TELEDYNE API
Everywhereyoulook™

User Manual

Model T500U
CAPS NO_2 Analyzer

with NumaView™ software

© TELEDYNE API (TAPI)
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-sales@teledyne.com**
Website:	**http://www.teledyne-api.com/**

083730510C DCN8582
29 September 2022

NOTICE OF COPYRIGHT

TRADEMARKS

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

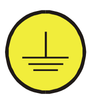
HAZARD: Strong oxidizer

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
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

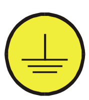
DANGER : Oxydant puissant

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
083730510	T500U NO_2 Analyzer with NumaView™ software (this manual)
n/a	MODBUS Registers, Appendix A
078480000	T500 Interconnect Diagram, Appendix B

Support manuals, such as electrostatic discharge (ESD) prevention, are available on the TAPI website http://www.teledyne-api.com.

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.**

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION, SPECIFICATIONS, APPROVALS, & COMPLIANCE

Teledyne API's Model T500U CAPS NO_2 Analyzer uses Cavity-Attenuated Phase-Shift (CAPS) spectroscopy to render direct, true measurements of nitrogen dioxide (NO_2). This technology eliminates the need for catalytic conversion or reagents that then introduce measurement artifacts from traditional heated metal converter-based chemiluminescence instruments The T500U operates as an optical absorption spectrometer, wherein the absorbance (lost light) is directly proportional to the path-length and the concentration of the absorbing gas (Beer-Lambert law), providing direct measurement of NO_2.

The T500U uses few components: an optical cell, a pair of highly reflective spherical mirrors centered at 450nm (strong NO_2 absorbance band), a light emitting diode (LED), and a vacuum phototube detector. The LED is located behind a mirror at one end of the cell, and the detector behind the other mirror at the opposite end of the cell. The LED emits ultraviolet light (UV) into the cell; the light reflects back and forth between the two mirrors, building intensity and running a very long path length. The long path length extends the "time" or "life" of the photon, thus providing ample time to measure absorbance when NO_2 is present. Through the use of precisely timed data acquisition coupled with a proprietary algorithm the measured absorption is translated into a phase shift, from which the NO_2 concentration is calculated. The phase shift decreases as the NO_2 signal increases.

The CAPS method is faster than the traditional chemiluminescence method since the sample does not require cycling through a catalytic converter to calculate a difference measurement. Its speed also makes measurement more precise due to the ability to capture samples closer to "real time" before ventilation vortices (e.g., urban canyons and other traffic-related forces) can scatter the concentration.

Economically, the Model T500U CAPS method is less costly to operate than traditional analyzers in that it uses less power (~80W) and fewer components.

The section on Principles of Operation provides more detail on the behavior and technique of the CAPS method for NO_2 measurement.

1.1. SPECIFICATIONS

Table 1-1. Specifications

Parameter	Description	
Range	Min: 0-5 ppb NO_2 Max: 0-1 ppm NO_2 (User-selectable)	
Measurement Units	ppb, ppm, µg/m^3, mg/m^3 (User-selectable)	
Zero Noise	< 20 ppt	
Span Noise	< 0.1% of reading + 20 ppt	
Zero Drift	< 0.1 ppb / 24 hours	
Span Drift	< 0.5% of reading / 24 hours	
Lower Detectable Limit	< 40 ppt	
Response Time	< 40 Seconds to 95%	
Linearity	< 1% Full Scale	
Precision	0.5% of reading above 5 ppb	
Sample Flow Rate	900 cm^3/min ±10%	
AC Power	Rating	Typical Power Consumption
	110 - 120 V~ 60 Hz 3.0 A 220 - 240 V~ 50 Hz 3.0 A	80 W 80 W
Analog Output Ranges	10V, 5V, 1V, 0.1V (selectable)	
Analog Output Resolution	1 part in 4096 of selected full-scale voltage	
Communications		
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 2 4-20mA current outputs	
Operating Temperature	5-40 ºC	
Humidity Range	0-95% RH, Non-Condensing	
Dimensions HxWxD	7" x 17" x 23.5" (178 x 432 x 597 mm) (19" rack mount, 5U, 24" deep)	
Weight	33 lbs (15 kg)	
Environmental Conditions	• Installation Category (Over Voltage Category) II Pollution Degree 2 • Intended for Indoor Use Only at Altitudes ≤ 2000m	
Note: All specifications are based on constant conditions		

1.2. EPA DESIGNATION

Teledyne API's Model T500U cavity attenuated phase shift spectroscopy nitrogen dioxide analyzer is officially designated as a US EPA Federal Equivalent Method (FEM), Designation number EQNA-0514-212 for NO_2 measurement as defined in 40 CFR Part 53. The official "List of Designated Reference and Equivalent Methods" is published in the U.S. Federal Register.

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 the cover backward until it clears the instrument's front bezel.
   c. Lift the cover straight up.
2. Inspect the interior of the instrument 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 or reconnect PCAs, wiring harnesses or electronic subassemblies while instrument is under power.

2.1.1. Ventilation Clearance

Whether the instrument is set up on a bench or installed in a 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

2.2. INSTRUMENT LAYOUT

Instrument layout includes front panel, rear panel connectors, and the 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).

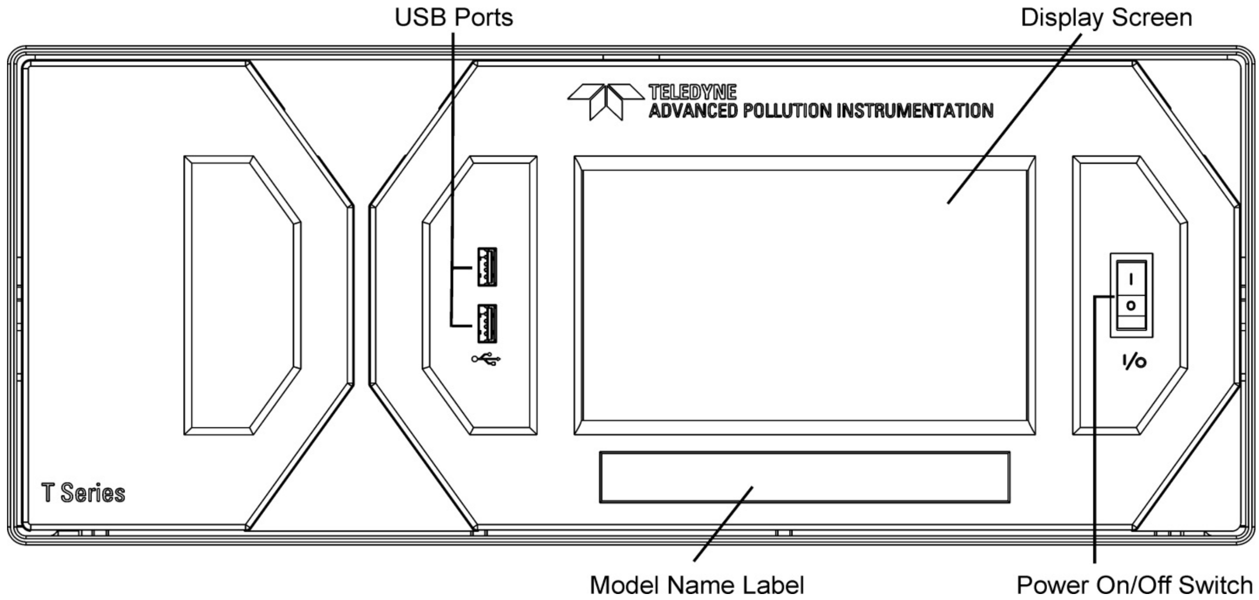


Figure 2-1. Front Panel Layout

2.2.2. Rear Panel

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

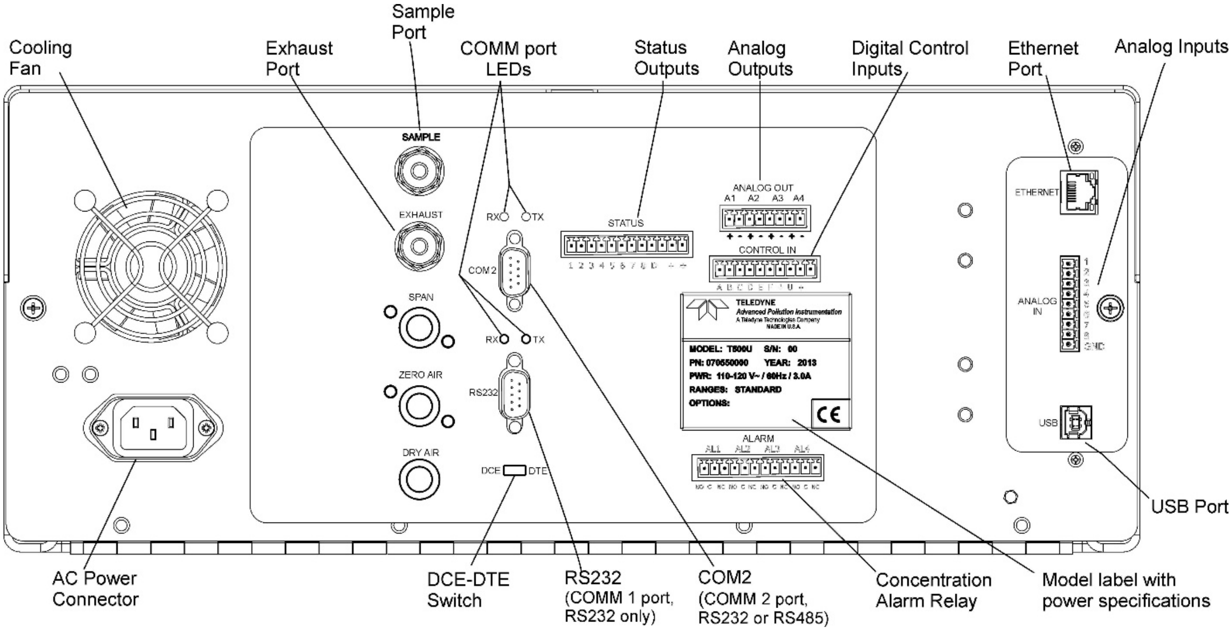


Figure 2-2. Rear Panel Layout

Table 2-2. 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 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 can also enter here on units without zero/span/shutoff valve options 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. The line must be ¼" tubing or greater.
SPAN	On units with zero/span valve option installed, connect a gas line to the source of calibrated span gas here.
ZERO AIR	On units with zero/span valve option installed, attach a gas line to the source of zero air here. If a permeation oven, also known as internal zero/span valve (IZS), option is installed attach the zero air scrubber here.
DRY AIR	Not Used
RX TX	LEDs indicate receive (RX) and transmit (TX) activity when blinking.
COM 2	Serial communications port for RS-232 or RS-485 (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.
ALARM	Option for concentration alarms and system warnings.
ETHERNET	Connector for network or Internet remote communication, using Ethernet cable
USB (option)	Option for direct connection to laptop computer, using USB cable.
Model Label	Includes voltage and frequency specifications

2.2.3. Internal Chassis

Figure 2-3 shows the internal chassis layout.

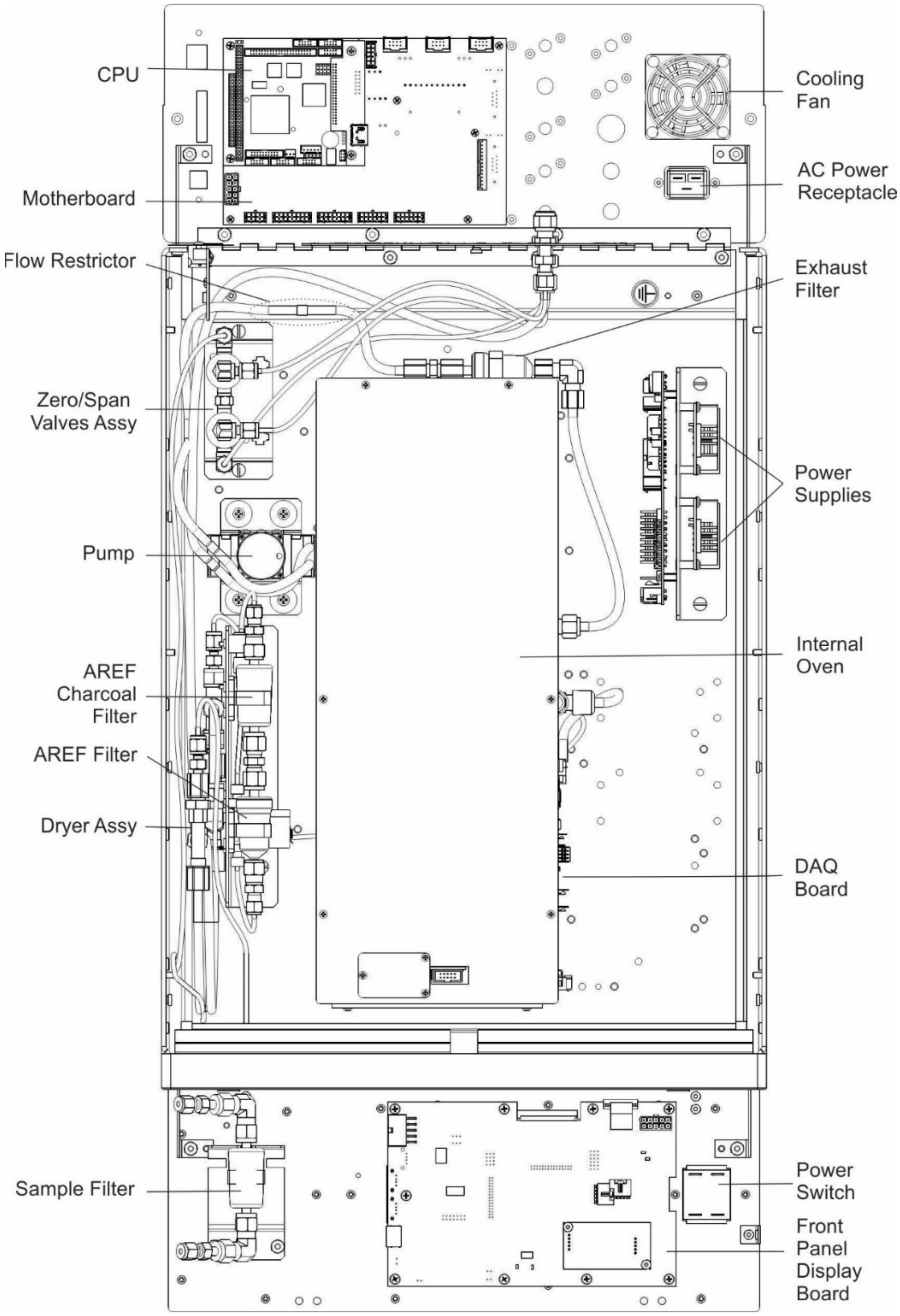


Figure 2-3. Internal Chassis Layout

2.3. CONNECTIONS AND STARTUP

This section presents the electrical (Section 2.3.1) and pneumatic (Section 2.3.2) connections for setting up and preparing the instrument for operation (Section 2.3.3).

2.3.1. Electrical Connections

Note **To maintain compliance with EMC standards, cable length must be no greater 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.**

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)

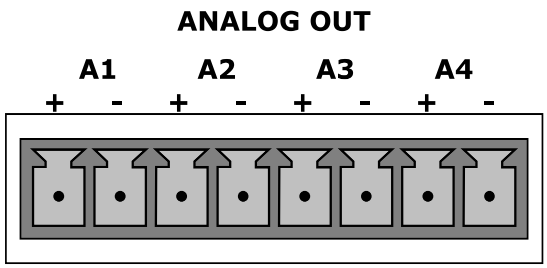


Figure 2-4. Analog Output Connector

Table 2-3. Analog Output Pin Assignments

PIN	ANALOG OUTPUT	SIGNAL OUT	STANDARD VOLTAGE OUTPUT	CURRENT LOOP OPTION
1	A1	User-selected through the Setup>Analog Outputs menu.	V +	I Out +
2			Ground	I Out -
3	A2		V +	I Out +
4			Ground	I Out -
3	A3		V +	I Out +
4			Ground	I Out -
7	A4		V +	Not Available
8			Ground	Not Available

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 combined with two voltage outputs. Next 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 2.5.8).

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.

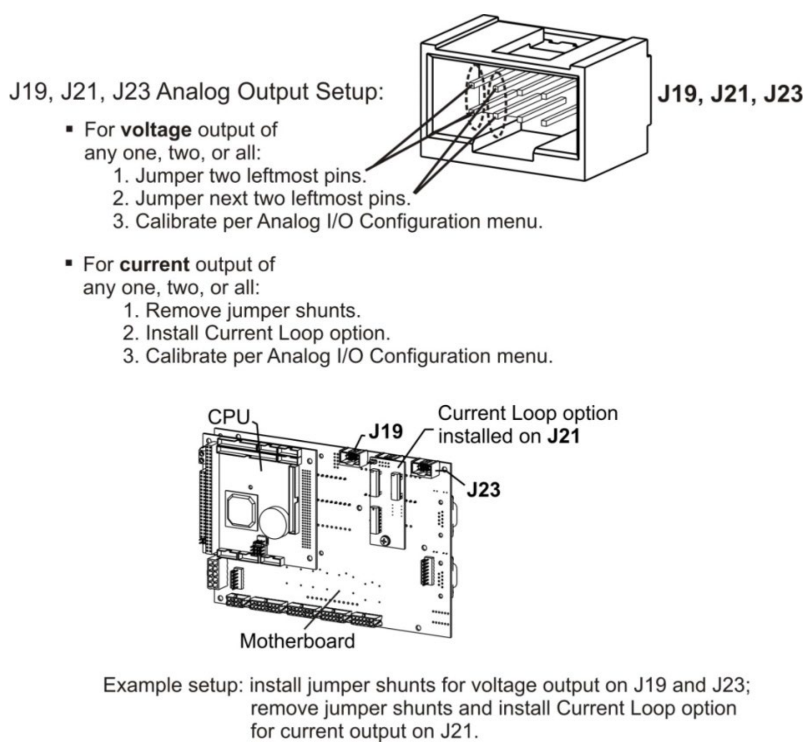


Figure 2-5. Current Loop Option Installed on the Motherboard

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 is connected to the output being modified, disconnect it.
3. Remove the top cover.
   - Remove the screws fastening the top cover to the unit (one per side).
   - Slide the cover back and lift the cover 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 adjacent pins (see Figure 2-5).
7. Return the top cover to the analyzer and secure.

The analyzer can now have a voltage-sensing recording device attached to that output.

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 that 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 PLC's 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.

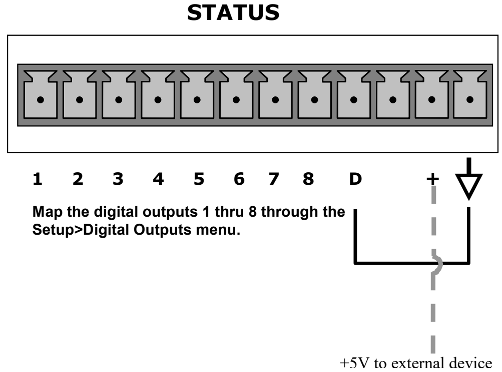


Figure 2-6. Status Output Connector for Digital Outputs

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 the Zero and Span valves option installed, two digital control inputs in the rear panel CONTROL IN connector, can be used to remotely activate the zero and span calibration modes (see Section 4.2.2.1).

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.

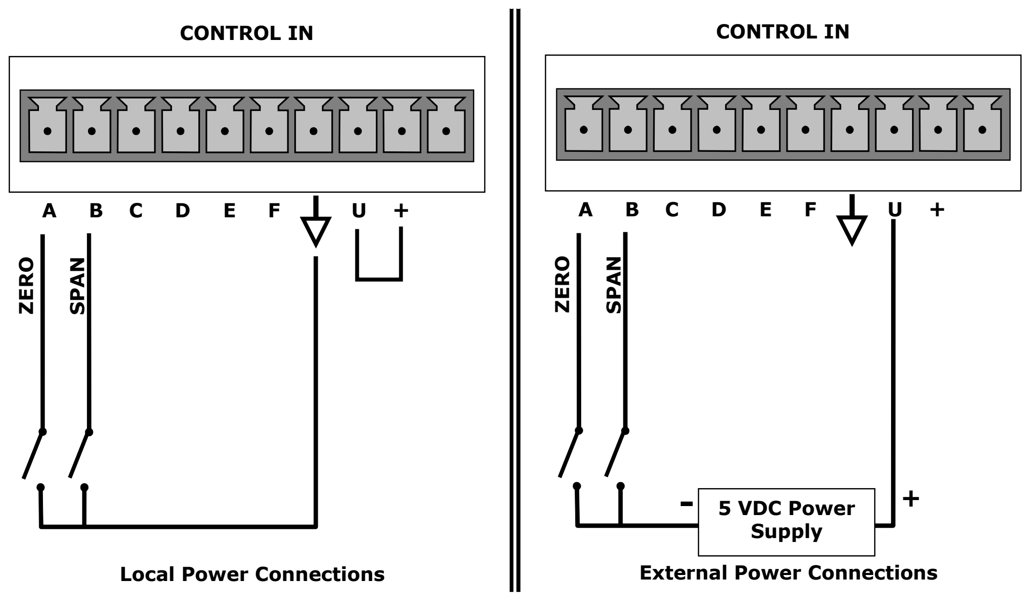


Figure 2-7. Energizing the Control Inputs

Table 2-5. Control Input Pin Assignments

INPUT #	STATUS DEFINITION	ON CONDITION
A	Remote Zero Cal	The analyzer is placed in Zero Calibration mode.
B	Remote Span Cal	The analyzer is placed in Lo Span Calibration mode.
C, 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 is 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. CONCENTRATION ALARM RELAY (OPTION 61)

The concentration relay 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].

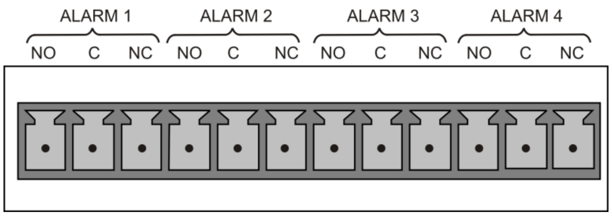


Figure 2-8. Concentration Alarm Relay

2.3.1.7. CONNECTING COMMUNICATIONS INTERFACES

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 port. Although the analyzer is shipped with DHCP enabled by default, it should be manually configured with a static IP address.

Configuration: Section 2.5.10.5

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 a computer USB port. Computer and instrument baud rates must match.

Note **If this option is installed, the rear panel RS232 (COM2) port cannot be used for anything other than RS-232 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 (Teledyne API part number WR000077) or a DB9-female-to-DB25-male cable (Option 60A), as applicable, from the analyzer's RS-232 port (see Figure 2-9 for connector pin assignments) to the device. Adjust the rear panel DCE-DTE switch to select DTE or DCE as appropriate (Section 3.1).

Configuration: Section 3.2.1 and Section 3.4.2 (for Hessen protocol)

Important **IMPACT ON READINGS OR DATA**

Cables that appear to be compatible because of matching connectors may incorporate internal wiring that makes the link inoperable. Check cables acquired from sources other than Teledyne API for pin assignments (Figure 2-9) before using.

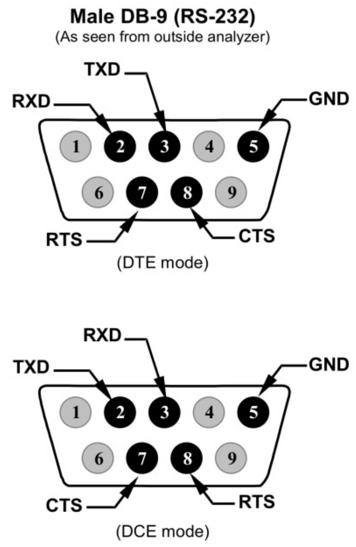


Figure 2-9. Rear Panel Connector Pin-Outs for RS-232 Mode

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 and J12 (Figure 2-10).

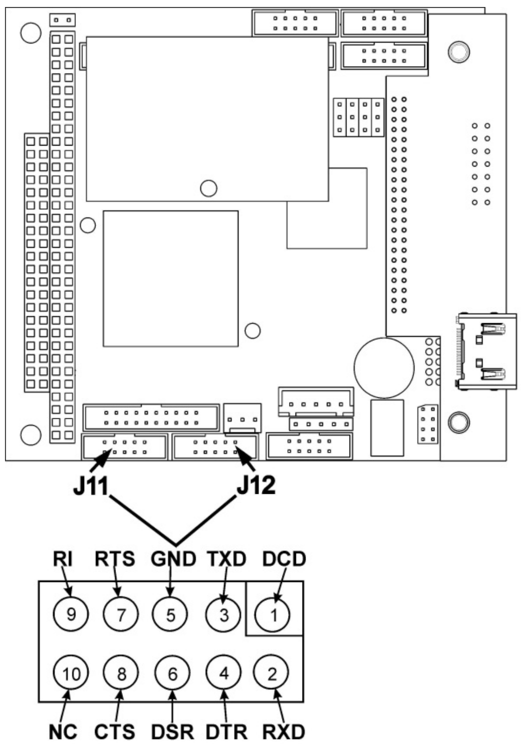


Figure 2-10. Default Pin Assignments for CPU COM Port Connector (RS-232)

Teledyne API offers two mating cables, one of which should be applicable for your use.

- P/N WR000077, a DB-9 female to DB-9 female cable, 6 feet long. Allows connection of the serial ports of most personal computers.
- P/N WR000024, a DB-9 female to DB-25 male cable. Allows connection to the most common styles of modems (e.g. Hayes-compatible) and code activated switches.

Both cables are configured with straight-through wiring and should require no additional adapters.

To assist in properly connecting the serial ports to either a computer or a modem, there are activity indicators just above the RS-232 port. Once a cable is connected between the analyzer and a computer or modem, both the red and green LEDs should be on.

- If the lights are not lit, locate the small switch on the rear panel to switch it between DTE and DCE modes.
- If both LEDs are still not illuminated, ensure that the cable properly constructed.

Received from the factory, the analyzer is set up to emulate an RS-232 DCE device. (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 62) Connection

When the RS-232 Multidrop option is installed, connection adjustments and configuration through the menu system are required. This section provides instructions for the internal connection adjustments, then for 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 electro-static 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. 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.

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 Figure 2-11. (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
     (Be aware 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

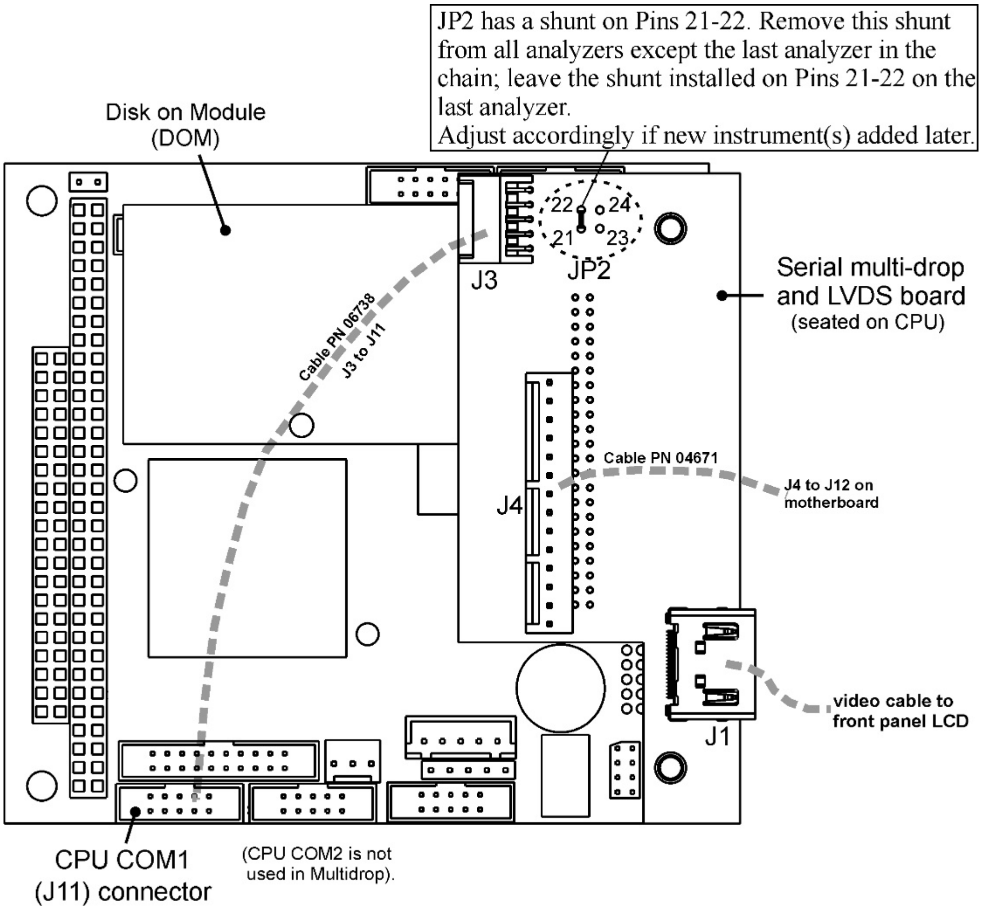


Figure 2-11. Jumper and Cables for Multidrop Mode

Note	If you are adding an instrument to the end of a previously configured chain, remove the shunt between Pins 21 and 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 Figure 2-10).

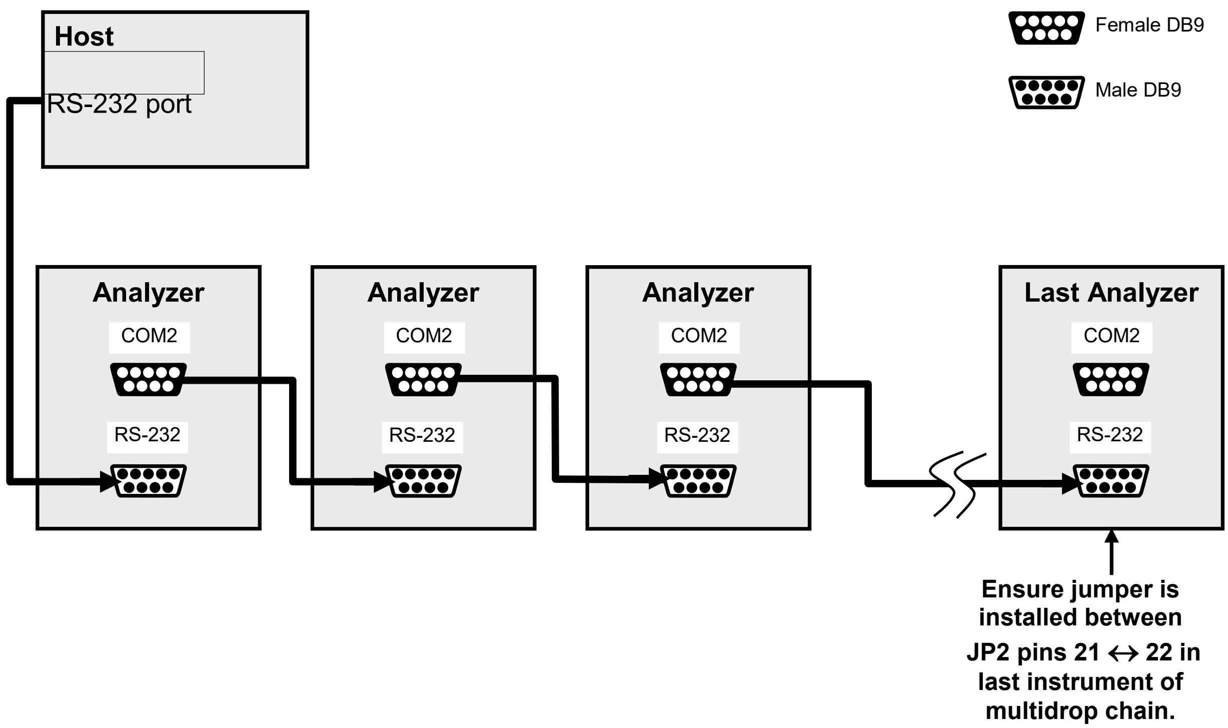


Figure 2-12. RS-232 Multidrop PCA Option Host/Analyzer Interconnect Diagram

7. BEFORE communicating from the host, power on the instruments and check that the user-selectable Instrument ID 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	**The (communication) Host instrument can address only one instrument at a time, each by its unique ID (see step 7 above).**

Note	**Teledyne API recommends setting up the first link that runs 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 pneumatic connection and setup instructions for basic and valve option configurations. 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

Do not vent calibration gas, exhaust gas or sample gas into enclosed areas.

CAUTION – General Safety Hazard

In units with a permeation tube option installed, vacuum pump must be connected and powered on to maintain constant gas flow though the analyzer at all times. Insufficient gas flow allows gas to build up to levels that will contaminate the instrument or present a safety hazard to personnel.

Remove the permeation tube when taking the analyzer out of operation and store in sealed container (use the original shipping packaging).

(See Section 5.6.4 for instructions on how to remove the permeation tube when the unit is not in operation).

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

VENT PRESSURIZED GAS:

When any gas (span, zero air, sample) is received from a pressurized manifold, always provide a vent to equalize the pressure with the ambient atmosphere before it enters the instrument to ensure that the gases input do not exceed the instrument's maximum inlet pressure, as well as to prevent back diffusion and pressure effects

REMOVE DUST PLUGS:

Remove dust plugs from rear panel exhaust and supply line fittings before powering on the instrument.

Keep dust plugs for reuse in future storage or shipping to prevent debris from entering the pneumatics.

Important

IMPACT ON READINGS OR DATA

- **Sample and calibration gases should only come into contact with PTFE tubing.**
- **Do NOT place any mufflers or filters downstream of the pump, i.e., external to the instrument.**
- **Run a leak check once the appropriate pneumatic connections have been made; check all pneumatic fittings for leaks per Section 5.4.12.1 (or Section 5.4.12.2 for detailed check if any leaking is suspected).**

2.3.2.1. CRITICAL TUBING, PRESSURE, VENTING AND EXHAUST REQUIREMENTS

The requirements presented in this section apply to all pneumatic connection instructions.

Tubing:

- PTFE material
- Outer diameter (OD) minimum ¼"
- Min/max length 2 meters to 10 meters

Pressure:

- All Sample gas pressure must be at ambient atmospheric pressure, no greater than 1.0 psig.

Venting (to prevent back diffusion and pressure effects):

- Run tubing outside the enclosure or at least away from immediate area surrounding the instrument.

Exhaust Outlet:

- Run tubing outside the enclosure.

Calibration Gas Sources:

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

2.3.2.2. BASIC CONNECTIONS FROM CALIBRATOR

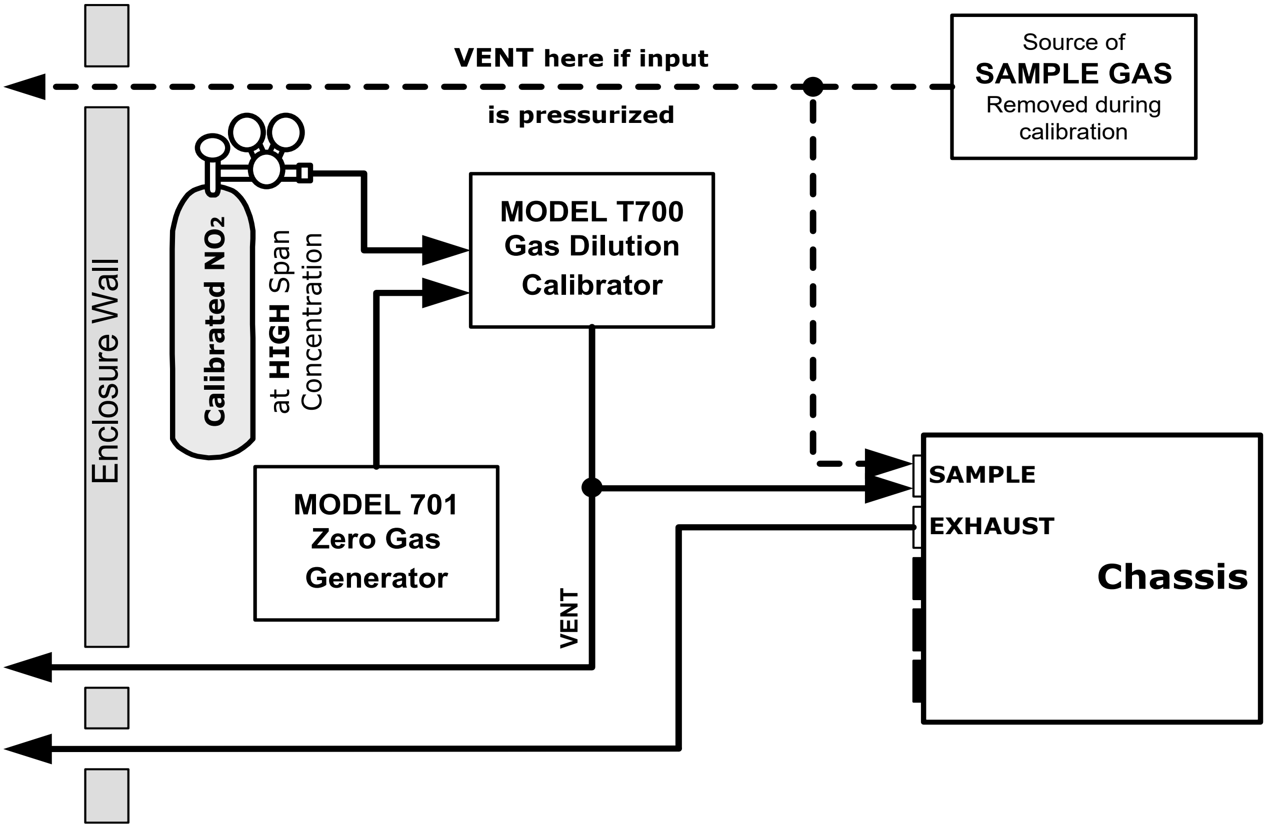


Figure 2-13. Gas Line Connections from Calibrator – Basic Configuration

For the analyzer's basic configuration, in addition to tubing, pressure, venting, and exhaust requirements set out in Section 2.3.2.1, attach the following pneumatic lines:

Sample Gas Source

Connect a sample gas line to the SAMPLE inlet.

Calibration Gas Sources

CAL GAS & ZERO AIR SOURCES: The source of calibration gas is attached to the SAMPLE inlet, but only when a calibration operation is actually being performed.

Venting

Vent the output of the calibrator if calibrator not already vented.

Exhaust Outlet

Attach an exhaust line to the EXHAUST outlet fitting and vent outside the shelter.

2.3.3. Pneumatic Flow Diagrams

This section shows a diagram of the basic pneumatic flow with the zero/span valves option (Figure 2-14) and with the internal zero/span Option (Figure 2-15).

Pneumatic Flow for Basic Configuration

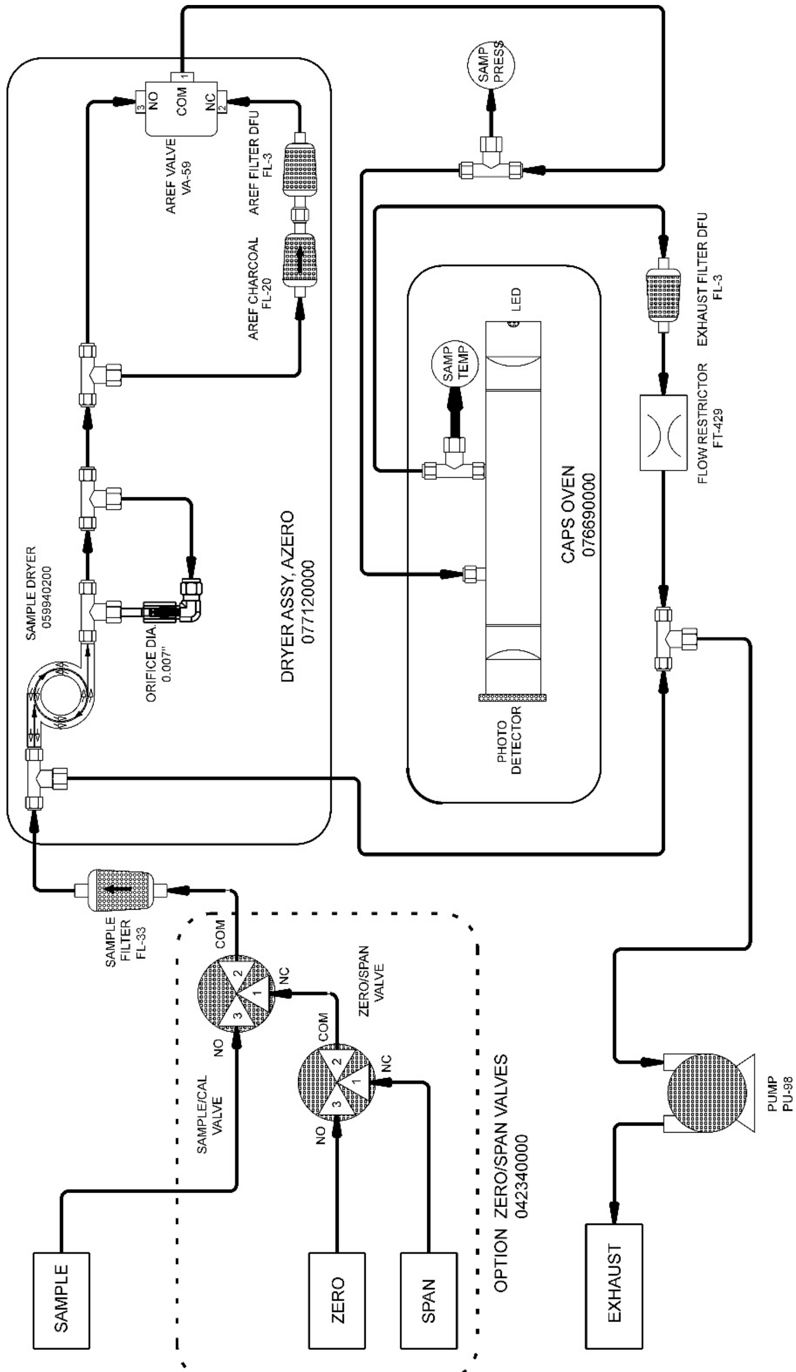


Figure 2-14. Pneumatics, Basic Configuration with Zero/Span Valve Option

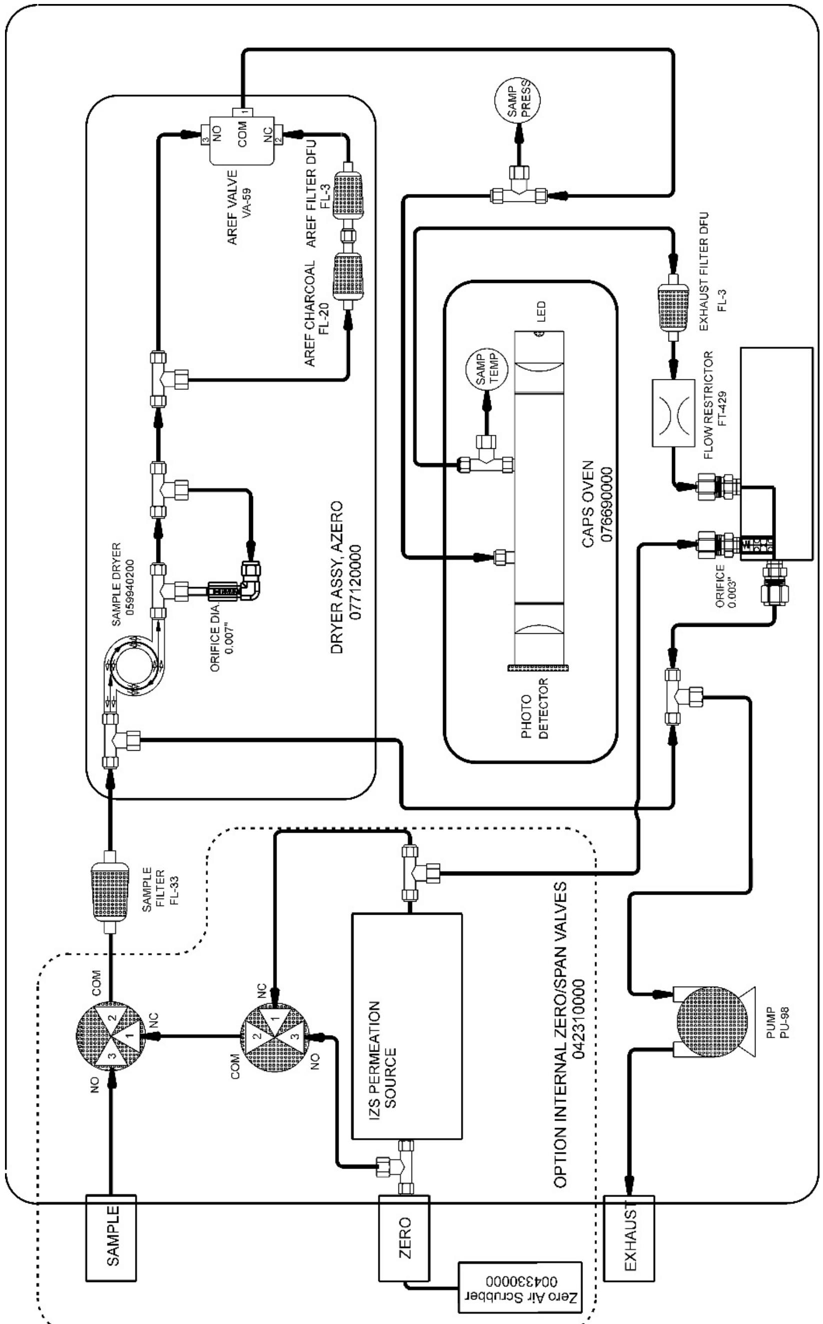


Figure 2-15. Pneumatics with Internal Zero/Span Valves Option (OPT 50A)

2.3.4. STARTUP, FUNCTIONAL CHECKS AND 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 2.3.4.4). 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 2-16) appear prior to the Home page (Figure 2-17).

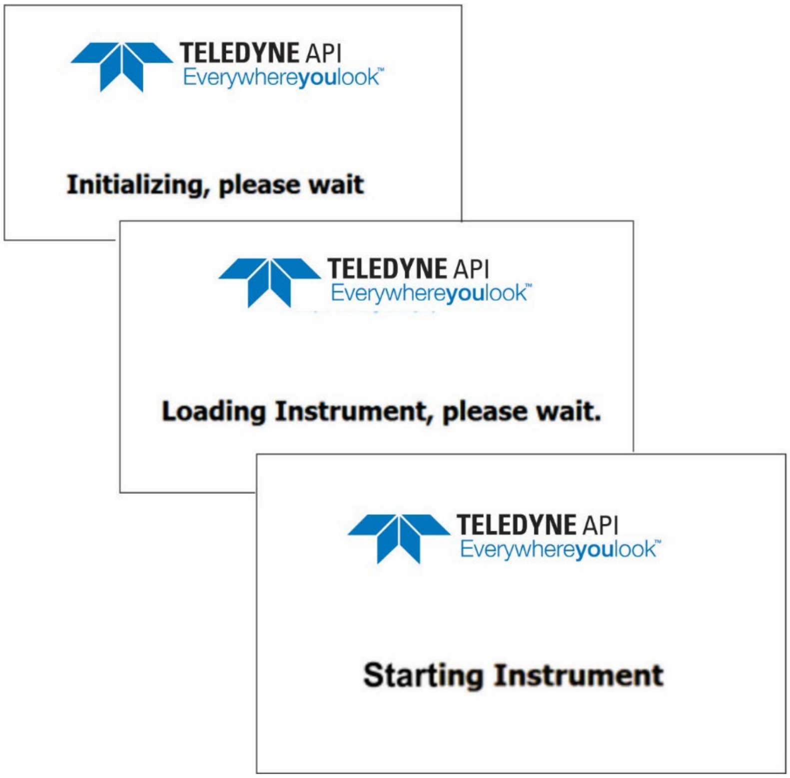


Figure 2-16. Status Screens at Startup

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

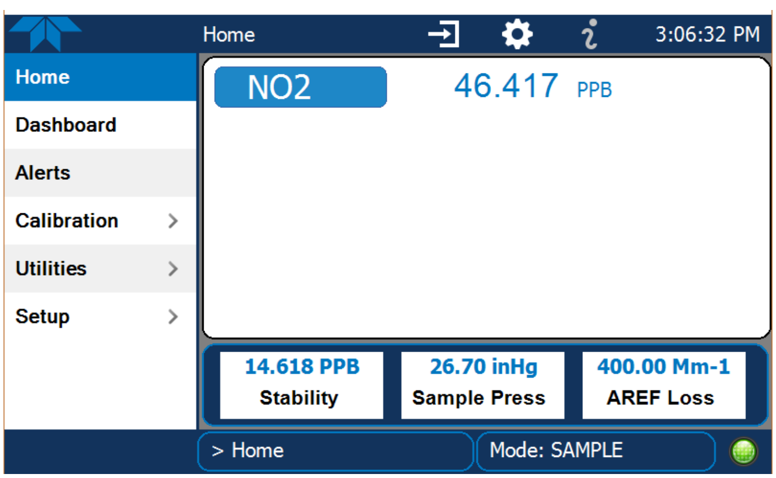


Figure 2-17. Home Page Example

2.3.4.2. ALERTS: WARNINGS AND OTHER MESSAGES

Because internal temperatures and other conditions may be outside the specified limits during the warm-up period, the software will suppress most Alerts for 30 minutes after power up. The Alerts page (Figure 2-18) 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.

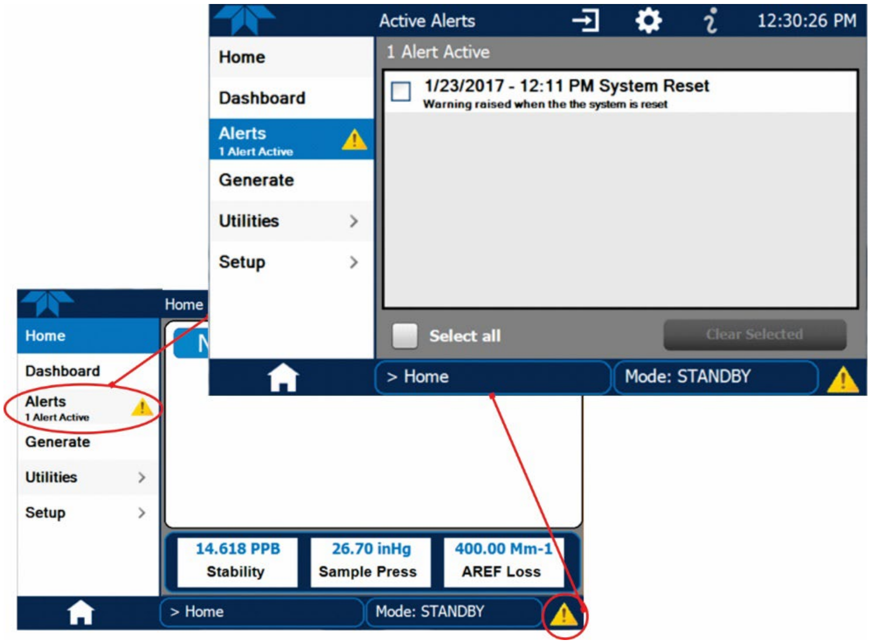


Figure 2-18. Viewing Active Alerts Page

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).

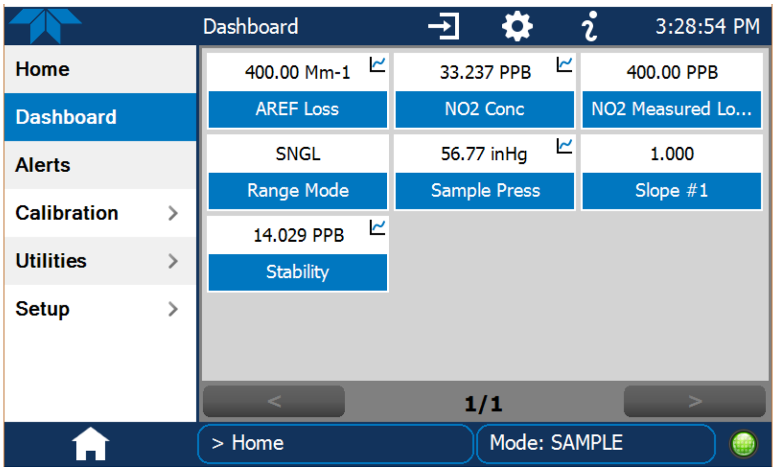


Figure 2-19. Sample Dashboard Page

2.3.4.4. CALIBRATION

Before operation begins, the analyzer requires zero and span calibrations. 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 presented in Section 4.

2.4. MENU OVERVIEW

Table 2-6 describes the main menus and provides cross-references to the respective sections with configuration details.

Table 2-6. Menu Overview

MENU		DESCRIPTION	LOCATION
Home		View and plot concentration readings and other selectable parameter values (Figure 2-21).	Section 2.4.1
Dashboard		View user-selected parameters and their values, some of which can be displayed in a live-plot graph (Figure 2-22).	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 calibrations or calibration checks on the NO_2 gas.	Sections 2.4.4 and 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 2-19) 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 2-20).	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 2-20 presents an orientation to the main display screen; Figure 2-21 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.

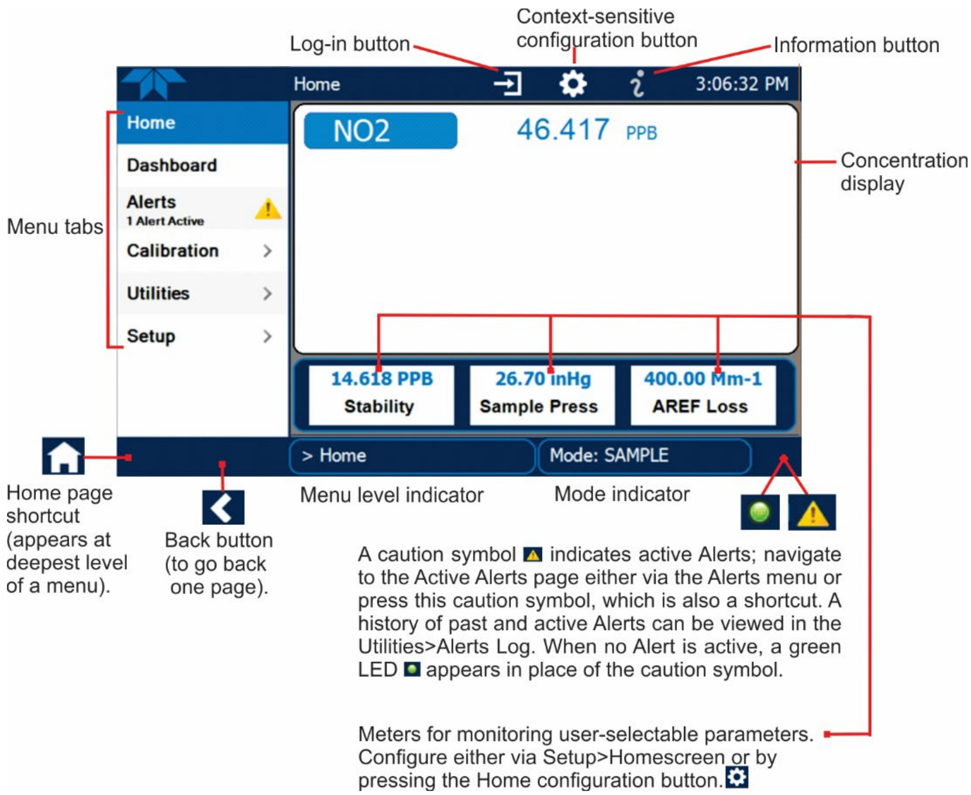


Figure 2-20. User Interface Orientation

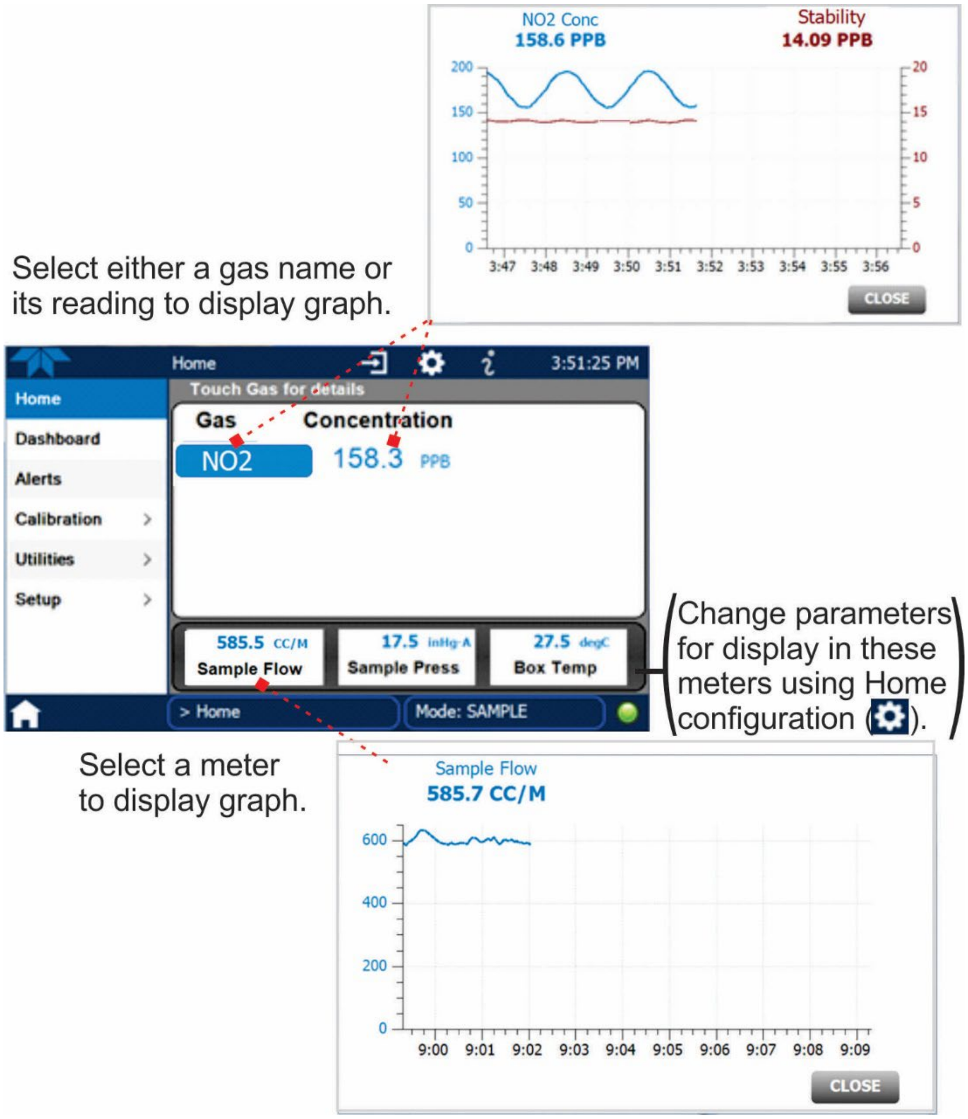


Figure 2-21. Concentration and Stability Graph (top) and Meter Graph (bottom)

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 2-22.

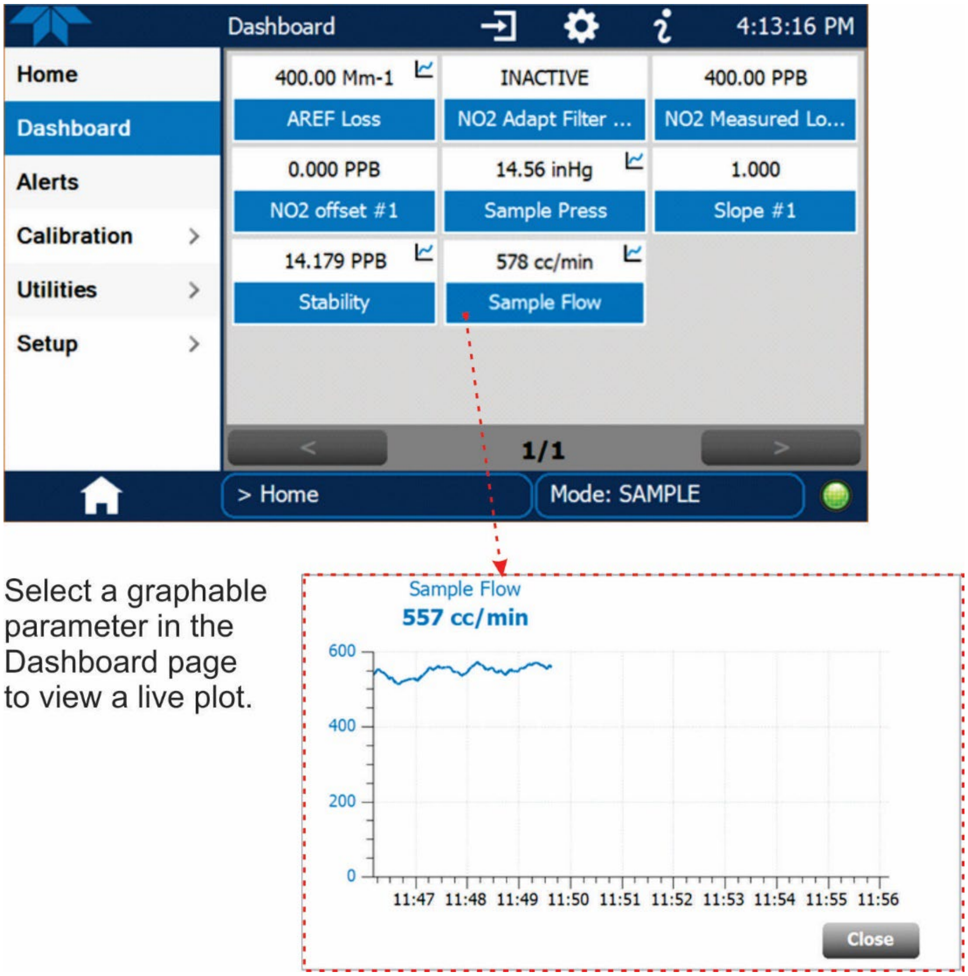


Figure 2-22. Dashboard Page

Several of the common parameters and their descriptions are presented in Table 2-7.

Table 2-7. Common Dashboard Parameters

PARAMETER	UNITS	DESCRIPTION
Box Temp	ºC	The temperature inside the analyzer chassis.
NO_2 Offset	PPB	The offset calculated during the most recent zero/span calibration.
Oven Temp	ºC	The temperature inside the oven.
Sample Flow	CC/MIN	Gas flow rate of the sample gas into the reaction cell.
Sample Press	IN-HG-A	The current pressure of the sample gas.
Slope	-	The slope calculated during the most recent zero/span calibration.
Stability	PPB	The standard deviation of concentration readings of the selected gas. • 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 2-23).

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

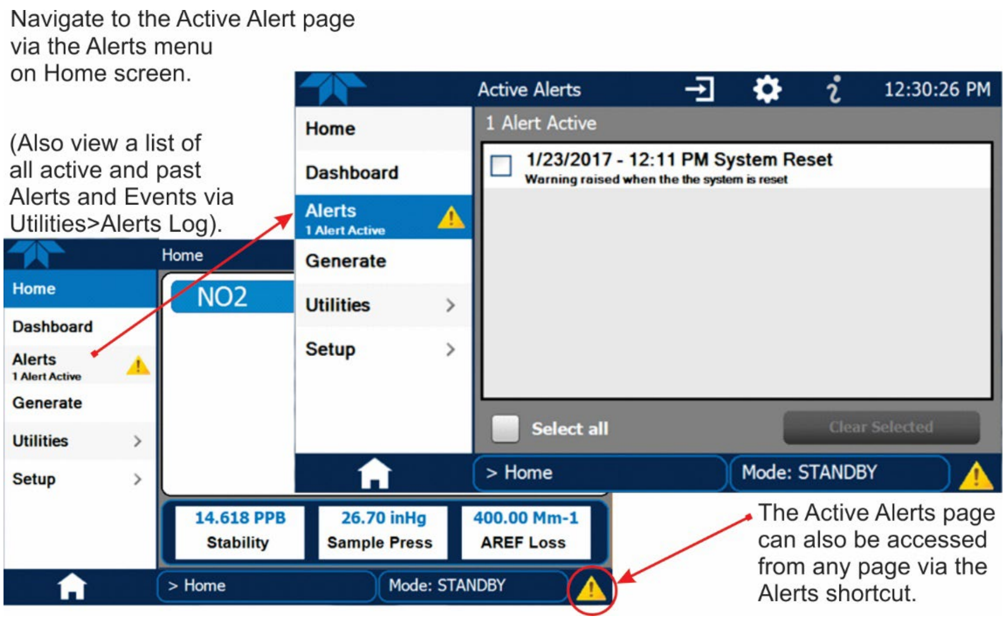


Figure 2-23. Navigating to the Active Alerts Page

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 2-24). However, Alerts can reappear if the conditions causing them are not resolved. For troubleshooting guidance, refer to Section 5.7.

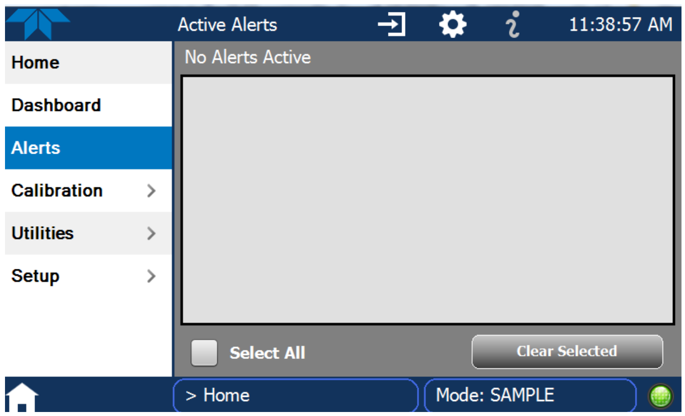


Figure 2-24. Active Alerts Cleared

Alerts and Events remain recorded in the Utilities>Alerts Log (Figure 2-25).

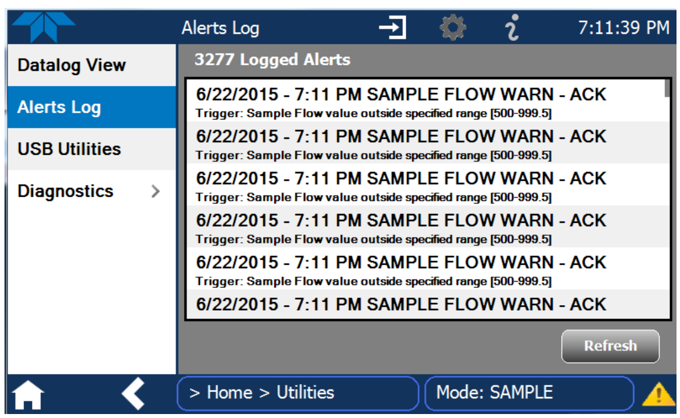


Figure 2-25. Utilities>Alerts Log of Active and Past Alerts and Events

2.4.4. Calibration

The Calibration menu is used for zero/span/multipoint calibrations 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 2-8.

Table 2-8. 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: • 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) • transfer instrument configuration from/to other same-model instruments (Section 2.6) • download a basic operation functionality report (Section 5.3).	
Diagnostics	Provides access to various pages that facilitate troubleshooting.	
	Analog Inputs	Measure voltage signals of several analog input parameters, including those from other instrumentation when the External Analog Inputs Option (Section 2.3.1.2) is installed. These can be logged in the internal data acquisition system (DAS), by configuring the Data Logger in the Setup>Data Logging menu (Section 2.5.1).
	Analog Outputs	Show the voltage signals for the functions selected and configured in the Setup>Analog Outputs menu (Section 2.5.8). Rear panel connections were presented in Section 2.3.1.2.
	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 (Section 2.3.1.5).
	Digital Outputs	Show the function of user-specified parameters configured in the Setup>Digital Outputs menu (Section 2.5.7).
	Manual AREF	At 20 minutes after power up and periodically thereafter when in Sample mode, the analyzer conducts a background measurement, known as an auto reference (AREF), whereby the sample is routed through an internal charcoal scrubber. This measurement accounts for drift in the baseline loss. A manual AREF is recommended prior to initial calibration (Section 4.2) or after general maintenance. Please note that AREF becomes disabled during calibration if the instrument stays in calibration mode (CALZ or CALS) for longer than it would normally take to run a calibration. To ensure that AREF is enabled, return to Sample mode after conducting a calibration.
	Pressure Cal	Adjust/calibrate pressure using reading from calibrated external pressure flow meter.
	Config Transfer	Import/export configuration settings

2.4.6. Setup

The Setup menu is used to configure the instrument's various features, functions, and data log. 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 2-26 shows a new log; Figure 2-27 shows a sample existing log, which can be edited or deleted, and Figure 2-28 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.

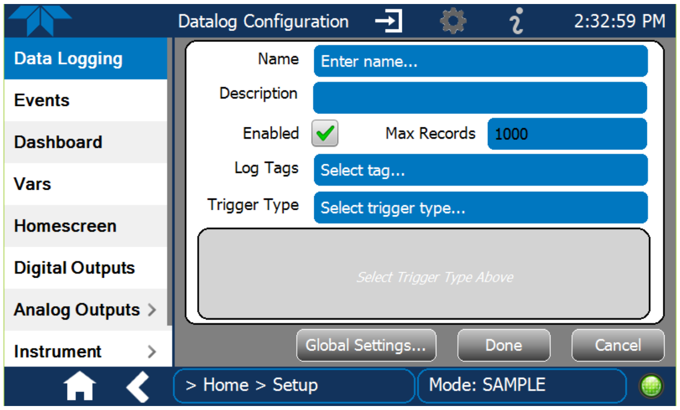


Figure 2-26. Datalog Configuration, New Log Page

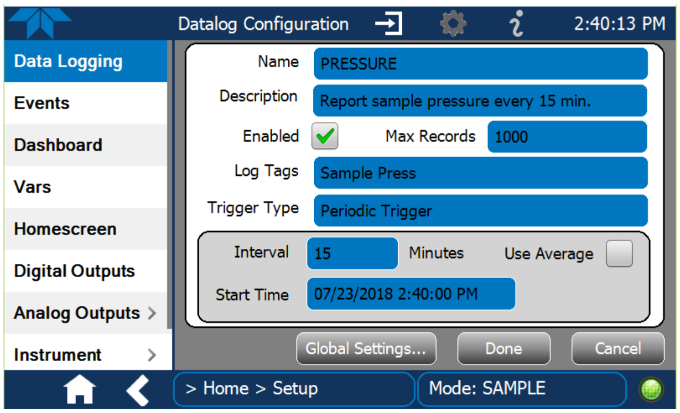


Figure 2-27. Datalog Configuration, Existing Log

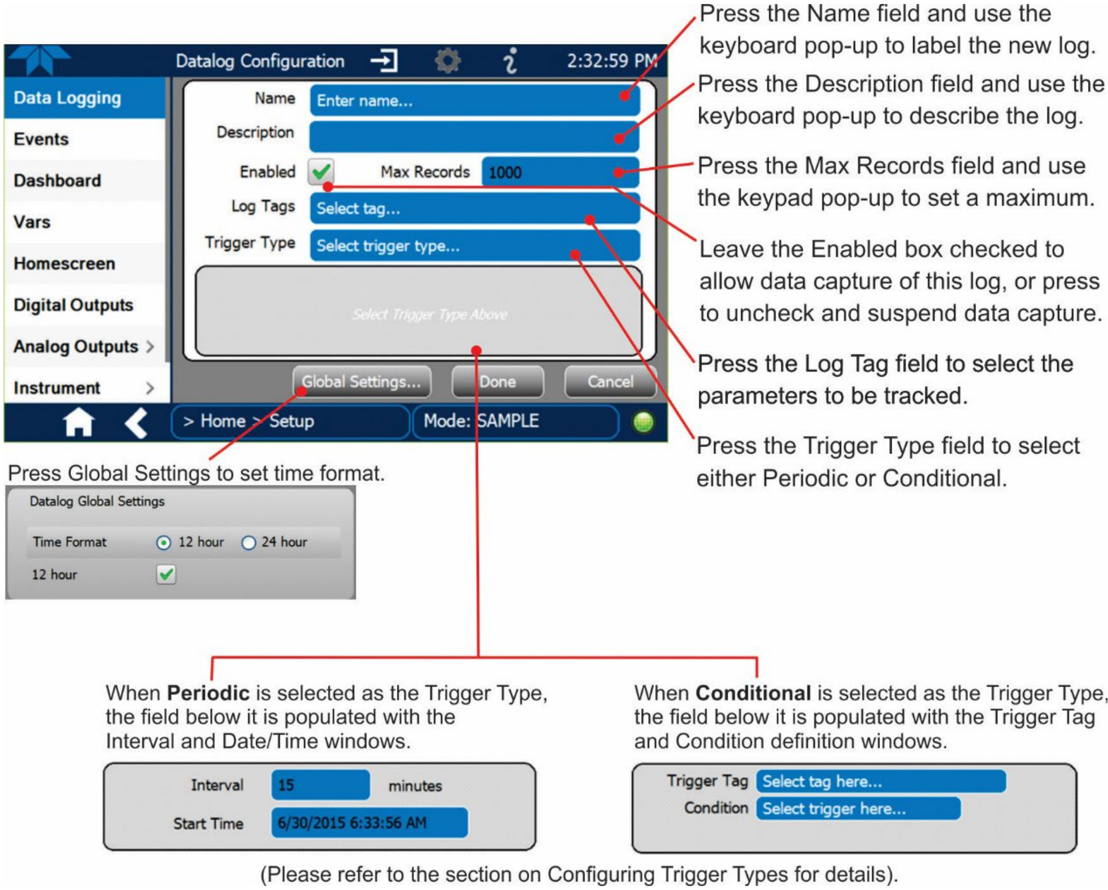


Figure 2-28. Creating a New Data Log

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.

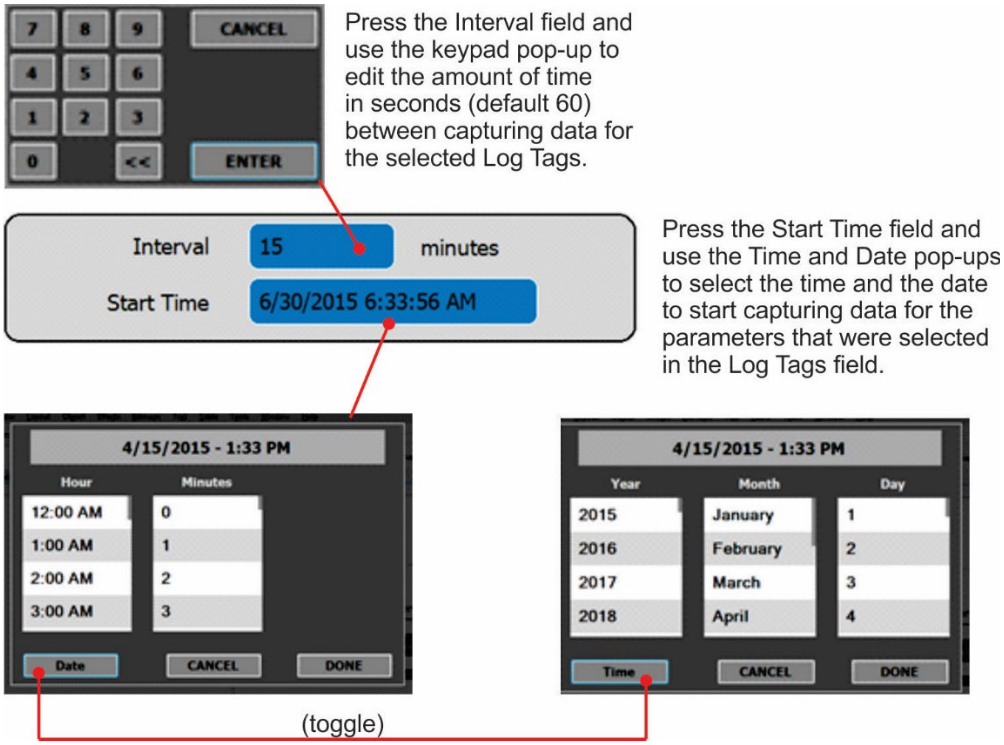


Figure 2-29. Datalog Periodic Trigger Configuration

2.5.1.2. CONFIGURING TRIGGER TYPES: CONDITIONAL

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

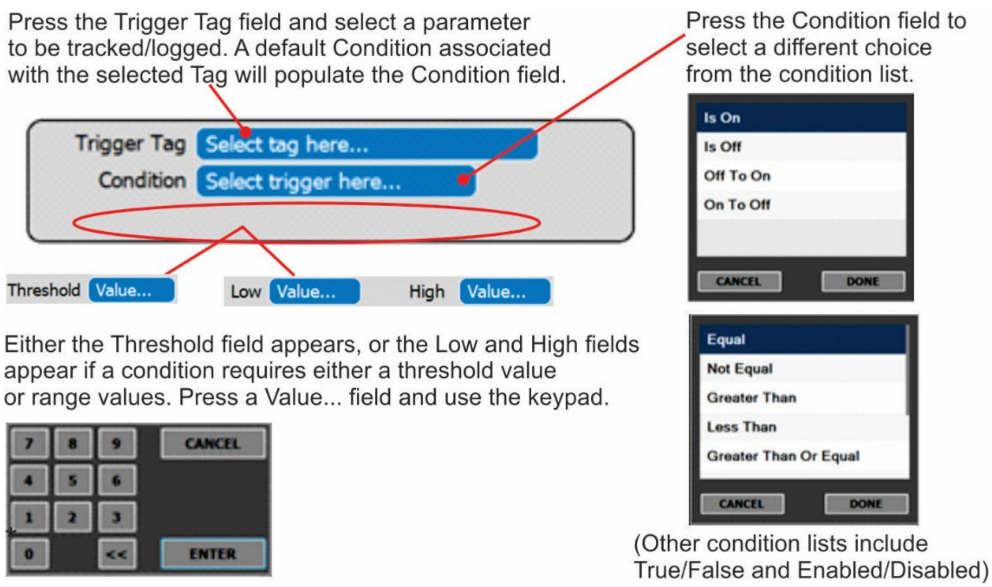


Figure 2-30. Datalog - Conditional Trigger Configuration

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.

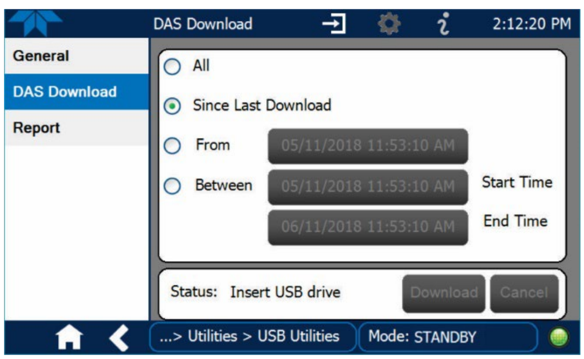


Figure 2-31. DAS Download Page

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 2-32) under the Setup menu.

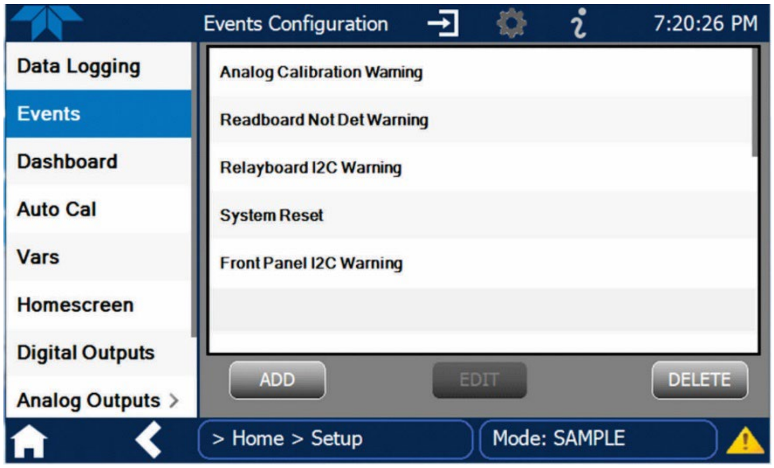


Figure 2-32. Events List

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 2-32). Press ADD to create a new Event (refer to Figure 2-33 for details), or select an existing Event to either Edit or Delete it (Figure 2-35).

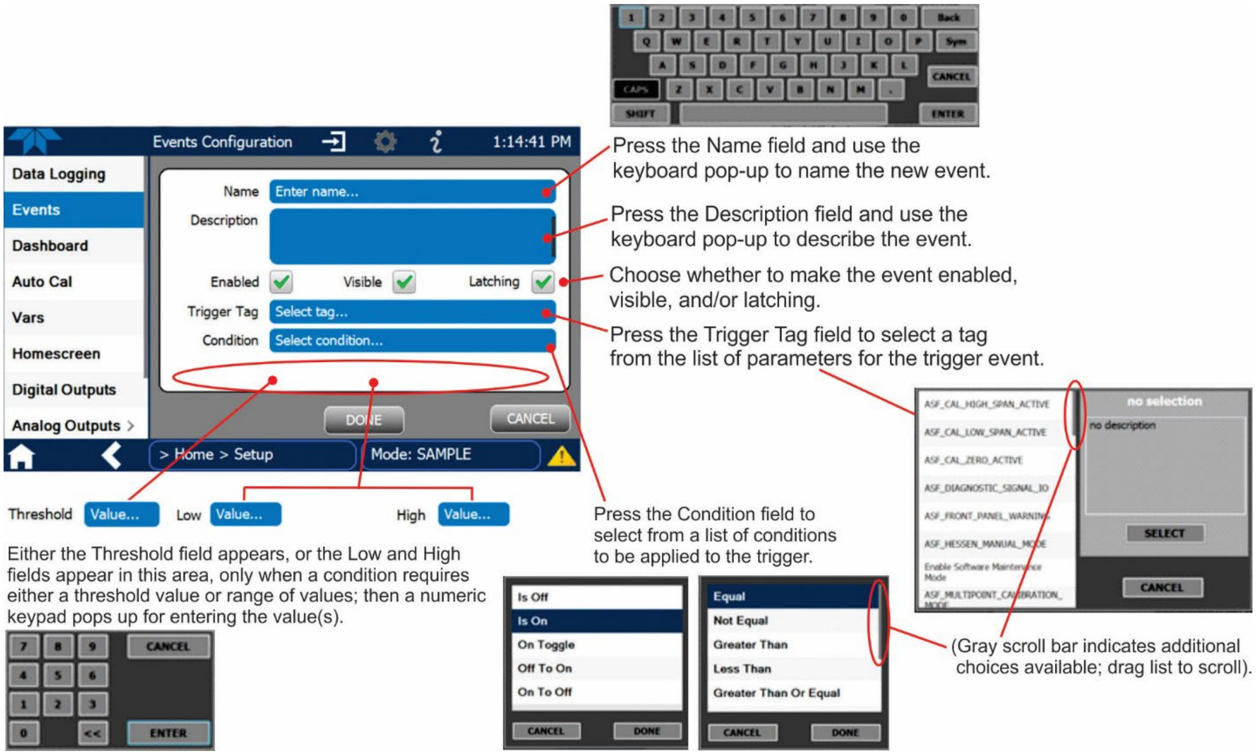


Figure 2-33. Event Configuration

- 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).

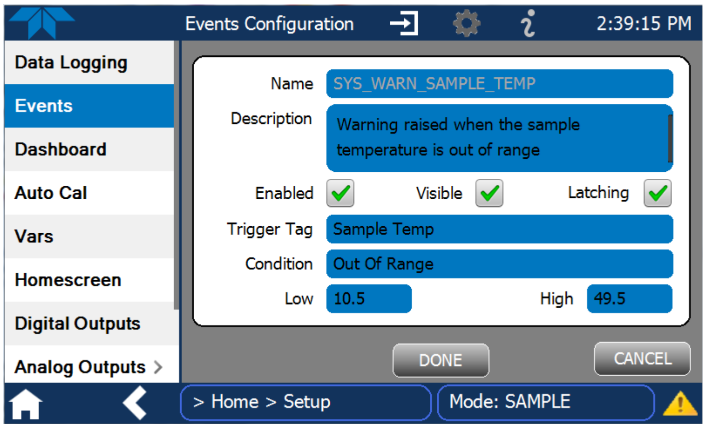


Figure 2-34. Configured Event Sample

2.5.2.1. EDITING OR DELETING EVENTS

Select an Event from the list (Figure 2-32) and press the Edit button to view or edit the details (Figure 2-34), or press the Delete button to delete the Event.

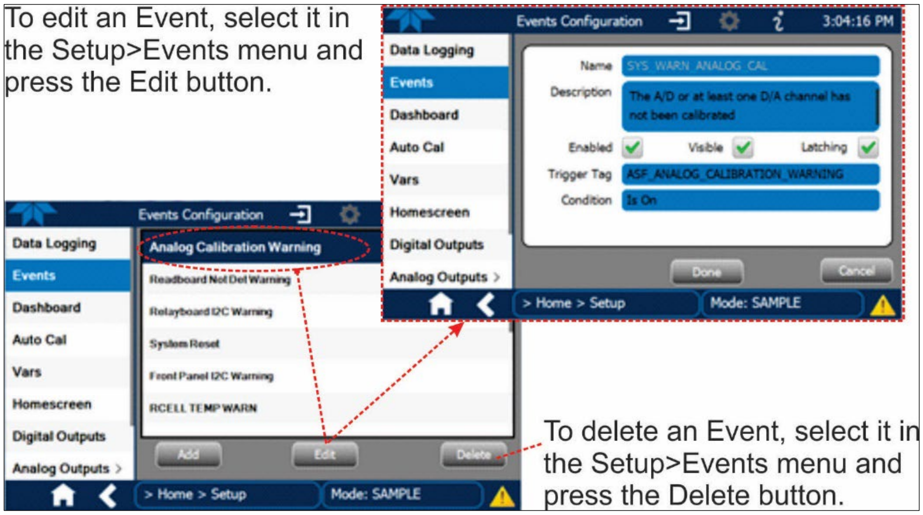


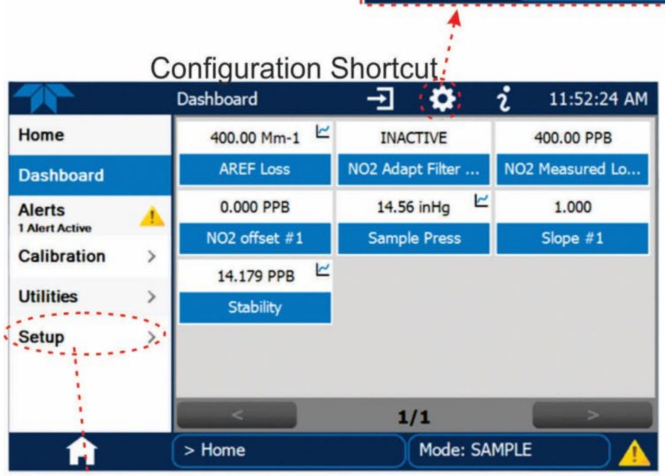
Figure 2-35. Edit or Delete an Event

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

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 2-36. Dashboard Display and Configuration

2.5.4. SETUP>AUTOCAL (WITH VALVE OPTION)

Auto Cal is available with installed valve options (see Section 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 2-9. List of Variables with Descriptions

VARIABLE	DESCRIPTION
NOTE: This list includes several of the most 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 NO2 concentration calculation 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. 1. Set the appropriate units of measure (Setup>Vars>User Units). 2. Select the reporting range mode (Setup>Vars>Range Mode) and set the reporting range upper limit (Setup>Analog Output). Ensure that the upper span limit entered for the reporting range is the maximum expected concentration of the undiluted gas. 3. 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). 4. 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.
Dynamic Span Enable (with Z/S valve option)	Dynamic span automatically adjusts the offset and slope of the NO_2 response when performing a span point calibration during an AutoCal (Section 4.3).
Dynamic Zero Enable (with Z/S valve option)	Dynamic zero automatically adjusts offset and slope of the NO_2 response when performing a zero point calibration during an AutoCal (Section 4.3).
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)
LED Disable	To turn on or off the Bench LED without cycling the instrument power.
Maint 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 (2.3.1.7) or Hessen protocol networks.
Pump Status	Disable or activate the pump without cycling the instrument power.
Range Mode	Controls range mode, single (SNGL) or dual (DUAL). (When set to DUAL, ensure that Max Concentration Range has been set).
System Hours	Total system runtime hours

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 2-37).

Figure 2-37. Homescreen Configuration

An orientation to the Homescreen was presented in Section 2.4.1, including Figure 2-20 and Figure 2-21.

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.

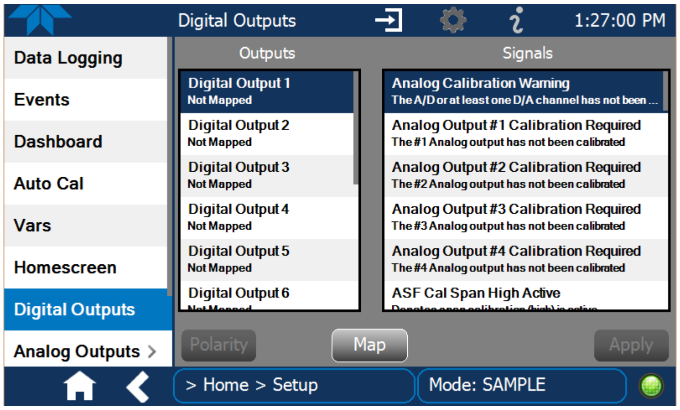


Figure 2-38. Digital Outputs Setup

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.

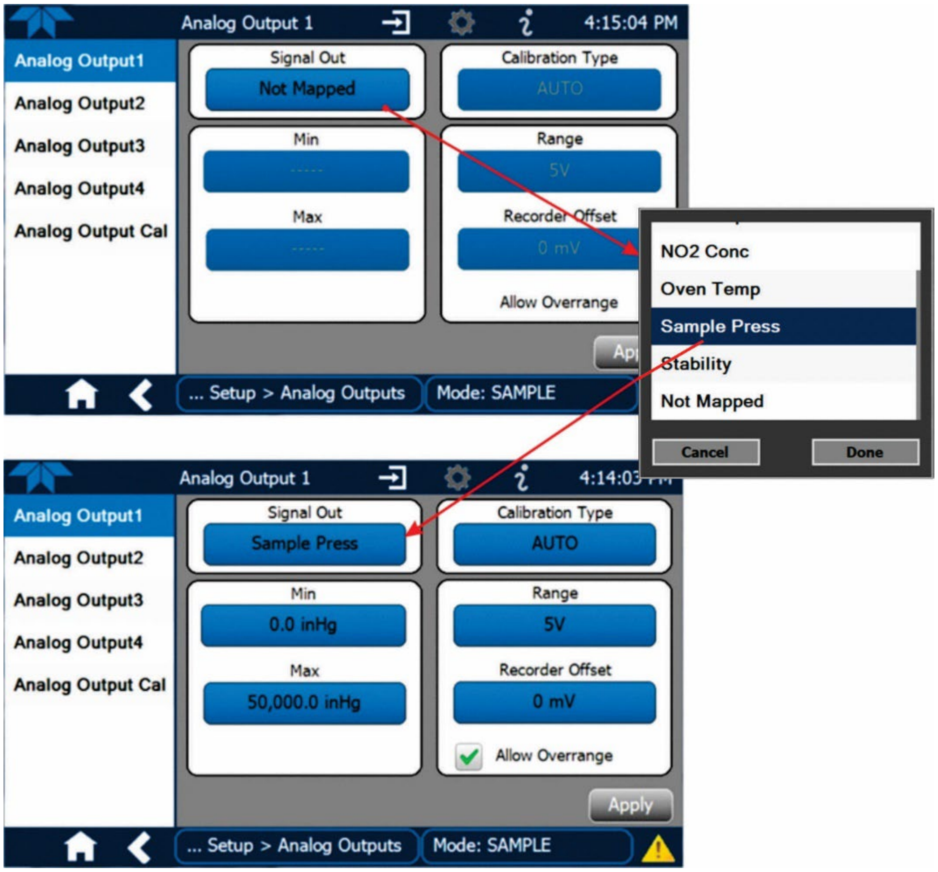


Figure 2-39. Analog Output Configuration Example

Refer to Figure 2-39 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 2-40) of the analog outputs (cannot be selected when Current is selected for the Range)
  - MANUAL for individual calibration (Figure 2-41) 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 2-10).
- Recorder Offset: add a zero offset for recording slightly negative readings from noise around the zero point.
- Allow Overrange: check to allow a ± 5% over-range; uncheck to disable over-range if the recording device is sensitive to excess voltage or current.

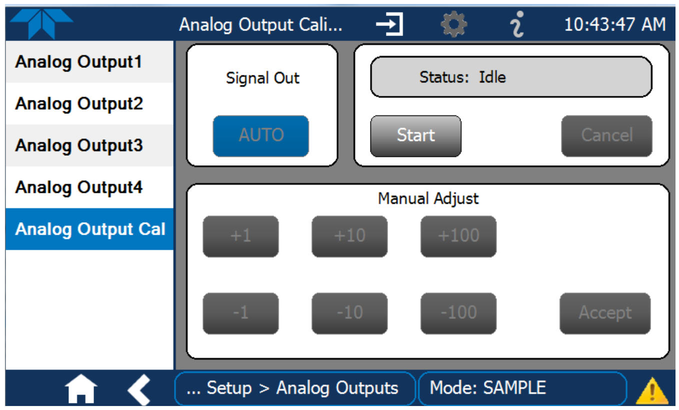


Figure 2-40. Analog Outputs Group Calibration Screen

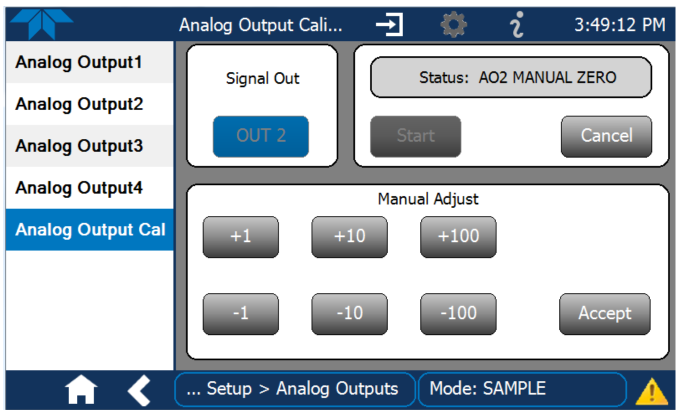


Figure 2-41. Analog Outputs Manual Calibration Screen (AOUT2 Example)

Table 2-10. 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 2-42) and changing the output signal level in the Manual Adjust field of the Analog Outputs Calibration screen (Figure 2-41). Refer to Table 2-11 for voltage tolerances.

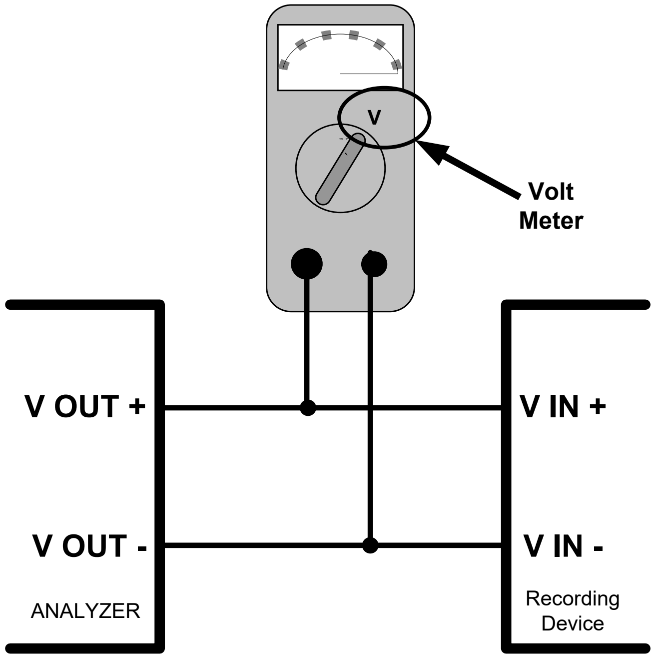


Figure 2-42. Setup for Checking / Calibrating DCV Analog Output Signal Levels

Table 2-11. 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.

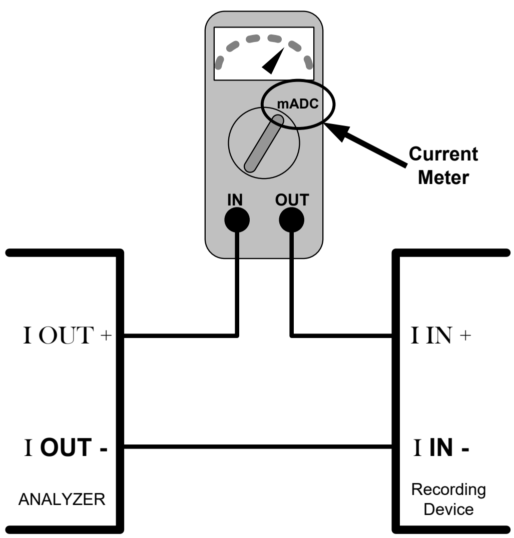


Figure 2-43. Setup for Checking / Calibration Current Output Signal Levels

An alternate method for measuring the output of the Current Loop converter is to connect a 250 ohm ±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.

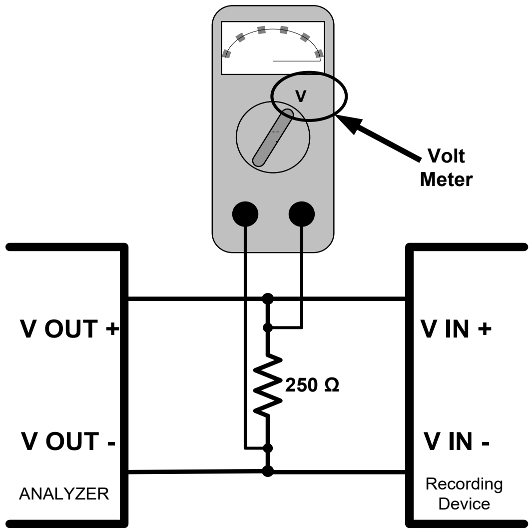


Figure 2-44. Alternative Setup Using 250Ω Resistor for Checking Current Output Signal Levels

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

Table 2-12. 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 2-13, view product and system information and network settings, edit network settings, and perform certain maintenance tasks.

Table 2-13. 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 2-14.

Table 2-14. 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 2-15 for information).

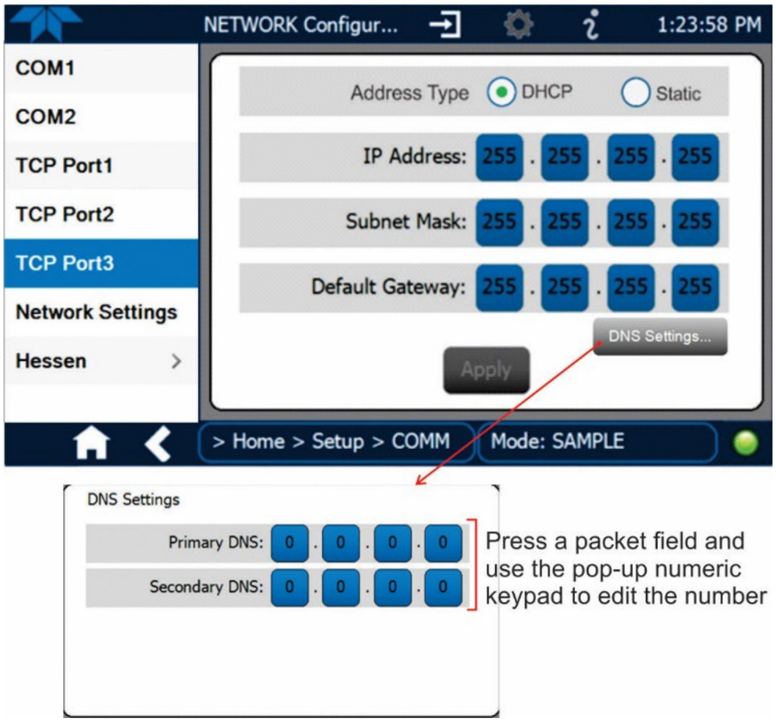


Figure 2-45. Communications Configuration, Network Settings

Table 2-15. 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.

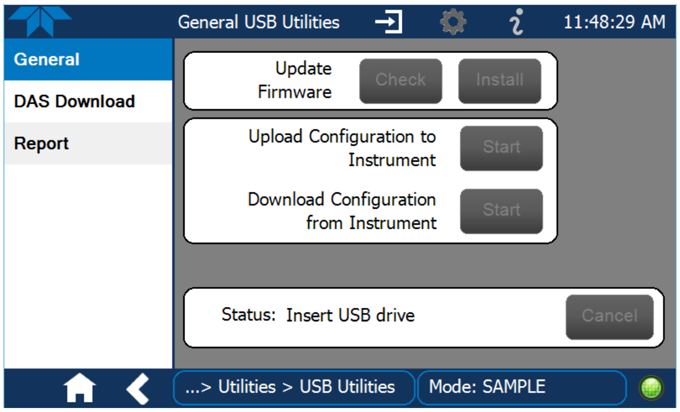


Figure 2-46. Configuration Transfer

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 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 2-14, 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.

3.2.2. 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).

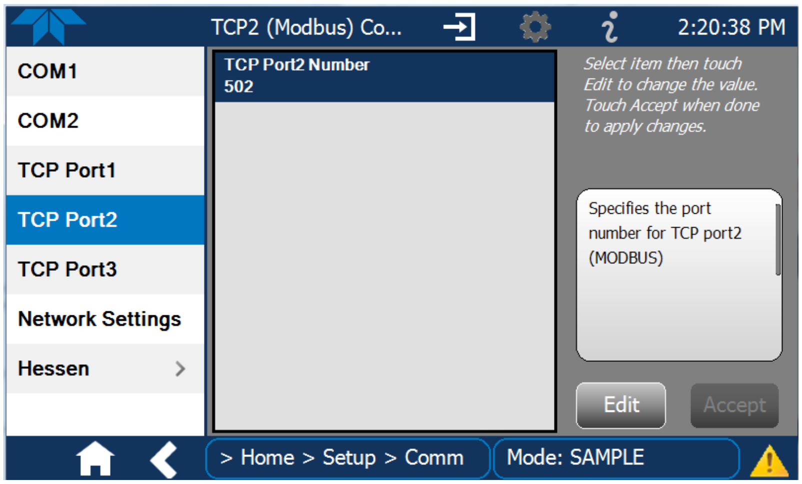


Figure 3-1. MODBUS via Ethernet

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 2-14).

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).

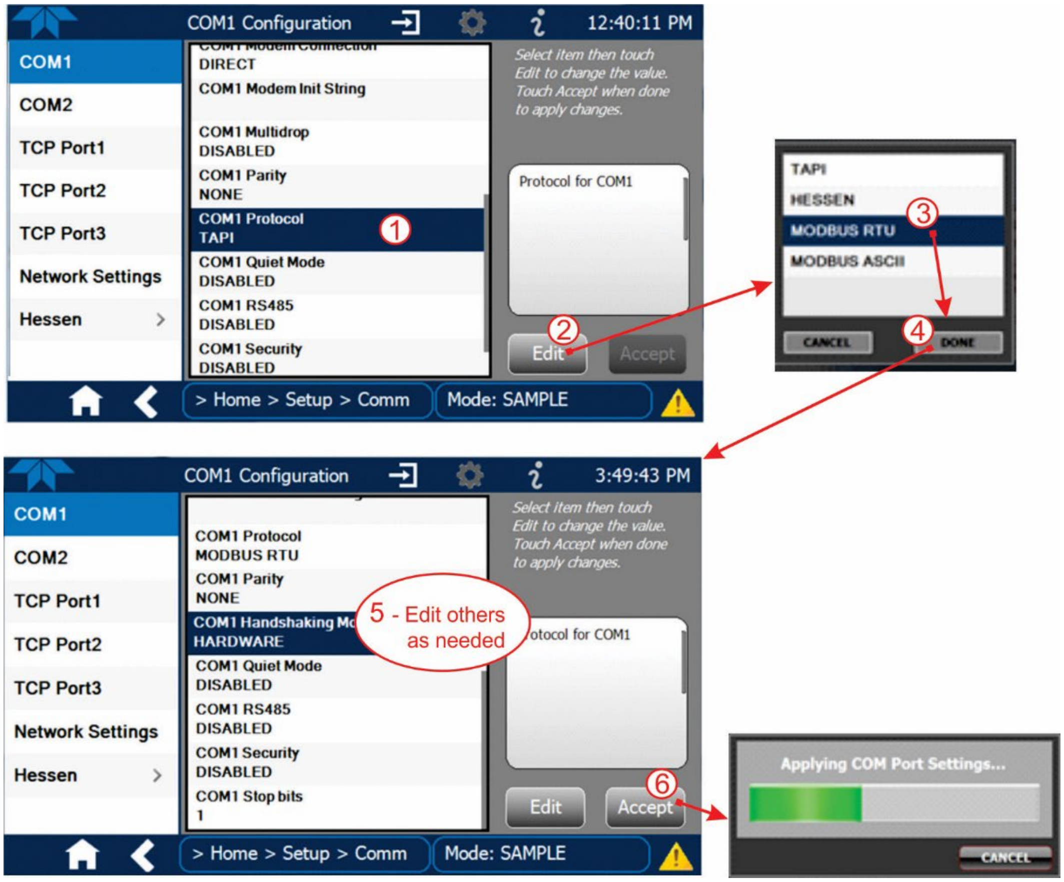


Figure 3-2. MODBUS via Serial Communication (example)

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.

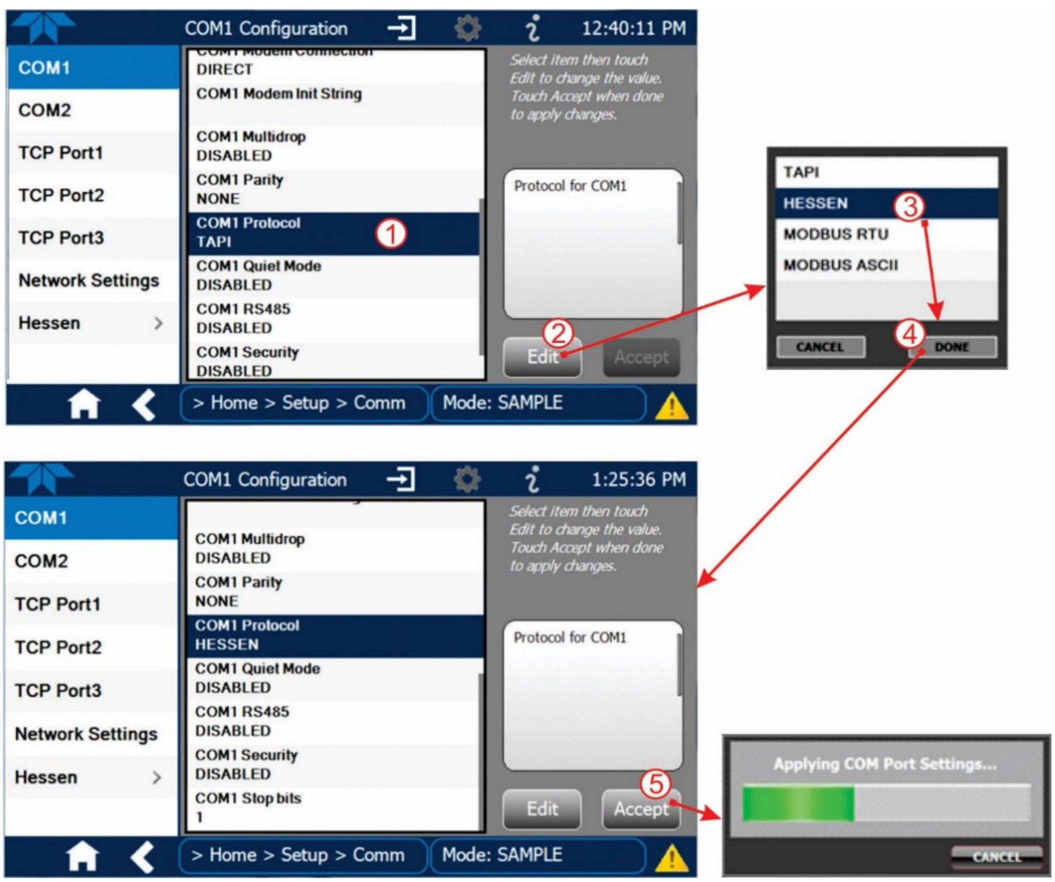


Figure 3-3. Serial Communication, Setting Hessen Protocol

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. Reponses 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. Hessen Status Flags and Default Bit Assignments

STATUS FLAG NAME	DEFAULT BIT ASSIGNMENT HEX	BITS
OPERATIONAL FLAGS (8 BITS)		
In MANUAL Calibration Mode	x02	0000 0010
In ZERO Calibration Mode	x04	0000 0100
In SPAN Calibration Mode	x08	0000 1000
INVALID CONC	x80	1000 0000
SPARE/UNUSED	x01	0000 0001
UNITS OF MEASURE FLAGS (ONLY BITS 5 AND 6 OF THE OPERATIONAL FLAG)		
UGM		00
MGM		01
PPB		10
PPM		11
WARNING FLAGS (8 BITS)		
ANY PRESS WARN	x04	0000 0100
SAMPLE TEMP WARNING	x08	0000 1000
INTERNAL PUMP OVERRIDE SET TO OFF	x10	0001 0000
IZS TEMP WARNING[1]	x20	0010 0000
BENCH LED DISABLED	x40	0100 0000
OVEN TEMP WARNING	x80	1000 0000

UNASSIGNED FLAGS	
MANIFOLD TEMPERATURE[2]	FRONT PANEL COMMUNICATION WARNING
BOX TEMP WARNING	ANALOG CALIBRATION WARNING
SYSTEM RESET	DYNAMIC ZERO WARNING
RELAY BOARD WARNING	DYNAMIC SPAN WARNING
REAR BOARD NOT DETECTED	IN MULTI-POINT CALIBRATION MODE
AUTOREF WARNING	

[1] Only applicable if the optional internal span gas generator is installed.

[2] Only applicable if the T500U is equipped with the optional manifold.

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.

Be careful not to assign conflicting flags to the same bit as each status bit will be triggered if any of the assigned flags is active.

3.4.2.3. HESSEN GAS LIST

In the T500U there is no Hessen Gas List to configure as there is only one gas, NO2, the Hessen ID for which is 213.

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: describes the procedure for manually checking calibration and performing actual calibration of the instrument.

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 Analysis: describes how to evaluate quality of each calibration.

SECTION 4.5 – EPA Protocol Calibration: provides links to the US EPA website for references regarding calibration with EPA protocols.

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

The following equipment, supplies, and expendables are required for calibration:

- Zero-air source
- Span gas source
- Gas lines - all gas line materials should be stainless steel or Teflon-type (PTFE or FEP).
- High-concentration NO_2 gas transported over long distances may require stainless steel lines to avoid oxidation due to the possibility of O_2 diffusing into the tubing.

Optional equipment: 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).

The method for performing an initial calibration for the analyzer differs between the standard instrument and those with options.

- See Section 4.2.1 for instructions for initial calibration of the analyzer in its base configuration.
- See Section 4.2.2 for information regarding setup and calibration of the analyzer with Z/S Valve options.

Note **Zero air and span gases must be supplied at twice the instrument's specified gas flow rate. Therefore, the T500U zero and span gases should be supplied to their respective inlets in excess of 1800 cc/min (~900 cc/min x 2).**

4.1.2. Zero Air

Zero air or zero calibration gas is similar in chemical composition to the measured medium but without the gas to be measured by the analyzer. A zero generator, such as the Teledyne API Model 701, can be used.

4.1.3. Calibration (Span) Gas

Calibration gas is specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the desired reporting range.

Alternatively, if a calibrator is available that is a trusted source of stable ozone, e.g., Teledyne API Model T700U with certified photometer, it is possible to use that O_3 output directly to obtain the NO_2 concentration.

CAUTION!

If the presence of ozone is detected at any time, power down the instrument and contact Teledyne API Technical Support as soon as possible:

+1 800-324-5190 or email: api-techsupport@teledyne.com

4.1.4. Span Gas for Multipoint Calibration

Some applications, such as EPA monitoring, require a multipoint calibration where span gases of different concentrations are needed. We recommend using an NO_2 gas of higher concentration combined with a gas dilution calibrator such as the Teledyne API Model T700. Calibrators mix high concentration gas with zero air to accurately produce span gas of the desired concentration. Linearity profiles can be automated with these models and run unattended overnight.

If a dynamic dilution system is used to dilute high concentration gas standards to low, ambient concentrations, ensure that the NO_2 concentration of the reference gas matches the dilution range of the calibrator. (Section 2.5.5 contains information about the dilution option).

Choose the NO_2 gas concentration so that the dynamic dilution system operates in its mid-range and not at the extremes of its dilution capabilities.

EXAMPLE:

- A dilution calibrator with 10-10000 dilution ratio will not be able to accurately dilute a 5000 ppm NO_2 gas to a final concentration of 500 ppb, as this would operate at the very extreme dilution setting.
- A 100 ppm NO_2 gas in nitrogen is much more suitable to calibrate the analyzer (dilution ratio of 200, in the mid-range of the system's capabilities).

4.1.5. NO_2 Permeation Tubes

Teledyne API offers an optional internal span gas generator that utilizes an NO_2 permeation tube as a span gas source. The accuracy of these devices is only about ±5%. Whereas this may be sufficient for quick, daily calibration checks, we recommend using certified NO_2 gases for accurate calibration.

CAUTION!

Insufficient gas flow allows gas to build up to levels that will contaminate the instrument or present a safety hazard to personnel.

In units with a permeation tube installed, either the tube must be removed and stored in a sealed container (use original container that tube was shipped in) during periods of non-operation, or vacuum pump must be connected and powered on to maintain constant gas flow though the analyzer at all times.

(See Section 5.6.4 for removal instructions).

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 either the Ethernet, 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, the analyzers provide an internal data logger, which is configured through the Setup>Data Logger menu (Section 2.5.1).

NumaView™ Remote is a remote control program, which is also available as a convenient and powerful tool for data viewing and handling, download, storage, quick check and plotting.

4.2. CALIBRATION PROCEDURES

Check that the pneumatic connections for the specific instrument configuration are as instructed in Section 2.3.2. Calibration procedures include setting the expected span gas concentration (see Note below).

Verify/change (if needed) the settings in the Setup>Vars menu as follows:

- User Units (unit of Measure): PPB
- Max Concentration Range (highest concentration expected to measure)
- Range Mode: SNGL

Then perform the calibration:

- Perform a Zero calibration using zero air.
- Perform a Span calibration using a known concentration of NO_2 span gas.

Note **The span gas concentration should be at 80% of range of concentration values likely to be encountered in your application.**

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 a 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 NO_2 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.

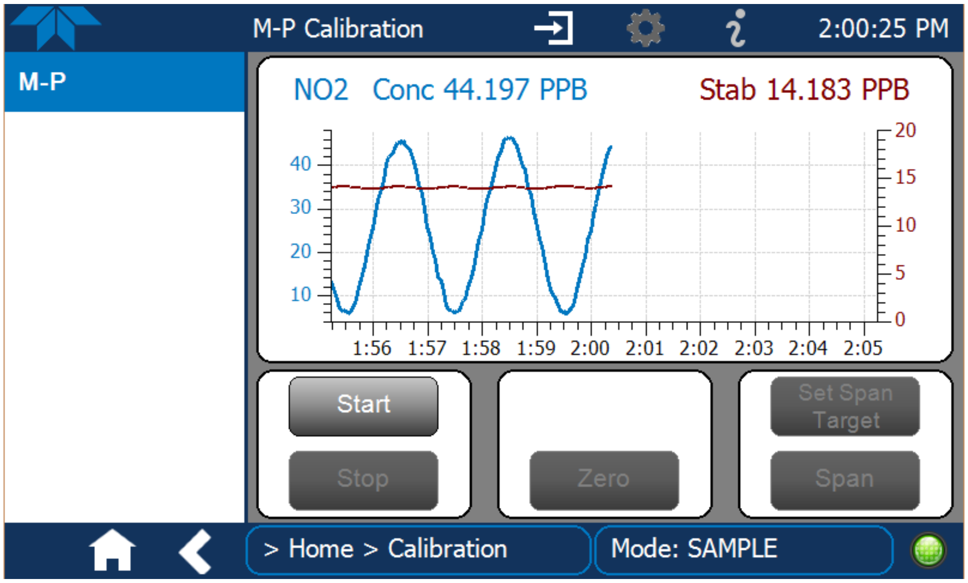


Figure 4-1. Multi-Point Calibration Page

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:	ACTUAL CALIBRATION:
a. Wait for reading to stabilize. b. Press Stop and check the reading.	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 NO_2 Span gas through the Sample port and press the Start button.
2. Either check or calibrate as follows:

CHECK ONLY:	ACTUAL CALIBRATION:
a. Wait to reach stability, then press Stop. b. Record the reading(s).	a. Press the Set Span Target button and enter the NO_2 concentration. b. Verify the concentration reading is the same as the NO_2 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 and the Offset. (See Table 4-4 in Section 4.4, Calibration Quality Analysis, for expected/acceptable 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 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.

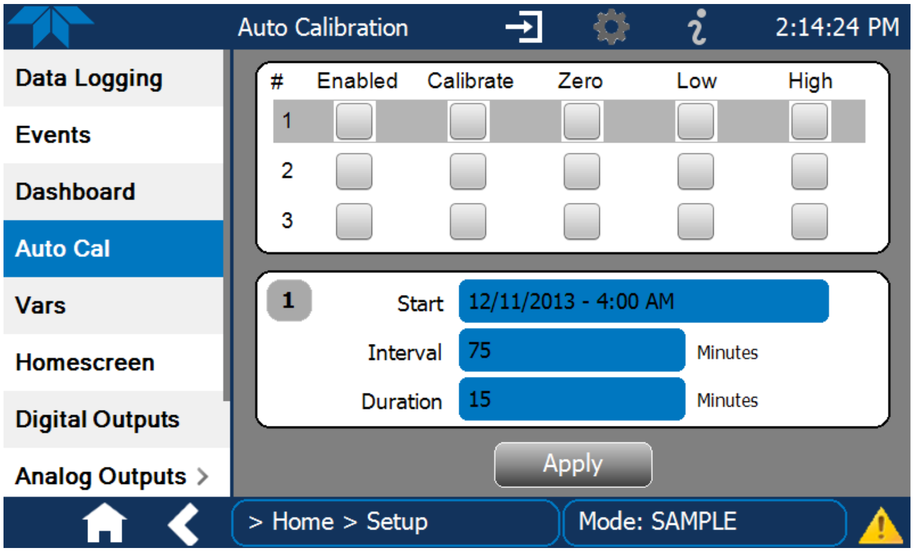


Figure 4-3. Auto Cal Page

Table 4-1. AUTO CAL States

MODE NAME	ACTION
Enabled	☑ enables the sequence; ☐ disables the sequence.
Calibrate	☑ enables an actual calibration when the Enabled box is also ☑. ☐ allows a calibration check when the Enabled box is also ☑.
Zero	☑ causes the sequence to perform a Zero calibration when both the Calibrate and Enabled boxes are also ☑. ☑ causes a Zero check when the Enabled box is also ☑ and the Calibrate box is unchecked (☐). ☐ disables Zero calibration and check
Low	☑ causes the sequence to perform a Low Span calibration when both the Calibrate and Enabled boxes are also ☑. ☑ causes a Low Span check when the Enabled box is also ☑ and the Calibrate box is unchecked (☐). ☐ disables Low Span calibration and check
High	☑ causes the sequence to perform a High Span concentration calibration when both the Calibrate and Enabled boxes are also ☑ . ☑ causes a High Span check when the Enabled box is also ☑ and the Calibrate box is unchecked (☐). ☐ 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	☑	☐	☑	☐	☐
	Calibrate	☑	☑	☑	☐	☐
Low	Check	☑	☐	☐	☑	☐
	Calibrate	☑	☑	☐	☑	☐
High	Check	☑	☐	☐	☐	☑
	Calibrate	☑	☑	☐	☐	☑
Zero Low High	Check	☑	☐	☑	☑	☑
	Calibrate	☑	☑	☑	☑	☑

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" ✓, 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 ANALYSIS

It is important to evaluate the analyzer's calibration Slope and Offset parameters. Their values describe the linear response curve of the analyzer, indicating the quality of the calibration.

Set up the Data Logger with a Periodic trigger to record the values of the Slope and Offset parameters.

Ensure that these parameters are within the limits listed in Table 4-4 and frequently compare them to those values on the *Final Test and Validation Data Sheet* that came with your instrument, which should not be significantly different. Otherwise, refer to the troubleshooting Section 5.7.6.

Table 4-4. Calibration Data Quality Evaluation

FUNCTION	MINIMUM VALUE	OPTIMUM VALUE	MAXIMUM VALUE
SLOPE	-0.800	1.000	1.200
OFFSET	-10 ppb	0.0 ppb	10.0 ppb

4.5. 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 and can be found on the EPA.gov website; this List specifies the settings and configurations for EPA calibration protocol). 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 on the govinfo.gov website, and with Quality Assurance Guidance documents available on the EPA website. Give special attention to specific regulations regarding the use and operation of ambient NO_X analyzers using cavity attenuated phase shift spectroscopy (CAPS) technology.

5. MAINTENANCE AND SERVICE

Although the T500U analyzer requires little service, a few simple procedures should be performed regularly to ensure that the T500U continues to operate accurately and reliably over its lifetime. In general, the exterior can be wiped down with a lightly damp cloth. Service and troubleshooting are covered in Section 5.7.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY
Avoid spraying anything directly onto any part of the analyzer.

5.1. MAINTENANCE SCHEDULE

Table 5-1 shows a typical maintenance schedule. 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.

In certain environments (e.g., dusty, very high ambient pollutant levels) some maintenance procedures may need to be performed more often than shown.

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 some of the maintenance procedures listed herein. 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.

DO NOT press the Zero or Span buttons at the end of each operation (actual calibration), as this will reset the stored values for OFFSET and SLOPE and alter the instrument's calibration.

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

Table 5-1. Maintenance Schedule

ITEM	ACTION	FREQ	CAL CHECK REQ'D	DATE PERFORMED									
TEST functions	Review and evaluate	Weekly	No										
Zero/span check	Evaluate offset and slope	Weekly	No										
Zero/span calibration	Zero and span calibration	Every 3 months	Yes										
Sample filter	Change sample filter	Annually (may need more frequently in a high dust load environment)	No										
AREF filter and charcoal filter	Change both	Annually	Yes										
Spectrometer mirrors	Contact Technical Support	As necessary due to excessive Measured Loss	Yes										
Pneumatic sub-system	Check for leaks in gas flow paths	Annually or after repairs involving pneumatics	Yes if a leak is repaired										
Internal Pump	Replace	Measured Flow less than 800 cm^3/min	Yes										

5.2. PREDICTIVE DIAGNOSTICS

Predictive diagnostic functions, including failure warnings and alarms built into the analyzer's firmware, aid in determining whether and when repairs are necessary.

Dashboard Functions can also be used to predict failures by looking at how their values change over time, compared to the values recorded on the printed record of the *Final Test and Validation Data Sheet*. The internal data logger is a convenient way to record and track these changes (set up through the Data Logger, Section 2.5.1). Use NumaView™ Remote to download and review this data from a remote location.

The following table, checked weekly, can be used as a basis for taking action as these values change with time.

Table 5-2. Predictive Uses for Dashboard Functions

FUNCTION	EXPECTED	ACTUAL	INTERPRETATION & ACTION
Sample Press (pressure)	Constant within atmospheric changes	Fluctuating	Developing leak in pneumatic system. Check for leaks.
		Slowly increasing	Flow path is clogging up. Replace orifice filters.
		Slowly decreasing	Developing leak in pneumatic system to vacuum (developing valve failure). Check for leaks.
AREF	Constant within ±100Mm-1 of check-out value	Significantly increasing	Developing AREF valve failure. Replace valve.
			PMT cooler failure. Check cooler, circuit, and power supplies.
			Developing leak in pneumatic system. Check for leaks.
			Debris on mirrors. Replace charcoal scrubber.
NO_2 Conc (Concentration)	Constant for constant concentration	Decreasing over time	Developing leak in pneumatic system. Check for leaks.

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.

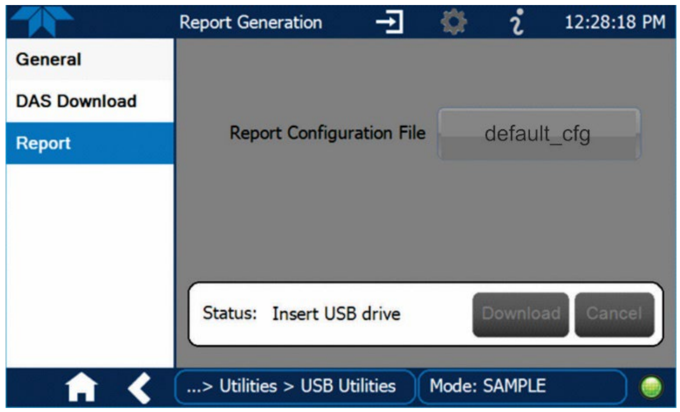


Figure 5-1: Report Generation Page

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.

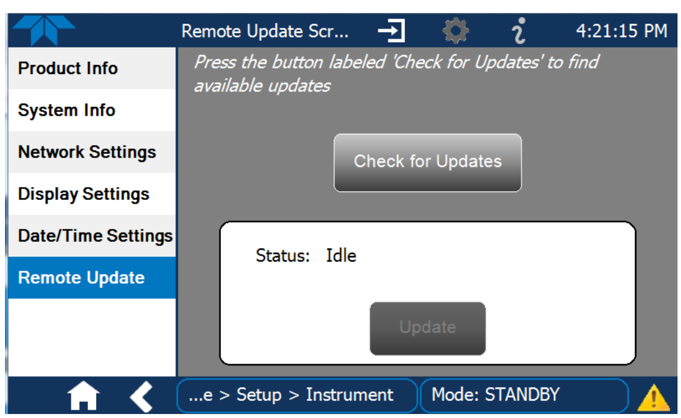


Figure 5-2. Remote Update Page

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.

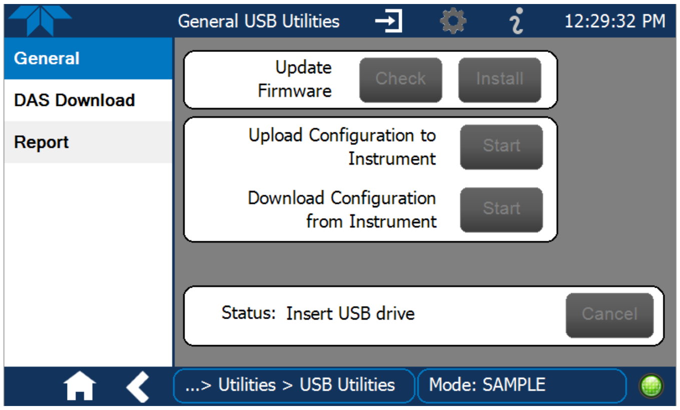


Figure 5-3. Manual Update Page (and other utilities)

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.

5.5. 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.

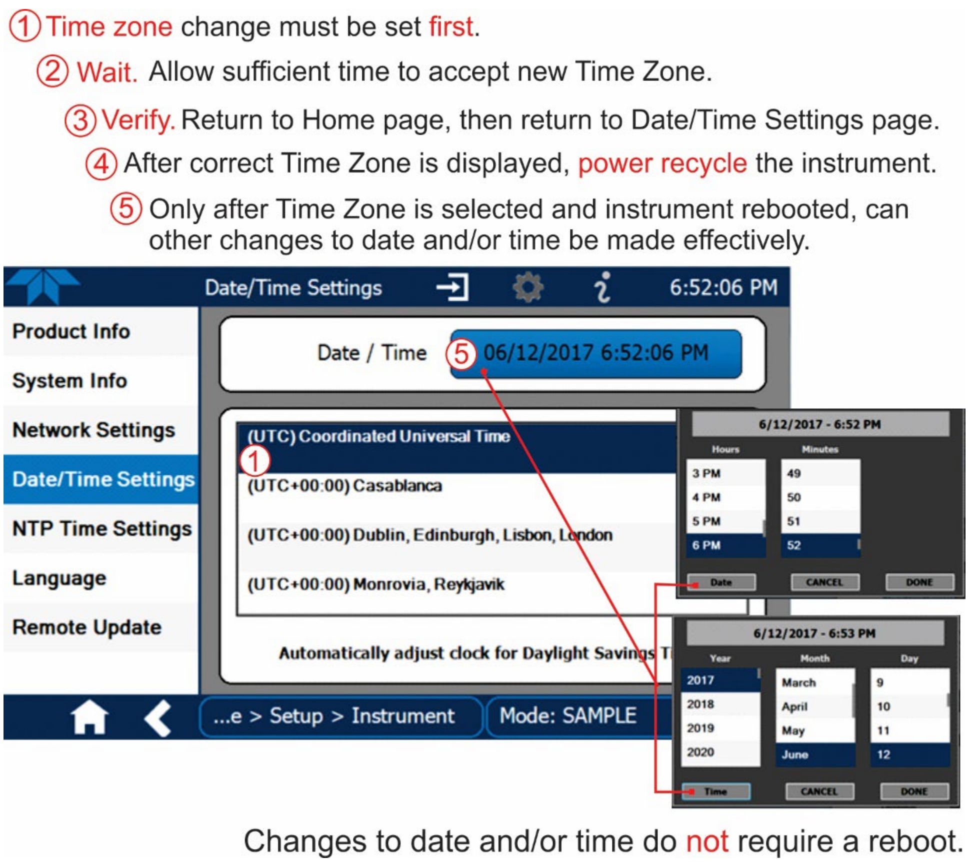


Figure 5-4. Time Zone Change Requirements

5.6. HARDWARE MAINTENANCE PROCEDURES

Perform the following procedures as standard maintenance per Table 5-1.

5.6.1. Replacing the Sample Filter

Inspect the particulate filter often for signs of plugging or contamination..

To change the filter:

1. Turn OFF the analyzer to prevent drawing debris into the instrument.
2. Open the hinged front panel and disconnect the pneumatic fittings, using the appropriate wrenches, and remove the disposable sample filter.
3. Insert new filter and reconnect pneumatic fittings.
4. Close the front panel

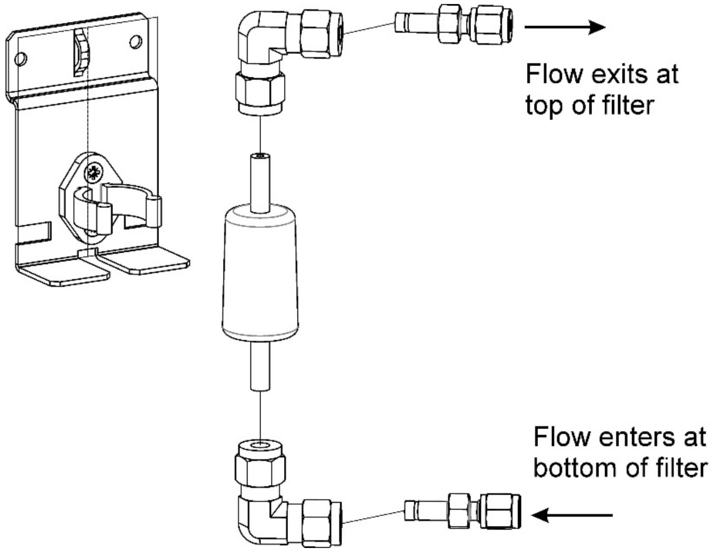


Figure 5-5. Replacing the Sample Filter

5.6.2. Replacing the AREF Filter and Charcoal Filter

The AREF filter assembly consists of the AREF filter, which is a backup particulate filter, and the charcoal filter, which is an NO_2 gas scrubber.

1. Turn OFF the analyzer (this is important to avoid potential for contamination of the measurement cell), unplug the power cord and remove the cover.
2. Using snips, remove the zip tie holding the pair of fittings to the mounting bracket.
3. Using a wrench, disconnect the fitting that is connected to the AREF filter. Then disconnect the fitting that is connected to the charcoal filter. This will free up the AREF filter assembly.
4. Remove the AREF filter assembly from the mounting brackets.
5. Remove the fittings that connect the two filters to one another.
6. Install replacement filters and reconnect AREF assembly and fittings in reverse order.

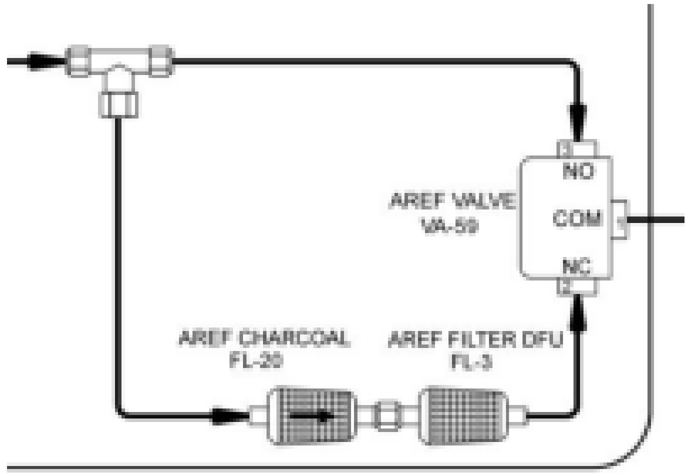


Figure 5-6. Pneumatic Layout of AREF Filter and Charcoal Filter

5.6.3. Replacing the Internal Pump

To replace the internal pump:

1. Turn OFF the analyzer (this is important to avoid potential for contamination of the measurement cell).
2. Remove the top cover of the analyzer.
3. Locate the vacuum pump and using snips, remove the zip ties that secure the four hoses that connect to the pump (two on each side)

   (It may be a good idea to mark the tubes with color codes to be sure they are reconnected properly).
4. Remove the four tubes from the hose barb connections on the pump.
5. Remove the four screws that hold the pump/bracket assembly to the bottom of the chassis.
6. Disconnect the power connector labeled “pump” located about 4 inches down the black/red cable coming from the top of the pump.
7. Pull pump assembly out and set aside.
8. Install replacement pump/bracket assembly
9. Be sure to reconnect tubes in the proper orientation and zip tie to secure
10. Replace screws for the pump mounting bracket into the bottom of the chassis.

11. Connect the power connector.
12. Once complete, replace the instrument cover and perform a system leak check procedure.
13. Use caution when fastening the new pump into position to ensure that no wires or pneumatic tubes get pinched under the pump mounting bracket.

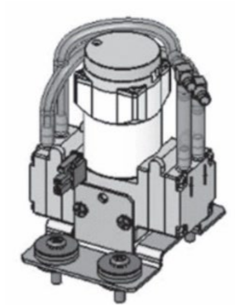


Figure 5-7. Internal Pump

5.6.4. Changing the Internal Span Gas Generator Permeation Tube

1. Turn off the analyzer, unplug the power cord and remove the cover.
2. Locate the permeation tube (Sample Gas Conditioner, see Section 5.6.4).
3. Remove the top layer of insulation if necessary.
4. Unscrew the black aluminum cover of the oven (3 screws) using a medium Phillips-head screw driver.
   - Leave the fittings and tubing connected to the cover.
5. Remove the old permeation tube and replace it with the new tube (or store the permeation tube in its original container if the instrument will not be operated for several or more hours).
   - Ensure that the tube is placed into the larger of two holes and that the open permeation end of the tube (plastic) is facing up.
6. Re-attach the cover with three screws.
   - Ensure that the three screws are tightened evenly.
7. Replace the analyzer cover, plug the power cord back in and turn on the analyzer.
8. Carry out a span check to see if the new permeation device works properly (see Section 4).
9. The permeation rate may need several days to stabilize.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Do not leave instrument turned off for more than 8 hours without removing the permeation tube. Do not ship the instrument without removing the permeation tube. The tube continues to emit NO_2, even at room temperature and will contaminate the entire instrument.

5.6.5. Checking for Pneumatic Leaks

This section covers a simple leak check and a detailed leak check.

CAUTION - TECHNICAL INFORMATION

Do not exceed 15 psi when pressurizing the system during either Simple or Detailed checks.

5.6.5.1. DETAILED PRESSURE LEAK CHECK

Obtain a leak checker that contains a small pump, shut-off valve, and pressure gauge to create both over-pressure and vacuum. Alternatively, a tank of pressurized gas, with the two-stage regulator adjusted to ≤ 10 psi, a shutoff valve and a pressure gauge may be used.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Once tube fittings have been wetted with soap solution under a pressurized system, do not apply or reapply vacuum as this will cause soap solution to be sucked into the instrument, contaminating inside surfaces.

1. Turn OFF power to the instrument and remove the instrument cover.
2. Install a leak checker on the sample inlet at the rear panel.
3. Cap rear panel ports and cap the pump port.
   - If zero/span valves are installed, disconnect the tubing from the zero and span gas ports and cap the ports (Figure 2-2).
4. Pressurize the instrument with the leak checker, allowing enough time to fully pressurize the instrument.
   - Do not exceed 10 psi pressure.
5. Once the leak has been located and repaired, the leak-down rate of the indicated pressure should be less than 1 psi in 5 minutes after the pressure is turned off. Replace the instrument cover and restart the analyzer.
6. If the leak still cannot be found, check each tube connection (fittings, hose clamps) with soap bubble solution, looking for fine bubbles.
   - Pressurize the instrument with the leak checker, allowing enough time to fully pressurize the instrument.
   - Do not exceed 10 psi pressure.
   - Wet the bench last with soap solution.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Once the fittings have been wetted with soap solution, do not reapply vacuum as doing so will draw soap solution into the instrument and contaminate it.

7. Clean surfaces from soap solution, reconnect the sample and pump lines and replace the instrument cover.
8. Restart the analyzer.

5.6.5.2. PERFORMING A SAMPLE FLOW CHECK

Important | **IMPACT ON READINGS OR DATA**

Use an external calibrated flow meter capable of measuring flows between 0 and 1000 cm³/min to measure the gas flow rate though the analyzer.

Sample flow checks are useful for monitoring the actual flow of the instrument. A decreasing sample flow may point to slowly clogging pneumatic paths, most likely the sample flow restrictor or the sample filter. To perform a sample flow check:

1. Disconnect the sample inlet tubing from the rear panel SAMPLE port.
2. Attach the outlet port of a flow meter to the sample inlet port on the rear panel.
   - Ensure that the inlet to the flow meter is at atmospheric pressure.
3. Check that the sample flow measured with the external flow meter is within specification.
4. If sample flow is out of specification, first check for kinks in the tubing, then check for leaks.
5. Once kinks and leaks are ruled out, first replace the sample flow restrictor, and if the sample flow is still out of specification, replace the sample filter.
6. If flow is still out of spec, call Technical Support.

5.7. SERVICE AND TROUBLESHOOTING

This section contains methods to identify the source of performance problems with the analyzer and procedures to service the instrument.

Note | **Section 6, Principles of Operation, provides information about how the instrument works, to support your understanding of the technical details of maintenance.**

CAUTION

The operations outlined in this section must be performed by qualified maintenance personnel only.

WARNING – RISK OF ELECTRICAL SHOCK

Some operations need to be carried out with the analyzer open and running.

Exercise caution to avoid electrical shocks and electrostatic or mechanical damage to the analyzer.

Do not drop tools into the analyzer or leave them 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:

1. Note any Alerts and take corrective action as necessary (see Table 5-3).
2. Examine the values of all basic functions in the Dashboard 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!
   - Customer service 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, damaged / malfunctioning pumps, etc.
5. Follow the procedures defined in Section 2.3.4.3 to confirm that the analyzer's vital functions are working (power supplies, CPU, relay PCA, touchscreen, PMT cooler, etc.).

5.7.1. FAULT DIAGNOSIS WITH ALERTS

Table 5-3 lists brief descriptions of warning Alerts that may occur during start up and describes their possible causes for diagnosis and troubleshooting..

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 sub-system (power supply, relay PCA, motherboard) has failed rather than an indication of the specific failures referenced by the warnings.

Table 5-3. Warning Alerts, Fault Conditions and Possible Causes

WARNING	FAULT CONDITION	POSSIBLE CAUSES
AUTO REF WARNING	AREF value outside allowable limit.	Drift in baseline loss due to large leak. Sample filter bypassed..Mirrors may be dirty – contact Technical Support to confirm
BOX TEMP WARNING	Temperature of chassis is outside specified limits. (typically < 7°C or > 48°C)	Box Temperature typically runs ~7°C warmer than ambient temperature Poor/blocked ventilation to the analyzer Stopped Exhaust-Fan Ambient Temperature outside of specified range
CANNOT DYN SPAN [1]	Dynamic Span operation failed. (Contact closure span calibration failed while *DYN_SPAN* was set to *ON*).	Measured concentration value is too high or low Concentration Slope value to high or too low
CANNOT DYN ZERO [2]	Dynamic Zero operation failed. (Contact closure zero calibration failed while *DYN_ZERO* was set to *ON*).	Measured concentration value is too high Concentration Offset value to high
CONFIG INITIALIZED	Configuration and Calibration data reset to original Factory state or erased.	Failed Disk on Module User erased data
DATA INITIALIZED	Data Storage in DAS was erased before the last power up occurred.	Failed Disk-on-Module User cleared data.
REAR BOARD NOT DET	Motherboard not detected on power up. (CPU unable to communicate with motherboard).	This warning only appears on Serial I/O COM Port(s). Front panel display will be frozen, blank or will not respond. Failure of motherboard
RELAY BOARD WARN	The CPU unable to communicate with the Relay PCA.	I^2C Bus failure Failed Relay Board Loose connectors/wiring
SAMPLE PRESS WARN	Sample pressure is too high or too low for accurate NO readings. (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: •Blocked Particulate Filter •Blocked Sample Inlet/Gas Line •Failed Pressure Sensor/circuitry If Sample Pressure is > 35 in-Hg: •Bad Pressure Sensor/circuitry •Pressure too high at Sample Inlet.
SYSTEM RESET	The computer has rebooted.	This message occurs at power on. If it is confirmed that power has not been interrupted: Failed +5 VDC power Fatal Error caused software to restart Loose connector/wiring

[1] Clears the next time successful zero calibration is performed.
[2] Clears the next time successful span calibration is performed.

5.7.2. Fault Diagnosis With Dashboard Functions

In addition to being useful as predictive diagnostic tools, the functions viewable in the Dashboard can be used to isolate and identify many operational problems when combined with a thorough understanding of the analyzer's principles of operation (see Section 6).

The acceptable ranges for these functions are listed in the "Nominal Range" column of the analyzer *Final Test and Validation Data Sheet* 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 acceptable ranges but have significantly changed from the measurement recorded on the factory data sheet may also indicate a failure.

Make note of these values for reference in troubleshooting.

Note	**If no value displays for any of these Dashboard functions, it indicates an OUT OF RANGE reading.**

Note	**Sample Pressure measurements are represented in terms of "Absolute Atmospheric Pressure" because this is the least ambiguous method for reporting gas pressure.** **Absolute atmospheric pressure is about 29.92 in-Hg-A at sea level. It decreases about 1 in-Hg per 1000 ft gain in altitude. A variety of factors such as air conditioning systems, passing storms, and air temperature, can also cause changes in the absolute atmospheric pressure.**

Table 5-4. Dashboard Functions - Indicated Failures

DASHBOARD FUNCTION	INDICATED FAILURE(S)
Box Temp	Environment out of temperature operating range; broken thermistor
IZS Temp (option)	Malfunctioning heater; relay board communication (I^2C bus); relay burnt out
Manifold Temp	Manifold temperature out of range; broken thermistor.
Oven Temp	Oven temperature out of range; broken thermistor.
Sample Pressure	Leak; malfunctioning valve; malfunctioning pump; clogged flow orifices; sample inlet overpressure
Sample Temp	Sample temperature out of range; broken thermistor.
Stability	Unstable concentrations; leaks

5.7.3. Using the Diagnostic Signal I/O Functions

The signal I/O functions in the Utilities>Diagnostics menu allows access to the digital and analog I/O in the analyzer. Some of the digital signals can be controlled through the Setup menu. These signals, combined with a thorough understanding of the instrument's principles of operation (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. Using the Analog Output Channels

Signals available for output over the analyzer's analog output channel (configured in the Setup>Analog Outputs menu; see Section 2.5.8) can also be used as diagnostic tools through the Utilities>Diagnostics menu.

5.7.5. Using the Internal Electronic Status LEDs

Several LEDs are located inside the instrument to assist in determining if the analyzer's CPU, I^2C bus and Relay PCA are functioning properly.

5.7.5.1. CPU STATUS INDICATOR

DS5, a red LED located on the motherboard (Figure 5-8), flashes when the CPU is running the main program loop. After power-up, approximately 30 – 60 seconds, DS5 should flash on and off. If the front panel displays properly but DS5 does not flash, then the program files have become corrupted, contact Teledyne API's Technical Support Department (see Section 5.9) because it may be possible to recover operation of the analyzer. If after 30 – 60 seconds, neither DS5 is flashing nor does the front panel display properly then the CPU is bad and must be replaced.

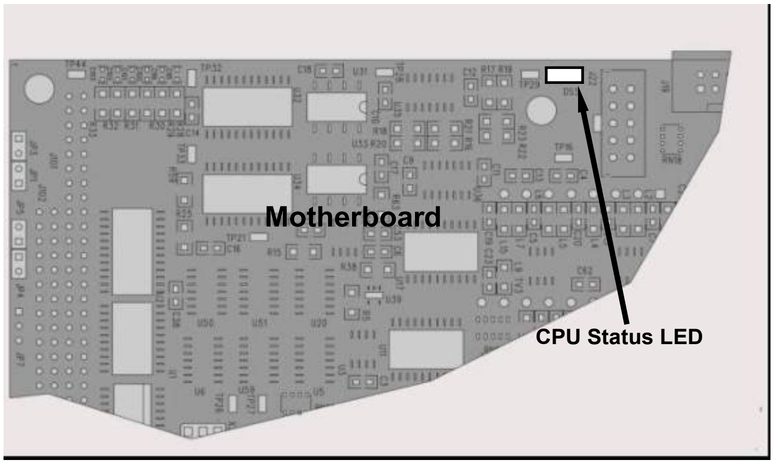


Figure 5-8. CPU Status Indicator

5.7.5.2. RELAY PCA WATCHDOG AND STATUS LEDS

There are sixteen LEDs located on the Relay PCA (some are not used on this model). The most important of the LEDs is D1 (see Figure 5-9), which indicates the health of the I^2C bus.

Relay PCA Status LEDs

LEDs that remain continuously on or off (not blinking) indicate a default state for their respective components as described in Table 5-5

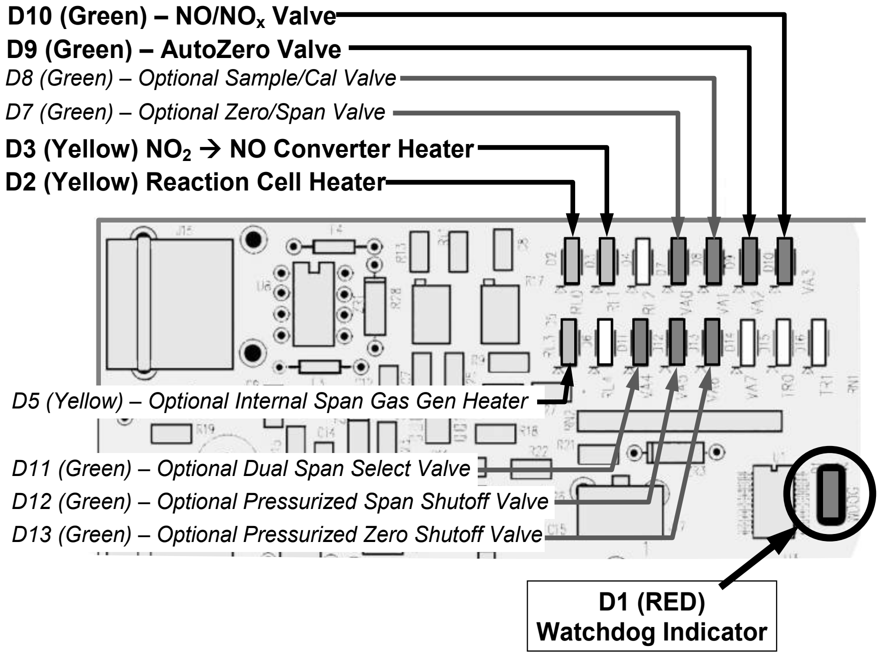


Figure 5-9. Relay PCA Status LEDS Used for Troubleshooting

Table 5-5. Relay PCA Watchdog and Status LED Failure Indications

LED	COLOR	FUNCTION	INDICATED FAILURE(S)
D1	Red	I2C bus Health (Watchdog Circuit	Failed/Halted CPU. Faulty Motherboard, Touchscreen or Relay PCA. Faulty Connectors/Wiring between Motherboard, Touchscreen or Relay PCA. Failed/Faulty +5 VDC Power Supply (PS1).
LED ROW 1			
D2	Yellow	Reaction Cell heater	Heater broken, thermistor broken
D3	Yellow	NO_2 converter heater	Heater broken, thermocouple broken
D7	Green	Zero/Span valve status	Valve broken or stuck, valve driver chip broken
D8	Green	Sample/Cal valve status	Valve broken or stuck, valve driver chip broken
D9	Green	Auto-zero valve status	Valve broken or stuck, valve driver chip broken
D10	Green	NO/NO_x valve status	Valve broken or stuck, valve driver chip broken

LED	COLOR	FUNCTION	INDICATED FAILURE(S)
LED ROW 2			
D5[1]	Yellow	Internal span gas generator perm tube heater	Heater broken, thermistor broken
D11[2]	Green	Dual span select valve	Valve broken or stuck, valve driver chip broken
D12[3]	Green	Pressurized Span shutoff valve	Valve broken or stuck, valve driver chip broken
D13[4]	Green	Pressurized Zero shutoff valve	Valve broken or stuck, valve driver chip broken

[1] **Only active when the optional internal span gas generator is installed.**
[2] **Only active when the dual pressurized span option is installed.**
[3] **Only active when one of the pressurized span gas options is installed.**
[4] **Only active when one of the pressurized zero gas options is installed.**

Note: D4, D6, and D14-16 are not indicated as they are not used.

5.7.6. Calibration Problems

This section describes possible causes of calibration problems.

5.7.6.1. NEGATIVE CONCENTRATIONS

Negative concentration values can be caused calibration error: If the zero air were contaminated, and the analyzer was calibrated at “zero”, the analyzer may report a negative value when measuring air that contains little or no NO_2.

5.7.6.2. ABSENCE OF ANALYZER RESPONSE TO SAMPLE GAS

If the instrument shows no response (display value is near zero) even though sample gas is supplied properly and the instrument seems to perform correctly:

1. Confirm the lack of response by supplying or NO_2 span gas of about 80% of the range value to the analyzer.
2. Check the sample flow rate for proper value.
3. Check for disconnected cables to the sensor module.

5.7.6.3. UNSTABLE ZERO AND SPAN

Leaks in the instrument or in the external gas supply and vacuum systems are the most common source of unstable and non-repeatable concentration readings.

1. Check for leaks in the pneumatic systems as described in Section 5.6.5.
2. Consider pneumatic components in the gas delivery system outside the analyzer such as a change in zero air source (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.
3. Once the instrument passes a leak check, do a flow check (this chapter) to ensure that the instrument is supplied with adequate sample and ozone air.
4. Confirm the sample pressure, sample temperature, and sample flow readings are correct and steady.
5. Verify that the sample filter element is clean and does not need to be replaced.

5.7.6.4. INABILITY TO SPAN - DEACTIVATED SPAN BUTTON

In general, the analyzer will deactivate certain buttons whenever the actual value of a parameter is outside of the expected range for that parameter. If the Span is grayed out, the actual concentration must be outside of the range of the expected span gas concentration, which can have several causes.

1. Verify that the expected concentration is set properly to the actual span gas concentration in the CONC sub-menu.
2. Confirm that the NO_x span gas source is accurate.
   - This can be done by comparing the source with another calibrated analyzer, or by having the NO_x source verified by an independent traceable photometer.
3. Check for leaks in the pneumatic systems as described in Section 5.6.5.
   - Leaks can dilute the span gas and, hence, the concentration that the analyzer measures may fall short of the expected concentration defined in the CONC sub-menu.
4. If the low-level, hardware calibration has drifted (changed PMT response) or was accidentally altered by the user, a low-level calibration may be necessary to get the analyzer back into its proper range of expected values.
   - One possible indicator of this scenario is a slope or offset value that is outside of its allowed range (0.8-1.2 for slope, -10 to 10 for offsets).

5.7.6.5. INABILITY TO ZERO - DEACTIVATED ZERO BUTTON

In general, the analyzer will deactivate certain buttons whenever the actual value of a parameter is outside of the expected range for that parameter. If the Zero button is grayed out, the actual gas concentration must be significantly different from the actual zero point (as per last calibration), which may be for any of several reasons.

1. Confirm that there is a good source of zero air.
2. Check to ensure that there is no ambient air leaking into zero air line.
3. Check for leaks in the pneumatic systems as described in Section 5.6.5.

5.7.6.6. NON-LINEAR RESPONSE

The analyzer was factory calibrated to a high level of NO_2 and should be linear to within 1% of full scale. Common causes for non-linearity are:

- Leaks in the pneumatic system:
  - Leaks can add ambient air, zero air or span gas to the current sample gas stream, which may be changing in concentrations as the linearity test is performed.
  - Check for leaks as described in Section 5.6.5.
- The calibration device is in error:
  - Check flow rates and concentrations, particularly when using low concentrations.
  - If a mass flow calibrator is used and the flow is less than 10% of the full scale flow on either flow controller, you may need to purchase lower concentration standards.

- The standard gases may be mislabeled as to type or concentration.
  - Labeled concentrations may be outside the certified tolerance.
- The sample delivery system may be contaminated.
  - Check for dirt in the sample lines or reaction cell.
- Dilution air contains sample or span gas.
- Incoming concentrations may not be linear.
  - Check input bottles.
- Span gas overflow is not properly vented and creates a back-pressure on the sample inlet port.
  - Also, if the span gas is not vented at all and does not supply enough sample gas, the analyzer may be evacuating the sample line.
  - Ensure to create and properly vent excess span gas.

5.7.6.7. DISCREPANCY BETWEEN ANALOG OUTPUT AND DISPLAY

If the concentration reported through the analog outputs does not agree with the value reported on the front panel, you may need to recalibrate the analog outputs.

- This becomes more likely when using a low concentration or low analog output range.
- Analog outputs running at 0.1 V full scale should always be calibrated manually.
- See Section 2.5.8.1 for a detailed description of this procedure.

5.7.7. OTHER PERFORMANCE PROBLEMS

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

5.7.7.1. EXCESSIVE NOISE

Excessive noise levels under normal operation usually indicate leaks in the sample supply or the analyzer itself.

- Ensure that the sample or span gas supply is leak-free, and carry out a detailed leak check as described earlier in this chapter.

Other sources of measurement noise may be related to cabling issues.

- Gain access to the instrument, when powered down, and reset the cable connectors.

5.7.7.2. SLOW RESPONSE

If the analyzer starts responding too slow to any changes in sample, zero or span gas, check for the following:

- Dirty or plugged sample filter or sample lines.
- Sample inlet line is too long.
- Dirty or plugged flow restrictor. Check flows, pressures and, if necessary, change restrictor.
- Wrong materials in contact with sample - use glass, stainless steel or Teflon materials only.
- Insufficient time for purging lines upstream of the analyzer. Wait for stability is reached.
- Insufficient time for NO_2 calibration gas source to stabilize. Wait until stability is reached.

5.7.7.3. AREF WARNINGS

Auto Reference (AREF) warnings occur if the signal measured during an AREF cycle is higher than 1100 Mm-1.

Note	**The AREF warning displays the value of the Auto Reference reading when the warning occurs.** **(Also note that there will not be an AREF warning if the AREF feature was disabled due to prolonged time in CAL mode. Ensure the instrument is returned to SAMPLE mode as soon as a calibration has been completed).**

- If this value is higher than 1100 Mm-1, check that the Auto Reference valve is operating properly.
  - To do so, use the Utilities>Diagnostics>Digital Outputs menu to toggle the valve on and off.
  - Listen to hear whether the valve is switching, and see if the respective LED on the relay board lights accordingly
  - Check the power supply to the valve (12 V to the valve should turn on and off when measured with a voltmeter).

Note	**It takes only a small leak across the ports of the valve to show excessive Auto Zero values when supplying high concentrations of span gas.**

If the Auto Reference valve is working properly, then the problem could be due to dirty mirrors. Please contact Technical Support (Section 5.9) to confirm this and to rule out other possibilities.

5.7.8. SUBSYSTEM CHECK FOR TROUBLESHOOTING

The preceding sections of this manual discussed a variety of methods for identifying possible sources of failures or performance problems within the analyzer. This section describes how to determine if a certain component or subsystem is actually the cause of the problem being investigated.

5.7.8.1. AC MAIN POWER

The 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.
- If the instrument is equipped with an internal pump, it will begin to run. If it does not:
  - Verify that the pump connection is mated correctly.
  - Verify that there are no kinks in the tubing that would restrict pump operation.
  - Note that the pump will stop running if the sample pressure reaches 15 InHg, and will restart after the sample pressure reaches an acceptable level.
- If the configuration plug is set for 115 or 100 VAC and the unit is plugged into a 230 VAC circuit, the circuit breaker built into the ON/OFF Switch on the front panel will trip to the OFF position immediately after power is switched on.

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.

5.7.8.2. DC POWER SUPPLY

If the analyzer's AC mains power is working but the unit is still not operating properly, check the DC output with a voltmeter at the test points described in Table 5-6 and shown in Figure 5-10. Refer to Table 5-7 for acceptable values.

Check for excessive noise (> 100 mV p-p), using an oscilloscope in AC mode with band limiting turned on.

Table 5-6. DC Power Test Point and Wiring Color Codes

NAME	TEST POINT#	COLOR	DEFINITION
DGND	**1**	Black	Digital ground
+5V	**2**	Red	
AGND	**3**	Green	Analog ground
+15V	**4**	Blue	
-15V	**5**	Yellow	
+12R	**6**	Purple	12 V return (ground) line
+12V	**7**	Orange	

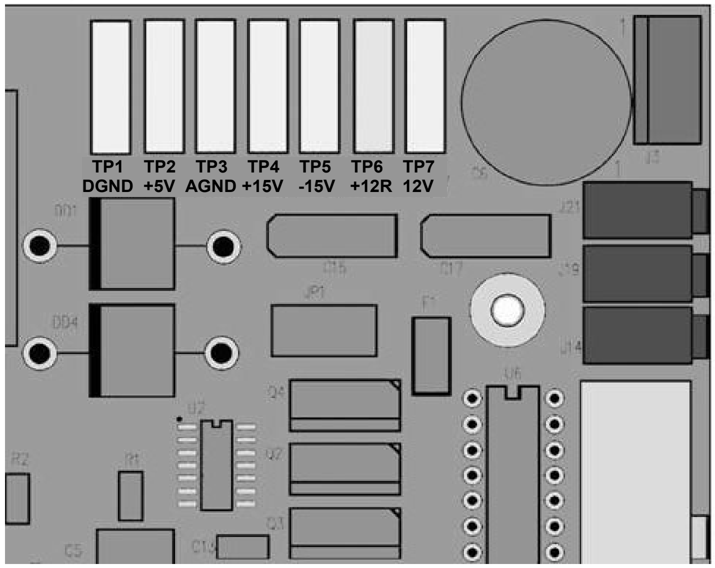


Figure 5-10. Location of DC Power Test Points on Relay PCA

Table 5-7. DC Power Supply Acceptable Levels

POWER SUPPLY	VOLTAGE	CHECK RELAY BOARD TEST POINTS				MIN V	MAX V
		FROM Test Point		**TO** Test Point			
		NAME	**#**	**NAME**	**#**		
PS1	+5	DGND	1	+5	2	+4.85	+5.25
PS1	+15	AGND	3	+15	4	+13.5	+16.0
PS1	-15	AGND	3	-15V	5	-13.5	-16.0
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	+11.8	+12.5
PS2	DGND	+12V Ret	6	DGND	1	-0.05	+0.05

5.7.8.3. I^2C BUS

Verify operation of the I^2C bus by checking whether the LEDs are flashing at the Relay PCA's D1 and the Valve Driver PCA's D2. If both are solid lit or are not on, and the DC power supplies are operating properly, there is a problem with the I^2C bus.

5.7.8.4. LCD/DISPLAY MODULE

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 and other indications of its state as the CPU goes through its initialization process.

5.7.8.5. RELAY PCA

The Relay PCA can be most easily checked by observing the condition of its status LEDs (see Section 5.7.5.2), and using the Utilities>Diagnostics>Digital Outputs menu (see Section 5.7.3) to toggle each LED ON or OFF.

If D1 on the Relay PCA 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 PCA is bad.

5.7.8.6. DATA ACQUISITION (DAQ) PCA

If the warning message, BENCH COM WARNING, appears on the front panel display, check that the serial cable between the DAQ PCA and the CPU is seated properly.

If any adjustment to that cable does not resolve the issue, the DAQ PCA can be checked by observing LEDs D10 through D13 (Figure 5-11). If they are not blinking, the DAQ may need to be changed. Although not all test points (TP) on the DAQ are used, if the values for TP14 through TP21, TP23 and TP24 do not come back as expected (Figure 5-11), contact Teledyne API Technical Support for a replacement.

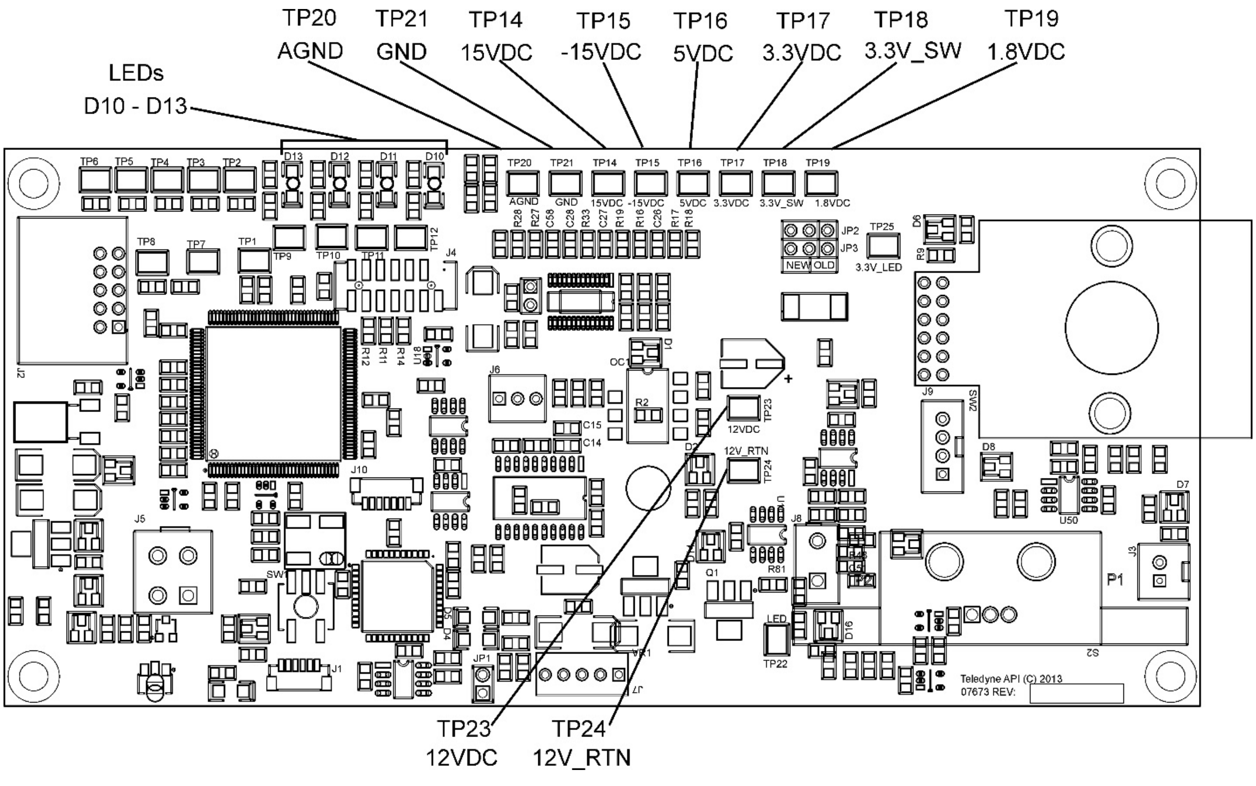


Figure 5-11. DAQ PCA Test Points and LEDs

5.7.8.7. MOTHERBOARD

A/D FUNCTIONS

The simplest method to check the operation of the A-to-D converter on the motherboard is to navigate to the Dashboard and check the two A/D reference voltages and input signals that can be easily measured with a voltmeter (configure the Dashboard to show the necessary parameters).

1. Navigate to the Dashboard to view the value of Ref 4096mV and Ref Ground (configure if needed: Section 2.5.3).
   - If both are within 3 mV of nominal (4096 and 0), and are stable (±0.2 mV) then the basic A/D is functioning properly. If not then the motherboard is bad.

2. Choose a parameter in the Dashboard function list such as Raw Box Temp.
   - Compare the voltage at its origin (see 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.

STATUS OUTPUTS

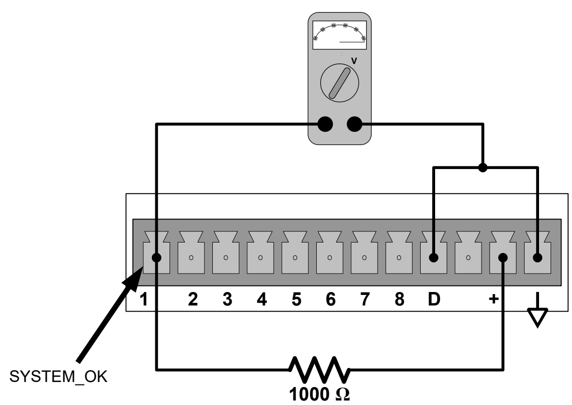


Figure 5-12. Typical Set Up of Status Output Test

To test the status output electronics:

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.
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. Alternately 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.

CONTROL INPUTS

The control input bits can be tested by applying a trigger voltage to an input and watching changes in the status of the associated function in the Utilities>Diagnostics menu:

EXAMPLE: to test the "A" and "B" control inputs:

1. Under the Utilities> Diagnostics>Digital Inputs menu, scroll through the signals to find Ext Zero Cal.
2. Connect a jumper from the "+" pin on the appropriate connector to the "U" on the same connector.
3. Connect a second jumper from the "▽" pin on the connector to the "A" pin.
4. The status of Ext Zero Cal should change to read "ON".
5. Connect a second jumper from the "▽" pin on the connector to the "B" pin.
6. The status of Ext High Span Cal should change to read "ON."

5.7.8.8. 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 (described next) occurs, contact the factory.

For a complete failure, 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.
- For a failure associated with the DOM, the analyzer could stop during initialization (the front panel display shows a fault or warning message), a likely indicator that the DOM, the firmware or the configuration and data files have been corrupted.

5.7.8.9. RS-232 COMMUNICATIONS

GENERAL RS-232 TROUBLESHOOTING

Teledyne API's analyzers use the RS-232 communications protocol to allow the instrument to be connected to a variety of computer-based equipment. Problems with RS-232 connections usually center around five general areas:

- Incorrect cabling and connectors. See Section 2.3.1.7 under RS-232 Connection for connector and pin-out information.
- The BAUD rate and protocol are incorrectly configured. See Section 2.3.1.7 under RS-232 Connection.
- If a modem is being used, additional configuration and wiring rules must be observed. See Sections 3.1 and 3.2.
- Incorrect setting of the DTE – DCE Switch. See Section 3.1 to set correctly.
- Possible improper/incomplete seating of the cable (P/N 03596) that connects the serial COM ports of the CPU to J12 of the motherboard.

TROUBLESHOOTING ANALYZER/MODEM OR TERMINAL OPERATION

These are the general steps for troubleshooting problems with a modem connected to a Teledyne API's analyzer.

1. Check cables for proper connection to the modem, terminal or computer.
2. Check to ensure that the DTE-DCE is in the correct position as described in Section 3.1.
3. Check to ensure that the set up command is correct.
4. Verify that the Ready to Send (RTS) signal is at logic high. The analyzer sets pin 7 (RTS) to greater than 3 volts to enable modem transmission.
5. Ensure that the BAUD rate, word length, and stop bit settings between modem and analyzer match.
6. Use the RS-232 test function to send “w” characters to the modem, terminal or computer.
7. Get your terminal, modem or computer to transmit data to the analyzer (holding down the space bar is one way); the green LED should flicker as the instrument is receiving data.
8. Ensure that the communications software or terminal emulation software is functioning properly.

5.7.8.10. INTERNAL SPAN GAS GENERATOR AND VALVE OPTIONS

The zero/span valves and internal span gas generator options need to be enabled in the software (contact the factory on how to do this).

The semi-permeable PTFE membrane of the permeation tube is severely affected by humidity. Variations in humidity between day and night are usually enough to yield very variable output results. If the instrument is installed in an air-conditioned shelter, the air is usually dry enough to produce good results. If the instrument is installed in an environment with variable or high humidity, variations in the permeation tube output will be significant. In this case, a dryer for the supply air is recommended (dewpoint should be –20° C or less).

The permeation tube of the internal span gas generator option is heated with a proportional heater circuit and the temperature is maintained at 50°C ±1°C. Check the IZS Temp in the Dashboard or the IZS Temp Raw signal in the Utilities>Diagnostics>Analog Inputs menu. At 50° C, the temperature signal from the IZS thermistor should be around 2500 mV.

5.7.8.11. BOX TEMPERATURE SENSOR

The box temperature sensor (thermistor) is mounted on the motherboard below the bottom edge of the CPU board when looking at it from the front. It cannot be disconnected to check its resistance.

- Box temperature will vary with, but will usually read about 5° C higher than, ambient (room) temperature because of the internal heating zones.
- To check the box temperature functionality, we recommend checking the Box Temp signal voltage in the Utilities>Diagnostics>Analog Inputs menu (Section 5.7.3).
- At about 30° C, the signal should be around 1500 mV.
- To check the accuracy of the sensor, use a calibrated external thermometer/ temperature sensor to verify the accuracy of the box temperature by:

- Placing it inside the chassis, next to the thermistor labeled XT1 (above connector J108) on the motherboard.
- Compare its reading to the value of the BOX TEMP.

5.7.9. SERVICE PROCEDURES

This section contains some procedures that may need to be performed when a major component of the analyzer requires repair or replacement.

Note **Regular maintenance procedures are discussed in Section 5.5 and are not listed here). Also, there may be more detailed service notes for some of the below procedures. Contact Teledyne API's Technical Support Department.**

WARNING – ELECTRICAL SHOCK HAZARD

Unless the procedure being performed requires the instrument to be operating, turn it off and disconnect power before opening the analyzer and removing, adjusting or repairing any of its components or subsystems.

CAUTION – QUALIFIED TECHNICIAN

The operations outlined in this chapter are to be performed by qualified maintenance personnel only.

5.7.9.1. DISK-ON-MODULE REPLACEMENT PROCEDURE

ATTENTION **COULD DAMAGE INSTRUMENT AND VOID WARRANTY**

Servicing 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. While 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.

5.7.9.2. REMOVING / REPLACING THE RELAY PCA FROM THE INSTRUMENT

This is the most commonly used version of the Relay PCA. It includes a bank of solid state AC relays. This version is installed in analyzers where components such as AC powered heaters must be turned ON & OFF.

A retainer plate is installed over the relay to keep them securely seated in their sockets.

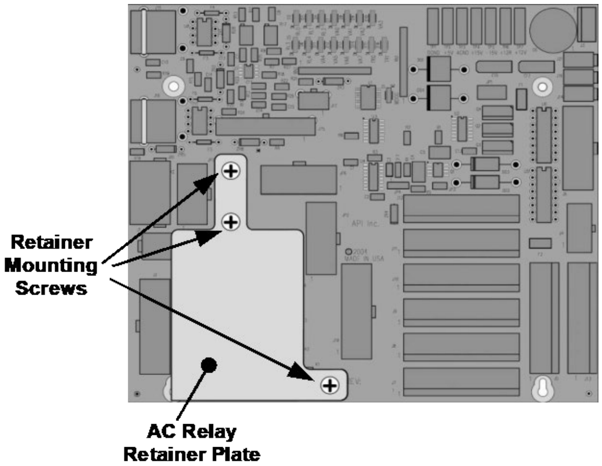


Figure 5-13. Relay PCA with AC Relay Retainer In Place

The Relay retainer plate installed on the relay PCA covers the lower right mounting screw of the relay PCA. Therefore, when removing the relay PCA, the retainer plate must be removed first.

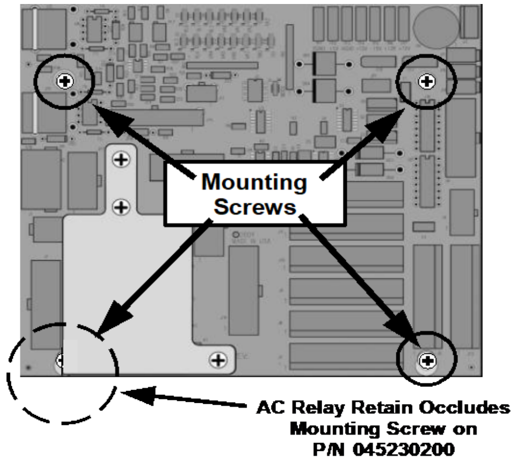


Figure 5-14. Relay PCA Mounting Screw Locations

5.8. FREQUENTLY ASKED QUESTIONS

The following list was compiled from the Teledyne API's Technical Support Department's ten most commonly asked questions relating to the analyzer.

QUESTION	ANSWER
Why does the ENTR button sometimes disappear on the front panel display?	Sometimes the ENTR button will disappear if you select a setting that is invalid or out of the allowable range for that parameter, such as trying to set the 24-hour clock to 25:00:00 or a range to less than 1 or more than 20000 ppb. Once you adjust the setting to an allowable value, the ENTR button will re-appear.
Why is the ZERO or SPAN button deactivated during calibration?	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. EXAMPLE: The span set point is 400 ppb but gas concentration being measured is only 50 ppb.
How do I enter or change the value of my Span Gas?	See Section 4.2.1.2.
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?	Yes. However, the accuracy of the IZS option's permeation tube is only ±5%. To achieve highest accuracy, it is recommended to use cylinders of calibrated span gases in combination with a zero air source.
How do I measure the sample flow?	For accurate measurement, attach a calibrated volumetric flow meter to the sample inlet port, and get a reading while the instrument is operating. The sample flow should be as specified in Table 1-1. (To calibrate, use the Utilities>Diagnostics menu; refer to Section 5.6.5.2).
How often do I need to change the particulate filter?	Refer to the Maintenance Schedule in Table 5-1. Keep in mind that highly polluted sample air may require more frequent changes.

QUESTION	ANSWER
How long does the sample pump last?	The sample pump should last one to two years and the pump head should be replaced when necessary. If the reaction cell pressure value goes above 10 in-Hg-A, on average, the pump head needs to be rebuilt.
Why does my RS-232 serial connection not work?	There are several possible reasons: • The wrong cable: please use the provided or a generic “straight-through” cable (do not use a “null-modem” type cable) and ensure the pin assignments are correct (Section 2.3.1.7 under RS-232 Connection. • The DCE/DTE switch on the back of the analyzer is not set properly; ensure that both green and red lights are on (Section 3.1). • The baud rate of the analyzer’s COM port does not match that of the serial port of your computer/data logger (Table 2-14).
How do I set up and use the contact closures (Control Inputs) on the rear panel of the analyzer?	See Section 2.3.1.5.

5.9. TECHNICAL ASSISTANCE

If this manual and its troubleshooting & service section 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/

6. PRINCIPLES OF OPERATION

The Cavity Attenuated Phase Shift (CAPS) NO_2 monitor operates as an optical absorption spectrometer that yields both reliable and accurate measurements of ambient nitrogen dioxide down to sub ppb concentrations, with lower noise levels than chemiluminescence-based monitors. The CAPS method uses light from a blue Ultraviolet (UV) light emitting diode (LED) centered at 450 nm, a measurement cell with high reflectivity mirrors located at either end to provide an extensive optical path length, and a vacuum phototube detector. These components are assembled into the optical cell which resides in a temperature-controlled oven. The oven raises the ambient temperature of the sample gas to 45 degrees Celsius. This mitigates the formation of moisture on the surfaces of the mirrors while also minimizing changes in the absorption coefficient due to temperature fluctuations.

As stated, the T500U analyzer measures NO_2 directly, using optical absorption. This phenomenon is well-defined and is described by Beer's Law, where the Absorbance (lost light) is directly proportional to both the path-length and concentration of the absorbing gas.

$$A = \varepsilon\, l\, c$$

(A = Absorbance, ε = Molar absorptivity, l = Mean path Length, c = concentration)

The CAPS method employed in the T500U is unique in that it applies this fundamental optical absorption law in the frequency domain, rather than using relative changes in light intensity as the primary signal. Ultraviolet light (UV) from the modulating high intensity LED enters a near confocal optical cell (Figure 6-1) through the rear of mirror A. The intensity of the light, as observed by the detector, which is also modulating at a slightly different frequency, located behind Mirror B, builds exponentially in the cell while the LED is ON. The opposite is true when the LED is OFF. Because both mirrors are highly reflective at 450 nm, a prominent absorption band for NO_2, the light takes a considerable amount of time to plateau in the absence of the absorbing gas. However, when NO_2 is present, the mean path length traveled by the light is significantly reduced. This has two effects on the observed intensity as measured by the detector:

- The light plateau intensity level is lower, more importantly for the T500U
- The light intensity plateaus sooner.

Thus, an observed phase shift from the modulating LED is detected (Figure 6-2). The phase shift is largest when measuring zero air and decreases when NO_2 is present.

Both the LED and the Detector are modulated ON and OFF such that the observed signal has a much lower frequency, equal to the difference between the modulated frequencies and is referred to as a beat frequency. The system hardware and software take advantage of this, as it makes it easier to post process the signal using a micro controller. The technique is known as heterodyning.

The instrument translates the phase shift from the presence of absorbing gas into a concentration measurement. Typical absorption techniques of other analyzers take a reference and measure value of the light intensity "level" in order to derive concentration and compensate for source drift. Using the CAPS technique the amount of phase shift remains constant for a given concentration, even if the LED drifts over time. The measurement approach offers many advantages over traditional (or "Chemi") analyzers, such as faster response (single gas stream), lower noise at span and more importantly greater specificity.

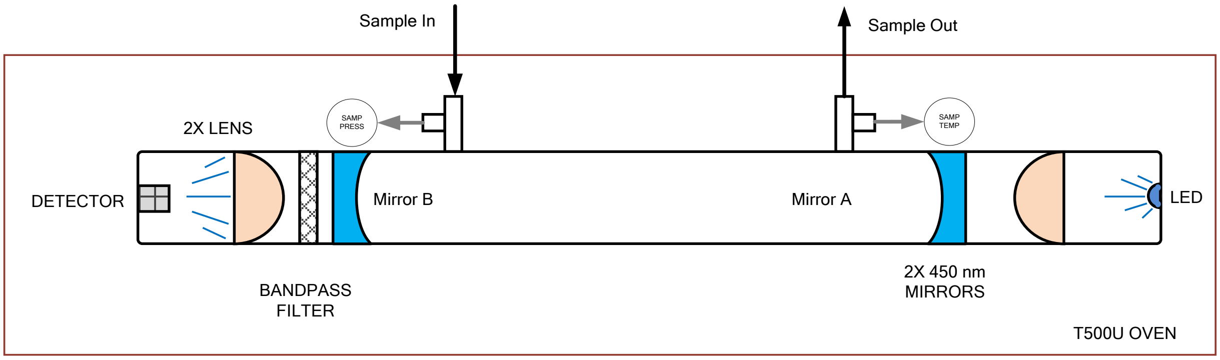


Figure 6-1. T500U Optical Absorption Cell

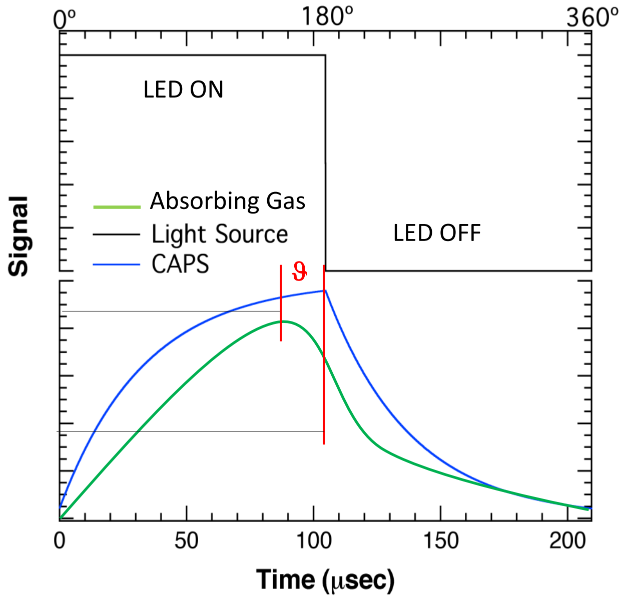


Figure 6-2. Phase Shift Representation of Increased Concentration of NO_2

(Black = LED State, Blue = Light build up in the absence of NO_2, Green = phase shifted\attenuated light)

GLOSSARY

TERM	DESCRIPTION/DEFINITION
10BaseT	an Ethernet standard that uses twisted ("T") pairs of copper wires to transmit at 10 megabits per second (Mbps)
100BaseT	same as 10BaseT except ten times faster (100 Mbps)
APICOM	name of a remote control program offered by Teledyne-API to its customers
ASSY	*Assembly*
CAS	*Code-Activated Switch*
CD	*Corona Discharge*, 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	*Converter Efficiency*, the percentage of the total amount that is actually converted (e.g., light energy into electricity; NO_2 into NO, etc.)
CEM	*Continuous Emission Monitoring*
Chemical elements that may be included in this document:	
CO_2	carbon dioxide
C_3H_8	propane
CH_4	methane
H_2O	water vapor
HC	general abbreviation for hydrocarbon
HNO_3	nitric acid
H_2S	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_2O and other compounds as well)
NH_3	ammonia
O_2	molecular oxygen
O_3	ozone
SO_2	sulfur dioxide
cm^3	metric abbreviation for *cubic centimeter* (replaces the obsolete abbreviation "cc")
CPU	*Central Processing Unit*
DAC	*Digital-to-Analog Converter*
DAS	*Data Acquisition System*
DCE	*Data Communication Equipment*
DFU	*Disposable Filter Unit*
DHCP	*Dynamic Host Configuration Protocol.* 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
DOM	*Disk On Module,* a 44-pin IDE flash drive with up to 128MB storage capacity for instrument's firmware, configuration settings and data
DOS	*Disk Operating System*
DRAM	*Dynamic Random Access Memory*
DR-DOS	*Digital Research DOS*

TERM	DESCRIPTION/DEFINITION
DTE	*Data Terminal Equipment*
EEPROM	*Electrically Erasable Programmable Read-Only Memory* also referred to as a FLASH chip or drive
ESD	*Electro-Static Discharge*
ETEST	*Electrical Test*
Ethernet	a standardized (IEEE 802.3) computer networking technology for local area networks (LANs), facilitating communication and sharing resources
FEP	*Fluorinated Ethylene Propylene* polymer, one of the polymers that Du Pont markets as *Teflon®*
Flash	non-volatile, solid-state memory
FPI	*Fabry-Perot Interface*: a special light filter typically made of a transparent plate with two reflecting surfaces or two parallel, highly reflective mirrors
GFC	*Gas Filter Correlation*
I^2C bus	a clocked, bi-directional, serial bus for communication between individual analyzer components
IC	*Integrated Circuit*, 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	*Internet Protocol*
IZS	*Internal Zero Span*
LAN	*Local Area Network*
LCD	*Liquid Crystal Display*
LED	*Light Emitting Diode*
LPM	*Liters Per Minute*
MFC	*Mass Flow Controller*
M/R	*Measure/Reference*
NDIR	*Non-Dispersive Infrared*
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	*Non-Dispersive Infrared*
NIST-SRM	*National Institute of Standards and Technology - Standard Reference Material*
PC	*Personal Computer*
PCA	P*rinted Circuit Assembly*, the PCB with electronic components, ready to use
PC/AT	*Personal Computer / Advanced Technology*
PCB	*Printed Circuit Board*, the bare board without electronic component
PFA	*Per-Fluoro-Alkoxy*, an inert polymer; one of the polymers that *Du Pont* markets as *Teflon®*
PLC	*Programmable Logic Controller*, a device that is used to control instruments based on a logic level signal coming from the analyzer
PLD	*Programmable Logic Device*
PLL	*Phase Lock Loop*

TERM	DESCRIPTION/DEFINITION
PMT	*Photo Multiplier Tube*, a vacuum tube of electrodes that multiply electrons collected and charged to create a detectable current signal
P/N (or PN)	*Part Number*
PSD	*Prevention of Significant Deterioration*
PTFE	*Poly-Tetra-Fluoro-Ethylene*, a very inert polymer material used to handle gases that may react on other surfaces; one of the polymers that *Du Pont* markets as *Teflon*®
PVC	*Poly Vinyl Chloride*, 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	*Storage and Retrieval of Aerometric Data*
SLAMS	*State and Local Air Monitoring Network Plan*
SLPM	*Standard Liters Per Minute* of a gas at standard temperature and pressure
STP	*Standard Temperature and Pressure*
TCP/IP	*Transfer Control Protocol / Internet Protocol*, the standard communications protocol for Ethernet devices
TEC	*Thermal Electric Cooler*
TPC	*Temperature/Pressure Compensation*
USB	*Universal Serial Bus*: 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	*Variables*, the variable settings of the instrument
V-F	*Voltage-to-Frequency*
Z/S	*Zero / Span*

APPENDIX A – MODBUS REGISTERS

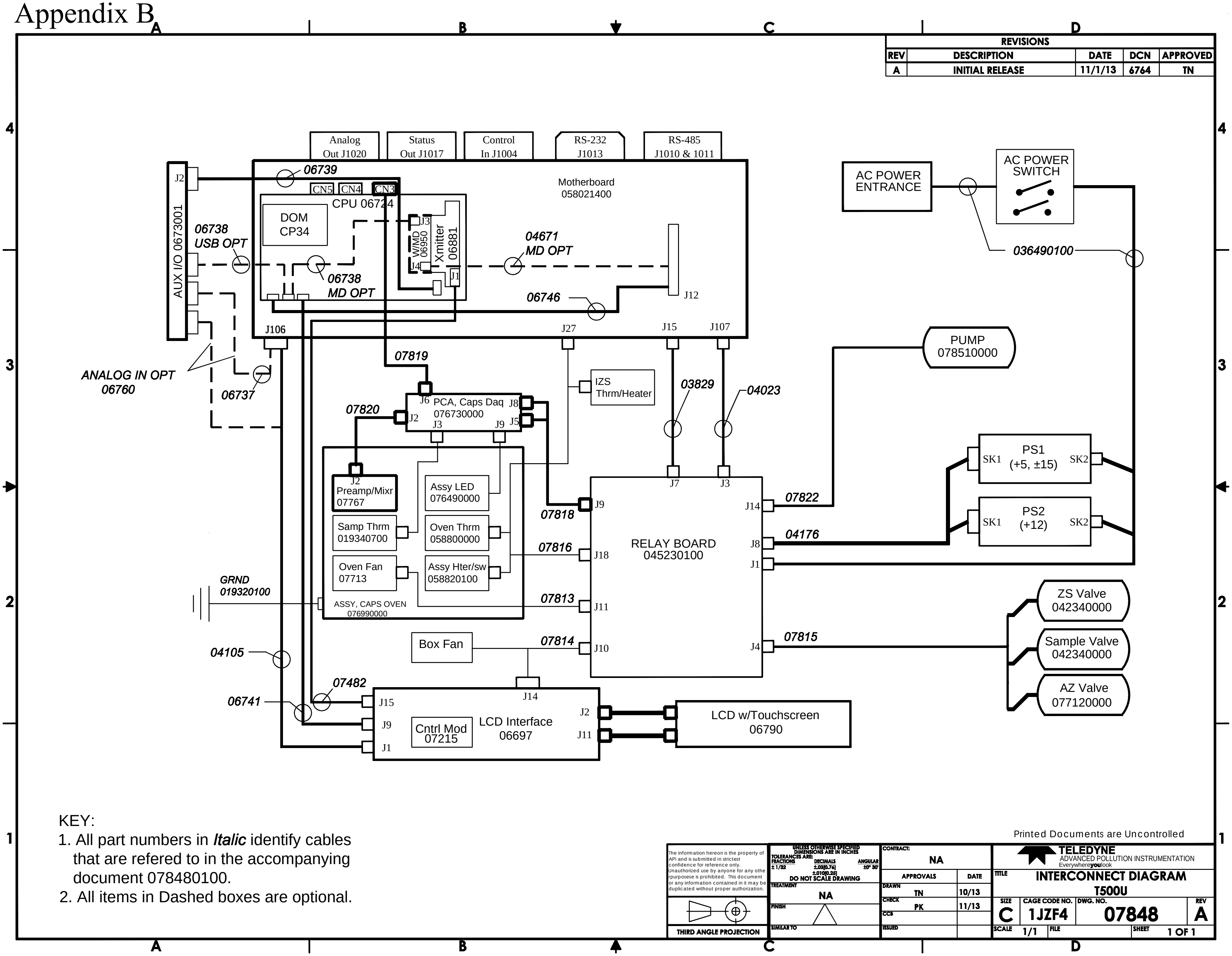
MODBUS REGISTER ADDRESS (DEC., 0-BASED)	DESCRIPTION	UNITS
MODBUS Floating Point Input Registers (32-bit IEEE 754 format; read in high-word, low-word order; read-only)		
6	Slope for range #1	—
8	Slope for range #2	—
10	Offset for range #1	PPB
12	Offset for range #2	PPB
14	Concentration for range #1 during 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	Auto-ref value	Mm^{-1}
26	Oven temperature	°C
28	Oven temperature duty cycle	%
30 [5]	Manifold temperature	°C
32 [5]	Manifold temperature duty cycle	%
34 [6]	IZS lamp temperature	°C
36 [6]	IZS temperature duty cycle	%
38	Sample temperature	°C
40	Sample pressure	Inches Hg
42	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
54	Ground reference	mV
56	Precision 4.096 mV reference	mV
130 [10]	External analog input 1 value	Volts
132 [10]	External analog input 1 slope	eng unit /V
134 [10]	External analog input 1 offset	eng unit
136 [10]	External analog input 2 value	Volts
138 [10]	External analog input 2 slope	eng unit /V
140 [10]	External analog input 2 offset	eng unit
142 [10]	External analog input 3 value	Volts
144 [10]	External analog input 3 slope	eng unit /V
146 [10]	External analog input 3 offset	eng unit
148 [10]	External analog input 4 value	Volts
150 [10]	External analog input 4 slope	eng unit /V

MODBUS REGISTER ADDRESS (DEC., 0-BASED)	DESCRIPTION	UNITS
152 [10]	External analog input 4 offset	eng unit
154 [10]	External analog input 5 value	Volts
156 [10]	External analog input 5 slope	eng unit /V
158 [10]	External analog input 5 offset	eng unit
160 [10]	External analog input 6 value	Volts
162 [10]	External analog input 6 slope	eng unit /V
164 [10]	External analog input 6 offset	eng unit
166 [10]	External analog input 7 value	Volts
168 [10]	External analog input 7 slope	eng unit /V
170 [10]	External analog input 7 offset	eng unit
172 [10]	External analog input 8 value	Volts
174 [10]	External analog input 8 slope	eng unit /V
176 [10]	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)		
2	Maps to *NO2_SPAN1* variable; target span concentration for range #1	Conc. units
6	Maps to *NO2_SPAN2* variable; target span concentration for range #2	Conc. units
MODBUS Discrete Input Registers (single-bit; read-only)		
0	Auto-ref warning	
1	Oven temperature warning	
2 [5]	Manifold temperature warning	
3 [6]	IZS temperature warning	
4	Baseline loss warning	
5	Bench com warning	
6		
7	Box temperature warning	
8	Sample temperature warning	
9		
10	Sample pressure warning	
11	System reset warning	
12	Rear board communication warning	
13	Relay board communication warning	
14		
15	Front panel communication warning	
16	Analog calibration warning	
17	Dynamic zero warning	
18	Dynamic span warning	
19	Invalid concentration	

MODBUS REGISTER ADDRESS (DEC., 0-BASED)	DESCRIPTION	UNITS
20	In zero calibration mode	
21		
22	In span calibration mode	
23	In multi-point calibration mode	
24	System is OK (same meaning as *SYSTEM_OK* I/O signal)	
25 [3]	NO_2 concentration alarm limit #1 exceeded	
26 [3]	NO_2 concentration alarm limit #2 exceeded	
27 [4]	In Manual mode	
MODBUS Coil Registers (single-bit; read/write)		
0	Maps to relay output signal 36 (*MB_RELAY_36* in signal I/O list)	
1	Maps to relay output signal 37 (*MB_RELAY_37* in signal I/O list)	
2	Maps to relay output signal 38 (*MB_RELAY_38* in signal I/O list)	
3	Maps to relay output signal 39 (*MB_RELAY_39* in signal I/O list)	
20 [1]	Triggers zero calibration of NO_2 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 NO_2 range #2 (on enters cal.; off exits cal.)	
25 [1]	Triggers span calibration of NO_2 range #2 (on enters cal.; off exits cal.)	

[1] Refer to the Calibration section of this manual for running a calibration check without changing slope and offset vs actual calibration.
[3] Concentration alarm option.
[4] Hessen option.
[5] Manifold heater option.
[6] IZS option.
[10] External analog input option.

Appendix B



REVISIONS
REV | DESCRIPTION | DATE | DCN | APPROVED
A | INITIAL RELEASE | 11/1/13 | 6764 | TN
Analog Out J1020
Status Out J1017
Control In J1004
RS-232 J1013
RS-485 J1010 & 1011
Motherboard 058021400
CPU 06724
DOM CP34
CN5 CN4 CN3
W/MD 06950
Xmitter 06881
AUX I/O 0673001
06739
06738 USB OPT
06738 MD OPT
04671 MD OPT
06746
J12
J106 J27 J15 J107
ANALOG IN OPT 06760
06737
07819
07820
PCA, Caps Daq 076730000
IZS Thrm/Heater
03829
04023
Preamp/Mixr 07767
Assy LED 076490000
Samp Thrm 019340700
Oven Thrm 058800000
Oven Fan 07713
Assy Hter/sw 058820100
ASSY, CAPS OVEN 076990000
GRND 019320100
07818
07816
07813
07814
RELAY BOARD 045230100
07822
04176
07815
AC POWER ENTRANCE
AC POWER SWITCH
036490100
PUMP 078510000
PS1 (+5, ±15)
PS2 (+12)
SK1 SK2
ZS Valve 042340000
Sample Valve 042340000
AZ Valve 077120000
Box Fan
04105
06741
07482
LCD Interface 06697
Cntrl Mod 07215
LCD w/Touchscreen 06790
KEY:
1. All part numbers in *Italic* identify cables that are refered to in the accompanying document 078480100.
2. All items in Dashed boxes are optional.
Printed Documents are Uncontrolled
TELEDYNE ADVANCED POLLUTION INSTRUMENTATION Everywhereyoulook
INTERCONNECT DIAGRAM T500U
SIZE C CAGE CODE NO. 1JZF4 DWG. NO. 07848 REV A
SCALE 1/1 SHEET 1 OF 1
DRAWN TN 10/13
CHECK PK 11/13
CONTRACT: NA
TREATMENT NA
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION