4 SETUP>AUTO CAL (WITH VALVE OPTION)

Auto Cal, automatic zero/span calibration or calibration check, is available with installed valve options (see Sections 2.3.2 and 4.3).

2.5.5 SETUP>VARS

Vars are software variables that define operational parameters automatically set by the instrument's firmware, and are user-adjustable through this menu. Access the menu to see the list of variables; select a variable to view its description; touch the Edit button to change its setting(s).

Table 2-11. List of Variables with Descriptions

VARIABLE	DESCRIPTION
NOTE: This list includes several of the more common Vars; selecting any Var in the NumaView™ software interface will display its description in the information field to its right. Depending on configuration, some, all, or more of these variables appear in your instrument's Vars menu.	
Conc Precision (or PRIGAS/SECGAS Precision)	Sets the number of significant digits to the right of the decimal point display of concentration and stability values. ("PRIGAS" = primary gas with two or more other gases; "SECGAS" = secondary gas)
Daylight Savings Enable	Enable or disable Daylight Savings Time (also see Setup>Instrument>Date/Time Settings)
Dilution Factor Option	Sets the instrument to compensate for diluted sample gas, such as in continuous emission monitoring (CEM) where the quality of gas in a smoke stack is being tested and the sampling method used to remove the gas from the stack dilutes the gas. Once the degree of dilution is known, this feature allows the user to add an appropriate scaling factor to the analyzer's O ₃ concentration calculations so that the undiluted values for measurement range and concentration are shown on the instrument's front panel display and reported via the instrument's various outputs.
Dynamic Zero Enable	Dynamic zero automatically adjusts offset and slope when performing a zero point calibration during an AutoCal (Section 4.3).
Dynamic Span Enable	Dynamic span automatically adjusts the offset and slope when performing a span point calibration during an AutoCal (Section 4.3).
[Enable] Software Maintenance Mode	Set instrument to continue sampling, while ignoring calibration, diagnostic, and reset instrument commands. This feature is of particular use for instruments connected to Multidrop (Section 2.3.1.7) or Hessen protocol networks (see Sections 2.5.10, 3.4.2).
Instrument ID	Set unique identifier number for the instrument when it is connected with other instruments in multidrop configuration or on the same Ethernet LAN, or when applying MODBUS or Hessen protocols. (Setup>Vars>Instrument ID)
Range Mode	Controls range mode, single (SNGL) or dual (DUAL).
System Hours	Total system runtime hours
TPC Enable	Enables or disables the Temperature and Pressure Compensation (TPC) feature (Section 6.2.2).
User Conc Units	Change the concentration units of measure.

2.5.6 SETUP>HOMESCREEN

To select a parameter (“tag”) for display in each of the three meters at the bottom of the Home page, navigate to the Homescreen configuration page through either the Setup>Homescreen menu or from Home page using the configuration icon (Figure 2-42).

From Home page, either navigate to Setup>Homescreen or select configuration button.



Figure 2-42. Homescreen Configuration

An orientation to the Homescreen was presented in Section 2.4.1, including Figure 2-25 and Figure 2-26.

2.5.7 SETUP>DIGITAL OUTPUTS

Specify the function of each digital output (connected through the rear panel STATUS connector) by mapping the output to a selection of “Signals” present in the instrument. Create custom “Signals” in the Setup>Events menu (Section 2.5.2). (If the Motherboard Relay Option was installed, the four additional relays can also be mapped).

To map Digital Outputs to Signals, select a pin in the Outputs list, then make a selection from the Signals list and press the Map button; if/as needed, change the polarity by pressing the Polarity button. Save any changes by pressing the Apply button, or discard the changes by pressing the Home or the back button (a pop-up provides a warning that the changes will be lost, and will prompt for confirmation to apply changes or not).

Go to the Utilities>Diagnostics>Digital Outputs menu to change the state (ON/OFF) of individual digital outputs.

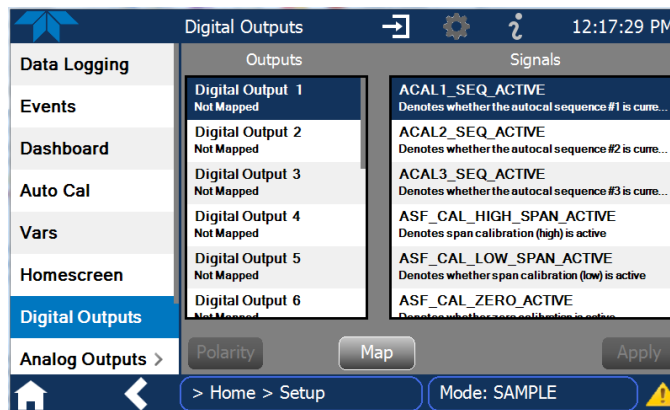


Figure 2-43. Digital Outputs Setup

2.5.8 SETUP>ANALOG OUTPUTS

Map the four user-configurable Analog Outputs to any of a wide variety of “Signals” present in the instrument and customize their respective configurations.



Figure 2-44. Analog Output Configuration Example

Refer to Figure 2-44 for the following:

- Signal Out: select a Signal for the output.
- Min/Max: edit minimum and maximum values associated with the selected Signal.
- Calibration Type:
 - AUTO for group calibration (Figure 2-45) of the analog outputs (cannot be selected when Current is selected for the Range)
 - MANUAL for individual calibration (Figure 2-46) of analog outputs where manual adjustments can be made (the only calibration type allowed when Current is selected for the Range). See Sections 2.5.8.1 and 2.5.8.2 .
- Range: assign a voltage or select Current (refer to Table 2-12).
- Recorder Offset: add a zero offset for recording slightly negative readings from noise around the zero point.
- Allow Overrange: check to allow a $\pm 5\%$ over-range; uncheck to disable over-range if the recording device is sensitive to excess voltage or current.

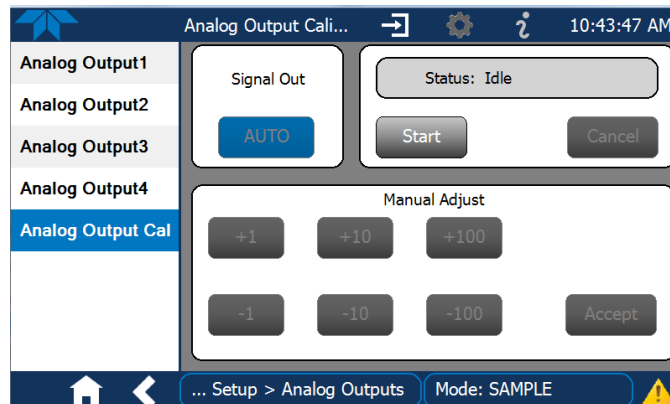


Figure 2-45. Analog Outputs Group Calibration Screen

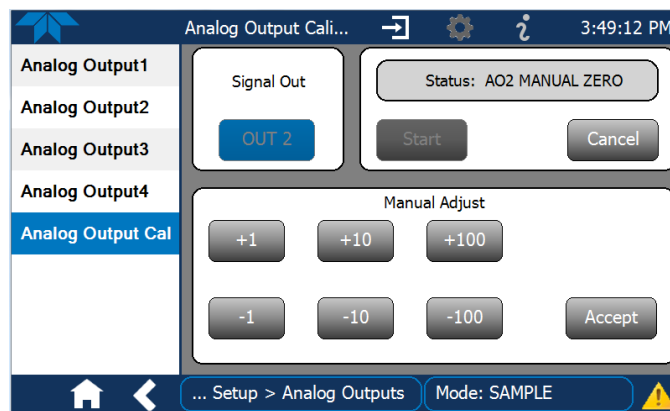


Figure 2-46. Analog Outputs Manual Calibration Screen (AOUT2 Example)

Table 2-12. Analog Output Voltage/Current Range

RANGE ¹	RANGE SPAN	MINIMUM OUTPUT	MAXIMUM OUTPUT
100mV	0-100 mVDC	-5 mVDC	105 mVDC
1V	0-1 VDC	-0.05 VDC	1.05 VDC
5V	0-5 VDC	-0.25 VDC	5.25 VDC
10V	0-10 VDC	-0.5 VDC	10.5 VDC
Current ²	0-20 mA	0 mA	20 mA

¹ Each range is usable from -5% to +5% of the rated span.

² While these are the physical limits of the current loop modules, typical applications use 2-20 mA or 4-20 mA for the lower and upper limits.

For manual calibration adjustments, see Section 2.5.8.1 for voltage and Section 2.5.8.2 for current.

2.5.8.1 MANUAL CALIBRATION OF VOLTAGE RANGE ANALOG OUTPUTS

It is possible to manually calibrate the voltages by using a voltmeter connected across the output terminals (Figure 2-47) and changing the output signal level in the Manual Adjust field of the Analog Outputs Calibration screen (Figure 2-46). Refer to Table 2-13 for voltage tolerances.

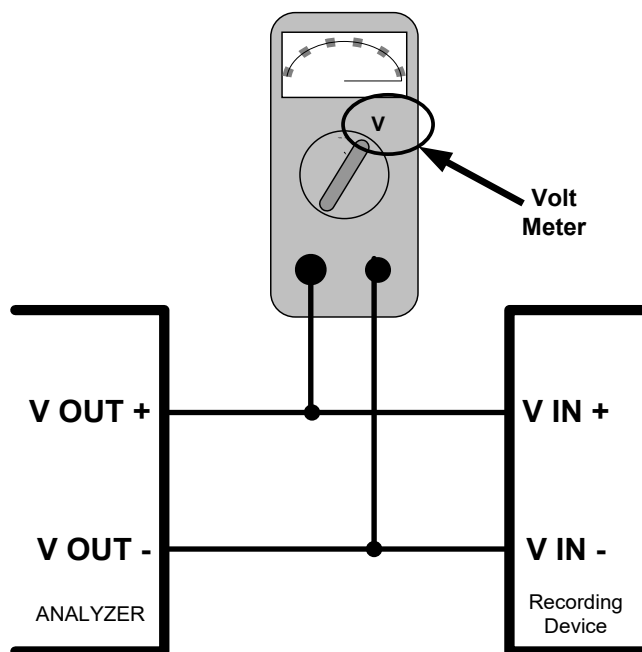


Figure 2-47. Setup for Checking / Calibrating DCV Analog Output Signal Levels

Table 2-13. Voltage Tolerances

FULL SCALE	ZERO TOLERANCE	SPAN VOLTAGE	SPAN TOLERANCE	MINIMUM ADJUSTMENT (1 count)
0.1 VDC	±0.0005V	90 mV	±0.001V	0.02 mV
1 VDC	±0.001V	900 mV	±0.001V	0.24 mV
5 VDC	±0.002V	4500 mV	±0.003V	1.22 mV
10 VDC	±0.004V	4500 mV	±0.006V	2.44 mV

2.5.8.2 MANUAL ADJUSTMENT OF CURRENT RANGE ANALOG OUTPUTS

These instructions assume that the Current Loop Option is installed (Section 2.3.1.3).

This option places circuitry in series with the output of the D-to-A converter on the motherboard that changes the normal DC voltage output to a 0-20 milliamp signal.

Adjusting the signal zero and span levels of the current loop output is done by raising or lowering the voltage output of the D-to-A converter circuitry on the analyzer's motherboard. This raises or lowers the signal level produced by the current loop option circuitry.

The software allows this adjustment to be made in 100, 10 or 1 count increments. Since the exact amount by which the current signal is changed per D-to-A count varies from output-to-output and instrument-to-instrument, you will need to measure the change in the signal levels with a separate, current meter placed in series with the output circuit. See Figure 2-4 for pin assignments and diagram of the analog output connector.



CAUTION!

Do not exceed 60 V peak voltage between current loop outputs and instrument ground.

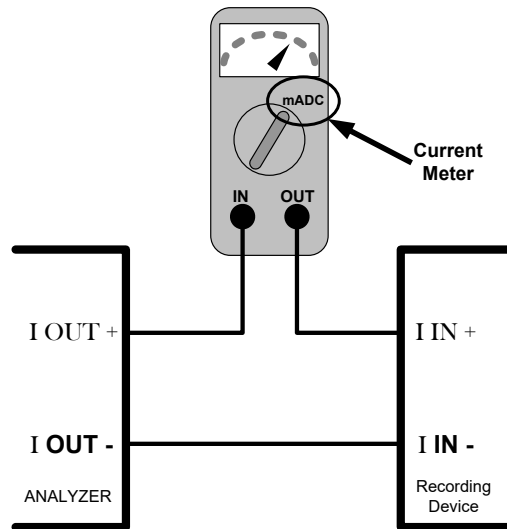


Figure 2-48. Setup for Checking / Calibration Current Output Signal Levels

An alternate method for measuring the output of the Current Loop converter is to connect a 250 ohm $\pm 1\%$ resistor across the current loop output in lieu of the current meter (see Figure 2-4 for pin assignments and diagram of the analog output connector). This allows the use of a voltmeter connected across the resistor to measure converter output as VDC or mVDC.

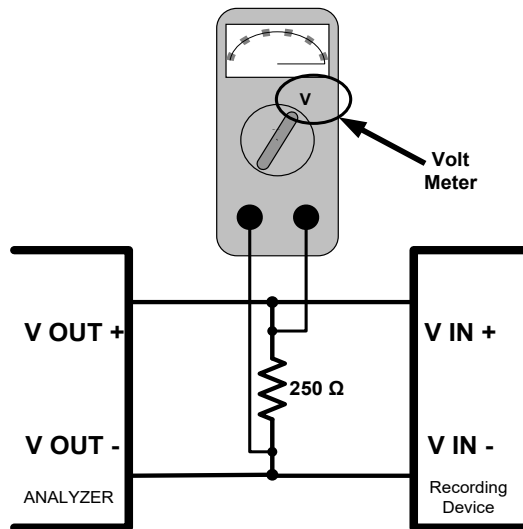


Figure 2-49. Alternative Setup Using 250Ω Resistor for Checking Current Output Signal Levels

In this case, follow the procedure above but adjust the output for the following values:

Table 2-14. Current Loop Output Check

% FS	Voltage across Resistor for 2-20 mA	Voltage across Resistor for 4-20 mA
0	500 mVDC	1000 mVDC
100	5000 mVDC	5000 mVDC

2.5.9 SETUP>INSTRUMENT

As presented in Table 2-15, view product and system information and network settings, edit network settings, and perform certain maintenance tasks.

Table 2-15. Setup>Instrument Menu

MENU	DESCRIPTION
Product Info	View Model, Part, and Serial Numbers and Package and Driver Versions, and options information.
System Info	View Windows and RAM information.
Network Settings	View the network settings (configurable through the Setup>Comm>Network Settings menu).
Date/Time Settings	Adjust date, hour, and minutes, select a time zone*, and set the system clock to automatically adjust for Daylight Savings Time or not. (Also see Setup>Vars>Daylight Savings Enable). *Time Zone change requires a special procedure; see Maintenance Section 5.5.
NTP Time Settings	Configure Network Time Protocol settings for clock synchronization.
Language	Select an available language.
Remote Update	When an instrument is connected to a network that is connected to the Internet, follow the instructions on this Remote Update page to check for and activate software/firmware updates. (Also refer to Section 5.3).

2.5.10 SETUP>COMM (COMMUNICATIONS)

This menu is for specifying the various communications configurations.

2.5.10.1 COM1/COM2

Configure the instrument's COM1 or COM2 ports to operate in modes listed in Table 2-16.

Table 2-16. COM1/COM2 Configuration

MODE	DESCRIPTION
Baud Rate	Set the baud rate for the COM1 or COM2 port being configured.
Command Prompt Display	Enable/disable a command prompt to be displayed when in terminal mode.
Data Bits	Set the data bits to 7 or 8 (typically set in conjunction with Parity and Stop bits).
Echo and Line Editing	Enable/disable character echoing and line editing.
Handshaking Mode	Choose SOFTWARE handshaking for data flow control (do NOT use SOFTWARE handshaking mode when using MODBUS RTU for Protocol mode; select only HARDWARE or OFF for MODBUS RTU), or HARDWARE for CTS/RTS style hardwired transmission handshaking. (This style of data transmission handshaking is commonly used with modems or terminal emulation protocols). Or choose to turn OFF handshaking.
Hardware Error Checking	Enable/disable hardware error checking.
Hardware FIFO	Enable/disable the hardware First In – First Out (FIFO) for improving data transfer rate for that COM port.
Modem Connection	Select either a modem connection or a direct cable connection.
Modem Init String	Input an initialization string to enable the modem to communicate.
Multidrop	Enable/disable multidrop mode for multi-instrument configuration on a single communications channel. Multidrop requires a unique ID for each instrument in the chain (Setup>Vars>Instrument ID).
Parity	Select odd, or even, or no parity (typically set in conjunction with Data Bits and Stop Bits).
Protocol	Select among the communications protocols: TAPI, Hessen, MODBUS RTU, or MODBUS ASCII (MODBUS: Section 3.4.1; Hessen: Section 3.4.2).
Quiet Mode	Enable/disable Quiet mode, which suppresses any feedback from the analyzer (such as warning messages) to the remote device and is typically used when the port is communicating with a computer program where such intermittent messages might cause communication problems. Such feedback is still available, but a command must be issued to receive them.
RS-485	Enable/disable the rear panel COM2 Port for RS-485 communication. RS-485 mode has precedence over Multidrop mode if both are enabled. Also, RS-485 configuration disables the rear panel USB port.
Security	Enable/disable the requirement for a password for this serial port to respond. The only command that is active is the request-for-help command (? CR).
Stop bits	Select either 0 or 1 stop bit (typically set in conjunction with Parity and Data bits).

2.5.10.2 TCP PORT1

TCP Port1 allows choosing whether or not to display the command prompt, editing the Port 1 number for defining the terminal control port by which terminal emulation software addresses the instrument, such as Internet or NumaView™ Remote software, and enabling or disabling security on this port.

2.5.10.3 TCP PORT2

TCP Port2 is configured with the port number for MODBUS.

2.5.10.4 TCP PORT3

TCP Port3 is configured with the port number for Hessen.

2.5.10.5 NETWORK SETTINGS

The Setup>Comm>Network Settings menu is for Ethernet configuration. The address settings default to automatic configuration by Dynamic Host Configuration Protocol (DHCP). Most users will want to configure the instrument with a static IP address: click the Static radio button to manually assign a static IP address (consult your network administrator, and see Table 2-17 for information).

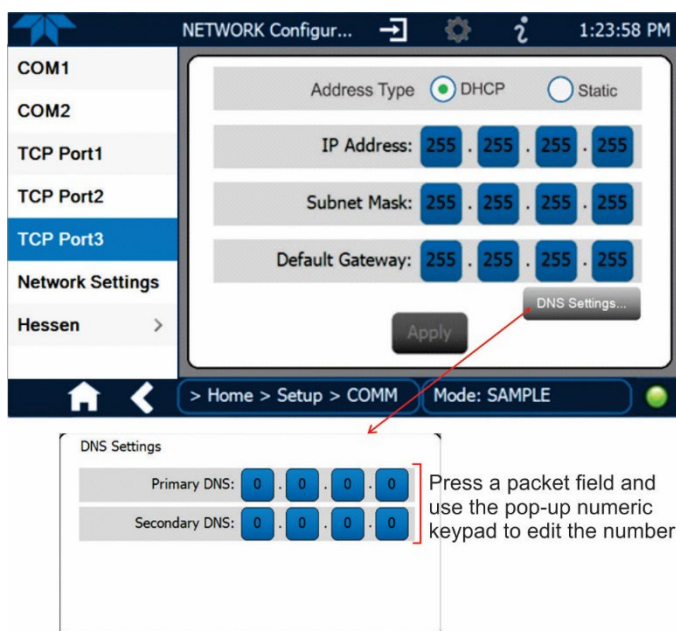


Figure 2-50. Communications Configuration, Network Settings

Table 2-17. LAN/Ethernet Configuration Properties

PROPERTY	DESCRIPTION
IP address	A string of four packets of 1 to 3 numbers each (e.g. 192.168.76.55.) is the internet protocol address of the instrument itself.
Subnet Mask	A string of four packets of 1 to 3 numbers each (e.g. 255.255.252.0) number that masks an IP address, and divides the IP address into network address and host address and identifies the LAN to which the device is connected. All addressable devices and computers on a LAN must have the same subnet mask. Any transmissions sent to devices with different subnets are assumed to be outside of the LAN and are routed through the gateway computer onto the Internet.
Default Gateway	A string of numbers very similar to the Instrument IP address (e.g. 192.168.76.1.) that is the address of the computer used by your LAN and serves as a router to access the Internet or another network.

2.6 TRANSFERRING CONFIGURATION TO OTHER INSTRUMENTS

Once an instrument is configured, the same configuration can be copied to other instruments of the same Model. This encompasses essentially anything the user can configure and does not apply to instrument-specific settings such as those that are configured at the factory for calibration.

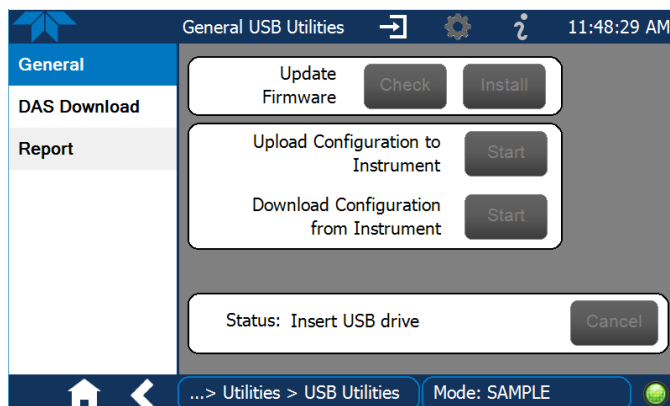


Figure 2-51. Configuration Transfer

1. In the source instrument, go to the Home>Utilities>USB Utilities>General page.
2. Insert a flash drive into either of the two front panel USB ports.
3. When the Status field indicates that the USB drive has been detected, press the “Download Configuration from Instrument” Start button.
4. When the Status field indicates that the download is complete, remove the flash drive.
5. In the target instrument, go to the Home>Utilities>USB Utilities>General page.
6. Insert a flash drive into either of the two front panel USB ports.
7. When the Status field indicates that the USB drive has been detected, press the “Upload Configuration to Instrument” Start button.
8. When the Status field indicates that the upload is complete, remove the flash drive.

3 COMMUNICATIONS AND REMOTE OPERATION

This instrument's rear panel connections can include an Ethernet port, a USB port (option) and two serial communications ports labeled RS232, which is the COM1 port in the software menu, and COM2 (refer to Figure 2-2). These ports allow the ability to communicate with, issue commands to, and receive data from the analyzer through an external computer system or terminal. Connection instructions were provided in Section 2.3.1.7. Configuration information was provided in Section 2.5.10.

This Section provides pertinent information regarding communication equipment, the communications ports, and communications protocol. Data acquisition is set up through the Datalogger (Section 2.5.1).

3.1 DATA TERMINAL/COMMUNICATION EQUIPMENT (DTE DCE)

RS-232 was developed for allowing communications between data terminal equipment (DTE) and data communication equipment (DCE). Basic terminals always fall into the DTE category whereas modems are always considered DCE devices. The difference between the two is the pin assignment of the Data Receive and Data Transmit functions.

- DTE devices receive data on pin 2 and transmit data on pin 3.
- DCE devices receive data on pin 3 and transmit data on pin 2.

To allow the analyzer to be used with terminals (DTE), modems (DCE) and computers (which can be either), a switch mounted below the serial ports on the rear panel, labeled DCE DTE (Figure 2-2), allows the user to set the RS-232 configuration for one of these two data devices. This switch exchanges the Receive and Transmit lines on RS-232 emulating a cross-over or null-modem cable. The switch has no effect on COM2.

3.2 MODES, BAUD RATE AND SERIAL COMMUNICATION

Referring to Table 2-16, use the SETUP>COMM menu to configure COM1 (labeled RS232 on instrument rear panel) and/or COM2 (labeled COM2 on instrument rear panel) for communication modes, baud rate and serial communications. If using a USB option communication connection, setup requires that the instrument's baud rate and personal computer baud rate match.

3.2.1 SERIAL COMMUNICATION: RS-232

The RS232 and COM2 communications ports operate on the RS-232 protocol (default configuration). Configurations possible for these two ports are:

- RS232 port can also be configured to operate in single or RS-232 Multidrop mode (Option 62); refer to Section 2.3.1.7.
- COM2 port can be left in its default configuration for standard RS-232 operation including multidrop, or it can be reconfigured for half-duplex RS-485 operation (please contact the factory for this configuration).

Note

When the rear panel COM2 port is in use, except for multidrop communication, the rear panel USB port cannot be used. (Alternatively, when the USB port is enabled, COM2 port cannot be used except for multidrop).

A code-activated switch (CAS), can also be used on either port to connect typically between 2 and 16 send/receive instruments (host computer(s) printers, data loggers, analyzers, monitors, calibrators, etc.) into one communications hub. Contact Teledyne API Sales (front cover, this manual) for more information on CAS systems.

3.2.1.1 SERIAL COMMUNICATION: RS-485 (OPTION)

The COM2 port of the instrument’s rear panel is set up for RS-232 communication but can be reconfigured for RS-485 communication. Contact Technical Support for reconfiguration unless this option was elected at the time of purchase, then the rear panel was preconfigured at the factory.

3.3 ETHERNET

When using the Ethernet interface, the analyzer can be connected to any standard 10BaseT or 100BaseT Ethernet network via low-cost network hubs, switches or routers. The interface operates as a standard TCP/IP device on port 3000. This allows a remote computer to connect through the network to the analyzer using NumaView™ Remote, terminal emulators or other programs.

The Ethernet connector has two LEDs that are on the connector itself, indicating its current operating status.

Table 3-1. Ethernet Status Indicators

LED	FUNCTION
amber (link)	On when connection to the LAN is valid.
green (activity)	Flickers during any activity on the LAN.

The analyzer is shipped with DHCP enabled by default. This allows the instrument to be connected to a network or router with a DHCP server; however, it should be configured with a Static IP address as soon as practical. See Section 2.5.10.5 for configuration details.

3.4 COMMUNICATIONS PROTOCOLS

MODBUS (Section 3.4.1) and Hessen (Section 3.4.2) are available with the analyzer. MODBUS registers are provided in Appendix A.

3.4.1 MODBUS

These instructions assume that the user is familiar with MODBUS communications, and provide minimal information to get started. Please refer to the Teledyne API MODBUS manual, PN 06276, and to www.modbus.org for MODBUS communication protocols.

Minimum Requirements:

- Instrument firmware with MODBUS capabilities installed
- MODBUS-compatible software (TAPI uses MODBUS Poll for testing; see www.modbustools.com)
- Personal computer with communications cable (Ethernet or USB or RS232), and possibly a null modem adapter or cable

3.4.1.1 MODBUS COM PORT CONFIGURATION

MODBUS communications can be configured for transmission over Ethernet or serial COM port through the Setup>Comm menu. Make the appropriate cable connections (Ethernet or COM port) between the instrument and a PC.

Check the instrument’s Modbus Units selection in the Setup>Vars menu and edit if needed.

Ethernet: MODBUS is available on TCP port 502. By default, port 502 is assigned to the instrument’s TCP Port 2. (Setup>Comm> TCP Port2, Figure 3-1).

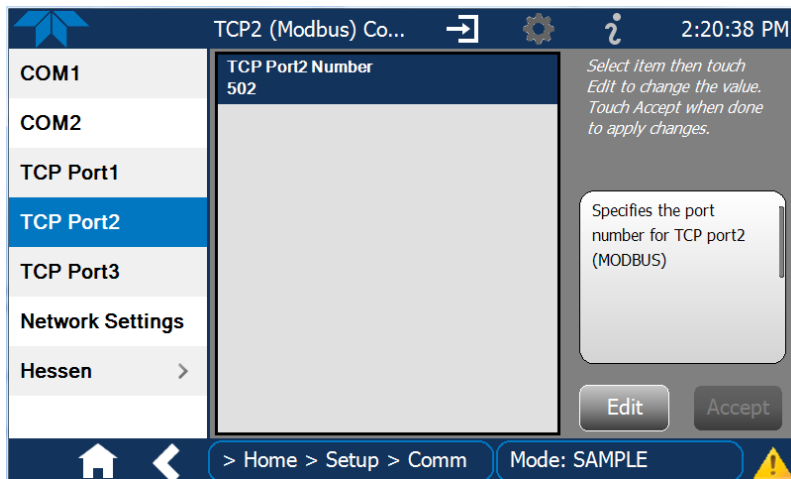


Figure 3-1. MODBUS via Ethernet

Serial COM: Both COM1 (labeled “RS232” on the instrument’s rear panel) and COM2 are configurable for RS-232 or RS-485 communication with either MODBUS RTU or MODBUS ASCII transmission modes. In the Setup>Comm COM1[COM2] menu, edit the Protocol parameter to select a MODBUS transmission mode; edit Baud Rate, Parity, Data Bits, etc., if necessary (see descriptions in Table 2-16).

Important

When using MODBUS RTU, ensure that the COM1[COM2] Handshaking Mode is set to either Hardware or OFF. Do NOT set it to Software.

Press the Accept button to apply the settings. (Figure 3-2 shows an example for MODBUS RTU).

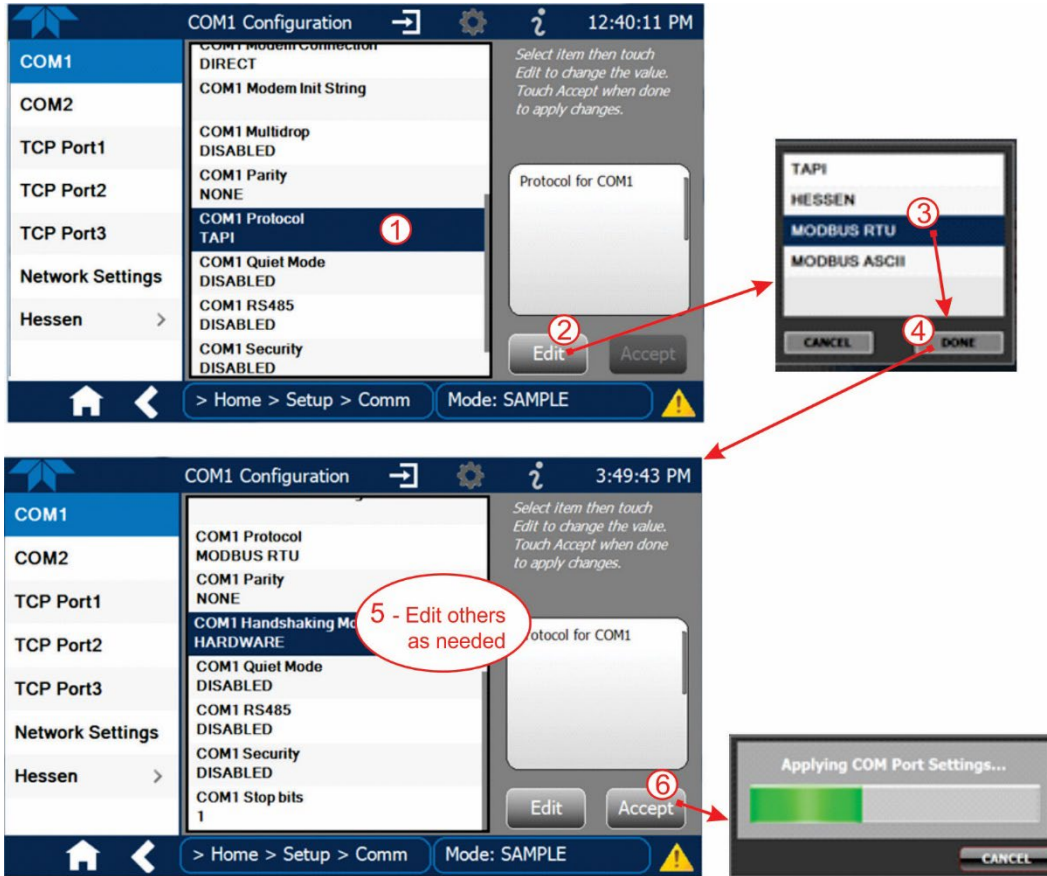


Figure 3-2. MODBUS via Serial Communication (example)

Important

When more than one analyzer is connected to the network, create a unique identification number for each in the Setup>Vars>Instrument ID menu.

Next, for the settings to take effect, power off the analyzer, wait 5 seconds, and power it on again.

3.4.2 HESSEN

Hessen is a multidrop protocol, in which several remote instruments (slaves) are connected via a common communications channel to a host computer. Slaves respond only to commands sent by the host using their unique identification.

Important Create a unique identification number for each instrument in the multidrop chain via the Setup>Vars>Instrument ID menu.

The Hessen protocol is not strictly defined; therefore, while Teledyne API's application is completely compatible with the protocol itself, it may be different from implementations by other companies.

3.4.2.1 HESSEN COM PORT CONFIGURATION

Configure the COM1/COM2 port for Hessen protocol through the Setup>Comm>COM1[COM2] menu: select COM1[COM2] Protocol and press Edit to select HESSEN, then press Accept.

Ensure that the communication parameters of the host computer are also properly set.

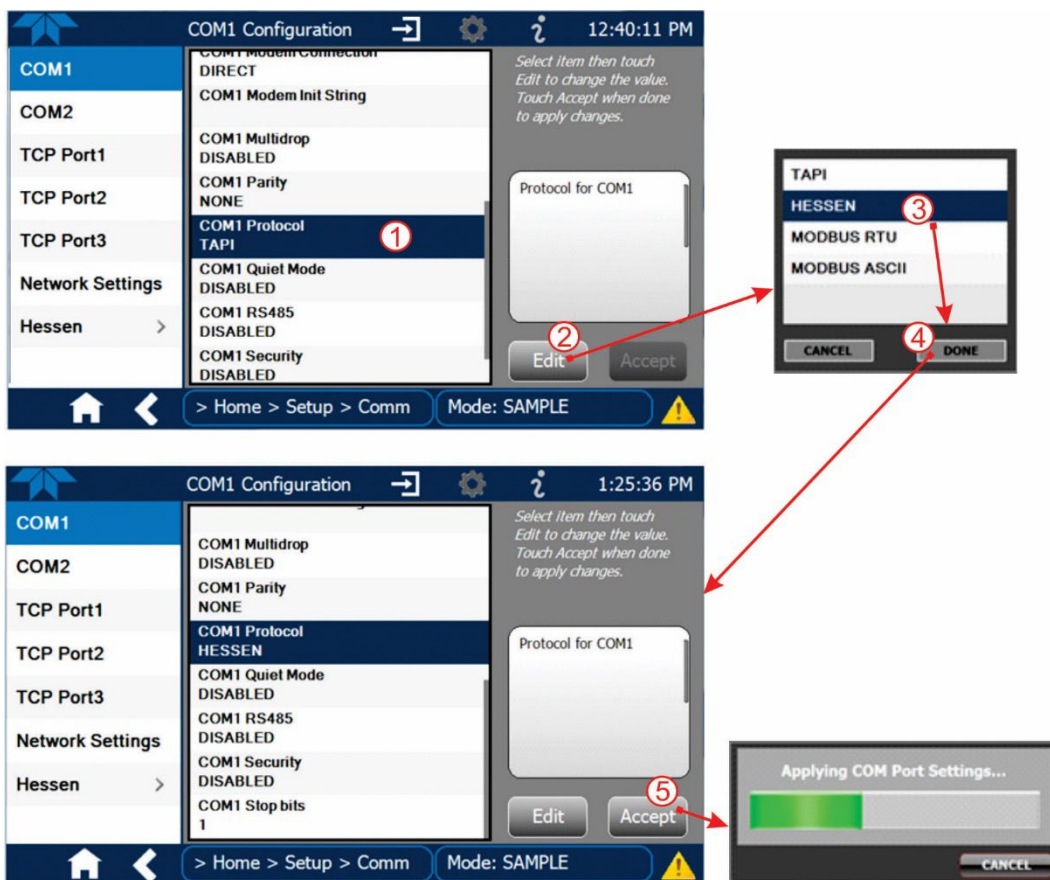


Figure 3-3. Serial Communication, Setting Hessen Protocol

Note The instrument software has a 200 ms latency period before it responds to commands issued by the host computer. This latency should present no problems, but be mindful of issuing commands to the instrument too

frequently.

3.4.2.2 HESSEN SETTINGS CONFIGURATION

Hessen configuration includes settings for alarms, version, response mode, status flags and gas list. Locate the alarms in the Hessen Settings list (Setup>Comm>Hessen>Hessen Settings) and edit as desired.

HESSEN VARIATION

For the Hessen Variation setting, there are two versions.

- TYPE 1 is the original implementation.
- TYPE 2 has more flexibility when operating with instruments that can measure more than one type of gas. For more specific information about the difference between the two versions, download the *Manual Addendum for Hessen Protocol* from the Teledyne API's web site: <http://www.teledyne-api.com/manuals/>.

HESSEN PROTOCOL RESPONSE MODE

Set the response mode under Hessen Response Mode, referring to Table 3-2 for descriptions.

Table 3-2. Teledyne API's Hessen Protocol Response Modes

MODE ID	MODE DESCRIPTION
CMD	This is the default setting. Responses from the instrument are encoded as the traditional command format. Style and format of responses depend on exact coding of the initiating command.
BCC	Responses from the instrument are always delimited with <STX> (at the beginning of the response, <ETX> (at the end of the response followed by a 2 digit Block Check Code (checksum), regardless of the command encoding.
TEXT	Responses from the instrument are always delimited with <CR> at the beginning and the end of the string, regardless of the command encoding.

HESSEN STATUS FLAGS

Locate the various status flags in the Hessen Settings list and edit as needed. They are listed by status flag name with their default bit assignments. (Those with unassigned flags are listed as “0x0000”).

- The status bits are included in the instrument's responses to inform the host computer of its condition. Each bit can be assigned to one operational and warning message flag.
- It is possible to assign more than one flag to the same Hessen status bit. This allows the grouping of similar flags, such as all temperature warnings, under the same status bit.
- Assigning conflicting flags to the same bit will cause each status bit to be triggered if any of the assigned flags is active.

Table 3-3. Default Hessen Status Flag Assignments

STATUS FLAG NAME	DEFAULT BIT ASSIGNMENT
WARNING FLAGS	
SAMPLE FLOW WARNING	0001
PHOTO REF WARNING	0002
SAMPLE PRESS WARN	0004
SAMPLE TEMP WARN	0008
O3 GEN LAMP WARNING¹	0020
O3 GEN TEMP WARN¹	0040 ²
PHOTO TEMP WARNING	0040 ²
OPERATIONAL FLAGS	
In MANUAL Calibration Mode	0200
In ZERO Calibration Mode	0400
In SPAN Calibration Mode	0800 ²
In LO SPAN Calibration Mode	0800 ²
UNITS OF MEASURE FLAGS	
UGM	0000
MGM	2000
PPB	4000
PPM	6000
Spare/Unused Bits	0080, 0100, 1000, 8000
UNASSIGNED FLAGS (0000)	
LAMP STABIL WARN	LAMP DRIVER WARN
O3 SCRUB TEMP WARN³	ANALOG CAL WARNING
BOX TEMP WARNING	CANNOT DYN ZERO
SYSTEM RESET	CANNOT DYN SPAN
RELAY BOARD WARNING	INVALID CONC
REAR BOARD NOT DETECTED	Instrument is in MP CAL mode
	Instrument is in MP CAL mode

¹ Only appears if the IZS option is installed

4 CALIBRATION

This Section is organized into subsections as follows:

- SECTION 4.1 Important Precalibration Information: contains important information you should know before calibrating the instrument.
- SECTION 4.2 Calibration Procedures: provides procedures for both calibration and calibration checks of basic and valve option configurations.
- SECTION 4.3 Automatic Zero/Span Cal/Check (Auto Cal): describes the procedure for using the AutoCal feature to check calibration or to calibrate the instrument. (The AutoCal feature requires that either the zero/span valve option or the internal span gas generator option be installed and operating).
- SECTION 4.4 Calibration Quality: describes how to evaluate the quality of each calibration.

4.1 IMPORTANT PRECALIBRATION INFORMATION

Note

A start-up period of 4-5 hours is recommended prior to calibrating the analyzer.

4.1.1 CALIBRATION REQUIREMENTS

Calibration equipment and supplies include, but are not limited to, the following:

- Zero-air source
- Span gas source
- Gas lines - All Gas lines should be PTFE (Teflon) or FEP
- Optionally, a recording device such as a strip-chart recorder and/or data logger. (For electronic documentation, the internal data acquisition system DAS can be used by configuring the Datalogger through the Setup>Data Logging menu, Section 2.5.1).
- Traceability Standards

4.1.2 ZERO AIR

Zero air or zero calibration gas is defined as a gas that is similar in chemical composition to the measured medium but without the gas to be measured by the analyzer.

For O₃ measuring devices, zero air should be:

- Devoid of O₃ and Mercury Vapor
- Have a dew point of -20°C

Devices that condition ambient air by drying and removing any pollutants, such as the Teledyne API' Model 701 Zero Air Module, are ideal for producing Zero Air.

4.1.3 CALIBRATION (SPAN) GAS

Span Gas is a gas specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the desired measurement range and should be certified traceable to NIST Standard Reference Materiald (SRM). It is recommended that the span gas used have a concentration equal to 80% of the full measurement range. (For example, if the application is to measure between 0 ppm and 500 ppb, an appropriate span gas would be 400 ppb; between 0 ppb and 1000 ppb, an appropriate Span Gas would be 800 ppb).

If Span Gas is sourced directly from a calibrated, pressurized bottle, use the exact concentration value printed on the bottle.

Because of the instability of O₃, it is impractical, if not impossible, to produce stable concentrations of bottled, pressurized O₃. Therefore, when varying concentrations of O₃ is required for span calibrations they must be generated locally. We recommend using a gas dilution calibrator with a built in O₃ generator, such as a Teledyne API Model T700, as a source for O₃ span gas.

4.1.4 INTERFERENTS

The detection of O₃ is subject to interference from a number of sources including SO₂, NO₂, NO, H₂O and aromatic hydrocarbon meta-xylene and mercury vapor. The Model T400 successfully rejects interference from all of these with the exception of mercury vapor.

If the Model T400 is installed in an environment where the presence of mercury vapor is suspected, steps should be taken to remove the mercury vapor from the sample gas before it enters the analyzer.

For a more detailed discussion of this topic, see Section 6.1.4.

4.1.5 DILUTION RATIO OPTION SOFTWARE SET UP

If your application involves diluting the sample gas before it enters the analyzer, and the Dilution Ratio Option is enabled:

1. Set the appropriate units of measure (Setup>Vars>User Units).
2. Select the reporting range mode (Setup>Vars>Range Mode [Single or Dual]).
3. Set the reporting range (Setup>Analog Outputs>Analog Output[#]>O₃ Concentration, Min Max). Ensure that the upper span limit entered for the reporting range (in the Max field) is the maximum expected concentration of the undiluted gas.
4. Set the dilution factor as a gain, e.g., a value of 20 means 20 parts diluent and 1 part sample gas (Setup>Vars>Dilution Factor).
5. Calibrate the analyzer; ensure that the calibration span gas is either supplied through the same dilution system as the sample gas or has an appropriately lower actual concentration.

EXAMPLE: If the reporting range limit is set for 100 ppm and the dilution ratio of the sample gas is 20 gain, either:

- a span gas with the concentration of 100 ppm can be used if the span gas passes through the same dilution steps as the sample gas, or;
- a 5 ppm span gas must be used if the span gas **IS NOT** routed through the dilution system.

4.1.6 DATA RECORDING DEVICES

A strip chart recorder, data acquisition system or digital data acquisition system should be used to record data from the serial or analog outputs.

- If analog readings are used, the response of the recording system should be checked against a NIST traceable voltage source or meter.
- Data recording devices should be capable of bi-polar operation so that negative readings can be recorded.
- For electronic data recording, make use of the internal data acquisition system (DAS) by setting up the Data Logger.

4.2 CALIBRATION PROCEDURES

Check that the pneumatic connections for the specific instrument configuration are as instructed in Section 2.3.2.

Verify/change (if needed) the settings as follows:

- User Units (unit of measure): PPB (Setup>Vars>User Conc Units)
- Min and Max Concentration Range (Max should be highest concentration expected to measure) (Setup>Analog Outputs>Analog Output[#], Signal Out, [Gas] Concentration)
- Range Mode: SNGL (Setup>Vars>Range Mode)

Note

Tips for Setting the Expected Span Gas Concentration:

- **When setting expected concentration values, consider impurities in your span gas source.**
- **The expected span gas concentration should be 80% of the reporting range of the instrument.**

To calibrate or to perform a calibration check for basic configuration instruments, see Section 4.2.1.

To calibrate or to perform a calibration check for instruments with valve options, see Section 4.2.2.

To perform automatic calibration check for instruments with the internal span gas generator, see Section 4.3.

4.2.1 CALIBRATION AND CHECK PROCEDURES FOR BASIC CONFIGURATION

Although this Section uses the Calibration menu for both check and actual calibration, a check does not require the Calibration menu. Instead, while in Home page, simply flow the zero air or the applicable span gas through the Sample port, and check the reading after the Stability falls below 1.0 PPB (either in the gas graph or in the Dashboard).

Otherwise, follow the steps presented in Sections 4.2.1.1 and 4.2.1.2.

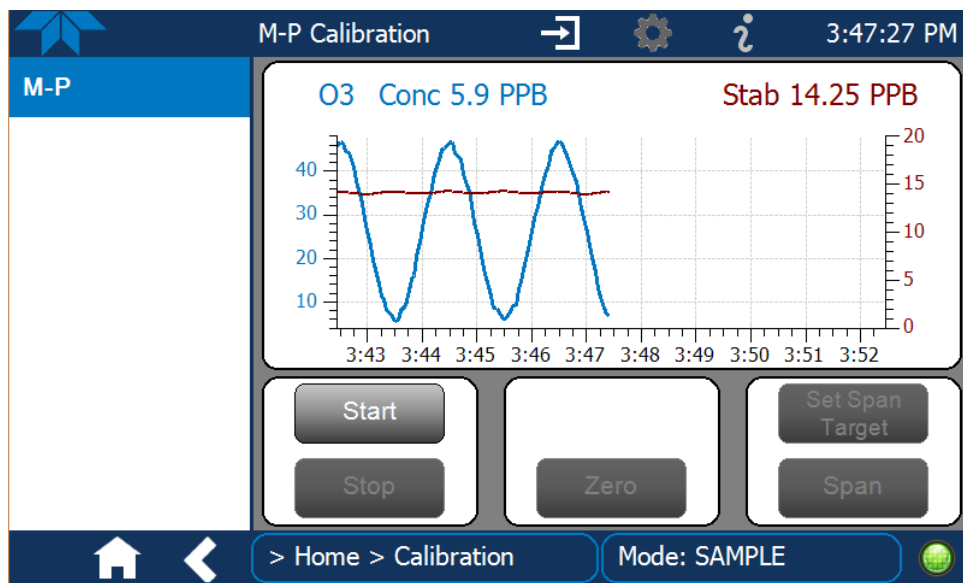


Figure 4-1. Multi-Point Calibration Page

4.2.1.1 ZERO CALIBRATION CHECK AND ACTUAL CALIBRATION

1. Go to the Calibration>M-P menu.
2. Input Zero air through the Sample port and press the Start button.
3. Either check or calibrate as follows:

CHECK ONLY:

- a. Wait for reading to stabilize.
- b. Press Stop and check the reading.

ACTUAL CALIBRATION:

- a. Press the Zero button.
- b. Press Stop and check the reading.

4.2.1.2 SPAN CALIBRATION CHECK AND ACTUAL CALIBRATION

1. While still in the Calibration>M-P menu, input Span gas through the Sample port and press the Start button.
2. Either check or calibrate as follows:

CHECK ONLY:

- a. Wait to reach stability, then press Stop.
- b. Record the reading(s).

ACTUAL CALIBRATION:

- a. Press the Set Span Target button and enter the span gas concentration.
- b. Verify the concentration reading is the same as the span gas concentration being supplied.
- c. If correct, wait to reach stability, then press the Span button.
- d. In the Cal Result window, press OK.

3. Press the Stop button and return to Home screen.
4. In the Dashboard, check and record the Slope(s) and the Offset(s). (See Section 4.4 regarding these values).

4.2.2 CALIBRATION AND CHECK PROCEDURES WITH VALVE OPTIONS INSTALLED

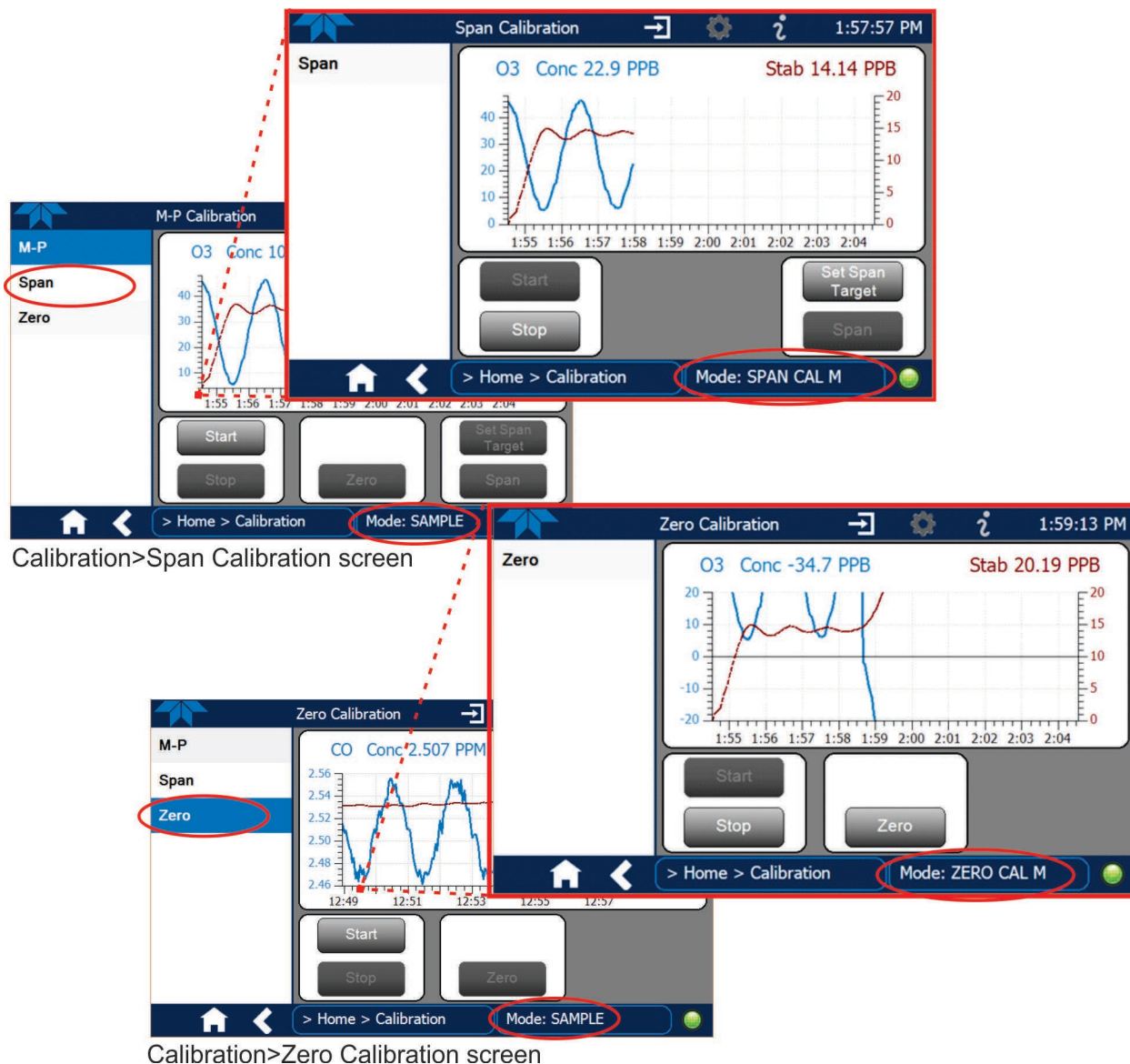


Figure 4-2. Zero and Span Calibration Screens

Follow the instructions in Section 4.2.1, except instead of the M-P menu, go to the Calibration>Zero menu for Zero cal and to the Calibration>Span menu for O3 Span cal.

4.2.2.1 USE OF ZERO/SPAN VALVE WITH REMOTE CONTACT CLOSURE

Contact closures for controlling calibration and calibration checks are located on the rear panel CONTROL IN connector. Instructions for setup and use of these contacts are in Section 2.3.1.5.

When the contacts are closed for at least 5 seconds, the instrument switches into zero, low span or high span mode and the internal zero/span valves will be automatically switched to the appropriate configuration.

- The remote calibration contact closures may be activated in any order.
- It is recommended that contact closures remain closed for at least 10 minutes to establish a reliable reading.
- The instrument will stay in the selected mode for as long as the contacts remain closed.

If contact closures are being used in conjunction with the analyzer's AutoCal (see Section 4.3) feature and the AutoCal attribute "Calibrate" is enabled (selection box is checked), the analyzer will not recalibrate the analyzer UNTIL the contact is opened. At this point, the new calibration values will be recorded before the instrument returns to SAMPLE mode.

If the AutoCal attribute "Calibrate" is disabled (selection box is unchecked), the instrument will return to SAMPLE mode, leaving the instrument's internal calibration variables unchanged.

4.3 AUTOMATIC ZERO/SPAN CAL/CHECK (AUTO CAL)

The Auto Cal feature allows unattended periodic operation of the ZERO/SPAN valve options by using the instrument's internal time of day clock. Auto Cal operates by executing preprogrammed calibrations or calibration checks set up by the user to initiate the various calibration states of the analyzer and to open and close valves appropriately. It is possible to set up and run up to three separate preprogrammed calibrations or calibration checks (labeled # 1, 2 and 3). Each calibration or check can operate in one of three modes (Zero, Low or High), or be disabled.

Table 4-1 and Table 4-2 show how to set up the operating states of each calibration or check, and Table 4-3 shows how to program the execution of each.

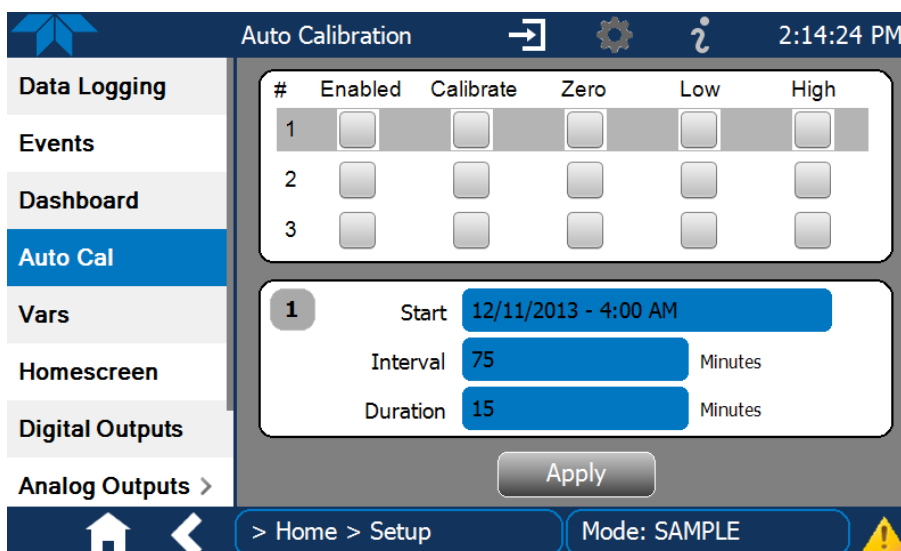


Figure 4-3. Auto Cal Page

Table 4-1. AUTO CAL States

MODE NAME	ACTION
Enabled	<input checked="" type="checkbox"/> enables the sequence; <input type="checkbox"/> disables the sequence.
Calibrate	<input checked="" type="checkbox"/> enables an actual calibration when the Enabled box is also <input checked="" type="checkbox"/> <input type="checkbox"/> allows a calibration check when the Enabled box is also <input checked="" type="checkbox"/> .
Zero	<input checked="" type="checkbox"/> causes the sequence to perform a Zero calibration when both the Calibrate and Enabled boxes are also <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> causes a Zero check when the Enabled box is also <input checked="" type="checkbox"/> and the Calibrate box is unchecked (<input type="checkbox"/>) <input type="checkbox"/> disables Zero calibration and check
Low	<input checked="" type="checkbox"/> causes the sequence to perform a Low Span calibration when both the Calibrate and Enabled boxes are also <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> causes a Low Span check when the Enabled box is also <input checked="" type="checkbox"/> and the Calibrate box is unchecked (<input type="checkbox"/>) <input type="checkbox"/> disables Low Span calibration and check
High	<input checked="" type="checkbox"/> causes the sequence to perform a High Span concentration calibration when both the Calibrate and Enabled boxes are also <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> causes a High Span check when the Enabled box is also <input checked="" type="checkbox"/> and the Calibrate box is unchecked (<input type="checkbox"/>) <input type="checkbox"/> disables the High Span calibration and check.

Table 4-2 shows how the selection boxes would be enabled/disabled for calibration checks and calibrations.

Table 4-2. Auto Cal Setup Combinations

MODE	ACTION	STATE				
		Enabled	Calibrate	Zero	Low	High
Zero	Check	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Calibrate	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Low	Check	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Calibrate	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
High	Check	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Calibrate	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Zero Low High	Check	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	Calibrate	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

For each sequence, there are four parameters that control operational details: Date, Time (both in the Start field), Interval, and Duration, as presented in Table 4-3.

Table 4-3. Auto Cal Programming Sequence Execution

ATTRIBUTE	ACTION
Start	When the Enabled box is “on” <input checked="" type="checkbox"/> , the Sequence (identified by its number) begins on the date and time shown in the configurable Start field. (Click the field for the pop-up window and toggle between the Time (Hour/Minutes) and the Date (Year/Month/Day) attributes to edit as needed).
Interval	Number of minutes to skip between each Sequence execution. (Click the field to input the number of minutes in the pop-up window).
Duration	Number of minutes that each Sequence execution is to run. (Click the field to input the number of minutes in the pop-up window).

Important

IMPACT ON READINGS OR DATA

- The programmed STARTING_TIME must be a minimum of 5 minutes later than the real time clock for setting real time clock (Setup>Instrument, Section 2.5.9).
- Avoid setting two or more sequences at the same time of the day.
- Any new sequence that is initiated whether from a timer, the COM ports or the contact closure inputs will override any sequence that is in progress.
- **It is recommended that calibrations be performed using external sources of Zero Air and Span Gas whose accuracy is traceable to EPA standards.**

4.4 CALIBRATION QUALITY

After completing any of the calibration procedures described above, it is important to evaluate the analyzer's calibration **SLOPE** and **OFFSET** parameters. These values describe the linear response curve of the analyzer. The values for these terms, both individually and relative to each other, indicate the quality of the calibration.

To perform this quality evaluation, check these parameters in the Dashboard (Setup>Dashboard to configure if needed) and frequently compare them to those values on the *Final Test and Validation Data Sheet* that was shipped with your instrument, which should not be significantly different. If they are, refer to the Troubleshooting content in Section 5.

4.5 CALIBRATION OF THE ELECTRONIC SUBSYSTEMS

There are several electronic characteristics of the T400 analyzer's photometer that may occasionally need checking or calibration. These calibrations include Dark Calibration, Pressure Cal and Flow Cal (and O₃ Gen Cal when the O₃ Generator option is installed), all located under the Utilities>Diagnostics menu.

4.5.1 PRESSURE CALIBRATION

A sensor at the exit of the sample chamber continuously measures the pressure of the sample gas. The data for Sample Pressure are used to compensate the final gas concentration calculation for changes in atmospheric pressure and are stored in the CPU's memory.

IMPORTANT

IMPACT ON READINGS OR DATA

This calibration must be performed when the pressure of the sample gas is equal to ambient atmospheric pressure. Before performing the following pressure calibration procedure, disconnect the sample gas pump and sample gas-line vent from the rear panel sample gas inlet.

Activate this procedure in the Utilities>Diagnostics>Pressure Cal menu.

4.5.2 FLOW CALIBRATION

The flow calibration allows the user to adjust the values of the sample flow rates as they appear in the Dashboard to match the actual flow rate measured at the sample inlet. This does not change the hardware measurement of the flow sensors, only the software-calculated values.

To carry out this adjustment, connect an external, sufficiently accurate flow meter to the sample inlet per Section 5.6.6. Once the flow meter is attached and is measuring actual gas flow, use the Utilities>Diagnostics>Flow Cal menu to input the flow meter reading and calibrate.

4.5.3 O₃ GEN CALIBRATION

This function calibrates the O₃ Generator that comes with the IZS option, by setting the IZS O₃ Generator output to a series of levels between zero and full scale, and matching each level to a drive voltage from the generator lamp. This calibration is typically performed when the O₃ Generator lamp requires adjustment or replacement (Section 5.7.13).

4.6 EPA PROTOCOL CALIBRATION

When running this instrument for U.S. EPA compliance, always calibrate prior to use, adhering to the EPA designation requirements for this instrument. (The official List of Designated Reference and Equivalent Methods is published in the U.S. Federal Register: <http://www3.epa.gov/ttn/amtic/criteria.html>). Pay strict attention to the built-in warning features, periodic inspection, regular zero/span checks, regular test parameter evaluation for predictive diagnostics and data analysis, and routine maintenance. Any instrument(s) supplying the zero air and span calibration gasses used must themselves be calibrated and that calibration must be traceable to an EPA/NIST primary standard.

Comply with Code of Federal Regulations, Title 40 (downloadable from the U.S. Government Publishing Office at <http://www.gpo.gov/fdsys/>) and with Quality Assurance Guidance documents (available on the EPA website, <http://www3.epa.gov/ttn/amtic/qalist.html>). Give special attention to specific regulations regarding the use and operation of photometric ozone analyzers.

5. MAINTENANCE AND SERVICE

Predictive diagnostic functions, including data acquisition records, failure warnings and test functions built into the analyzer, allow the user to determine when repairs are necessary. A minimal number of simple, regularly performed maintenance procedures (Section 5.1) will ensure that the analyzer continues to operate accurately and reliably over its lifetime. Repairs and troubleshooting are covered in Section 5.7 of this manual.

5.1 MAINTENANCE SCHEDULE

Table 5-1 shows a typical maintenance schedule for the instrument. The actual frequency of performing these procedures can vary depending on the operating environment. Additionally, in some cases, there are local regulations or standards that also need to be considered.



WARNING – Electrical Shock Hazard

Disconnect power before performing any of the following operations that require entry into the interior of the analyzer.



CAUTION – Qualified Personnel

These maintenance procedures must be performed by qualified technicians only.

Important

IMPACT ON READINGS OR DATA

A Span and Zero Calibration Check (see CAL CHECK REQ'D Column of Table 5-1) must be performed following certain of the maintenance procedure listed below. To perform a CHECK of the instrument's Zero or Span Calibration, refer to Sections 4.2.1.1 and 4.2.1.2, respectively.

Alternatively, use the Auto Cal feature described in Section 4.3 with the CALIBRATE attribute set to OFF (not enabled).

Table 5-1. T400 Maintenance Schedule

ITEM	ACTION	FREQ	CAL CHECK REQ'D. ¹	MANUAL SECTION	DATE PERFORMED								
Particulate Filter	Replace	Weekly or as needed	Yes	5.6.1									
Verify Dashboard Functions	Record and analyze	Weekly or after any Maintenance or Repair	No	5.7.2									
Pump Diaphragm	Replace	As Needed	Yes	--									
O ₃ Reference Scrubber	Replace	Every 2-5 years, as needed	Yes	5.7.15.2									
IZS Zero Air Scrubber	Replace	Annually	No	5.7.15.3									
Desiccant (Option 56)	Replace	Regularly as needed	No	5.6.4									
Absorption Tube	Inspect --- Clean	Annually --- As Needed	Yes	5.6.7									
Flow Check	Perform Flow Check	Every 6 Months	No	5.6.6									
Leak Check	Perform Leak Check	Annually or after any Maintenance or Repair	Yes	5.6.5									
Pneumatic lines	Examine and clean	As needed	Yes if cleaned	--									

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5.2 PREDICTING DIAGNOSTICS

These Functions can be used to predict failures by looking at how their values change over time. Initially it may be useful to compare the state of these functions to the values recorded on the printed record of the Final Test and Validation Data Sheet for your instrument. Table 5-2 can be used as a basis for taking action as these values change with time. The Data Logger (internal data acquisition system or DAS) is a convenient way to record and track these changes (Section 2.5.1). Use NumaView™ Remote to download and review this data from a remote location.

Table 5-2. Predictive Uses for Dashboard Functions

FUNCTION	CONDITION	BEHAVIOR	INTERPRETATION
STABILITY	Zero Cal	Increasing	<ul style="list-style-type: none"> • Pneumatic leaks – instrument & sample system • Malfunctioning UV lamp (Bench)
O3 REF	Sample	Decreasing	<ul style="list-style-type: none"> • Lamp Aging • Mercury contamination
O3 DRIVE	CalS	Increasing	<ul style="list-style-type: none"> • Aging IZS UV lamp (only if reference detector option is installed)
PRESSURE	Sample	Increasing > 1"	<ul style="list-style-type: none"> • Pneumatic Leak between sample inlet and optical bench
		Decreasing > 1"	<ul style="list-style-type: none"> • Dirty particulate filter • Pneumatic obstruction between sample inlet and optical bench • Obstruction in sampling manifold
SAMPLE FLOW	Sample	Decreasing	<ul style="list-style-type: none"> • Pump diaphragm deteriorating • Sample flow orifice plugged/obstructed • Pneumatic obstruction between sample inlet and optical bench • Obstruction in sampling manifold
OFFSET	Zero Cal	Increasing	<ul style="list-style-type: none"> • Obstructed/leaking Meas/Ref Valve • Pneumatic leaks – instrument & sample system
		Decreasing	<ul style="list-style-type: none"> • Contaminated zero calibration gas • Obstructed Meas/Ref Valve • Pneumatic leaks – instrument & sample system
SLOPE	Span Cal	Increasing	<ul style="list-style-type: none"> • Pneumatics becoming contaminated/dirty • Dirty particulate filter • Pneumatic leaks – instrument & sample system
		Decreasing	<ul style="list-style-type: none"> • Contaminated calibration gas

5.3 OPERATIONAL HEALTH CHECKS

Navigate to the Utilities>USB Utilities>Report menu (Figure 5-1) to download a report on the basic operations of the instrument. To download the report for your own viewing on a computer or to send to others, insert a flash drive into a front panel USB port and press the Download button, which is enabled when the instrument detects the flash drive.

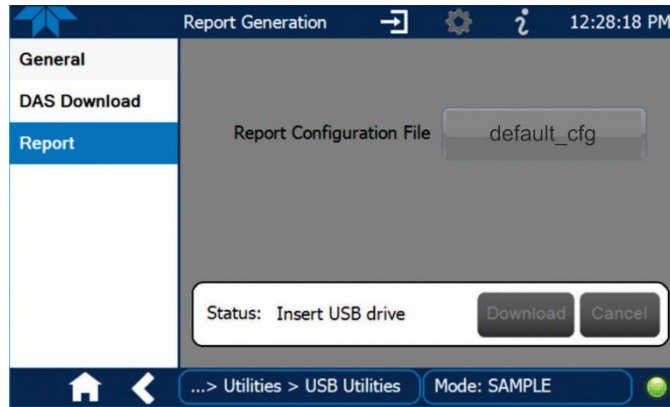


Figure 5-1. Report Generation Page

The report can also be set to generate periodically and sent to a Web services “cloud” where it is available for viewing by Teledyne API technical support personnel. Set this function with two Vars:

Setup>Vars>Upload Report to Cloud: set to True.

Setup>Vars>Report Upload>Interval: edit the number of hours between report uploads.

5.4 SOFTWARE/FIRMWARE UPDATES

There are two ways to check for and acquire updates: either remotely or manually.

5.4.1 REMOTE UPDATES

The instrument must be connected to a network that is connected to the Internet. In the Setup>Instrument menu, select the Remote Update menu and press the Check for Updates button. If an update is available, it can be downloaded through this page.

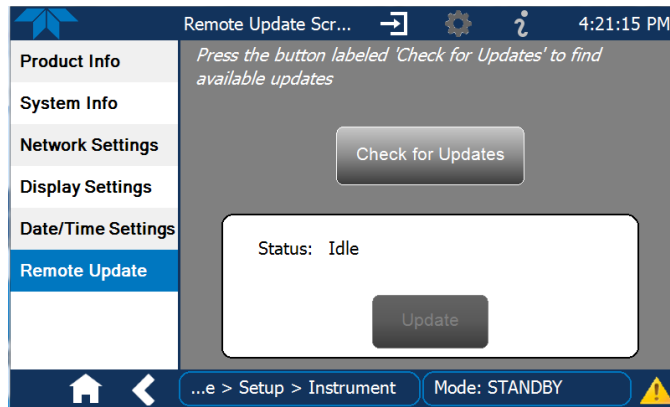


Figure 5-2. Remote Update Page

5.4.2 MANUAL RELOAD/UPDATE PROCEDURES

To reload or update firmware, first contact Technical Support to obtain the applicable file(s): api-techsupport@teledyne.com /+1 800-324-5190.

1. Follow Technical Support's instructions for copying the firmware files to a flash drive.
2. Go to the Utilities>USB Utilities>General menu.

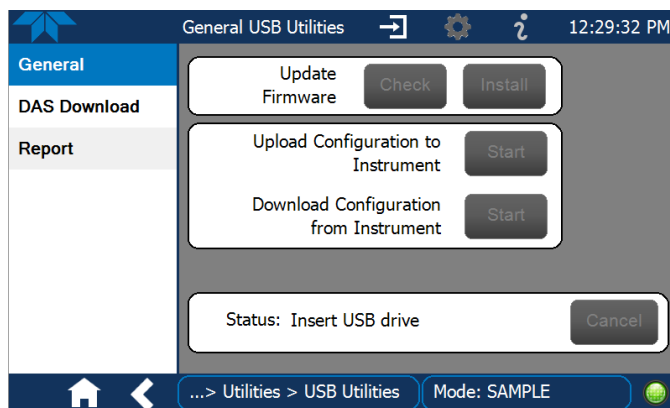


Figure 5-3. Manual Update Page (and other utilities)

3. Insert a flash drive into a front panel USB port and wait for the Status field to indicate that the drive has been detected.
4. In the Update Firmware field, press the Check button for the instrument to determine whether the firmware on the flash drive is more recent than what is currently installed. Once it's been determined that the firmware is new, the Install button will be enabled; if the firmware version on the flash drive is the same as or older than the current firmware of the instrument, the Install button will not be enabled.
5. Press the Install button, and note the messages in the Status field at the bottom of the page. Use the Cancel button if necessary.
6. When complete, as indicated in the Status field, press the Done button, which replaces the Cancel button, and remove the flash drive.
7. Power off and restart the instrument to complete the new firmware installation.

5.4.3 INSTRUMENT DISPLAY CALIBRATION (FOR EARLIER INSTRUMENTS)

This Section applies to instruments shipped before January 2017. Although unlikely, if ever the touchscreen appears unresponsive or responds incorrectly, the screen can be calibrated via the Setup>Instrument>Display Settings menu.

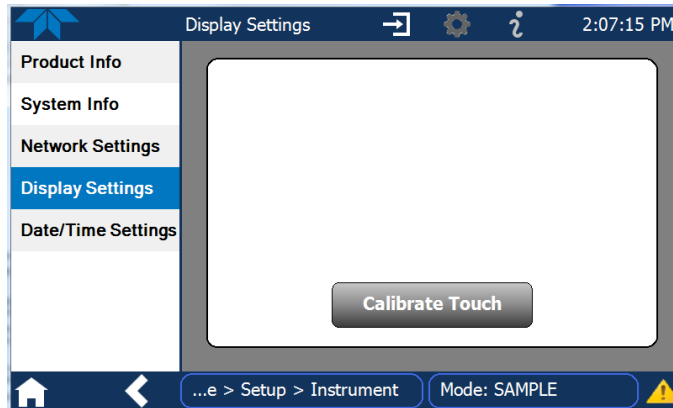


Figure 5-4. Touchscreen Calibration Page

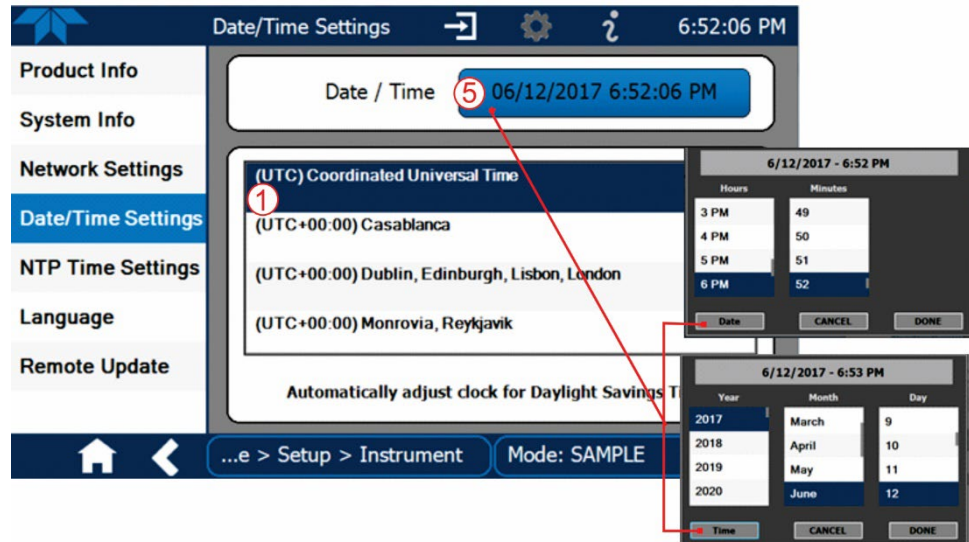
1. Connect a mouse to either of the front panel USB ports.
2. Navigate with the pointer to Setup>Instrument>Display Settings.
3. Click on “Calibrate Touch” and a crosshair appears in the center of the display screen.
4. Note that a timer function is enabled, allowing only 15 seconds to start the calibration process. If the timer expires, the instrument will exit the calibration screen and return to normal operation.
5. Click the very center of the crosshair.
6. When a new crosshair appears in the upper left corner of the screen, carefully and accurately click and hold the very center of that crosshair until it finishes shrinking, then release.
7. Repeat Step 6 for each of the corners.
8. Once the process is completed, a CANCEL and an ACCEPT button appear in the lower left corner: Test the accuracy of the calibration by touching parts of the screen and see that the mouse pointer follows your touches.
9. If you press the CANCEL button, the calibration won’t be altered. Otherwise, press the ACCEPT button.

5.5 TIME ZONE CHANGES

There is an option to change between 12-hour and 24-hour format in the Setup>Vars menu (System Time Format). Effectively changing the Time Zone requires a specific procedure as follows:

1. In Setup>Instrument>Date/Time Settings select the applicable Time Zone.
2. Allow adequate time for the selected Time Zone to be properly accepted.
3. Verify: return to Home page then back to the Date/Time Settings page, and check that the selected Time Zone is now highlighted.
4. Without making any other changes, power OFF the instrument and power ON again.
5. Once restarted, return to the Date/Time Settings page where the newly selected Time Zone should be highlighted. (If not, it means that not enough time had passed for the instrument to accept the change before the power was cycled OFF).
6. After the Time Zone is implemented first (Steps 1 through 5), then other changes to the date and/or time can be made, and recycling the power is not necessary.

- ① Time zone change must be set first.
- ② Wait. Allow sufficient time to accept new Time Zone.
- ③ Verify. Return to Home page, then return to Date/Time Settings page.
- ④ After correct Time Zone is displayed, power recycle the instrument.
- ⑤ Only after Time Zone is selected and instrument rebooted, can other changes to date and/or time be made effectively.



Changes to date and/or time do **not** require a reboot.

Figure 5-5. Time Zone Change Requirements

5.6 MAINTENANCE PROCEDURES

The following procedures are to be performed periodically as part of the standard maintenance of the T400.

5.6.1 REPLACING THE SAMPLE PARTICULATE FILTER

The particulate filter should be inspected often for signs of plugging or contamination. We recommend that the filter and the wetted surfaces of the filter housing be handled as little as possible when you change the filter. Do not touch any part of the housing, filter element, PTFE retaining ring, glass cover and the o-ring with bare hands; rather, use PTFE-coated tweezers or similar handling to avoid contamination of the sample filter assembly.

To change the filter:

1. Turn OFF the analyzer to prevent drawing debris into the instrument.
2. Open the T400's hinged front panel and unscrew the knurled retaining ring on the filter assembly.

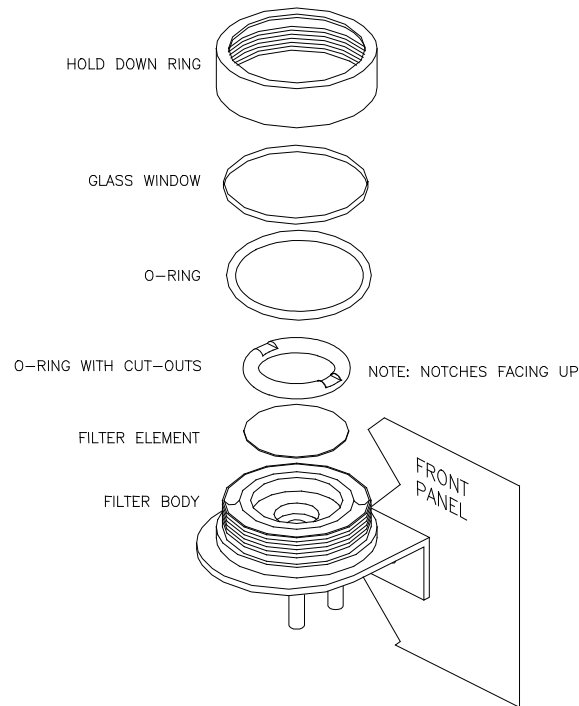


Figure 5-6. Replacing the Particulate Filter

3. Carefully remove the retaining ring, PTFE o-ring, glass filter cover and filter element.
4. Replace the filter, being careful that the element is fully seated and centered in the bottom of the holder.
5. Re-install the PTFE o-ring (with the notches up), the glass cover, then screw on the retaining ring and hand tighten. Inspect the seal between the edge of filter and the o-ring to assure a proper seal.
6. Re-start the Analyzer.

5.6.2 REBUILDING THE SAMPLE PUMP

The diaphragm in the sample pump periodically wears out and must be replaced. A sample rebuild kit is available – see label on the pump itself for the part number of the pump rebuild kit. Instructions and diagrams are included with the kit.

Always perform a flow check (Section 5.6.6) and a leak check (Section 5.6.5) after rebuilding the Sample Pump.

5.6.3 REPLACING THE IZS OPTION ZERO AIR SCRUBBER

1. Power OFF the analyzer.
2. Remove the cover from the analyzer.
3. Disconnect the white nylon ¼"-1/8" fitting from the Zero Air Scrubber (See Figure 5-7).
4. Remove the old scrubber by disconnecting the 9/16" fitting at the top of the O₃ generator tower, then removing the scrubber.
5. Install the new scrubber by reversing these instructions.

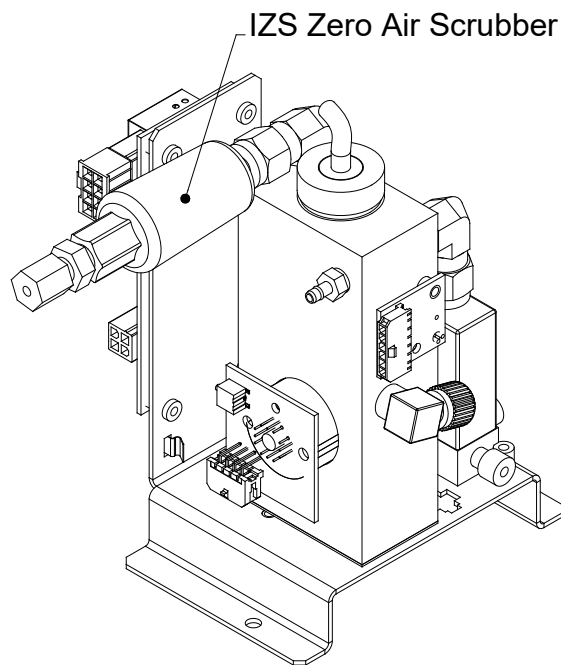


Figure 5-7. Replacing the IZS Zero Air Scrubber

5.6.4 IZS DESICCANT OPTION

The analyzer can be fitted with a desiccant dryer to provide a dry air source to the IZS sub-system. This option consists of a rear panel mounted scrubber cartridge filled with anhydrous calcium sulfate (CaSO_4) desiccant.

The desiccant material is expendable and must be replaced at regular intervals per the Maintenance Schedule. Replacement guidelines are as follows:

- Initially the desiccant should be monitored frequently until a standard replacement interval can be established.
- Replace when the material exhibits a color change from blue to pink where it has been saturated with water vapor.
- Refill the scrubber cartridge before the entire scrubber turns pink.
- Replacement interval will depend on how often the IZS is used, as well as ambient levels of humidity in your application.

5.6.5 PERFORMING LEAK CHECKS

Leaks are the most common cause of analyzer malfunction; Section 5.6.5.1 presents a simple leak check procedure. Section 5.6.5.2 details a more thorough procedure.

5.6.5.1 VACUUM LEAK CHECK AND PUMP CHECK

This method is easy and fast. It detects, but does not locate most leaks. It also verifies that the sample pump is in good condition.

1. Turn the analyzer ON, and allow enough time for flows to stabilize.
2. Cap the sample inlet port.
3. After a few minutes, when the pressure has stabilized, note the SAMPLE PRESSURE reading in the Dashboard.
 - If the reading is < 10 in-Hg, the pump is in good condition and there are no large leaks.
4. Check the sample gas flow.
 - If the flow is < 10 cm^3/min and stable, there are no large leaks in the instrument's pneumatics.

5.6.5.2 PRESSURE LEAK CHECK

If you can't locate the leak by the above procedure, obtain a leak checker that contains a small pump, shut-off valve and pressure gauge. Alternatively, use a tank of pressurized gas, with the two-stage regulator adjusted to less than 15 psi with a shutoff valve and pressure gauge.



CAUTION

Do not use bubble solution with vacuum applied to the analyzer, as the solution may contaminate the instrument. Do not exceed 15 PSIG pressure.

1. Turn OFF power to the instrument.
2. Install a leak checker or tank of gas as described above on the sample inlet at the rear panel.
3. Install a cap on the rear panel's EXHAUST fitting.
4. Remove the instrument cover and locate the sample pump. Disconnect the two fittings on the sample pump and install a union fitting in place of the pump. The analyzer cannot be leak checked with the pump in line due to internal leakage that normally occurs in the pump.
5. Pressurize the instrument with the leak checker, allowing enough time to fully pressurize the instrument through the critical flow orifice. Check each fitting with soap bubble solution, looking for bubbles. Once the fittings have been wetted with soap solution, do not re-apply vacuum, as it will suck soap solution into the instrument and contaminate it. Do not exceed 15 psi pressure.
6. If the instrument has one of the zero and span valve options, the normally closed ports on each valve should also be separately checked. Connect the leak checker to the normally closed ports and check with soap bubble solution.
7. If the analyzer is equipped with an IZS option, connect the leak checker to the dry air inlet and check with soap bubble solution.
8. Once the leak has been located and repaired, the leak-down rate should be < 1 in-Hg (0.4 psi) in 5 minutes after the pressure is shut off.

5.6.6 PERFORMING A SAMPLE FLOW CHECK

CAUTION



Always use a separate calibrated flow meter capable of measuring flows in the 0 – 1000 cc/min range to measure the gas flow rate though the analyzer.

DO NOT use the built in flow measurement viewable from the Front Panel of the instrument. This measurement is only for detecting major flow interruptions such as clogged or plugged gas lines.

See rear panel for **SAMPLE** port location.

1. Power off the analyzer.
2. Attach the flow meter to the sample inlet port on the rear panel. Ensure that the inlet to the flow meter is at atmospheric pressure.
3. Sample flow should be $800 \text{ cm}^3/\text{min} \pm 10\%$.
 - Low flows indicate blockage somewhere in the pneumatic pathway, typically a plugged sintered filter or critical flow orifice in one of the analyzer's flow control assemblies.
 - High flows indicate leaks downstream of the Flow Control Assembly.
4. Once an accurate measurement has been recorded by the method described above, adjust the analyzer's internal flow sensors (See Section 4.5.2).

5.6.7 MAINTAINING THE PHOTOMETER ABSORPTION TUBE

NOTE

This procedure should never be needed as long as the photometer is supplied with clean, dry, particulate-free zero air only. However, this procedure is included for the rare event that cleaning or replacing the absorption tube is required.

1. Power off the unit.
2. Remove the cover from analyzer.
3. Locate the optical bench (see **Error! Reference source not found.**).
4. Remove the top cover of the optical bench.
5. Unclip the sample thermistor from the tube.
6. Loosen the two screws on the round tube retainers at either end of the tube.
7. Using both hands, carefully rotate the tube to free it.
8. Slide the tube towards the lamp housing.
 - Slide the front of the tube past the detector block and out of the instrument.



CAUTION – General Safety Hazard

Do not cause the tube to bind against the metal housings: the tube may break and cause serious injury.

9. Clean the tube only with de-ionized water.

10. Air dry the tube.
11. Check the cleanliness by looking down the bore of the tube.
 - It should be free from dirt and lint.
12. Inspect the o-rings that seal the ends of the optical tube (these o-rings may stay seated in the manifolds when the tube is removed.)
 - If there is any noticeable damage to these o-rings, they should be replaced.
13. Re-assemble the tube into the lamp housing and return the top cover of the optical bench.
14. Prior to tightening the retainer screws, gently push the tube all the way toward the front of the optical bench when it is reassembled; this will ensure that the tube is assembled with the forward end against the stop inside the detector manifold.
15. Return the cover to the analyzer and power up the analyzer.
16. Perform an **AUTO LEAK CHECK** on the instrument.

5.6.8 ADJUSTING THE OPTICAL BENCH UV LAMP

This procedure details the steps for adjustment of the UV source lamp in the optical bench assembly. This procedure should be done whenever the test function **O3 REF** value drops below 3000 mV



CAUTION – UV Radiation Risk

Do not look directly at the light of the UV lamp. Use safety glasses rated for UV protection while performing this adjustment.

1. Make sure the analyzer is warmed-up and has been running for at least 15 minutes before proceeding.
2. Remove the cover from the analyzer.
3. Locate the **UV DETECTOR GAIN ADJUST POT** on the photometer assembly, shown below in Figure 5-8

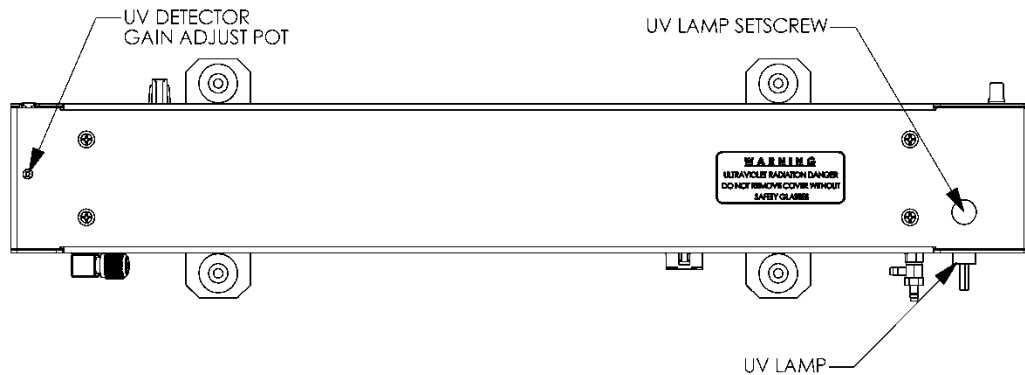


Figure 5-8. Optical Bench – Lamp Adjustment/ Installation

4. Navigate to Utilities>Diagnostics>Analog Inputs>Photo Detector.

5. Using an insulated pot adjustment tool, turn the UV DETECTOR GAIN ADJUST POT until the Photo Detector signal value is as close as possible to 4600 mV. (Additional adjustments can be made by physically rotating the lamp in its housing: loosen the UV lamp setscrew and slightly rotating the lamp up to ¼ turn in either direction while watching the signal value. Retighten setscrew when complete).
 - If a minimum reading of 3500.0 mV cannot be reached, the lamp must be replaced.
6. Replace the cover on the analyzer.

5.6.9 REPLACING THE OPTICAL BENCH UV LAMP

This procedure details the steps for replacement of the UV source lamp in the optical bench assembly. This procedure should be done whenever the Photo Detector signal value can no longer adjusted to or above 3500 mV.

CAUTION – UV Radiation Risk



Power off the instrument before proceeding with lamp replacement. When the instrument is powered back on during this procedure, do not look directly at the light of the UV lamp. Use safety glasses rated for UV protection while performing the adjustments.

1. Power off the analyzer.
2. Remove the cover from the analyzer.
3. Locate the UV lamp at the front of the optical bench assembly (see Figure 2-3).
4. Unplug the lamp cable from the power supply connector on the side of the optical bench.
5. Slightly loosen (do not remove) the UV lamp setscrew and pull the lamp from its housing.
6. Install a new lamp in the housing, pushing it all the way in.
 - Leave the UV lamp setscrew loose for now.
7. Turn the analyzer back on and allow it to warm up for at least 15 minutes.
8. Navigate to Utilities>Diagnostics>Analog Inputs>Photo Detector.
9. Turn the UV GAIN ADJUSTMENT POT (Figure 5-8) clockwise to its minimum value (the pot should click softly when the limit is reached).
10. While ensuring that the new lamp is pushed all the way into the housing, slightly rotate the lamp up to ¼ turn in either direction until the MINIMUM Photo Detector signal value is observed.
11. At the point where the Photo Detector signal reaches minimum observed value, tighten the lamp setscrew at that position.
12. Using an insulated pot adjustment tool, turn the UV DETECTOR GAIN ADJUST POT (Figure 5-8) until the Photo Detector signal value is as close as possible to 4600 mV.
13. Replace the cover on the analyzer.

5.6.10 ADJUSTING OR REPLACING THE IZS OZONE GENERATOR OPTION'S UV LAMP

This procedure details the steps for replacing and calibrating the UV lamp of the O₃ Generator that is included in the Internal Zero Span (IZS) option. If adjusting an existing lamp, skip to Step 8.



CAUTION – Mercury Exposure Risk

The UV lamp contains mercury (Hg), which is considered hazardous waste. The lamp should be disposed of in accordance with local regulations regarding waste containing mercury.

1. Power off the analyzer.
2. Remove the cover from the analyzer.
3. Locate the O₃ generator (see Figure 2-3).

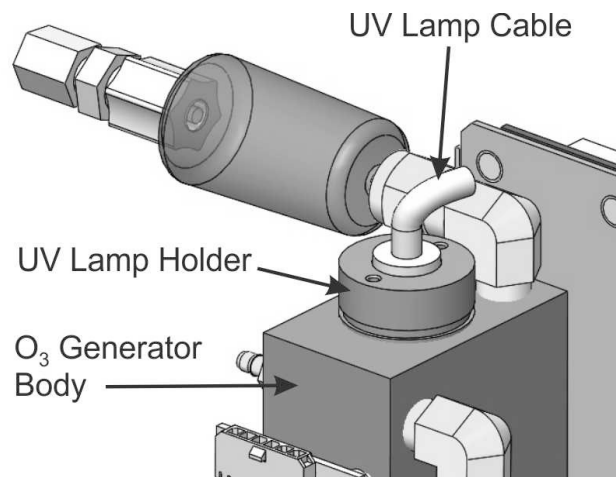


Figure 5-9. O₃ Generator UV Lamp

4. Unscrew the UV lamp holder and gently pull out the old lamp.
5. Inspect the o-ring beneath the lamp holder and replace if damaged.
6. Install the new lamp in O₃ generator housing, and partially tighten the UV lamp holder.
 - The lamp should be free enough to be rotated in the assembly by grasping the lamp cable.
7. Power on the analyzer and allow it to stabilize for at least 20 minutes.

8. Locate the potentiometer used to adjust the O₃ generator UV output.

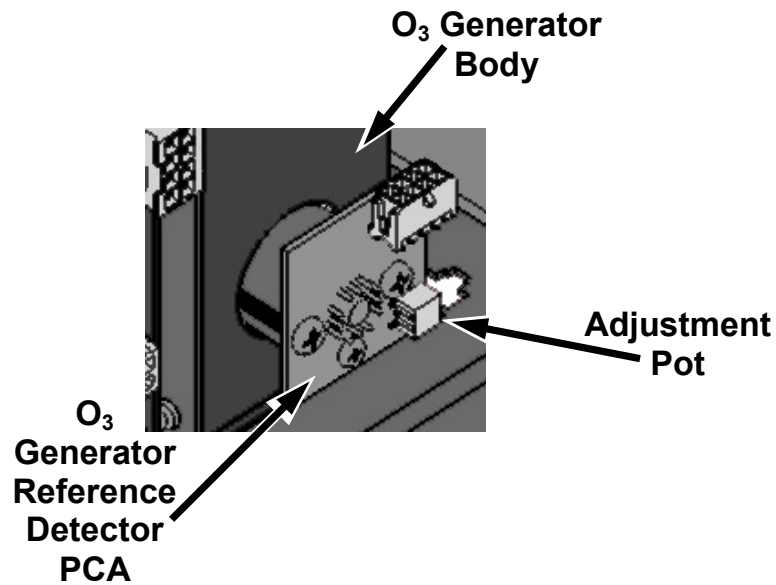


Figure 5-10. Location of O₃ Generator Adjustment Pot

9. Navigate to Utilities>Diagnostics>Analog Inputs>O3 Gen Ref.
10. Using an insulated pot adjustment tool, turn the O₃ Generator Adjustment Pot (Figure 5-10) until the value of O3 Gen Ref is 2500.0 mV \pm 100 mV.
11. Finish screwing in the UV lamp holder so that it is snug but not excessively tight.
12. Replace the analyzer's cover.
13. Perform a leak check (Section 5.6.5).
14. Perform an ozone generator calibration (Section 4.5.3).

5.7 SERVICE AND TROUBLESHOOTING

This contains a variety of methods for identifying the source of performance problems with the analyzer. Also included in this are procedures that are used in repairing the instrument.



QUALIFIED PERSONNEL REQUIRED

The operations presented in this Section must be performed by qualified maintenance personnel only.



WARNING – Risk of Electrical Shock

Some operations require that the instrument be open and running. Exercise caution to avoid electrical shocks



CAUTION

Exercise caution to avoid electrostatic or mechanical damage to the analyzer.

Do not drop tools into the analyzer or leave those after your procedures.

Do not short or touch electric connections with metallic tools while operating inside the analyzer.

Use common sense when operating inside a running analyzer.

The analyzer has been designed so that problems can be rapidly detected, evaluated and repaired. During operation, it continuously performs diagnostic tests and provides the ability to evaluate its key operating parameters without disturbing monitoring operations.

A systematic approach to troubleshooting will generally consist of the following five steps (some are listed in :

1. Note Alerts and take corrective action as necessary.
2. Examine the values of all parameter functions and compare them to factory values. Note any major deviations from the factory values and take corrective action.
3. Use the internal electronic status LEDs to determine whether the electronic communication channels are operating properly.
 - Verify that the DC power supplies are operating properly by checking the voltage test points on the relay PCA.
 - Note that the analyzer's DC power wiring is color-coded and these colors match the color of the corresponding test points on the relay PCA.
4. **SUSPECT A LEAK FIRST!**
 - Technical Support data indicate that the majority of all problems are eventually traced to leaks in the internal pneumatics of the analyzer or the diluent gas and source gases delivery systems.
 - Check for gas flow problems such as clogged or blocked internal/external gas lines, damaged seals, punctured gas lines, a damaged / malfunctioning pumps, etc.

5. Follow the procedures defined in Section 5.7.9 to confirm that the analyzer's vital functions are working (power supplies, CPU, relay PCA, touchscreen, PMT cooler, etc.).
 - As needed, refer to Figure 2-3 for the general layout of components and sub-assemblies in the analyzer.
 - As needed, refer to the wiring interconnect diagram in Appendix B.

5.7.1 FAULT DIAGNOSIS WITH ALERTS

The most common and/or serious instrument failures will result in a warning message, called an Alert. Table 5-3 lists some of the more common Alert messages, along with their meaning and recommended corrective action.

It should be noted that if more than two or three warning Alerts occur at the same time, it is often an indication that some fundamental analyzer sub-system (power supply, relay board, motherboard) has failed, rather than being an indication of the specific failures referenced by the warning Alerts.

Table 5-3. Alerts - Indicated Failures

ALERT	FAULT CONDITION	POSSIBLE CAUSES
PHOTO TEMP WARNING	The optical bench temperature lamp temp is $\geq 51^{\circ}\text{C}$.	<ul style="list-style-type: none"> •Bench lamp heater •Bench lamp temperature sensor •Relay controlling the bench heater •Entire Relay Board •I²C Bus •"Hot" Lamp
BOX TEMP WARNING	Box Temp is $< 5^{\circ}\text{C}$ or $> 48^{\circ}\text{C}$.	<ul style="list-style-type: none"> •Box Temperature typically runs $\sim 7^{\circ}\text{C}$ warmer than ambient temperature. •Poor/blocked ventilation to the analyzer •Stopped Exhaust-Fan •Ambient Temperature outside of specified range
CANNOT DYN SPAN	Dynamic Span operation failed.	<ul style="list-style-type: none"> •Measured concentration value is too high or low •Concentration Slope value to high or too low
CANNOT DYN ZERO	Dynamic Zero operation failed.	<ul style="list-style-type: none"> •Measured concentration value is too high •Concentration Offset value to high
CONFIG INITIALIZED	Configuration and Calibration data reset to original Factory state.	<ul style="list-style-type: none"> •Failed Disk on Module •User erased data
DATA INITIALIZED	Data Storage in DAS was erased.	<ul style="list-style-type: none"> •Failed Disk on Module •User cleared data.
LAMP STABIL WARN	Reference value is unstable.	<ul style="list-style-type: none"> •Faulty UV source lamp •Noisy UV detector •Faulty UV lamp power supply
REAR BOARD NOT DET	Motherboard not detected on power up.	<p>This warning only appears on Serial I/O COM Port(s) Front Panel Display will be frozen, blank or will not respond.</p> <ul style="list-style-type: none"> •Failure of Motherboard
RELAY BOARD WARN	The CPU cannot communicate with the Relay Board.	<ul style="list-style-type: none"> •I²C Bus failure •Failed Relay Board •Loose connectors/wiring
SAMPLE FLOW WARN	Sample flow rate is < 500 cc/min or > 1000 cc/min.	<ul style="list-style-type: none"> •Failed Sample Pump •Blocked Sample Inlet/Gas Line •Dirty Particulate Filter •Leak downstream of Critical Flow Orifice •Failed Flow Sensor

ALERT	FAULT CONDITION	POSSIBLE CAUSES
SAMPLE PRES WARN	Sample Pressure is <15 in-Hg or > 35 in-Hg Normally 29.92 in-Hg at sea level decreasing at 1 in-Hg per 1000 ft of altitude (with no flow – pump disconnected).	If Sample Pressure is < 15 in-HG: <ul style="list-style-type: none"> •Blocked Particulate Filter •Blocked Sample Inlet/Gas Line •Failed Pressure Sensor/circuitry If Sample Pressure is > 35 in-HG: <ul style="list-style-type: none"> •Bad Pressure Sensor/circuitry
SAMPLE TEMP WARN	Sample temperature is < 10°C or > 50°C.	<ul style="list-style-type: none"> •Ambient Temperature outside of specified range •Failed Sample Temperature Sensor •Relay controlling the Bench Heater •Failed Relay Board •I²C Bus
PHOTO REF WARNING	Occurs when Ref is <2500 mVDC or >4950 mVDC.	<ul style="list-style-type: none"> •UV Lamp •UV Photo-Detector Preamp
O3 GEN TEMP WARNING	IZS Ozone Generator Temp is outside of control range of 48°C ± 3°C.	<ul style="list-style-type: none"> •No IZS option installed, instrument improperly configured •O₃ generator heater •O₃ generator temperature sensor •Relay controlling the O₃ generator heater •Entire Relay Board •I²C Bus
SYSTEM RESET	The computer has rebooted.	<ul style="list-style-type: none"> •This message occurs at power on. •If it is confirmed that power has not been interrupted: <ul style="list-style-type: none"> •Failed +5 VDC power •Fatal Error caused software to restart •Loose connector/wiring

A failure of the analyzer’s CPU or Motherboard can result in any or all of the preceding messages.

5.7.2 FAULT DIAGNOSIS WITH DASHBOARD FUNCTIONS

Besides being useful as predictive diagnostic tools, the functions viewable from the front panel can be used to isolate and identify many operational problems when combined with a thorough understanding of the analyzer’s Theory of Operation (see Section 6).

The acceptable ranges for these test functions are listed in the “Nominal Range” column of the analyzer *Final Test and Validation Data Sheet* that was shipped with the instrument. Values outside these acceptable ranges indicate a failure of one or more of the analyzer’s subsystems. Functions whose values are still within the acceptable range but have significantly changed from the measurement recorded on the factory data sheet may also indicate a failure.

The following table contains some of the more common causes for these values to be out of range.

Table 5-4. Dashboard Functions - Indicated Failures

FUNCTIONS (AS DISPLAYED)	INDICATED FAILURE(S)
RANGE	<p>Incorrectly configured measurement range(s) could cause response problems with a Data logger or chart recorder attached to one of the analog output.</p> <p>If the Range selected is too small, the recording device will over range.</p> <p>If the Range is too big, the device will show minimal or no apparent change in readings.</p>
STABIL	<p>Indicates noise level of instrument or concentration of sample gas.</p>
O3 MEAS & O3 REF	<p>If the value displayed is too high the UV Source has become brighter. Adjust the variable gain potentiometer on the UV Preamp Board in the optical bench.</p> <p>If the value displayed is too low:</p> <ul style="list-style-type: none"> • < 100mV – Bad UV lamp or UV lamp power supply. • < 2000mV – Lamp output has dropped, adjust UV Preamp Board or replace lamp. <p>If the value displayed is constantly changing:</p> <ul style="list-style-type: none"> • Bad UV lamp. • Defective UV lamp power supply. • Failed I²C Bus. <p>If the O₃ Ref value changes by more than 10mV between zero and span gas:</p> <ul style="list-style-type: none"> • Defective/leaking switching valve.
PRES	<p>See Table 5-3 for SAMPLE PRES WARN.</p>
SAMPLE FL	<p>Check for gas flow problems (see Section 5.7.5).</p>
SAMP TEMP	<p>SAMPLE TEMP should be close to BENCH TEMP. Temperatures outside of the specified range or oscillating temperatures are cause for concern.</p>
PHOTO LAMP	<p>Bench temp control improves instrument noise, stability and drift. Temperatures outside of the specified range or oscillating temperatures are cause for concern. Table 5-3 for PHOTO TEMP WARNING.</p>
BOX TEMP	<p>If the box temperature is out of range, check fan in the power supply module. Areas to the side and rear of instrument should allow adequate ventilation. See Table 5-3 for BOX TEMP WARNING.</p>
O3 GEN TEMP	<p>If the O₃ Generator Temperature is out of range, check the O₃ Generator heater and temperature sensor. See Table 5-3 for O3 GEN TEMP WARNING</p>
SLOPE	<p>Values outside range indicate</p> <p>Contamination of the zero air or span gas supply</p> <p>Instrument is miscalibrated</p> <p>Blocked gas flow</p> <p>Faulty sample pressure sensor (P1) or circuitry</p> <p>Bad/incorrect span gas concentration.</p>
OFFSET	<p>Values outside range indicate</p> <p>Contamination of the zero air supply</p>

5.7.3 THE DIAGNOSTIC SIGNAL I/O FUNCTION

The Utilities>Diagnostics menu provides a view of the digital and analog I/O signals in the analyzer. These signals, combined with a thorough understanding of the instrument's Theory of Operation (found in Section 6), are useful for troubleshooting in three ways:

- The technician can view the raw, unprocessed signal level of the analyzer's critical inputs and outputs.
- Many of the components and functions that are normally under algorithmic control of the CPU can be manually exercised.
- The technician can directly control the signal level Analog and Digital Output signals.

This allows the technician to observe systematically the effect of directly controlling these signals on the operation of the analyzer. Use the Utilities>Diagnostics menu to view the raw voltage of an input signal or the Setup menu to control the state of an output voltage or control signal.

5.7.4 STATUS LEDs

Several color-coded light-emitting diodes (LEDs) are located inside the instrument to assist in determining if the analyzer's CPU, I²C bus and relay board are functioning properly.

5.7.4.1 CPU STATUS INDICATOR

DS5, a red LED that is located on the upper portion of the motherboard, just to the right of the CPU board, flashes when the CPU is running the main program loop. After power-up, approximately 30 to 60 seconds, DS5 should flash on and off. If the front panel display is working, but DS5 does not flash, then the program files have become corrupted. If after 30 – 60 seconds neither the DS5 is flashing nor is the front panel display working, then the CPU is bad and must be replaced.

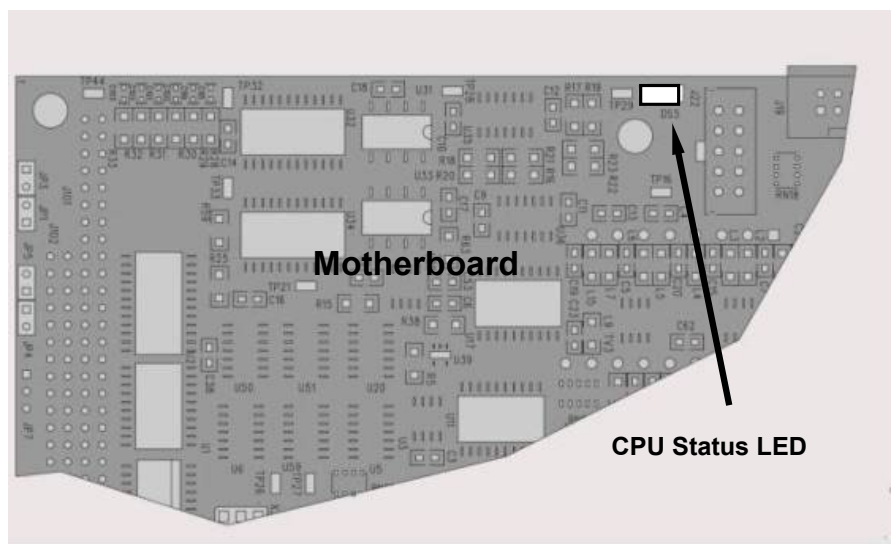


Figure 5-11. CPU Status Indicator

5.7.4.2 I²C BUS WATCHDOG STATUS LED

The most important of the Relay Board Status LEDs is D1, which indicates the health of the I²C bus. LEDs that remain continuously off or on (not blinking) indicate a fault state for their respective components.

Table 5-5. Relay PCA Watchdog LED Failure Indication

LED	FUNCTION	FAULT STATUS	INDICATED FAILURE(S)
D1 (Red)	I ² C bus Health (Watchdog Circuit)	Continuously ON or Continuously OFF	Failed/Halted CPU Faulty Motherboard, Valve Driver board or Relay PCA Faulty connectors/wiring between Motherboard, Valve Driver board or Relay PCA Failed/Faulty +5 VDC Power Supply (PS1)

5.7.4.3 O₃ OPTION STATUS LED

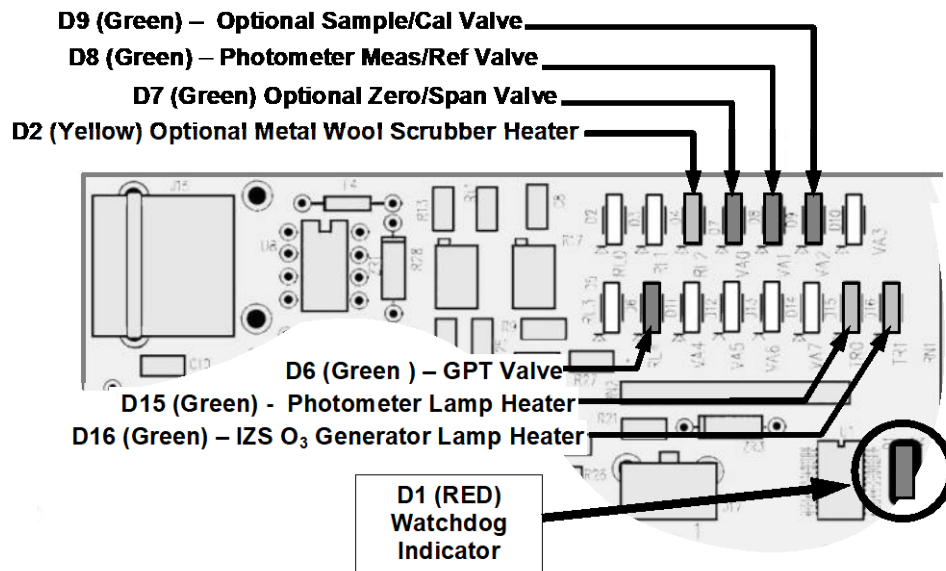


Figure 5-12. Relay PCA Status LEDs Used for Troubleshooting

Table 5-6. Relay Board Watchdog and Status LED Failure Indications

LED	FUNCTION	SIGNAL I/O PARAMETER		DIAGNOSTIC TECHNIQUE
		ACTIVATED BY	VIEW RESULT	
D2 ¹ Yellow	Metal Wool Scrubber Heater ¹	O3_SCRUB_HEATER	O3 SCRUB	Voltage displayed should change. If not: <ul style="list-style-type: none"> • Failed Heater • Faulty Temperature Sensor • Failed AC Relay • Faulty connectors/wiring
D7 Green	Zero/Span Gas Valve ²	SPAN_VALVE	N/A	Valve should audibly change states. If not: <ul style="list-style-type: none"> • Failed Valve • Failed Relay Drive IC on Relay PCA • Failed Relay PCA • Faulty +12 VDC Supply (PS2) • Faulty connectors/wiring
D8 Green	Measure/Ref Valve	PHOTO_REF_VALVE	N/A	
D9 Green	Sample/Cal Gas Valve ³	CAL_VALVE	N/A	
D15 Green	Photometer UV Lamp Heater	PHOTO_LAMP_HEATER	PHOTO_LAMP	Voltage displayed should change. If not: <ul style="list-style-type: none"> • Failed Heater • Faulty Temperature Sensor • Failed AC Relay • Faulty connectors/wiring
D16 ² Green	IZS O ₃ Generator UV Lamp Heater	O3_GEN_HEATER	O3 GEN TEMP	

¹ Only applies on analyzers with metal wool scrubber option installed.

² Only applies to instruments with calibration valve options installed.

³ Only applies on analyzers with IZS options installed.

5.7.5 FLOW PROBLEMS

When troubleshooting flow problems, it is a good idea to first confirm that the actual flow and not the analyzer's flow sensor and software are in error, or the flow meter is in error. Use an independent flow meter to perform a flow check as described in Section 5.6.6. If this test shows the flow to be correct, check the pressure sensors as described in Section 5.7.9.7.

In general, flow problems can be divided into three categories:

- Flow is zero (no flow).
- Flow is greater than zero, but is too low, and/or unstable.
- Flow is too high .

When troubleshooting flow problems, it is crucial to confirm the actual flow rate without relying on the analyzer's flow display. The use of an independent, external flow meter to perform a flow check as described in Section 5.6.6 is essential.

The flow diagrams found in Section 2.3.3 can help in trouble-shooting flow problems.

5.7.5.1 FLOW IS ZERO

The unit displays a **SAMPLE FLOW** warning message on the front panel display or the **SAMPLE FLOW** test function reports a zero or very low flow rate.

Confirm that the sample pump is operating (turning). If not, use an AC voltmeter to make sure that power is being supplied to the pump if no power is present at the electrical leads of the pump.

1. If AC power is being supplied to the pump, but it is not turning, replace the pump.
2. If the pump is operating but the unit reports no gas flow, perform a flow check as described in Section 5.6.6.
3. If no independent flow meter is available:
 - Disconnect the gas lines from both the sample inlet and the exhaust outlet on the rear panel of the instrument.
 - Make sure that the unit is in basic **SAMPLE Mode**.
 - Place a finger over an Exhaust outlet on the rear panel of the instrument.
 - If gas is flowing through the analyzer, you will feel pulses of air being expelled from the Exhaust outlet.
4. If gas flows through the instrument when it is disconnected from its sources of zero air, span gas or sample gas, the flow problem is most likely not internal to the analyzer. Check to make sure that:
 - All calibrators/generators are turned on and working correctly.
 - Gas bottles are not empty or low.
 - Valves, regulators and gas lines are not clogged or dirty.

5.7.5.2 LOW FLOW

1. Check if the pump diaphragm is in good condition. If not, rebuild the pump (see Section 5.6.2). Check the Spare Parts List for information on pump rebuild kits.
2. Check for leaks as described in Section 5.6.3. Repair the leaking fitting, line or valve and re-check.
3. Check for the sample filter and the orifice filter for dirt. Replace filters (see 5.6.1).
4. Check for partially plugged pneumatic lines, or valves. Clean or replace them.
5. Check for plugged or dirty critical flow orifices. Replace them.
6. If an IZS option is installed in the instrument, press CALZ and CALS. If the flow increases then suspect a bad sample/cal valve.

5.7.5.3 HIGH FLOW

The most common cause of high flow is a leak in the sample flow control assembly or between there and the pump. If no leaks or loose connections are found in the fittings or the gas line between the orifice and the pump, replace the critical flow orifice (s) inside the sample flow control assembly.

5.7.5.4 ACTUAL FLOW DOES NOT MATCH DISPLAYED FLOW

If the actual flow measured does not match the displayed flow, but is within the limits of 720-880 cm³/min, adjust the calibration of the flow measurement as described in Section 5.6.6.

5.7.5.5 SAMPLE PUMP

The sample pump should start immediately after the front panel power switch is turned ON. With the Sample Inlet plugged, the Pressure reading should be about 10 in-Hg for a pump that is in good condition. The pump needs rebuilding if the reading is above 10 in-Hg. If the Sample Flow reading is greater than 10 cm³/min there is a leak in the pneumatic lines.

5.7.6 CALIBRATION PROBLEMS

5.7.6.1 MISCALIBRATED

There are several symptoms that can be caused by the analyzer being miscalibrated. This condition is indicated by out of range Slopes and Offsets as displayed through the test functions and is frequently caused by the following:

- Contaminated span gas. This can cause a large error in the slope and a small error in the offset. Span gas contaminated with a major interferent such as Mercury Vapor, will cause the analyzer to be calibrated to the wrong value. Also could be caused if the span gas concentration entered into the analyzer during the calibration procedure is not the precise concentration value of the gas used.
- Contaminated zero gas. This can cause either a positive or negative offset and will indirectly affect the slope. If contaminated with O₃, it will cause a positive offset.
- Dilution calibrator not set up correctly or is malfunctioning. This will also cause the slope, but not the zero, to be incorrect. Again the analyzer is being calibrated to the wrong value.
- Too many analyzers on the manifold. This can cause either a slope or offset error because ambient gas with its pollutants will dilute the zero or span gas.

5.7.6.2 NON-REPEATABLE ZERO AND SPAN

As stated earlier, leaks both in the T400 and in the external system are a common source of unstable and non-repeatable readings.

- Check for leaks in the pneumatic systems as described in Section 5.6.3. Also consider pneumatic components in the gas delivery system outside the analyzer such as:
- A change in zero air source such as ambient air leaking into zero air line, or;
- A change in the span gas concentration due to zero air or ambient air leaking into the span gas line.
- Once the instrument passes a leak check, perform a flow check (see Section 5.6.6) to make sure adequate sample is being delivered to the sensor assembly.
- Confirm the sample pressure, sample temperature, and sample flow readings are correct and have steady readings.
- Verify that the sample filter element is clean and does not need to be replaced.

5.7.6.3 INABILITY TO SPAN – NO SPAN BUTTON (CAL3)

- Confirm that the O₃ span gas source is accurate. This can be done by inter-comparing the source with another calibrated monitor, or having the O₃ source verified by an independent traceable photometer.
- Check for leaks in the pneumatic systems as described in Section 5.6.3.
- Make sure that the expected span gas concentration entered into the instrument during calibration is the correct span gas concentration and not too different from expected span value.
- Check to make sure that there is no ambient air or zero air leaking into span gas line.

5.7.6.4 INABILITY TO ZERO – NO ZERO BUTTON (CALZ)

- Confirm that there is a good source of zero air. If the IZS option is installed, compare the zero reading from the IZS zero air source to the calibration zero air source.
- Check for leaks in the pneumatic systems as described in 5.6.3.
- Check to ensure that there is no ambient air leaking into zero air line.

5.7.7 OTHER PERFORMANCE PROBLEMS

Dynamic problems (i.e. problems which only manifest themselves when the analyzer is monitoring sample gas) can be the most difficult and time consuming to isolate and resolve. The following provides an itemized list of the most common dynamic problems with recommended troubleshooting checks and corrective actions.

5.7.8 TEMPERATURE PROBLEMS

Individual control loops are used to maintain the set point of the UV Lamp, IZS Ozone Generator (Optional) and Metal Wool Scrubber (Optional) temperatures. If any of these temperatures are out of range or are poorly controlled, the T400 will perform poorly.

5.7.8.1 BOX TEMPERATURE

The box temperature sensor is mounted to the motherboard and cannot be disconnected to check its resistance. Rather check the **BOX TEMP** signal using the signal voltage in the Utilities>Diagnostics>Analog Inputs menu (Section 5.7.3). This parameter will vary with ambient temperature, but at ~30°C (6-7° above room temperature) the signal should be ~1450 mV.

5.7.8.2 SAMPLE TEMPERATURE

Sample Temperature should read approximately 5.0°C higher than the box temperature.

5.7.8.3 UV LAMP TEMPERATURE

There are three possible causes for the UV Lamp temperature to have failed.

- The UV Lamp heater has failed.
 - Check the resistance between pins 5 and 6 on the six-pin connector adjacent to the UV Lamp on the Optical Bench.
 - It should be approximately 30 Ohms.
- Assuming that the I²C bus is working and that there is no other failure with the Relay Board, the FET Driver on the Relay Board may have failed.
 - Using the **PHOTO_LAMP_HEATER** parameter under the **SIGNAL I/O** function of the **DIAG** menu, as described above, turn on and off the UV Lamp Heater (D15 on the relay board should illuminate as the heater is turned on).
 - Check the DC voltage present between pins 1 and 2 on J13 of the Relay Board.
 - If the FET Driver has failed, there will be no change in the voltage across pins 1 and 2.
- If the FET Driver Q2 checks out OK, the thermistor temperature sensor in the lamp assembly may have failed.
 - Unplug the connector to the UV Lamp Heater/Thermistor PCB, and measure the resistance of the thermistor between pins 5 and 6 of the six-pin connector.

The resistance near the 58°C set point is ~8.1k ohms.

5.7.8.4 IZS OZONE GENERATOR TEMPERATURE (OPTIONAL)

There are three possible causes for the Ozone Generator temperature to have failed.

- The O₃Gen heater has failed.
 - Check the resistance between pins 5 and 6 on the six-pin connector adjacent to the UV Lamp on the O₃Generator.
 - It should be approximately 5 Ohms.

- Assuming that the I²C bus is working and that there is no other failure with the Relay Board, the FET Driver on the Relay Board (see Section **Error! Reference source not found.**) may have failed.
 - Using the **O3_GEN_HEATER** parameter under the **SIGNAL I/O** function of the **DIAG** menu, as described above, turn on and off the UV Lamp Heater.
 - Check the DC voltage present between pins 1 and 2 on J14 of the Relay Board.
 - If the FET Driver has failed, there should be no change in the voltage across pins 1 and 2.
- If the FET Driver checks out OK, the thermistor temperature sensor in the lamp assembly may have failed.
 - Unplug the connector to the Ozone Generator Heater/Thermistor PCB, and measure the resistance of the thermistor between pins 5 and 6.

5.7.9 SUBSYSTEM CHECKOUT

The preceding content discussed a variety of methods for identifying possible sources of failures or performance problems within the analyzer. In most cases this included a list of possible causes. If the problem is not resolved at this point, the next step is to check the subsystems. This Section describes how to determine whether an individual component or subsystem is the cause of the problem being investigated.



WARNING – ELECTRICAL SHOCK HAZARD

Should the AC power circuit breaker trip, investigate and correct the condition causing this situation before turning the analyzer back on.

5.7.9.1 AC MAINS CONFIGURATION

The T400 analyzer's electronic systems will operate with any of the specified power regimes. As long as system is connected to 100-120 VAC or 220-240 VAC at either 50 or 60 Hz it will turn on and after about 30 seconds show a front panel display.

- Internally, the status LEDs located on the Relay PCA, Motherboard and CPU should turn on as soon as the power is supplied.
- If they do not, check the circuit breaker built into the ON/OFF switch on the instrument's front panel

The analyzer is correctly configured for the AC mains voltage in use if:

- The Sample Pump is running.

If incorrect power is suspected, check that the correct voltage and frequency is present at the line input on the rear panel, and verify that the pump power configuration plug is properly wired.

Note

- **If the unit is set for 230 VAC and is plugged into 115 VAC or 100 VAC, the sample pump will not start, and the heaters will not come up to temperature.**
- **If the unit is set for 115 or 100 VAC and is plugged into a 230 VAC circuit, the circuit breaker built into the ON/OFF Switch on the Front Panel will trip to OFF status immediately after power is switched on.**

5.7.9.2 DC POWER SUPPLY

If you have determined that the analyzer’s AC mains power is working, but the unit is still not operating properly, there may be a problem with one of the instrument’s switching power supplies. The supplies can have two faults, namely no DC output, and noisy output.

To assist tracing DC Power Supply problems, the wiring used to connect the various printed circuit assemblies and DC Powered components and the associated test points on the relay board follow a standard color-coding scheme as defined in the following table.

Table 5-7. DC Power Test Point and Wiring Color Codes

NAME	TEST POINT#	TP AND WIRE COLOR
Dgnd	1	Black
+5V	2	Red
Agnd	3	Green
+15V	4	Blue
-15V	5	Yellow
+12R	6	Purple
+12V	7	Orange

A voltmeter should be used to verify that the DC voltages are correct per the values in the table below, and an oscilloscope, in AC mode, with band limiting turned on, can be used to evaluate if the supplies are producing excessive noise (> 100 mV p-p).

Table 5-8. DC Power Supply Acceptable Levels

POWER SUPPLY ASSY	VOLTAGE	CHECK RELAY BOARD TEST POINTS				MIN V	MAX V
		FROM TEST POINT		TO TEST POINT			
		NAME	#	NAME	#		
PS1	+5	Dgnd	1	+5	2	4.8	5.25
PS1	+15	Agnd	3	+15	4	13.5	16V
PS1	-15	Agnd	3	-15V	5	-14V	-16V
PS1	Agnd	Agnd	3	Dgnd	1	-0.05	0.05
PS1	Chassis	Dgnd	1	Chassis	N/A	-0.05	0.05
PS2	+12	+12V Ret	6	+12V	7	11.75	12.5
PS2	Dgnd	+12V Ret	6	Dgnd	1	-0.05	0.05

5.7.9.3 I²C BUS

Operation of the I²C bus can be verified by observing the behavior of D1 on the relay PCA. Assuming that the DC power supplies are operating properly, the I²C bus is operating properly if D1 on the relay PCA is flashing.

5.7.9.4 TOUCHSCREEN INTERFACE

Verify the functioning of the touchscreen by observing the display when pressing a touchscreen control button. Assuming that there are no wiring problems and that the DC power supplies are operating properly, if pressing a control button on the display does not change the display, any of the following may be the problem:

- The touchscreen controller may be malfunctioning.
- The internal USB bus may be malfunctioning.

You can verify this failure by logging on to the instrument using APICOM or a terminal program to any of the communications ports. If the analyzer responds to remote commands and the display changes accordingly, the touchscreen interface may be faulty.

5.7.9.5 LCD DISPLAY MODULE

Verify the functioning of the front panel display by observing it when power is applied to the instrument. Assuming that there are no wiring problems and that the DC power supplies are operating properly, the display screen should light and show the splash screen with logo and other indications of its state as the CPU goes through its initialization process.

5.7.9.6 RELAY BOARD

The relay board PCA (P/N 04135) can be most easily checked by observing the condition of the its status LEDs on the relay board, as described in Section 5.7.4.2, and the associated output when toggled on and off through signal I/O function in the diagnostic menu, see Section 5.7.3.

- If the front panel display responds to button presses and D1 on the relay board is NOT flashing then either the wiring between the touchscreen and the relay board is bad, or the relay board is bad.
- If D1 on the relay board is flashing and the status indicator for the output in question (heater power, valve drive, etc.) toggles properly using the signal I/O function, then the associated control device on the relay board is bad.
 - Several of the control devices are in sockets and can be easily replaced.
 - The table below lists the control device associated with a particular function:

Table 5-9. Relay Board Control Devices

FUNCTION	CONTROL DEVICE	IN SOCKET
UV Lamp Heater	Q2	No
Optional IZS O ₃ Gen Heater	Q3	No
Optional Metal Wool Scrubber	K1	Yes
All Valves	U5	Yes

5.7.9.7 PRESSURE/FLOW SENSOR ASSEMBLY

This assembly is only present in analyzers with O₃ generator and/or photometer options installed. The pressure/flow sensor PCA, located at the rear of the instrument between the photometer and the pump, can be checked with a voltmeter. The following procedure assumes that the wiring is intact and that the motherboard as well as the power supplies are operating properly:

BASIC PCA OPERATION:

- Measure the voltage across C2: it should be 5 VDC ± 0.25 VDC. If not, then the board is bad
- Measure the voltage between TP2 and TP1 and also across C1: it should be 10 VDC ± 0.25 VDC. If not, then the board is bad.

PHOTOMETER PRESSURE SENSOR:

1. Measure the pressure on the inlet side of S1 with an external pressure meter.
2. Measure the voltage across TP4 and TP1.
 - The expected value for this signal should be:

$$\text{Expected mVDC} = \left(\frac{\text{Pressure}}{30.0_{\text{In-Hg-A}}} \times 4660_{\text{mVDC}} \right) + 250_{\text{mVDC}} \quad \pm 10\%_{\text{rdg}}$$

EXAMPLE: If the measured pressure is 20 In-Hg-A, the expected voltage level between TP4 and TP1 would be between 2870 mVDC and 3510 mVDC.

EXAMPLE: If the measured pressure is 25 In-Hg-A, the expected voltage level between TP4 and TP1 would be between 3533 mVDC and 4318 mVDC.

- If this voltage is out of range, then pressure transducer S1 is bad, or the board is bad, or there is a pneumatic failure preventing the pressure transducer from sensing the absorption cell pressure properly.

PHOTOMETER FLOW SENSOR:

- Measure the voltage across TP3 and TP1.
 - With proper flow (800 cc³/min through the photometer), this should be approximately 4.5V (this voltage will vary with altitude).
 - With flow stopped (photometer inlet disconnected or pump turned OFF) the voltage should be approximately 1V.
 - If the voltage is incorrect, the flow sensor S3 is bad, the board is bad or there is a leak upstream of the sensor.

5.7.10 MOTHERBOARD

5.7.10.1 A/D FUNCTIONS

The simplest method to check the operation of the A-to-D converter on the motherboard is to use the Signal I/O functions under the Utilities>Diagnostics menu to check the two A/D reference voltages and input signals that can be easily measured with a voltmeter.

- View the value of REF_4096_MV and REF_GND.
 - If both are within 3 mV of nominal (4096 and 0), and are stable, ± 0.5 mV then the basic A/D is functioning properly. If not then the motherboard is bad.
- Choose other parameters such as SAMPLE PRESSURE or SAMPLE FLOW,.
 - Compare these voltages at their origin (refer to the interconnect drawing in Appendix B) with the voltage displayed through the signal I/O function.
 - If the wiring is intact but there is a large difference between the measured and displayed voltage (± 10 mV) then the motherboard is bad.

See also Section 5.7.3.

5.7.10.2 STATUS OUTPUTS

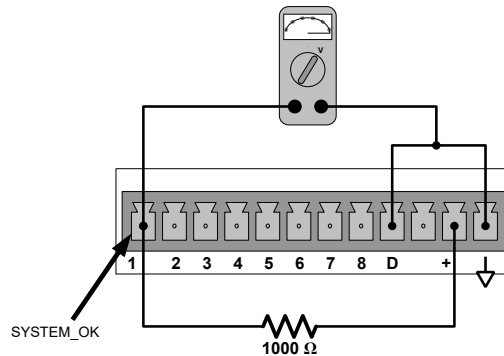


Figure 5-13. Typical Set Up of Status Output Test

To test the Status outputs:

1. Connect a jumper between the “D” pin and the “▽” pin on the status output connector.
2. Connect a 1000 ohm resistor between the “+” pin and the pin for the status output that is being tested.
3. Connect a voltmeter between the “▽” pin and the pin of the output being tested (see table below).
4. In the Utilities>Diagnostics>Digital Outputs menu (see Section 5.7.3), scroll through the outputs until you get to the output in question.
5. Alternatively, turn on and off the output noting the voltage on the voltmeter.
 - It should vary between 0 volts for ON and 5 volts for OFF.

5.7.10.3 CONTROL INPUTS – REMOTE ZERO, SPAN

To test the control inputs:

1. Jumper the +5 pin on the Status connector to the U on the Control In connector.
2. Connect a second jumper from the – pin on the Status connector to the A pin on the Control In connector. The instrument should switch from Sample Mode to ZERO CAL R mode.
3. Connect a second jumper from the – pin on the Status connector to the B pin on the Control In connector. The instrument should switch from Sample Mode to SPAN CAL R mode.
4. In each case, the analyzer should return to Sample Mode when the jumper is removed.

5.7.11 CPU

There are two major types of CPU board failures, a complete failure and a failure associated with the Disk On Module (DOM). If either of these failures occurs, contact the factory.

For complete failures, assuming that the power supplies are operating properly and the wiring is intact, the CPU is faulty if on power-on, the watchdog LED on the motherboard is not flashing.

In some rare circumstances, this failure may be caused by a bad IC on the motherboard, specifically U57, the large, 44 pin device on the lower right hand side of the board. If this is true, removing U57 from its socket will allow the instrument to start up but the measurements will be invalid.

If the analyzer stops during initialization (the front panel display shows a fault or warning message), it is likely that the DOM, the firmware or the configuration and data files have been corrupted.

5.7.12 RS-232 COMMUNICATIONS

5.7.12.1 GENERAL RS-232 TROUBLESHOOTING

Teledyne API analyzers use the RS-232 communications protocol to allow the instrument to be connected to a variety of computer-based equipment. RS-232 has been used for many years and as equipment has become more advanced, connections between various types of hardware have become increasingly difficult. Generally, every manufacturer observes the signal and timing requirements of the protocol very carefully.

Problems with RS-232 connections usually center around the following general areas:

1. Incorrect cabling and connectors. See Section 2.3 for connector and pin-out information.
2. The BAUD rate and protocol are incorrectly configured. See Section 2.3.1.7 under RS-232.
3. Incorrect setting of the DTE-DCE Switch. Ensure that switch is set correctly. See Section 3.1.
4. Verify that the cable that connects the serial COM ports of the CPU to J12 of the motherboard is properly seated.

5.7.13 TROUBLESHOOTING THE PHOTOMETER

This section involves checking the measure/reference valve and the photometer UV lamp power supply.

5.7.13.1 CHECKING THE MEASURE/REFERENCE VALVE

To check the function of the photometer's measure / reference valve:

1. View the **O3 REF** function in the Dashboard (Setup>Dashboard to configure).
2. Follow the instruction in Section 4.2.1.1 for performing a zero point calibration check.
 - Press **ZERO** and allow the analyzer to stabilize.
3. Note the displayed value.
4. Follow the instruction in Section 4.2.1.2 for performing a span point calibration check.
 - Press **SPAN** and allow the analyzer to stabilize.
5. Note the displayed value for **O3 REF**.
 - If the **O3 REF** value has decreased by more than 2 mV from its value with zero gas, then there is a "cross-port" leak in the M/R valve or a bad O₃ reference scrubber. Refer to Section 5.7.15.2 for replacement instructions.
 - Press the **EXIT** button to interrupt the span point calibration process (**DO NOT PRESS** the ENTR button).

5.7.13.2 CHECKING THE PHOTOMETER UV LAMP POWER SUPPLY



WARNING – ELECTRICAL SHOCK HAZARD

Hazardous voltage present - use caution.



CAUTION – UV RADIATION RISK

Do not look at the UV lamp while the unit is operating. UV light can cause eye damage. Always use safety glasses made from UV blocking material when working with the UV Lamp Assembly. (Generic plastic glasses are not adequate).

Although it is not always possible to determine with certainty whether a UV lamp problem lies with the lamp or with its power supply, the following steps will provide a reasonable confidence test of the lamp power supply.

1. Unplug the cable connector at P1 on the lamp power supply and confirm that +15VDC is present between Pins 1 and 2 on the cable connector.
2. If this voltage is incorrect, check the DC test points on the relay PCA as described in Section 5.7.9.2

3. Remove the cover of the photometer and check for the presence of the following voltages on the UV lamp power supply PCA (see Figure 6-16):
 - +4500 mVDC \pm 10 mVDC between TP1 and TP4 (grnd)
 - If this voltage is incorrect, either the UV lamp power supply PCA is faulty or the I²C bus is not communicating with the UV lamp power supply PCA.
 - +5VDC between TP3 and TP4 (grnd)
 - If this voltages is less than 4.8 or greater than 5.25 either the 5 VDC power supply or the UV lamp power supply PCA are faulty.
 - If the above voltages check out, it is more likely that a problem is due to the UV lamp than due to the lamp power supply.
 - Replace the lamp and if the problem persists, replace the lamp power supply.

5.7.14 TROUBLESHOOTING THE IZS OPTION'S O₃ GENERATOR

The only significant components of the O₃ generator that might reasonably malfunction is the power supply assembly for the UV source lamp and the lamp itself. The lamp power supply for the IZS Option's O₃ generator is the same assembly used for the photometer's lamp power supply. The method for checking it out is identical to that listed in Section 5.7.13 above.

5.7.15 SERVICE PROCEDURES

This contains procedures that might need to be performed on rare occasions when a major component of the analyzer requires repair or replacement.

5.7.15.1 REPAIRING SAMPLE FLOW CONTROL ASSEMBLY

The critical flow orifice is housed in the flow control assembly (Teledyne API P/N 001760400) located on the top of the optical bench. A sintered filter protects the jewel orifice so it is unusual for the orifice to need replacing, but if it does, or the filter needs replacement please use the following procedure (see the Spare Parts list in Appendix B for part numbers and kits):

1. Turn off power to the analyzer.
2. Locate the assembly attached to the sample pump.
3. Disconnect the pneumatic connection from the flow assembly and the assembly from the pump.
4. Remove the fitting and the components as shown in the exploded view below.
5. Replace the o-rings (P/N OR0000001) and the sintered filter (P/N FL0000001).
6. If replacing the critical flow orifice itself (P/N 000941000), make sure that the side with the colored window (usually red) is facing downstream to the gas flow.
7. Apply new Teflon[®] tape to the male connector threads.
8. Re-assemble in reverse order.
9. After reconnecting the power and pneumatic lines, flow check the instrument as described in Section 5.6.6.

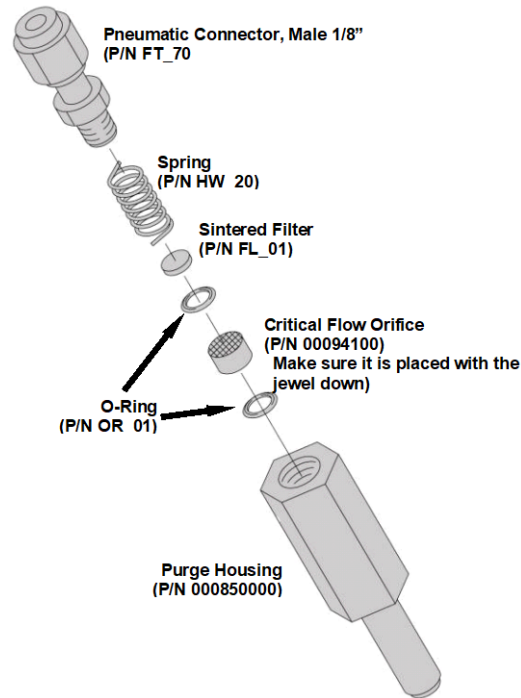


Figure 5-14. Critical Flow Restrictor Assembly/Disassembly

5.7.15.2 REPLACING THE STANDARD REFERENCE O₃ SCRUBBER

To determine whether the reference O₃ scrubber requires replacement, follow the procedures in Section **Error! Reference source not found.**

1. Turn off power to the instrument.
2. Remove instrument cover.
3. The reference scrubber is a blue colored canister located at the rear of the measure/reference valve assembly. See **Error! Reference source not found.**
4. Disconnect the top 1/8" brass tube fitting from the scrubber.
5. Carefully remove the scrubber from the retaining clip.
6. Remove the bottom 1/8" brass tube fitting from the scrubber.
7. Perform the above steps in reverse to install the new scrubber.
8. Run the instrument for at least 24 hours with the new scrubber installed, and recalibrate the instrument.

5.7.15.3 REPLACING THE IZS O₃ SCRUBBER

1. Turn off power to the instrument.
2. Remove instrument cover.
3. The IZS zero air scrubber is attached to the brass elbow inlet fitting on the top of the O₃ generator assembly. See Figure 5-15.
4. Disconnect 1/4" Tube Fitting nut on O₃ generator inlet fitting.

5. Disconnect 1/8" tube fitting on the other end of the scrubber.
6. Remove the scrubber and install new scrubber
7. Reassemble by reversing these steps.

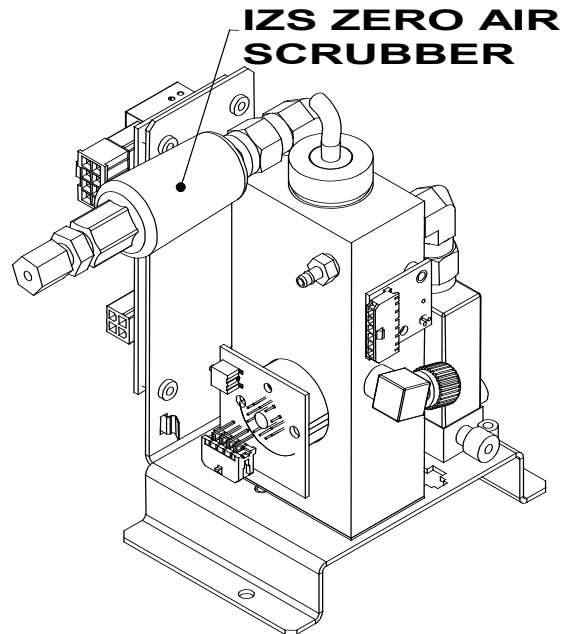


Figure 5-15: IZS O₃ Generator Zero Air Scrubber Location

5.7.15.4 REPLACING THE METAL WOOL SCRUBBER OPTION

Please contact Teledyne API's Technical Support for this procedure.

5.7.15.5 REPLACING THE UV LAMP DRIVER BOARD

Refer to Figure 5-16 for the following instructions:

1. Power off instrument and remove top.
2. Remove bench Phillips head screws and remove bench cover.
3. Unplug driver board/communications power and lamp power supply connectors.
4. Pop out retaining clip that holds transistor and thermal pad in place.
5. With a blunt tool that will not damage any surface, pry up driver board assembly from swage fittings.
6. Put new driver board assembly lightly in place.
7. Insert thermal pad that's included with driver board replacement kit beneath transistor, lining up their respective holes.
 IMPORTANT: This pad serves as an insulator to prevent electrical shorts.
8. Press driver board assembly onto swage fittings until tightly secure.
9. Return transistor clip securely into place.

10. Reinsert driver board/communications power and lamp power supply connectors.
11. Return bench cover and screw into place.
12. Return cover to instrument.
13. Power on and check readings for accuracy.

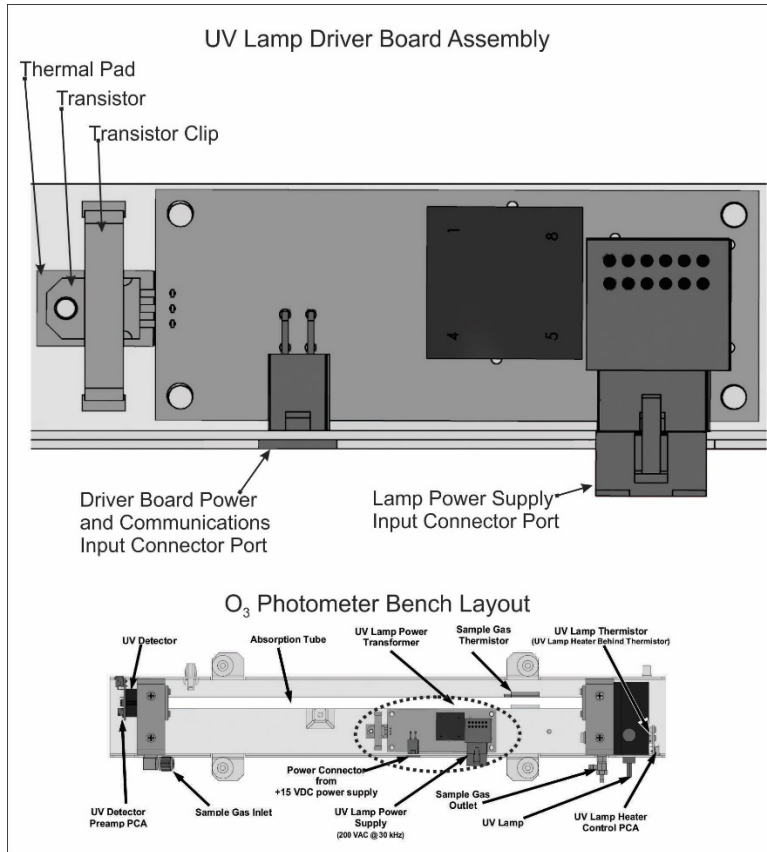


Figure 5-16: UV Lamp Driver Board Replacement

5.7.15.6 DISK-ON-MODULE REPLACEMENT

ATTENTION**COULD DAMAGE INSTRUMENT AND VOID WARRANTY**

Service of circuit components requires electrostatic discharge protection, i.e. ESD grounding straps, mats and containers. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty. For information on preventing ESD damage, refer to the manual, Fundamentals of ESD, PN 04786, which can be downloaded from our website at <http://www.teledyne-api.com> under Help Center > Product Manuals in the Special Manuals section.

Replacing the Disk-on-Module (DOM) will cause loss of all DAS data; it may also cause loss of some instrument configuration parameters unless the replacement DOM carries the exact same firmware version. Whenever changing the version of installed software, the memory must be reset. Failure to ensure that memory is reset can cause the analyzer to malfunction, and invalidate measurements. After the memory is reset, the A/D converter must be re-calibrated, and all information collected in Step 1 below must be re-entered before the instrument will function correctly. Also, zero and span calibration should be performed.

1. Document all analyzer parameters that may have been changed, such as range, auto-cal, analog output, serial port and other settings before replacing the DOM
2. Turn off power to the instrument, fold down the rear panel by loosening the mounting screws.
3. When looking at the electronic circuits from the back of the analyzer, locate the Disk-on-Module in the right-most socket of the CPU board.
4. The DOM should carry a label with firmware revision, date and initials of the programmer.
5. Remove the nylon standoff clip that mounts the DOM over the CPU board, and lift the DOM off the CPU. Do not bend the connector pins.
6. Install the new Disk-on-Module, making sure the notch at the end of the chip matches the notch in the socket.
7. It may be necessary to straighten the pins somewhat to fit them into the socket. Press the chip all the way in.
8. Close the rear panel and turn on power to the machine.
9. If the replacement DOM carries a firmware revision, re-enter all of the setup information.

5.8 FREQUENTLY ASKED QUESTIONS

The following is a list from the Teledyne API's Technical Support Department of the most commonly asked questions relating to this analyzer.

QUESTION	ANSWER
Why is the ZERO or SPAN button not displayed during calibration?	<p>This happens when the measured gas concentration differs significantly from the span or zero gas concentration value entered by the user. This prevents accidental recalibration of the analyzer to an out-of-range response curve.</p> <p>EXAMPLE: The span set point is 40 ppm but gas concentration being measured is only 5 ppm.</p> <p>For more information, see Sections 5.7.6.3 and 5.7.6.4.</p>
How do I enter or change the value of my Span Gas?	See Section 4.2.1.2.
Why does the analyzer not respond to span gas?	There could be something wrong with a span gas tank, or a span gas concentration was entered incorrectly, or there could be a pneumatic leak. Section 5.7.6.3 addresses these issues.
Is there an optional midpoint calibration?	Midpoint calibration checks can be performed using the instrument's AutoCal feature. The IZS option is required in order to perform a midpoint span check.
What do I do if the concentration displayed does not match the value recorded or displayed on my data logger even if both instruments are calibrated?	This most commonly occurs when an independent metering device is used besides the data logger/recorder to determine gas concentration levels while calibrating the analyzer. These disagreements result from the analyzer, the metering device and the data logger having slightly different ground levels.
How do I perform a leak check?	Section 5.6.3 provides leak check instructions.
How do I measure the sample flow?	Sample flow is measured by attaching a calibrated rotameter, wet test meter, or other flow-measuring device to the sample inlet port when the instrument is operating. The sample flow should be 800 cm ³ /min ±10%. See Section 5.6.6.
How long does the IR source last?	Typical lifetime is about 2-3 years.
Can I automate the calibration of my analyzer?	Any analyzer with zero/span valve or IZS option can be automatically calibrated using the instrument's AutoCal feature (Section 4.3).
Can I use the IZS option to calibrate the analyzer?	<p>Yes. However, whereas this may be acceptable for basic calibration checks, the IZS option is not as accurate as the external span and zero gas bottles.</p> <p>To achieve highest accuracy, it is recommended to use cylinders of calibrated span gases in combination with a zero air source.</p>

5.9 TECHNICAL ASSISTANCE

If this manual and its troubleshooting / repair sections do not solve your problems, technical assistance may be obtained from:

Teledyne API Technical Support
9970 Carroll Canyon Road
San Diego, California 92131-1106 USA

Toll-free Phone: +1 800-324-5190

Phone: +1 858-657-9800

Fax: +1 858-657-9816

Email: api-techsupport@teledyne.com

Website: <http://www.teledyne-api.com/>

Before contacting Teledyne API Tech Support, please fill out the problem report form, available online for electronic submission at <http://www.teledyne-api.com>.

6. THEORY OF OPERATION

The Model T400 ozone analyzer is a microprocessor-controlled analyzer that determines the concentration of Ozone (O_3) in a sample gas drawn through the instrument. It requires that sample and calibration gasses be supplied at ambient atmospheric pressure in order to establish a stable gas flow through the absorption tube where the gas' ability to absorb ultraviolet (UV) radiation of a certain wavelength (in this case 254 nm) is measured.

Calibration of the instrument is performed in software and does not require physical adjustments to the instrument. During calibration, the microprocessor measures the current state of the UV Sensor output and various other physical parameters of the instrument and stores them in memory.

The microprocessor uses these calibration values, the UV absorption measurements made on the Sample Gas in the absorption tube along with data regarding the current temperature and pressure of the gas to calculate a final O_3 concentration.

This concentration value and the original information from which it was calculated are stored in the unit's internal data acquisition system (DAS).

6.1 MEASUREMENT METHOD

This Section presents measurement principles and fundamentals for this instrument.

6.1.1 CALCULATING O₃ CONCENTRATION

The basic principle by which the analyzer works is called the Beer-Lambert Law or Beer's Law. It defines how light of a specific wavelength is absorbed by a particular gas molecule over a certain distance. The mathematical relationship among these three parameters is:

Equation 6-1

$$I = I_0 e^{-\alpha Lc}$$

Where:

I₀ is the intensity of the light if there was no absorption.

I is the intensity with absorption.

e is the mathematical constant (Euler's number)

L is the absorption path, or the distance the light travels as it is being absorbed.

C is the concentration of the absorbing gas (in the case of the T400, Ozone (O₃)).

α is the absorption coefficient that tells how well O₃ absorbs light at the specific wavelength of interest.

To solve this equation for **C**, the concentration of the absorbing Gas (in this case O₃), the application of a little algebra is required to rearrange the equation as follows:

Equation 6-2

$$C = \ln\left(\frac{I_0}{I}\right) \times \left(\frac{1}{\alpha L}\right) \quad \text{at STP}$$

Unfortunately, both ambient temperature and pressure influence the density of the sample gas and therefore the number of ozone molecules present in the absorption tube thus changing the amount of light absorbed.

In order to account for this effect the following addition is made to the equation:

Equation 6-3

$$C = \ln\left(\frac{I_0}{I}\right) \times \left(\frac{1}{\alpha L}\right) \times \left(\frac{T}{273K} \times \frac{29.92 \text{ inHg}}{P}\right)$$

Where:

T = sample temperature in Kelvin

P = sample pressure in inches of mercury

Finally, to convert the result into parts per billion (PPB), the following change is made:

Equation 6-4

$$C = \ln\left(\frac{I_0}{I}\right) \times \left(\frac{10^{-9}}{\alpha L}\right) \times \left(\frac{T}{273K} \times \frac{29.92 \text{ inHg}}{P}\right)$$

Briefly, the Model T400 Ozone Analyzer:

- Measures each of the above variables: sample temperature; sample pressure; the intensity of the UV light beam with and without O₃ present,
- Inserts known values for the length of the absorption path and the absorption coefficient, and
- Calculates the concentration of O₃ present in the sample gas.

6.1.2 THE PHOTOMETER UV ABSORPTION PATH

In the most basic terms, the photometer of the Model T400 uses a high energy, mercury vapor lamp to generate a beam of UV light. This beam passes through a window of material specifically chosen to be both non-reactive to O₃ and transparent to UV radiation at 254nm and into an absorption tube filled with Sample Gas.

Because ozone is a very efficient absorber of UV radiation the absorption path length required to create a measurable decrease in UV intensity is short enough (approximately 42 cm) that the light beam is only required to make one pass through the absorption tube. Therefore, no complex mirror system is needed to lengthen the effective path by bouncing the beam back and forth.

Finally, the UV then passes through similar window at the other end of the absorption tube and is detected by a specially designed vacuum diode that only detects radiation at or very near a wavelength of 254nm. The specificity of the detector is high enough that no extra optical filtering of the UV light is needed.

The detector assembly reacts to the UV light and outputs a voltage that varies in direct relationship with the light's intensity. This voltage is digitized and sent to the instrument's CPU to be used in computing the concentration of O₃ in the absorption tube.

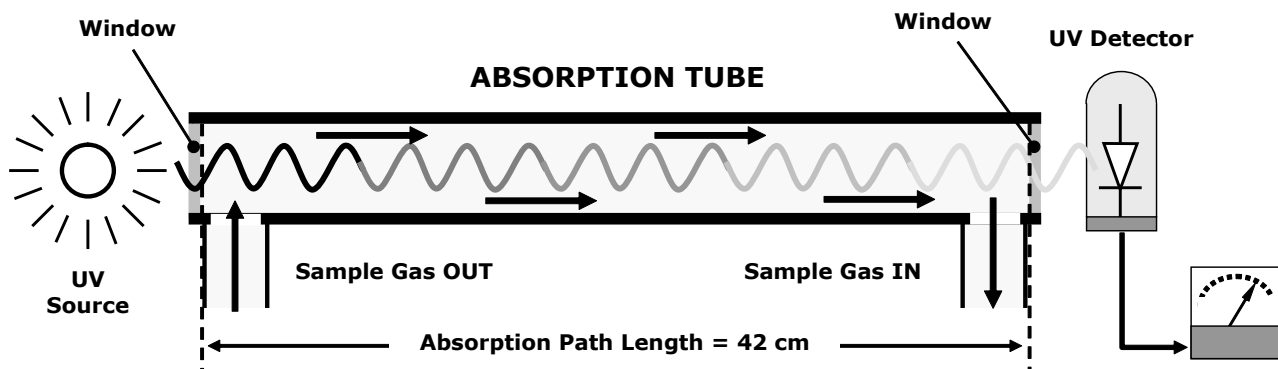


Figure 6-1. O₃ Absorption Path

6.1.3 THE REFERENCE / MEASUREMENT CYCLE

In order to solve the Beer-Lambert equation (see Section 6.1.1), it is necessary to know the intensity of the light passing through the absorption path both when O₃ is present and when it is not. The Model T400 accomplishes this by alternately sending the sample gas directly to the absorption tube and passing it through a chemical scrubber that removes any O₃ present.

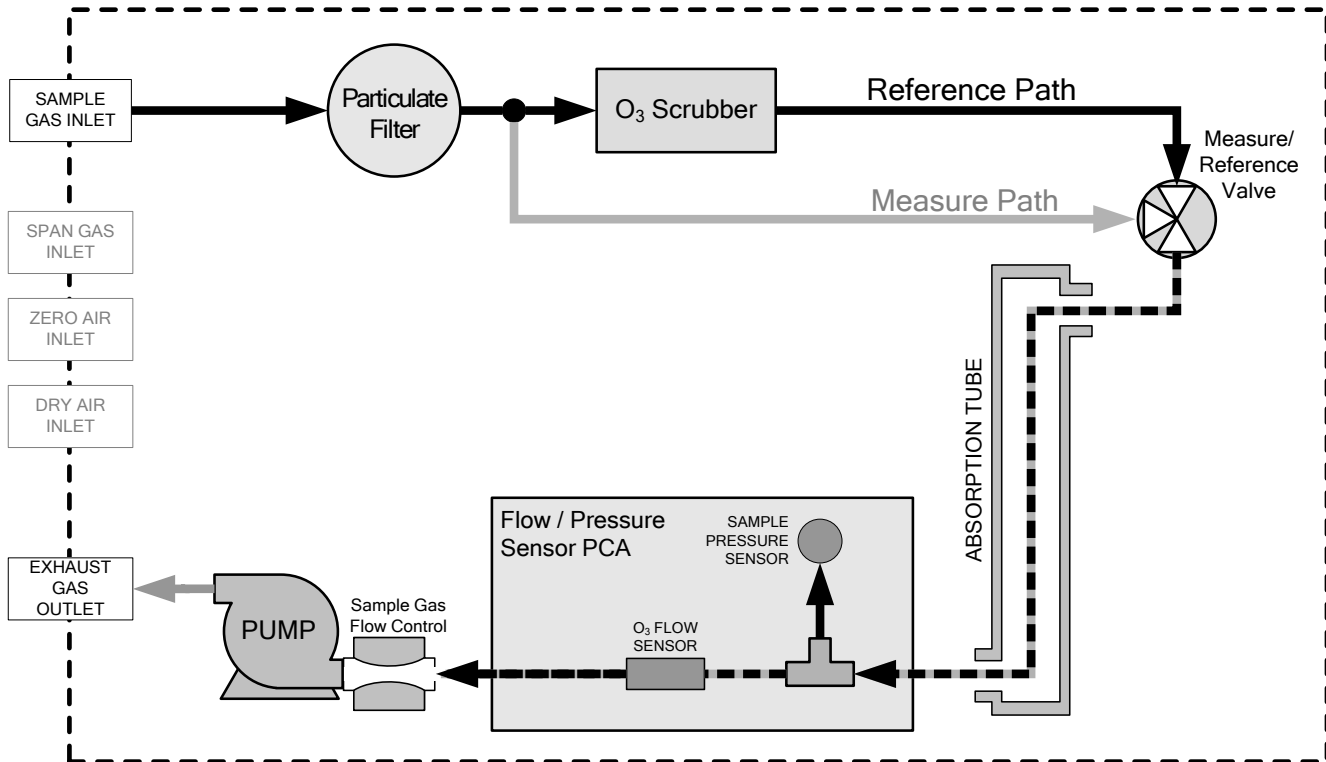


Figure 6-2. Reference / Measurement Gas Cycle

The Measurement / Reference Cycle encompasses the following states and ~durations:

- 0 seconds Measure/Reference Valve Opens to the Measure Path.
- 0 – 2 seconds Wait Period. Ensures that the Absorption tube has been adequately flushed of any previously present gasses.
- 2 – 3 seconds Analyzer measures the average UV light intensity of O₃-bearing Sample Gas (I) during this period.
- 3 seconds Measure/Reference Valve Opens to the Reference Path.
- 3 – 5 seconds Wait Period. Ensures that the Absorption tube has been adequately flushed of O₃ bearing gas.
- 5 – 6 seconds Analyzer measures the average UV light intensity of non-O₃-bearing Sample Gas (I₀) during this period.

CYCLE REPEATs EVERY 6 SECONDS

6.1.4 INTERFERENT REJECTION

The detection of O₃ is subject to interference from a number of sources including: SO₂, NO₂, NO, H₂O, aromatic hydrocarbons such as meta-xylene and mercury vapor. The Model T400's basic method of operation successfully rejects interference from most of these molecules.

The O₃ scrubber located on the reference path (see Figure 6-2) is specifically designed ONLY to remove O₃ from the sample gas. Thus, the variation in intensities of the UV light detected during the instrument's measurement phase versus the reference phase is ONLY due to the presence or absence of O₃. Thus, the effect of interferents on the detected UV light intensity is ignored by the instrument.

Even if the concentration of interfering gases were to fluctuate so wildly as to be significantly different during consecutive reference and measurement phases, this would only cause the O₃ concentration reported by the instrument to become noisy. The average of such noisy readings would still be a relatively accurate representation of the O₃ concentration in the sample gas.

Interference from SO₂, NO₂, NO and H₂O are very effectively rejected by the Model T400. The two types of interferents that may cause problems for the Model T400 are aromatic hydrocarbons and mercury vapor.

6.1.4.1 AROMATIC HYDROCARBONS

While the instrument effectively rejects interference from meta-xylene, it should be noted that there are a very large number of volatile aromatic hydrocarbons that could potentially interfere with ozone detection. This is particularly true of hydrocarbons with higher molecular weights. If the Model T400 is installed in an environment where high aromatic hydrocarbon concentrations are suspected, specific tests should be conducted to reveal the amount of interference these compounds may be causing.

6.1.4.2 MERCURY VAPOR

Mercury vapor absorbs radiation in the 254nm wavelength so efficiently that its presence, even in small amounts, will reduce the intensity of UV light to almost zero during both the Measurement and Reference Phases rendering the analyzer useless for detecting O₃.

If the Model T400 is installed in an environment where the presence of mercury vapor is suspected, specific steps **MUST** be taken to remove the mercury vapor from the sample gas before it enters the analyzer.

6.2 PNEUMATIC OPERATION

CAUTION



It is important that the sample airflow system is both leak tight and not pressurized over ambient pressure.

Regular leak checks should be performed on the analyzer as described in the maintenance schedule, Table 5-1.

Procedures for correctly performing leak checks can be found in Section 5.6.3.

6.2.1 SAMPLE GAS AIR FLOW

The flow of sample gas through the T400 analyzer is produced by an internal pump that draws a small vacuum on the downstream side of a critical flow orifice thereby creating a controlled airflow through the analyzer's absorption tube and other components. This requires the analyzer gas inlets be at or near ambient pressure usually managed by placing a vent line on the incoming gas line (see connections in Section 2.3.2).

By placing the pump down stream from the sample chamber, several problems are avoided.

- First, the pumping process heats and compresses the sample air complicating the measurement process.
- Additionally, certain physical parts of the pump itself are made of materials that might chemically react with the sample gas.
- Finally, in certain applications where the concentration of the target gas might be high enough to be hazardous, maintaining a negative gas pressure relative to ambient means that should a minor leak occur, no sample gas would be pumped into the atmosphere surrounding analyzer.

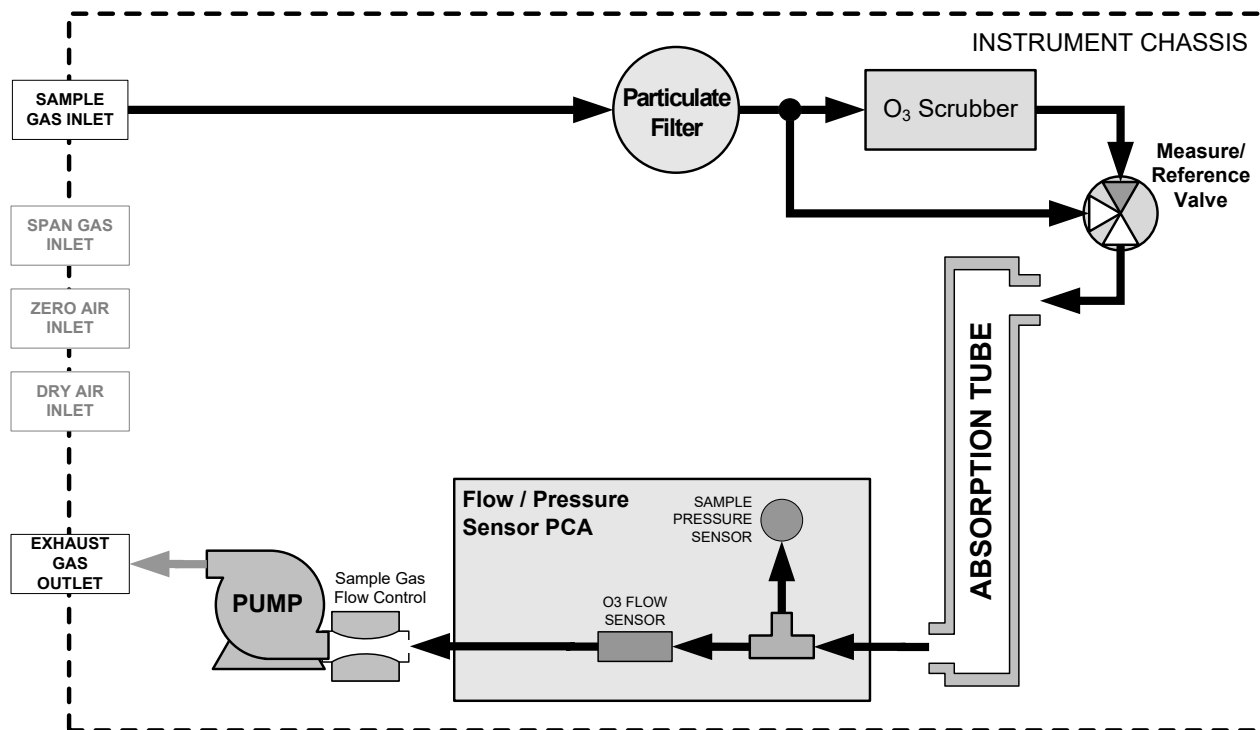


Figure 6-3. Internal Pneumatic Flow – Basic Configuration

6.2.2 FLOW RATE CONTROL

To maintain a constant flow rate of the sample gas through the instrument, the T400 uses a special flow control assembly located downstream from the absorption tube and in the exhaust gas line just before the pump (see Figure 10-7). This assembly consists of:

- A critical flow orifice.
- Two o-rings: Located just before and after the critical flow orifice, the o-rings seal the gap between the walls of assembly housing and the critical flow orifice.
- A spring: Applies mechanical force needed to form the seal between the o-rings, the critical flow orifice and the assembly housing.

The critical flow orifice is the most important component of this flow control assembly is the critical flow orifice.

Critical flow orifices are a remarkably simple way to regulate stable gas flow rates. They operate without moving parts by taking advantage of the laws of fluid dynamics. By restricting the flow of gas through the orifice, a pressure differential is created. This pressure differential combined with the action of the analyzer's pump draws the gas through the orifice.

As the pressure on the downstream side of the orifice (the pump side) continues to drop, the speed that the gas flows through the orifice continues to rise. Once the ratio of upstream pressure to downstream pressure is greater than 2:1, the velocity of the gas through the orifice reaches the speed of sound. As long as that ratio stays at least 2:1, the gas flow rate is unaffected by any fluctuations, surges, or changes in downstream pressure because such variations only travel at the speed of sound themselves and are therefore cancelled out by the sonic shockwave at the downstream exit of the critical flow orifice.

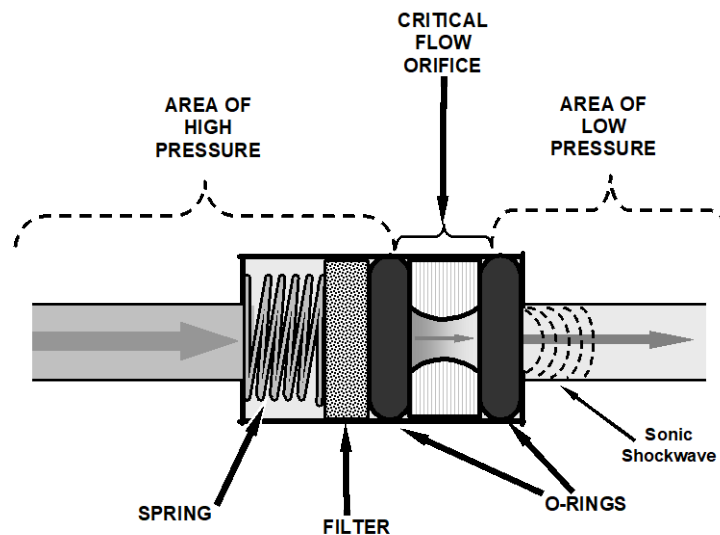


Figure 6-4. Flow Control Assembly & Critical Flow Orifice

The actual flow rate of gas through the orifice (volume of gas per unit of time), depends on the size and shape of the aperture in the orifice. The larger the hole, the more gas molecules (moving at the speed of sound) pass through the orifice. Using this critical flow orifice design extends the useful life of the pump. Once the pump degrades to the point where the sample-to-vacuum-pressure ratio is less than 2:1, a critical flow rate can no longer be maintained.

6.2.3 PARTICULATE FILTER

The T400 Ozone Analyzer comes equipped with a 47 mm diameter, Teflon, particulate filter with a 5 micron pore size. The filter is accessible through the front panel, which folds down to allow access, and should be changed according to the suggested maintenance schedule described in Table 5-1.

6.2.4 PNEUMATIC SENSORS

There are two pneumatic sensors: one each to measure sample pressure and flow.

6.2.4.1 SAMPLE PRESSURE SENSOR

An absolute value pressure transducer plumbed to the outlet of the sample chamber is used to measure sample pressure. The output of the sensor is used to compensate the concentration measurement for changes in air pressure. This sensor is mounted to a printed circuit board next to the internal pump.

6.2.4.2 SAMPLE FLOW SENSOR

A thermal-mass flow sensor is used to measure the sample flow through the analyzer. The sensor is located downstream from the absorption tube but upstream from the critical flow orifice. This sensor is mounted to the same printed circuit board as the pressure sensor.

6.3 ELECTRONIC OPERATION

Figure 6-5 shows a block diagram of the major electronic components of the analyzer.

The core of the analyzer is a microcomputer/central processing unit (CPU) that controls various internal processes, interprets data, makes calculations, and reports results using specialized firmware developed by Teledyne API. It communicates with the user as well as receives data from and issues commands to a variety of peripheral devices via a separate printed circuit assembly called the motherboard.

The motherboard is directly mounted to the inside rear panel and collects data, performs signal conditioning duties and routes incoming and outgoing signals between the CPU and the analyzer's other major components.

An analog signal is generated by an optical bench that includes the Photometer UV Lamp, the Absorption Tube assembly and the UV Detector and Preamp. This signal constantly cycles between a voltage level corresponding to concentration of O₃ in the measure gas and a voltage level corresponding to the lack of O₃ in the reference gas. This signal is transformed converted into digital data by a unipolar, analog-to-digital converter, located on the motherboard.

A variety of sensors report the physical and operational status of the analyzer's major components, again through the signal processing capabilities of the motherboard. These status reports are used as data for the O₃ concentration calculation and as trigger events for certain control commands issued by the CPU. This information is stored in memory by the CPU and in most cases can be viewed but the user via the front panel display.

The CPU issues commands via a series of relays and switches (also over the I²C bus) located on a separate printed circuit assembly to control the function of key electromechanical devices such as heaters, motors and valves.

The CPU communicates with the user and the outside world in several ways:

- Through the analyzer's front panel capacitive touch-screen interface
- Serial I/O
- Several digital I/O channels
- Ethernet

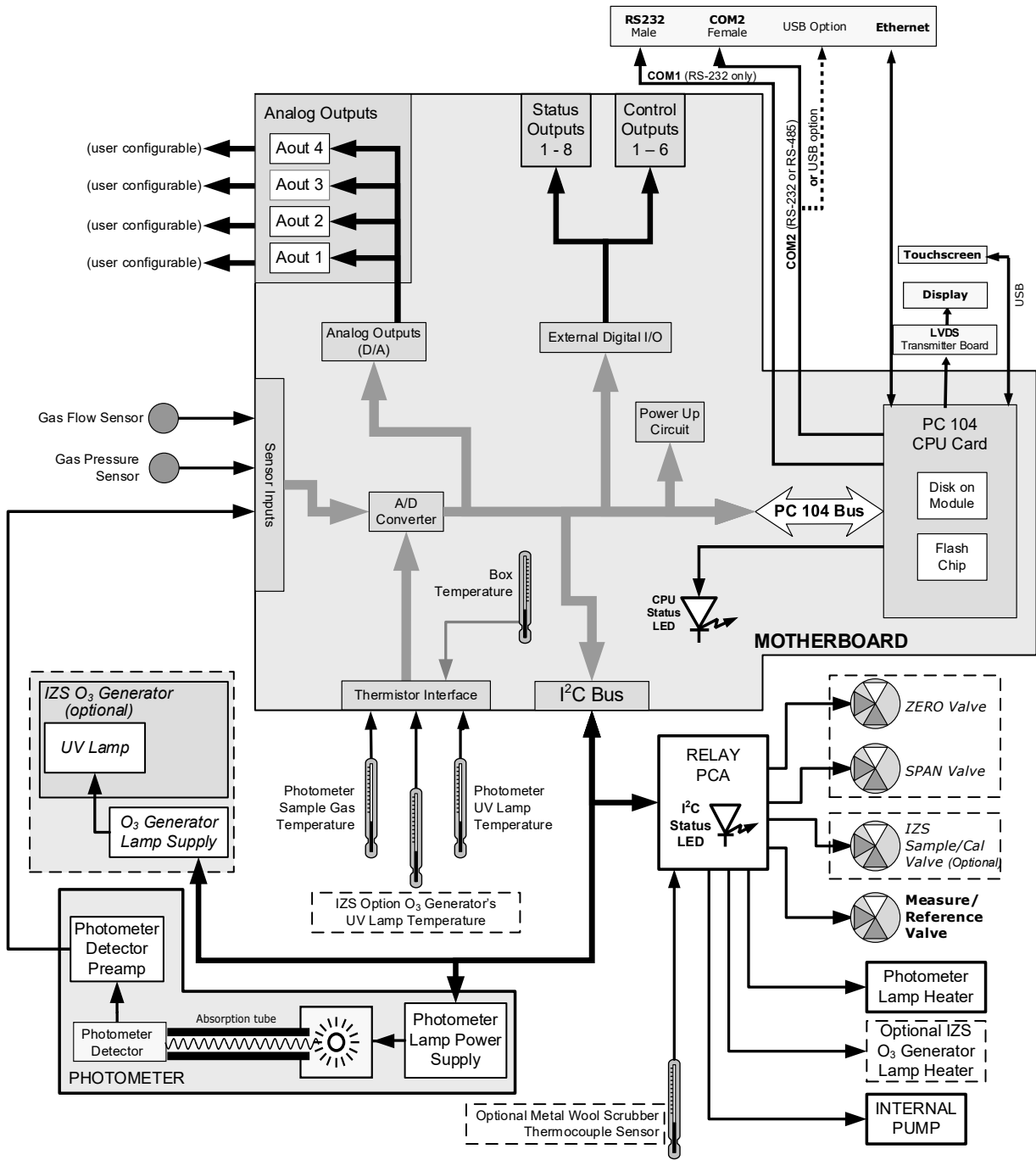


Figure 6-5. Electronic Block Diagram

6.3.1 CPU

The unit's CPU card is installed on the motherboard located inside the rear panel. It is a low power (5 VDC, 720mA max), high performance, Vortex 86SX-based microcomputer running Windows CE. Its operation and assembly conform to the PC/104 specification.

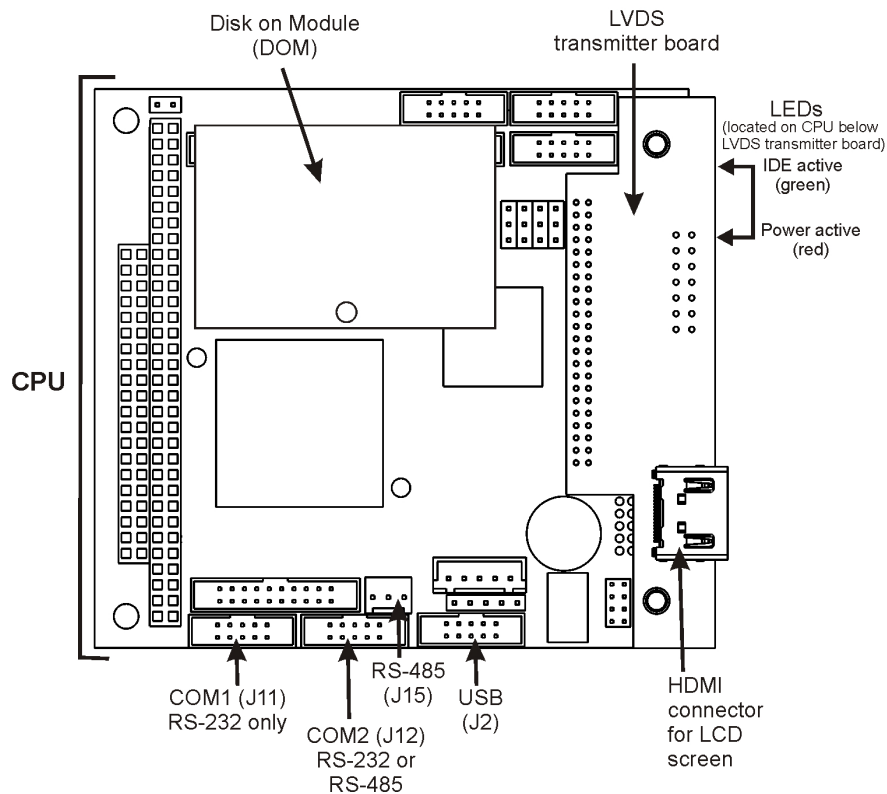


Figure 6-6. CPU Board

The CPU includes two types of non-volatile data storage: a Disk-On-Module (DOM) and an embedded flash chip.

6.3.1.1 DISK-ON-MODULE (DOM)

The DOM is a 44-pin IDE flash drive with a storage capacity up to 128 MB. It is used to store the computer's operating system, the Teledyne API firmware, and most of the operational data generated by the analyzer's internal data acquisition system (DAS).

6.3.1.2 FLASH CHIP

This non-volatile, embedded flash chip includes 2MB of storage for calibration data as well as a backup of the analyzer configuration. Storing these key data on a less heavily accessed chip significantly decreases the chance of data corruption.

In the unlikely event that the flash chip should fail, the analyzer will continue to operate with just the DOM. However, all configuration information will be lost, requiring that the unit be recalibrated.

6.3.2 MOTHERBOARD

This printed circuit assembly provides a multitude of functions including, A/D conversion, digital input/output, PC-104 to I²C translation, temperature sensor signal processing and is a pass through for the RS-232 and RS-485 signals.

6.3.2.1 A TO D CONVERSION

Analog signals, such as the voltages received from the analyzer's various sensors, are converted into digital signals that the CPU can understand and manipulate by the analog to digital converter (A/D). Under the control of the CPU, this functional block selects a particular signal input and then converts the selected voltage into a digital word.

The A/D consists of a Voltage-to-Frequency (V-F) converter, a Programmable Logic Device (PLD), three multiplexers, several amplifiers and some other associated devices. The V-F converter produces a frequency proportional to its input voltage. The PLD counts the output of the V-F during a specified time period, and sends the result of that count, in the form of a binary number, to the CPU.

The A/D can be configured for several different input modes and ranges, but in the T400 it is used in uni-polar mode with a +5V full scale. The converter includes a 1% over and under-range. This allows signals from -0.05V to +5.05V to be fully converted.

For calibration purposes, two reference voltages are supplied to the A/D converter: Reference Ground and +4.096 VDC. During calibration, the device measures these two voltages, outputs their digital equivalent to the CPU. The CPU uses these values to compute the converter's offset and slope and uses these factors for subsequent conversions.

6.3.2.2 SENSOR INPUTS

The key analog sensor signals are coupled to the A/D through the master multiplexer from two connectors on the motherboard. 100K terminating resistors on each of the inputs prevent cross talk from appearing on the sensor signals.

O₃ DETECTOR OUTPUT

This is the primary signal used in the computation of the O₃ concentration.

GAS PRESSURE SENSOR

This sensor measures the gas pressure in the sample chamber upstream of the critical flow orifice. The sample pressure is used by the CPU to calculate O₃ Concentration.

GAS FLOWSENSOR

This sensor measures the flow rate of the sample gas through the instrument. This information is used as a diagnostic tool for determining gas flow problems.

6.3.2.3 THERMISTOR INTERFACE

This circuit provides excitation, termination and signal selection for several negative-coefficient, thermistor temperature sensors located inside the analyzer. They are as follows:

SAMPLE TEMPERATURE SENSOR

The source of this signal is a thermistor attached to the absorption tube inside the sample chamber of the optical bench assembly. It measures the temperature of the sample gas in the chamber. This data is used to during the calculation of the O₃ concentration value.

UV LAMP TEMPERATURE SENSOR

This thermistor is attached to the UV lamp in the optical bench and reports the current temperature of that lamp to the CPU as part of the lamp heater control loop.

IZS OPTION LAMP TEMPERATURE SENSOR

This thermistor is attached to the UV lamp of the O₃ generator in the IZS option, and reports the current temperature of that lamp to the CPU as part of a control loop that keeps the lamp temperature constant.

BOX TEMPERATURE SENSOR

A thermistor is attached to the motherboard. It measures the analyzer's internal temperature. This information is stored by the CPU and can be viewed in the Dashboard.

6.3.2.4 ANALOG OUTPUTS

The analyzer comes equipped with four analog outputs: **A1**, **A2**, **A3** and **A4**. The type of data and electronic performance of these outputs are configurable by the user (see Section 2.5.8).

OUTPUT LOOP-BACK

The analog outputs are connected back to the A/D converter through a loop-back circuit. This permits the voltage outputs to be calibrated by the CPU without need for any additional tools or fixtures.

6.3.2.5 EXTERNAL DIGITAL I/O

This External Digital I/O performs two functions: status outputs and control inputs.

STATUS OUTPUTS

Logic-Level voltages are output through an optically isolated 8-pin connector (labeled STATUS) located on the rear panel of the analyzer. These outputs convey good/bad and on/off information about certain analyzer conditions. They can be used to interface with certain types of programmable devices (See Section 2.3.1.3).

CONTROL INPUTS

By applying +5VDC power supplied from an external source such as a PLC or Data logger (See Section 2.3.1.5), Zero and Span calibrations can be initiated remotely by contact closures (labeled CONTROL IN) on the rear panel.

6.3.2.6 POWER UP CIRCUIT

This circuit monitors the +5V power supply during start-up and sets the analog outputs, external digital I/O ports, and I²C circuitry to specific values until the CPU boots and the instrument software can establish control.

6.3.2.7 I²C DATA BUS

I²C is a two-wire, clocked, bi-directional, digital serial I/O bus that is used widely in commercial and consumer electronic systems. A transceiver on the motherboard converts data and control signals from the PC-104 bus to I²C. The data are then fed to the relay board and valve driver board circuitry.

6.3.3 RELAY BOARD

By actuating various switches and relays located on the Relay Board, the CPU controls the status of other key components. The relay board receives instructions in the form of digital signals over the I²C bus, interprets these digital instructions and activates its various switches and relays appropriately.

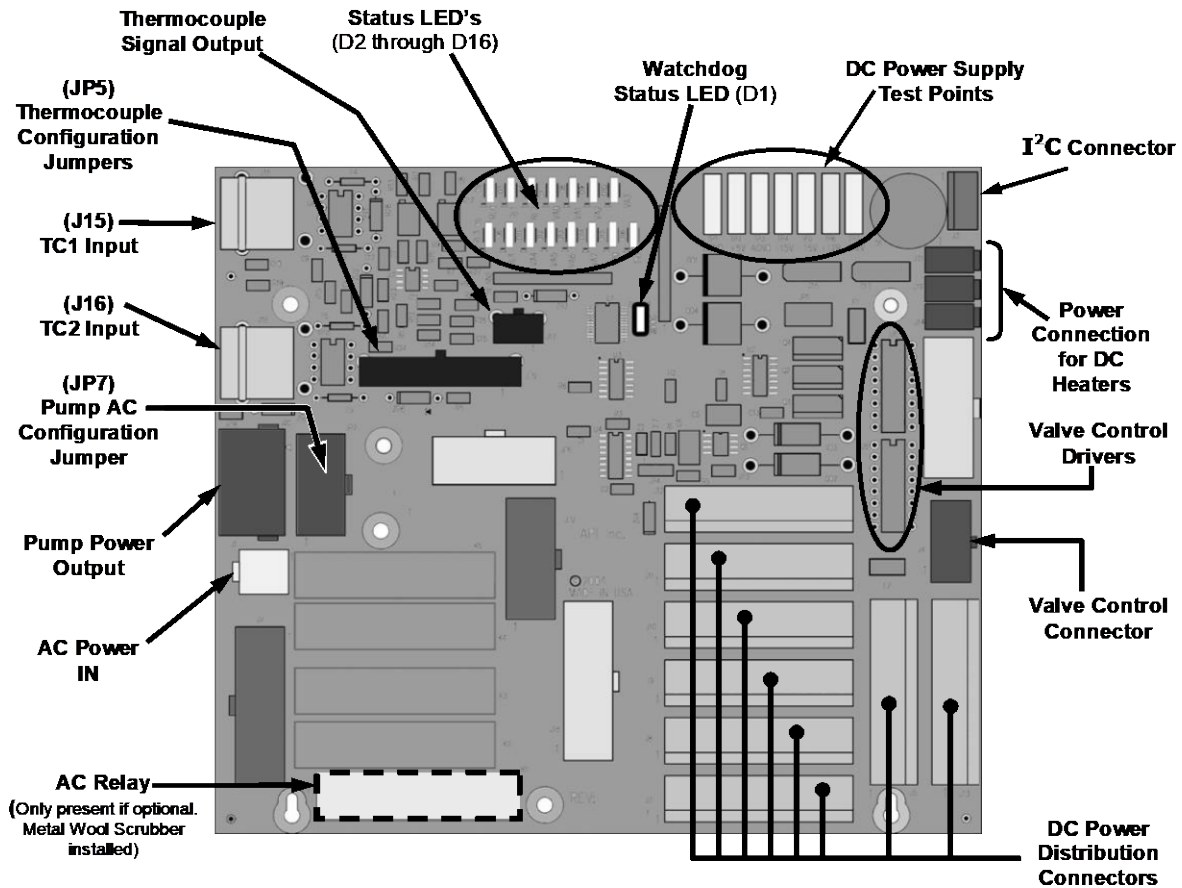


Figure 6-7. Relay Board Layout

The most commonly used version of the Relay PCA installed in the T400 analyzer does not include the AC relays used in instruments where there are AC powered components requiring control. A plastic insulating safety shield covers the empty AC Relay sockets.

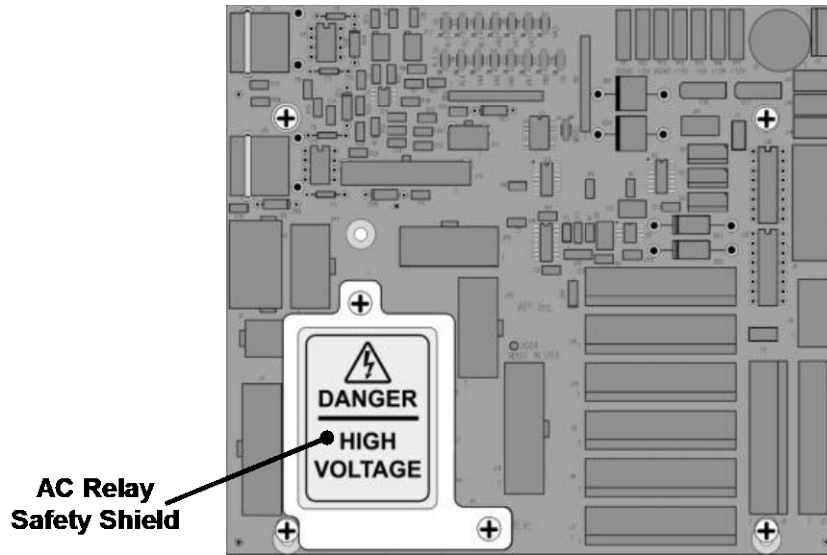


Figure 6-8: Relay Board with Safety Shield In Place

On instruments where the optional Metal Wool Scrubber is installed, the relay PCA includes a solid state AC relay (see Figure 6-7). A retainer plate is installed over the relays to keep them securely seated in their sockets.

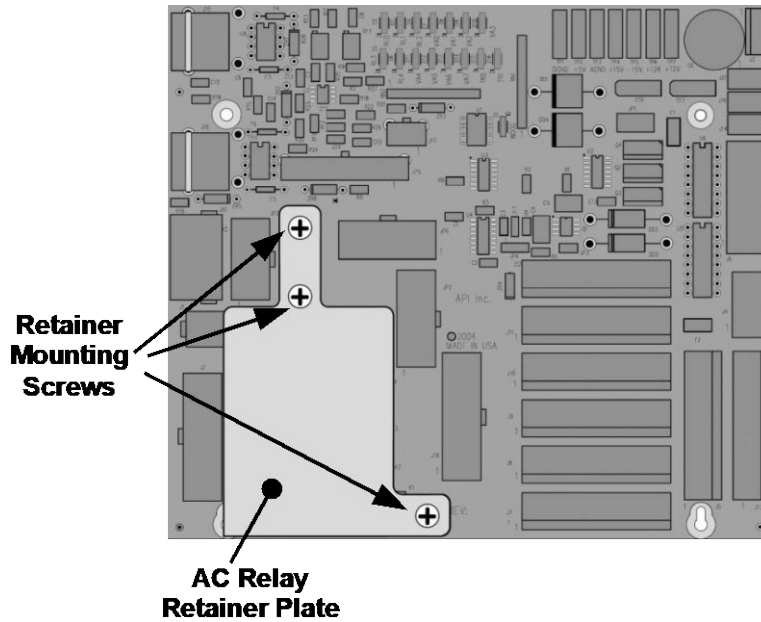


Figure 6-9: Relay Board with AC Relay Retainer in Place

6.3.3.1 STATUS LEDS

The LEDs located on the analyzer’s relay board show the current status on the various control functions performed by the relay board. They are listed on Table 6-1.

Table 6-1. Relay Board Status LEDs

LED	COLOR	FUNCTION	STATUS WHEN LIT	STATUS WHEN UNLIT
D1	RED	Watch Dog Circuit	Cycles On/Off every 3 seconds under direct control of the analyzer's CPU.	
D2	YELLOW	Metal Wool Scrubber Heater	HEATING	NOT HEATING
D3-D6			SPARE	
D7	GREEN	Zero/Span Gas Valve ¹	Valve Open to SPAN GAS FLOW	Valve Open to ZERO GAS FLOW
D8	GREEN	Measure/Ref Valve	Valve Open to REFERENCE path	Valve Open to MEASURE path
D9	GREEN	Sample/Cal Gas Valve ²	Valve Open to CAL Gas Flow	Valve Open to SAMPLE Gas Flow
D10-D14			SPARE	
D15	GREEN	Photometer UV Lamp Heater	HEATING	NOT HEATING
D16	GREEN	IZS O ₃ Generator UV Lamp Heater	HEATING	NOT HEATING

¹ Only present when the Z/S valve option is installed. ² Only present when either the Z/S valve option or the IZS valve option is present.

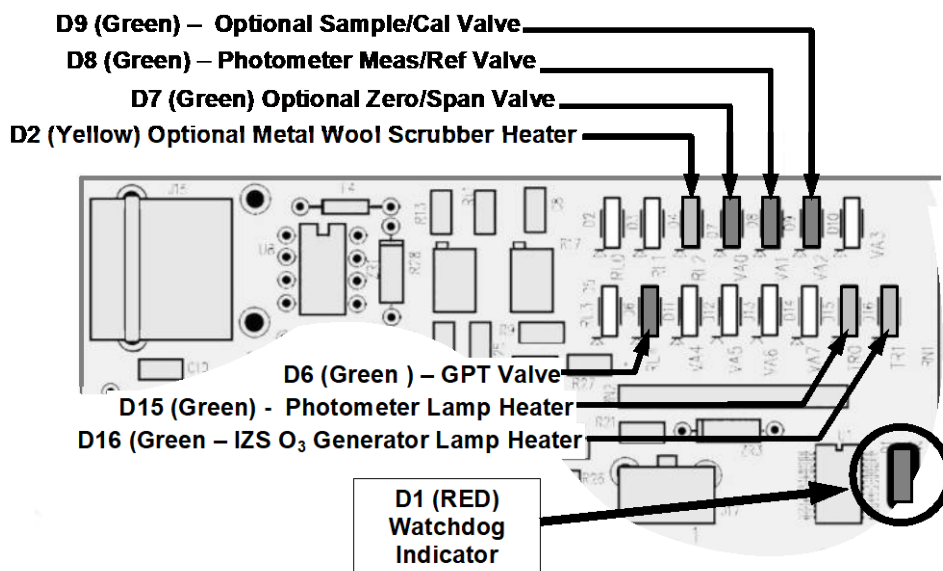


Figure 6-10. Relay Board Status LED Locations

6.3.3.2 I²C WATCH DOG CIRCUITRY

Special circuitry on the relay board monitors the activity on the I²C bus and drives LED D1. Should this LED ever stay ON or OFF for 30 seconds, the watch dog circuit will automatically shut off all valves as well as turn off the UV sources and all heaters. The Sample Pump will still be running as it is not controlled by the relay board.

6.3.3.3 HEATER CONTROL

In the base version of the Model T400 photometric analyzer, there is only one DC heater operated by the relay PCA. It is attached to the Photometer UV Lamp housing and maintains the temperature of the UV Lamp at a constant 58°C.

Additional DC heaters also controlled by the relay PCA, are included in the following optional components:

- On instruments with Zero/Span valve option (OPT-50A) the metal wool scrubber option (OPT- 68) there is a DC heater embedded in the scrubber, which maintains it at a constant 110°C.
- On instruments with the IZS valve option (OPT- 50G) there is a DC heater attached to the IZS O₃ generator UV Lamp, which maintains it at a constant 48°C.

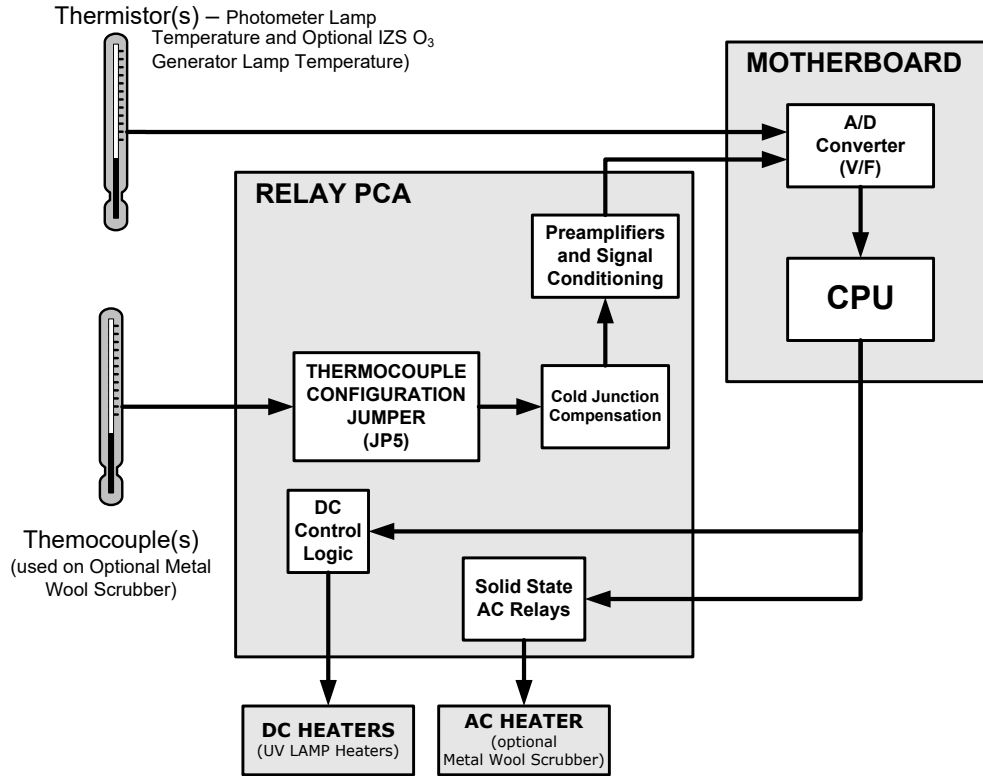


Figure 6-11: Heater Control Loop Block Diagram

6.3.3.4 VALVE CONTROL

The valve that switches the gas stream to and from the analyzer's O₃ scrubber during the measure/reference cycle is operated by an electronic switch located on the relay PCA. This switch, under CPU control, supplies the +12VDC needed to activate each valve's solenoid.

Similar valves also controlled by the relay PCA are included in the following optional components:

- On instruments with the **ZERO/SPAN** valve option (OPT- 50A) there are two additional valves:
 - The **ZERO/SPAN** valve selects which calibration gas inlet (the **ZERO** gas inlet or the **SPAN** Gas inlet) is the source of gas when the analyzer is in one of its calibration modes.
 - The **SAMPLE/CAL** valve selects either the sample inlet when the analyzer is in **SAMPLE** mode or the calibration gas stream when the analyzer is in one of its calibration modes.
- On instruments with the **IZS** valve option (OPT- 50G) one additional valve (the **SAMPLE/CAL** valve) selects either the sample inlet when the analyzer is in **SAMPLE** mode or the dry air inlet when the analyzer is in one of its calibration modes.

6.3.3.5 THERMOCOUPLE INPUTS AND CONFIGURATION JUMPER (JP5)

In its base configuration, the T400 analyzer does not include any thermocouple sensors; however, in instruments where the optional metal wool scrubber (OPT-68) is installed, one thermocouple is used to sense the temperature of the scrubber. By default, this single thermocouple input is plugged into the TC1 input (J15) on the relay PCA. TC2 (J16) is currently not used.

Table 6-2. Thermocouple Configuration Jumper (JP5) Pin-Outs

TC INPUT	JUMPER PAIR	DESCRIPTION	FUNCTION
TC1	1 – 11	Gain Selector	Selects preamp gain factor for J or K TC OUT = K TC gain factor; IN = J TC gain factor
	2 – 12	Output Scale Selector	Selects preamp gain factor for J or K TC OUT = 10 mV / °C; IN = 5 mV / °C
	3 – 13	Type J Compensation	When present, sets Cold Junction Compensation for J type Thermocouple
	4 – 14	Type K Compensation	When present, sets Cold Junction Compensation for K type Thermocouple
	5 – 15	Termination Selector	Selects between Isolated and grounded TC IN = Isolate TC; OUT = Grounded TC
TC2	NOT USED		

6.3.4 POWER SUPPLY/ CIRCUIT BREAKER

The analyzer operates on 100 VAC, 115 VAC or 230 VAC power at either 50 Hz or 60Hz. Individual instruments are set up at the factory to accept any combination of these five attributes. Power enters the analyzer through a standard IEC 320 power receptacle located on the rear panel of the instrument. From there it is routed through the ON/OFF Switch located on the front panel. A 6.75 Amp circuit breaker is built into the ON/OFF Switch.

AC Line power is stepped down and converted to DC power by two DC Power Supplies. One supplies +12 VDC, for various valves and valve options, while a second supply provides +5 VDC and ± 15 VDC for logic and analog circuitry as well as the power supplies for the Photometer and IZS UV Lamps.

All AC and DC voltages are distributed via the Relay PCA.

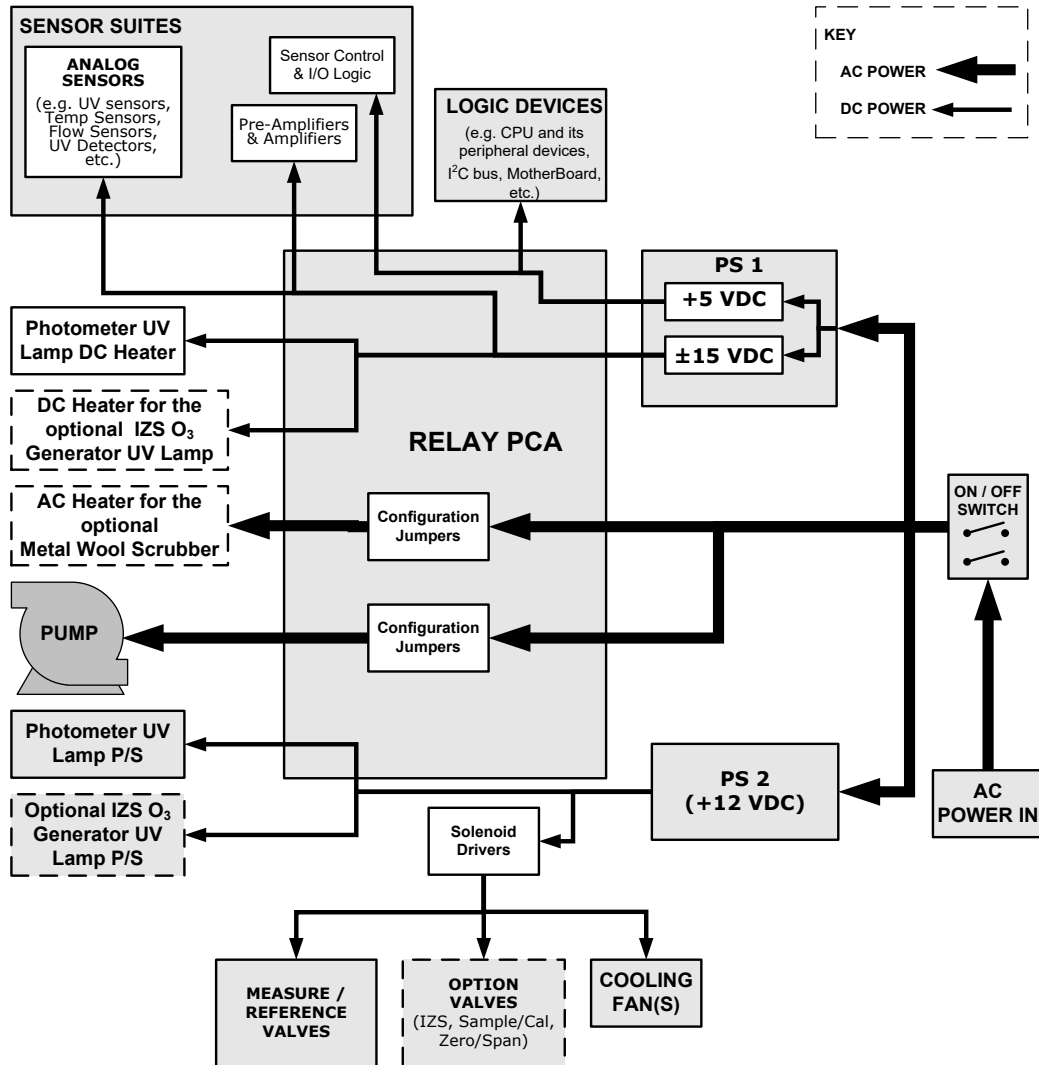


Figure 6-12. Power Distribution Block Diagram

6.3.5 AC POWER CONFIGURATION

The T400 analyzer's digital components will operate with any of the specified power regimes. As long as instrument is connected to 100-120 VAC or 220-240 VAC at either 50 or 60 Hz it will turn on and after about 30 seconds show a front panel display. Internally, the status LEDs located on the Relay PCA, Motherboard and CPU should turn on as soon as the power is supplied.

However, some of the analyzer's non-digital components, such as the pump and the AC powered heater for the optional metal wool scrubber (OPT-68) must be properly configured for the type of power being supplied to the instrument.

Configuration of the power circuits is set using several jumper sets located on the instrument's relay PCA.

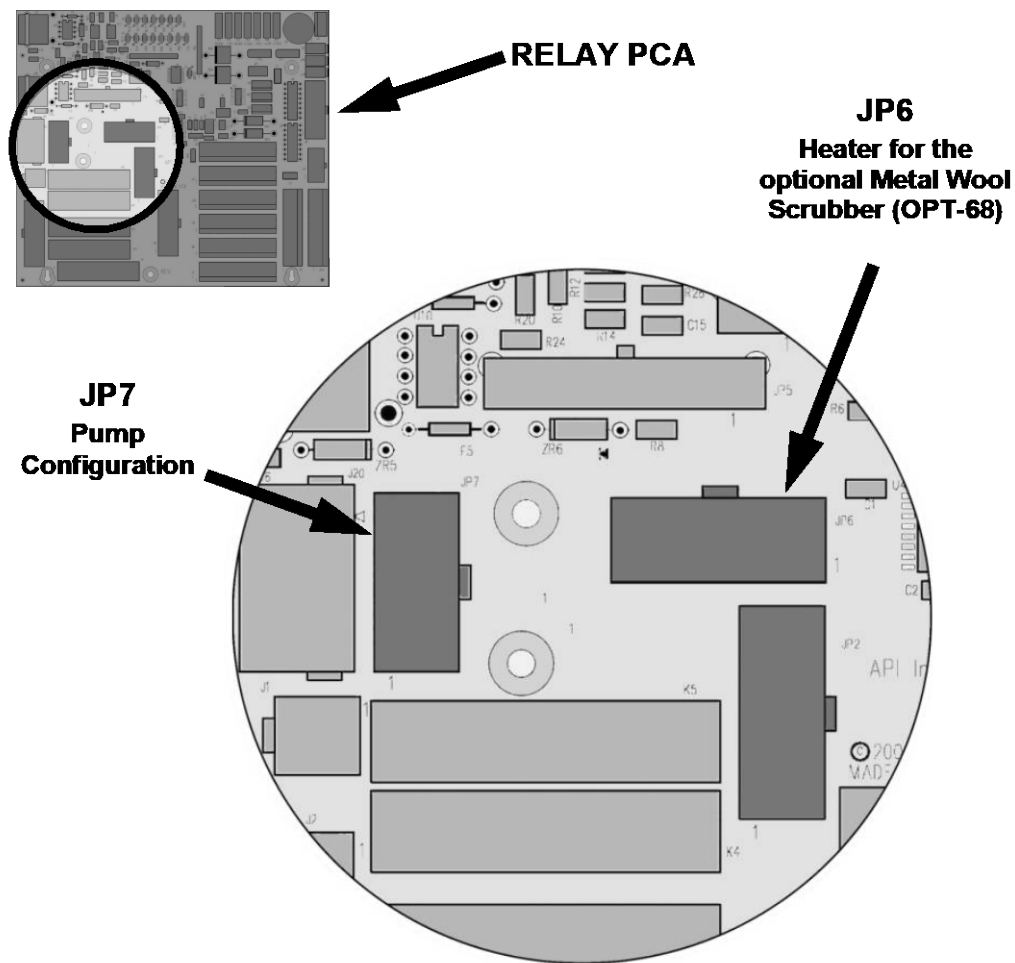


Figure 6-13. Location of AC Power Configuration Jumpers

6.3.5.1 AC CONFIGURATION – INTERNAL PUMP (JP7)

Table 6-3. AC Power Configuration for Internal Pumps (JP7)

LINE POWER	LINE FREQUENCY	JUMPER COLOR	FUNCTION	JUMPER BETWEEN PINS
110VAC 115 VAC	60 HZ	WHITE	Connects pump pin 3 to 110 / 115 VAC power line	2 to 7
			Connects pump pin 3 to 110 / 115 VAC power line	3 to 8
			Connects pump pins 2 & 4 to Neutral	4 to 9
	50 HZ ¹	BLACK	Connects pump pin 3 to 110 / 115 VAC power line	2 to 7
			Connects pump pin 3 to 110 / 115 VAC power line	3 to 8
			Connects pump pins 2 & 4 to Neutral	4 to 9
220VAC 240 VAC	60 HZ	BROWN	Connects pump pins 3 and 4 together	1 to 6
			Connects pump pin 1 to 220 / 240VAC power line	3 to 8
	50 HZ ¹	BLUE	Connects pump pins 3 and 4 together	1 to 6
			Connects pump pin 1 to 220 / 240VAC power line	3 to 8

¹ A jumper between pins 5 and 10 may be present on the jumper plug assembly, but is not functional on the T400.

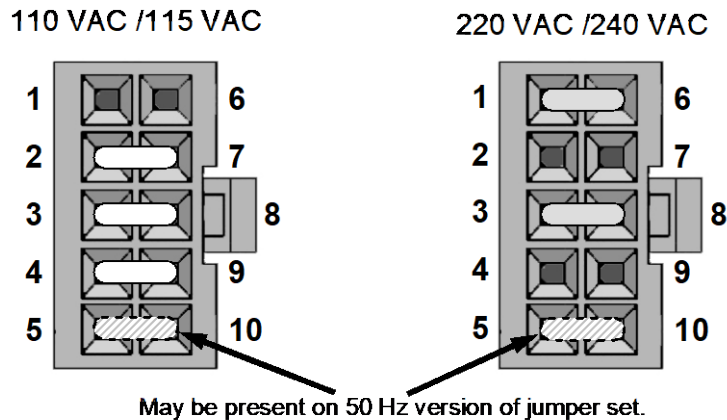


Figure 6-14. Pump AC Power Jumpers (JP7)

6.3.5.2 AC CONFIGURATION – HEATERS FOR OPTION PACKAGES (JP6)

The optional metal wool scrubber (OPT-68) includes an AC heater that maintains the scrubber at an optimum operating temperature. Jumper set JP6 is used to connect the heaters associated with those options to AC power. Since these heaters work with either 110/155 VAC or 220/240 VAC, there is only one jumper configuration.

Table 6-4. Power Configuration for Optional Metal Wool Scrubber Heater (JP6)

JUMPER COLOR	HEATER(S)	JUMPER BETWEEN PINS	FUNCTION
RED	Metal Wool Scrubber Heater	1 to 8	Common
		2 to 7	Neutral to Load

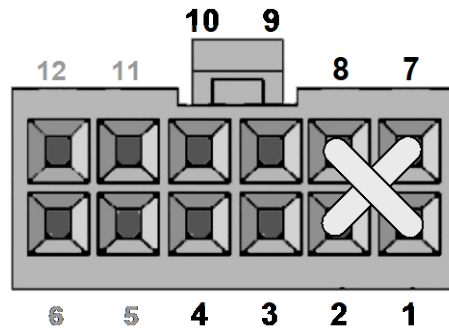


Figure 6-15. Typical Jumper Set (JP2) Set Up of Optional Metal Wool Scrubber Heater

6.3.6 PHOTOMETER LAYOUT AND OPERATION

The Photometer is the component where the absorption of UV light by ozone is measured and converted into a voltage. It consists of several sub-assemblies:

- A mercury-vapor UV lamp. This lamp is coated in a material that optically screens the UV radiation output to remove the O_3 producing 185nm radiation. Only light at 254nm is emitted.
- An AC power supply to supply the current for starting and maintaining the plasma arc of the mercury vapor lamp.
- A thermistor and DC heater attached to the UV lamp to maintain the lamp at an optimum operating temperature.
- 42 cm long quartz absorption tube.
- A thermistor attached to the quartz tube for measuring sample gas temperature.
- Gas inlet and outlet mounting blocks that route sample gas into and out of the photometer.
- The vacuum diode, UV detector that converts UV light to a DC current.
- A preamplifier assembly, which convert the Detector's current output into a DC Voltage then amplifies it to a level readable by the A-to-D converter circuitry of the instrument's motherboard.



CAUTION – UV RADIATION RISK

Do not look at the UV lamp while the unit is operating. UV light can cause eye damage. Always use safety glasses made from UV blocking material when working with the UV Lamp Assembly. (Generic plastic glasses are not adequate).

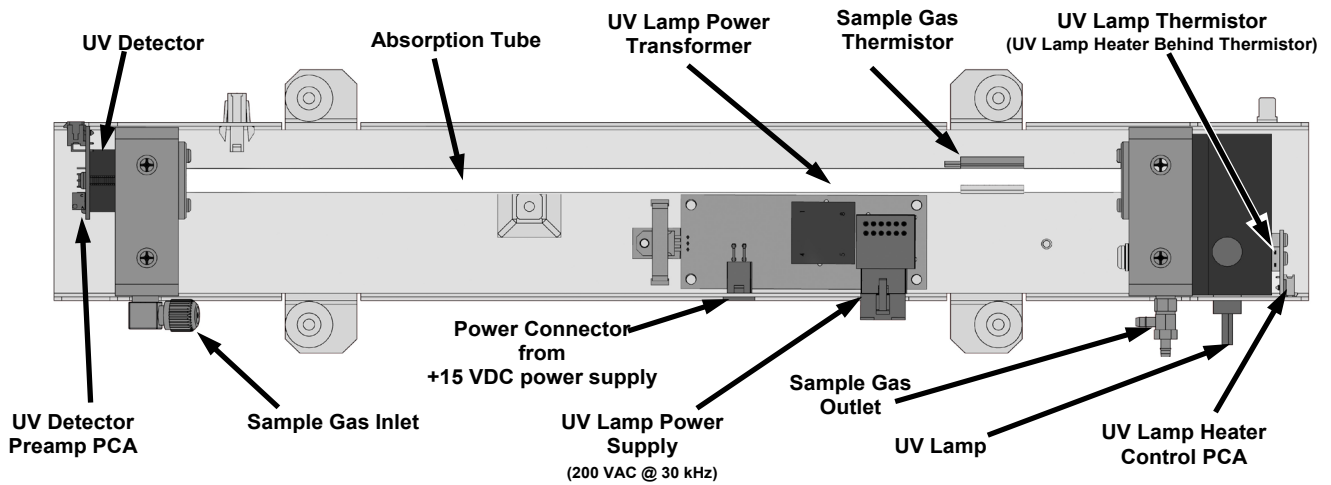


Figure 6-16. O₃ Photometer Layout – Top Cover Removed

6.3.7 FRONT PANEL TOUCHSCREEN/DISPLAY INTERFACE

Users can input data and receive information directly through the front panel touchscreen display. The LCD display is controlled directly by the CPU board. The touchscreen is interfaced to the CPU by means of a touchscreen controller that connects to the CPU via the internal USB bus and emulates a computer mouse.

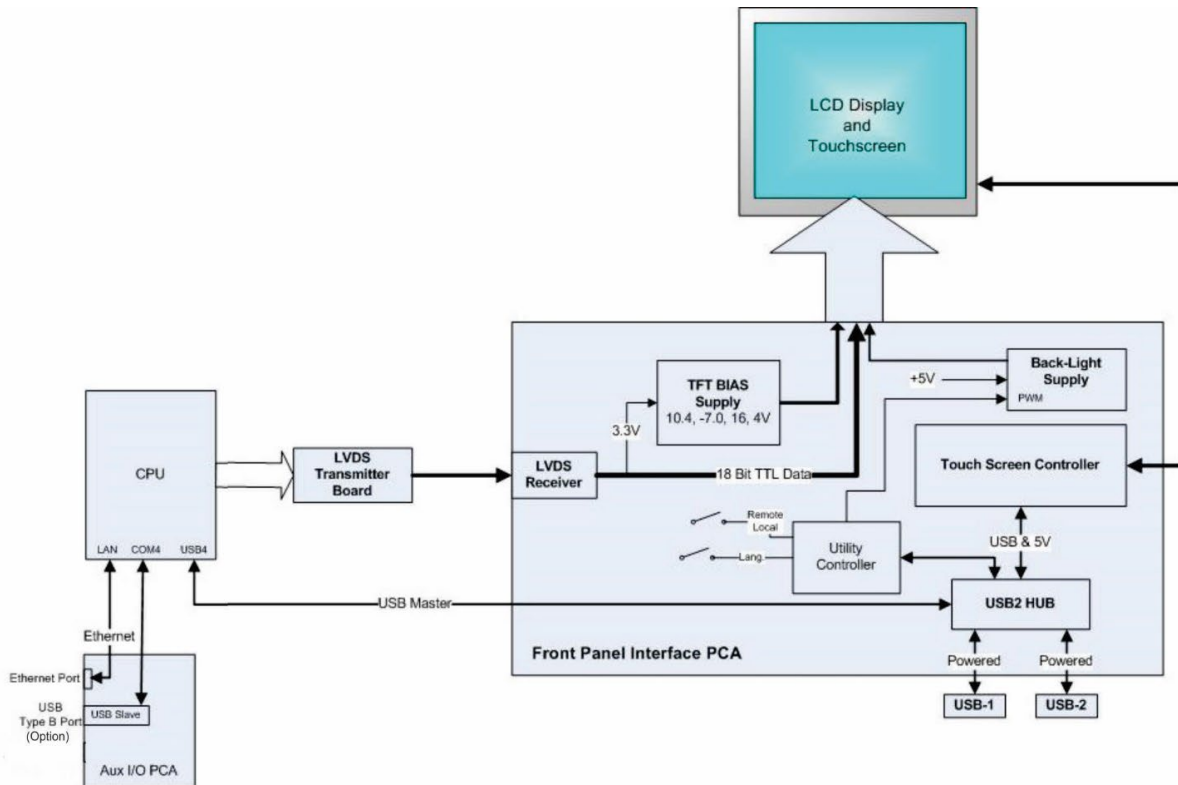


Figure 6-17. Front Panel and Display Interface Block Diagram

6.1.1.1 LVDS TRANSMITTER BOARD

The LVDS (low voltage differential signaling) transmitter board converts the parallel display bus to a serialized, low voltage, differential signal bus in order to transmit the video signal to the LCD interface PCA.

6.1.1.2 FRONT PANEL TOUCHSCREEN/DISPLAY INTERFACE PCA

The front panel touchscreen/display interface PCA controls the various functions of the display and touchscreen. For driving the display it provides connection between the CPU video controller and the LCD display module. This PCA also contains:

- power supply circuitry for the LCD display module
- a USB hub that is used for communications with the touchscreen controller and the two front panel USB device ports
- the circuitry for powering the display backlight

6.2 SOFTWARE OPERATION

The instrument's core module is a high performance, X86-based microcomputer running Windows CE. Inside Windows CE, special software developed by Teledyne API interprets user commands via the various interfaces, performs procedures and tasks, stores data in the CPU's various memory devices and calculates the concentration of the sample gas.

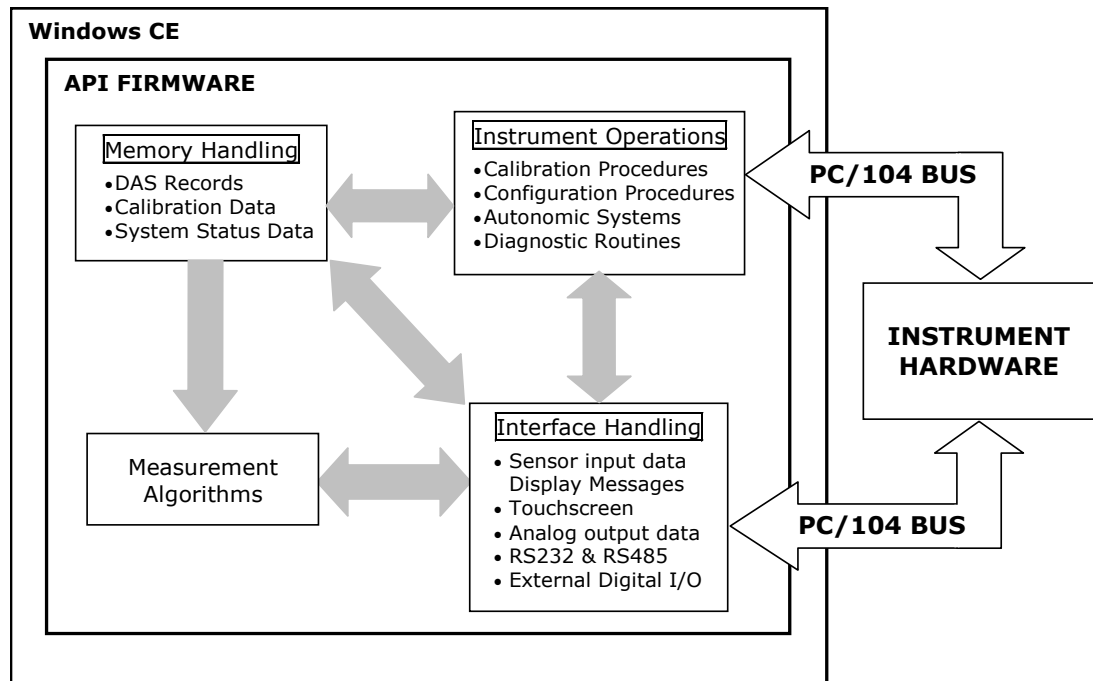


Figure 6-18. Basic Software Operation

6.2.1 ADAPTIVE FILTER

The Model T400 software processes sample gas measurement and reference data through an adaptive filter built into the software. Unlike other analyzers that average the output signal over a fixed time period, the Model T400 averages over a set number of samples, where a new sample is calculated approximately every 3 seconds - this is a technique is known as boxcar averaging. During operation, the software automatically switches between two different length filters, short and long, based on the conditions at hand.

During conditions of constant or nearly constant concentration, the software, by default, computes an average of the last 32 samples (long), or approximately 96 seconds. This provides the calculation portion of the software with smooth, stable readings. If a rapid change in concentration is detected, the filter length is changed to average the last 6 samples (short), approximately 18 seconds of data, to allow the analyzer to respond more quickly. If necessary, these boxcar lengths can be changed between 1 and 1000 samples but with corresponding tradeoffs in rise time and signal-to-noise ratio (contact Technical Support for more information).

Two conditions must be simultaneously met to switch to the short filter. First, the instantaneous concentration must exceed the average in the long filter by a fixed amount. Second, the instantaneous concentration must exceed the average in the long filter by a portion, or percentage, of the average in the long filter.

6.2.2 TEMPERATURE/PRESSURE COMPENSATION (TPC)

The software includes a feature that compensates for some temperature and pressure changes that might affect measurement of the gas concentrations.

When the TPC feature is enabled (default setting; can be enabled/disabled in the Setup>Vars menu), the analyzer divides the value of the PMT output signal (PMT

Signal) by a value called TP_FACTOR, which is calculated using the temperature and pressure parameters. As the values for these parameters increase, the value of TP_FACTOR increases and, hence, the PMT Signal value decreases. These adjustments are meant to counteract changes in the concentrations caused by these parameters.

The preset gain parameters are set at the factory and may vary from analyzer to analyzer.

6.2.3 CALIBRATION - SLOPE AND OFFSET

Calibration of the analyzer is performed exclusively in software.

During instrument calibration (see Section 4) the user enters expected values for zero and span via the front panel controls, and commands the instrument to make readings of calibrated sample gases for both levels. The readings taken are adjusted, linearized, and compared to the expected values. With this information, the software computes values for instrument slope and offset and stores these values in memory for use in calculating the O₃ concentration of the sample gas.

The instrument slope and offset values recorded during the last calibration are viewable in the Dashboard (Setup>Dashboard to configure).

GLOSSARY

Note: Some terms in this glossary may not occur elsewhere in this manual.

TERM	DESCRIPTION/DEFINITION
10Base-T	an Ethernet standard that uses twisted (“T”) pairs of copper wires to transmit at 10 megabits per second (Mbps)
100Base-T	same as 10BaseT except ten times faster (100 Mbps)
APICOM	name of a remote control program offered by Teledyne-API to its customers
ASSY	<i>Assembly</i>
CAS	<i>Code-Activated Switch</i>
CD	<i>Corona Discharge</i> , a frequently luminous discharge, at the surface of a conductor or between two conductors of the same transmission line, accompanied by ionization of the surrounding atmosphere and often by a power loss
CE	<i>Converter Efficiency</i> , the percentage of light energy that is actually converted into electricity
CEM	<i>Continuous Emission Monitoring</i>
Chemical formulas that may be included in this document:	
CO ₂	carbon dioxide
C ₃ H ₈	propane
CH ₄	methane
H ₂ O	water vapor
HC	general abbreviation for hydrocarbon
HNO ₃	nitric acid
H ₂ S	hydrogen sulfide
NO	nitric oxide
NO ₂	nitrogen dioxide
NO _x	nitrogen oxides, here defined as the sum of NO and NO ₂
NO _y	nitrogen oxides, often called odd nitrogen: the sum of NO _x plus other compounds such as HNO ₃ (definitions vary widely and may include nitrate (NO ₃), PAN, N ₂ O and other compounds as well)
NH ₃	ammonia
O ₂	molecular oxygen
O ₃	ozone
SO ₂	sulfur dioxide
cm ³	metric abbreviation for <i>cubic centimeter</i> (replaces the obsolete abbreviation “cc”)
CPU	<i>Central Processing Unit</i>
DAC	<i>Digital-to-Analog Converter</i>
DAS	<i>Data Acquisition System</i>
DCE	<i>Data Communication Equipment</i>
DFU	<i>Dry Filter Unit</i>
DHCP	<i>Dynamic Host Configuration Protocol</i> . A protocol used by LAN or Internet servers to automatically set up the interface protocols between themselves and any other addressable device connected to the network
DIAG	<i>Diagnostics</i> , the diagnostic settings of the analyzer.
DOM	<i>Disk On Module</i> , a 44-pin IDE flash drive with up to 128MB storage capacity for instrument’s firmware, configuration settings and data

DOS	<i>Disk Operating System</i>
DRAM	<i>Dynamic Random Access Memory</i>
DR-DOS	<i>Digital Research DOS</i>
DTE	<i>Data Terminal Equipment</i>
EEPROM	<i>Electrically Erasable Programmable Read-Only Memory</i> also referred to as a FLASH chip or drive
ESD	<i>Electro-Static Discharge</i>
ETEST	<i>Electrical Test</i>
Ethernet	a standardized (IEEE 802.3) computer networking technology for local area networks (LANs), facilitating communication and sharing resources
FEP	<i>Fluorinated Ethylene Propylene</i> polymer, one of the polymers that Du Pont markets as <i>Teflon</i> [®]
Flash	non-volatile, solid-state memory
FPI	<i>Fabry-Perot Interface</i> : a special light filter typically made of a transparent plate with two reflecting surfaces or two parallel, highly reflective mirrors
GFC	<i>Gas Filter Correlation</i>
I ² C bus	a clocked, bi-directional, serial bus for communication between individual analyzer components
IC	<i>Integrated Circuit</i> , a modern, semi-conductor circuit that can contain many basic components such as resistors, transistors, capacitors etc in a miniaturized package used in electronic assemblies
IP	<i>Internet Protocol</i>
IZS	<i>Internal Zero Span</i>
LAN	<i>Local Area Network</i>
LCD	<i>Liquid Crystal Display</i>
LED	<i>Light Emitting Diode</i>
LPM	<i>Liters Per Minute</i>
MFC	<i>Mass Flow Controller</i>
M/R	<i>Measure/Reference</i>
MOLAR MASS	the mass, expressed in grams, of 1 mole of a specific substance. Conversely, one mole is the amount of the substance needed for the molar mass to be the same number in grams as the atomic mass of that substance. EXAMPLE: The atomic weight of Carbon is 12 therefore the molar mass of Carbon is 12 grams. Conversely, one mole of carbon equals the amount of carbon atoms that weighs 12 grams. Atomic weights can be found on any Periodic Table of Elements.
NDIR	<i>Non-Dispersive Infrared</i>
NIST-SRM	<i>National Institute of Standards and Technology - Standard Reference Material</i>
PC	<i>Personal Computer</i>
PCA	<i>Printed Circuit Assembly</i> , the PCB with electronic components, ready to use
PC/AT	<i>Personal Computer / Advanced Technology</i>
PCB	<i>Printed Circuit Board</i> , the bare board without electronic component
PFA	<i>Perfluoroalkoxy</i> , an inert polymer; one of the polymers that <i>Du Pont</i> markets as <i>Teflon</i> [®]
PLC	<i>Programmable Logic Controller</i> , a device that is used to control instruments based on a logic level signal coming from the analyzer
PLD	<i>Programmable Logic Device</i>
PLL	<i>Phase Lock Loop</i>
PMT	<i>Photo Multiplier Tube</i> , a vacuum tube of electrodes that multiply electrons collected and

	charged to create a detectable current signal
P/N (or PN)	<i>Part Number</i>
PSD	<i>Prevention of Significant Deterioration</i>
PTFE	<i>Polytetrafluoroethylene</i> , a very inert polymer material used to handle gases that may react on other surfaces; one of the polymers that <i>Du Pont</i> markets as <i>Teflon</i> ®
PVC	<i>Poly Vinyl Chloride</i> , a polymer used for downstream tubing
Rdg	Reading
RS-232	specification and standard describing a serial communication method between DTE (Data Terminal Equipment) and DCE (Data Circuit-terminating Equipment) devices, using a maximum cable-length of 50 feet
RS-485	specification and standard describing a binary serial communication method among multiple devices at a data rate faster than RS-232 with a much longer distance between the host and the furthest device
SAROAD	<i>Storage and Retrieval of Aerometric Data</i>
SLAMS	<i>State and Local Air Monitoring Network Plan</i>
SLPM	<i>Standard Liters Per Minute</i> of a gas at standard temperature and pressure
STP	<i>Standard Temperature and Pressure</i>
TCP/IP	<i>Transfer Control Protocol / Internet Protocol</i> , the standard communications protocol for Ethernet devices
TEC	<i>Thermal Electric Cooler</i>
TPC	<i>Temperature/Pressure Compensation</i>
USB	<i>Universal Serial Bus</i> : a standard connection method to establish communication between peripheral devices and a host controller, such as a mouse and/or keyboard and a personal computer or laptop
VARS	<i>Variables</i> , the variable settings of the instrument
V-F	<i>Voltage-to-Frequency</i>
Z/S	<i>Zero / Span</i>

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Appendix A – T400 MODBUS Registers

Register Address (dec., 0-based)	Description	Units
MODBUS Floating Point Input Registers (32-bit IEEE 754 format; read in high-word, low-word order; read-only)		
0	Photometer detector measure reading	mV
2	Photometer detector reference reading	mV
4	Photometer lamp stability	%
6	Slope for range #1	—
8	Slope for range #2	—
10	Offset for range #1	PPB
12	Offset for range #2	PPB
14	Concentration for range #1 during zero/span calibration, just before computing new slope and offset	PPB
16	Concentration for range #2 during zero/span calibration, just before computing new slope and offset	PPB
18	Concentration for range #1	PPB
20	Concentration for range #2	PPB
22	Concentration stability	PPB
24	Ozone generator reference detector reading	mV
26	Ozone generator lamp drive	mV
28	Ozone generator lamp temperature	°C
30	Ozone scrubber temperature	°C
32	Ozone scrubber temperature duty cycle	Fraction (1.0 = 100%)
34	Photometer lamp temperature	°C
36	Photometer lamp temperature duty cycle	Fraction (1.0 = 100%)
38	Sample temperature	°C
40	Sample flow rate	cc/m
42	Sample pressure	Inches Hg
44	Internal box temperature	°C
46	Diagnostic test input (TEST_INPUT_7)	mV
48	Diagnostic test input (TEST_INPUT_8)	mV
50	Diagnostic temperature input (TEMP_INPUT_6)	°C
52	Diagnostic temperature input (TEMP_INPUT_7)	°C
54	Ground reference	mV
56	Precision 4.096 mV reference	mV
130 ⁴	External analog input 1 value	Volts
132 ⁴	External analog input 1 slope	eng unit /V
134 ⁴	External analog input 1 offset	eng unit
136 ⁴	External analog input 2 value	Volts

Register Address (dec., 0-based)	Description	Units
138 ⁴	External analog input 2 slope	eng unit /V
140 ⁴	External analog input 2 offset	eng unit
142 ⁴	External analog input 3 value	Volts
144 ⁴	External analog input 3 slope	eng unit /V
146 ⁴	External analog input 3 offset	eng unit
148 ⁴	External analog input 4 value	Volts
150 ⁴	External analog input 4 slope	eng unit /V
152 ⁴	External analog input 4 offset	eng unit
154 ⁴	External analog input 5 value	Volts
156 ⁴	External analog input 5 slope	eng unit /V
158 ⁴	External analog input 5 offset	eng unit
160 ⁴	External analog input 6 value	Volts
162 ⁴	External analog input 6 slope	eng unit /V
164 ⁴	External analog input 6 offset	eng unit
166 ⁴	External analog input 7 value	Volts
168 ⁴	External analog input 7 slope	eng unit /V
170 ⁴	External analog input 7 offset	eng unit
172 ⁴	External analog input 8 value	Volts
174 ⁴	External analog input 8 slope	eng unit /V
176 ⁴	External analog input 8 offset	eng unit

**MODBUS Floating Point Holding Registers
(32-bit IEEE 754 format; read/write in high-word, low-word order; read/write)**

0	Maps to O3_TARG_ZERO1 variable; target zero concentration for range #1	Conc. units
2	Maps to O3_SPAN1 variable; target span concentration for range #1	Conc. units
4	Maps to O3_TARG_ZERO2 variable; target zero concentration for range #2	Conc. units
6	Maps to O3_SPAN2 variable; target span concentration for range #2	Conc. units

**MODBUS Discrete Input Registers
(single-bit; read-only)**

0	O ₃ generator reference detector warning
1	O ₃ generator lamp intensity warning
2	O ₃ generator lamp temperature warning
3	O ₃ scrubber temperature warning
4	Photometer reference warning
5	Photometer lamp stability warning
6	Photometer lamp temperature warning
7	Box temperature warning
8	Sample temperature warning
9	Sample flow warning
10	Sample pressure warning
11	System reset warning

Register Address (dec., 0-based)	Description	Units
12	Rear board communication warning	
13	Relay board communication warning	
14	O ₃ generator or photometer lamp I ² C driver chip communication warning	
15	Front panel communication warning	
16	Analog calibration warning	
17	Dynamic zero warning	
18	Dynamic span warning	
19	Invalid concentration	
20	In zero calibration mode	
21	In low span calibration mode	
22	In span calibration mode	
23	In multi-point calibration mode	
24	System is OK (same meaning as <i>SYSTEM_OK</i> I/O signal)	
25 ³	O ₃ concentration alarm limit #1 exceeded	
26 ³	O ₃ concentration alarm limit #2 exceeded	
MODBUS Coil Registers (single-bit; read/write)		
0	Maps to relay output signal 36 (<i>MB_RELAY_36</i> in signal I/O list)	
1	Maps to relay output signal 37 (<i>MB_RELAY_37</i> in signal I/O list)	
2	Maps to relay output signal 38 (<i>MB_RELAY_38</i> in signal I/O list)	
3	Maps to relay output signal 39 (<i>MB_RELAY_39</i> in signal I/O list)	
20 ¹	Triggers zero calibration of O ₃ range #1 (on enters cal.; off exits cal.)	
21 ²	Triggers low span calibration of O ₃ range #1 (on enters cal.; off exits cal.)	
22 ¹	Triggers span calibration of O ₃ range #1 (on enters cal.; off exits cal.)	
23 ¹	Triggers zero calibration of O ₃ range #2 (on enters cal.; off exits cal.)	
24 ²	Triggers low span calibration of O ₃ range #2 (on enters cal.; off exits cal.)	
25 ¹	Triggers span calibration of O ₃ range #2 (on enters cal.; off exits cal.)	
¹ Set <i>DYN_ZERO</i> or <i>DYN_SPAN</i> variables to <i>ON</i> to enable calculating new slope or offset. Otherwise a calibration check is performed. ² O ₃ generator or zero/span valve factory options must be enabled. ³ Concentration alarm option. ⁴ External analog input option.		

Appendix B - Wiring Diagram

