



TELEDYNE API
Everywhereyoulook™



User Manual
Model T802
Paramagnetic Oxygen Analyzer

with NumaView™ software

© TELEDYNE API (TAPI)
9970 CARROLL CANYON ROAD
SAN DIEGO, CALIFORNIA 92131-1106
USA

Toll-free Phone: +1 800-324-5190
Phone: +1 858-657-9800
Fax: +1 858-657-9816
Email: api-sales@teledyne.com
Website: <http://www.teledyne-api.com/>



NOTICE OF COPYRIGHT

© 2020 Teledyne API (TAPI). All rights reserved.

TRADEMARKS

All trademarks, registered trademarks, brand names or product names appearing in this document are the property of their respective owners and are used herein for identification purposes only.

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(es) with this product!

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: 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 produit!

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

Support manuals, such as Fundamentals of Electro-Static Discharge (ESD), PN 04786, and NumaView™ Remote, PN 04892, are available on the TAPI website <http://www.teledyne-api.com>. The NumaView™ Software Addendum to T-Series Analyzer Manuals also may be helpful.

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

Safety Messages.....	ii
Warranty	iv
Table of Contents	vi
List of Figures	ix
List of Tables.....	xi
1. INTRODUCTION, SPECIFICATIONS, APPROVALS, & COMPLIANCE	12
1.1. Specifications	12
1.2. Safety.....	13
1.3. EMC	13
1.4. Other Certifications.....	13
2. GETTING STARTED.....	14
2.1. Unpacking.....	14
2.1.1. Ventilation Clearance.....	15
2.2. Instrument Layout.....	16
2.2.1. Front Panel.....	16
2.2.2. Rear Panel	17
2.2.3. Internal Chassis	19
2.3. Connections and Startup.....	20
2.3.1. Electrical Connections.....	20
2.3.1.1. Connecting Power	20
2.3.1.2. Connecting Analog Outputs	21
2.3.1.3. Current Loop Analog Outputs (Option 41) Setup	22
2.3.1.4. Connecting the Status Outputs (Digital Outputs)	23
2.3.1.5. Connecting the Control Inputs (Digital Inputs)	24
2.3.1.6. Concentration Alarm Relay (Option 61).....	25
2.3.1.7. Connecting Communications Interfaces	25
2.3.2. Pneumatic Connections	31
2.3.2.1. Critical Tubing, Pressure, Venting and Exhaust Requirements.....	32
2.3.2.2. Basic pneumatic Connections	32
2.3.3. Pneumatic Flow Diagrams	34
2.3.4. Startup, Functional Checks and Calibration.....	35
2.3.4.1 Startup.....	35
2.3.4.2 Alerts: Warnings and Other Messages.....	36
2.3.4.3 Functional Checks.....	37
2.3.4.4 Calibration	37
2.4. Menu Overview.....	38
2.4.1 Home Page	39
2.4.2 Dashboard	41
2.4.3 Alerts	42
2.4.4 Calibration	43
2.4.5 Utilities.....	44
2.4.6 Setup.....	44
2.5. Setup Menu: Features/Functions Configuration	45
2.5.1 Setup>Data Logging (Data Acquisition System, DAS).....	45
2.5.1.1 Configuring Trigger Types: Periodic	47



2.5.1.2	Configuring Trigger Types: Conditional	48
2.5.1.3	Downloading DAS (Data Acquisition System) Data	48
2.5.2	Setup>Events	49
2.5.2.1	Editing or Deleting Events	50
2.5.2.2	Using Events as Triggers for Data Logging	51
2.5.3	Setup>Dashboard	51
2.5.4	Setup>Vars.....	52
2.5.5	Setup>Homescreen	53
2.5.6	Setup>Digital Outputs	54
2.5.7	Setup>Analog Outputs	55
2.5.7.1	Manual Calibration of Voltage Range Analog Outputs	57
2.5.7.2	Manual Adjustment of Current Range Analog Outputs	58
2.5.8	Setup>Instrument.....	59
2.5.9	Setup>Comm (Communications)	60
2.5.9.1	COM1/COM2.....	60
2.5.9.2	TCP Port1.....	61
2.5.9.3	TCP Port2.....	61
2.5.9.4	TCP Port3.....	61
2.5.9.5	Network Settings.....	61
2.6	Transferring Configuration to Other Instruments	62
3	COMMUNICATIONS AND REMOTE OPERATION	64
3.1	Data Terminal/Communication Equipment (DTE DCE).....	64
3.2	Modes, Baud Rate and Serial Communication	64
3.2.1	Serial Communication: RS-232	65
3.2.2	Serial Communication: RS-485 (Option).....	65
3.3	Ethernet	65
3.4	Communications Protocols	66
3.4.1	MODBUS	66
3.4.1.1	MODBUS Com Port Configuration	66
3.4.2	Hessen	68
3.4.2.1	Hessen Com Port Configuration	68
3.4.2.2	Hessen Settings Configuration	69
3.4.2.3	Hessen Gas List Configuration.....	71
4	CALIBRATION.....	72
4.1	Important Precalibration Information.....	72
4.1.1	Calibration Requirements.....	72
4.1.2	Zero Air	72
4.1.3	Calibration (Span) Gas	72
4.1.4	Physical Range Measurements.....	73
4.1.5	Interferents.....	73
4.1.6	Data Recording Devices	73
4.2	Calibration Procedures	74
4.2.1	Zero Calibration Check and Actual Calibration.....	74
4.2.2	Span Calibration Check and Actual Calibration	75
4.3	Calibration Quality Analysis	75
5.	MAINTENANCE AND SERVICE	77
5.1	Maintenance Schedule	77



5.2	Predictive Diagnostics	78
5.3	Operational Health Checks	79
5.4	Software/Firmware Updates	79
5.4.1	Remote Updates	80
5.4.2	Manual Reload/Update Procedures	80
5.5	Time Zone Changes	82
5.6	Maintenance and Service	83
5.6.1	Replacing the Sample Particulate Filter	83
5.6.2	Replacing the Sample Pump Diaphragm	84
5.6.3	Checking for Pneumatic Leaks	84
5.6.3.1	Vacuum Leak Check and Pump Check	84
5.6.3.2	Simple Vacuum Leak and Pump Check	84
5.6.3.3	Detailed Pressure Leak Check	85
5.6.4	Performing Flow Checks/Calibrations	86
5.6.4.1	Flow Check	86
5.6.4.2	Flow Calibration	86
5.6.5	Performing Pressure Calibration	87
5.6.6	Fault Diagnosis with Alerts	87
5.6.7	Fault Diagnosis With Dashboard Functions	89
5.6.8	Using the Diagnostic Signal I/O Functions	89
5.6.9	Using the Internal Electronic Status LEDs	90
5.6.9.1	CPU Status Indicator	90
5.6.9.2	Relay PCA Watchdog and Status LEDs	90
5.6.10	Flow Problems	91
5.6.10.1	Sample Flow is Zero or Low	92
5.6.10.2	High Flow	93
5.6.10.3	Sample Flow is Zero or Low but Analyzer Reports Correct Flow	93
5.6.11	Calibration Problems	94
5.6.11.1	Miscalibrated	94
5.6.11.2	Non-Repeatable Zero and Span	94
5.6.11.3	Inability to Span – No Span Button	94
5.6.11.4	Inability to Zero – No Zero Button	95
5.6.12	Other Performance Problems	95
5.6.12.1	Excessive Noise	95
5.6.12.2	Slow Response	95
5.6.13	Subsystem Check for Troubleshooting	96
5.6.13.1	AC Main Power	96
5.6.13.2	DC Power Supply	97
5.6.13.3	I ² C Bus	97
5.6.13.4	Touchscreen Interface	98
5.6.13.5	LCD/Display Module	98
5.6.13.6	Relay PCA	98
5.6.13.7	A/D Functions	99
5.6.13.8	Status Outputs	99
5.6.13.9	Pneumatic Pressure / Flow Sensor Assembly	100
5.6.13.10	CPU	100
5.6.13.11	RS-232 Communications	101
5.6.13.12	Optional CO ₂ Sensor	102



5.6.13.13	Temperature Problemss.....	102
5.6.14	Service Procedures	102
5.6.14.1	Repairing Sample Flow Control Assembly.....	103
5.6.14.2	Disk-On-Module Replacement Procedure	104
5.6.14.3	Sensor Module Repair and Cleaning	104
5.7	Frequently Asked Questions	105
5.8	Technical Assistance	106
6	PRINCIPLES OF OPERATION.....	107
6.1	Oxygen (O ₂) Sensor Principles of Operation	107
6.1.1	Magnetic Properties of O ₂ Gas	107
6.1.2	Principle of Measurement	107
6.2	NDIR Measurement of CO ₂	108
6.2.1	Operation within the T802	109
6.3	PNEUMATIC OPERATION	109
6.3.1	Flow Rate Control	109
6.3.2	Sample Pressure Sensor	110
6.3.3	Sample Flow Sensor.....	110
6.4	ELECTRONIC OPERATION	111
6.4.1	Central Processing Unit (CPU)	112
6.4.2	Relay Board.....	113
6.4.3	Status LEDs	113
6.4.4	Temperature Control.....	113
6.4.5	Motherboard	113
6.4.6	A to D Conversion	113
6.4.7	Sensor Inputs.....	114
6.4.8	Sample Pressure and Flow.....	114
6.4.9	Thermistor Interface.....	114
6.4.10	Analog Outputs.....	114
6.4.11	External Digital I/O	115
6.4.12	I ² C Data Bus	115
6.4.13	Powerup circuit	115
6.4.14	Power Supply / Circuit Breaker.....	115
6.4.15	Front Panel Touchscreen/Display Interface	117
6.4.15.1	LVDS TRANSMITTER BOARD.....	117
6.4.15.2	FRONT PANEL TOUCHSCREEN/DISPLAY INTERFACE PCA	117
6.5	SOFTWARE OPERATION	118
6.5.1	Adaptive Filter	118
6.5.2	Calibration – Slope and Offset.....	119
6.5.3	Temperature and Pressure Compensation	119
6.5.4	Internal Data Acquisition System (DAS)	119
	Glossary.....	120

Appendix A - MODBUS Registers

Appendix B - Interconnect Diagram

LIST OF FIGURES

Figure 2-1. Front Panel Layout	16
Figure 2-2. Rear Panel Layout, Base Unit (options include additional pneumatic ports)	17
Figure 2-3. Internal Chassis Layout	19
Figure 2-4. Analog Output Connector	21
Figure 2-5. Current Loop Option Installed on the Motherboard	22
Figure 2-6. Status Output Connector for Digital Outputs	23
Figure 2-7. Energizing the Control Inputs	24
Figure 2-8. Concentration Alarm Relay	25
Figure 2-9. Rear Panel Connector Pin-Outs for RS-232 Mode	26
Figure 2-10. Default Pin Assignments for CPU COM Port Connector (RS-232)	27
Figure 2-11. Jumper and Cables for Multidrop Mode	29
Figure 2-12. RS-232 Multidrop PCA Option Host/Analyzer Interconnect Diagram	30
Figure 2-13. Basic Configuration, Using Bottled Span Gas	32
Figure 2-14. Internal Gas Flow, Basic Configuration	34
Figure 2-15. Internal Gas Flow with CO ₂ Sensor Option	34
Figure 2-16. Status Screens at Startup	35
Figure 2-32. Home Page Example (when installed, CO ₂ option conc displays below O ₂ conc)	36
Figure 2-33. Viewing Active Alerts Page	36
Figure 2-34. Sample Dashboard Page	37
Figure 2-35. User Interface Orientation	39
Figure 2-36. Concentration and Stability Graph (top) and Sample Flow Graph (bottom)	40
Figure 2-37. Dashboard Page	41
Figure 2-38. Navigating to the Active Alerts Page	42
Figure 2-39. Active Alerts Cleared	43
Figure 2-40. Utilities>Alerts Log of Active and Past Alerts and Events	43
Figure 2-41. Datalog Configuration, New Log Page	45
Figure 2-42. Datalog Configuration, Existing Log	45
Figure 2-43. Creating a New Data Log	46
Figure 2-44. Datalog Periodic Trigger Configuration	47
Figure 2-45. Datalog - Conditional Trigger Configuration	48
Figure 2-46. DAS Download Page	48
Figure 2-47. Events List	49
Figure 2-48. Event Configuration	49
Figure 2-49. Configured Event Sample	50
Figure 2-50. Edit or Delete an Event	50
Figure 2-51. Dashboard Display and Configuration	51
Figure 2-52. Homescreen Configuration	53
Figure 2-53. Digital Outputs Setup	54
Figure 2-54. Analog Output Configuration Example	55
Figure 2-55. Analog Outputs Group Calibration Screen	56
Figure 2-56. Analog Outputs Manual Calibration Screen (AOUT2 Example)	56
Figure 2-57. Setup for Checking / Calibrating DCV Analog Output Signal Levels	57
Figure 2-58. Setup for Checking / Calibration Current Output Signal Levels	58
Figure 2-59. Alternative Setup Using 250Ω Resistor for Checking Current Output Signal Levels	59
Figure 2-60. Communications Configuration, Network Settings	61
Figure 2-61. Configuration Transfer	62
Figure 3-1. MODBUS via Ethernet	66
Figure 3-2. MODBUS via Serial Communication (example)	67
Figure 3-3. Serial Communication, Setting Hessen Protocol	68
Figure 3-4. Hessen Gas List Configuration	71
Figure 4-2. Calibration Menu for O ₂ and CO ₂ Sensors	74
Figure 4-3. Sample Calibration Page for O ₂ Sensor	75
Figure 5-1. Report Generation Page	79

Figure 5-2. Remote Update Page	80
Figure 5-3. Manual Update Page (and other utilities)	80
Figure 5-5. Time Zone Change Requirements	82
Figure 5-6. Replacing the Particulate Filter	83
Figure 5-9. Flow Calibration Menu	86
Figure 5-12. CPU Status Indicator	90
Figure 5-13. Relay PCA Status LED Locations	91
Figure 5-15. Typical Set Up of Status Output Test	99

LIST OF TABLES

Table 1-1. Specifications	12
Table 2-1. Ventilation Clearance	15
Table 2-2. Rear Panel Description	18
Table 2-3. Analog Output Pin Assignments	21
Table 2-4. Status Output Pin Assignments	24
Table 2-5. Control Input Pin Assignments	25
Table 2-9. Menu Overview	38
Table 2-10. Utilities Submenu Descriptions	44
Table 2-11. Typical Variables with Descriptions	52
Table 2-12. Analog Output Voltage/Current Range	56
Table 2-13. Voltage Tolerances	57
Table 2-14. Current Loop Output Check	59
Table 2-15. Setup>Instrument Menu	59
Table 2-16. COM1/COM2 Configuration	60
Table 2-17. LAN/Ethernet Configuration Properties	62
Table 3-1. Ethernet Status Indicators	65
Table 3-2. Teledyne API's Hessen Protocol Response Modes	69
Table 3-3. T100, T100U Hessen Status Flags and Default Bit Assignments	70
Table 3-4. T100H Hessen Status Flags and Default Bit Assignments	Error! Bookmark not defined.
Table 3-5. Hessen Gas List Definitions	71
Table 4-4. Calibration Data Quality Evaluation	76
Table 5-1. Maintenance Schedule	78
Table 5-2. Predictive Uses for Dashboard Functions	79
Table 5-3. Warning Alerts, Fault Conditions and Possible Causes	88
Table 5-4. Dashboard Functions - Possible Causes for Out-of-Range Values	89
Table 5-5. Relay PCA Watchdog and Status LED Failure Indications	91
Table 5-7. DC Power Test Point and Wiring Color Code	97
Table 5-8. DC Power Supply Acceptable Levels	97

1. INTRODUCTION, SPECIFICATIONS, APPROVALS, & COMPLIANCE

The Teledyne API Model T802 (also referred to as T802) Paramagnetic Oxygen Analyzer is a microprocessor-controlled analyzer that determines the concentration of molecular oxygen (O₂) in a sample gas drawn through the instrument. It uses a paramagnetic sensor that relies on the relatively high reactivity of O₂ molecules to magnetic fields to generate a current that is proportional to the amount of O₂ present in the sensor chamber.

The T802 analyzer's multi-tasking software gives the ability to track and report a large number of operational parameters in real time. These readings are compared to diagnostic limits kept in the analyzer's memory where, should any fall outside of those limits, the analyzer issues automatic warnings.

Proprietary software allows configurable data acquisition capability that can be triggered conditionally or periodically, enabling operators to perform predictive diagnostics and enhanced data analysis by tracking parameter trends. Reports can be downloaded onto a USB flash drive or via the I/O ports. Operators can also view real-time graphing with one touch of the interface screen.

1.1. SPECIFICATIONS

Table 1-1. Specifications

Parameter	Description	
	O ₂ Sensor	Optional CO ₂ Sensor
Ranges	Min: 0-1% full scale Max: 0-100% full scale (selectable)	Min: 0-1% full scale Max: 0-20% full scale
Zero Noise	< 0.02% (RMS)	< 0.02% (RMS)
Span Noise	< 0.05% of reading (RMS)	< 0.1% of reading (RMS)
Zero Drift	< ±0.02% /24 hrs; < ±0.05% /7 days	< ±0.02%/24 hrs; < ±0.05%/7 days
Span Drift	< ±0.1% /7 days	< ±0.1%/7 days
Lower Detectable Limit	< 0.04%	< 0.04%
Accuracy	< ±0.1%	< ±(1.5% of range +2% of reading)
Temperature Coefficient	< ±0.1% per degree C	< ±0.01%/degree C
Linearity	< ±0.1%	
Response Time	< 60 seconds to 95%	
Sample Flow Rate	120 ml ± 20ml/min	
Analog Output Ranges	10V, 5V, 1V, 0.1V (selectable)	
Recorder Offset	± 10%	
AC Power	Rating	Typical Power Consumption
	110-120 V~, 60 Hz, 3.0 A	77 W
	220-240 V~, 50/60 Hz, 3.0 A	80 W



Parameter	Description
Communications	
Standard I/O	1 Ethernet: 10/100Base-T 2 RS-232 (300 – 115,200 baud) 2 USB device ports 8 opto-isolated digital status outputs 6 opto-isolated digital control inputs 4 analog outputs
Optional I/O	1 USB com port 1 RS485 8 analog inputs (0-10V, 12-bit) 4 digital alarm outputs Multidrop RS232 3 4-20mA current outputs
Operating Temperature	5-40 °C
Humidity Range	0-95% RH, Non-Condensing
Pressure Range	25 - 31 in Hg
Dimensions HxWxD	7" x 17" x 23.5" (178 x 432 x 597 mm)
Weight	28 lbs (12.7 kg)
Environmental Conditions	<ul style="list-style-type: none">• 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. 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

1.3. 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

1.4. OTHER CERTIFICATIONS

For additional certifications, please contact Technical Support:

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

Phone: +1 858-657-9800

Fax: +1 858-657-9816

Email: api-techsupport@teledyne.com

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 side-panel screws that hold the cover in place.
 - 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 the instrument is under power.

2.1.1. VENTILATION CLEARANCE

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

Table 2-1. Ventilation Clearance

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

2.2. INSTRUMENT LAYOUT

This section illustrates the front and rear panels 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).

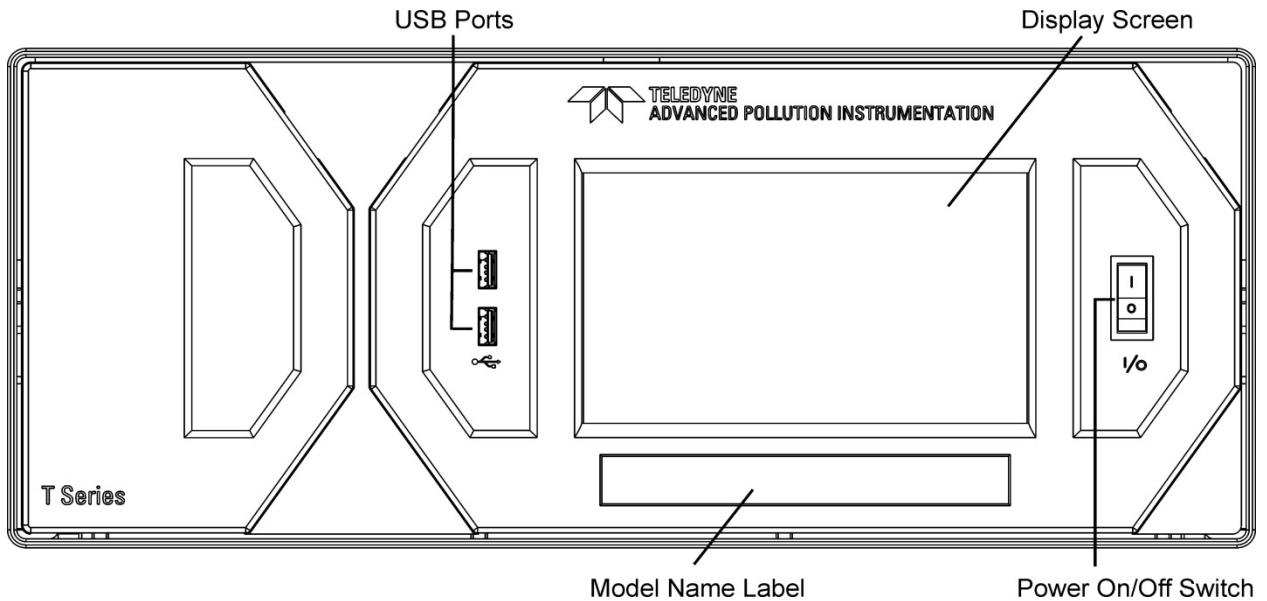


Figure 2-1. Front Panel Layout

2.2.2. REAR PANEL

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

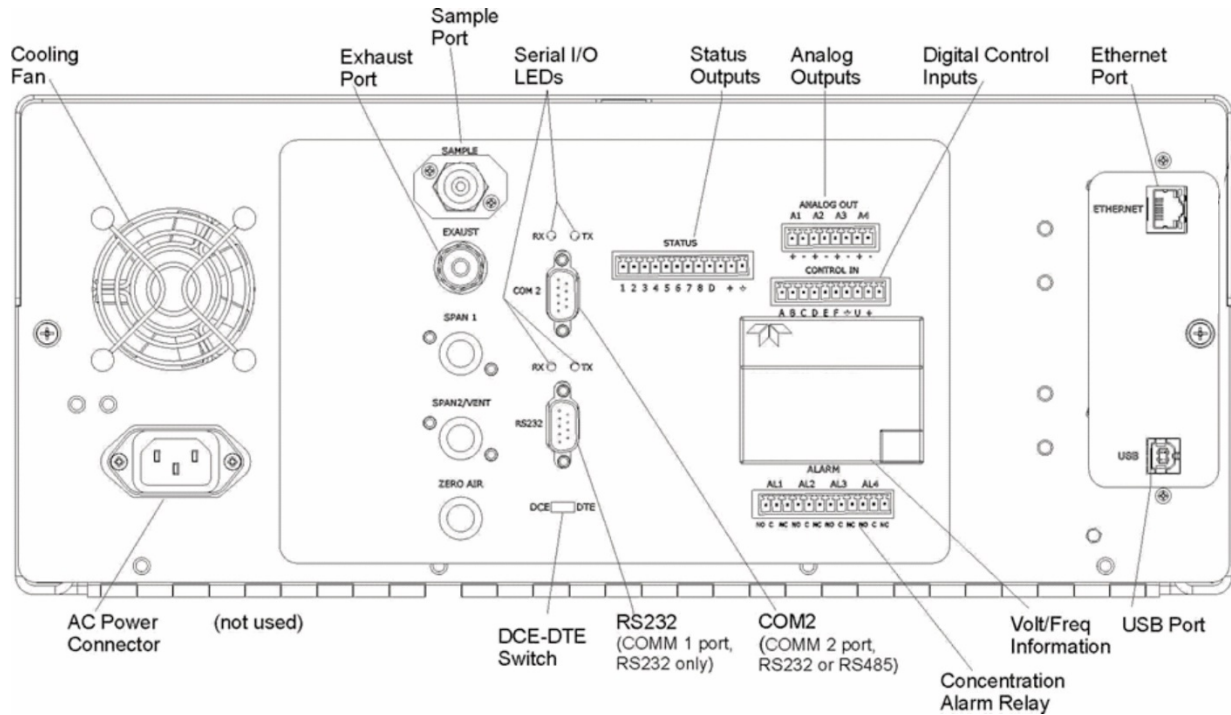



Figure 2-2. Rear Panel Layout, Base Unit (options include additional pneumatic ports)

Table 2-2. Rear Panel Description

COMPONENT	FUNCTION
cooling fan	Pulls ambient air into chassis through side vents and exhausts through rear.
 AC power connector	Connector for three-prong cord to apply AC power to the analyzer. CAUTION! The cord's power specifications (specs) MUST comply with the power specs on the analyzer's rear panel Model number label
Model/specs label	Identifies the analyzer model number and provides power specs
SAMPLE	Inlet connection to be used for any one of the following: <ul style="list-style-type: none"> • Sample gas • Span gas • Calibration gas • Zero air
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.
SPAN 1	Not used.
SPAN2/VENT	Not used.
ZERO AIR	Not used.
RX TX	LEDs indicate receive (RX) and transmit (TX) activity when blinking.
COM 2	Serial communications port for RS-232 or RS-485.
RS-232	Serial communications port for RS-232 only.
DCE DTE	Switch to select either data terminal equipment or data communication equipment during RS-232 communication.
STATUS	For outputs to devices such as Programmable Logic Controllers (PLCs).
ANALOG OUT	For voltage or current loop outputs to a strip chart recorder and/or a data logger.
CONTROL IN	For remotely activating the zero and span calibration modes.
ALARM	Option for concentration alarms and system warnings.
ETHERNET	Connector for network or Internet remote communication, using Ethernet cable.
USB (option)	Connector for direct connection to laptop computer, using USB cable.

2.2.3. INTERNAL CHASSIS

Figure 2-3 shows the internal chassis configuration including the CO₂ sensor option..

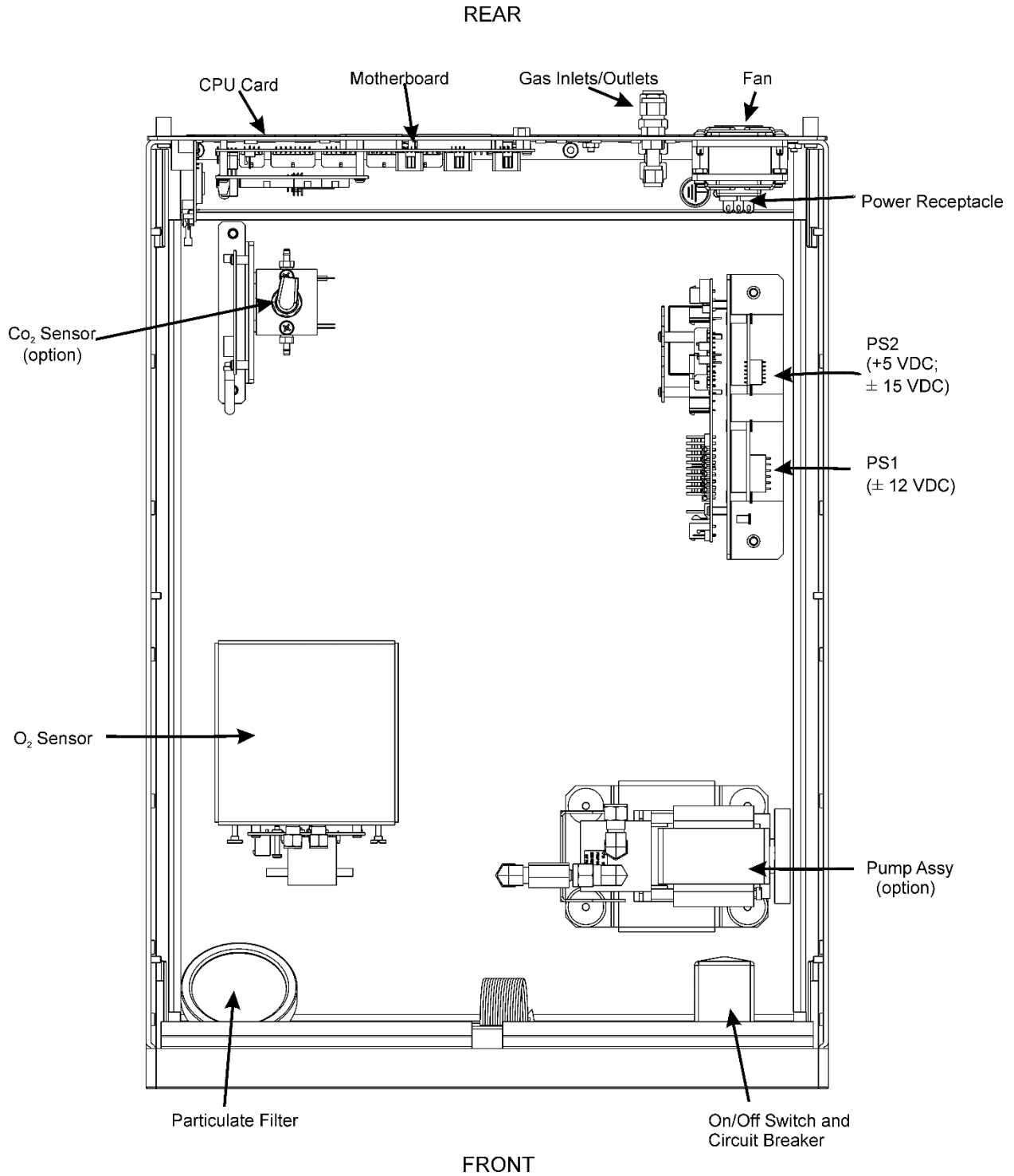


Figure 2-3. Internal Chassis Layout

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 go greater than 3 meters for all I/O connections.

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.

**WARNING – Electrical Shock Hazard**

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

**CAUTION – Avoid Damage to the Instrument**

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

2.3.1.1. CONNECTING POWER

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

2.3.1.2. CONNECTING ANALOG OUTPUTS

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

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

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

Configure through the Setup>Analog Outputs menu (Section 2.5.7)

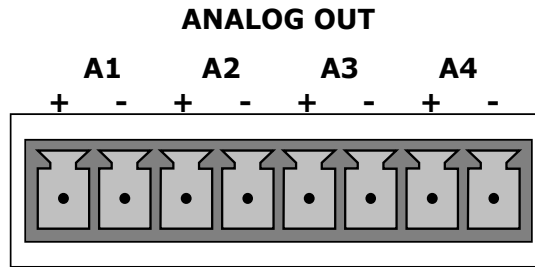


Figure 2-4. Analog Output Connector


Table 2-3. Analog Output Pin Assignments

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

2.3.1.3. CURRENT LOOP ANALOG OUTPUTS (OPTION 41) SETUP

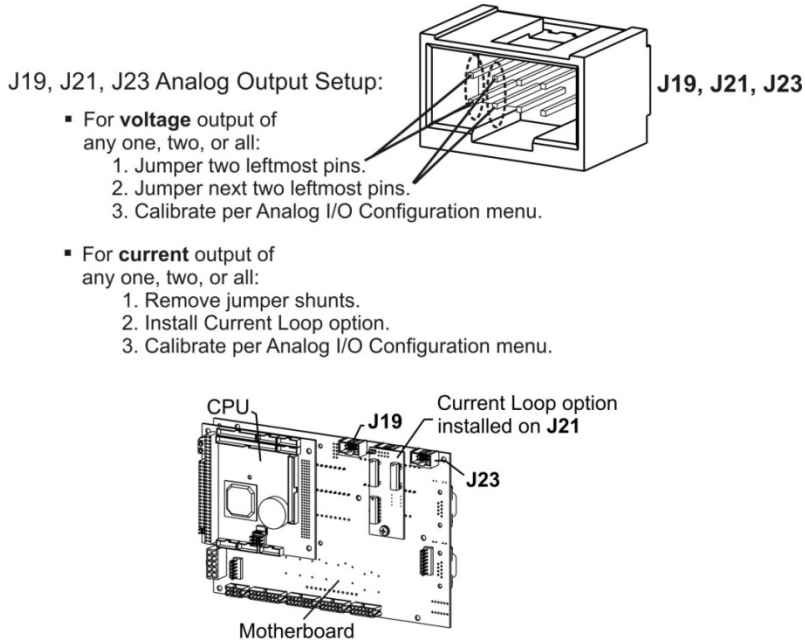
If your analyzer had this option installed at the factory, there are no further connections to be made. Otherwise, it can be installed as a retrofit for each of the analog outputs. This option converts the DC voltage analog output to a current signal with 0-20 mA output current, which can be scaled to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

Figure 2-5 provides installation instructions and illustrates a sample configuration of one current output combined with two voltage outputs. Next are instructions for converting current loop analog outputs to standard 0-to-5 VDC outputs. To calibrate or adjust these outputs use the Setup>Analog Outputs menu (Section 2.5.7).



CAUTION – Avoid Invalidating Warranty

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



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

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

CONVERTING CURRENT LOOP ANALOG OUTPUTS TO STANDARD VOLTAGE OUTPUTS

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

1. Turn off power to the analyzer.
2. If a recording device is connected to the output being modified, disconnect it.
3. Remove the top cover.
 - Remove the set screw located in the top, center of the rear panel.
 - Remove the screws fastening the top cover to the unit (one per side).
 - Slide the cover back and lift the cover straight up.
4. Remove the screw holding the current loop option to the motherboard.
5. Disconnect the current loop option PCA from the appropriate connector on the motherboard (see Figure 2-5).
6. Each connector, J19 and J23, requires two shunts. Place one shunt on the two left most pins and the second shunt on the two adjacent pins (see Figure 2-5).
7. Return the top cover to the analyzer and secure.

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

2.3.1.4. CONNECTING THE STATUS OUTPUTS (DIGITAL OUTPUTS)

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

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

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

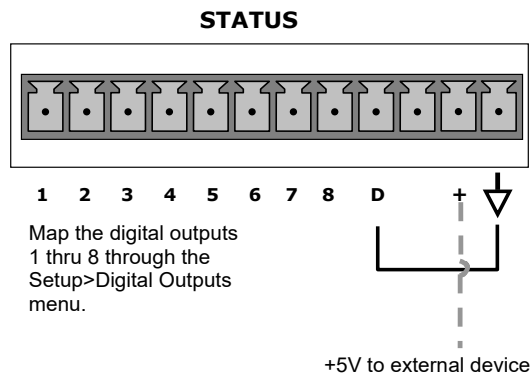


Figure 2-6. Status Output Connector for Digital Outputs

Table 2-4. Status Output Pin Assignments

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

2.3.1.5. CONNECTING THE CONTROL INPUTS (DIGITAL INPUTS)

The rear panel CONTROL IN connector, can be used to remotely activate the zero and span calibration modes. Energize the Control Inputs either by the internal +5V available from the pin labeled “+” (more convenient), or by a separate external 5 VDC power supply (ensures that these inputs are truly isolated). Refer to Figure 2-7.

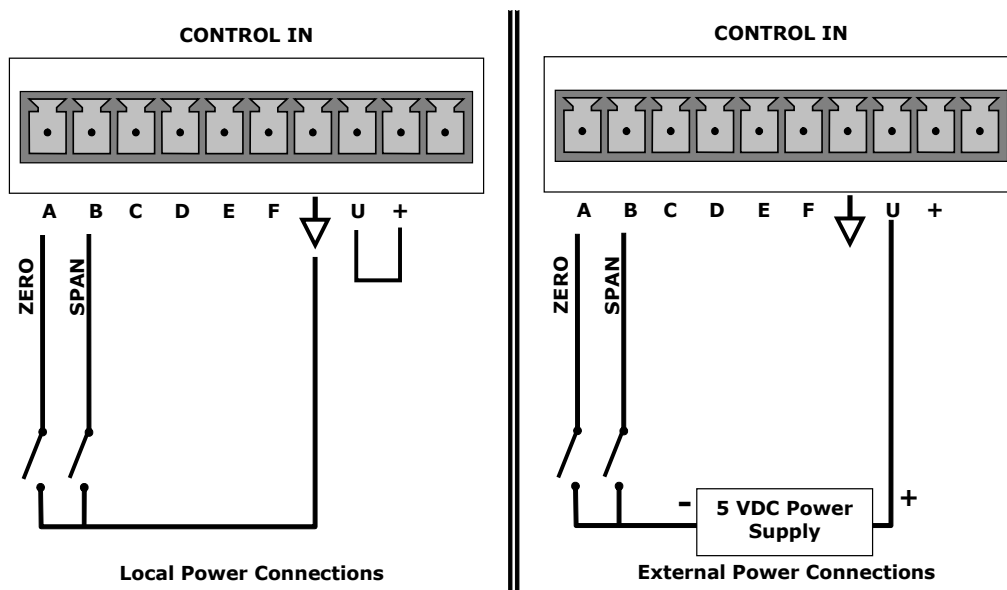



Figure 2-7. Energizing the Control Inputs

Table 2-5. Control Input Pin Assignments

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

2.3.1.6. CONCENTRATION ALARM RELAY (OPTION 61)

The concentration relay option provides four (4) “dry contact” relays on the rear panel (Figure 2-8), each with 3 pins: Common (C), Normally Open (NO), and Normally Closed (NC). The Relays can be mapped to reflect various internal instrument conditions and states. Configure these outputs through the Setup>Digital Outputs menu (Section 2.5.6) under MB Relay [1 thru 4].

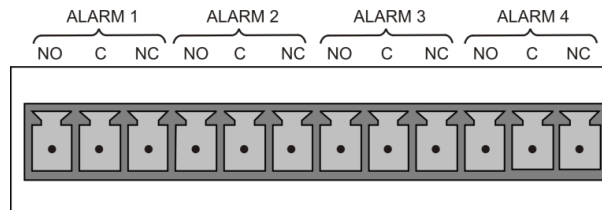


Figure 2-8. Concentration Alarm Relay

2.3.1.7. CONNECTING COMMUNICATIONS INTERFACES

ETHERNET CONNECTION

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

Configuration: Section 2.5.9.5

USB (OPTION) CONNECTION

The rear panel USB option is for direct communication between the analyzer and a PC. Connect a USB cable between the analyzer and a computer USB port. Computer and instrument baud rates must match.

Note If this option is installed, the rear panel RS232 (COM2) port cannot be used for anything other than RS-232 Multidrop communication.

RS-232 CONNECTION

For RS-232 communications with data terminal equipment (DTE) or with data communication equipment (DCE) connect either a DB9-female-to-DB9-female cable (Teledyne API part number WR000077) or a DB9-female-to-DB25-male cable (Option 60A), as applicable, from the analyzer's RS-232 port (see Figure 2-9 for connector pin assignments) to the device. Adjust the rear panel DCE-DTE switch to select DTE or DCE as appropriate (Section 3.1).

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

Important

IMPACT ON READINGS OR DATA

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

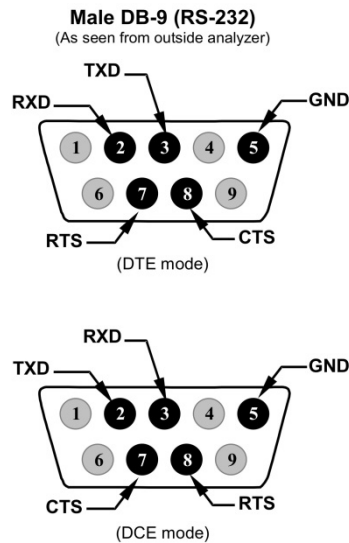


Figure 2-9. Rear Panel Connector Pin-Outs for RS-232 Mode

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

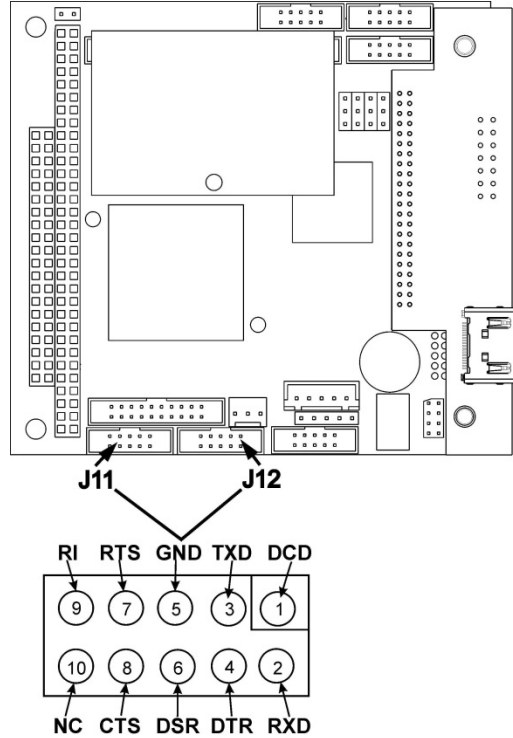


Figure 2-10. Default Pin Assignments for CPU COM Port Connector (RS-232)

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

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

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

Note

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

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

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

Received from the factory, the analyzer is set up to emulate an RS-232 DCE device. (View these parameters in the Setup>Comm>COM1[COM2] menu).

RS-232 (COM1): RS-232 (fixed) DB-9 male connector

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

COM2: RS-232 (configurable to RS 485), DB-9 female connector

- **Baud rate:** 19200 bits per second (baud)
- **Data Bits:** 8 data bits with 1 stop bit
- **Parity:** None

RS-232 MULTIDROP (OPTION 62) CONNECTION

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

Note

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

ATTENTION

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

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

1. With **NO power** to the instrument, remove its top cover and lay the rear panel open for access to the Multidrop/LVDS PCA, which is seated on the CPU.
2. On the Multidrop/LVDS PCA's JP2 connector, remove the shunt that jumpers Pins 21 ↔ 22 as indicated in. (Do this for all but the last instrument in the chain where the shunt should remain at Pins 21 ↔ 22).

3. Check that the following cable connections are made in *all* instruments (again refer to Figure 2-11):
 - J3 on the Multidrop/LVDS PCA to the CPU's COM1 connector
(Be aware that the CPU's COM2 connector is not used in Multidrop)
 - J4 on the Multidrop/LVDS PCA to J12 on the motherboard
 - J1 on the Multidrop/LVDS PCS to the front panel LCD

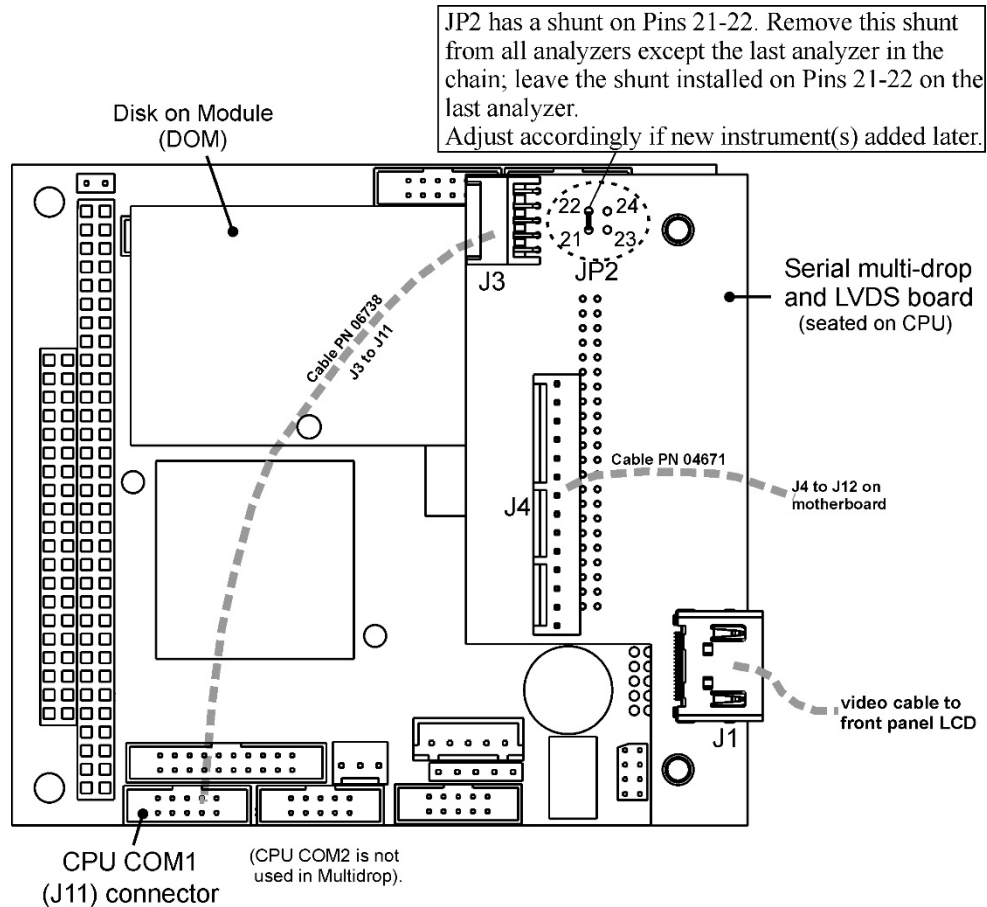


Figure 2-11. Jumper and Cables for Multidrop Mode

Note

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

4. Close the instrument.
5. Referring to Figure 2-12 use straight-through DB9 male → DB9 female cables to interconnect the host RS232 port to the first analyzer's RS232 port; then from the first analyzer's COM2 port to the second analyzer's RS232 port; from the second analyzer's COM2 port to the third analyzer's RS232 port, etc., connecting in this fashion up to eight analyzers, subject to the distance limitations of the RS-232 standard.
6. On the rear panel of each analyzer, adjust the DCE DTE switch so that the green and the red LEDs (RX and TX) of the COM1 connector (labeled

RS232) are both lit. (Ensure you are using the correct RS-232 cables internally wired specifically for RS-232 communication; see Figure 2-10).

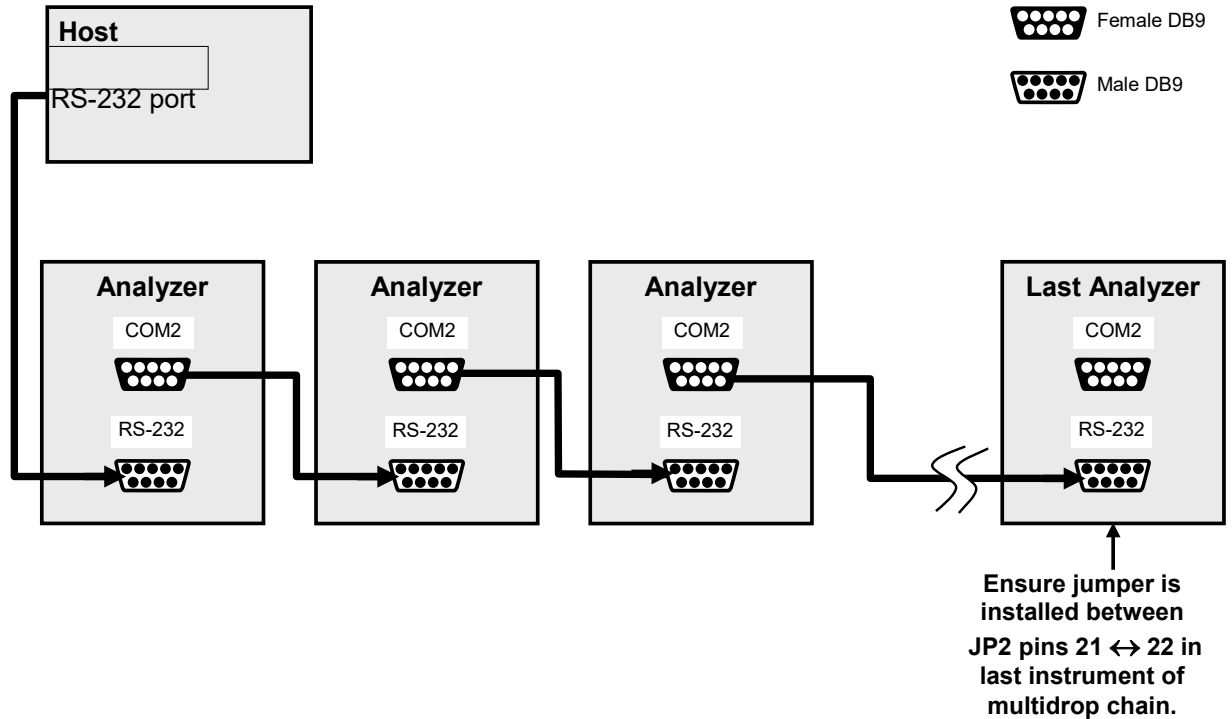


Figure 2-12. RS-232 Multidrop PCA Option Host/Analyzer Interconnect Diagram

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

Note The (communication) Host instrument can address only one instrument at a time, each by its unique ID (see step 7 above).

Note Teledyne API recommends setting up the first link, between the Host and the first analyzer, and testing it before setting up the rest of the chain.

2.3.2. PNEUMATIC CONNECTIONS

This section provides pneumatic connection and setup instructions for basic and optional 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



While O₂ is itself not toxic, the sample gas measured by, and in some cases the calibration gases used with the T802 can contain other components that are hazardous (e.g. NO, NO₂, SO₂, CO, etc).

Obtain a Material Safety Data Sheet (MSDS) for each such gas. Read and rigorously follow the safety guidelines described there.

Do not vent sample gases containing hazardous components into enclosed areas.

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.

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:

- Maximum pressure of any gas at the SAMPLE inlet should not exceed 1.5 in-Hg above ambient pressure and ideally should equal ambient atmospheric pressure.

Venting (to prevent back diffusion and pressure effects):

- The span gas, zero air supply and sample gas line MUST be vented (Figure 2-13)
- In applications where the sample gas is received from a pressurized manifold, a vent must be placed on the sample gas before it enters the analyzer (Figure 2-13).
- Run tubing outside the shelter or immediate area surrounding the instrument.

Exhaust Outlet:

- Run tubing outside the enclosure or at least into a well-ventilated area.

2.3.2.2. BASIC PNEUMATIC CONNECTIONS

Figure 2-13 shows the basic configuration for pneumatic connections using bottled span gas.

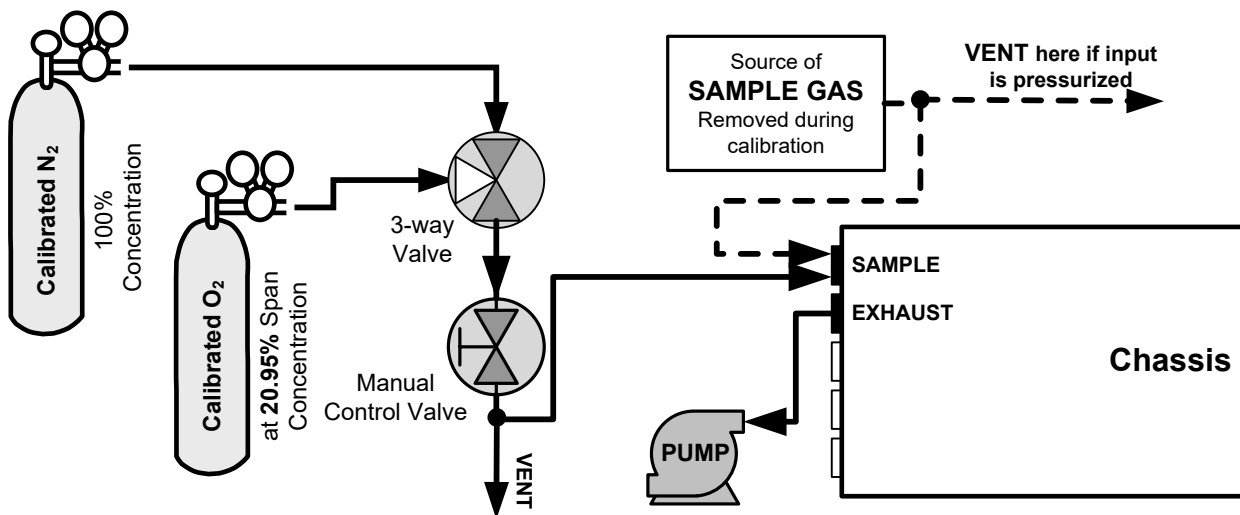


Figure 2-13. Basic Configuration, Using Bottled Span Gas

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

SAMPLE INLET

Connect ¼” gas line not more than 2 m long, from sample gas source to this inlet.

- Maximum pressure of any gas at the SAMPLE inlet should not exceed 1.5 in-Hg above ambient pressure and ideally should equal ambient atmospheric pressure.
- In applications where the sample gas is received from a pressurized manifold, a vent must be placed on the sample gas before it enters the analyzer(Figure 2-13).

EXHAUST OUTLET

Connect exhaust line to the analyzer’s EXHAUST outlet fitting, ensuring that it is vented outside the T802 analyzer’s enclosure, preferably outside the shelter or at least into a well-ventilated area.

CALIBRATOR GAS SOURCES AND VENTING

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

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

Note

Zero air and span gas flows should be supplied in excess of the 120 cm³/min demand of the analyzer.

Important

IMPACT ON READINGS OR DATA

Run a leak check once the appropriate pneumatic connections have been made; check all pneumatic fittings for leaks using the procedures defined in Section 5.6.2.

2.3.3. PNEUMATIC FLOW DIAGRAMS

This section shows the flow diagrams for basic and CO₂ option configurations.

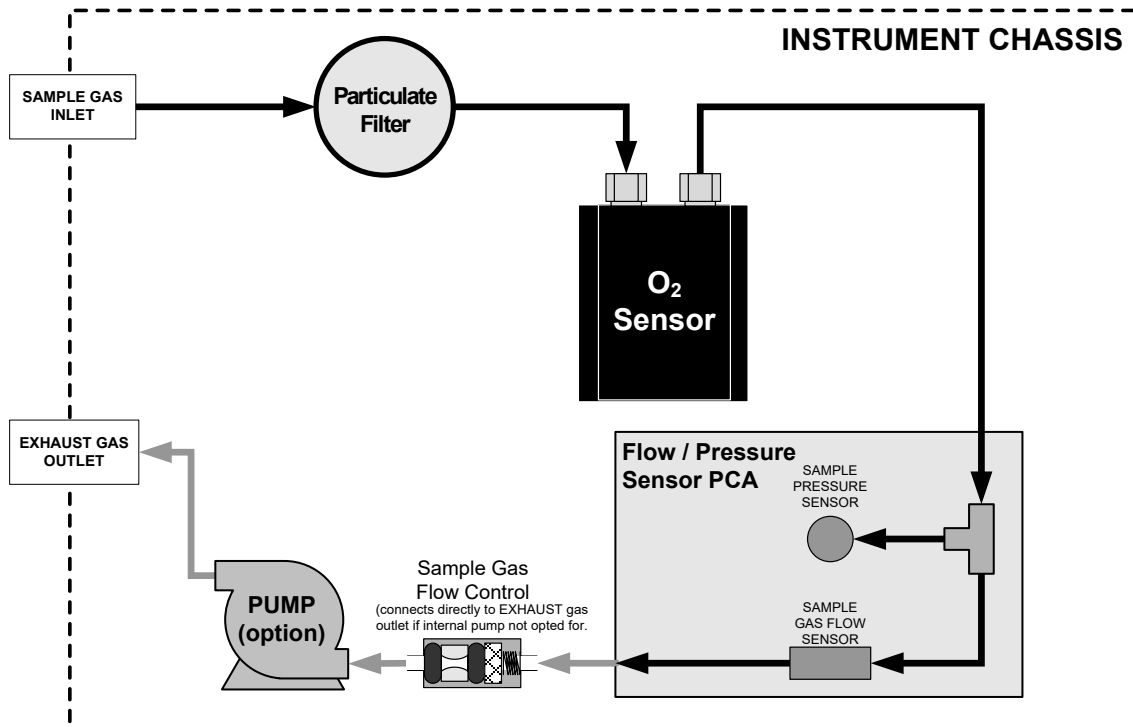


Figure 2-14. Internal Gas Flow, Basic Configuration

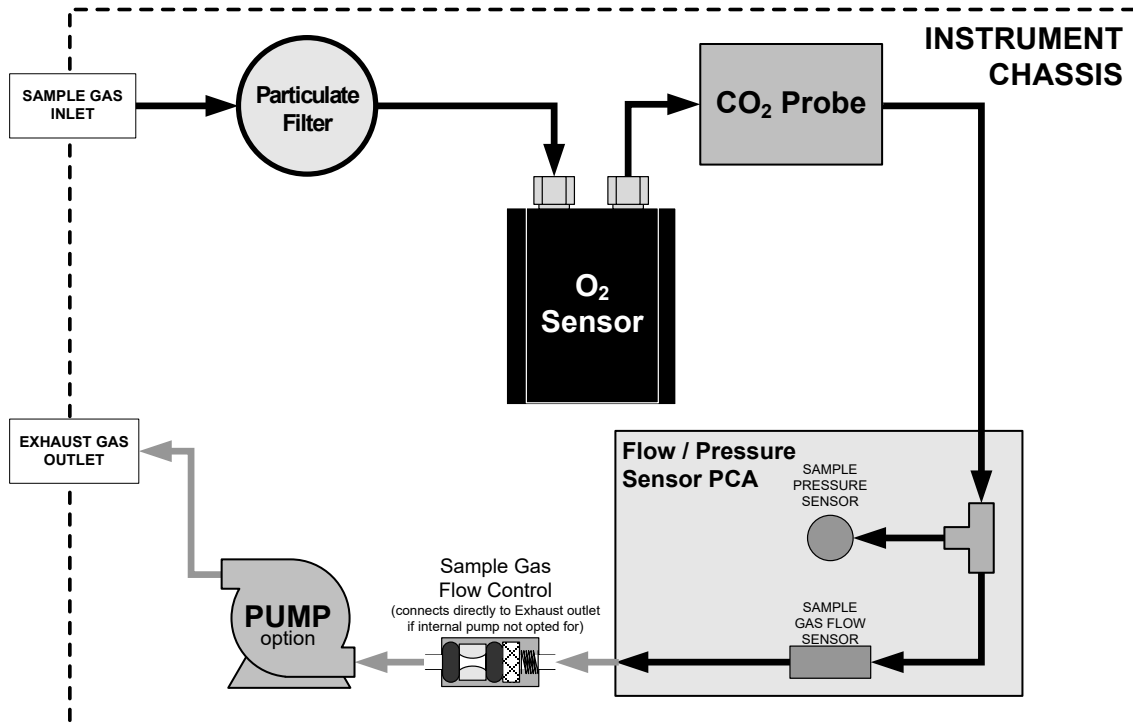


Figure 2-15. Internal Gas Flow with CO₂ Sensor Option

2.3.4. STARTUP, FUNCTIONAL CHECKS AND CALIBRATION

Important

IMPACT ON READINGS OR DATA

The analyzer's cover must be installed to ensure that the temperatures of the internal components are properly controlled.

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

When the instrument is first started (Section 2.3.4.1), check its functionality (Section 2.3.4.3) and run an initial calibration (Section 2.3.4.4). Section 2.4 introduces the menu system, and Section 2.5 provides setup/customization instructions.

2.3.4.1 STARTUP

Upon initial startup, a sequence of status screens (Figure 2-16) appear prior to the Home page (Figure 2-17).

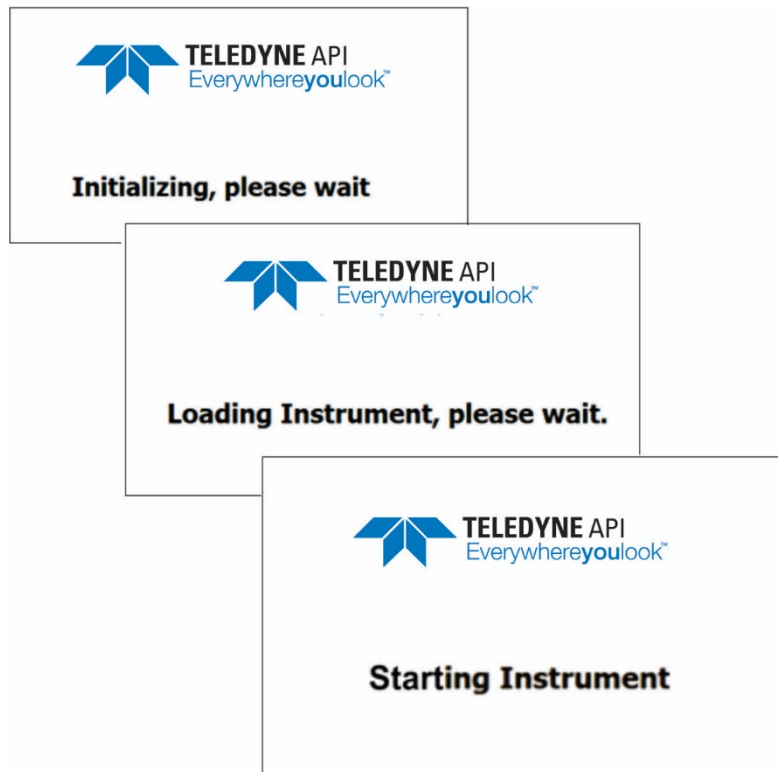


Figure 2-16. Status Screens at Startup

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

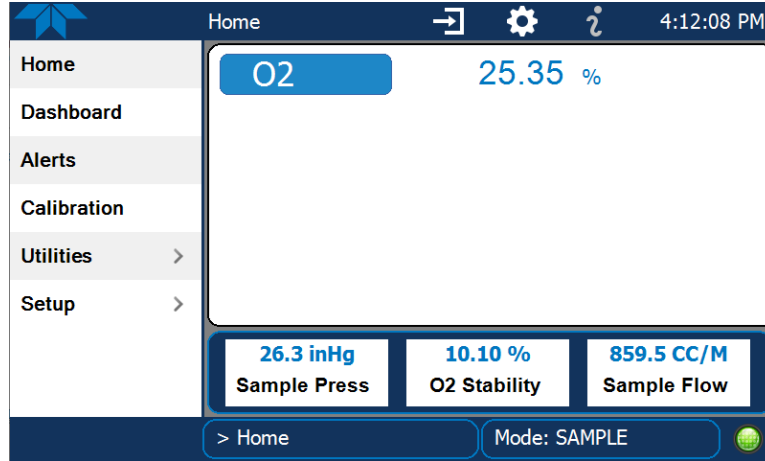


Figure 2-17. Home Page Example (when installed, CO₂ option conc displays below O₂ conc)

2.3.4.2 ALERTS: WARNINGS AND OTHER MESSAGES

Because internal temperatures and other conditions may be outside the specified limits during the warm-up period, the software will suppress most Alerts for 30 minutes after power up. The Alerts page (Figure 2-18) shows the status of any active warning conditions or user-configured Events. (Section 2.4.3 provides more detailed information about Alerts, and Section 2.5.2 addresses Events).

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

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

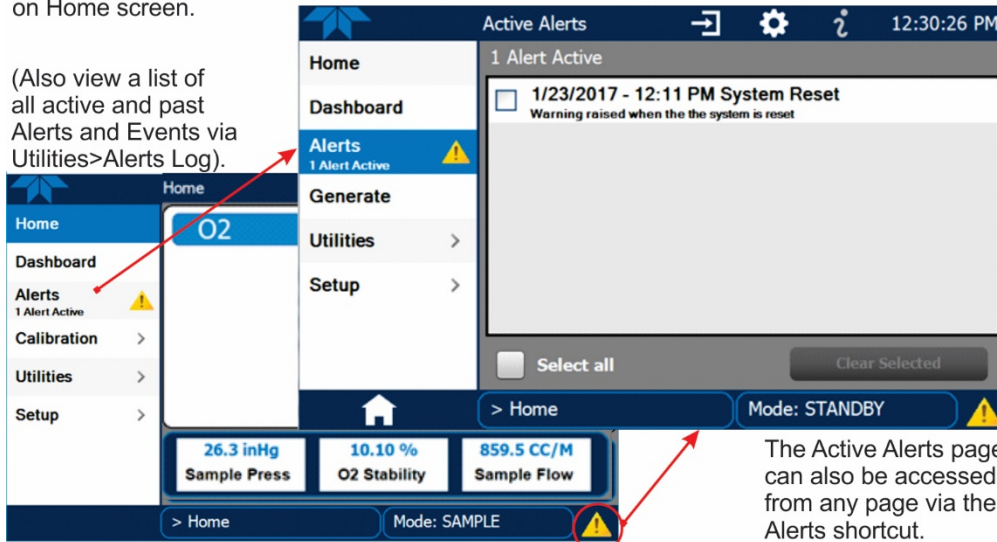


Figure 2-18. Viewing Active Alerts Page

If alerts of warning conditions persist after the warm up period or after being cleared, investigate their cause using the troubleshooting guidelines in Section **Error! Reference source not found.**

2.3.4.3 FUNCTIONAL CHECKS

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

These functions are also useful tools for diagnosing problems (information provided in Section 5.6.7).

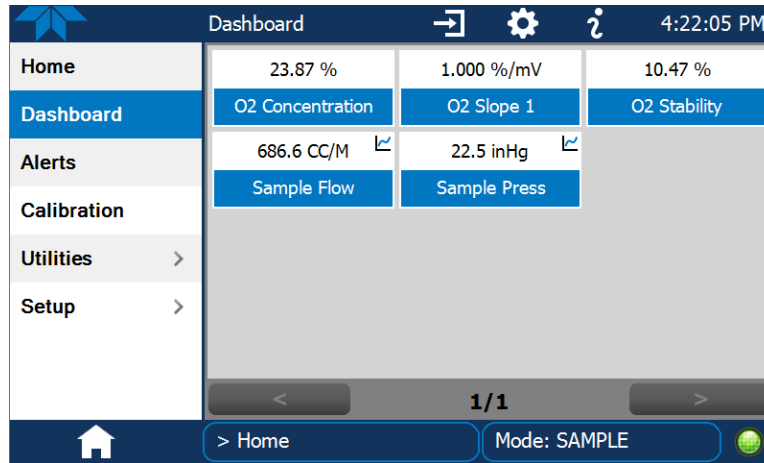


Figure 2-19. Sample Dashboard Page

2.3.4.4 CALIBRATION

Before operation begins, the analyzer requires zero and span calibrations. Also, any time an analyzer is moved or its configuration changed, it must be calibrated. Follow the appropriate calibration instructions presented in Section 4.

2.4 MENU OVERVIEW

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

Table 2-6. Menu Overview

MENU	DESCRIPTION	LOCATION
Home	View and plot concentration readings and other selectable parameter values (Figure 2-21).	Section 2.4.1
Dashboard	View user-selected parameters and their values, some of which can be displayed in a live-plot graph (Figure 2-22).	Section 2.4.2
Alerts	View and clear active Alerts that were triggered by factory-defined Events as well as user-defined Events. (Active and past Alerts are recorded in the Utilities>Alerts Log).	Section 2.4.3
Calibration	Run calibrations or calibration checks on the SO ₂ channel (and second gas sensor if installed).	Sections 2.4.4 and 4
Utilities	View logs, download data and firmware updates, copy configurations between instruments, and run diagnostics.	Section 2.4.5
Setup	Configure a variety of features and functions through these submenus for customized operation.	Section 2.5
Datalogging	Track and record concentration and calibration data and selectable diagnostic parameters, the reports for which can be viewed in the Utilities>Datalog View menu (Section 2.4.5) and downloaded to a flash drive via the Utilities>USB Utilities menu (Section 2.4.5). Also, select configured Events (Section 2.5.2) and create customized triggers for data logging functions.	Section 2.5.1
Events	Select parameters and define the conditions by which they are to be flagged and recorded in the Alerts log (Section 2.4.3) when they are triggered. Once configured, Events can be used to trigger Datalogs. (Section 2.5.1). Note that some Events are predefined and are not editable.	Section 2.5.2
Dashboard	Monitor instrument functionality (Figure 2-19) via selectable parameters.	Section 2.5.3
Vars	Manually adjust several software variables that define specific operational parameters.	Section 2.5.4
Homescreen	Select up to three parameters to be displayed in the meters (Figure 2-20).	Section 2.5.5
Digital Outputs	Map the rear-panel digital outputs to a variety of signals present in the instrument to monitor the status of operating conditions or custom Events.	Section 2.5.6
Analog Outputs	Send user-selected parameter readings in the form of user-defined voltage or current loop signals as outputs to a strip chart recorder and/or the data logger.	Section 2.5.7
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 2.5.8
Comm	View and configure network and serial communications.	Section 2.5.9

2.4.1 HOME PAGE

Figure 2-20 presents an orientation to the main display screen; Figure 2-21 shows that pressing the gas name or its concentration value or a meter below displays a live plot of their respective readings. Section 2.5.5 provides configuration instructions.

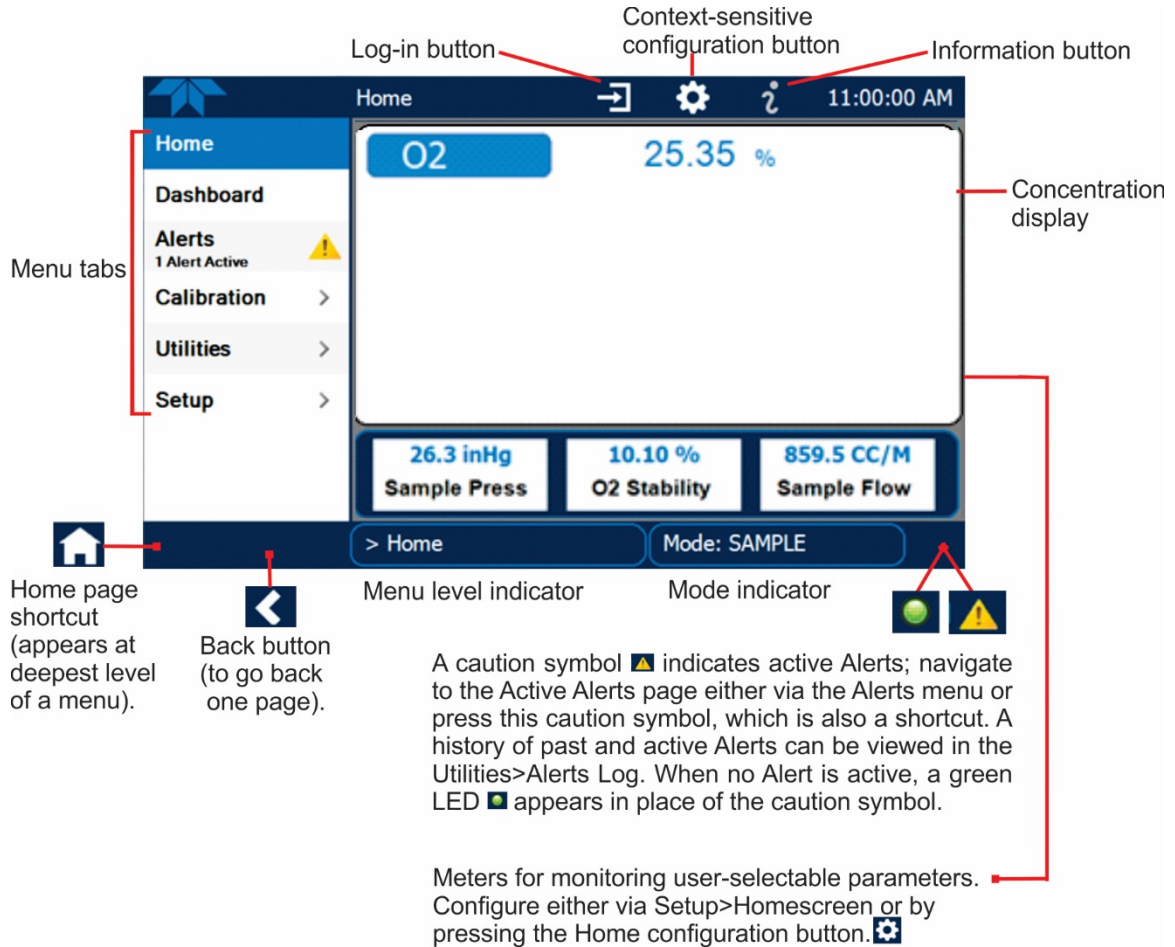


Figure 2-20. User Interface Orientation

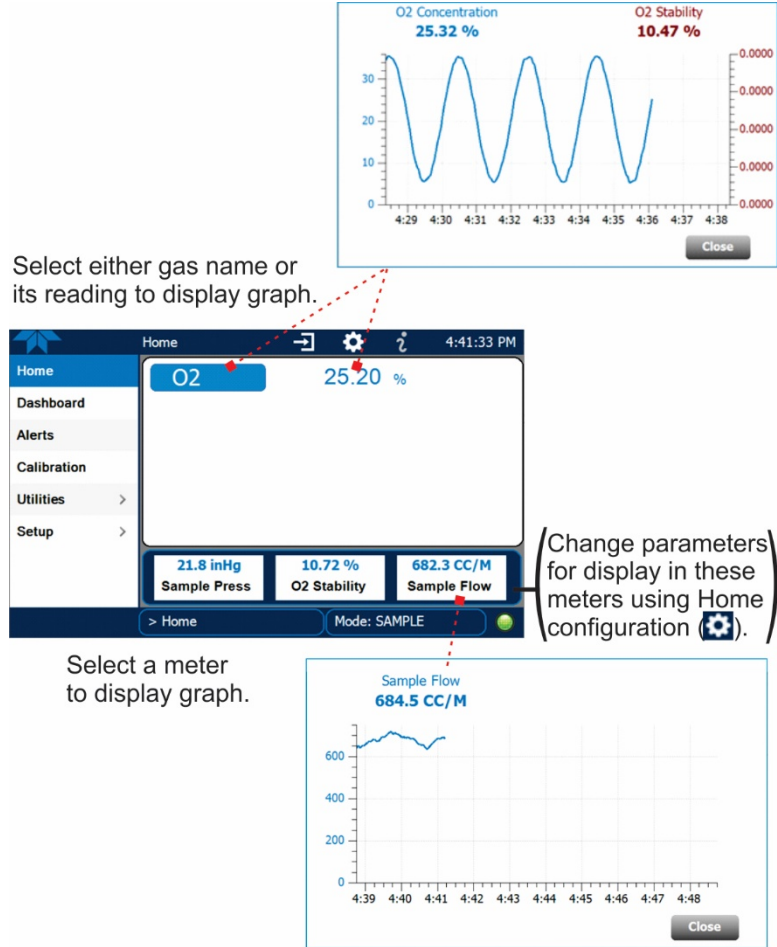
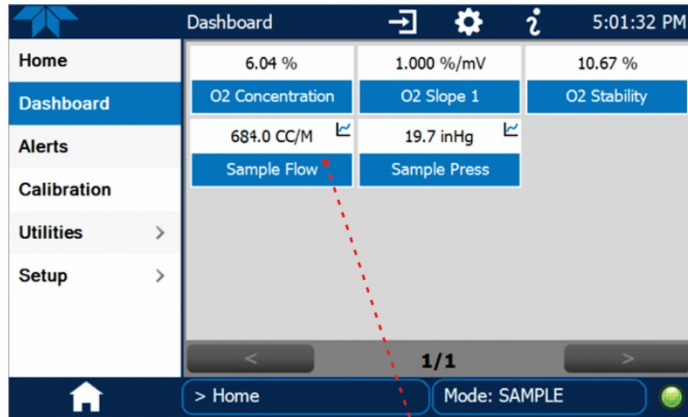


Figure 2-21. Concentration and Stability Graph (top) and Sample Flow Graph (bottom)

2.4.2 DASHBOARD

The Dashboard displays an array of user-selectable parameters and their values (Section 2.5.3 provides configuration instructions). If there is a graphing icon in the upper right corner of a parameter, pressing that parameter displays a live plot of its readings as in Figure 2-22.



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

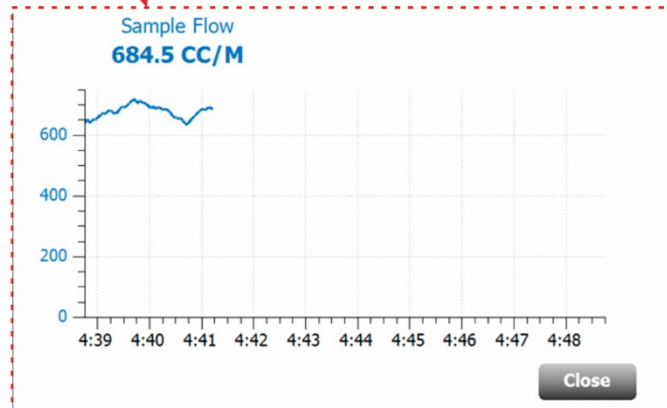


Figure 2-22. Dashboard Page

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 2-23).

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

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

(Also view a list of all active and past Alerts and Events via Utilities>Alerts Log).

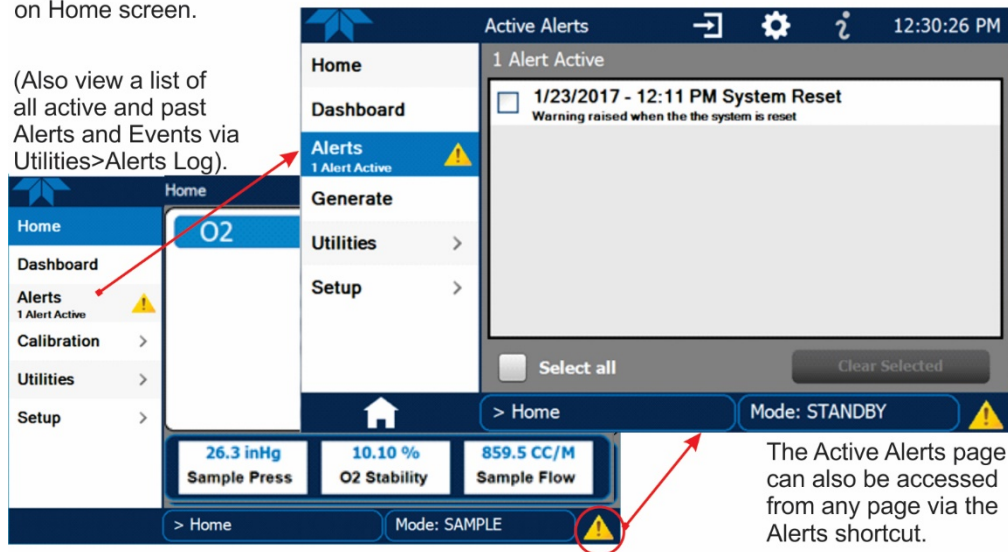


Figure 2-23. Navigating to the Active Alerts Page

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

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

When all Alerts are cleared, the Alerts menu tab no longer shows the caution symbol, and a green LED replaces the caution symbol in the bottom right corner of the interface (Figure 2-24). However, Alerts can reappear if the conditions causing them are not resolved.

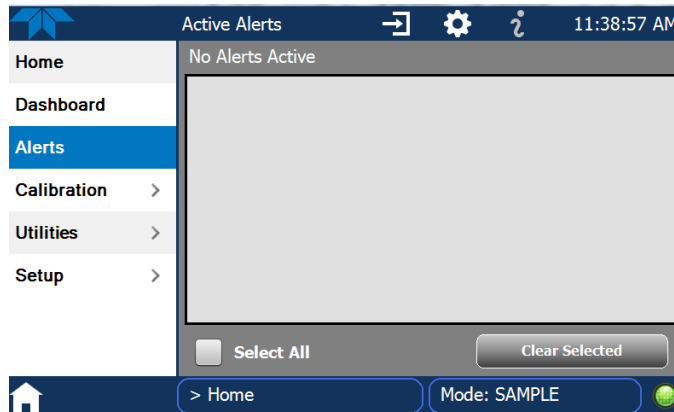


Figure 2-24. Active Alerts Cleared

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

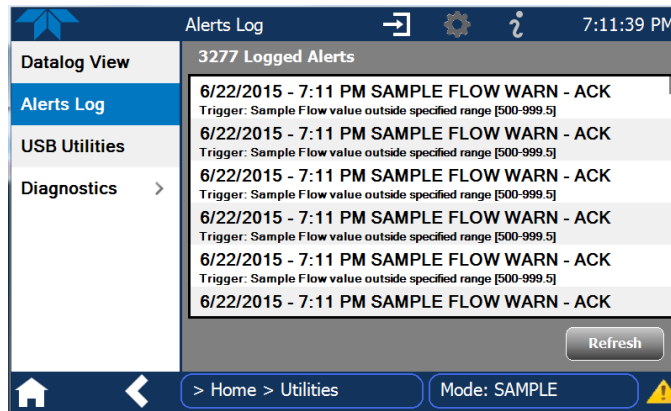


Figure 2-25. Utilities>Alerts Log of Active and Past Alerts and Events

2.4.4 CALIBRATION

The Calibration menu is used for zero and span calibrations, the procedures for which 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: <ul style="list-style-type: none"> • download data from the instrument's Data Acquisition System (DAS), the Data Logger, to a flash drive (Section 2.5.1.3) • update firmware (Section 5.3) • transfer instrument configuration from/to other same-model instruments (Section 2.6) • download a basic operation functionality report (Section 5.3).
Diagnostics	Provides access to various pages that facilitate troubleshooting.
Analog Inputs	Measure voltage signals of several analog input parameters. These can be logged in the internal data acquisition system (DAS), by configuring the Data Logger in the Setup>Data Logging menu (Section 2.5.1).
Analog Outputs	Show the voltage signals for the functions selected and configured in the Setup>Analog Outputs menu (Section 2.5.7). Rear panel connections were presented in Section 2.3.1.2.
Digital Inputs	Show whether specific available features are turned ON or OFF; for example, whether or not Maintenance Mode input or Language selection can be controlled through the front panel, or whether a zero or span calibration can be activated remotely when an external source is connected to the rear panel Control In connector (Section 2.3.1.5).
Digital Outputs	Show the function of user-specified parameters configured in the Setup>Digital Outputs menu (Section 2.5.6).
Flow Cal	Used to calibrate the sample gas flow reading with actual flow measured by an external device. (See Section 5.6.4).
Pressure Cal	Used to compensate for changes in atmospheric pressure (Section 5.6.5).

2.4.6 SETUP

The Setup menu is used to configure the instrument's software features, gather information on the instrument's performance, and configure and access data from the Datalogger, the instrument's internal data acquisition system (DAS). 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 for examination and analysis.

Figure 2-26 shows a new log; Figure 2-27 shows a sample existing log, which can be edited or deleted, and Figure 2-28 provides illustrated instructions for setting up a new log, with Sections 2.5.1.1 and 2.5.1.2 providing additional details.

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

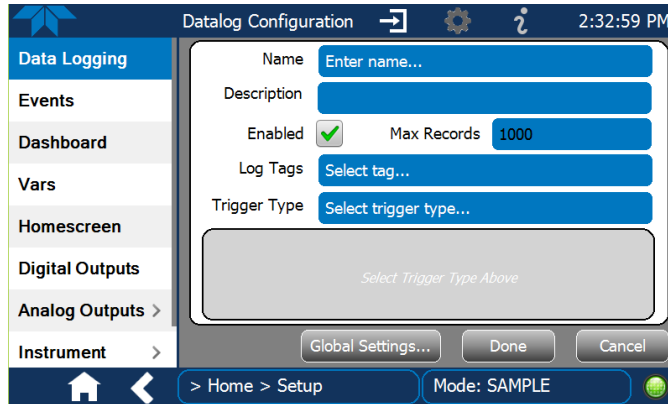


Figure 2-26. Datalog Configuration, New Log Page

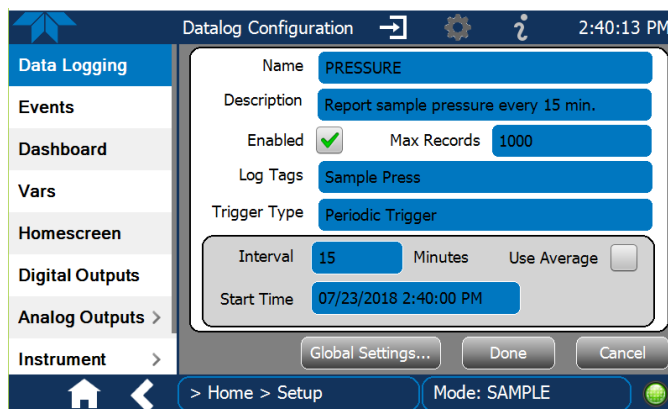
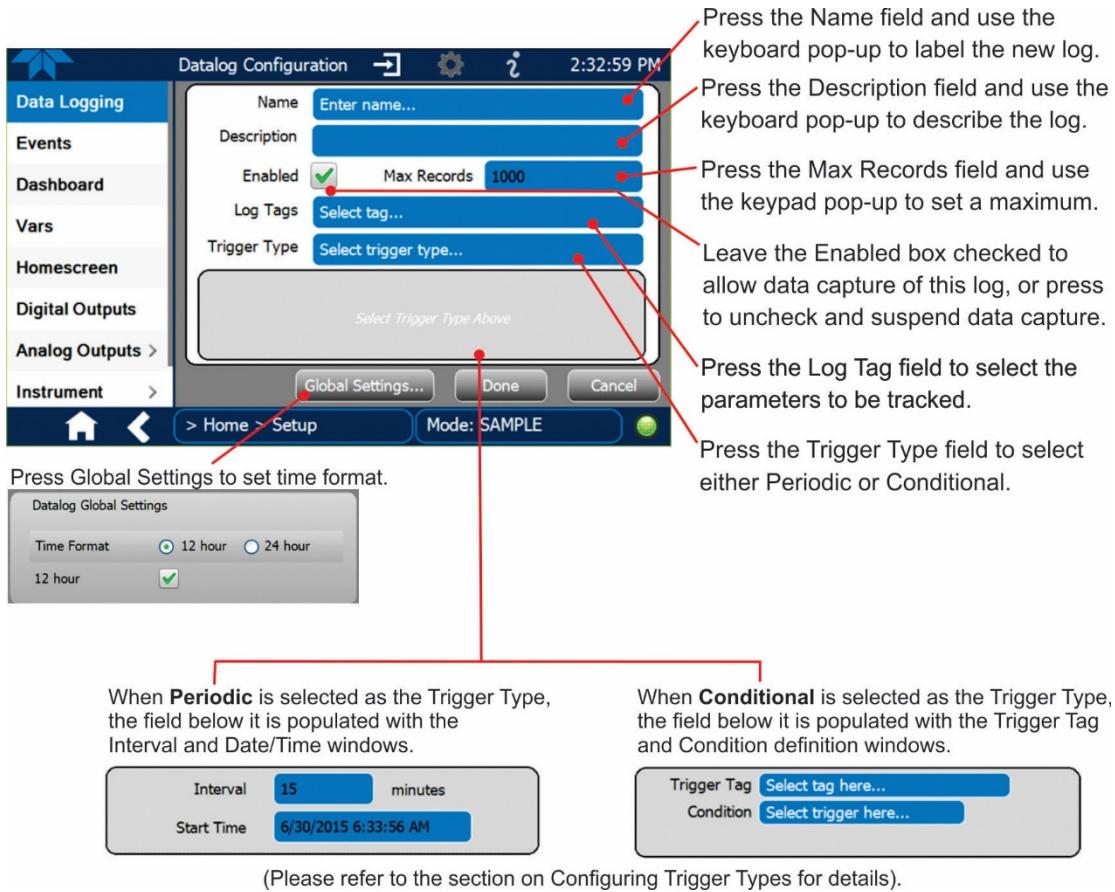


Figure 2-27. Datalog Configuration, Existing Log



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

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

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

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

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

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

Press Global Settings to set time format.

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

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

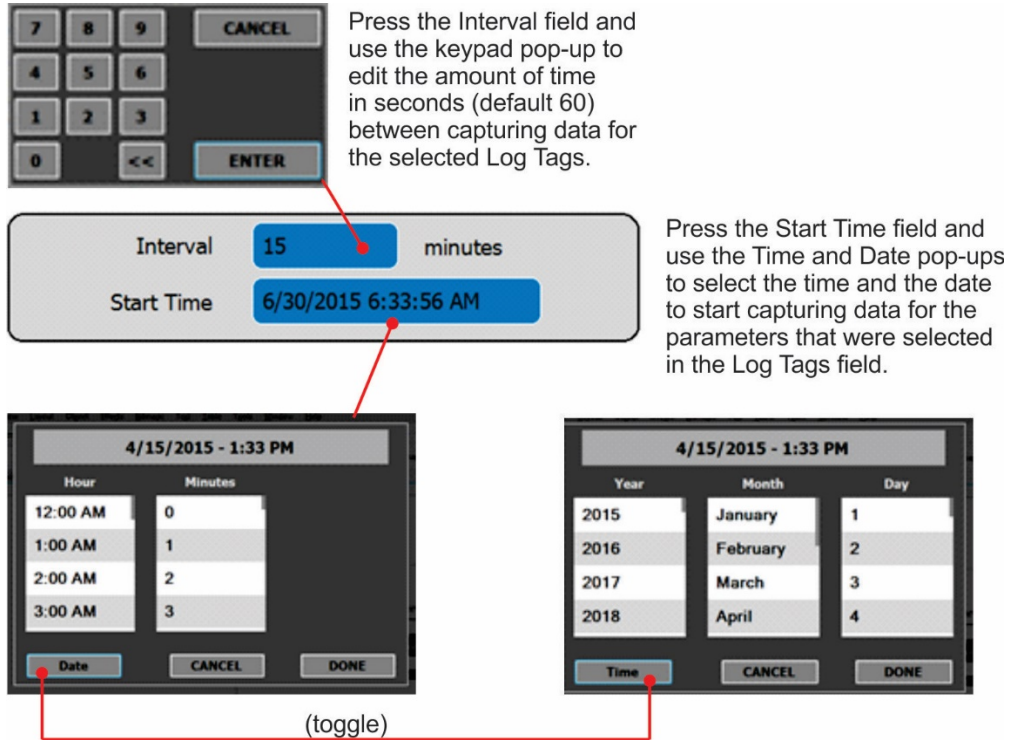
(Please refer to the section on Configuring Trigger Types for details).

Figure 2-28. Creating a New Data Log

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

2.5.1.1 CONFIGURING TRIGGER TYPES: PERIODIC

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



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

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

(toggle)

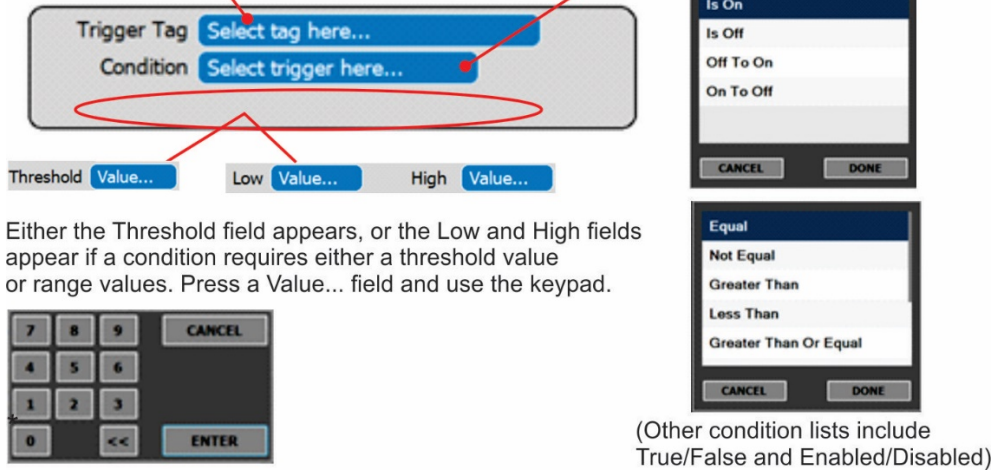
Figure 2-29. Datalog Periodic Trigger Configuration

2.5.1.2 CONFIGURING TRIGGER TYPES: CONDITIONAL

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

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

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



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

(Other condition lists include True/False and Enabled/Disabled)

Figure 2-30. Datalog - Conditional Trigger Configuration

2.5.1.3 DOWNLOADING DAS (DATA ACQUISITION SYSTEM) DATA

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

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

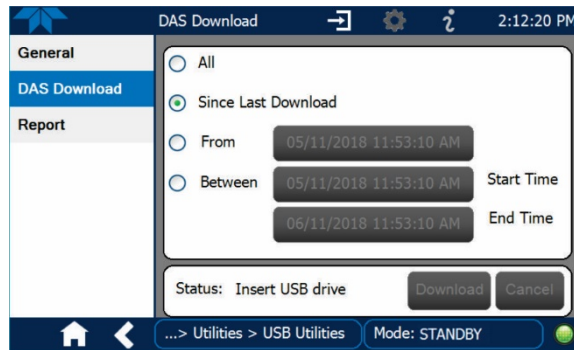


Figure 2-31. DAS Download Page

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

2.5.2 SETUP>EVENTS

Events are occurrences that relate to any operating function, and are used to define the conditions that can be set to trigger Alerts (Section 2.4.3). Events can provide diagnostic information about the instrument, typically referred to as “Warnings”, or they can provide other information on instrument functionality, such as concentration alarms. Some Events are standard and not editable while others are user-configurable, described here. Existing Events are listed in the Events page (Figure 2-32) under the Setup menu.

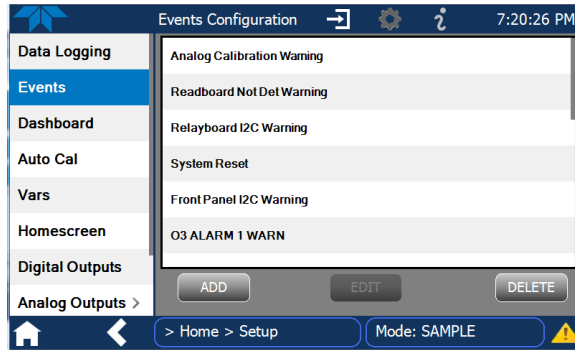


Figure 2-32. Events List

Access the Events Configuration page either from the Active Alerts page (Alerts Menu) by pressing the configuration button, or through the Home>Setup>Events menu (Figure 2-32). Press ADD to create a new Event (refer to Figure 2-33 for details), or select an existing Event to either Edit or Delete it (Figure 2-35).

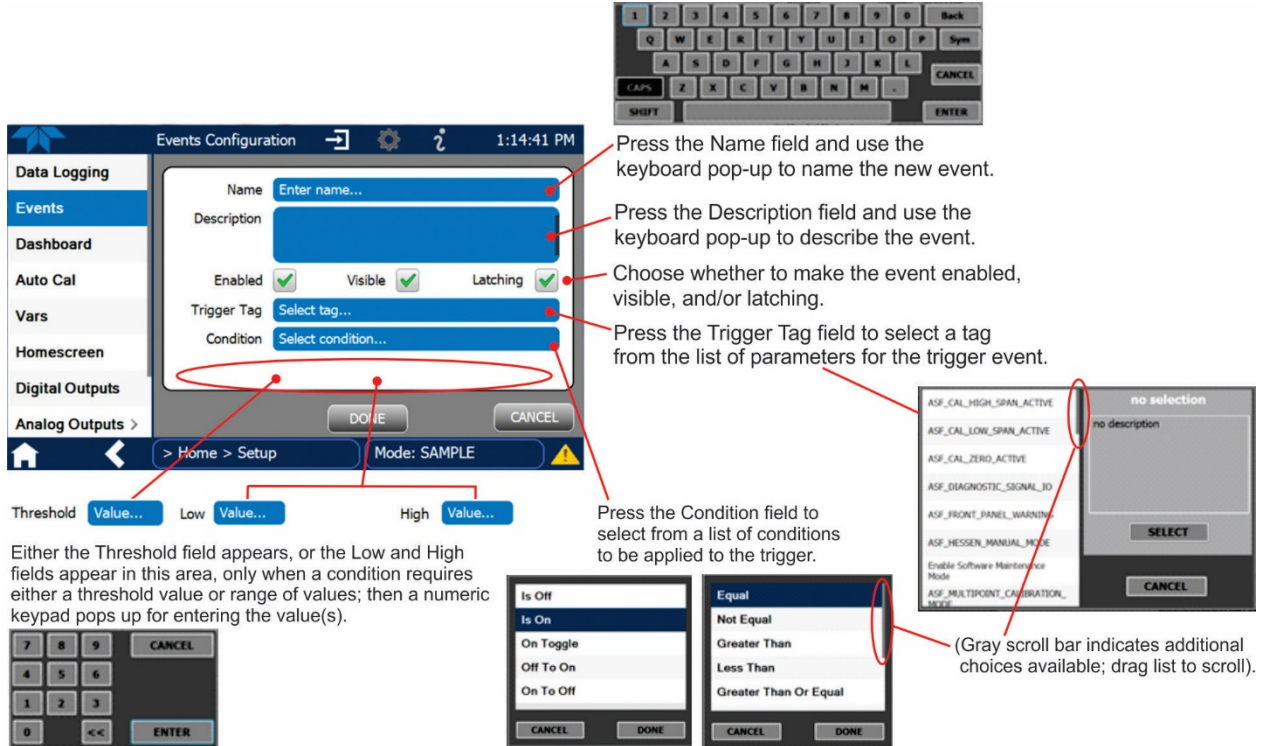


Figure 2-33. Event Configuration

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

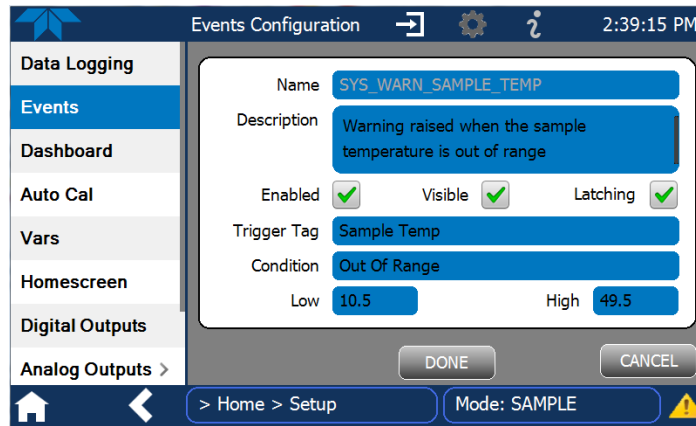


Figure 2-34. Configured Event Sample

2.5.2.1 EDITING OR DELETING EVENTS

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

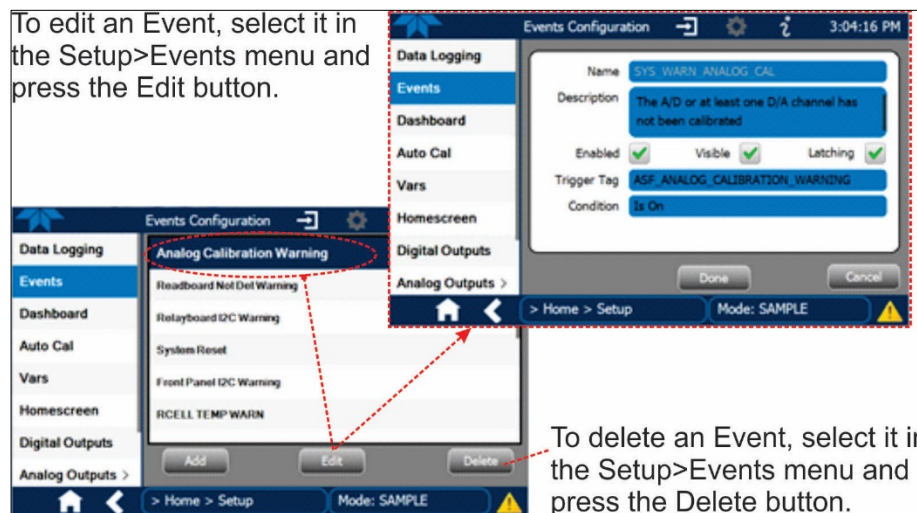


Figure 2-35. Edit or Delete an Event

2.5.2.2 USING EVENTS AS TRIGGERS FOR DATA LOGGING

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

2.5.3 SETUP>DASHBOARD

From Dashboard page, select the configuration shortcut, or navigate to Setup>Dashboard.

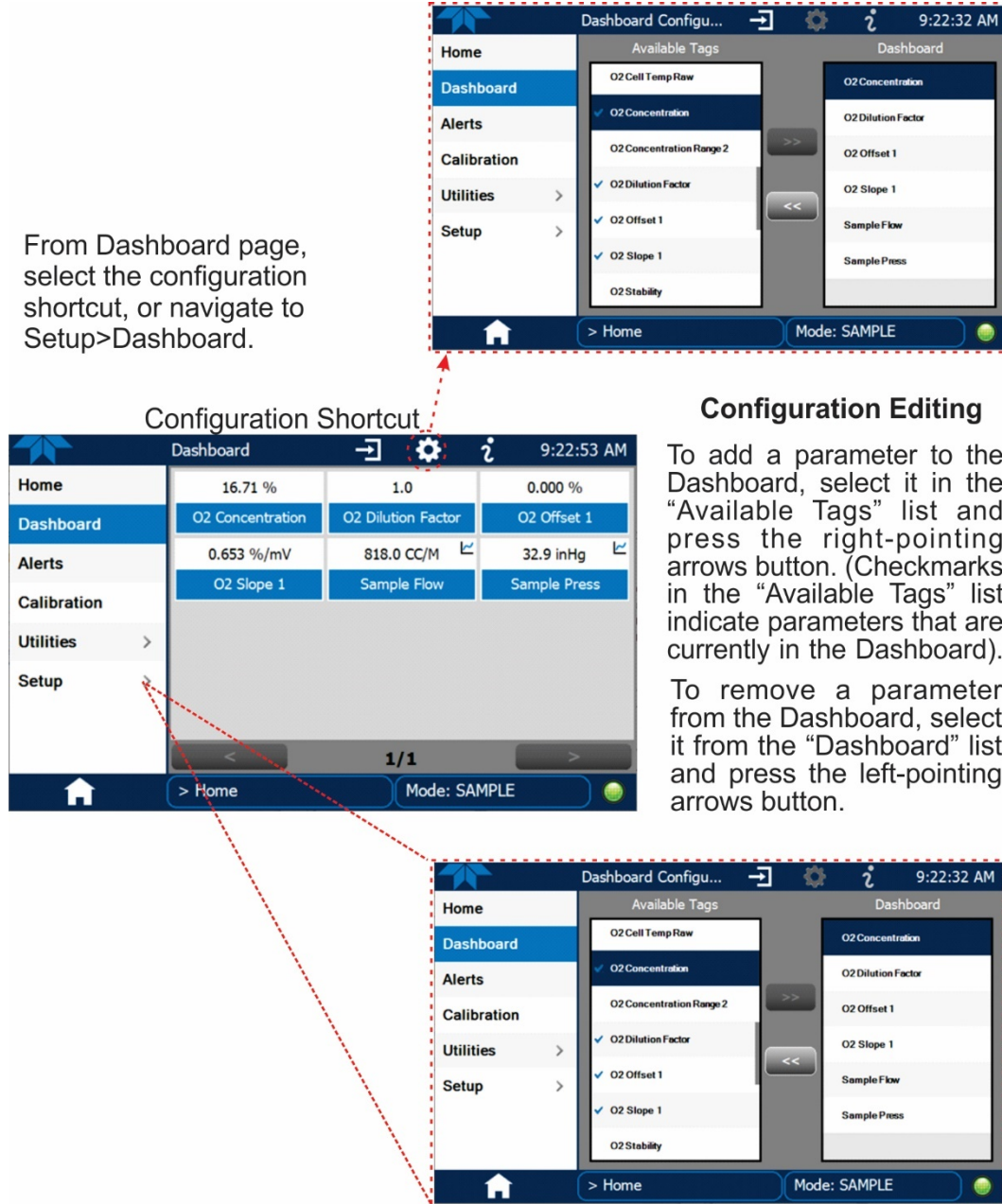


Figure 2-36. Dashboard Display and Configuration

2.5.4 SETUP>VARS

Vars are software variables that define operational parameters automatically set by the instrument's firmware, and are user-adjustable through this menu. Access the menu to see the list of variables (Vars); select a Var to view its description; touch the Edit button to change its setting(s). Table 2-8 describes some of the Vars.

Table 2-8. Typical Variables with Descriptions

VARIABLE	DESCRIPTION
<p>NOTE: This list includes several of the most common Vars; selecting any Var in the NumaView™ software interface will display its description in the information field to its right. Depending on configuration, some, all, or more of these variables appear in your instrument's Vars menu.</p>	
Background Periodic Report Upload	Allow a periodic report to be automatically uploaded to cloud service at a frequency (in hours) set in the Report Upload Interval var.
Daylight Savings Enable	Enable or disable Daylight Savings Time (also see Setup>Instrument>Date/Time Settings)
Dilution Factor Enable	<p>Sets the instrument to compensate for diluted sample gas, such as in continuous emission monitoring (CEM) where the quality of gas in a smoke stack is being tested and the sampling method used to remove the gas from the stack dilutes the gas. Once the degree of dilution is known, this feature allows the user to add an appropriate scaling factor to the analyzer's SO₂ 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.</p> <ol style="list-style-type: none"> 1. Set the appropriate units of measure (Setup>Vars>User Units). 2. Select the reporting range mode (Setup>Vars>Range Mode) and set the reporting range upper limit (Setup>Analog Output). Ensure that the upper span limit entered for the reporting range is the maximum expected concentration of the undiluted gas. 3. Set the dilution factor as a gain, e.g., a value of 20 means 20 parts diluent and 1 part sample gas (Setup>Vars>Dilution Factor). 4. Calibrate the analyzer; ensure that the calibration span gas is either supplied through the same dilution system as the sample gas or has an appropriately lower actual concentration.
Instrument ID	Set unique identifier number for the instrument when it is connected with other instruments in multidrop configuration or on the same Ethernet LAN, or when applying MODBUS or Hessen protocols (see Setup>Comm).
Maint Mode	Set instrument to continue sampling, while ignoring calibration, diagnostic, and reset instrument commands. This feature is of particular use for instruments connected to Multidrop (2.3.1.7) or Hessen protocol networks.
PRIGAS Precision	Sets the number of significant digits to the right of the decimal point display of primary gas concentration and stability values. (SECGAS Precision for secondary gas).
Range Mode	Controls range mode, single (SNGL) or dual (DUAL). (When set to DUAL, ensure that Max Concentration Range has been set).
System Hours	Total system runtime hours.
Upload Report to Cloud	Allows (True) or denies (False) instrument to upload report to cloud service.

2.5.5 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 Homescreeen configuration page through either the Setup>Homescreeen menu or from Home page using the configuration icon (Figure 2-37).

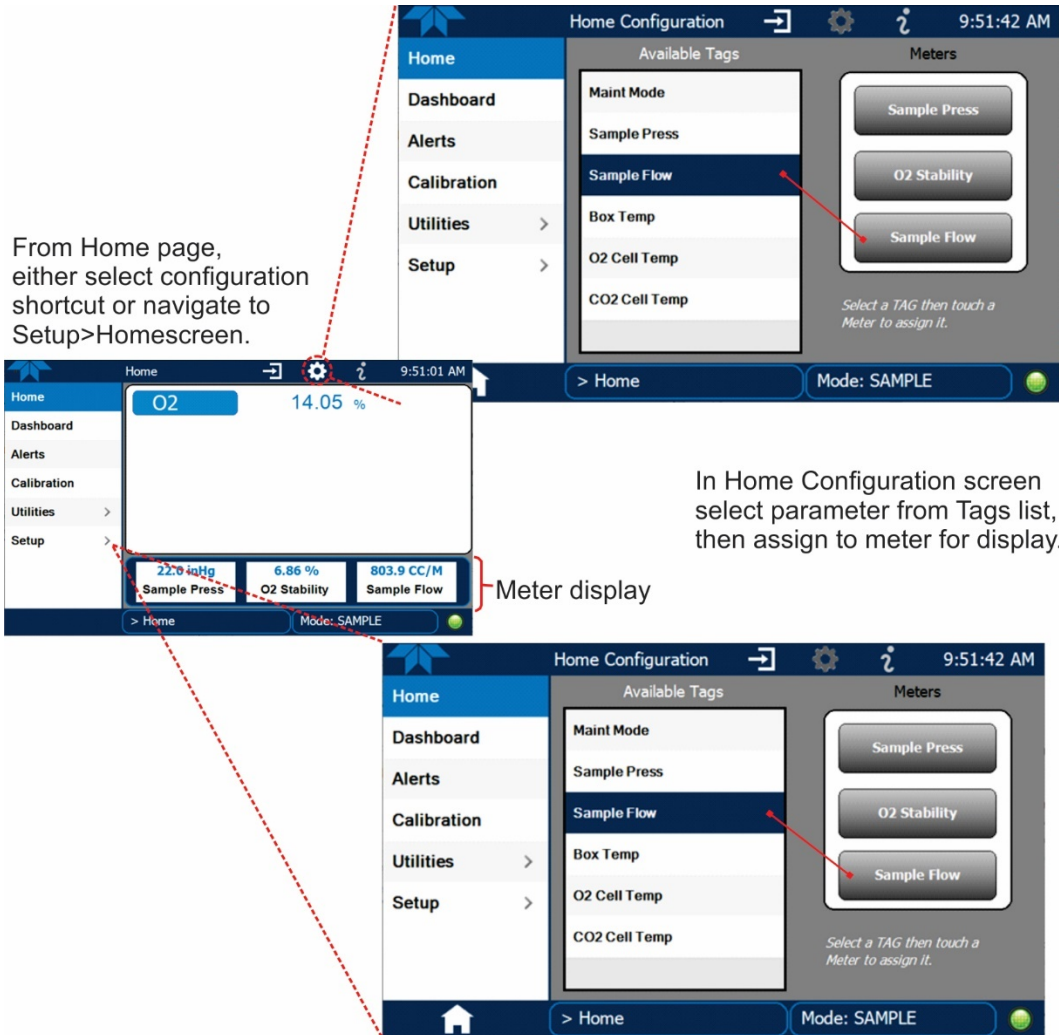


Figure 2-37. Homescreeen Configuration

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

2.5.6 SETUP>DIGITAL OUTPUTS

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

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

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

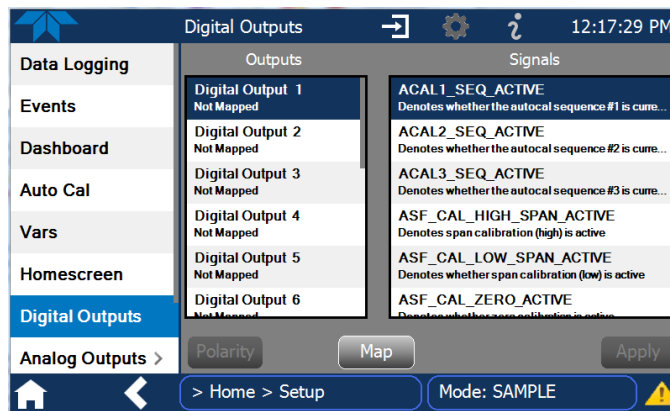


Figure 2-38. Digital Outputs Setup

2.5.7 SETUP>ANALOG OUTPUTS

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

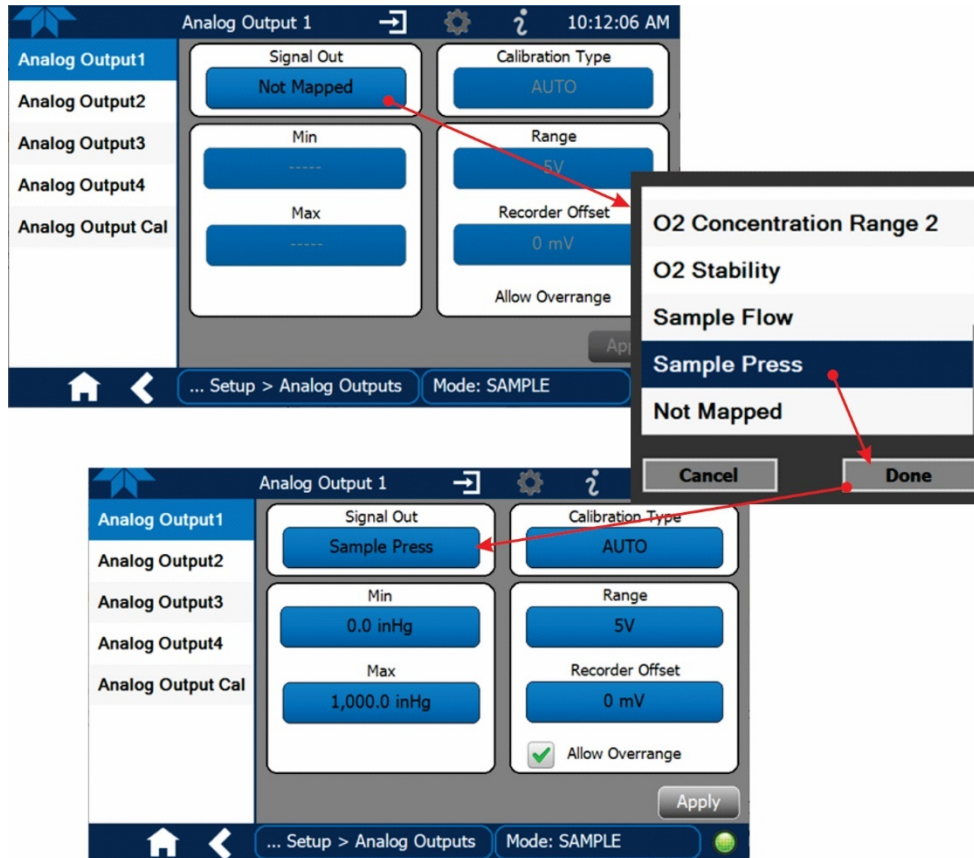


Figure 2-39. Analog Output Configuration Example

Refer to Figure 2-39 for the following:

- Signal Out: select a Signal for the output.
- Min/Max: edit minimum and maximum values associated with the selected Signal.
- Calibration Type:
 - AUTO for group calibration (Figure 2-40) of the analog outputs (cannot be selected when Current is selected for the Range)
 - MANUAL for individual calibration (Figure 2-41) of analog outputs where manual adjustments can be made (the only calibration type allowed when Current is selected for the Range). See Sections 2.5.7.1 and 2.5.7.2 .
- 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 $\pm 5\%$ over-range; uncheck to disable over-range if the recording device is sensitive to excess voltage or current.

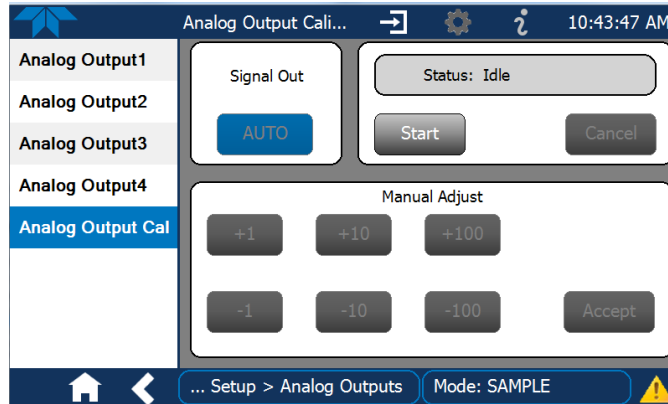


Figure 2-40. Analog Outputs Group Calibration Screen

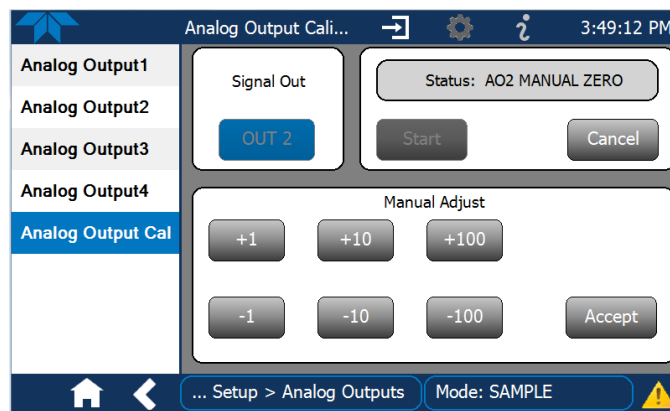


Figure 2-41. Analog Outputs Manual Calibration Screen (AOUT2 Example)

Table 2-9. Analog Output Voltage/Current Range

RANGE ¹	RANGE SPAN	MINIMUM OUTPUT	MAXIMUM OUTPUT
100mV	0-100 mVDC	-5 mVDC	105 mVDC
1V	0-1 VDC	-0.05 VDC	1.05 VDC
5V	0-5 VDC	-0.25 VDC	5.25 VDC
10V	0-10 VDC	-0.5 VDC	10.5 VDC
Current²	0-20 mA	0 mA	20 mA

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

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

For manual calibration adjustments, see Section 2.5.7.1 for voltage and Section 2.5.7.2 for current.

2.5.7.1 MANUAL CALIBRATION OF VOLTAGE RANGE ANALOG OUTPUTS

It is possible to manually calibrate the voltages by using a voltmeter connected across the output terminals (Figure 2-42) and changing the output signal level in the Manual Adjust field of the Analog Outputs Calibration screen (Figure 2-41). Refer to Table 2-10 for voltage tolerances.

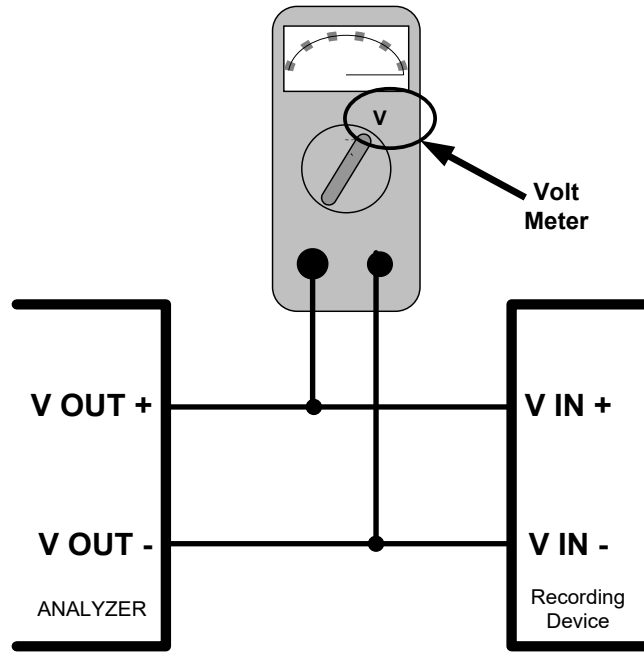


Figure 2-42. Setup for Checking / Calibrating DCV Analog Output Signal Levels

Table 2-10. Voltage Tolerances

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

2.5.7.2 MANUAL ADJUSTMENT OF CURRENT RANGE ANALOG OUTPUTS

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

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

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

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



CAUTION!

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

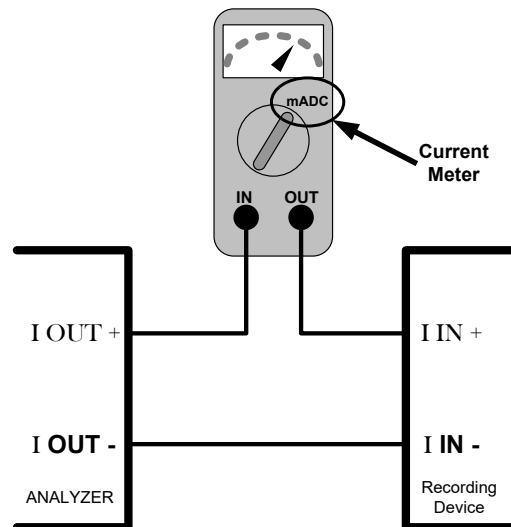


Figure 2-43. Setup for Checking / Calibration Current Output Signal Levels

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

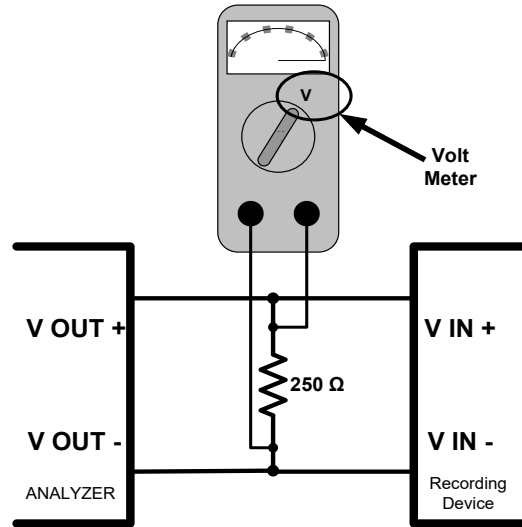


Figure 2-44. Alternative Setup Using 250Ω Resistor for Checking Current Output Signal Levels

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

Table 2-11. Current Loop Output Check

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

2.5.8 SETUP>INSTRUMENT

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

Table 2-12. 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).

2.5.9 SETUP>COMM (COMMUNICATIONS)

This menu is for specifying the various communications configurations.

2.5.9.1 COM1/COM2

Configure the instrument's COM1 or COM2 ports to operate in modes listed in Table 2-13.

Table 2-13. COM1/COM2 Configuration

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

2.5.9.2 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.

2.5.9.3 TCP PORT2

TCP Port2 is configured with the port number for MODBUS.

2.5.9.4 TCP PORT3

TCP Port3 is configured with the port number for Hessen.

2.5.9.5 NETWORK SETTINGS

The Setup>Comm>Network Settings menu is for Ethernet configuration. The address settings default to automatic configuration by Dynamic Host Configuration Protocol (DHCP). Most users will want to configure the instrument with a static IP address: click the Static radio button to manually assign a static IP address (consult your network administrator, and see Table 2-14 for information).

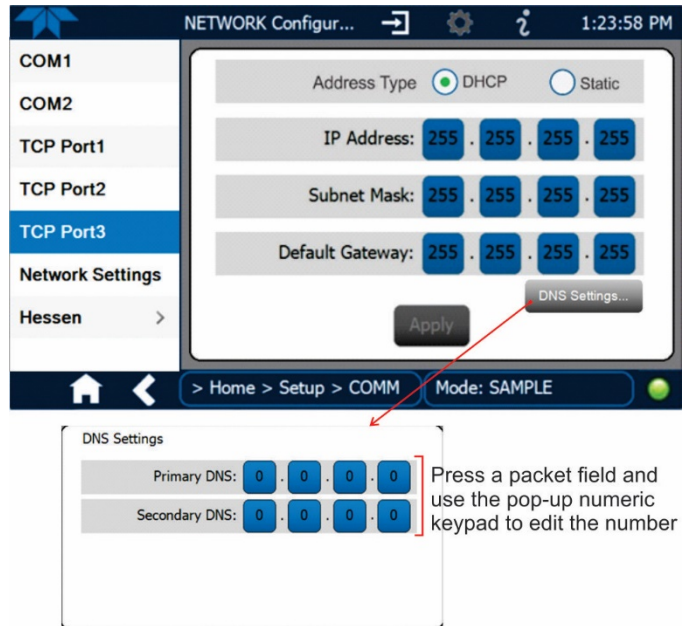


Figure 2-45. Communications Configuration, Network Settings

Table 2-14. LAN/Ethernet Configuration Properties

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

2.6 TRANSFERRING CONFIGURATION TO OTHER INSTRUMENTS

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

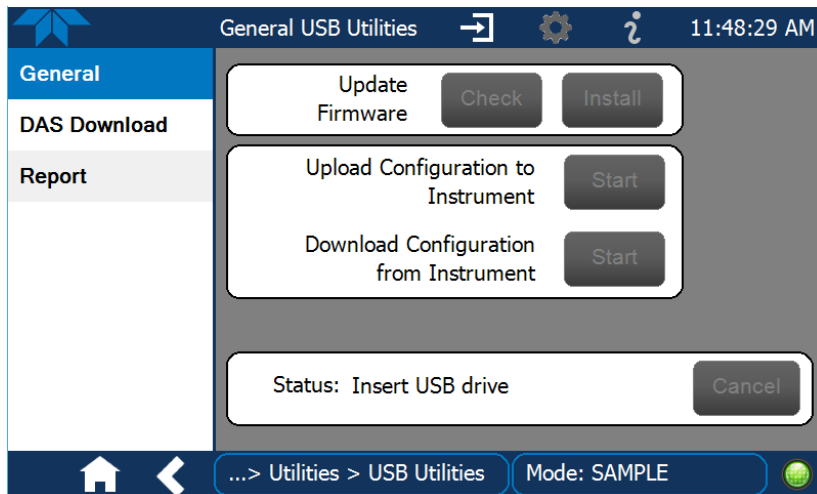


Figure 2-46. Configuration Transfer

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



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

3 COMMUNICATIONS AND REMOTE OPERATION

This instrument's rear panel connections include an Ethernet port, a USB port (option) and two serial communications ports labeled RS232, which is the COM1 port in the software menu, and COM2 (refer to Figure 2-2). These ports allow the ability to communicate with, issue commands to, and receive data from the analyzer through an external computer system or terminal or through NumaView™ Remote. Connection instructions were provided in Section 2.3.1.7. Configuration information was provided in Section 2.5.9.

This section provides pertinent information regarding communication equipment, the communications ports, and communications protocol. Data acquisition is set up through the Datalogger (Section 2.5.1). To use NumaView™ Remote, please refer to its own manual, Part Number 04892, which can be downloaded from the TAPI website <http://www.teledyne-api.com>.

3.1 DATA TERMINAL/COMMUNICATION EQUIPMENT (DTE DCE)

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

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

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

3.2 MODES, BAUD RATE AND SERIAL COMMUNICATION

Referring to Table 2-13, use the SETUP>COMM menu to configure COM1 (labeled RS232 on instrument rear panel) and/or COM2 (labeled COM2 on instrument rear panel) for communication modes, baud rate and serial communications. If using a USB option communication connection, setup requires that the instrument's baud rate and personal computer baud rate match.

3.2.1 SERIAL COMMUNICATION: RS-232

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

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

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

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

3.2.2 SERIAL COMMUNICATION: RS-485 (OPTION)

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

3.3 ETHERNET

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

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

Table 3-1. Ethernet Status Indicators

LED	FUNCTION
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 2.5.9.5 for configuration details.

3.4 COMMUNICATIONS PROTOCOLS

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

3.4.1 MODBUS

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

Minimum Requirements:

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

3.4.1.1 MODBUS COM PORT CONFIGURATION

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

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

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

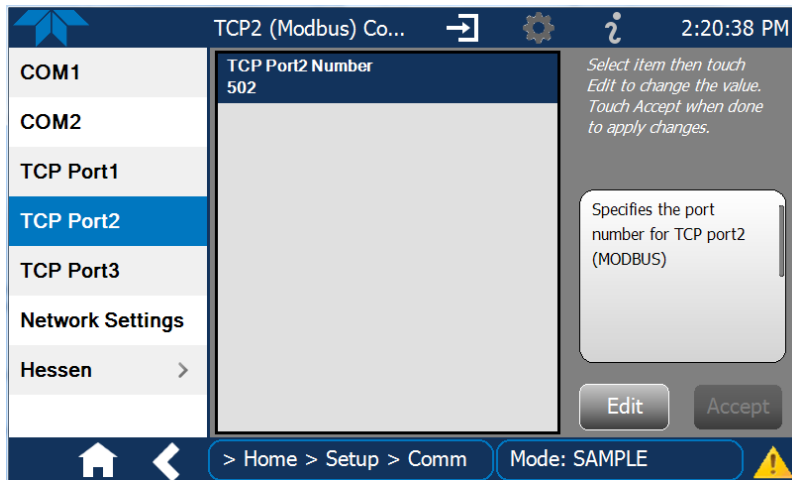


Figure 3-1. MODBUS via Ethernet

Serial COM: Both COM1 (labeled “RS232” on the instrument’s rear panel) and COM2 are configurable for RS-232 or RS-485 communication with either MODBUS RTU or MODBUS ASCII transmission modes. In the Setup>Comm COM1[COM2] menu, edit the Protocol parameter to select a MODBUS transmission mode; edit Baud Rate, Parity, Data Bits, etc., if necessary (see descriptions in Table 2-13).

Important

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

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

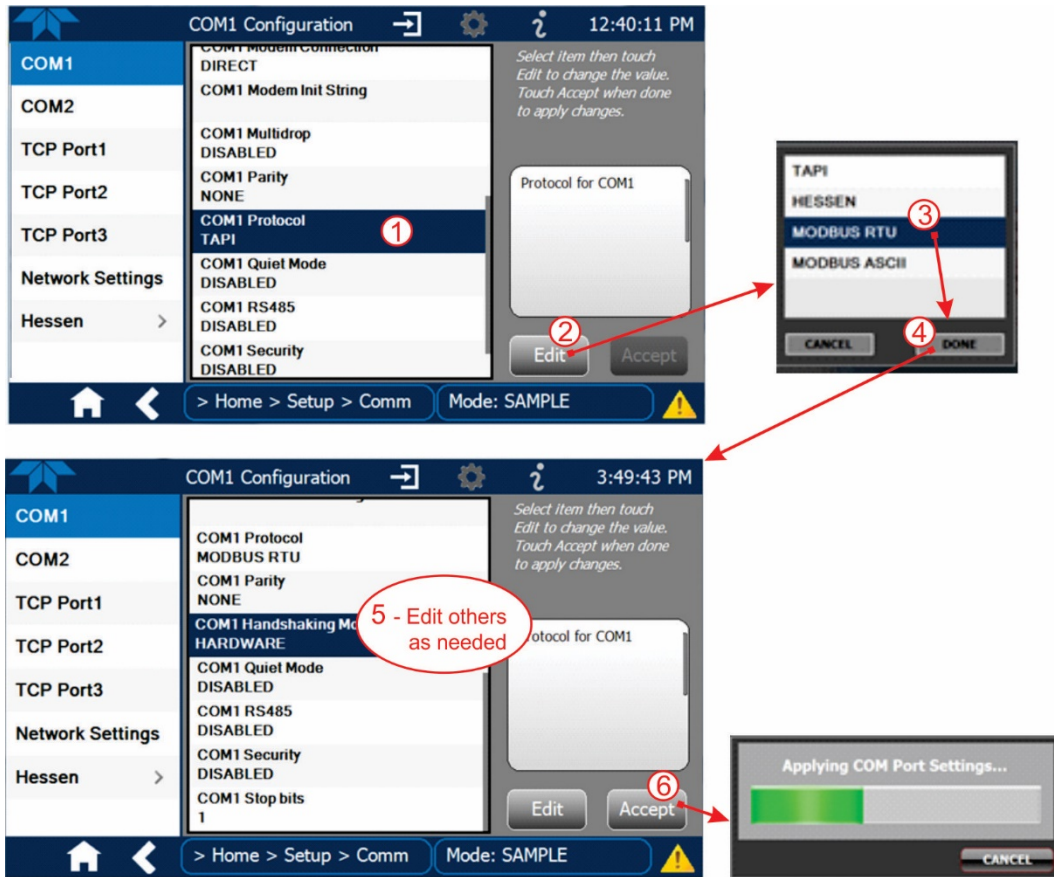


Figure 3-2. MODBUS via Serial Communication (example)

Important

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

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

3.4.2 HESSEN

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

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

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

3.4.2.1 HESSEN COM PORT CONFIGURATION

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

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

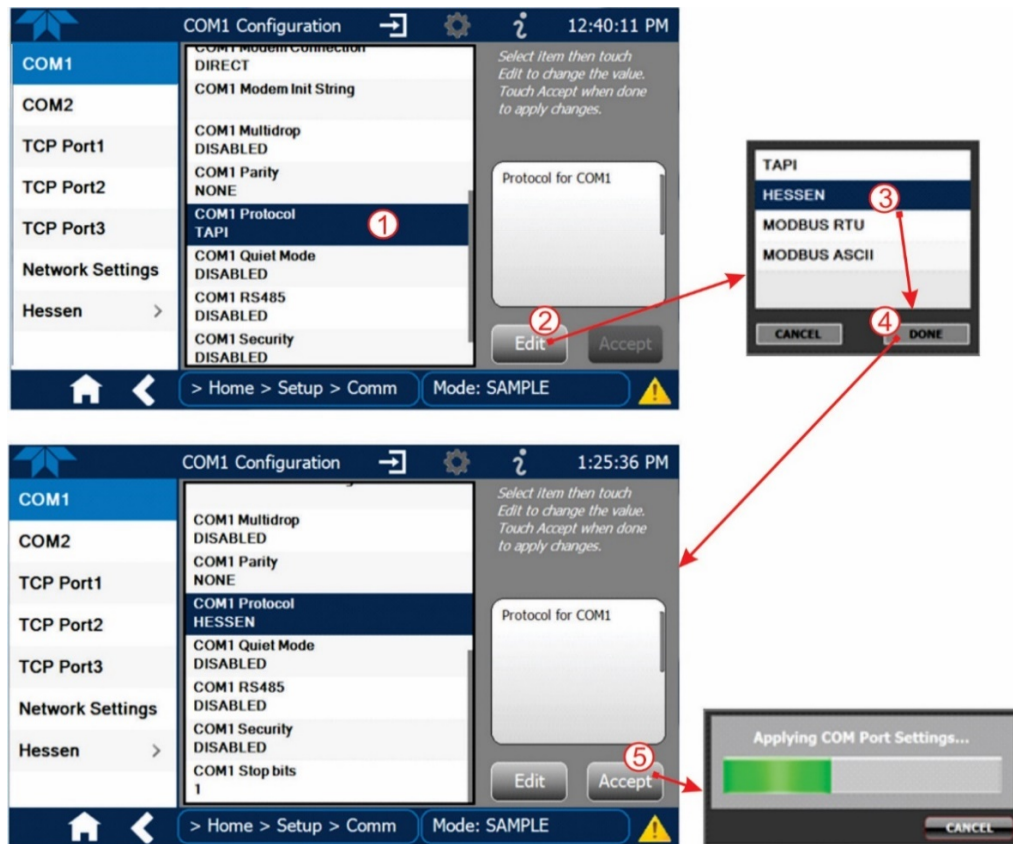


Figure 3-3. Serial Communication, Setting Hessen Protocol

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

3.4.2.2 HESSEN SETTINGS CONFIGURATION

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

HESSEN VARIATION

For the Hessen Variation setting, there are two versions.

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

HESSEN PROTOCOL RESPONSE MODE

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

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

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

HESSEN STATUS FLAGS

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

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

Table 3-3. Hessen Status Flags and Default Bit Assignments

STATUS FLAG NAME	DEFAULT BIT ASSIGNMENT (user editable; also see Note ²)
WARNING FLAGS¹	
SAMPLE FLOW WARNING	0001
INVALID CONC	0080
OPERATIONAL FLAGS¹	
In Manual Calibration Mode	0200
In O ₂ Zero Calibration Mode ³	0400
In CO ₂ Zero Calibration Mode ³	0400
In O ₂ Span Calibration Mode ³	0800
In CO ₂ Span Calibration Mode ³	0800
UNITS OF MEASURE FLAGS⁴	
UGM	0000
MGM	2000
PPB	4000
PPM	6000
Spare/Unused Bits	0001, 0002, 0004, 0008, 0010, 0020, 0040, 0100, 1000, 8000
UNASSIGNED FLAGS (0000)	
Box Temp Warning	O2 Conc Alarm 2 ²
O2 Cell Temp Warn	Analog Cal Warning
CO2 Cell Temp Warn	Cal MP O2
Sample Press Warning	Cal MP CO2
Relay Board Warning	Rear Board Not Detected
Cannot Dyn Span	System Reset
Cannot Dyn Zero	CO2 Conc Alarm 1 ²
O2 Conc Alarm 1 ²	CO2 Conc Alarm 2 ²

¹ These status flags are standard for all instruments and should probably not be modified.

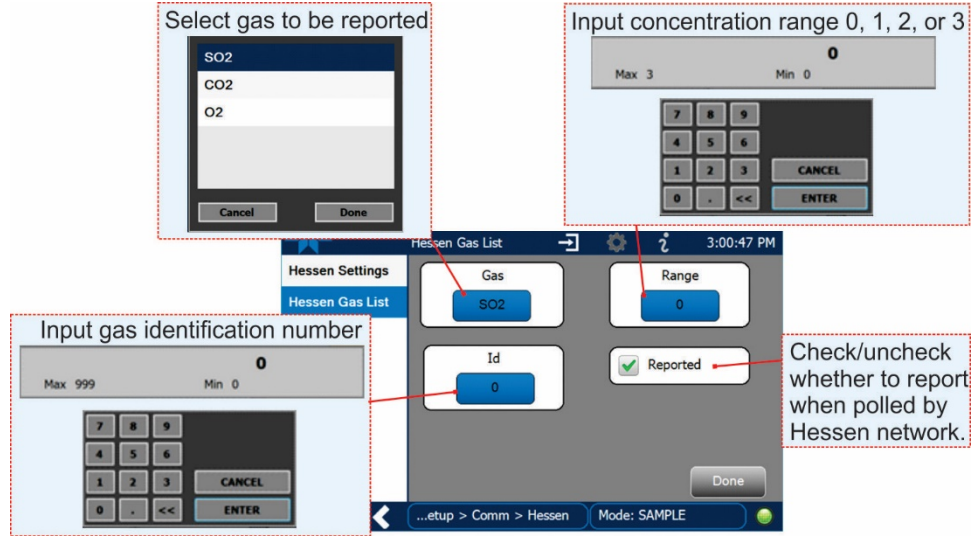
² Only applicable if the alarm option is installed.

³ It is possible to assign more than one flag to the same Hessen status bit. This allows the grouping of similar flags, such as all temperature warnings, under the same status bit.

⁴ While these units are assigned flags, they are not applicable in the T802 which reports in % when measuring O₂ and when reporting CO₂.
Be careful not to assign conflicting flags to the same bit as each status bit will be triggered if any of the assigned flags is active.

3.4.2.3 HESSEN GAS LIST CONFIGURATION

Configure the Hessen Gas List in the Setup>Comm>Hessen>Hessen Gas List page. Choose the Gas, the concentration Range, and enter the gas ID. Refer to and to the table below.



Menu: Setup>Comm>Hessen>Hessen Settings>Hessen Gas List

Figure 3-4. Hessen Gas List Configuration

Table 3-4. Hessen Gas List Definitions

PARAMETER	DEFINITION
Gas	type of gas to be reported
Range	concentration range to be reported (when Reported box is checked)
0	currently active range
1	only when range 1 or low range is active
2	only when range 2 or high range is active
3	Not Applicable
Id	specific gas identification
110	O ₂
111	CO ₂
Reported	choice of whether to report when polled by the Hessen network

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 – Calibration Quality Analysis: describes how to evaluate quality of each calibration.

4.1 IMPORTANT PRECALIBRATION INFORMATION

Note

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

4.1.1 CALIBRATION REQUIREMENTS

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

- Zero-air source
- Span gas source
- Gas lines - all gas line materials should be Teflon-type or glass.
- Traceability Standards

Optional equipment: See section 4.1.6 for data recording devices.

Note

Zero air and span gases must be supplied at 1.5 to 2 times the instrument's specified gas flow rate.

4.1.2 ZERO AIR

Zero air is similar in chemical composition to the Earth's atmosphere but scrubbed of all components that might affect the analyzer's readings. Teledyne API recommends using pure N₂ when calibrating the zero point of your O₂ or optional CO₂ sensor option.

4.1.3 CALIBRATION (SPAN) GAS

Span gas is a gas specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the desired measurement range. In this case, O₂ measurements made with the T802 analyzer, Teledyne API recommends using 21% O₂ in N₂ when calibrating the span point of the O₂ sensor option.

Cylinders of calibrated O₂ gas traceable to NIST-Standard Reference Material specifications (also referred to as SRMs or EPA protocol calibration gases) are commercially available.

4.1.4 PHYSICAL RANGE MEASUREMENTS

Functionally, the T802 analyzers have one hardware PHYSICAL RANGE that is capable of determining O₂ concentrations from 0.00 % to 100.00 %.

This architecture improves reliability and accuracy by avoiding the need for extra, switchable, gain-amplification circuitry. Once properly calibrated, the analyzer's front panel will accurately report concentrations along the entire span of its physical range.

Because many applications use only a small part of the analyzer's full physical range, data resolution problems can occur for most analog recording devices. For example, in a typical application where a T802 is being used to measure atmospheric O₂ concentration, the full scale of expected values is only 21% of the instrument's full measurement range. Unmodified, the corresponding output signal would also be recorded across only 21% of the range of the recording device.

The T802 analyzers solve this problem by allowing the user to select a scaled reporting range for the analog outputs that only includes that portion of the physical range relevant to the specific application.

Only this REPORTING RANGE of the analog outputs is scaled, the physical range of the analyzer and the readings displayed on the front panel remain unaltered.

4.1.5 INTERFERENTS

The fluorescence method for detecting SO₂ is subject to interference from a number of sources including hydrocarbons, which fluoresce similarly to SO₂. However, the analyzer has been designed to reject most of these interferences.

Nitrogen oxide (NO) also fluoresces in a spectral range near to SO₂. For critical applications where high levels of NO are expected, an optional optical filter is available that improves the rejection of NO (contact Technical Support for more information).

4.1.6 DATA RECORDING DEVICES

A strip chart recorder, data acquisition system or digital data acquisition system can 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 handling, download, storage, quick check and plotting.

4.2 CALIBRATION PROCEDURES

Although this section uses the Calibration menu for both check and actual calibration, a check does not require the Calibration menu. Instead, while in Home page, simply flow the zero air or the 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 and 4.2.2. after connecting the sources of zero air and span gas in either of the following two ways:

4.2.1 ZERO CALIBRATION CHECK AND ACTUAL CALIBRATION

1. Set up connections per Section 2.3.2.2.
2. Zero air through the Sample port and navigate to the Calibration menu. (If the CO₂ sensor is installed, the software provides a window to select between O₂ and CO₂).
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.

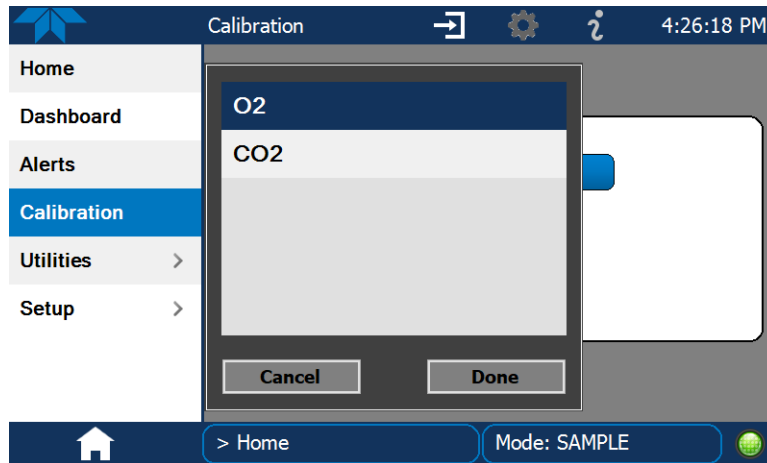


Figure 4-1. Calibration Menu for O₂ and CO₂ Sensors

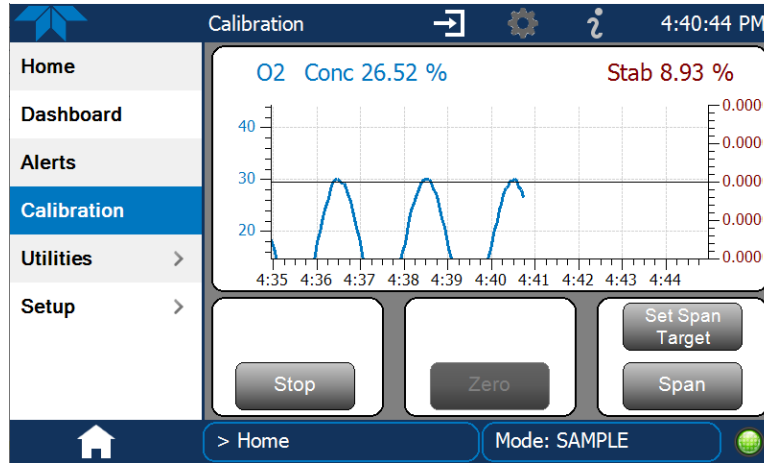


Figure 4-2. Sample Calibration Page for O₂ Sensor

4.2.2 SPAN CALIBRATION CHECK AND ACTUAL CALIBRATION

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

CHECK ONLY:

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

ACTUAL CALIBRATION:

- a. Press the Set Span Target button and enter the gas concentration (either the % of O₂ in N₂ or % of CO₂ in N₂, depending on sensor being cal'd).
 - b. Verify the concentration reading is the same as the concentration being supplied.
 - c. If correct, wait to reach stability, then press the Span button.
 - d. In the Cal Result window, press OK.
3. Press the Stop button and return to Home screen.
 4. In the Dashboard, check and record the Slope(s) and the Offset(s). (See Table 4-1 in Section 4.3 for expected/acceptable values).

4.3 CALIBRATION QUALITY ANALYSIS

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

Set up the Data Logger with a Periodic trigger (see Section 2.5.1) to record the values of the Slope and Offset parameters.

Ensure that these parameters are within the limits listed in Table 4-1 and frequently compare them to those values on the *Final Test and Validation Data Sheet* that came with

your instrument, which should not be significantly different. Otherwise, refer to the troubleshooting Section 5.6.11.

Table 4-1. Calibration Data Quality Evaluation

FUNCTION	MINIMUM VALUE	OPTIMUM VALUE	MAXIMUM VALUE
SLOPE	0.700	1.000	1.300
Offset	-0.500	0.000	0.500

5. MAINTENANCE AND SERVICE

The T802 Paramagnetic Oxygen Analyzer utilizes a technology that is non-depleting and requires very little maintenance. However, there are a minimal number of simple procedures that when performed regularly will ensure that the analyzer continues to operate accurately and reliably over its lifetime. To support your understanding of the technical details of maintenance and service, the principles of operation in Section 6 provides information about how the instrument works.

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.



WARNING – STRONG OXIDIZER

Oxygen is a strong oxidizer. Before working with the casing open, be sure to turn off power supply, and perform air or N2 gas purging of not only the analyzer inside, but also the sample gas line.

In addition, carefully prevent oil and grease from adhering to any piping. Otherwise, poisoning, fire or explosion may be caused due to gas leakage, etc..



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 and 4.2.2, respectively.

Table 5-1. Maintenance Schedule

ITEM	ACTION	FREQ	CAL CHECK REQ'D	DATE PERFORMED												
Dashboard functions	Review and evaluate (Section	Weekly	No													
¹ Particulate filter	Change	Weekly or as needed	No													
Zero/span check	Evaluate offset and slope	Weekly	No													
¹ Zero/span calibration	Calibrate Zero and span	As required per zero/span check	Yes													
¹ Flow	Check Flow	Every 6 months	No													
Software/Firmware	Check for updates	Every 6 months or as set in Vars (also see Section 5.4)	Yes													
Pneumatic sub-system	Check for leaks in gas flow paths and examine lines and clean lines as needed	Annually or after repairs involving pneumatics	Yes if a leak is repaired or if lines cleaned													
¹ Pump Diaphragm	Replace	Annually	Yes													

¹ These Items are required to maintain full warranty; all other items are strongly recommended.

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	CONDITION	BEHAVIOR	INTERPRETATION
Stability	O2 Zero Cal	Increasing	<ul style="list-style-type: none"> Pneumatic leaks – instrument and sample system
Pressure	Sample	Increasing > 1"	<ul style="list-style-type: none"> Pneumatic Leak between sample inlet and Sample Cell Change in sampling manifold
		Decreasing > 1"	<ul style="list-style-type: none"> Dirty particulate filter Pneumatic obstruction between sample inlet and sensor Obstruction in sampling manifold
Offset	Zero Cal	Increasing	<ul style="list-style-type: none"> Pneumatic Leaks Contaminated zero gas
		Decreasing	<ul style="list-style-type: none"> Contaminated zero gas
Slope	Span Cal	Increasing	<ul style="list-style-type: none"> Pneumatic Leaks – instrument & sample system Calibration system deteriorating
		Decreasing	<ul style="list-style-type: none"> Calibration system deteriorating

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. The report is generated every 24 hours to a Web services “cloud” where it is available for viewing by Teledyne API technical support personnel. 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.

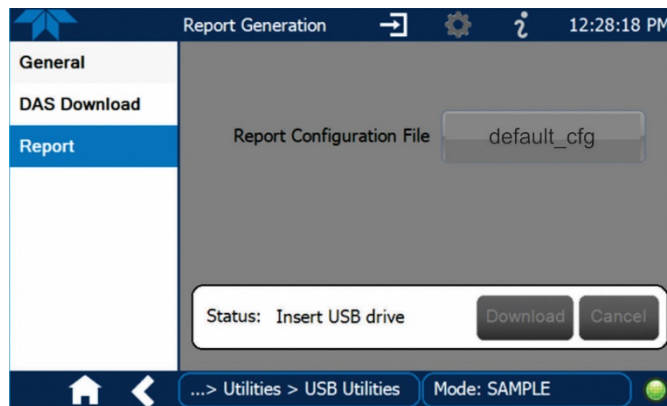


Figure 5-1. Report Generation Page

5.4 SOFTWARE/FIRMWARE UPDATES

An automatic weekly check for updates can be enabled in the Setup>Vars>Periodically Check for Updates menu, and/or a check for updates can be prompted at any time in the Setup>Instrument>Remote Update page. Downloading updates can be performed either remotely (5.4.1) or manually (5.4.2).

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 (Figure 5-2). If an update is available, the Update button will be enabled.

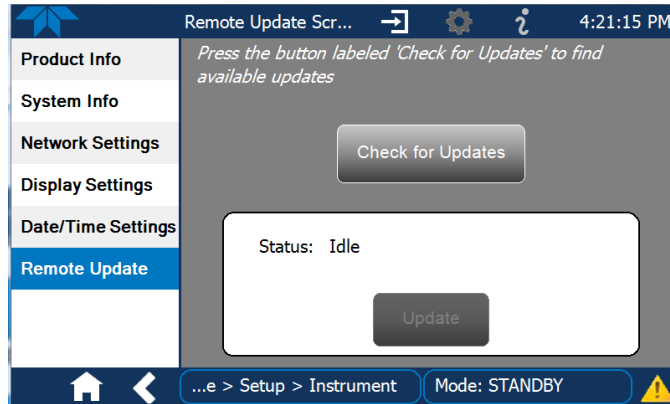


Figure 5-2. Remote Update Page

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 / 800-324-5190.

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

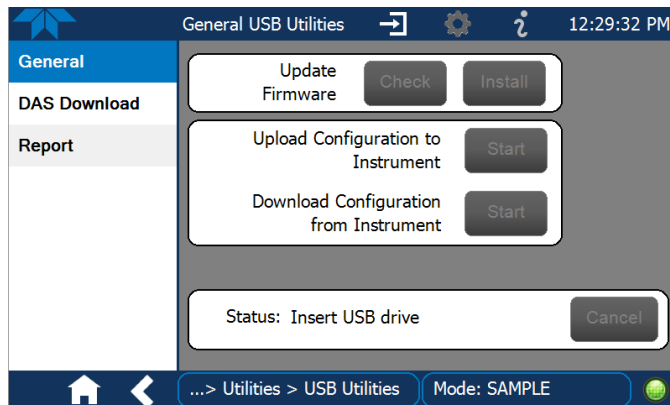


Figure 5-3. Manual Update Page (and other utilities)

3. Insert a flash drive into a front panel USB port and wait for the Status field to indicate that the drive has been detected.
4. In the Update Firmware field, press the Check button for the instrument to determine whether the firmware on the flash drive is more recent than what is currently installed. Once it's been determined that the firmware is new, the Install button will be enabled; if the firmware version on the flash drive is the same as or older than the current firmware of the instrument, the Install button will not be enabled.



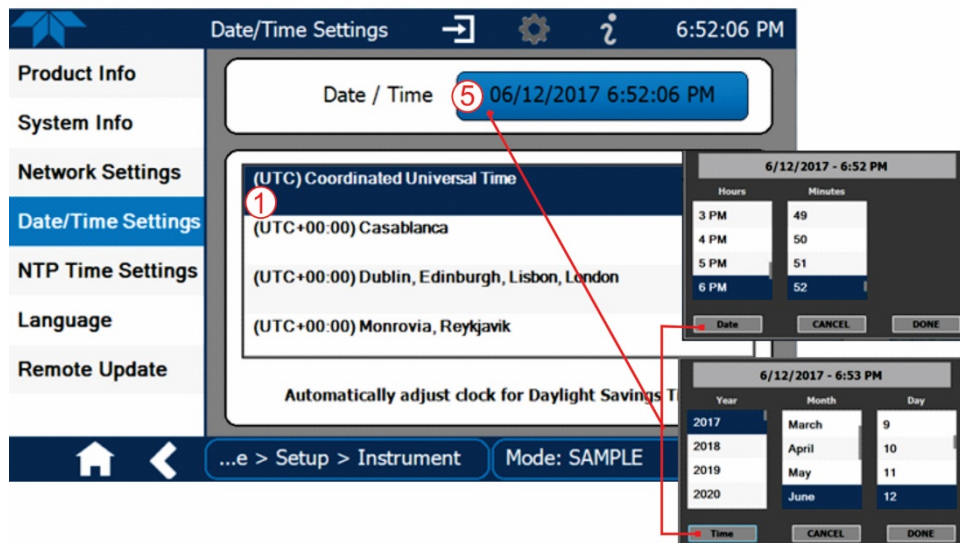
5. Press the Install button, and note the messages in the Status field at the bottom of the page. Use the Cancel button if necessary.
6. When complete, as indicated in the Status field, press the Done button, which replaces the Cancel button, and remove the flash drive.
7. Power off and restart the instrument to complete the new firmware installation.

5.5 TIME ZONE CHANGES

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

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

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



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

Figure 5-4. Time Zone Change Requirements

5.6 MAINTENANCE AND SERVICE

This section presents maintenance and service procedures as well as troubleshooting guidance.

5.6.1 REPLACING THE SAMPLE PARTICULATE FILTER

The particulate filter should be inspected often for signs of plugging or contamination. We recommend that when you change the filter; handle it and the wetted surfaces of the filter housing as little as possible.

Important

IMPACT ON READINGS OR DATA

Use gloves or PTFE coated tweezers or similar handling to avoid contamination of the sample filter assembly. Do not touch any part of the housing, filter element, PTFE retaining ring, glass cover and the o-ring with bare hands, as contamination can negatively impact accuracy of readings.

To change the filter:

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

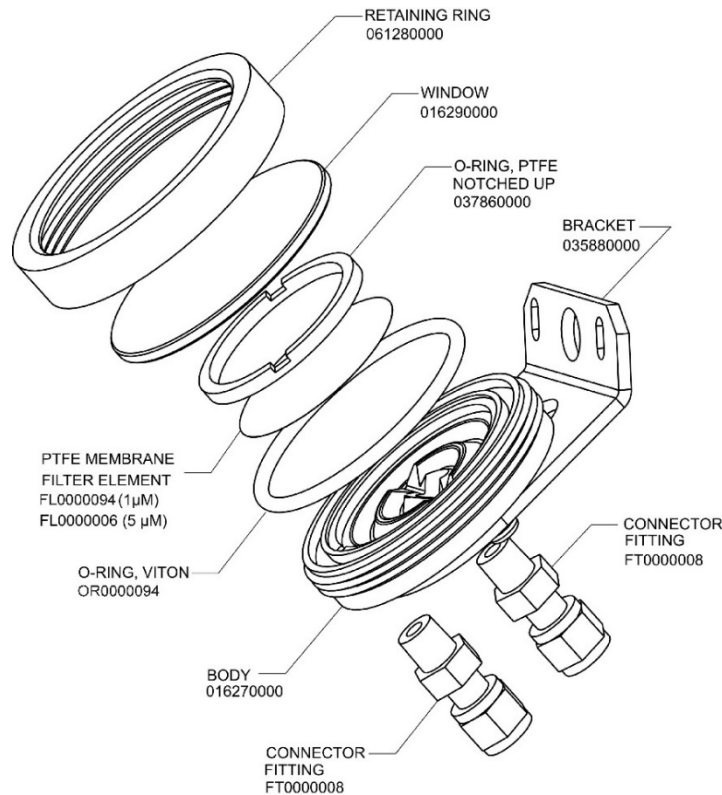


Figure 5-5. Replacing the Particulate Filter

3. Carefully remove the retaining ring, PTFE o-ring, glass window and filter element.

4. Replace the filter, being careful that the element is fully seated and centered in the bottom of the holder.
5. Reinstall the PTFE o-ring with the notches up; the glass window, then screw on the retaining ring and hand tighten. Inspect the seal between the edge of filter and the o-ring to assure a proper seal.
6. Close the panel and restart the analyzer.

5.6.2 REPLACING THE SAMPLE PUMP DIAPHRAGM

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

Always perform a Flow and Leak Check after rebuilding the Sample Pump.

5.6.3 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.

5.6.3.1 VACUUM LEAK CHECK AND PUMP CHECK

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

1. Turn the analyzer ON and allow enough time for flows to stabilize.
2. Cap the SAMPLE inlet port.
3. After several minutes, when the pressures have stabilized, note the Sample Press reading.
 - If the reading is < 10 in-Hg, the pump is in good condition and there are no large leaks.
4. Check the Sample Flow reading. If the flow is < 10 cm³/min and stable, there are no large leaks in the instrument's pneumatics.

5.6.3.2 SIMPLE VACUUM LEAK AND PUMP CHECK

Leaks are the most common cause of analyzer malfunction. This section presents a simple leak check, whereas the next section details a more thorough procedure. The method described here is easy, fast and detects, but does not locate, most leaks. It also verifies the sample pump condition.

1. If not already running, turn the analyzer ON, and allow at least 30 minutes for flows to stabilize.
2. Cap the sample inlet port (cap must be wrench-tight).

3. After several minutes, when the pressures have stabilized, note the Sample Pressure reading.
 - If equal to within 10% and less than 10 in-Hg-A, the instrument is free of large leaks.
 - It is still possible that the instrument has minor leaks.
 - If the reading greater than 10 in-Hg-A, the pump is in good condition.
 - A new pump will create a pressure reading of about 4 in-Hg-A (at sea level).
4. When finished, switch off the pump and open the cap to the sample inlet port slowly to minimize inrush flow.

5.6.3.3 DETAILED PRESSURE LEAK CHECK

Obtain a leak checker that contains a small pump, shut-off valve, and pressure gauge to create both over-pressure and vacuum. Alternatively, a tank of pressurized gas, with the two-stage regulator adjusted to ≤ 15 psi, a shutoff valve and a pressure gauge may be used.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

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

Also, do not exceed 15 psi when pressurizing the system.

1. Turn OFF power to the instrument and remove the instrument cover.
2. Install a leak checker or a tank of gas (compressed, oil-free air or nitrogen) as described above on the sample inlet at the rear panel.
3. Pressurize the instrument with the leak checker or tank gas, allowing enough time to fully pressurize the instrument through the critical flow orifice.
4. Check each tube connection (fittings, hose clamps) with soap bubble solution, looking for fine bubbles.
 - Once the fittings have been wetted with soap solution, do not reapply vacuum as it will draw soap solution into the instrument and contaminate it.
 - Do not exceed 15 psi pressure.
5. Once the leak has been located and repaired, the leak-down rate of the indicated pressure should be less than 1 in-Hg-A (0.4 psi) in 5 minutes after the pressure is turned off.
6. Clean surfaces from soap solution, reconnect the sample and pump lines and replace the instrument cover.
7. Restart the analyzer.

5.6.4 PERFORMING FLOW CHECKS/CALIBRATIONS

Important

IMPACT ON READINGS OR DATA

For accurate measurements use a separate, calibrated, volumetric flow meter capable of measuring the instrument's flow specifications. Do not use the built in flow measurement viewable in the Dashboard as this value is only calculated, not measured.

The sample gas flow rate through the analyzer is a key part of the gas concentration reading, but the reading is only a calculated value derived by the CPU. The Flow Cal feature under the Utilities>Diagnostics menu is used to check and to calibrate/adjust the calculations.

Sample flow checks, using an external, calibrated flow meter, are useful for monitoring the actual flow of the instrument to detect drift of the internal flow measurement. A decreasing, actual sample flow may point to slowly clogging pneumatic paths, most likely critical flow orifices or sintered filters.

5.6.4.1 FLOW CHECK

Low flows indicate blockage somewhere in the pneumatic pathway.

To check the Sample flow with the external flow meter:

1. Disconnect the sample inlet tubing from the rear panel SAMPLE port.
2. Attach the outlet port of a calibrated flow meter to the rear panel SAMPLE port.
 - Ensure that the inlet to the flow meter is at atmospheric pressure.
3. The sample flow measured with the external flow meter should be within $\pm 10\%$ of the analyzer's Flow specification (Table 1-1).

5.6.4.2 FLOW CALIBRATION

To calibrate the Sample flow (Flow Cal):

1. In the Utilities>Diagnostics>Flow Cal menu (Figure 5-6), edit the Actual Flow value by inputting the reading from the external flow meter obtained in the corresponding check of the flow to be calibrated.
2. Press the Calibrate button.

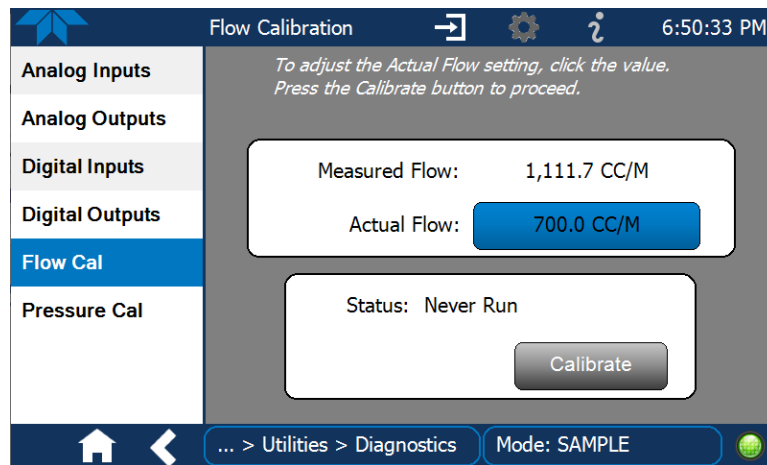
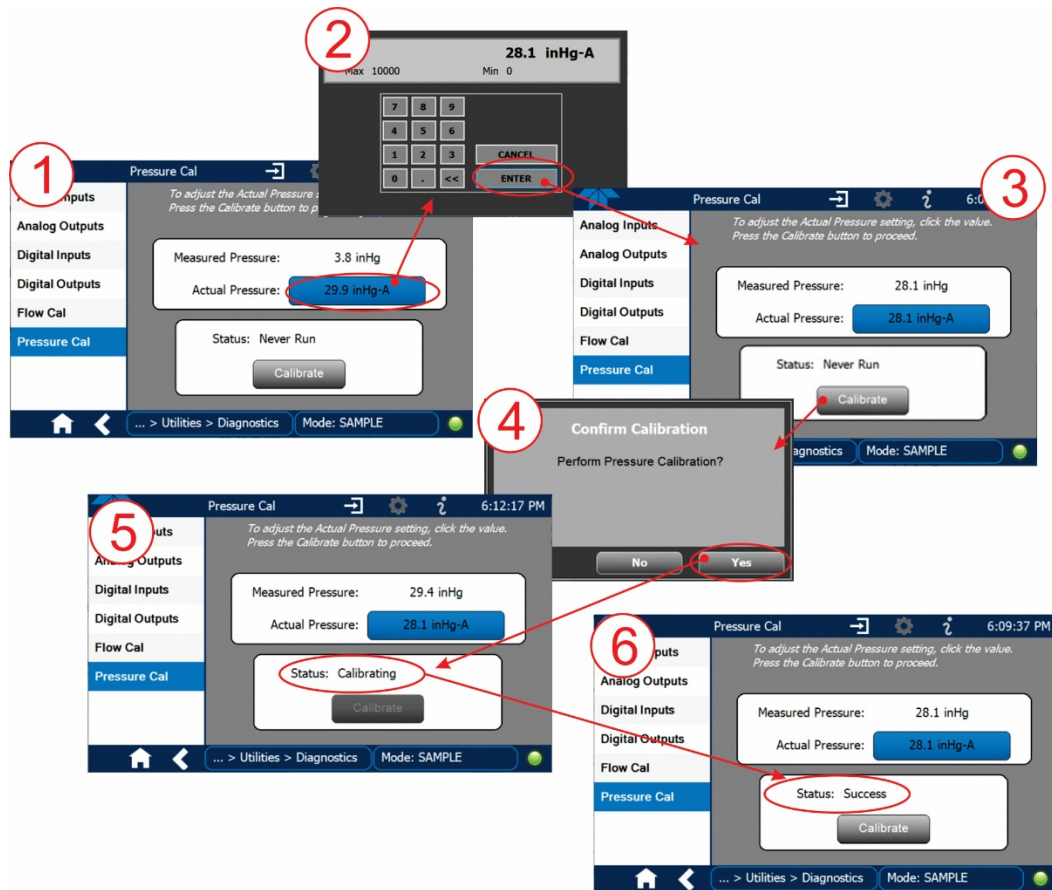


Figure 5-6. Flow Calibration Menu

5.6.5 PERFORMING PRESSURE CALIBRATION

A sensor at the exit of the sample chamber continuously measures the pressure of the sample gas. These data are used to compensate the final O₂ concentration calculation for changes in atmospheric pressure and are stored in the CPU's memory and displayed in the Dashboard as Sample Press (display configurable through Setup>Dashboard menu).

To adjust for the atmospheric pressure changes, remove the sample gas pump and the sample gas-line vent from the rear panel SAMPLE inlet.



1. Navigate to the Utilities>Diagnostics>Pressure Cal menu and press the blue button in the Actual Pressure field.
2. Input the inches of mercury reading from an external barometer and press ENTER
3. Press the Calibrate button.
4. Press the Yes button to start performing calibration.

5.6.6 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.

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

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

WARNING	FAULT CONDITION	POSSIBLE CAUSES
O2 CELL TEMP WARN	The instrument's A/D circuitry or one of its analog outputs is not calibrated	<ul style="list-style-type: none"> • A parameter for one of the analog outputs, even one not currently being used, has been changed and the analog output calibration routine was not re-run • A/D circuitry failure on motherboard • Other motherboard electronic failure
BOX TEMP WARNING	Temperature of chassis is outside specified limits. (typically < 7°C or > 48°C)	<ul style="list-style-type: none"> • Box Temperature typically runs ~7°C warmer than ambient temperature • Poor/blocked ventilation to the analyzer • Stopped Exhaust Fan • Ambient Temperature outside of specified range
CONFIG INITIALIZED	Configuration and Calibration data reset to original Factory state or erased.	<ul style="list-style-type: none"> • Failed Disk on Module • User erased data
DATA INITIALIZED	Data Storage in DAS was erased before the last power up occurred.	<ul style="list-style-type: none"> • Failed Disk-on-Module • User cleared data.
REAR BOARD NOT DET	Motherboard not detected on power up. (CPU unable to communicate with motherboard).	<p>This warning only appears on Serial I/O COM Port(s). Front panel display will be frozen, blank or will not respond.</p> <p>Failure of motherboard</p>
RELAY BOARD WARN	The CPU unable to communicate with the Relay PCA.	<ul style="list-style-type: none"> • I²C Bus failure • Failed Relay Board • Loose connectors/wiring
SAMPLE FLOW WARN	The flow rate of the sample gas is outside the specified limits.	<ul style="list-style-type: none"> • Failed Sample Pump • Blocked Sample Inlet/Gas Line • Dirty Particulate Filter • Leak downstream of Critical Flow Orifice • Failed flow sensor circuitry
SAMPLE PRES WARN	<p>Sample Pressure is <10 in-Hg or > 35 in-H</p> <p>Note: Normally 29.92 in-Hg at sea level decreasing at 1 in-Hg per 1000 ft of altitude (with no flow – pump disconnected)</p>	<p>If sample pressure is < 10 in-hg:</p> <ul style="list-style-type: none"> • Blocked particulate filter • Blocked sample inlet/gas line • Failed pressure sensor/circuitry <p>If sample pressure is > 35 in-hg:</p> <ul style="list-style-type: none"> • Blocked vent line on pressurized sample/zero/span gas supply • Bad pressure sensor/circuitry
SYSTEM RESET	The computer has rebooted.	<p>This message occurs at power on. If it is confirmed that power has not been interrupted:</p> <ul style="list-style-type: none"> • Failed +5 VDC power • Fatal Error caused software to restart • Loose connector/wiring

5.6.7 FAULT DIAGNOSIS WITH DASHBOARD FUNCTIONS

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

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

Make note of these values for reference in troubleshooting.

Note

Sample Pressure measurements are represented in terms of “Absolute Atmospheric Pressure” because this is the least ambiguous method for reporting gas pressure.

Absolute atmospheric pressure is about 29.92 in-Hg-A at sea level. It decreases about 1 in-Hg per 1000 ft gain in altitude. A variety of factors such as air conditioning systems, passing storms, and air temperature, can also cause changes in the absolute atmospheric pressure.

Table 5-4. Dashboard Functions - Possible Causes for Out-of-Range Values

DASHBOARD FUNCTION	INDICATED FAILURE(S)
Stability	High stability values indicate noise level of instrument or concentration of sample gas, which can be caused by pneumatic leak; defective preamp board; aging detectors.
Sample Flow	Gas flow problems can be caused by clogged critical flow orifice; pneumatic leak; faulty flow sensor; sample line flow restriction.
Box Temp	Out-of-range temperature reading could be caused by environment out of temperature operating range, stopped fan, or inadequate clearance for ventilation.
O2 Cell Temp	Incorrect temperature reading could be caused by high chassis temperature or fault with 12V power supply temperature sensor, relay board, I ² C bus
Pressure	Incorrect sample gas pressure could be due to pneumatic leak; blocked particulate filter, sample inlet or vent line; clogged flow orifices; sample inlet overpressure; faulty pressure sensor
O2 Slope	Slope out of range could be due to: poor calibration quality; contaminated zero air or span gas supply, blocked flow, incorrect span gas concentration input.
O2 Offset	High offset could be due to: incorrect span gas concentration/contaminated zero air/leak.

5.6.8 USING THE DIAGNOSTIC SIGNAL I/O FUNCTIONS

The signal I/O functions in the Utilities>Diagnostics menu allows access to the digital and analog I/O in the analyzer. Some of the digital signals can be controlled through the Setup menu. These signals, combined with a thorough understanding of the instrument’s principles of operation (Section 6), are useful for troubleshooting in three ways:

- The technician can view the raw, unprocessed signal level of the analyzer’s critical inputs and outputs.

- Many of the components and functions that are normally under algorithmic control of the CPU can be manually exercised.
- The technician can directly control the signal level Analog and Digital Output signals.

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

5.6.9 USING THE INTERNAL ELECTRONIC STATUS LEDs

Several color-coded LEDs are located inside the instrument to assist in determining if the analyzer's CPU, I²C communications bus and Relay board are functioning properly.

5.6.9.1 CPU STATUS INDICATOR

DS5, a red LED located on the motherboard (Figure 5-7), flashes when the CPU is running the main program loop. After power-up, approximately 30 – 60 seconds, DS5 should flash on and off. If the front panel displays properly but DS5 does not flash, then the program files may have become corrupted or the CPU may be defective; contact Teledyne API's Technical Support Department (see Section 5.8) because it may be possible to recover operation of the analyzer. If after 30 – 60 seconds DS5 is steadily off or steadily on, the CPU board is likely locked up and should the analyzer not respond (either with locked-up or dark front panel), then replace the CPU.

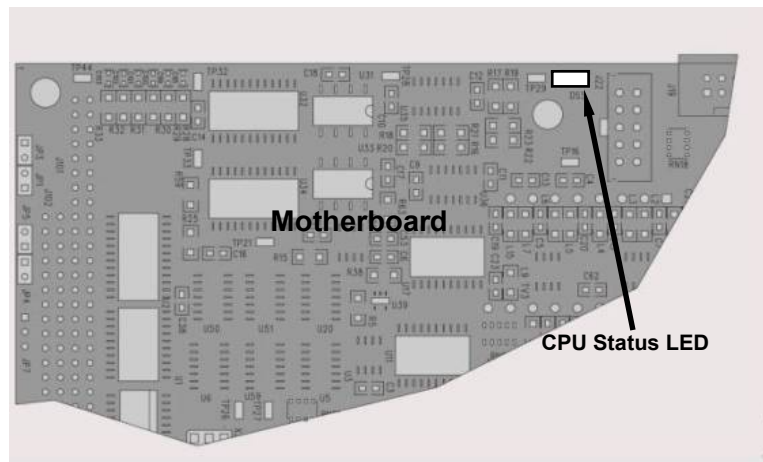


Figure 5-7. CPU Status Indicator

5.6.9.2 RELAY PCA WATCHDOG AND STATUS LEDs

There are several LEDs located on the Relay PCA (some are not used on this model), which indicate the status of several components. The most important of the LEDs is D1 (see Figure 5-8), which indicates the health of the CPU or the I²C bus: if either stops functioning, D1 will stay either ON or OFF, and after 30 seconds the “Watchdog Circuit” will automatically .

RELAY PCA STATUS LEDs

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

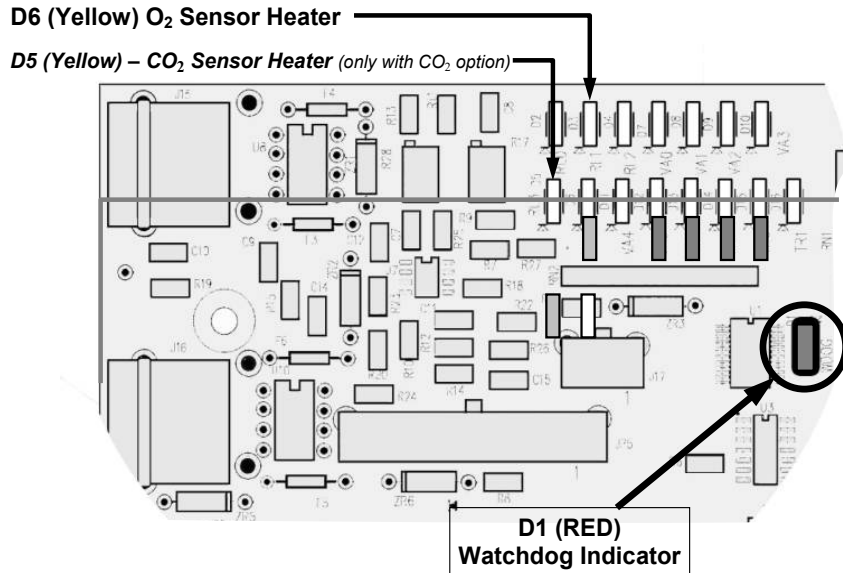


Figure 5-8. Relay PCA Status LED Locations

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

LED	COLOR	FUNCTION	STATUS WHEN LIT	STATUS WHEN UNLIT
D1	RED	Watchdog circuit	Cycles On/Off every 3 seconds under control of the CPU. If steadily ON or OFF, it indicates failed CPU or faulty motherboard or relay board (or faulty connectors/wiring between them). Could also mean failed/faulty +5 VDC power supply (PS1).	
D2-D4			Unused	
D5 ¹	YELLOW	CO ₂ Sensor heater	HEATING	NOT HEATING
D6	YELLOW	O ₂ Sensor heater	HEATING	NOT HEATING
D7-D16			Unused	

¹ Only active when the optional CO₂ sensor is installed

5.6.10 FLOW PROBLEMS

When troubleshooting flow problems, it is essential to confirm the actual flow rate without relying on the analyzer's flow display. The use of an independent, external, volumetric flow meter to perform a flow check as described in Section 5.6.4 is essential. Refer to the pneumatic flow diagrams as needed for reference. If this test shows the flow to be correct, check the pressure sensors as described in Section 5.6.13.9.

Typically, flow problems are when flow is zero or low, or too high, or zero or low but analyzer reports correct readings, each of which is presented next.

5.6.10.1 SAMPLE FLOW IS ZERO OR LOW

On flow failure, the unit will display a SAMPLE FLOW WARNING in the Active Alerts page and the respective function (Dashboard or Home Meter, if configured to display) shows nothing instead of a numerical value.

Note

Sample and vacuum pressures mentioned in this chapter refer to operation of the analyzer at sea level. Pressure values need to be adjusted for elevated locations, as the ambient pressure decreases by about 1 in-Hg per 300 m / 1000 ft.

If the pump is not running, use an AC voltmeter to ensure that the pump is supplied with the proper AC power. If AC power is supplied properly but the pump is not running, replace the pump.

If the pump is operating but the unit is not reporting gas flow value, take the following three steps:

1. Check for actual sample flow:
 - Disconnect the sample tube from the sample inlet on the rear panel of the instrument.
 - Ensure that the unit is in basic SAMPLE mode.
 - Place a finger over the inlet and feel for suction by the vacuum or, more properly, use the flow meter to measure the actual flow.
 - If there is proper flow (within spec), contact Technical Support.
 - If there is no flow or low flow, continue with the next step.

2. Check pressures:
 - Check that the sample pressure is at or around 28 in-Hg-A at sea level (adjust as necessary when in elevated location, the pressure should be about 1" below ambient atmospheric pressure) and that the Rx Cell pressure is below 10 in-Hg-A.
 - The analyzer will calculate a sample flow up to about 14 in-Hg-A RCEL pressure but a good pump should always provide less than 10 in-Hg-A.
 - If both pressures are the same and around atmospheric pressure, the pump does not operate properly or is not connected properly. The instrument does not get any vacuum.
 - If both pressures are about the same and low (probably under 10 in-Hg-A, or ~20" on sample and 15" on vacuum), there is a cross-leak between sample flow path and vacuum, most likely through the dryer flow paths. See troubleshooting the dryer later in this chapter.
 - If the sample and vacuum pressures are around their nominal values (28 and <10 in-Hg-A, respectively) and the flow still displays no numerical value, carry out a leak check as described in Section 5.6.2.
 - If gas flows through the instrument during the above tests but goes to zero or is low when it is connected to zero air or span gas, the flow problem is not internal to the analyzer but likely caused by the gas source such as calibrators/generators, empty gas tanks, clogged valves, regulators and gas lines.
 -

3. If none of these suggestions help, carry out a detailed leak check of the analyzer as described in Section 5.6.3.3.

5.6.10.2 HIGH FLOW

Flow readings that are significantly higher than the allowed operating range (typically ± 10 - 11% of the nominal flow) should not occur in the analyzer unless a pressurized sample, zero or span gas is supplied to the inlet ports.

- Ensure to vent excess pressure and flow just before the analyzer inlet ports.
- When supplying sample, zero or span gas at ambient pressure, a high flow could indicate a broken critical flow orifice (very unlikely case), allowing more than nominal flow, or were replaced with an orifice of wrong specifications.
- If the flows are within 15% above normal, we recommend measuring and recalibrating the flow electronically (Section 5.6.4), followed by a regular review of these flows over time to see if the new setting is retained properly.
- Also, check the flow assembly o-rings and replace as needed.

5.6.10.3 SAMPLE FLOW IS ZERO OR LOW BUT ANALYZER REPORTS CORRECT FLOW

The analyzer can report a correct flow rate even if there is no or a low actual sample flow through the reaction cell.

- The sample flow is only calculated from the sample pressure and critical flow condition is verified from the difference between sample pressure and vacuum pressure.
- If the critical flow orifice assembly is partially or completely clogged, both the sample and vacuum pressures are still within their nominal ranges (the pump keeps pumping, the sample port is open to the atmosphere), but there is no flow possible through the reaction cell.

Although measuring the actual flow is the best method, in most cases, this fault can also be diagnosed by evaluating the sample pressure value.

- Since there is no longer any flow, the sample pressure should be equal to ambient pressure, which is about 1 in-Hg-A higher than the sample pressure under normal operation.
- Taken together with a zero or low actual flow, this could indicate a clogged sample orifice.

Again, monitoring the pressures and flows regularly will reveal such problems, because the pressures would slowly or suddenly change from their nominal, mean values. Teledyne API recommends reviewing all test data once per week and to do an exhaustive data analysis for test and concentration values once per month, paying particular attention to sudden or gradual changes in all parameters that are supposed to remain constant, such as the flow rates.

If the actual flow measured does not match the displayed flow, but is within the limits of 100-140 cm³/min, adjust the calibration of the flow measurement (Section 5.6.4.2).

5.6.11 CALIBRATION PROBLEMS

This section describes possible causes of calibration problems.

5.6.11.1 MISCALIBRATED

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

- Bad span gas: This can cause a large error in the slope and a small error in the offset. Delivered from the factory, the T802's slope is within $\pm 15\%$ of nominal. Bad span gas will cause the analyzer to be calibrated to the wrong value. If in doubt have the span gas checked by an independent lab.
- Contaminated zero gas: Excess H₂O can cause a positive or negative offset and will indirectly affect the slope.
- Dilution calibrator not set up correctly or is malfunctioning: This will also cause the slope, but not the zero, to be incorrect. Again the analyzer is being calibrated to the wrong value.
- Too many analyzers on the manifold: This can cause either a slope or offset error because ambient gas with its pollutants will dilute the zero or span gas.

5.6.11.2 NON-REPEATABLE ZERO AND SPAN

As stated earlier, leaks both in the T802 and in the external system are a common source of unstable and non-repeatable readings.

1. Check for leaks in the pneumatic systems as described in Section 5.6.3. Don't forget to consider pneumatic components in the gas delivery system outside the T802, such as:
 - A change in zero air source such as ambient air leaking into zero air line, or;
 - A change in the span gas concentration due to zero air or ambient air leaking into the span gas line.
2. Once the instrument passes a leak check, do a flow check (See Section 10.3.4) to make sure adequate sample is being delivered to the sensor assembly.
3. Confirm the sample pressure, wheel temperature, bench temperature, and sample flow readings are correct and have steady readings.
4. Disconnect the exhaust line from the optical bench near the rear of the instrument and plug this line into the SAMPLE inlet creating a pneumatic loop. The concentration (either zero or span) now must be constant. If readings become quiet, the problem is in the external pneumatics supplies for sample gas, span gas or zero air.

5.6.11.3 INABILITY TO SPAN – NO SPAN BUTTON

1. Confirm that the oxygen span gas source is accurate; this can be done by opening the analyzer's SAMPLE inlet to ambient air. If the concentration is not displayed as $\sim 20.9\%$, there is a problem with the span gas.
2. Check for leaks in the pneumatic systems as described in Section 10.3.3.

3. Make sure that the expected span gas concentration entered into the instrument during calibration, is the correct span gas concentration and not too different from expected span value. This can be viewed via the CONC submenu of the Sample displays.
4. Check to make sure that there is no ambient air or zero air leaking into span gas line.

5.6.11.4 INABILITY TO ZERO – NO ZERO BUTTON

1. Confirm that there is a good source of zero air. Dilute a tank of span gas with the same amount of zero air from two different sources. If the O₂ Concentration of the two measurements is different, there is a problem with one of the sources of zero air.
2. Check for leaks in the pneumatic systems as described in 10.3.3.
3. Check to make sure that there is no ambient air leaking into zero air line..

5.6.12 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.

5.6.12.1 EXCESSIVE NOISE

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

- Ensure that the sample or span gas supply is leak-free and carry out a detailed leak check as described under Section 5.6.2.

Another possibility of excessive signal noise may be the preamplifier board, the high voltage power supply and/or the PMT detector itself.

- Contact the factory on troubleshooting these components.

5.6.12.2 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 critical flow orifices. Check flows and pressures.
- Wrong materials in contact with sample - use glass or Teflon materials only. Porous materials, in particular, will cause memory effects and slow changes in response.
- Sample vent line is located too far from the instrument sample inlet causing a long mixing and purge time. Locate sample inlet (overflow) vent as close as possible to the analyzer's sample inlet port.
- Dirty sample cell.
- Insufficient time allowed for purging of lines upstream of the analyzer. Wait until stability is low.

- Insufficient time allowed for calibration gas source to become stable. Wait until stability is low.

5.6.13 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. In most cases this included a list of possible causes and, in some cases, quick solutions or at least a pointer to the appropriate sections describing them. This section describes how to determine if a certain component or subsystem is actually the cause of the problem being investigated.

5.6.13.1 AC MAIN POWER

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Plugging the analyzer into a power supply that is too high a voltage or frequency can damage the pump and the AC Heaters.

Plugging the analyzer into a power supply that is too low a voltage or frequency will cause these components to not operate properly.

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

- If they do not, check the circuit breaker built into the ON/OFF switch on the instrument's front panel.



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.

If incorrect power configuration is suspected, check the serial number label located on the instrument's rear panel to ensure that the instrument was configured for the same voltage and frequency being supplied.

5.6.13.2 DC POWER SUPPLY

If the analyzer’s AC mains power is working, but the unit is still not operating properly, there may be a problem with one of the instrument’s switching power supplies, which convert AC power to 5 and ± 15 V (PS1) as well as +12 V DC power (PS2). The supplies can either have DC output at all or a noisy output (fluctuating).

To assist tracing DC Power Supply problems, the wiring used to connect the various printed circuit assemblies and DC powered components and the associated test points on the relay board follow a standard color-coding scheme as defined in Table 5-6.

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

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

A voltmeter should be used to verify that the DC voltages are correct as listed in Table 5-7. An oscilloscope, in AC mode and with band limiting turned on, can be used to determine whether the supplies are excessively noisy (>100 mV peak-to-peak).

Table 5-7. DC Power Supply Acceptable Levels

POWER SUPPLY	VOLTAGE	CHECK RELAY BOARD TEST POINTS				MIN V	MAX V
		FROM Test Point		TO Test Point			
		NAME	#	NAME	#		
PS1	+5	DGND	1	+5	2	+4.85	+5.25
PS1	+15	AGND	3	+15	4	+13.5	+16.0
PS1	-15	AGND	3	-15V	5	-13.5	-16.0
PS1	AGND	AGND	3	DGND	1	-0.05	+0.05
PS1	Chassis	DGND	1	Chassis	N/A	-0.05	+0.05
PS2	+12	+12V Ret	6	+12V	7	+11.75	+12.5
PS2	DGND	+12V Ret	6	DGND	1	-0.05	+0.05

5.6.13.3 I²C BUS

Operation of the I²C bus can be verified by observing the behavior of D1 on the Relay Board in conjunction with the performance of the front panel display. Assuming that the DC power supplies are operating properly and the wiring is intact, the I²C bus is operating properly if: D1 on the relay board is flashing, or D1 is not flashing but pressing a button on the touchscreen results in a change to the display.

5.6.13.4 TOUCHSCREEN INTERFACE

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

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

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

5.6.13.5 LCD/DISPLAY MODULE

Assuming that there are no wiring problems and that the DC power supplies are operating properly, the display screen should light and show the splash screen and other indications of its state as the CPU goes through its initialization process. However, if pressing a control button on the touch screen does not change the display, either the touch-screen controller or the internal USB bus may be malfunctioning.

You can verify this failure by logging on to the instrument remotely with Teledyne API's NumaView™ Remote software. If the analyzer responds to remote commands and the display changes accordingly, the touch-screen interface may be faulty.

5.6.13.6 RELAY PCA

The Relay PCA can be most easily checked by observing the condition of its status LEDs (see Section 5.6.9.2), and using the Utilities>Diagnostics> menu (see Section 5.6.8) to toggle each LED ON or OFF.

If D1 on the relay board is flashing, but toggling an output using the I/O functions in the Utilities>Diagnostics menu does not toggle the output's status LED, then there is a circuit problem, or possibly a blown driver chip, on the relay board.

If D1 on the Relay PCA is flashing and the status indicator for the output in question (heater power, etc.) toggles properly using the I/O functions in the Utilities>Diagnostics menu, then the associated device or its control device (driver) on the Relay PCA is malfunctioning.

Several of the control devices are in sockets and can be easily replaced. Motherboard

5.6.13.7 A/D FUNCTIONS

The simplest method to check the operation of the A-to-D converter on the motherboard is to navigate to the Dashboard and check the two A/D reference voltages and input signals that can be easily measured with a voltmeter (configure the Dashboard to show the Ref 4096mV and Ref Ground parameters).

- The nominal value for **REF_4096_MV** is 4096 mV \pm 10 mV.
- The nominal value for **REF_GND** is 0 mV \pm 3 mV
 - If these signals are stable to within ± 0.5 mV, the basic A/D converter is functioning properly.
 - If these values fluctuate largely or are off by more than specified above, one or more of the analog circuits may be overloaded or the motherboard may be faulty.

Choose one parameter in the Dashboard function list such as **SAMPLE PRESSURE** (refer to previous section on how to measure it). Compare the voltage at its origin (refer to the Wiring Diagram in Appendix B with the voltage displayed. If the wiring is intact but there is a difference of more than ± 10 mV between the measured and displayed voltage, the motherboard may be faulty

5.6.13.8 STATUS OUTPUTS

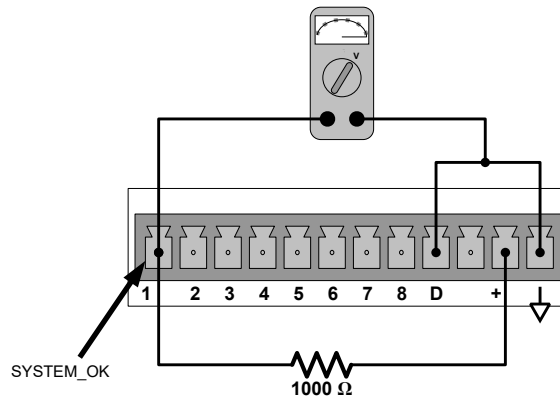


Figure 5-9. Typical Set Up of Status Output Test

To test the status output electronics:

1. Connect a jumper between the “D” pin and the “▽” pin on the status output connector.
2. Connect a 1000 ohm resistor between the “+” pin and the pin for the status output that is being tested.
3. Connect a voltmeter between the “▽” pin and the pin of the output being tested.
4. In the Utilities>Diagnostics>Digital Outputs menu (see Section 5.6.8), scroll through the outputs until you get to the output in question.
5. Alternately turn on and off the output noting the voltage on the voltmeter.
 - It should vary between 0 volts for ON and 5 volts for OFF.

5.6.13.9 PNEUMATIC PRESSURE / FLOW SENSOR ASSEMBLY

The pressure/flow sensor circuit board, located behind the sensor assembly, can be checked with a voltmeter in the following way which assumes that the wiring is intact and that the motherboard and the power supplies are operating properly.

SAMPLE PRESSURE SENSOR CHECK

Measure the voltage across test points TP1 and TP4.

- With the sample pump disconnected or turned off, this voltage should be 4500 ± 250 mV.
- With the pump energized it should be approximately 200 mV less. If not, then S1, the pressure transducer is bad, the board is bad, or there is a pneumatic failure preventing the pressure transducer from sensing the absorption cell pressure properly.
- If this voltage is significantly different, the pressure transducer S2 or the board may be faulty. A leak in the sample system to vacuum may also cause this voltage to be between about 0.6 and 4.5. Ensure that the front panel reading of the sample pressure is at about 1 in-Hg-A less than ambient pressure.

FLOW SENSOR CHECK

Measure the voltage across TP1 and TP2.

- With flow, it should be 10.0 ± 0.25 V. If not, the board may be faulty and in need of replacement.
- With flow stopped (SAMPLE inlet blocked) the voltage should be approximately 1 V. If not, the flow sensor is bad, the board is bad or there is a leak upstream of the sensor.

5.6.13.10 CPU

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

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

- In some rare circumstances, this failure may be caused by a bad IC on the motherboard, specifically U57, the large, 44 pin device on the lower right hand side of the board. If this is true, removing U57 from its socket will allow the instrument to start up but the measurements will be invalid.
- If the analyzer stops during initialization (the front panel display shows a fault or warning message), it is likely that the DOM, the firmware or the configuration and data files have been corrupted.

5.6.13.11 RS-232 COMMUNICATIONS

GENERAL RS-232 TROUBLESHOOTING

Teledyne API's analyzers use the RS-232 communications protocol to allow the instrument to be connected to a variety of computer-based equipment. Problems with RS-232 connections usually center around 4 general areas:

- Incorrect cabling and connectors. See Section 2.3.1.7 under RS-232 Connection for connector and pin-out information.
- The BAUD rate and protocol are incorrectly configured. See Section 2.3.1.7 under RS-232 Connection.
- If a modem is being used, additional configuration and wiring rules must be observed. See Sections 3.1 and 3.2.
- Incorrect setting of the DTE – DCE Switch. See Section 3.1 to set correctly.
- The cable (P/N 03596) that connects the serial COM ports of the CPU to J12 of the motherboard may not be properly seated (see Figure 2-10 for location of J12).

ANALYZER/MODEM OR TERMINAL OPERATION TROUBLESHOOTING

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

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

5.6.13.12 OPTIONAL CO₂ SENSOR

There are Two LEDs located on the CO₂ sensor PCA.

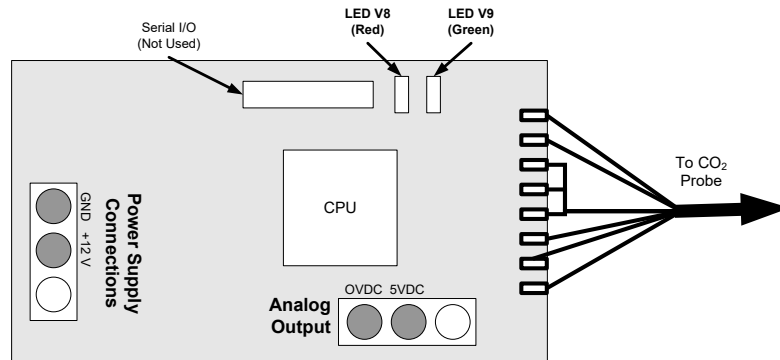


Figure 11 7. Location of Diagnostic LEDs on CO₂ Sensor PCA

- Normal Operation: V8 is not lit – V9 is Blinking
- Error State: Both LEDs are blinking.

Check to make sure that the cable to the CO₂ sensor is properly connected.

5.6.13.13 TEMPERATURE PROBLEMS

BOX TEMPERATURE SENSOR

The box temperature sensor (thermistor) is mounted on the motherboard below the bottom edge of the CPU board when looking at it from the front. It cannot be disconnected to check its resistance. Therefore, rather check the Box Temp Raw signal in the Utilities>Diagnostics>Analog Inputs menu. This parameter will vary with ambient temperature, but at ~30oC (6-7° above room temperature) the signal should be ~1450 mV.

5.6.14 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.

5.6.14.1 REPAIRING SAMPLE FLOW CONTROL ASSEMBLY

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

1. Turn off power to the analyzer.
2. Locate the assembly attached to the sample pump, see Figure 3 5.
3. Disconnect the pneumatic connection from the flow assembly and the assembly from the pump.
4. Remove the fitting and the components as shown in the exploded view below.
5. Replace the o-rings (PN OR000001) and the sintered filter (PN FL000001).
6. If replacing the critical flow orifice itself (PN 000940700), make sure that the side with the colored window (usually red) is facing upstream to the flow gas flow.
7. Apply new Teflon® tape to the male connector threads
8. Re-assemble in reverse order.
9. After reconnecting the power and pneumatic lines, flow check the instrument as described in the Section 5.6.4.1.

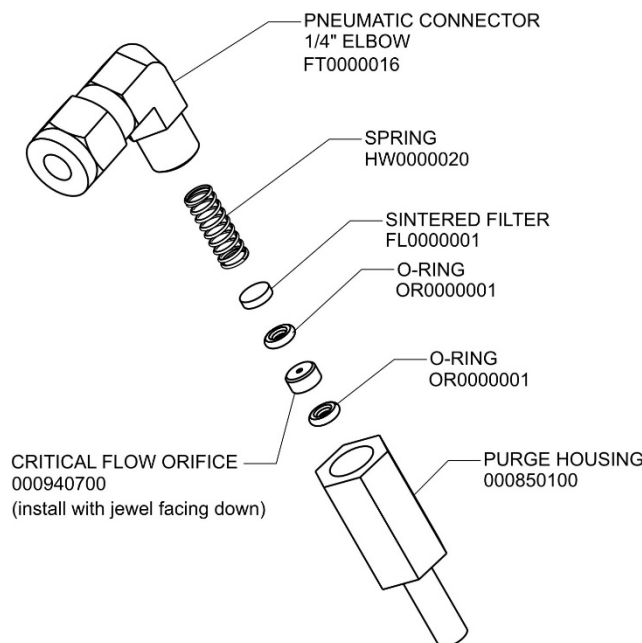


Figure 11 8. Critical Flow Restrictor Assembly / Disassembly

5.6.14.2 DISK-ON-MODULE REPLACEMENT PROCEDURE

ATTENTION**COULD DAMAGE INSTRUMENT AND VOID WARRANTY**

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

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

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

5.6.14.3 SENSOR MODULE REPAIR AND CLEANING

The T802 sensor assembly and optical bench are complex and delicate. Disassembly and cleaning is not recommended. Please check with the factory before disassembling the optical bench.

5.7 FREQUENTLY ASKED QUESTIONS

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

QUESTION	ANSWER
Why does the ENTR button sometimes disappear on the front panel display?	Sometimes the ENTR button will disappear if you select a setting that is invalid or out of the allowable range for that parameter, such as trying to set the 24-hour clock to 25:00:00. After you adjust the setting to an allowable value, the ENTR button will re-appear.
Why is the ZERO or SPAN button deactivated during calibration?	This happens when the measured gas concentration differs significantly from the span or zero gas concentration value entered by the user. This prevents accidental recalibration of the analyzer to an out-of-range response curve. EXAMPLE: The span set point is 400 ppb but gas concentration being measured is only 50 ppb.
How do I enter or change the value of my Span Gas?	See Section 4.2.2.
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 5.6.4).
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. If the reaction cell pressure value goes above 10 in-Hg-A, on average, the pump head needs to be rebuilt.
Why does my RS-232 serial connection not work?	There are several possible reasons: <ul style="list-style-type: none"> • The wrong cable: please use the provided or a generic "straight-through" cable (do not use a "null-modem" type cable) and ensure the pin assignments are correct (Section 2.3.1.7 under RS-232 Connection). • The DCE/DTE switch on the back of the analyzer is not set properly; ensure that both green and red lights are on (Section 3.1). • The baud rate of the analyzer's COM port does not match that of the serial port of your computer/data logger (Table 2-13).
How do I make the instrument's display and my data logger agree?	This most commonly occurs when an independent metering device is used besides the data logger/recorder to determine gas concentration levels while calibrating the analyzer. These disagreements result from the analyzer, the metering device and the data logger having slightly different ground levels. Use the data logger itself as the metering device during calibration procedures.
Do the critical flow orifices of my analyzer require regular replacement?	No. The o-rings and the sintered filter associated with them require replacement once a year, but the critical flow orifices do not.
How do I set up and use the contact closures (Control Inputs) on the rear panel of the analyzer?	See Section 2.3.1.5.



5.8 TECHNICAL ASSISTANCE

If this manual and its troubleshooting & service section do not solve your problems, technical assistance may be obtained from:

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

Toll-free Phone: 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

This section describes the principles of operation for the SO₂ analyzer and its two optional gas sensors, as well as its electronic and software operation.

6.1 OXYGEN (O₂) SENSOR PRINCIPLES OF OPERATION

The O₂ sensor applies paramagnetics to determine the concentration of oxygen in a sample gas drawn through the instrument.

6.1.1 MAGNETIC PROPERTIES OF O₂ GAS

Molecular oxygen, O₂, displays a particularly strong susceptibility to the effect of magnetic fields. This is due to the behavior of the electrons of the two oxygen atoms that make up the O₂ molecule.

When the electrons in an orbital are paired, they spin in opposite directions from each other thereby canceling any magnetic field effects. On the other hand, unpaired electrons, such as those of an O₂ molecule, spin in the same direction as each other, increasing the aggregate magnetic field.

6.1.2 PRINCIPLE OF MEASUREMENT

The type of paramagnetic sensor used in the T802 analyzer is called a magneto-mechanical sensor, which consists of a small dumbbell-shaped body (a sphere on either end) made of glass and filled with a gas of negative paramagnetic characteristic (in this case, N₂). The dumbbell body is suspended on a platinum fiber within the magnetic field of a permanent magnet in such a way that it is free to rotate. Because the N₂ inside the spheres has a small opposite magnetic charge from the field of the permanent magnet, the dumbbell's resting (neutral) position is slightly deflected away from the strong point of the field.

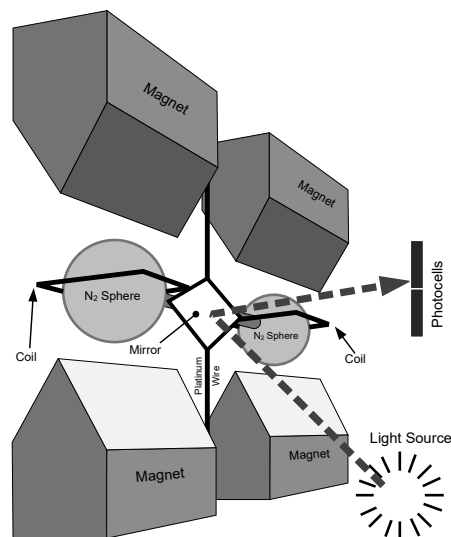


Figure 12 1. Paramagnetic O₂ Sensor Design

When sample gas containing oxygen flows into the magneto-mechanical sensor, the O₂ molecules are drawn toward the strong point of the magnetic field. This causes the N₂ filled spheres to deflect even more so that the suspended dumbbell body pivots on the platinum wire. The more O₂ present the further the dumbbell body is deflected from its neutral position.

The position of the dumbbell is detected by a pair of photocells that receive a light beam reflected from a mirror attached to the center of the dumbbell body. As the dumbbell body pivots, the angle of the reflected light beam on the photocells changes. The resulting potential difference creates a current.

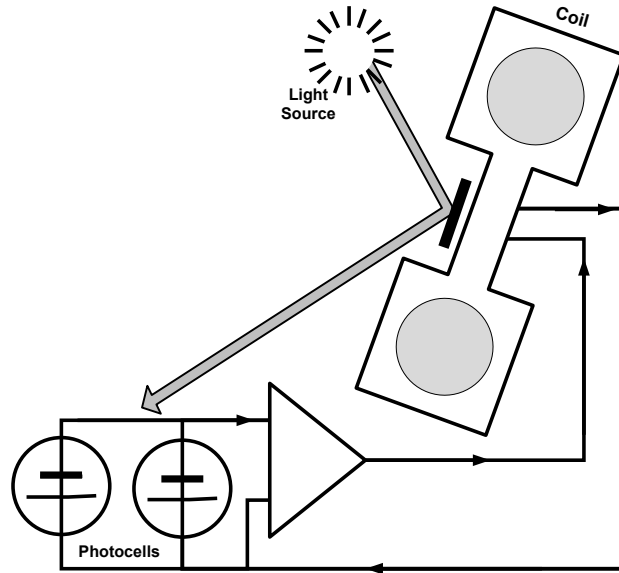


Figure 12.2. Paramagnetic O₂ Sensor Block Diagram

This current is passed to a feedback loop, which generates a second current to a wire winding (in effect, a small DC electric motor) mounted on the suspended mirror. The more O₂ present, the more the dumbbell and its attached mirror moves and the more current is needed to move the dumbbell back to its zero position. Finally, sensor measures the amount of current generated by the feedback control loop which is directly proportional to the concentration of oxygen within the sample gas mixture.

6.2 NDIR MEASUREMENT OF CO₂

The optional CO₂ sensor is a silicon based Non-Dispersive Infrared (NDIR) sensor. It uses a single-beam, dual wavelength measurement method.

An infrared source at one end of the measurement chamber emits IR radiation into the sensor's measurement chamber where light at the 4.3 μm wavelength is partially absorbed by any CO₂ present. A special light filter called a Fabry-Perot Interferometer (FPI) is electronically tuned so that only light at the absorption wavelength of CO₂ is allowed to pass and be detected by the sensor's IR detector.

A reference measurement is made by electronically shifting the filter band pass wavelength so that no IR at the CO₂ absorption wavelength is let through.

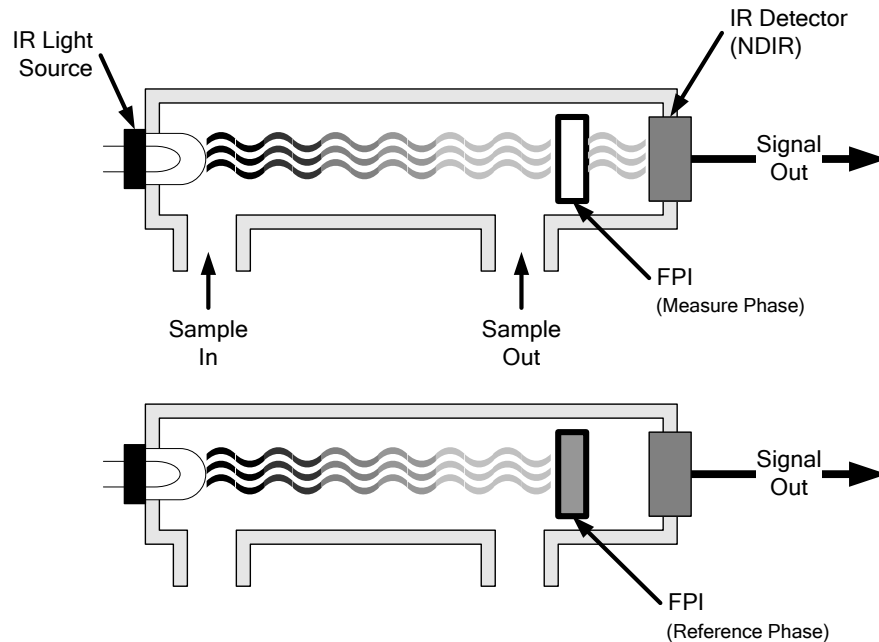


Figure 12.3. CO₂ Sensor Theory of Operation

The sensor computes the ratio between the reference signal and the measurement signal to determine the degree of light absorbed by CO₂ present in the sensor chamber. This dual wavelength method of measuring CO₂ allows the instrument to compensate for ancillary effects like sensor aging and contamination.

6.2.1 OPERATION WITHIN THE T802

Operationally, the CO₂ sensor option is transparently integrated into the core analyzer operation. All functions can be viewed or accessed through the front panel, just like the functions for O₂. The CO₂ concentration range is 0-20%. See Section 9.5.1 for information on calibrating the CO₂.

6.3 PNEUMATIC OPERATION

In pneumatic operation an internal pump evacuates the sample chamber creating a small vacuum that draws sample gas into the analyzer at near ambient pressure. When the CO₂ sensor option is installed, it is placed in line with the sample gas line between the particulate filter and the analyzer's sample chamber. It does not alter the gas flow rate of the sample through the analyzer.

6.3.1 FLOW RATE CONTROL

To maintain a constant flow rate of the sample gas through the instrument, the T802 uses a special flow control assembly located in the exhaust gas line just before the optional internal pump or connected to the rear panel if using an external pump. The most important component of this flow control assembly is the critical flow orifice, which operates without moving parts by taking advantage of the laws of fluid dynamics. It restricts the flow of

gas, which creates a pressure differential. This pressure differential combined with the action of the analyzer's pump draws the gas through the orifice.

As the pressure on the downstream side of the orifice (the pump side) continues to drop, the speed that the gas flows through the orifice continues to rise. Once the ratio of upstream pressure to downstream pressure is greater than 2:1, the velocity of the gas through the orifice reaches the speed of sound. As long as that ratio stays at least 2:1 the gas flow rate is unaffected by any fluctuations, surges, or changes in downstream pressure.

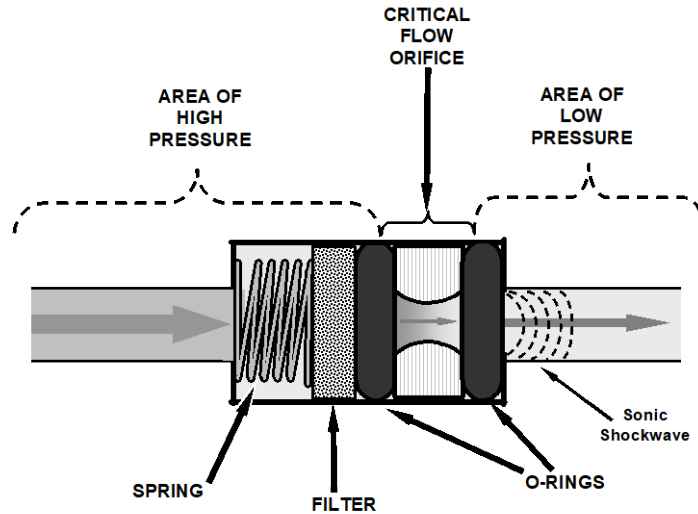


Figure 12 6. Flow Control Assembly & Critical Flow Orifice

The actual flow rate of gas through the orifice (volume of gas per unit of time), depends on the size and shape of the aperture in the orifice. The larger the hole, the more gas molecules, moving at the speed of sound, pass through the orifice. Because the flow rate of gas through the orifice is only related to the minimum 2:1 pressure differential and not absolute pressure, the flow rate of the gas is also unaffected by degradations in pump efficiency due to age.

The critical flow orifice used in the T802 is designed to provide a flow rate of 120 cm³/min.

6.3.2 SAMPLE PRESSURE SENSOR

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

6.3.3 SAMPLE FLOW SENSOR

A thermal-mass flow sensor is used to measure the sample flow through the analyzer. The sensor is calibrated at the factory with ambient air or N₂, but can be calibrated to operate with samples consisting of other gases such as O₂. This sensor is mounted to a printed circuit board along with the sample pressure sensor on the sample chamber.

6.4 ELECTRONIC OPERATION

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

The motherboard collects data, performs signal conditioning duties and routes incoming and outgoing signals between the CPU and the analyzer's other major components.

Data are generated by a gas-filter-correlation optical bench which outputs an analog signal corresponding to the concentration of O₂ in the sample gas. This analog signal is converted into digital data by a unipolar, analog-to-digital converter, located on the motherboard. The data are stored in memory by the CPU, typically viewable on the front panel display and in programmable data logging reports.

The CPU issues commands via a series of relays and switches located on a separate printed circuit assembly to control the function of key electromechanical devices.

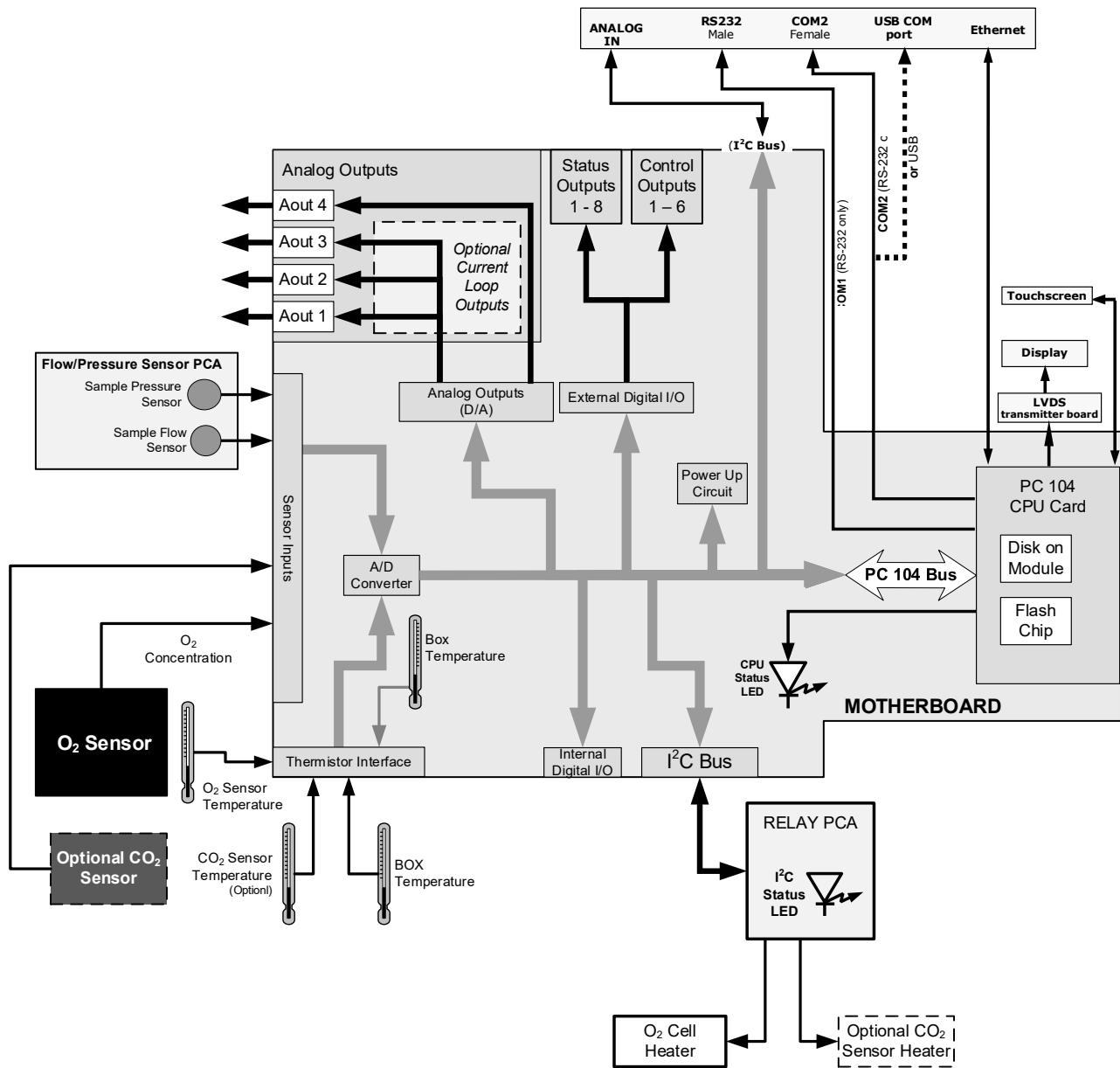


Figure 12 7. T802 Electronic Block Diagram

As for the CO₂ sensor, its PCA is powered by 12 VDC from the analyzer via the relay card, which outputs a 0-5 VDC analog signal to the analyzer's CPU via the motherboard that corresponds to the concentration of CO₂ measured by the probe.

6.4.1 CENTRAL PROCESSING UNIT (CPU)

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

The CPU includes two types of non-volatile data storage: an embedded 2MB flash chip and a Disk on Module (DOM). The DOM is a 44-pin IDE flash disk with a storage capacity up to 128MB. It is used to store the computer's operating system, the Teledyne API firmware, and most of the operational data generated by the analyzer's internal data acquisition system (DAS – Section 7). The LEDs on the DOM indicate power and reading/writing to or from the DOM.

6.4.2 RELAY BOARD

The CPU issues commands via a series of relays and switches located on a separate printed circuit assembly, called the Relay PCA, to control the function of key electromechanical devices such as heaters. The relay PCA receives instructions in the form of digital signals over the I²C bus, interprets these digital instructions and activates its various switches and relays appropriately.

6.4.3 STATUS LEDs

LEDs located on the Relay board show the current status of various control functions that this board performs. The most important of the status LEDs on the relay board is the red watch-dog LED. It is controlled directly by the analyzer's CPU over the I²C Bus. Special circuitry on the relay PCA watches the status of D1. Should this LED ever stay ON or OFF for 30 seconds, indicating that the CPU or I²C bus has stopped functioning, this Watchdog Circuit automatically shuts off all heaters.

6.4.4 TEMPERATURE CONTROL

At low magnetic field strengths levels, paramagnetic molecules follow Curie's law to good approximation, which indicates that the susceptibility of paramagnetic materials is inversely proportional to their temperature.

To minimize the effects of temperature variations on the O₂ concentration measurement the parametric sensor is raised to a high temperature level, 50°C. A cartridge heater implanted into the sensor is the heat source. The temperature of the sensor is measured by a thermistor also inserted into the sensor body.

6.4.5 MOTHERBOARD

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

6.4.6 A TO D CONVERSION

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

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

The A/D can be configured for several different input modes and ranges but in the T802 the A/D is used in uni-polar mode with a +5 V full scale. The converter includes a 1% over and under-range. This allows signals from -0.05 V to +5.05 V to be fully converted.

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

6.4.7 SENSOR INPUTS

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

6.4.8 SAMPLE PRESSURE AND FLOW

These are analog signals from two sensors that measure the pressure and flow rate of the gas stream at the outlet of the sample chamber. This information is used in two ways. First, the sample pressure is used by the CPU to calculate O₂ Concentration. Second, the pressure and flow rate are monitored as a test function to assist the user in predicting and troubleshooting failures.

6.4.9 THERMISTOR INTERFACE

This circuit provides excitation, termination and signal selection for several negative-coefficient, thermistor temperature sensors located inside the analyzer; there is a thermistor for the O₂ sample chamber housing, which reports the current temperature of the chamber housing to the CPU as part of the bench heater control loop. Another thermistor, attached to the motherboard, measures the analyzer's inside temperature (box temperature).

6.4.10 ANALOG OUTPUTS

The analyzer comes equipped with four analog outputs: A1, A2, A3 and A4. The type of data and electronic performance of these outputs are configurable by the user. (see Section 5.9.2). All four analog outputs are connected back to the A/D converter through a Loop-back circuit. This permits the voltage outputs to be calibrated by the CPU without need for any additional tools or fixtures.

6.4.11 EXTERNAL DIGITAL I/O

The External Digital I/O performs status outputs and control inputs. For status outputs, Logic-Level voltages are output through an optically isolated 8-pin connector located on the rear panel of the analyzer. These outputs convey good/bad and on/off information about certain analyzer conditions. They can be used to interface with certain types of programmable devices (See Section 3.3.1.5).

For Control Outputs, by applying +5VDC power supplied from an external source such as a PLC or Data logger (See Section 3.3.1.6), Zero and Span calibrations can be initiated by contact closures on the rear panel.

6.4.12 I²C DATA BUS

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

6.4.13 POWERUP CIRCUIT

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

6.4.14 POWER SUPPLY / CIRCUIT BREAKER

The analyzer operates on 100 VAC, 115 VAC or 230 VAC power at either 50Hz or 60Hz. Individual units are set up at the factory to accept any combination of these five attributes. Power enters the analyzer through a standard IEC 320 power receptacle located on the rear panel of the instrument, where its distribution is routed through the On/Off switch located in the lower right corner of the Front Panel. A 6.75 Amp circuit breaker is built into the ON/OFF Switch. AC power is distributed directly to the sample gas pump.

AC Line power is stepped down and converted to DC power by two DC power supplies. One supplies +12 VDC, while a second supply provides +5 VDC and ±15 VDC for logic and analog circuitry. All DC voltages are distributed via the relay board.

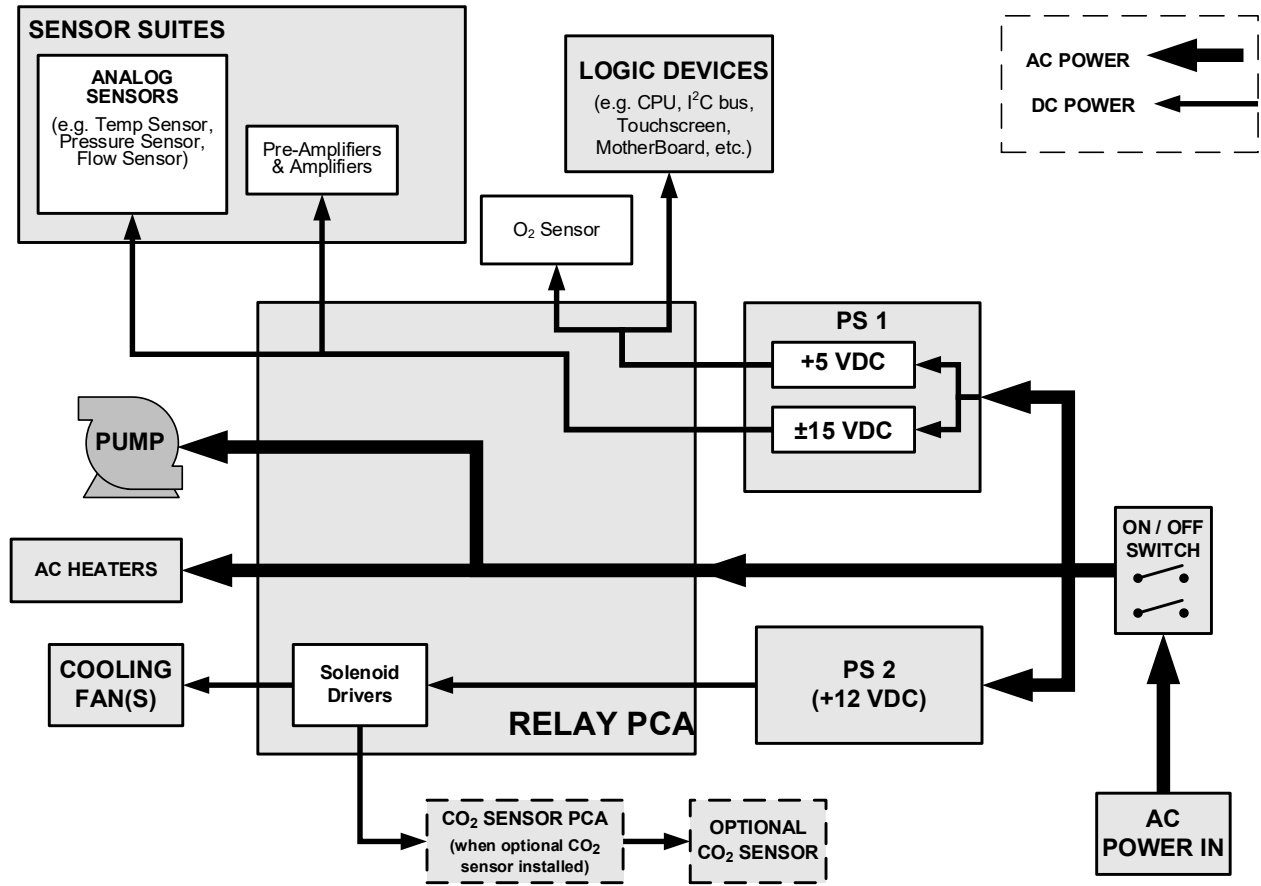


Figure 12 13. Power Distribution Block Diagram

6.4.15 FRONT PANEL TOUCHSCREEN/DISPLAY INTERFACE

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

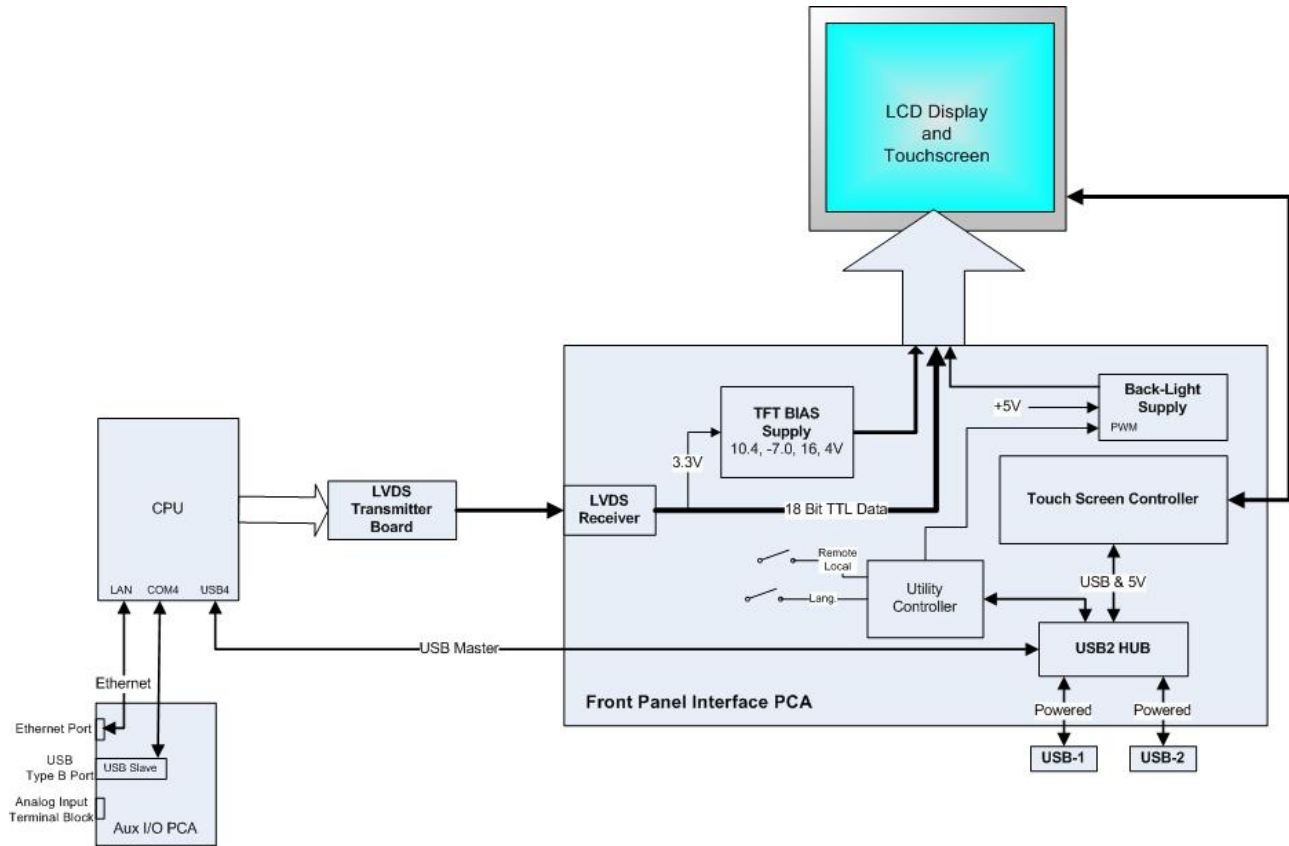


Figure 12 14. Front Panel and Display Interface Block Diagram

6.4.15.1 LVDS TRANSMITTER BOARD

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

6.4.15.2 FRONT PANEL TOUCHSCREEN/DISPLAY INTERFACE PCA

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

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

6.5 SOFTWARE OPERATION

The T802 uses a high performance, VortexX86-based microcomputer running Windows CE, inside of which special software developed by Teledyne API interprets user commands via the various interfaces, performs procedures and tasks, stores data in the CPU's various memory devices and calculates the concentration of the sample gas.

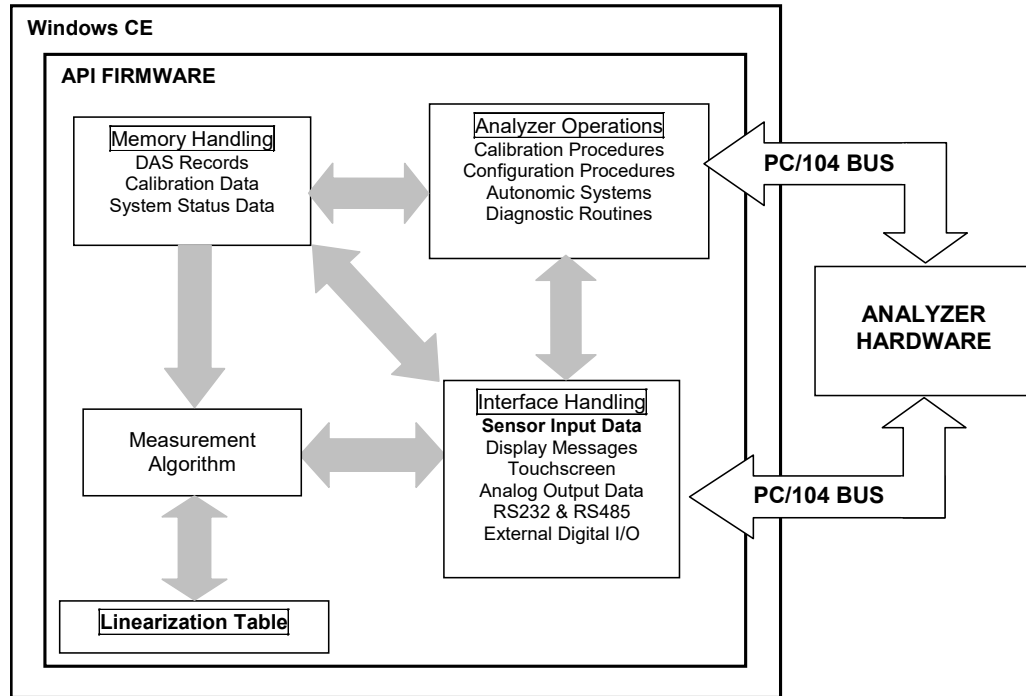


Figure 12 15. Basic Software Operation

6.5.1 ADAPTIVE FILTER

The T802 software processes the O₂ concentration signal after it is digitized by the motherboard, through an adaptive filter built into the software. Unlike other analyzers that average the output signal over a fixed time period, the T802 averages over a set number of samples, where each sample is 1 second. This technique is known as boxcar averaging. During operation, the software automatically switches between two different length filters based on the conditions at hand. Once triggered, the short filter remains engaged for a fixed time period to prevent chattering.

During conditions of constant or nearly constant concentration the software, by default, computes an average of the last 60 samples or 1 minute. This provides the calculation portion of the software with smooth stable readings. If a rapid change in concentration is detected the filter switches to 10 samples or 10 seconds measurement moving average to allow the analyzer to respond more quickly.

Two conditions must be simultaneously met to switch to the short filter. First, the instantaneous concentration must exceed the average in the long filter by a fixed amount (default setting is <2%). Second, the instantaneous concentration must exceed the average in the long filter by a portion, or percentage, of the average in the long filter (also <2% by default).

If necessary, these boxcar lengths as well as the threshold levels can be altered but with corresponding tradeoffs in rise time and signal-to-noise ratio (contact Teledyne API Technical Support for more information).

6.5.2 CALIBRATION – SLOPE AND OFFSET

Calibration of the analyzer is performed exclusively in software.

During instrument calibration the user enters expected values for zero and span via the front panel keypad and commands the instrument to make readings of calibrated sample gases for both levels. The readings taken are adjusted, linearized, and compared to the expected values. With this information the software computes values for instrument slope and offset and stores these values in memory for use in calculating the O₂ concentration of the sample gas.

6.5.3 TEMPERATURE AND PRESSURE COMPENSATION

Changes in ambient pressure can have a noticeable effect on the O₂ and optional CO₂ concentration calculations. To account for this, the T802 software includes a feature that allows the instrument to compensate both the O₂ and optional CO₂ calculations based on changes in ambient pressure. Both sensors are housed inside temperature-controlled manifolds. This minimizes temperature effects on the measured concentrations.

6.5.4 INTERNAL DATA ACQUISITION SYSTEM (DAS)

The DAS is designed to implement predictive diagnostics that store trending data for users to anticipate when an instrument will require service. Large amounts of data can be stored and retrieved for analysis. The DAS is configured and managed through the Data Logging menu (Section 2.5.1).

GLOSSARY

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

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

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



APPENDIX A – MODBUS REGISTERS

MODBUS REGISTER ADDRESS (DEC., 0-BASED)	DESCRIPTION	UNITS
MODBUS Floating Point Input Registers (32-bit IEEE 754 format; read in high-word, low-word order; read-only)		
0	O ₂ slope for range 1	—
2	O ₂ slope for range 2	—
4	O ₂ offset for range 1	%
6	O ₂ offset for range 2	%
8	O ₂ concentration for range 1 during zero/span calibration, just before computing new slope and offset	%
10	O ₂ concentration for range 2 during zero/span calibration, just before computing new slope and offset	%
12	O ₂ concentration for range 1	%
14	O ₂ concentration for range 2	%
16	O ₂ sensor cell temperature	°C
18	O ₂ sensor cell temperature control duty cycle	Fraction
20	Concentration stability	%
22	Sample flow	cc/m
24	Sample pressure	“Hg
26	Internal box temperature	°C
28	Ground reference (REF_GND)	mV
30	4096 mV reference (REF_4096_MV)	mV
100 ¹	CO ₂ slope for range 1	—
102	CO ₂ slope for range 2	—
104 ¹	CO ₂ offset for range 1	%
106	CO ₂ offset for range 2	%
108 ¹	CO ₂ concentration for range 1 during zero/span calibration, just before computing new slope and offset	%
110	CO ₂ concentration for range 2 during zero/span calibration, just before computing new slope and offset	%
112 ¹	CO ₂ concentration for range 1	%
114	CO ₂ concentration for range 2	%
116 ¹	CO ₂ sensor cell temperature	°C
118 ¹	CO ₂ sensor cell temperature control duty cycle	Fraction
130 ²	External analog input 1 value	Volts
132 ²	External analog input 1 slope	eng unit /V
134 ²	External analog input 1 offset	eng unit
136 ²	External analog input 2 value	Volts
138 ²	External analog input 2 slope	eng unit /V
140 ²	External analog input 2 offset	eng unit
142 ²	External analog input 3 value	Volts



MODBUS REGISTER ADDRESS (DEC., 0-BASED)	DESCRIPTION	UNITS
144 ²	External analog input 3 slope	eng unit /V
146 ²	External analog input 3 offset	eng unit
148 ²	External analog input 4 value	Volts
150 ²	External analog input 4 slope	eng unit /V
152 ²	External analog input 4 offset	eng unit
154 ²	External analog input 5 value	Volts
156 ²	External analog input 5 slope	eng unit /V
158 ²	External analog input 5 offset	eng unit
160 ²	External analog input 6 value	Volts
162 ²	External analog input 6 slope	eng unit /V
164 ²	External analog input 6 offset	eng unit
166 ²	External analog input 7 value	Volts
168 ²	External analog input 7 slope	eng unit /V
170 ²	External analog input 7 offset	eng unit
172 ²	External analog input 8 value	Volts
174 ²	External analog input 8 slope	eng unit /V
176 ²	External analog input 8 offset	eng unit

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

0	Maps to O2_TARG_SPAN1 variable; target conc. for range 1	%
2	Maps to O2_TARG_SPAN2 variable; target conc. for range 2	%
100 ¹	Maps to CO2_TARG_SPAN1 variable; target conc. for range 1	%
200 ¹	Maps to CO2_TARG_SPAN2 variable; target conc. for range 2	%

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

0	Box temperature warning
1	O ₂ cell temperature warning
2	Sample flow warning
3	Sample pressure warning
4	System reset warning
5	Rear board communication warning
6	Relay board communication warning
7	Front panel communication warning
8	Analog calibration warning
9	Dynamic zero warning
10	Dynamic span warning
11	Invalid concentration
12	In O ₂ zero calibration mode
13	In O ₂ span calibration mode
14	In O ₂ multi-point calibration mode



MODBUS REGISTER ADDRESS (DEC., 0-BASED)	DESCRIPTION	UNITS
15	System is OK (same meaning as <i>SYSTEM_OK</i> I/O signal)	
16	O ₂ concentration alarm limit #1 exceeded	
17	O ₂ concentration alarm limit #2 exceeded	
18	In Hessen manual mode	
100 ¹	CO ₂ cell temperature warning	
101 ¹	In CO ₂ zero calibration mode	
102 ¹	In CO ₂ span calibration mode	
103 ¹	In CO ₂ multi-point calibration mode	
104 ¹	CO ₂ concentration alarm limit #1 exceeded	
105 ¹	CO ₂ concentration alarm limit #2 exceeded	

**MODBUS Coil Registers
(single-bit; read/write)**

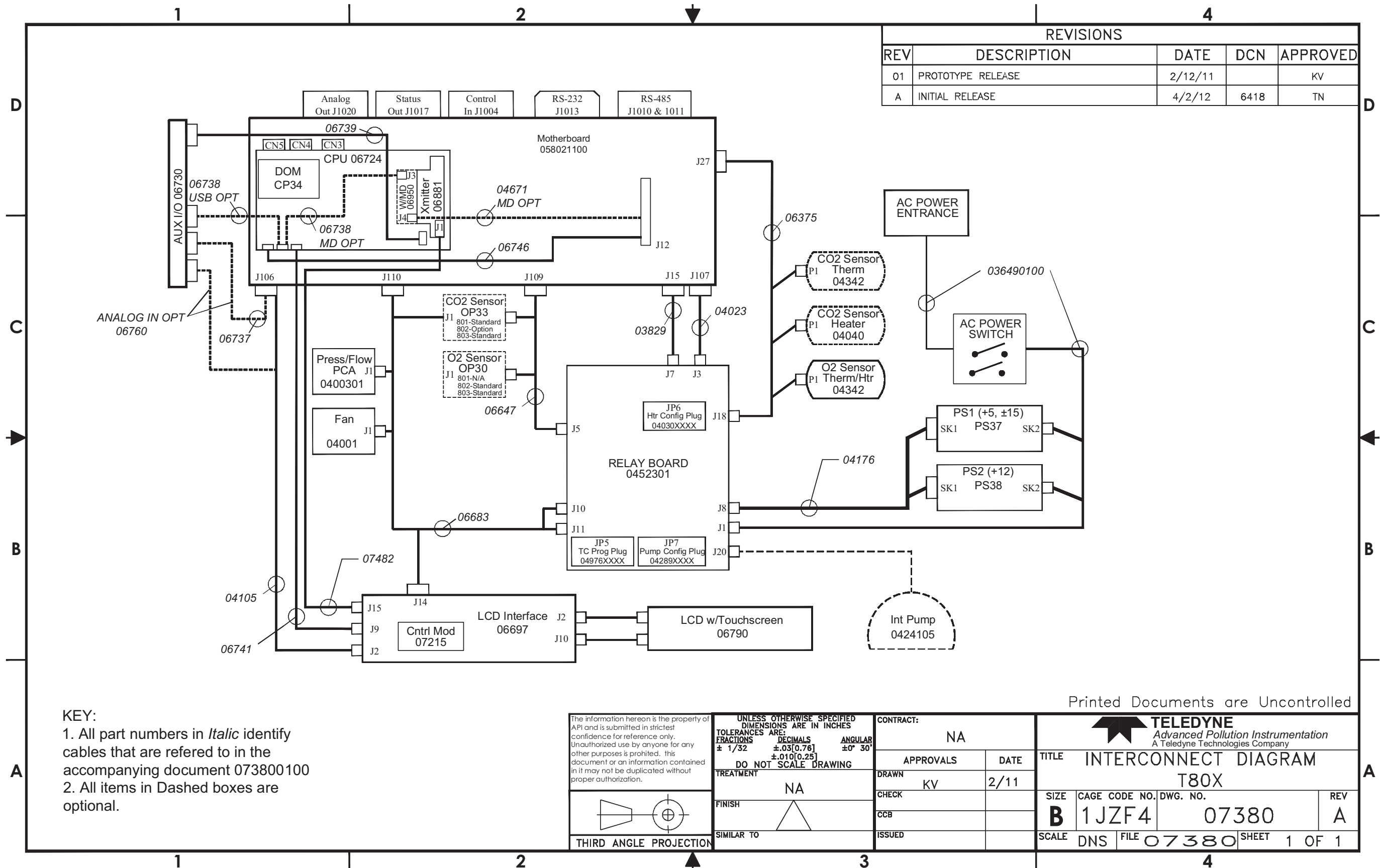
0	Maps to relay output signal 36 (<i>MB_RELAY_36</i> in signal I/O list)
1	Maps to relay output signal 37 (<i>MB_RELAY_37</i> in signal I/O list)
2	Maps to relay output signal 38 (<i>MB_RELAY_38</i> in signal I/O list)
3	Maps to relay output signal 39 (<i>MB_RELAY_39</i> in signal I/O list)
20 ³	Triggers O ₂ zero calibration of range 1 (on enters cal.; off exits cal.)
21 ³	Triggers O ₂ span calibration of range 1 (on enters cal.; off exits cal.)
22	Triggers O ₂ zero calibration of range 2 (on enters cal.; off exits cal.)
23	Triggers O ₂ span calibration of range 2 (on enters cal.; off exits cal.)
24 ^{1,3}	Triggers CO ₂ zero calibration of range 1 (on enters cal.; off exits cal.)
25 ³	Triggers CO ₂ span calibration of range 1 (on enters cal.; off exits cal.)
26 ³	Triggers CO ₂ zero calibration of range 2 (on enters cal.; off exits cal.)
27 ³	Triggers CO ₂ span calibration of range 2 (on enters cal.; off exits cal.)

¹ with CO₂ option.

² External analog input option.

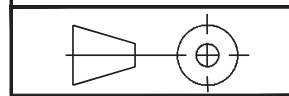
³ Set *DYN_ZERO* or *DYN_SPAN* variables to ON to enable calculating new slope or offset. Otherwise a calibration check is performed.

Appendix B - Interconnects



KEY:
 1. All part numbers in *Italic* identify cables that are referred to in the accompanying document 073800100
 2. All items in Dashed boxes are optional.

The information hereon is the property of API and is submitted in strictest confidence for reference only. Unauthorized use by anyone for any other purposes is prohibited. This document or an information contained in it may not be duplicated without proper authorization.



THIRD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
 TOLERANCES ARE:
 FRACTIONS ± 1/32
 DECIMALS ± .03 [0.76]
 ANGULAR ± 0° 30'
 ± .010 [0.25]
 DO NOT SCALE DRAWING

TREATMENT NA
 FINISH NA
 SIMILAR TO

CONTRACT: NA
 APPROVALS: KV
 DATE: 2/11
 DRAWN: KV
 CHECK: KV
 CCB: KV
 ISSUED: KV

Printed Documents are Uncontrolled



TITLE: INTERCONNECT DIAGRAM T80X
 SIZE: B
 CAGE CODE NO.: 1JZF4
 DWG. NO.: 07380
 REV: A
 SCALE: DNS
 FILE: 07380
 SHEET: 1 OF 1