TELEDYNE API
Everywhereyoulook™

User Manual

Model N500
CAPS NO_X Analyzer

© 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

08977C DCN8373
18 February 2021

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 instrument should only be used for the purpose and in the manner described in this manual. If you use this instrument in a manner other than that for which it was intended, unpredictable behavior could ensue with possible hazardous consequences.

NEVER use any combustible/explosive gas with this instrument!

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

Cet instrument doit être utilisé aux fins décrites et de la manière décrite dans ce manuel. Si vous utilisez cet instrument d'une autre manière que celle pour laquelle il a été prévu, l'instrument pourrait se comporter de façon imprévisible et entraîner des conséquences dangereuses.

NE JAMAIS utiliser de gaz explosive ou combustible avec cet instrument!

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 the following link: http://www.teledyne-api.com/terms_and_conditions.asp).

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 at http://www.teledyne-api.com/terms_and_conditions.asp

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

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 N500 CAPS NO_x-NO_2-NO Analyzer uses Cavity-Attenuated Phase-Shift (CAPS) spectroscopy to render direct, true measurements of nitrogen dioxide (NO_2). By combining direct NO_2 measurements with highly efficient gas phase titration (GPT), the N500 converts and measures the NO sample gas component as NO_2, thus allowing for the measurement of total NOx. Furthering its accuracy and dependability is an auto-reference cycle to account and compensate for any potential baseline drift in the measured loss, that may be caused by varying environmental conditions.

CAPS technology is superior to the traditional chemiluminescence method in both speed and precision since the sampled NO_2 does not require catalytic conversion to calculate a difference measurement.

Economically, the Model N500 CAPS NO_X instrument is less costly to operate and maintain than traditional analyzers in that it uses less power and fewer components.

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

1.1. SPECIFICATIONS

Table 1-1. Specifications

Parameter	Description	
Ranges	Min: 0-5 ppb Max: 0-1 ppm NO_X (full scale)	
Measurement Units	ppb, ppm, µg/m^3, mg/m^3 (user-selectable)	
Zero Noise	< 0.05 ppb (RMS)	
Span Noise	< 0.2% of reading + 50 ppt (RMS)	
Zero Drift	< 0.2 ppb / 24 hours	
Span Drift	< 0.5% of reading / 24 hours	
Lower Detectable Limit	< 0.1 ppb	
Response Time	< 60 Seconds to 95%	
Linearity	1% Full Scale	
Precision	0.5% of reading above 5 ppb	
Sample Flow Rate	1000 cc/min ±10%	
AC Power	Rating	Typical Power Consumption
	100 - 240 V~ 47-63 Hz 3.0 A	110 W
Power Entry Module Fuse	5.0 A, 250 V AC, 5 mm x 20 mm, SLO-BLO	

Parameter	Description
Communications	
Standard I/O	1 Ethernet: TCP/IP 1 RS-232 (300 – 115,200 baud) 2 front panel USB device ports
Optional I/O	Universal Analog Output Board (all user-definable): 4 x isolated voltage outputs (5 V, 10 V) 3 x individually isolated current outputs (4-20 mA) Digital I/O Expansion Board includes: 3 x isolated digital input controls (fixed) 5 x isolated digital output controls (user-definable) 3 x form C relay alarm outputs (user-definable)
Operating Temperature	0-40 ºC (with US EPA approval)
Humidity Range	0-95% RH, Non-Condensing
Dimensions HxWxD	7" x 17" x 23.5" (178 x 432 x 597 mm)
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 N500 CAPS NOx analyzer is officially designated as US EPA Automated Equivalent Method, Designation Number EQNA- 0320-256.

The official List of Designated Reference and Equivalent Methods is published in the U.S. Federal Register, http://www3.epa.gov/ttn/amtic/criteria.html, and specifies the instrument's settings and configurations.

1.3. SAFETY

IEC/EN 61010-1:2010 (3rd Edition), Safety requirements for electrical equipment for measurement, control, and laboratory use.

CE**:** 2014/35/EU, Low-Voltage Directive

1.4. EMC

IEC/EN 61326-1, Class A Emissions/Industrial Immunity

FCC 47 CFR Part 15B, Class A Emissions

CE**:** 2014/30/EU, Electromagnetic Compatibility Directive

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 to lift and carry 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 disconnect PCAs, wiring harnesses or electronic subassemblies while 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).

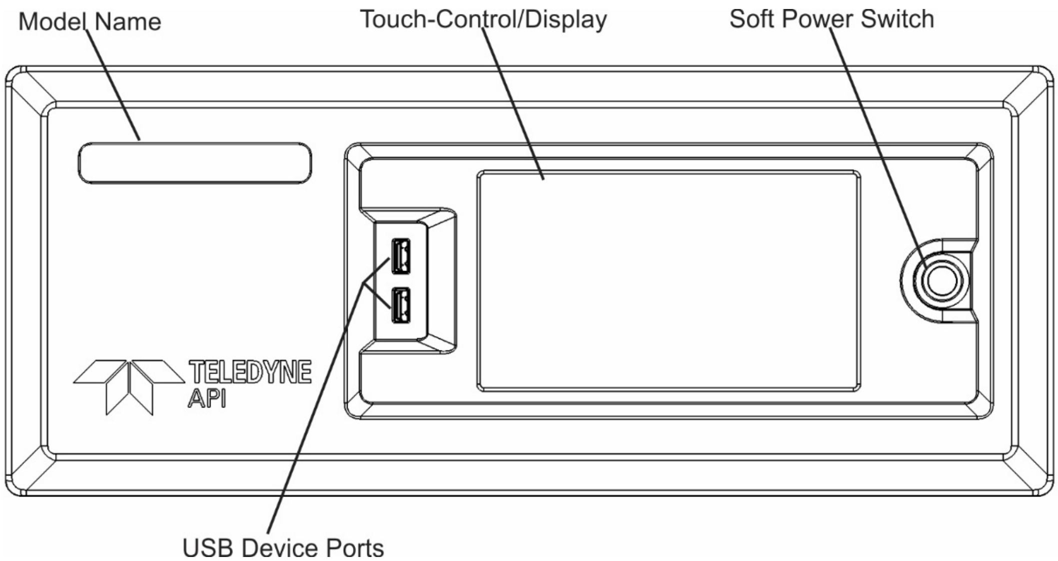


Figure 2-1. Front Panel Layout

2.2.2. REAR PANEL

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

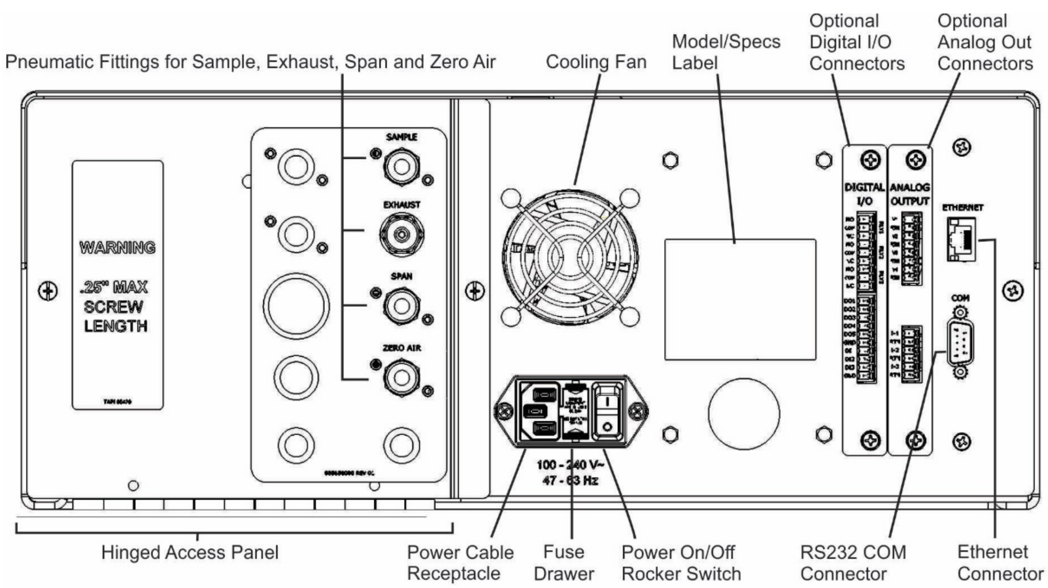


Figure 2-2. Rear Panel Layout

Table 2-2. Rear Panel Description

COMPONENT	FUNCTION
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.
Cooling fan	Pulls ambient air into chassis through side vents and exhausts through rear.
Power cable 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 label**
Power On/Off Switch	Rocker switch to power unit on or off. **CAUTION!** Prior to powering OFF, use front panel button for preliminary internal "soft" power-down to protect components from damage.
Fuse drawer	For circuit protection.
ANALOG OUT Option	For voltage or current loop outputs to a strip chart recorder and/or a data logger.
DIGITAL I/O Option	For remotely activating the zero and span calibration modes.
ETHERNET	Connector for network or Internet remote communication, using Ethernet cable.
COM	Serial communications port for RS-232.

2.2.3. INTERNAL CHASSIS

Figure 2-3 shows the internal chassis layout.

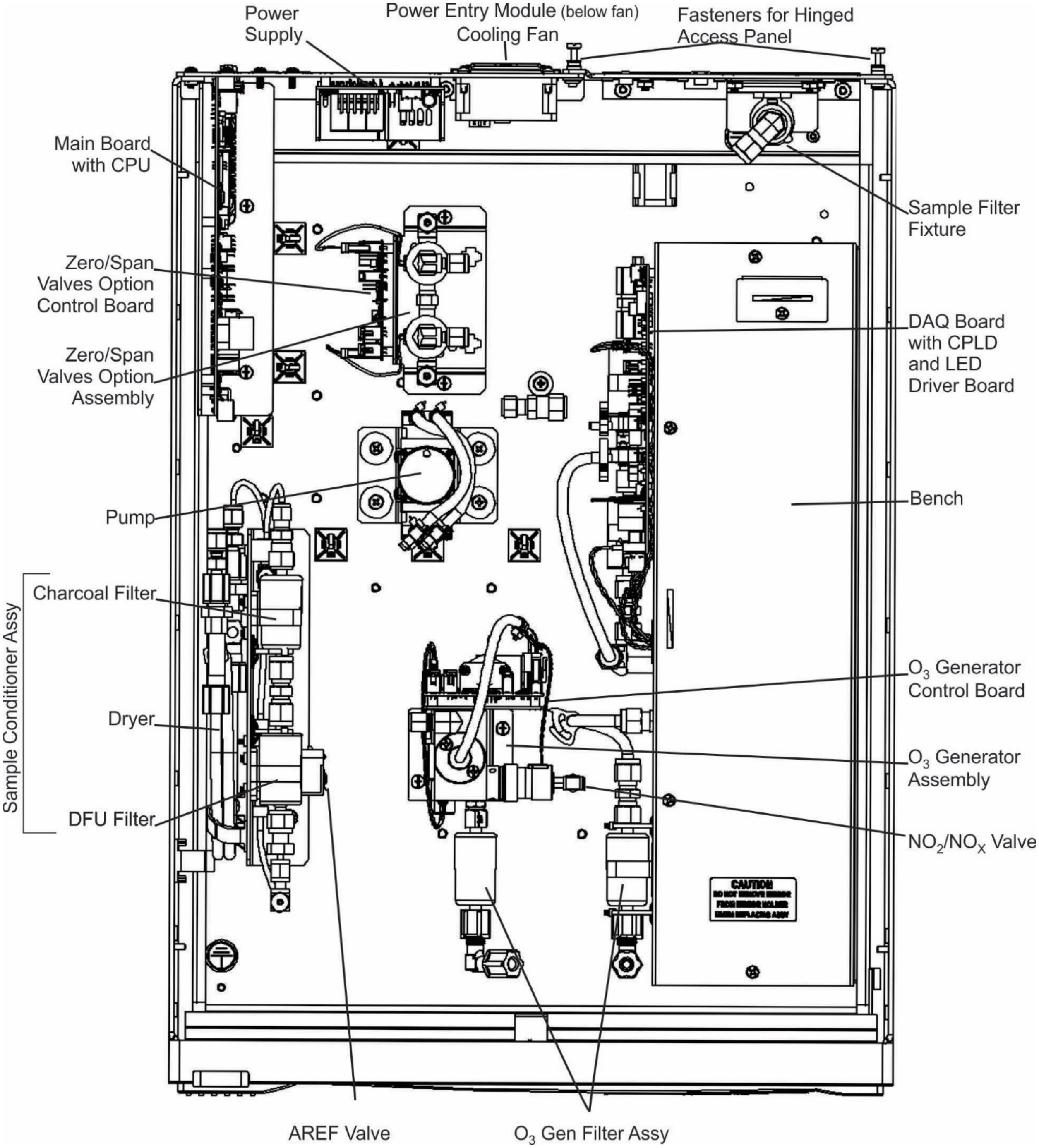


Figure 2-3. Internal Chassis Layout

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 rear panel before plugging it into line power.

2.3.1.1. CONNECTING POWER

ATTENTION **COULD DAMAGE INSTRUMENT AND VOID WARRANTY**

Never power off the instrument from the rear panel Hard Power switch before first placing the internal computerized components into deep sleep mode through the front panel Soft Power switch. Press and momentarily hold the front panel Soft Power switch, which triggers the Supervisory chip to safely shut down the internal components. The LED state then changes from solid lit to blinking, at which time the rear panel Hard Power switch can be used to power off the instrument.

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 Option

The optional rear panel Analog Output board offers several channels that 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.

The four **voltage** outputs (0-5 V or 0-10 V) are isolated from the instrument but share a common ground. The three **current** outputs are individually isolated from each other and from the instrument.

To access these signals, attach a strip chart recorder and/or data-logger to the appropriate analog output connections, and configure through the Setup>Analog Outputs menu.

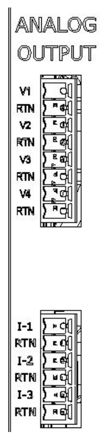


Figure 2-4. Analog Outputs Connectors Panel Option

Table 2-3. Analog Output Pin Assignments

PIN	OUTPUT	DESCRIPTION
Isolated Voltage Outputs		
V1	V +	User definable through the Setup>Analog Outputs menu.
RTN	Ground	
V2	V +	
RTN	Ground	
V3	V +	
RTN	Ground	
V4	V +	
RTN	Ground	
Isolated Current Outputs		
I-1	I Out +	User definable through the Setup>Analog Outputs menu.
RTN	I Out -	
I-2	I Out +	
RTN	I Out -	
I-3	I Out +	
RTN	I Out -	

2.3.1.3. Connecting the Digital I/O Expansion Board Option

The connections on this board include three relay alarms, five digital outputs, and three isolated digital input controls. The **Relays** can be mapped to reflect various internal instrument conditions and states. The **Outputs** are isolated from the instrument and consist of open collector transistors with a common ground; they can be mapped to reflect various internal instrument conditions and states; they can be used to interface with devices that accept logic-level digital inputs, such as Programmable Logic Controllers (PLCs). The **Inputs** are also isolated but share the same ground as the Outputs; they will work with relays, open collectors, or 3.3 V – 24 V logic. Pull low to activate. DI1 and DI2 are fixed (not mappable) for remote zero and span calibrations.

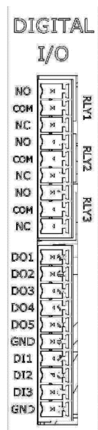


Figure 2-5. Digital I/O Connector Panel Option

Table 2-4. Digital Input/Output Pin Assignments

PIN	DESCRIPTION	
Relays		
NO	RLY1	Relay Alarms, user-configurable through the Setup>Digital Outputs menu.
COM		
NC		
NO	RLY 2	
COM		
NC		
NO	RLY 3	
COM		
NC		
Digital Outputs and Inputs		
DO1	Digital Outputs mappable in the Setup>Digital Outputs menu, and viewable in the Utilities>Diagnostics>Digital Outputs menu	
DO2		
DO3		
DO4		
DO5		
GND	Ground	
DI1	Digital Input1 = Remote Zero Cal Digital Input2 = Remote Span Cal (Digital Input3 not used) View status in Utilities>Diagnostics>Digital Inputs menu	
DI2		
DI3		
GND	Ground	

2.3.1.4. 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.

Serial Connection

Received from the factory, the analyzer COM port is set up for RS-232 communications with data communication equipment (DCE). This port can be reconfigured for RS-232 communications with data terminal equipment (DTE) by jumpering the pins on JP1 as indicated in Table 2-5 (view/edit software settings Table 2-12).

WARNING – ELECTRICAL SHOCK HAZARD

Disconnect power before performing any operation that requires entry into the interior of the analyzer.

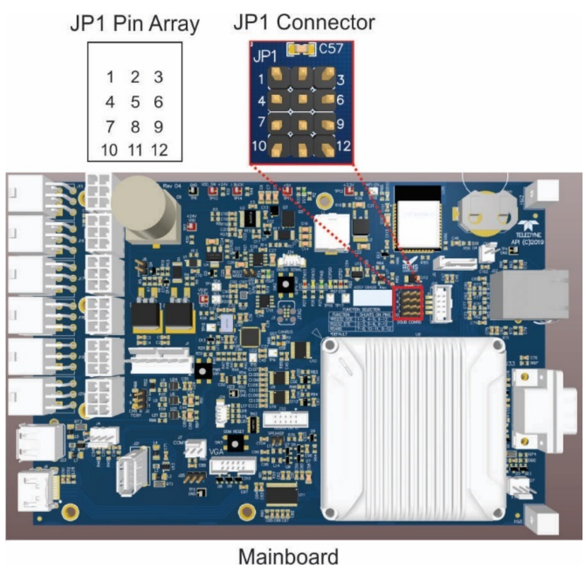


Figure 2-6. Mainboard JP1 Location and Pin Arrangements

Table 2-5. JP1 Configurations for Serial Communication

Function	Jumpers	DSub Pins	
		2	3
DCE RS232 (default)	1-2, 4-5, 9-12	232Tx	232Rx
DTE RS232	2-3, 5-6, 9-12	232Rx	232Tx

View/edit the Communications parameters in the Setup>Comm>COM1 menu.

- **Baud rate**: 115200 bits per second (baud)
- **Data Bits**: 8 data bits with 1 stop bit
- **Parity**: None

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

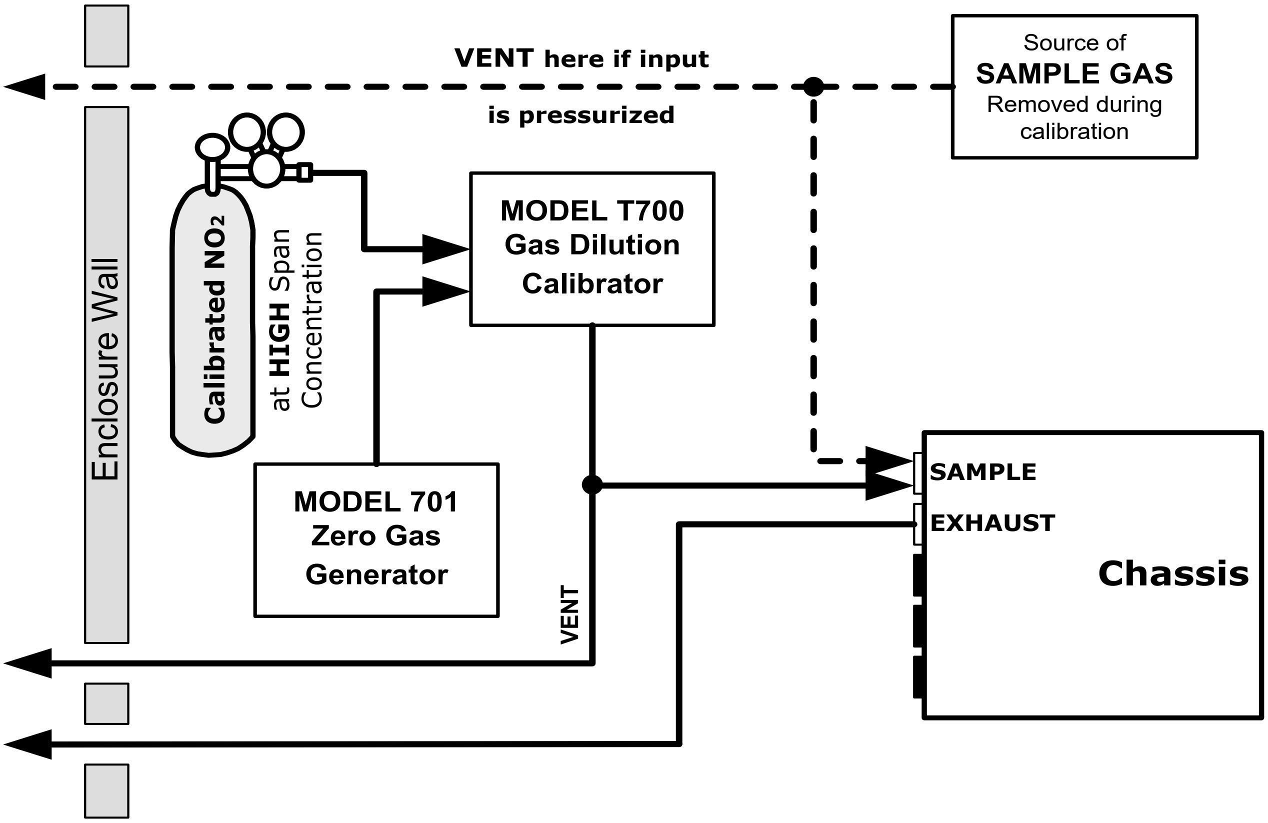


Figure 2-7. Gas Line Connections from Calibrator – Basic Configuration

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

NO_2 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

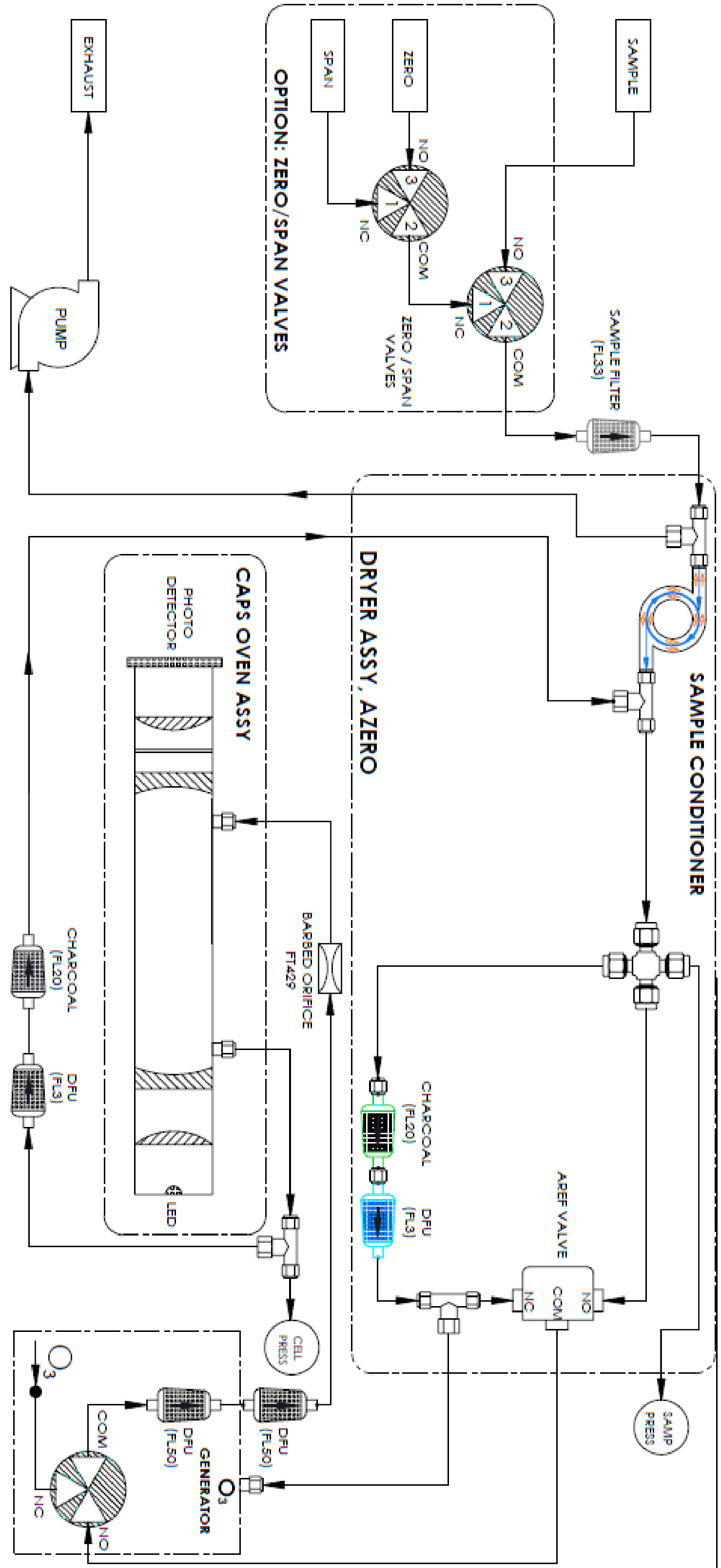


Figure 2-8. Pneumatic Flow Diagram including Zero/Span Valve Option

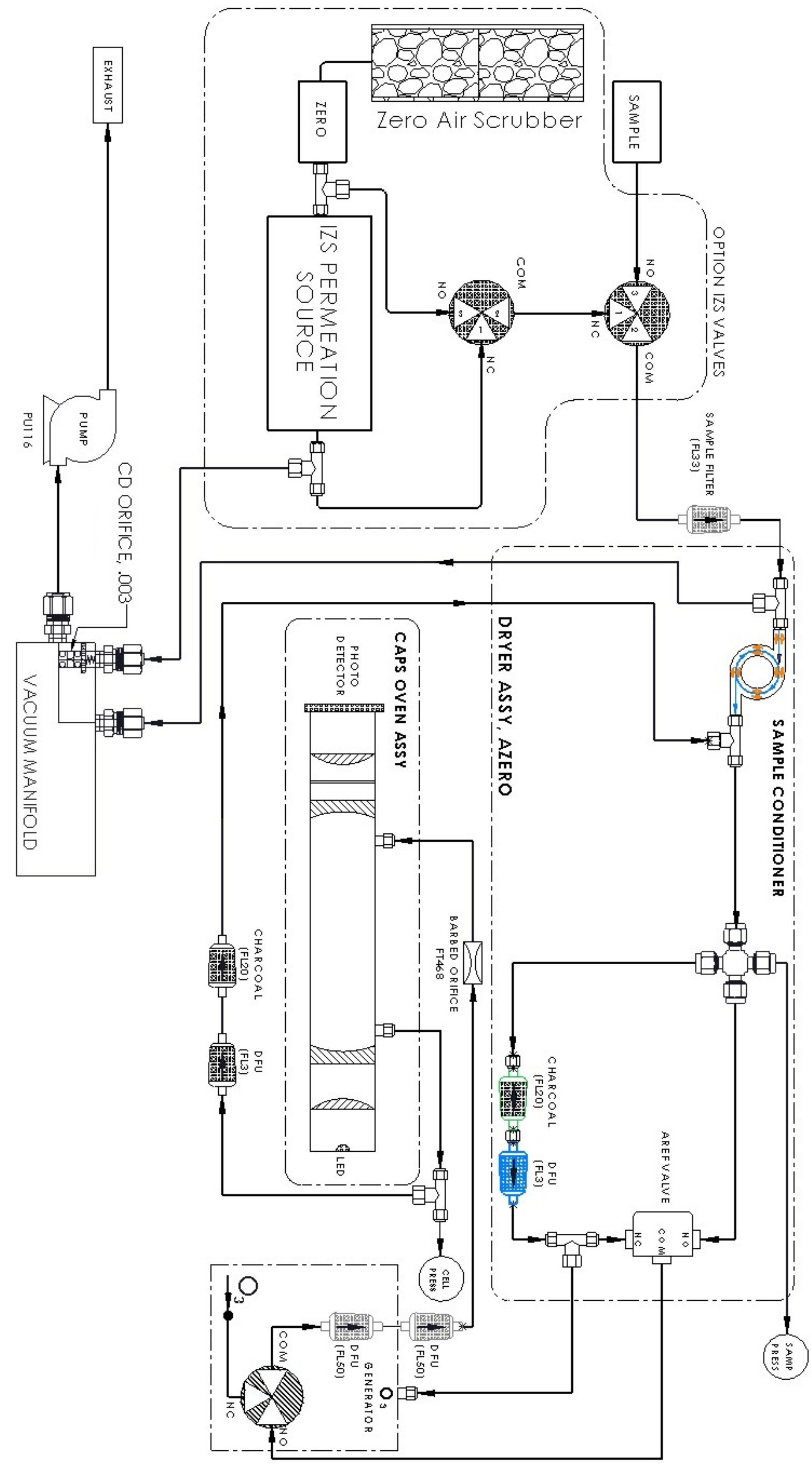


Figure 2-9. Pneumatic Flow Diagram including IZS Valve Option

2.3.4. STARTUP, FUNCTIONAL CHECKS AND CALIBRATION

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

Note **It is expected that all cautionary messages are being followed.**

The front panel Soft Power switch has a status LED that indicates whether:

- instrument is powered down (LED off)
- instrument powered on and internal components in deep sleep mode (LED blinking, achieved by pressing and momentarily holding the soft power button)
- instrument powered on and internal components are operating (LED solid lit, achieved when first powered up; must place in deep sleep mode before power off)

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 2-10) appear prior to the Home page (Figure 2-11).

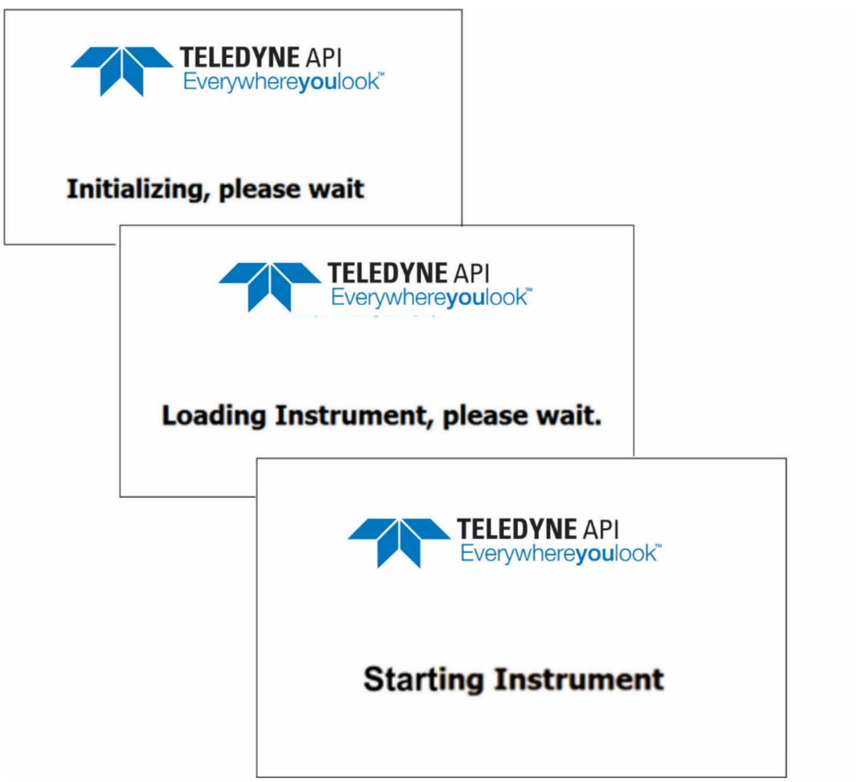


Figure 2-10. Status Screens at Startup

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

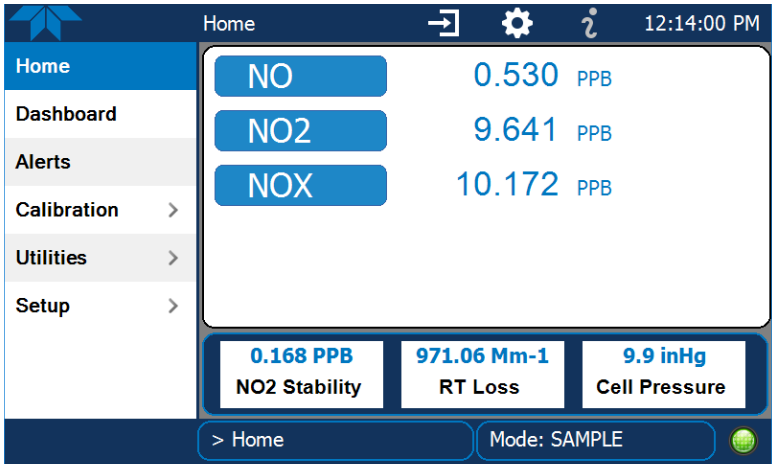


Figure 2-11. Home Page Example

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 45 minutes after power up. The Alerts page (Figure 2-12) 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.

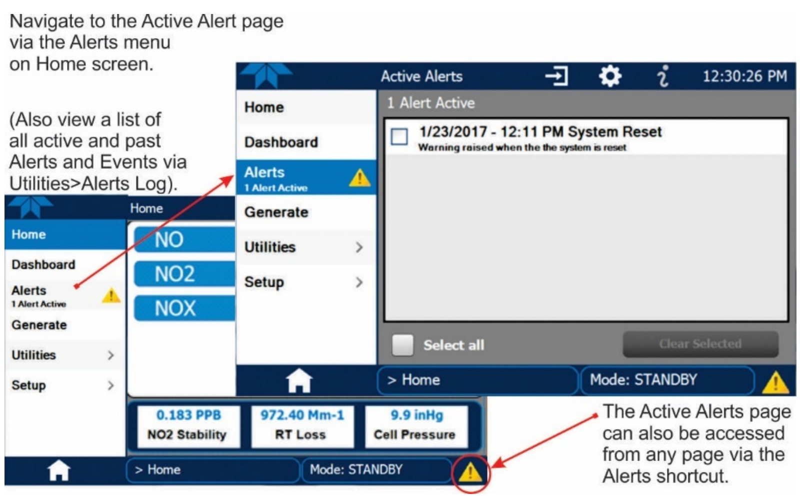


Figure 2-12. Viewing Active Alerts Page

If Alerts about warning conditions persist after the warm-up period or after being cleared, investigate their cause using the troubleshooting guidelines in Section 5.7.1.

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. View the Dashboard page to check that parameters show expected/reasonable values. (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).

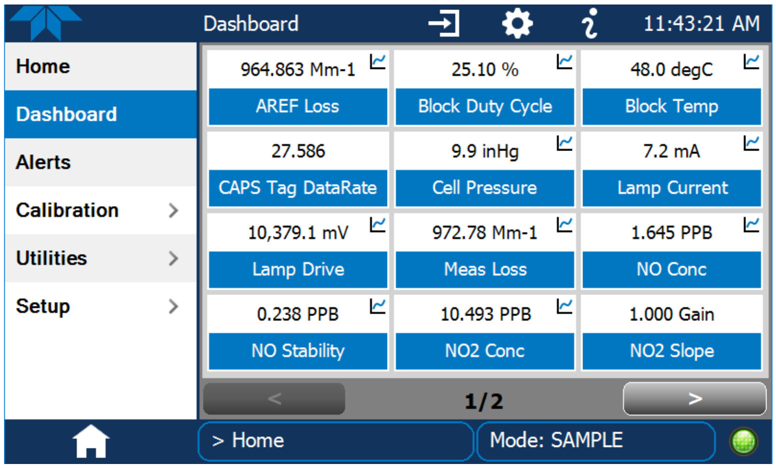


Figure 2-13. Sample Dashboard Page

2.3.4.4. Calibration

Before operation begins, the analyzer requires zero and span calibrations followed by a Titration Efficiency (TE) check. 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 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 2-15).	Section 2.4.1
Dashboard		View user-selected parameters and their values, some of which can be displayed in a live-plot graph (Figure 2-16).	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 on the NO_2 and NOx channels.	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 2-13) 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 2-14).	Section 2.5.6
	Digital I/O (option)	Map the rear-panel digital outputs to a variety of voltage or current signals present in the instrument to monitor the status of operating conditions or custom Events.	Section 2.5.7
	Analog Outputs (option)	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 2.5.7
	Comm	View and configure network and serial communications.	Section 2.5.10

2.4.1. HOME PAGE

Figure 2-14 presents an orientation to the main display screen; Figure 2-15 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.

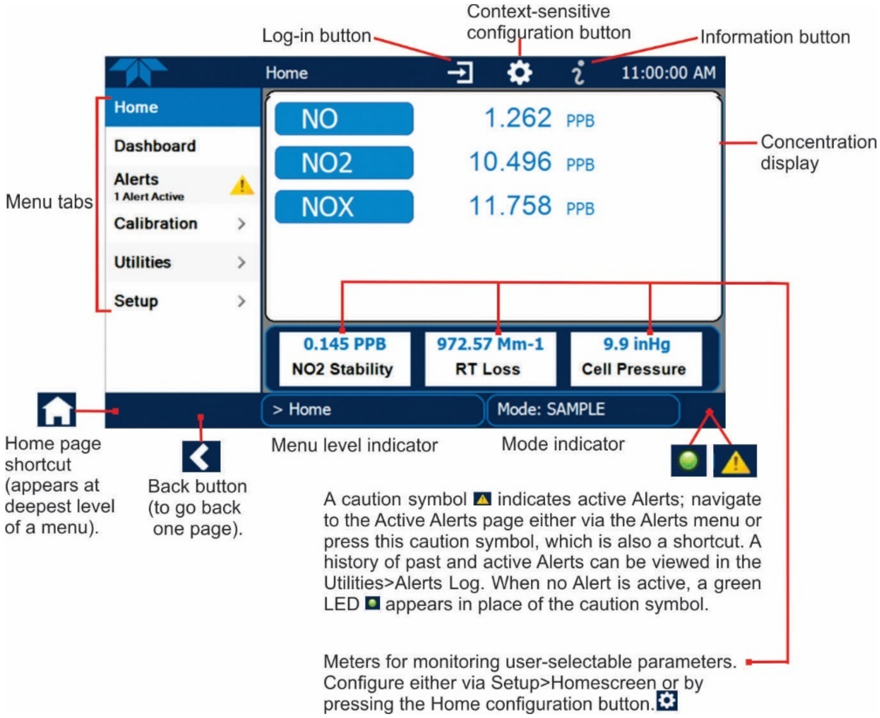


Figure 2-14. User Interface Orientation

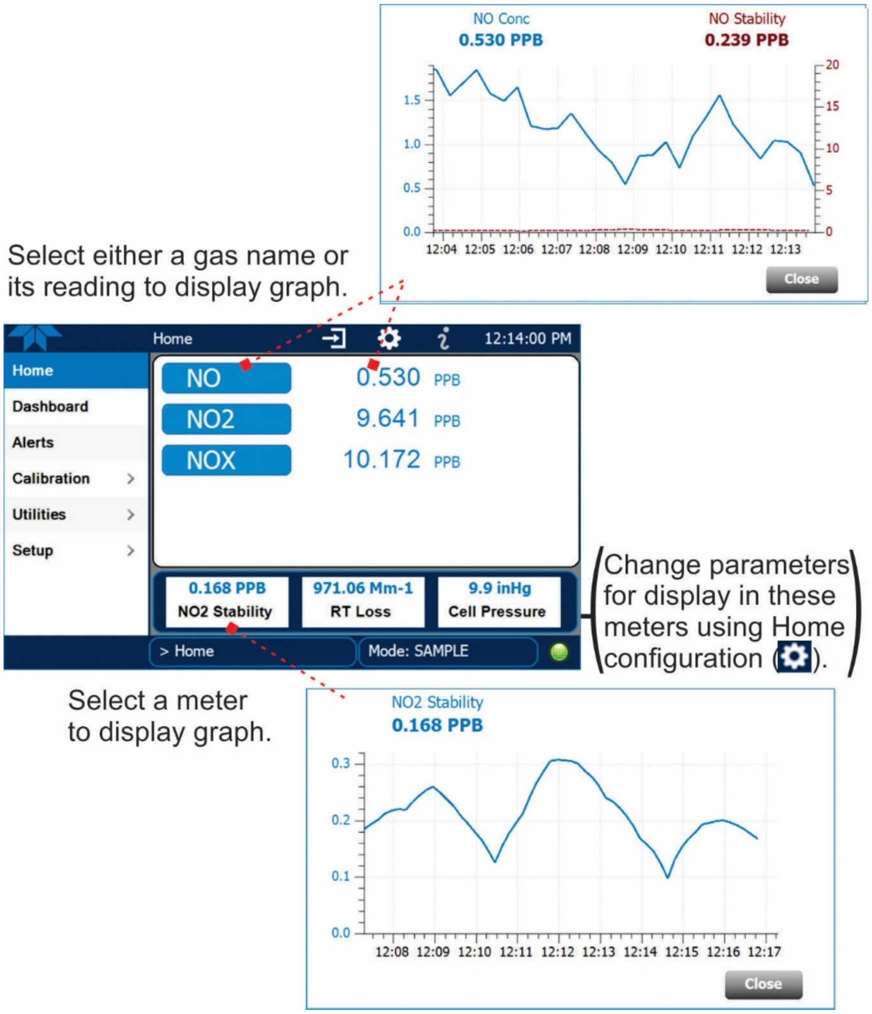


Figure 2-15. Concentration and Stability Graph (top) and Meter Graph (bottom)

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 2-16.

Figure 2-16. Dashboard Page

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 2-17).

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

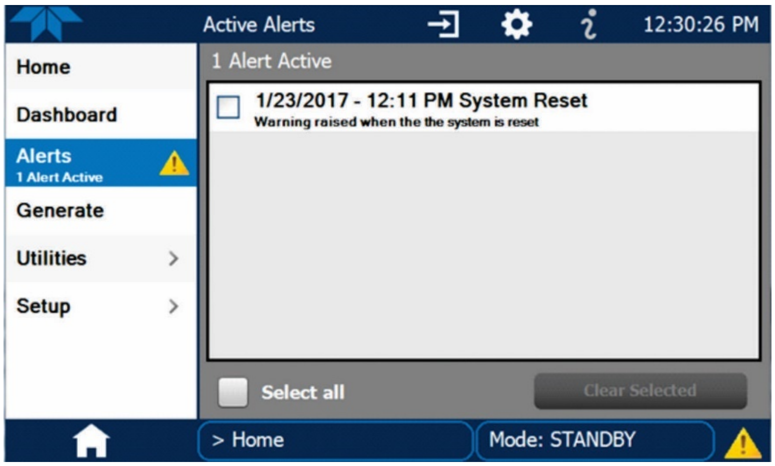


Figure 2-17. Active Alerts Page

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 2-18). However, Alerts can reappear if the conditions causing them are not resolved. For troubleshooting guidance, refer to Section 5.7.

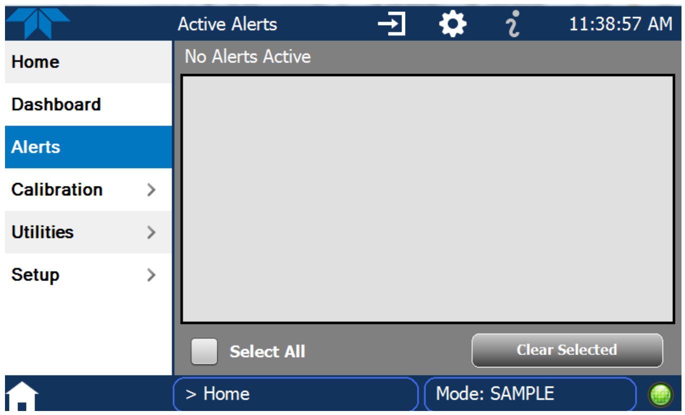


Figure 2-18. Active Alerts Cleared

Alerts and Events remain recorded in the Utilities>Alerts Log (Figure 2-19).

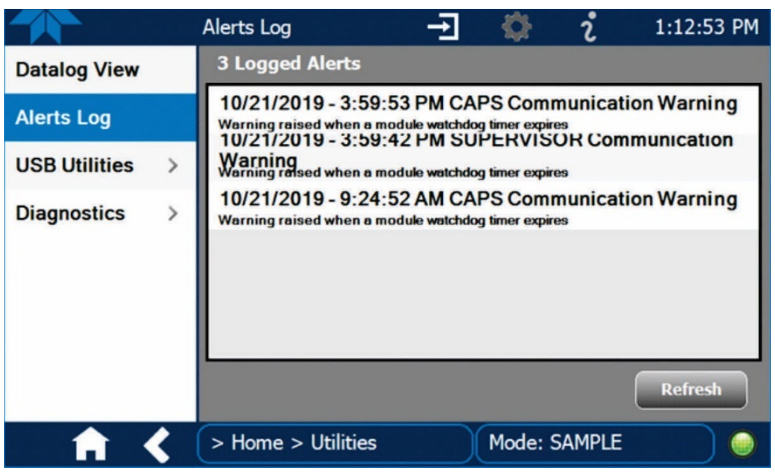


Figure 2-19. Utilities>Alerts Log of Active and Past Alerts and Events

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 2-7.

Table 2-7. 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	Show raw voltage of several internal analog input parameters. These can be logged in the internal data acquisition system (DAS) by configuring the Data Logger in the Setup menu.
	Analog Outputs	Show the voltage or current signals for the functions selected and configured in the Setup>Analog Outputs option menu. (Section 2.3.1.2 presents the rear panel connections).
	Digital Inputs	Show and change the ON/OFF state of specific, available features with the Digital I/O option.
	Digital Outputs	Show and change the ON/OFF state of user-defined (Setup>Digital Outputs menu) outputs and relays with the Digital I/O option.
	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 prior to the AREF valve. 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.
	O3 Gen Override	Used to override the Ozone Generator state when needed, such as for service (Section 5.7.7.3).

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 2-20 shows a new log; Figure 2-21 shows a sample existing log, which can be edited or deleted, and Figure 2-22 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.

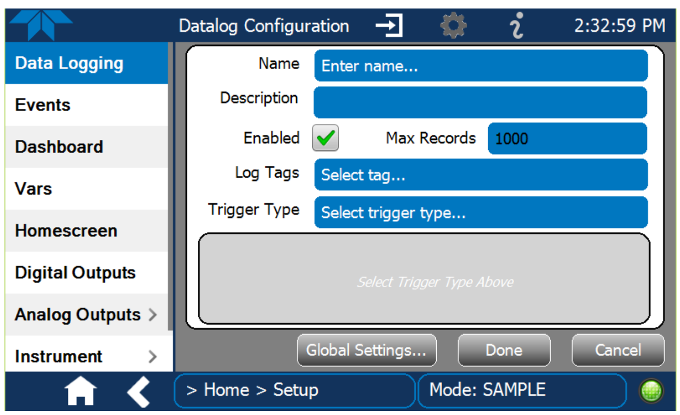


Figure 2-20. Datalog Configuration, New Log Page

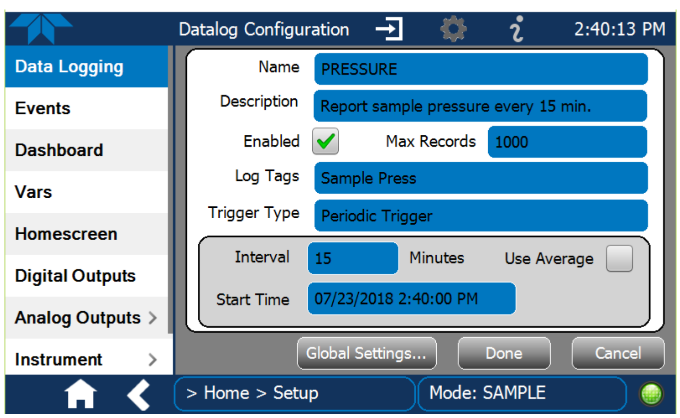


Figure 2-21. Datalog Configuration, Existing Log

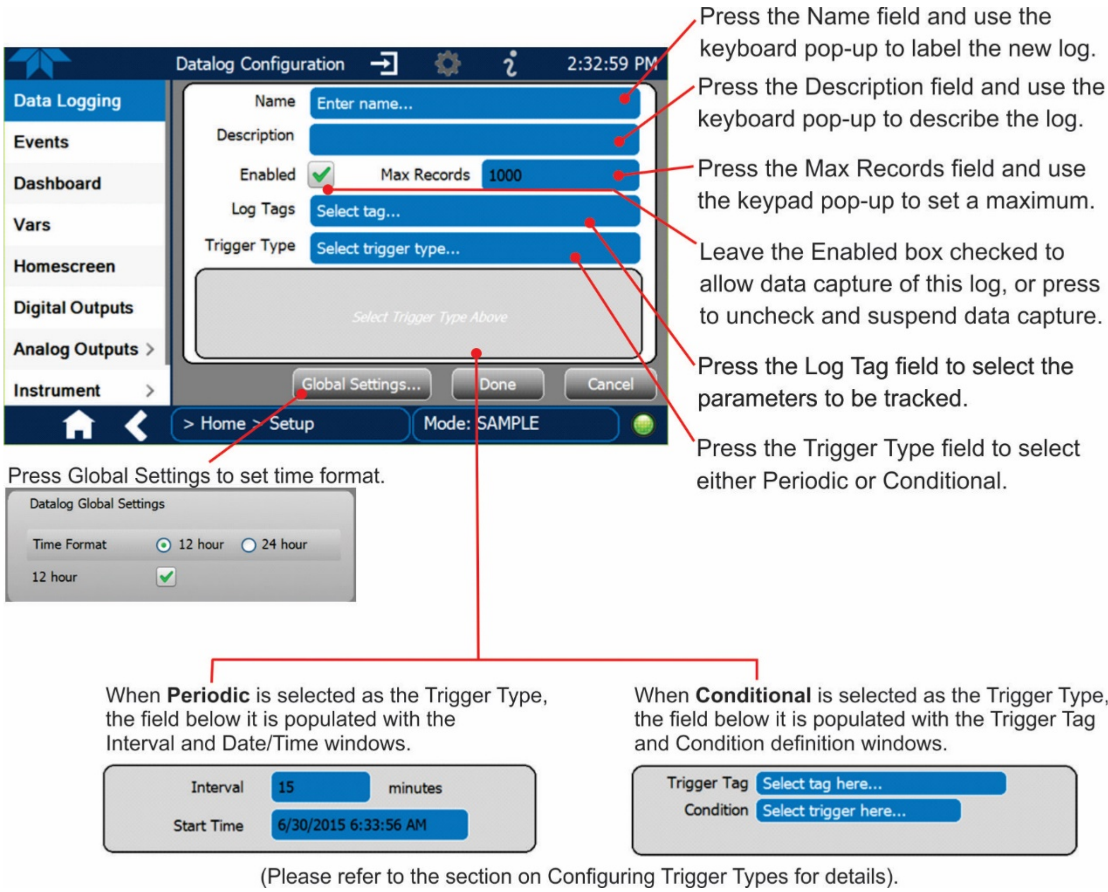


Figure 2-22. Creating a New Data Log

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.

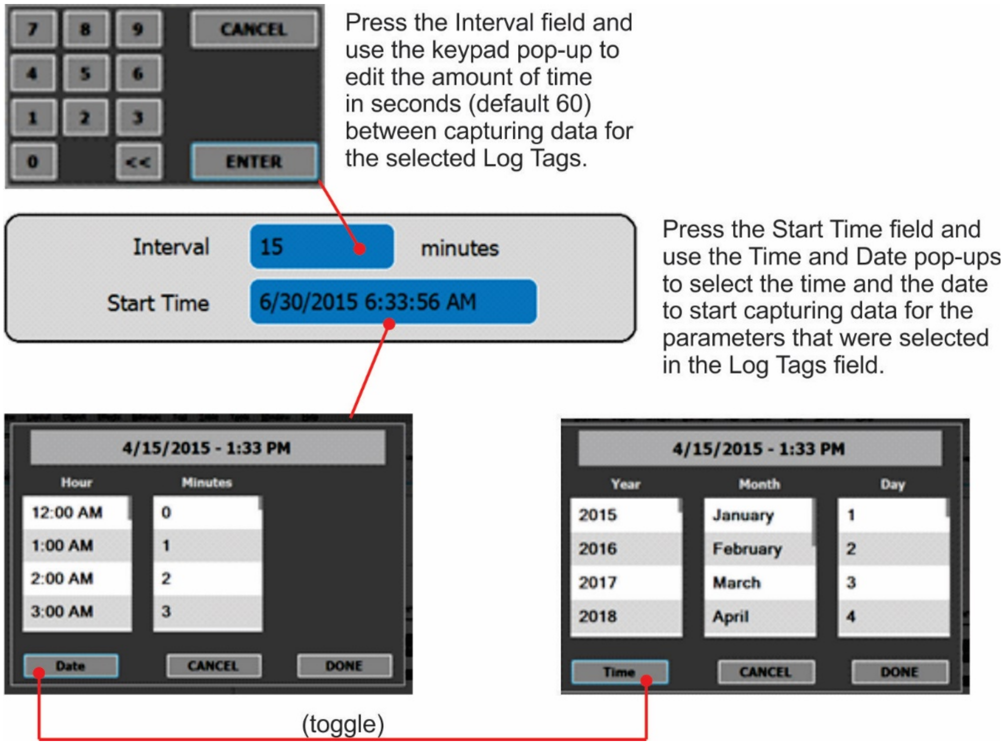


Figure 2-23. Datalog Periodic Trigger Configuration

2.5.1.2. Configuring Trigger Types: Conditional

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

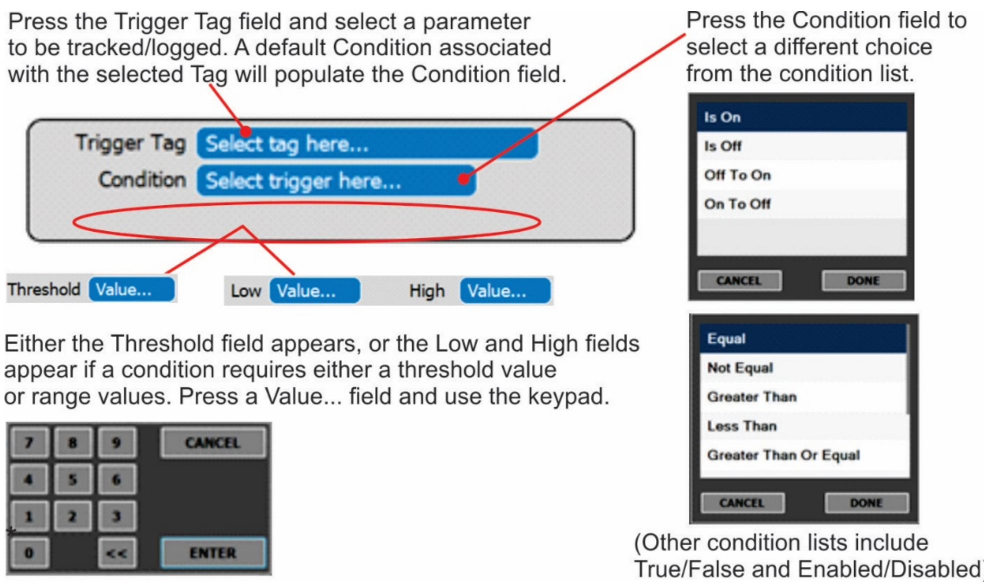


Figure 2-24. Datalog - Conditional Trigger Configuration

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 Indicates that the drive has been detected; available buttons will be enabled.

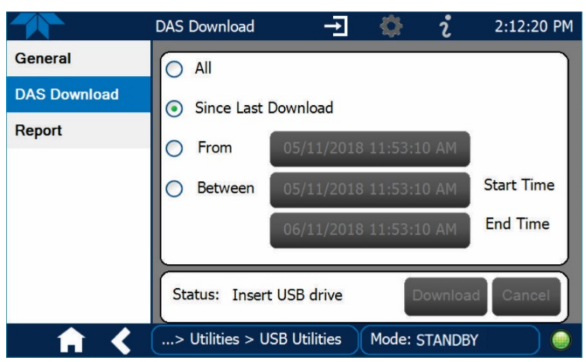


Figure 2-25. DAS Download Page

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 2-26) under the Setup menu.

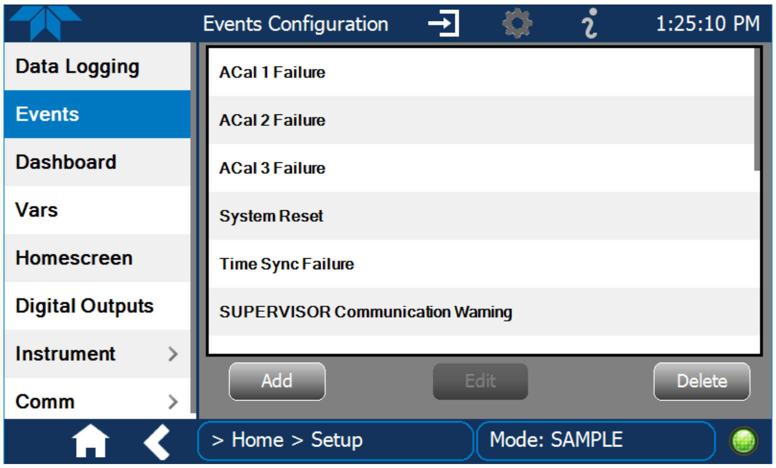


Figure 2-26. Events List

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 2-26). Press ADD to create a new Event (refer to Figure 2-27 for details), or select an existing Event to either Edit or Delete it (Figure 2-29).

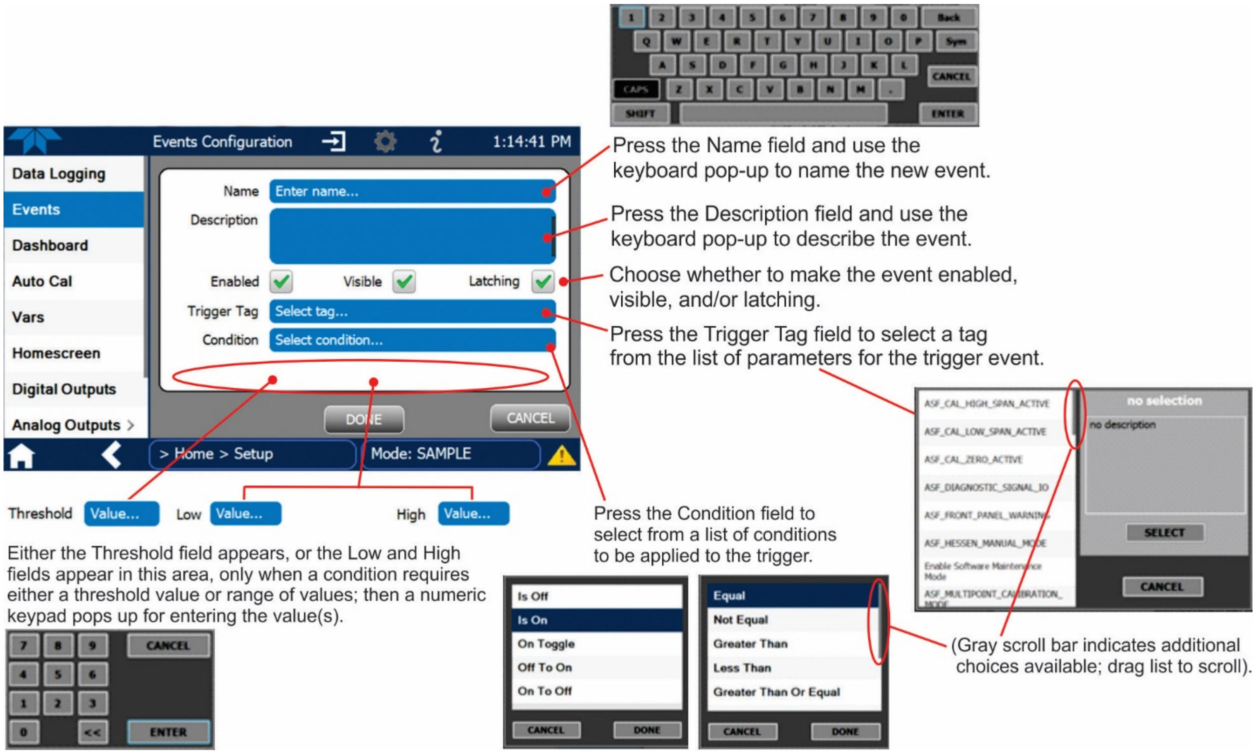


Figure 2-27. Event Configuration

- 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).

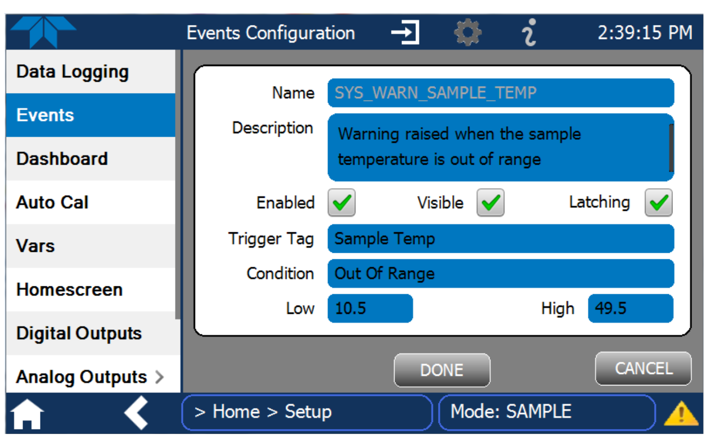


Figure 2-28. Configured Event Sample

2.5.2.1. Editing or Deleting Events

Select an Event from the list (Figure 2-26) and press the Edit button to view or edit the details (Figure 2-28), or press the Delete button to delete the Event.

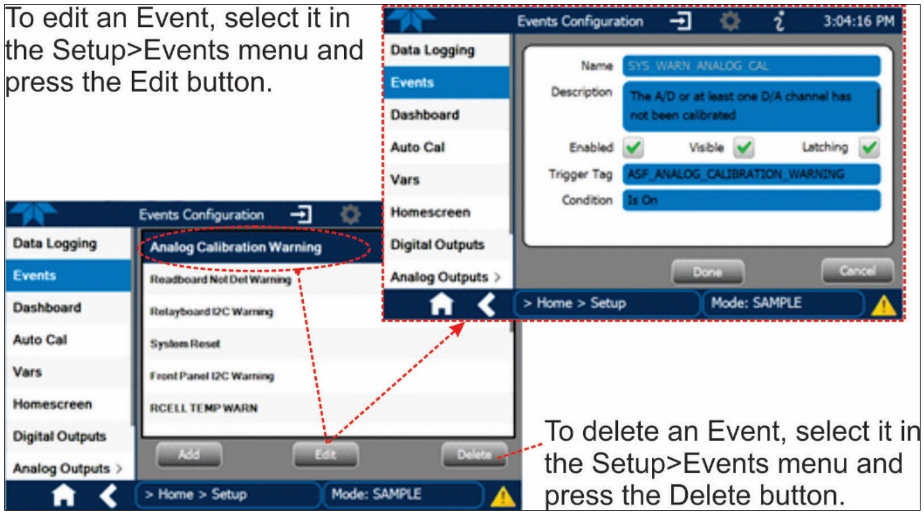


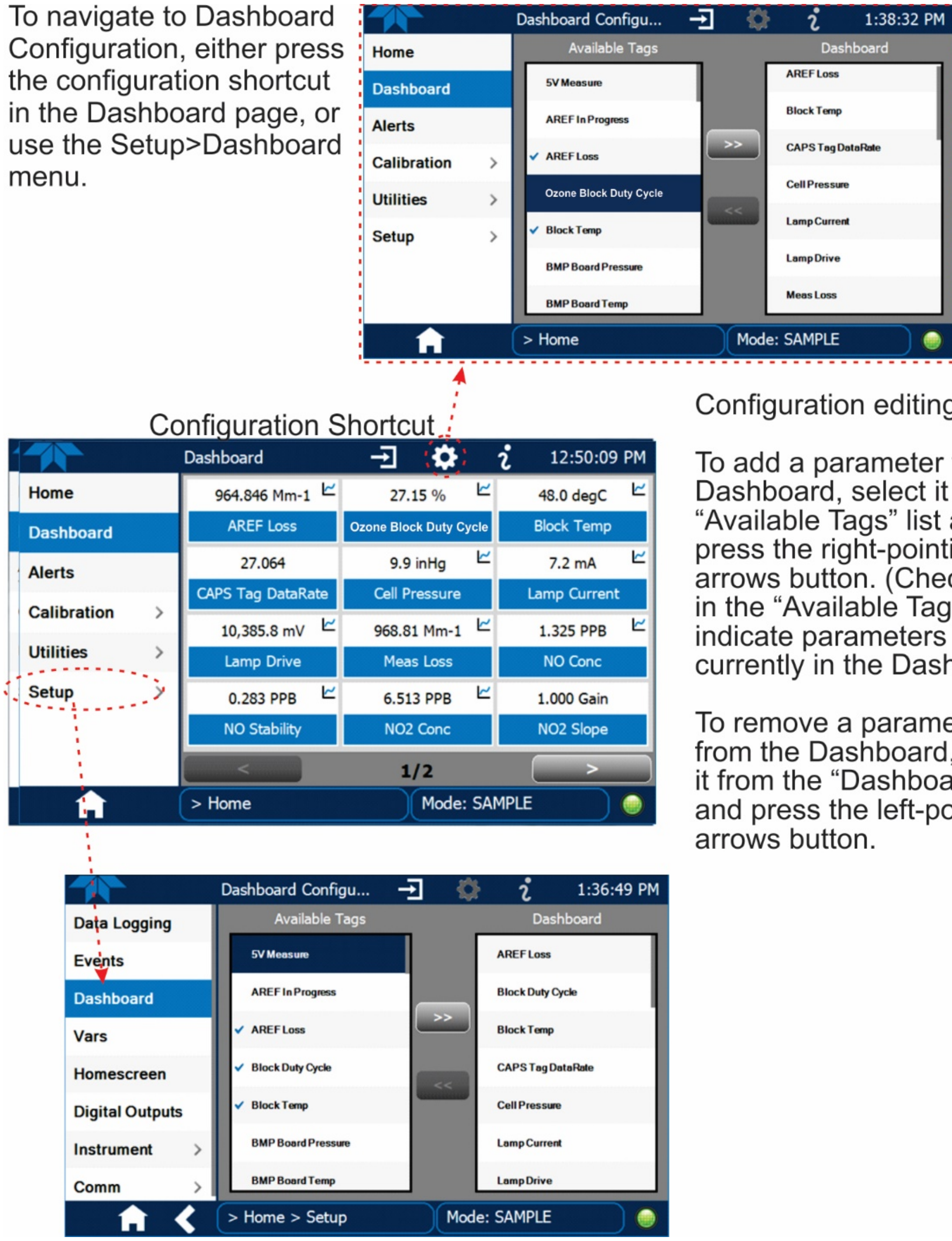
Figure 2-29. Edit or Delete an Event

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 2-30. 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 user-adjustable software variables that define operational parameters automatically set by the instrument's firmware. Access the menu to see the list of variables; select a variable to view its description; use the Edit button to change its setting(s).

Table 2-8. List of Variables with Descriptions

VARIABLE	DESCRIPTION
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.	
Background Periodic Report Upload	Allows/disallows uploading of basic functionality reports to a Web services "cloud" for TAPI Technical Support to view. (Frequency can be edited in Setup>Vars>Report Upload Interval).
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 smokestack 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 NO, NO_2 and NOx concentration calculations so that the undiluted values for measurement range and concentration are shown on the instrument's front panel display and reported via the instrument's various outputs. Set the appropriate units of measure (Setup>Vars>User Units). 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. 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). 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.
Instrument ID	Set unique identifier number for the instrument when it is connected with other instruments on the same Ethernet LAN, or when applying MODBUS protocol.
Measure Mode	Set gas measure mode.
Ozone Lamp Setpoint	(Adjustment is dependent on low Titration Efficiency, Section 4.4).
System Hours	Total system runtime hours
Titration Efficiency	Used for checking or calibrating efficiency of ozone titrating NO (Section 4.4).

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 2-31).

Figure 2-31. Homescreen Configuration

An orientation to the Homescreen was presented in Section 2.4.1, including Figure 2-14 and Figure 2-15.

2.5.7. SETUP>DIGITAL OUTPUTS (OPTION)

Specify the function of each digital output (connected through the rear panel Digital I/O connector, Figure 2-5) by mapping the outputs to a selection of "Signals" present in the instrument. Create custom "Signals" in the Setup>Events menu (Section 2.5.2). The three Relays can also be connected, and functions assigned.

To map Digital Outputs to Signals, select a pin in the Outputs list (DO1 thru DO5), 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). Map the Digital Relays in the same manner.

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

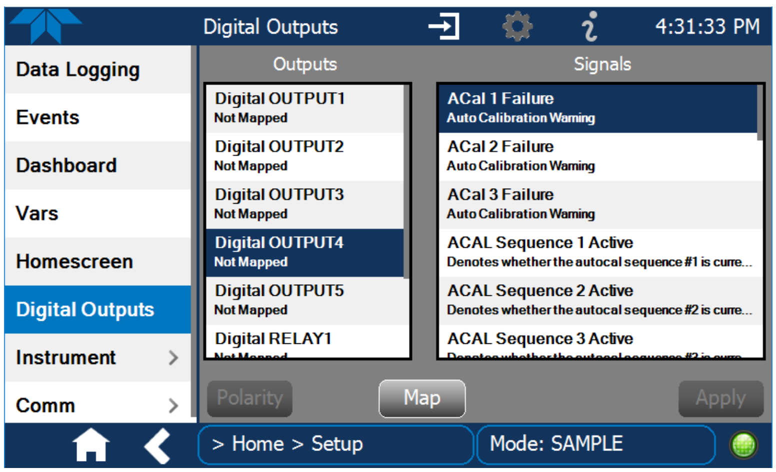


Figure 2-32. Digital Outputs Setup

2.5.8. SETUP>ANALOG OUTPUTS (OPTION)

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

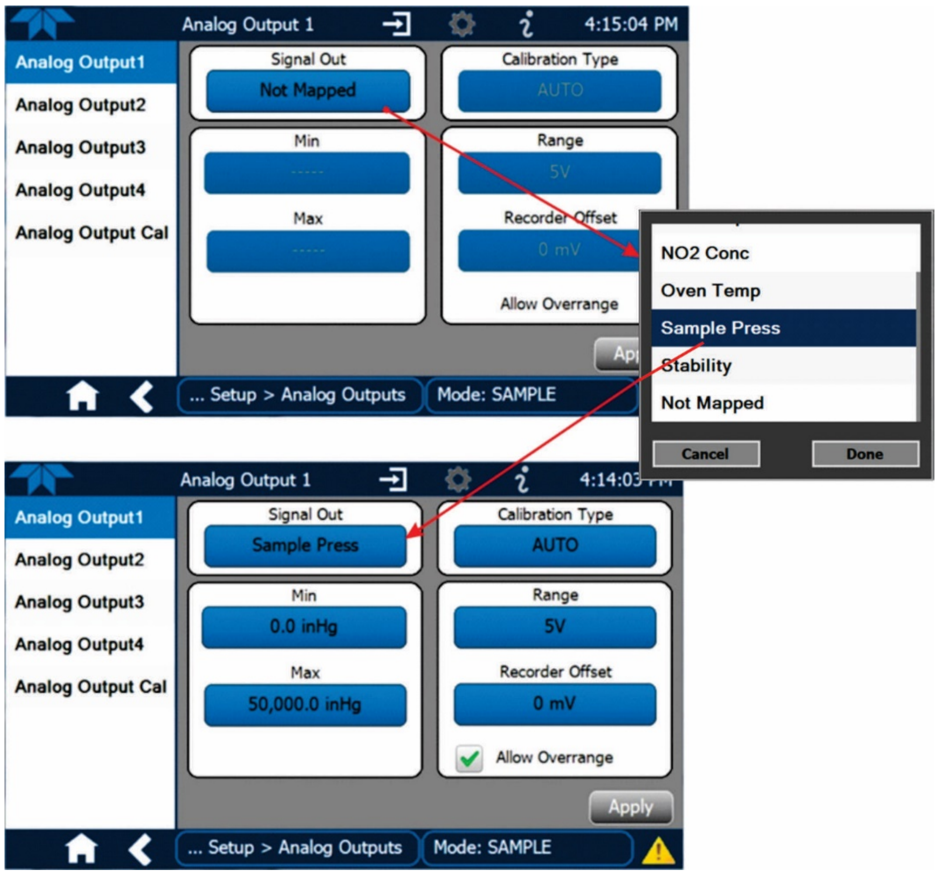


Figure 2-33. Analog Output Option Configuration Example

Refer to Figure 2-33 for the following settings in each of the fields:

- 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 2-34) of the analog outputs (cannot be selected when Current is selected for the Range)
    - MANUAL for individual calibration (Figure 2-35) 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 2-9).
- 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.

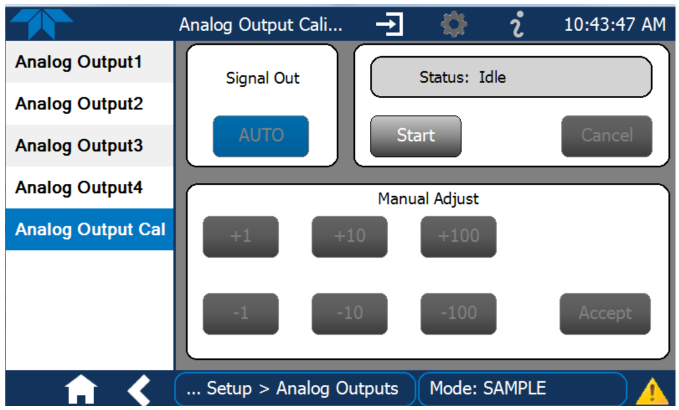


Figure 2-34. Analog Outputs Group Calibration Screen

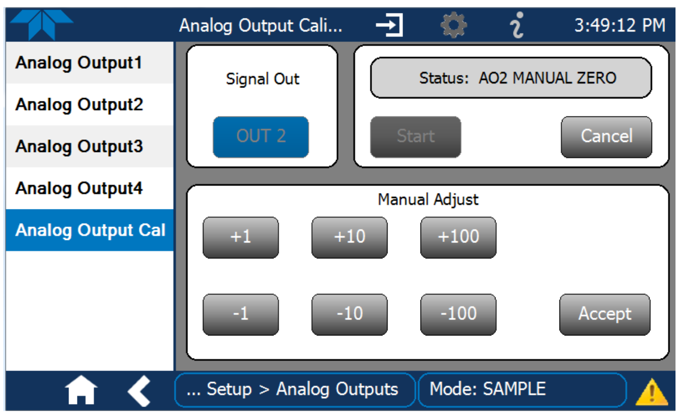


Figure 2-35. Analog Outputs Option Manual Calibration Screen (AOUT2 Example)

Table 2-9. Analog Output Option Voltage/Current Range

RANGE[1]	RANGE SPAN	MINIMUM OUTPUT	MAXIMUM OUTPUT
5V	0-5 VDC	- 1 VDC	6 VDC
10V	0-10 VDC	- 2 VDC	12 VDC
Current	4-20 mA	3 mA	21 mA

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

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 Option

It is possible to manually calibrate the voltages by using a voltmeter connected across the output terminals (Figure 2-36) and changing the output signal level when Manual is selected in the Calibration Type field of the Analog Output screen (Figure 2-35).

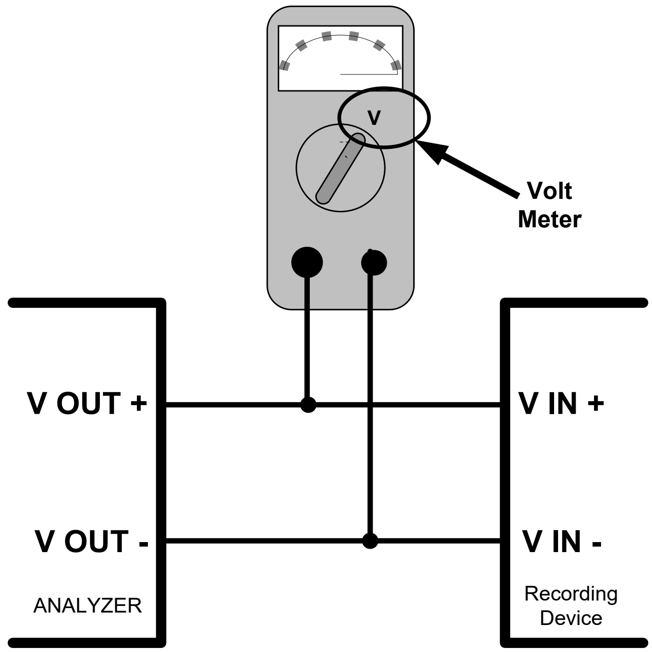


Figure 2-36. Setup for Checking / Calibrating DCV Analog Output Signal Levels

2.5.8.2. Manual Adjustment of Current Range Analog Outputs Option

This option changes the normal DC voltage output to a 4-20 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. 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.

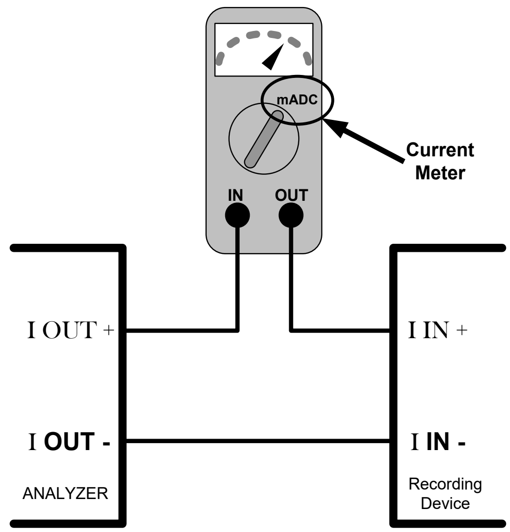


Figure 2-37. Setup for Checking / Calibrating Current Output Signal Levels

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.

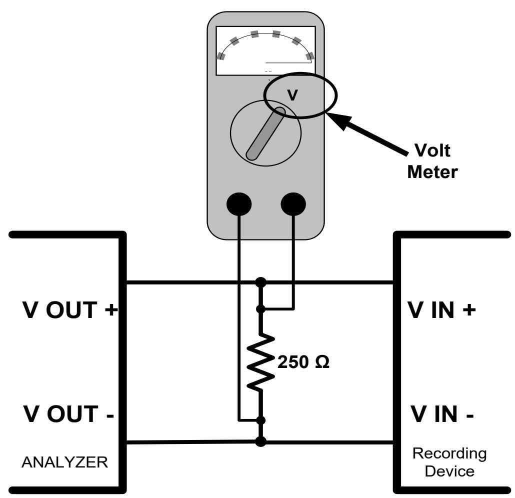


Figure 2-38. Alternative Setup Using 250Ω Resistor for Checking Current Output Signal Levels

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

Table 2-10. Current Loop Output Check

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

2.5.9. SETUP>INSTRUMENT

As presented in Table 2-11, view product and system information and network settings, edit network settings, and perform certain maintenance tasks.

Table 2-11. 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

Configure the instrument's COM port to operate in modes listed in Table 2-12.

Table 2-12. COM1 Setup

MODE	DESCRIPTION
Baud Rate	Set the baud rate.
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.

MODE	DESCRIPTION
Modem Init String	Input an initialization string to enable the modem to communicate.
Parity	Select odd, or even, or no parity (typically set in conjunction with Data Bits and Stop Bits).
Protocol	If selecting a MODBUS protocol, see Handshaking Mode notes, this table; MODBUS Registers are presented in Appendix A, this manual. Also see www.modbus.org.
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.
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 (Registers provided in Appendix A).

2.5.10.4. **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 2-13 for information).

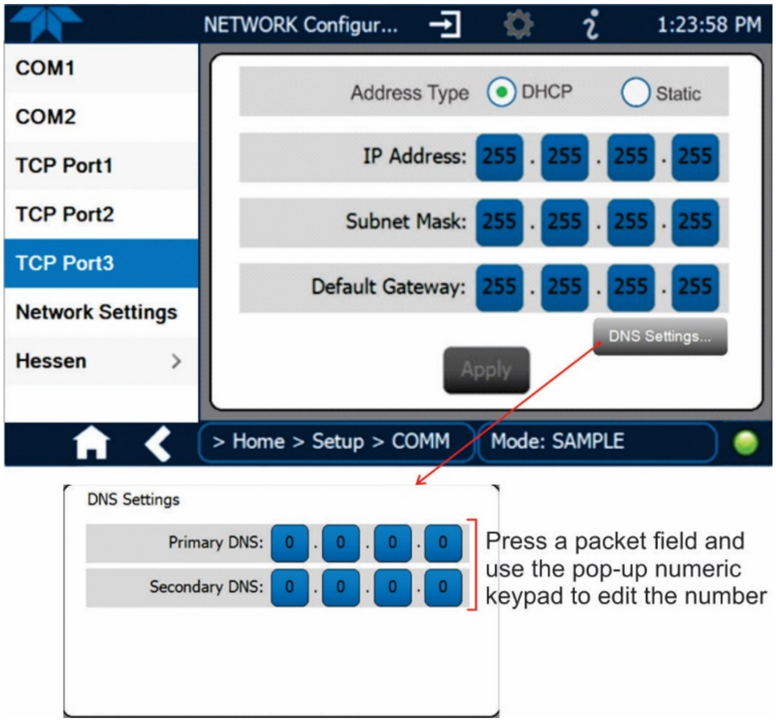


Figure 2-39. Communications Configuration, Network Settings

Table 2-13. 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.

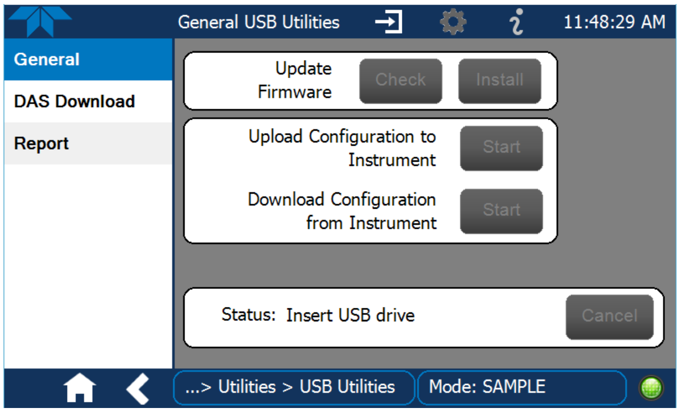


Figure 2-40. Configuration Transfer

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 and a serial communications port. Connection instructions were provided in Section 2.3.1.4. Configuration information was provided in Section 2.5.10.

Data acquisition is set up through the Datalogger (Section 2.5.1).

3.1. SERIAL COMMUNICATION

The rear panel COM port operates on the RS-232 protocol (default configuration is DCE RS-232), or it can be configured for DTE RS-232.

Referring to Table 2-12, use the SETUP>COMM menu to view/edit the communications settings for the COM port.

3.2. ETHERNET

When using the Ethernet interface, the analyzer can be connected to any 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
green (link)	On when connection to the LAN is valid.
amber (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 2.5.10.4 for configuration details.

3.3. NUMAVIEW™ REMOTE

For remote operation and data capture through an Ethernet connection, please refer to the NumaView™ Remote Software User Guide, PN 08492, available on our website.

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 – Titration Efficiency (TE) Check/Calibration: describes corrections made for titration effects.

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 Generator (e.g., T701)
- 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 of NO_2 due to the possibility of O_2 diffusing into the tubing.

Optional equipment:

Calibrator with photometer option (e.g., T700U) for use with NO and GPT to span the analyzer.

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.**

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 T701, can be used.

4.1.3. CALIBRATION (SPAN) GAS

NO_2 cylinder Calibration gas is diluted, using a T700 calibrator, to match the chemical composition of the type of gas being measured at near full scale of the desired reporting range. Thus, it is recommended that the span gas be of a concentration equal to 80% of the measurement range for your application.

Alternatively, if a calibrator is available that contains 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 using GPT.

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 cylinder of higher concentration combined with a gas dilution calibrator such as the Teledyne API Model T700. Calibrators mix high concentration span 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 module 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 User Units setting and Titration Efficiency (TE) value:

- User Units (unit of Measure): PPB
- TE is 96% or greater (check Titrate Eff in Dashboard; if less than .96, adjust in Setup>Vars – see Section 4.4. No adjustment needed if ≥ .96).

Then perform the calibration:

- Perform a Zero calibration using zero air on both NO_2 & NOx channels.
- Perform a Span calibration on both the NO_2 & NOx channels using a known concentration of NO_2 span gas.
- Perform the Titration Efficiency (TE) check using a known concentration of NO span gas. No adjustment of TE value is required if the efficiency is good.

Note	**The span gas concentration should be 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 calibration 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.

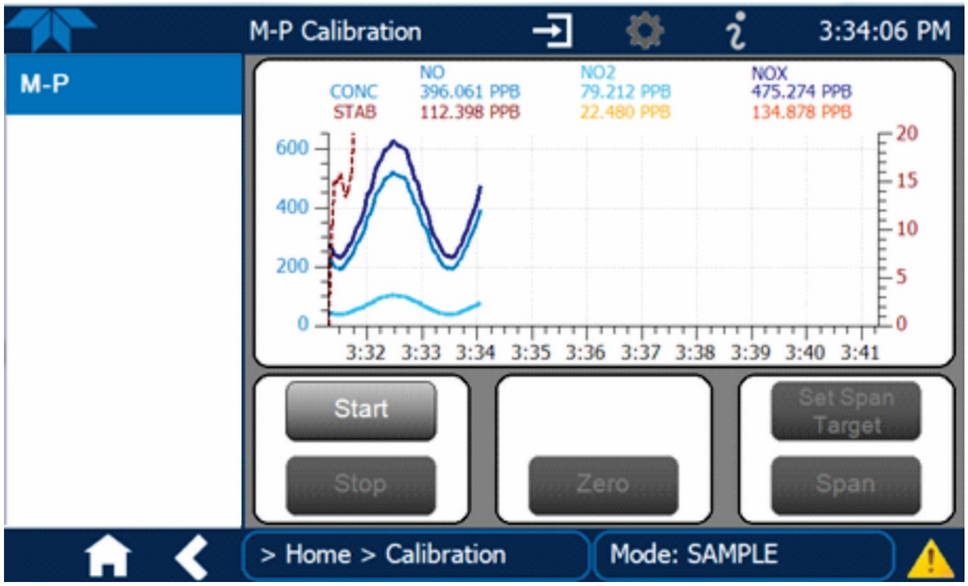


Figure 4-1. Multi-Point Calibration Page

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:

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

ACTUAL CALIBRATION:

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

4.2.1.2. SPAN CALIBRATION CHECK AND ACTUAL CALIBRATION

1. While still in the Calibration>M-P menu, input NO_2 Span gas through the Sample port and press the Start button.
2. Either check or calibrate as follows:

CHECK ONLY:

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

ACTUAL CALIBRATION:

a. Press the Set Span Target button and enter the NO_2 and NOx concentrations.
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(s) and the Offset(s).

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 NO_2 Span cal.

4.2.2.1. USE OF ZERO/SPAN VALVE WITH DIGITAL EXPANSION BOARD OPTION

Digital inputs are available for controlling calibration and calibration checks , when the Digital I/O Board option is installed. Instructions for setup and use of this option are outlined in Section 2.3.1.3.

When the Digital Inputs are activated 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 Digital Inputs may be activated in any order.
- It is recommended that the Digital Inputs 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 Input remains closed.

If Digital Inputs 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 Input 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.

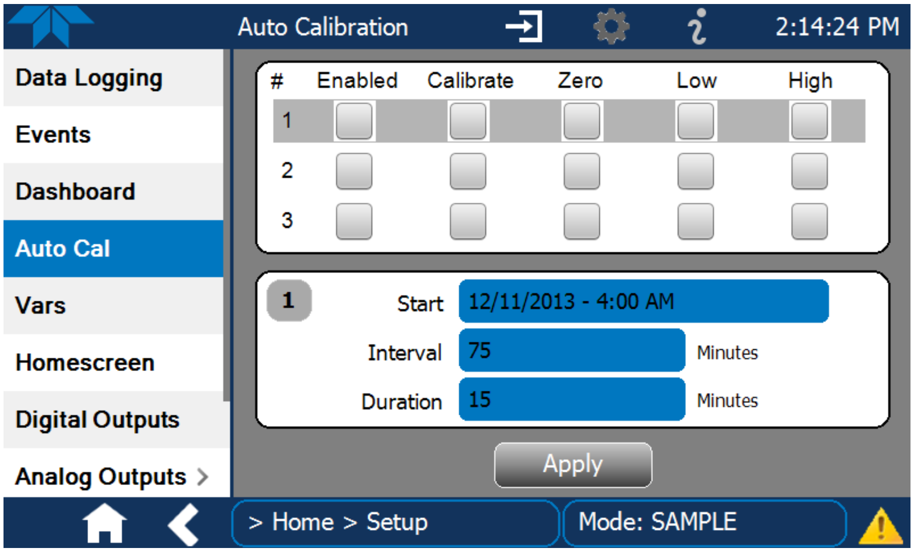


Figure 4-3. Auto Cal Page

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 2.5.7).**
- **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. TITRATION EFFICIENCY (TE) CHECK/CALIBRATION

The efficiency at which the O_3 titrates NO into NO_2 in the sample gas is consistently high, so the need for adjustment is rare. However, if efficiency comes under question , the firmware includes a Titration Efficiency (TE) gain factor that is used to adjust the calculated NO gas concentration. This gain factor is stored in the analyzer's memory.

The method is to first ensure that the instrument is calibrated with NO_2, then deliver a known concentration of NO span gas, typically 80%-90% of the desired range. Note that O_2 is needed in the sample path in order to produce the O_3 that will allow the indirect NO measurement through titration. After the instrument stabilizes, perform a TE adjustment in the Vars menu, if required (Setup>Vars>Titrate Eff). This adjusts the calculated NO concentration, which is then added to the measured NO_2 concentration to calculate the corrected NO_X value.

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: http://www3.epa.gov/ttn/amtic/criteria.html; 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 at http://www.gpo.gov/fdsys/) and with Quality Assurance Guidance documents (available on the EPA website: http://www3.epa.gov/ttn/amtic/qalist.html). Give special attention to specific regulations regarding the use and operation of ambient NO_X analyzers using Cavity Attenuated Phase Shift Spectroscopy method.

5. MAINTENANCE AND SERVICE

Although the Model N500 analyzer requires little service, a few simple procedures should be performed regularly to ensure that it 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									
Dashboard 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 assembly	Change	Annually	Yes										
Spectrometer mirrors	Contact Technical Support	As necessary due to excessive Measured Loss	Yes										
Sample conditioner filter assembly	Change	Only if necessary (contact Technical Support)	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
Cell Press (pressure)	Constant within atmospheric changes	Fluctuating	Developing leak in pneumatic system. Check for leaks.
		Slowly increasing	Developing leak in pneumatic system. Check for leaks. Pump aging.
		Slowly decreasing	Sample filter getting clogged with dust. Replace sample filter.
AREF	Constant within ±100 Mm-1 of check-out value	Significantly increasing	Developing AREF valve failure. Replace valve.
			Developing leak in pneumatic system. Check for leaks.
			Debris on mirrors. Contact Technical Support.
Gas Conc (concentration)	Constant for known gas 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.

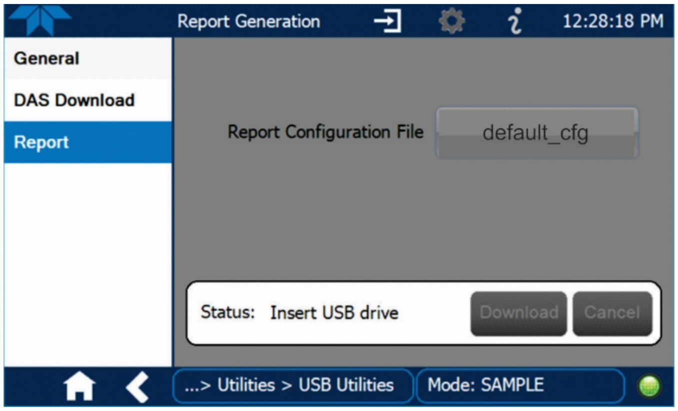


Figure 5-1: Report Generation Page

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.

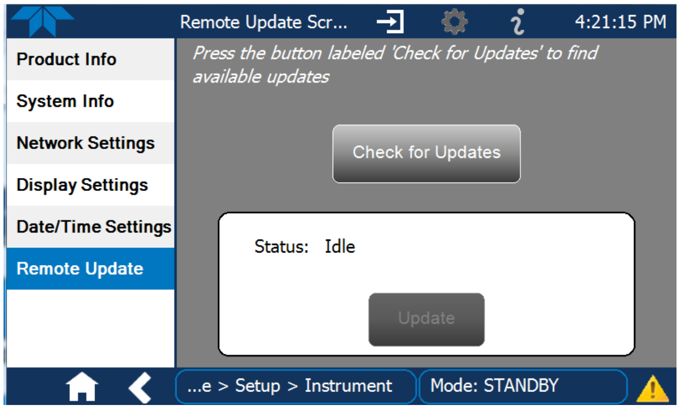


Figure 5-2. Remote Update Page

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.

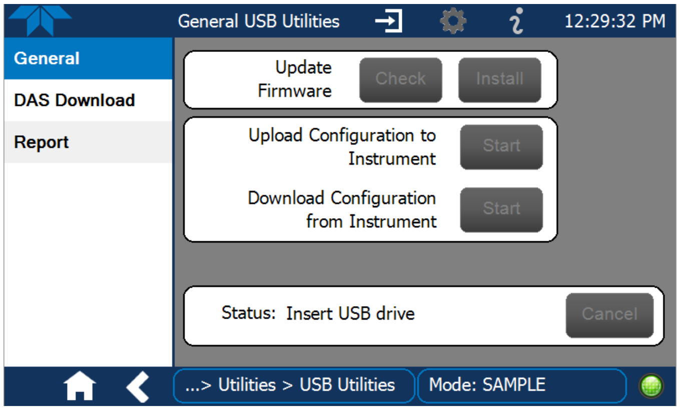


Figure 5-3. Manual Update Page (and other utilities)

3. Insert a flash drive into a front panel USB port and wait for the Status field to Indicates 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.

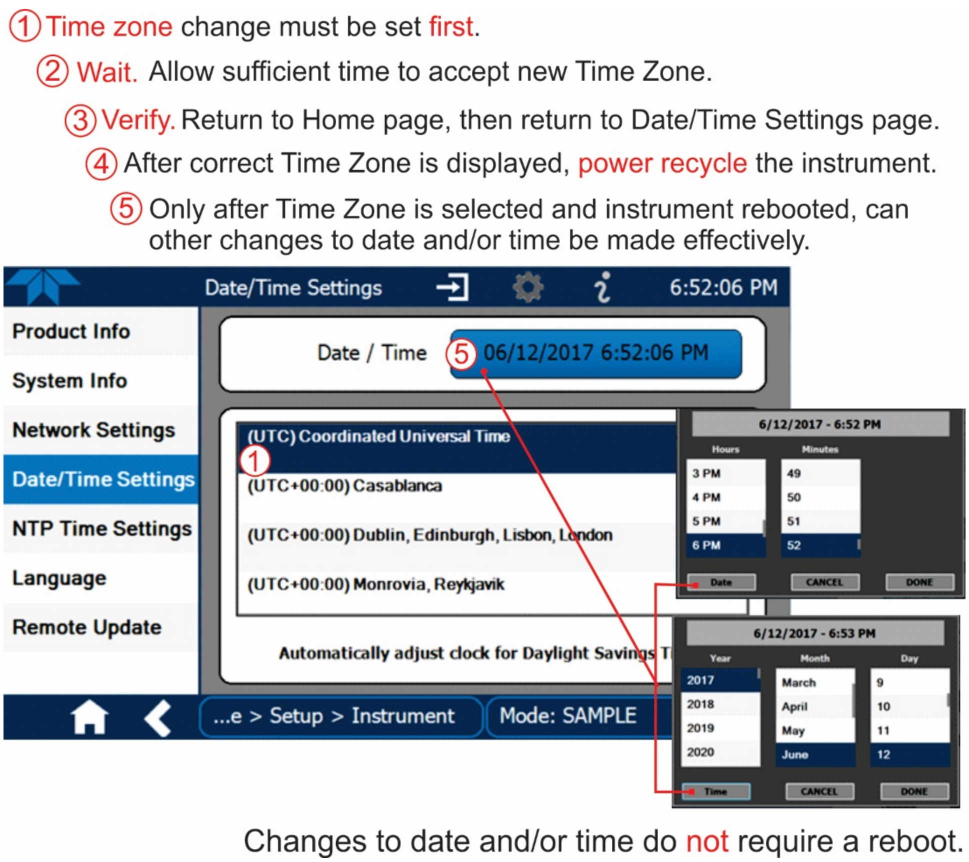


Figure 5-4. Time Zone Change Requirements

5.6. HARDWARE MAINTENANCE PROCEDURES

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

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Ensure there is no power to the unit so that there is no vacuum of any kind when changing anything in the pneumatic flow path. Dust entering the Optical Cell erroneously will contaminate the mirrors.

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 rear 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

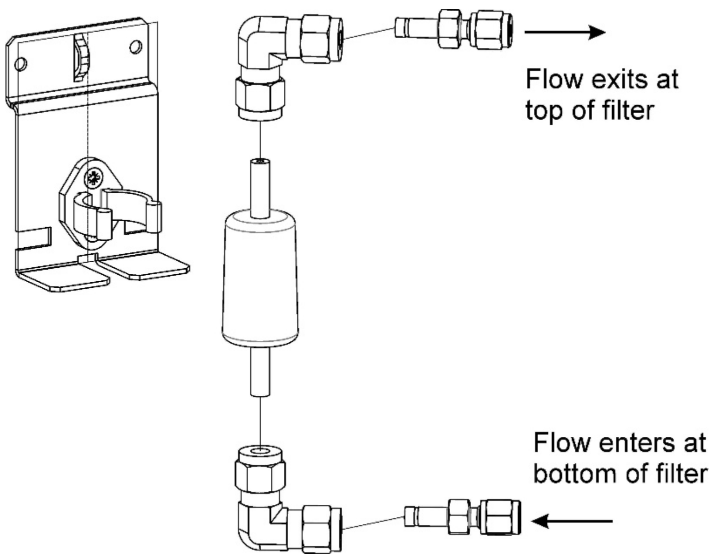


Figure 5-5. Replacing the Sample Filter

5.6.2. REPLACING THE AREF SCRUBBER AND FILTER ASSEMBLY

The AREF filter assembly consists of the AREF DFU filter, which is a backup particulate filter, and the charcoal filter, which is an NO_x 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.

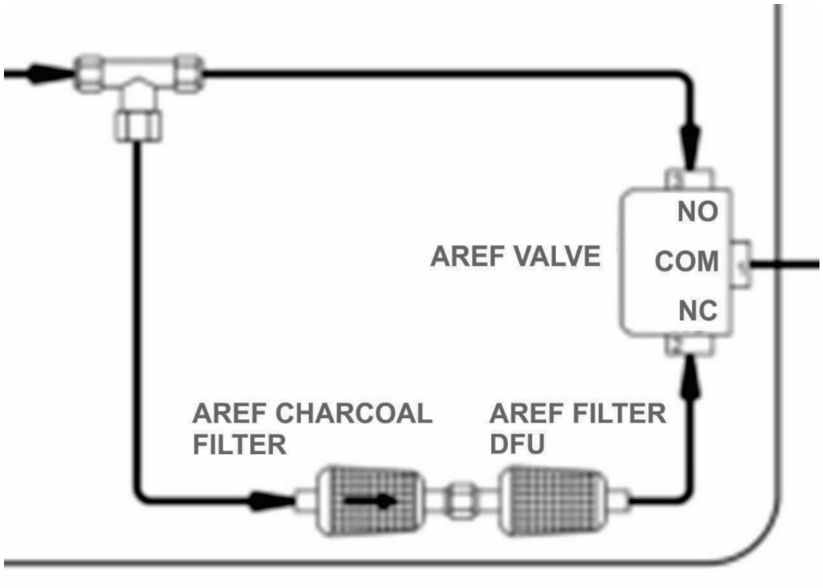


Figure 5-6. Pneumatic Layout of AREF Filter and Charcoal Filter

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, using caution against pinching wires or pneumatic tubes under bracket.
11. Connect the power connector.
12. Once complete, replace the instrument cover and perform a system leak check procedure.

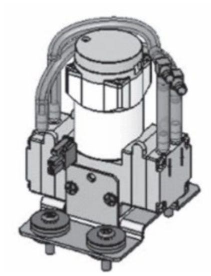


Figure 5-7. Internal Pump

5.6.4. CHANGING THE IZS PERMEATION TUBE OPTION

1. Turn off the analyzer, unplug the power cord and remove the cover.
2. Locate the oven with the internal zero span (IZS) gas permeation tube.
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 screwdriver.
    - Leave the fittings and tubing connected to the cover.
    - ***Never apply power to the analyzer when the internal pneumatics are disconnected.***
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 and return the insulation if removed.
    - 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 tube 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. 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 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.
   - When performing a pressure leak test, always pressurize through the **Sample port (not Exhaust)**.
   - Do not exceed 10 psi pressure.
   - Relieve pressure by removing cap fitting at **Exhaust port**.
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 first, allowing enough time to fully pressurize the instrument.
   - Do not exceed 10 psi pressure.
   - Wet the bench with soap solution last.
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.

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. Refer to Figure 5-8, Figure 5-9, and Figure 5-10
4. Suspect a leak first!
    - Customer service data Indicates 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.

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, smart module, mainboard) 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
CELL PRESS WARN	Cell pressure is too high or too low for accurate NO, NO_2, NO_x readings. (<5 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 Cell Pressure is < 5 in-Hg: •Failed Pressure Sensor/circuitry If Cell Pressure is > 35 in-Hg: •Bad Pressure Sensor/circuitry •Pressure too high at Sample Inlet.
CONFIG INITIALIZED	Configuration and Calibration data reset to original Factory state or erased.	User erased data
DATA INITIALIZED	Data Storage in DAS was erased before the last power up occurred.	User cleared data.

WARNING	FAULT CONDITION	POSSIBLE CAUSES
SAMPLE PRESS WARN	Sample pressure is too high or too low for accurate NO, NO_2, NO_x readings. (<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:Fatal Error caused software to restart •Loose connector/wiring

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.

The acceptable ranges for these functions are listed in the "Nominal Range" column of the analyzer's *Final Test and Validation Data Sheet* shipped with the instrument. Values outside these acceptable ranges Indicates 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 Indicates a failure.

Make note of these values for reference in troubleshooting.

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 functions in the analyzer. Some of the digital signals can be controlled through the Setup menu. These signals 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 use the Setup menu to control the state of an output voltage or control signal.

5.7.4. FAULT DIAGNOSIS WITH LEDS

The following illustrations show connectors and LEDs that can indicate where issues may lie. Figure 5-8 shows the layout for the mainboard; Figure 5-9 shows the layout for the CAPS DAQ smart board, and Figure 5-10 shows the layout for the ozone tower smart module.

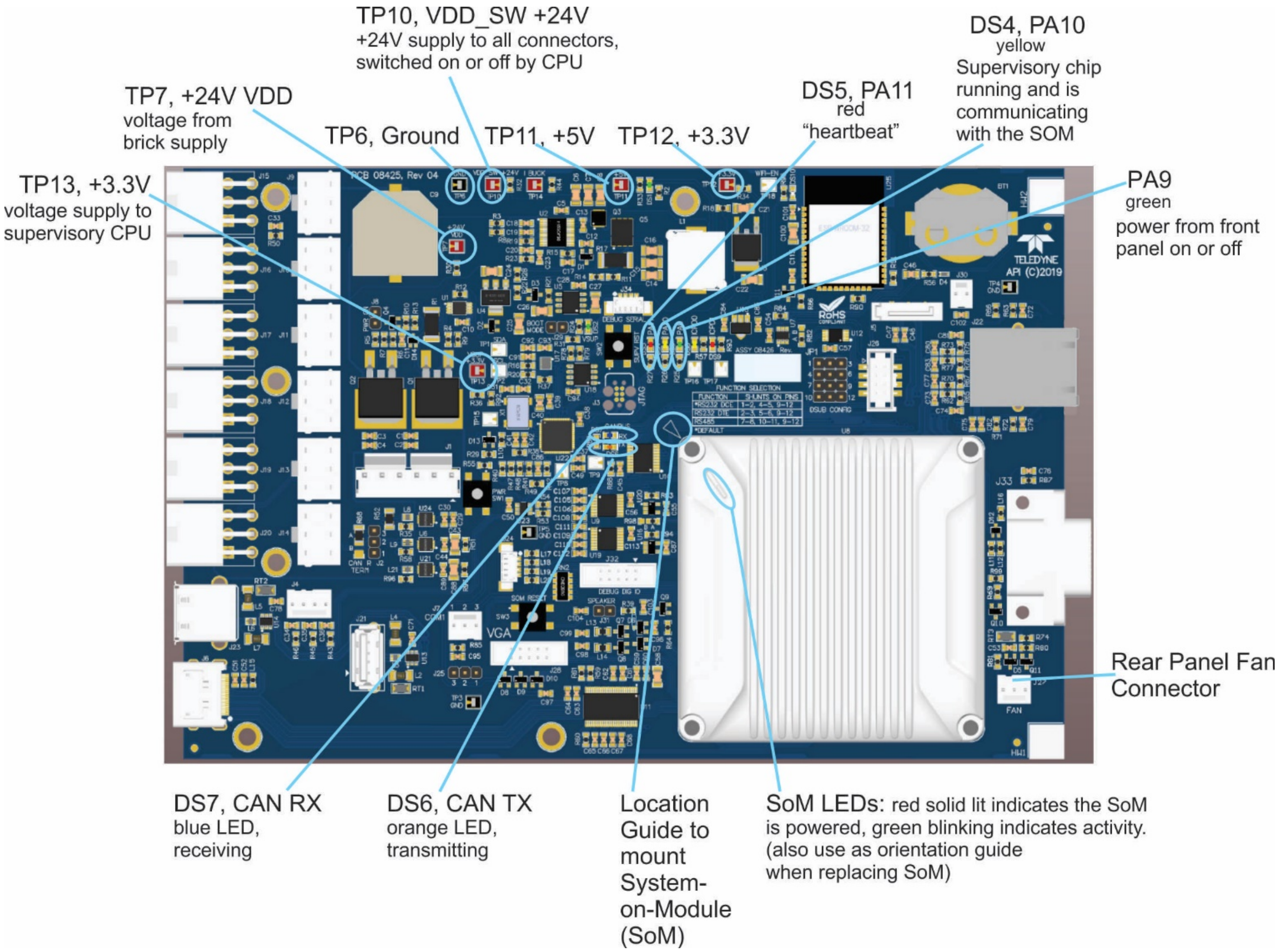


Figure 5-8. N500 Mainboard

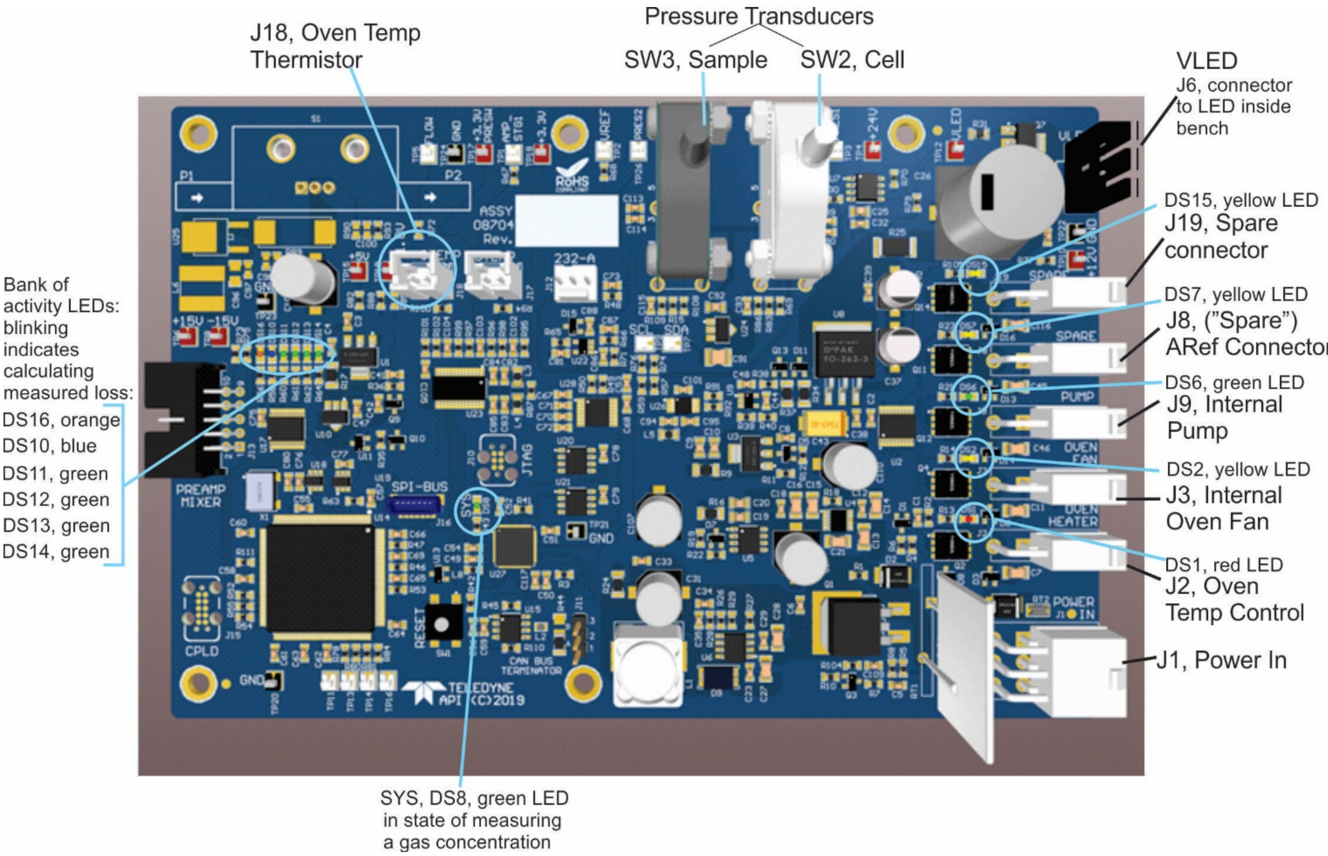


Figure 5-9. N500 CAPS DAQ Smart Board

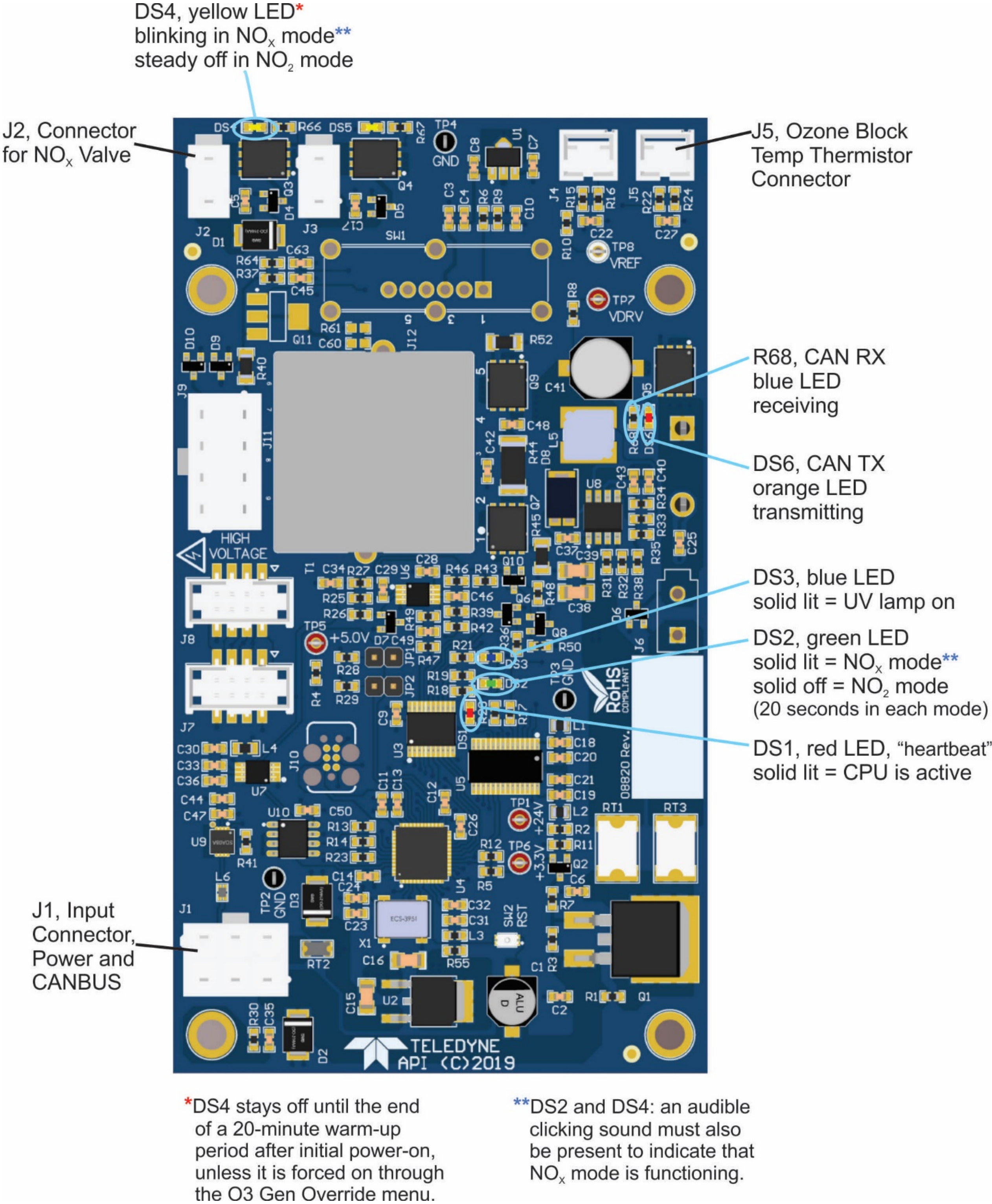


Figure 5-10. N500 Ozone Tower Smart Board

5.7.5. CALIBRATION PROBLEMS

This section describes possible causes of calibration problems.

5.7.5.1. Negative Concentrations

Negative concentration values can be caused by 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_x.

5.7.5.2. 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 NO2 span gas of about 80% of the range value to the analyzer.
2. Check the sample pressure and cell pressure for proper value.
3. Check for disconnected cables to the sensor module.
4. If delivering NO gas, check that the Lamp Current is 7-10 mA and the NOx valve is Pulsing in NOx mode. There is an audible clicking sound when the valve activates.

5.7.5.3. 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, cell pressure, and sample flow are correct and steady.
5. Verify that the sample filter element is clean and does not need to be replaced.

5.7.5.4. 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_2 span gas source is accurate.
   - This can be done by comparing the source with another calibrated analyzer.

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.

5.7.5.5. 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.

5.7.5.6. 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. 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.

5.7.6.1. Excessive Noise

Excessive noise levels under normal operation usually Indicates 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 or large ambient Temperature changes.

- Gain access to the instrument, when powered down, and reset the cable connectors.
- Do not locate the analyzer in the vicinity of the air conditioning ducting.

5.7.6.2. 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 calibration gas source to stabilize. Wait until stability is reached.

5.7.6.3. 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 its D7 LED (associated with J8 connector) on the CAPS DAQ board lights accordingly
  - Check the power supply to the valve (24 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.

5.7.7. 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.

5.7.7.1. AC MAIN POWER

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.

The instrument's electronic systems will operate with any of the specified power within the 100 VAC to 240 VAC, at 47 Hz to 63 Hz. Using the properly rated power cord, the instrument will power on when the rear panel Hard Power switch is placed in the ON position. (If the power source is disrupted, the instrument will turn on once the power is restored. If the instrument doesn't start, check the following possible causes and possible solutions:

- Check the power cord for damage, such as whether it's cut or burned.
- Check that the power cord is adequately rated for the instrument's specified power rating.
- Check that the power source is of the proper voltage for the instrument's specified power rating.
- If there are no findings in the preceding steps, then note whether the instrument had been opened for maintenance; if so, place the rear panel Hard Power switch in the OFF position, and disconnect the power cord; then reopen the instrument and check that no wiring had been dislodged, and no tools were left inside.
- If no other reason can be found for the instrument not powering on, then check the fuse with an ohmmeter to determine its viability: carefully follow the instructions in Section 5.7.8.1 to remove the fuse for testing.
    - If the fuse is blown, replace it with a fuse of the correct specifications as instructed in Section 5.7.8.1.
- If the fuse is not blown, or if the replacement fuse blows, then call Technical Support (Section 5.9).

5.7.7.2. LCD/Display Module

Assuming that there are no wiring problems and that the DC power supply is 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.

5.7.7.3. O_3 Generator Module

The ozone generator can fail in three ways, electronically (printed circuit board) and functionally - UV Lamp issues or NOx valve issues. Assuming that air is supplied properly to the generator, the generator should automatically turn on 30 minutes after the instrument is powered up. However, if the generator appears to be working properly but the sensitivity or calibration of the instrument is reduced, suspect a leak in the ozone generator pneumatics or a NOx valve that isn't cycling On/Off in NOx mode.

A leak in the dryer or between the dryer and the generator can reduce sensitivity and cause performance drift. Carry out a leak check (Section 5.6.5).

5.7.7.4. O_3 Generator Override

This feature in the Utilities>Diagnostics menu is used to manually turn the ozone generator off and on. This should be done before disconnecting the generator, to prevent ozone from leaking out, and after a system restart if the user does not want to wait the 30-minute warm-up time.

5.7.7.5. 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 highly 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 Outputs menu (configurable in the Setup>Analog Outputs menu). At 50° C, the temperature signal from the IZS thermistor should be around 2500 mV.

5.7.7.6. RS-232 Communications

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 such things as incorrect connector configuration, incorrect software settings, improper/incomplete seating of the internal cable. Do not do anything inside the instrument without first contacting Technical Support (Section 5.9). For additional information, see Section 2.3.1.4 under "Serial Connection."

5.7.8. 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.

5.7.8.1. FUSE REPLACEMENT PROCEDURE

ATTENTION — **COULD DAMAGE INSTRUMENT AND VOID WARRANTY**

Fuses do not typically fail without definite cause. Do not attempt to replace until after all measures to detect the cause of a power failure, per Section 5.7.7.1, have been carried out, including Soft Power switch LED not lit (neither solid nor blinking), but Hard Power switch is in ON position and instrument's power cord properly connected at both ends. If an ohmmeter shows that the fuse is good, or if a new fuse blows, call Technical Support (Section 5.9).

WARNING – ELECTRICAL SHOCK HAZARD

Never pull out fuse drawer without ensuring that the Hard Power switch is in OFF position and power cord disconnected, to ensure there is no power to the instrument before checking/changing fuse.

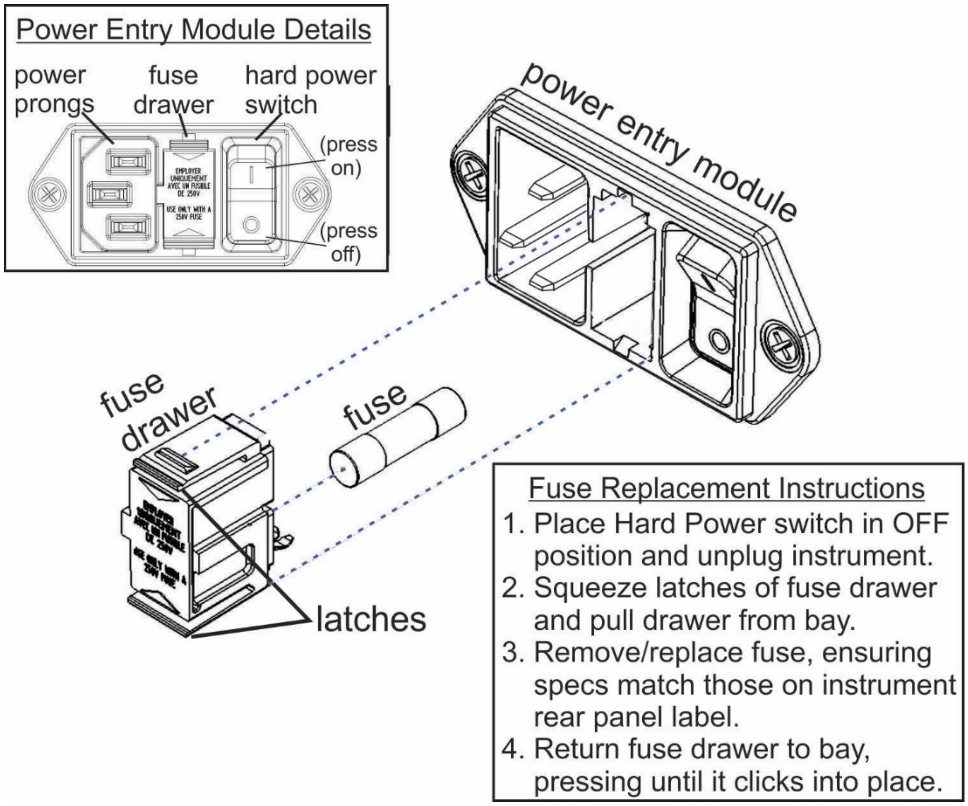


Figure 5-11. Fuse Access

5.7.8.2. O_3 Generator Replacement

The ozone tower has a printed circuit board (see Figure 2-3). The board has a blue LED that, when lit, indicates ozone is being generated. To replace the ozone generator:

1. Turn off the analyzer power; remove the power cord and the analyzer cover.
2. Disconnect the tubing from the ozone generator. ***Never apply power to the analyzer when the internal pneumatics are disconnected.***
3. Unplug the CANBUS cable that is connected to the PCA.
4. Unscrew the two mounting screws that attach the ozone generator to the chassis and take out the entire assembly.
5. With a complete replacement generator with circuit board and mounting bracket attached, simply reverse the above steps to replace the current generator.

Note	**Ensure to carry out a leak check (Section 5.6.5) and a recalibration after the analyzer has warmed up for about 60 minutes.**

5.7.8.3. SAMPLE CONDITIONER ASSEMBLY REPLACEMENT

The sample conditioner assembly includes a permeation dryer, a Charcoal scrubber (AREF), and a DFU filter.

Change the dryer component as follows:

1. Turn off power to the analyzer and pump and remove the power cord and the analyzer cover.
2. Disconnect tubing to and from assembly. ***Never apply power to the analyzer when the internal pneumatics are disconnected***.
3. Noting the orientation, unscrew the mounting screws and remove the assembly.
4. Install the new assembly in the same orientation as noted in the preceding Step, and secure in place with the mounting screws.
5. Reattach tubing to and from assembly.
6. Carry out a detailed leak check (see Section 5.6.5.1).
7. Close the analyzer and reconnect the power cord.
8. Power up pump and analyzer and re-calibrate the instrument after it stabilizes.

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 Enter button sometimes disappear in some of the menus?	Sometimes the Enter button will disappear if you input 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 outside its allowable limits. Once you adjust the setting to an allowable value, the Enter 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.
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. (Refer to Maintenance Schedule Table 5-1).
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 jumpers are correct (Section 2.3.1.4 under Serial Connection). • The baud rate of the analyzer's COM port does not match that of the serial port of your computer/data logger (Table 2-12).
How do I set up and use the contact closures (Control Inputs) on the rear panel of the analyzer?	See Section 2.3.1.3.

5.9. TECHNICAL ASSISTANCE

For spare parts, or 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_X monitor operates as an optical absorption spectrometer that yields both reliable and accurate measurements 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 405 nm, a measurement cell with high reflectivity mirrors located at either end to provide an extensive optical path length, and a vacuum photodiode 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.

Optical absorption 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 N500 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 405 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 N500
- 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, decreases when NO_2 is present, and is proportionate to the concentration of the NO_2.

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. This 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.

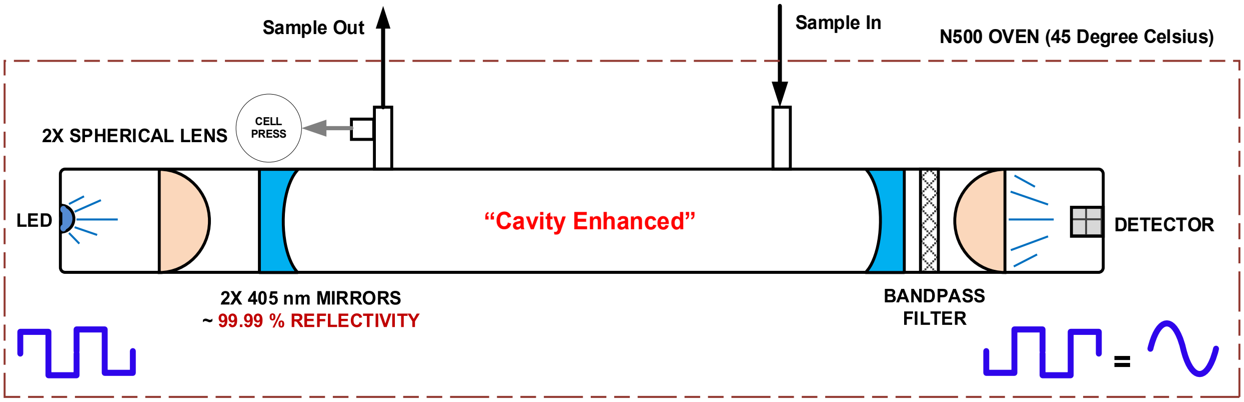


Figure 6-1. N500 Optical Absorption Cell

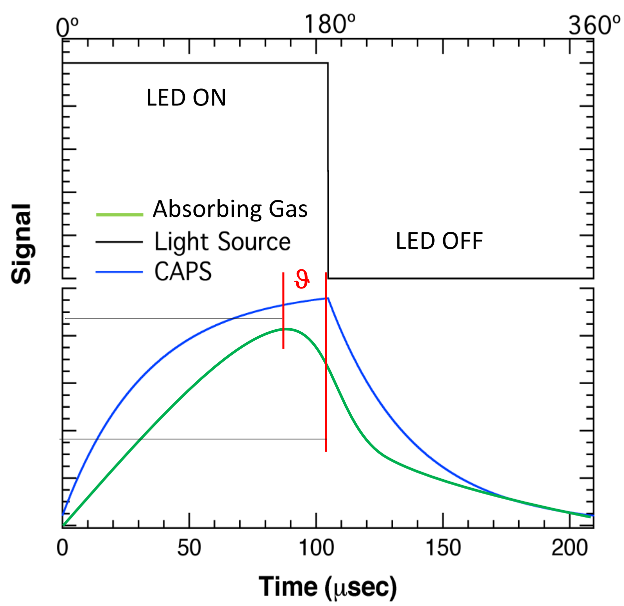


Figure 6-2. Phase Shift Representation of Increased Concentration of NO_2

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

6.1. PNEUMATIC OPERATION

An internal vacuum pump, which is located pneumatically downstream from all the instrument's other components, pulls the sample gas through the instrument's pneumatic pathway. The flow rate is controlled by a flow restrictor placed upstream of the sensor.

After being pulled through a series of filtering and conditioning components, the sample gas is routed through the sensor for a true NO_2 reading; the sample gas is alternately titrated with higher levels of ozone where the sensor reads a second, higher NO_2 concentration (NOx Mode), after which the two readings are used in calculations to provide a NO_X value and an NO concentration. The analyzer alternates between NO_2 mode for 20 seconds and then NO_X mode for 20 seconds.

The alternating valve toggling for ozone titration is very rapid and follows a pattern of signal processing states that the Dashboard displays in the "SigProc State" parameter as described in Table 6-1. To ensure accuracy, the analyzer periodically goes into AREF mode to run a background measurement while in Sample mode and adjusts for any baseline drift that may occur.

Table 6-1. Sensor Signal Processing States

STATE	DESCRIPTION
IDLE	Transitioning between measurement modes (very brief state, typically not visible)
NO2_WAIT	Flushing the cell of the prior NOx sample before taking the NO_2 measurement.
NO2_SAMPLE	Reading NO_2 concentration.
NOx_WAIT	Filling the cell with titrated NOx before taking the NOx measurement.
NOx_SAMPLE	Reading NO_2 concentration in titrated sample (which is representative of NOx concentration).
AUTOREF	In Auto Reference mode. Sample pulled through Charcoal scrubber.

Board LEDs shown in Figure 5-8, Figure 5-9, and Figure 5-10 also indicate what state the analyzer is in.

Briefly summarized, the Model N500 analyzer first measures NO_2 directly by way of optical absorption to yield a true reading of NO_2 concentration. Next, it uses a precisely-timed pulsation to mix the sample with an excessive concentration of O_3 to create NO_X. The software subtracts the NO_2 concentration from the resulting NO_X concentration to calculate an NO reading. The NO concentration is then corrected for titration efficiency (TE) which is then added to the measured NO_2 value to produce a corrected NO_X measurement.

Pressure transducers monitor the sample pressure and the cell pressure to verify pressure levels, which are used for a variety of important calculations and diagnostics.

6.2. ELECTRONIC OPERATION

The electronic platform is based on a Controller Area Network (CAN) bus modular system. CAN is the central networking system that enables communication among all the parts and facilitates centralized diagnoses of errors, as well as configuration of all the parts. CAN bus technology allows for a uniform cable architecture with interchangeable 6-pin connectors configured for power (5 V and 24 V) and communications (CAN high and CAN low serial lines).

The Mainboard is the main hub, which not only contains the Central Processing Unit (CPU) that communicates with other modules, but also directs power and communication distribution. The Mainboard includes an altitude sensor, a temperature sensor, and the Supervisory Chip.

The Supervisory Chip monitors power and the sensors, and when the front panel Soft Power switch is pressed (see Power Switches, Section 6.2.2), the Supervisory Chip directs the soft power down of the internal components, to safely shut down processes and close connections to prevent damage.

6.2.1. MODULES

Each module consists of its own board controlled by a microprocessor that receives messages from and sends information to the Mainboard on the CAN network. Depending on the signal line, CAN Low or CAN High, the modules can determine whether a message is intended for them and what the priority is, and then act on the applicable messages. These are called “Smart Modules,” which conduct local operations, such as activating the zero/span valves, toggling the NOx/NO_2 valve, or controlling manifold temperature. There is also the Sensor Module; it is comprised of the Optical Bench Unit which has the gas sensor inside the main oven and the CAPS data acquisition (DAQ) board with logic device, microcontroller and LED driver mounted on the outside. The Sensor Module calculates gas concentrations and may command the Smart Modules.

6.2.2. POWER SWITCHES

The front panel Soft Power switch is used to protect the internal components from damage. When the instrument is initially powered on, the Supervisory Chip spins up the internal computer components and places them in operational mode (indicated by LED’s solid-lit state). However, before powering off the instrument, pressing and momentarily holding the solid-lit Soft Power switch tells the Supervisory Chip to put the internal computer components through a soft-shutdown process and into deep sleep mode (indicated by LED’s blinking state) in order to protect them from damage when fully turning off power.

The rear panel Hard Power switch is used to turn on or off the instrument; however, before turning off the instrument, the Soft Power switch must be used first as described above. If there is an unexpected loss of source power while the instrument is running, it will power up in the ON state when source power is restored.

GLOSSARY

TERM	DESCRIPTION/DEFINITION
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*
DTE	*Data Terminal Equipment*
EEPROM	*Electrically Erasable Programmable Read-Only Memory* also referred to as a FLASH chip or drive
ESD	*Electro-Static Discharge*

TERM	DESCRIPTION/DEFINITION
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*
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	*Printed 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*
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

TERM	DESCRIPTION/DEFINITION
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

ADDR	DESCRIPTION	UNITS
Discrete Inputs		
1	SYS_WARN_CAPS_COM_WARNING	Indicates status of CAPS board communication warning
2	SYS_WARN_CELL_PRESSURE	Indicates status of cell pressure warning
3	SYS_WARN_MANUAL_AREF	Indicates status of manual auto reference warning
4	SYS_WARN_OZONE_PRESSURE	Indicates status of Ozone pressure warning
5	SYS_WARN_OZONE_TOWER_COM_WARNING	Indicates status of Ozone tower communication warning
6	SYS_WARN_RESET	Indicates status of system reset warning
7	SYS_WARN_SAMPLE_FLOW	Indicates status of sample flow warning
8	SYS_WARN_SAMPLE_PRESSURE	Indicates status of sample pressure warning
9	SYS_WARN_SAMPLE_TEMP_WARN	Indicates status of sample temperature warning
10	SYS_WARN_TIME_NOT_SYNCED	Indicates status of time-since warning
11	SYS_WARN_ACAL1_CAL_FAIL	Indicates Auto-Cal Seq 1 failed
12	SYS_WARN_ACAL2_CAL_FAIL	Indicates Auto-Cal Seq 2 failed
13	SYS_WARN_ACAL3_CAL_FAIL	Indicates Auto-Cal Seq 3 failed
Coils		
20	MB_ZERO_CAL_RANGE1	Trigger zero calibration of NO2 range 1
21	MB_SPAN_CAL_RANGE1	Trigger span calibration of NO2 range 1
Input Registers		
0	NO2_SLOPE1	Slope for range 1
4	NO2_OFFSET1	Offset for range 1 in PPB
8	NO2_PRE_CAL_CONC_1	Concentration just prior to last zero/span cal of range #1
12	NO2_CONC	NO2 concentration for range 1
16	NO2_STABILITY	NO2 stability
18	AI_REALTIME_LOSS	Realtime loss value in Mm-1
20	AI_OVEN_TEMP	Oven temperature in degree C
22	AI_OVEN_DUTY_CYCLE	Oven temperature duty cycle
24	AI_MANIFOLD_TEMP	Manifold temperature in degree C
26	AI_MANIFOLD_CYCLE	Manifold temperature duty cycle
28	AI_IZS_TEMP	IZS lamp temperature in degree C
30	AI_IZS_CYCLE	IZS temperature duty cycle
32	AI_SAMPLE_TEMP	Sample temperature in degree C
34	AI_SAMPLE_PRESSURE	Sample pressure in inches Hg-A
36	AI_BOX_TEMP	Box temperature in degree C
42	AI_PHASE_ANGLE	Phase angle value
44	NO_SLOPE1	NO slope for range 1
48	NO_OFFSET1	NO Offset for range 1
52	NO_PRE_CALC_CONC_1	NO concentration for range 1 during zero/span calibration
56	NO_CONC	NO concentration for range 1
60	NO_STABILITY	NO stability
62	NOX_SLOPE1	NOX slope for range 1

ADDR	DESCRIPTION	UNITS
68	NOX_OFFSET1	NOX Offset for range 1
72	NOX_PRE_CALC_CONC_1	NOX concentration for range 1 during zero/span calibration
76	NOX_CONC	NOX concentration for range 1
80	NOX_STABILITY	Concentration stability
Holding Registers		
0	NO2_TARGET_SPAN_CONC_1	NO2 Target span concentration for range #1
4	NOX_TARGET_SPAN_CONC_1	NOX Target span concentration for range #1

Appendix B - Wiring Diagram

REVISION HISTORY

ZONE	DCN	REV	DESCRIPTION	DATE	APPROVED
		01	INITIAL RELEASE, PROTOTYPE	8/9/2019	PVU
		02	REVISED WIRING, ADDED FAN	8/22/2019	PVU
		03	CHANGED CABLE PN#, ADDED NOTES	9/24/2019	PVU
		04	REMOVED "MARS" FROM DESCRIPTIONS	11/25/2019	JM