



OPERATION MANUAL

MODEL T802

PARAMAGNETIC OXYGEN ANALYZER

© TELEDYNE ADVANCED POLLUTION INSTRUMENTATION
9480 CARROLL PARK DRIVE
SAN DIEGO, CA 92121-5201
USA

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

ABOUT TELEDYNE ADVANCED POLLUTION INSTRUMENTATION (TAPI)

Teledyne Advanced Pollution Instrumentation, Inc. (TAPI) is a worldwide market leader in the design and manufacture of precision analytical instrumentation used for air quality monitoring, continuous emissions monitoring, and specialty process monitoring applications. Founded in San Diego, California, in 1988, TAPI introduced a complete line of Air Quality Monitoring (AQM) instrumentation, which comply with the United States Environmental Protection Administration (EPA) and international requirements for the measurement of criteria pollutants, including CO, SO₂, NO_x and Ozone.

Since 1988 TAPI has combined state-of-the-art technology, proven measuring principles, stringent quality assurance systems and world class after-sales support to deliver the best products and customer satisfaction in the business.

For further information on our company, our complete range of products, and the applications that they serve, please visit www.teledyne-api.com or contact api-sales@teledyne.com.

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SAFETY MESSAGES

Important safety messages are provided throughout this manual for the purpose of avoiding personal injury or instrument damage. Please read these messages carefully. Each safety message is associated with a safety alert symbol, and are 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 gas analyzer to sample combustible gas(es)!

Note

For Technical Assistance regarding use and maintenance of this or any other Teledyne API product, contact Teledyne API's Technical Support Department:
Telephone: 800-324-5190 Email: sda_techsupport@teledyne.com
or access 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 un analyseur de gaz pour échantillonner des gaz combustibles!

WARRANTY

WARRANTY POLICY (02024F)

Teledyne Advanced Pollution Instrumentation (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.

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 Invalidiation



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 "Packing Components for Return to Teledyne API's Technical Support" in the *Primer on Electro-Static Discharge* section of this manual, and for RMA procedures please refer to our Website at <http://www.teledyne-api.com> under Customer Support > Return Authorization.

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ABOUT THIS MANUAL

This operation manual, PN 07275, is comprised of multiple documents in PDF format, as listed below.

Part No.	Rev	Name/Description
07275	B	T802 Operation manual
06530	C	Menu Trees and Software Documentation (inserted as Appendix A in this manual)
07269	A	Spare Parts List (located in Appendix B of this manual)
06535	A	Expendables Kit (located in Appendix B of this manual)
06532	C	Repair Request Form (inserted as Appendix C in this manual)

Appendix D Documents:

0738001	A	Interconnect List
07380	A	Interconnect Diagram
05803	B	SCH, PCA 05802, MOTHERBOARD, GEN-5
06698	D	SCH, PCA 06697, INTRFC, LCD TCH SCR
06882	B	SCH, LVDS TRANSMITTER BOARD
06731	A	SCH, AUXILLIARY-I/O BOARD

Note

We recommend that this manual be read in its entirety before any attempt is made to operate the instrument.

ORGANIZATION

This manual is divided among three main parts and a collection of appendices at the end:

Part I contains introductory information that includes an overview of the analyzer, specifications, descriptions of the available options, installation and connection instructions, and the initial calibration and functional checks.

Part II comprises the operating instructions, which include setup and calibration, as well as remote operation, and ends with the specifics of calibrating for use in monitoring within EPA protocol.

Part III provides detailed technical information starting with maintenance, troubleshooting and service, frequently asked questions, principles of operation, a primer on electrostatic discharge, and a glossary.

The appendices at the end of the manual provide support information such as version-specific software documentation, lists of spare parts* and recommended stocking levels, and schematics.

*Part numbers do not reflect real-time updates – contact Sales or Technical Support).

CONVENTIONS USED

In addition to the safety symbols as presented in the *Important Safety Information* page, this manual provides *special notices* related to the safety and effective use of the analyzer and other pertinent information.

Special Notices appear as follows:

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

Could either affect accuracy of instrument readings or cause loss of data.

Note

Pertinent information associated with the proper care, operation or maintenance of the analyzer or its parts.

REVISION HISTORY

T802 Operation and Maintenance Manual, PN07275

Date	Rev	DCN	Description
2013 January 14	B	6418	Administrative Updates and specs updates
2011 February 18	A	6005	Initial Release

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APPENDIX B - T802 SPARE PARTS LIST

APPENDIX C - T802 REPAIR QUESTIONNAIRE

APPENDIX D - T802 ELECTRONIC SCHEMATICS

PART I
—
GENERAL INFORMATION AND SETUP

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1. INTRODUCTION, FEATURES AND OPTIONS

1.1. T802 OVERVIEW

The Model T802 (also referred to as T802) Paramagnetic Oxygen Analyzer is a microprocessor-controlled analyzer that determines the concentration of molecular oxygen (O_2) in a sample gas drawn through the instrument. It uses a paramagnetic sensor that relies on the relatively high reactivity of O_2 molecules to magnetic fields to generate a current that is proportional to the amount of O_2 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.

Built-in data acquisition capability using the analyzer's internal memory, allows the logging of multiple parameters including averaged or instantaneous concentration values, calibration data, and operating parameters such as pressure and flow rate. Stored data are easily retrieved through the serial port or optional Ethernet port via our APICOM software or from the front panel, allowing operators to perform predictive diagnostics and enhanced data analysis by tracking parameter trends. Multiple averaging periods of one minute to 365 days are available for over a period of one year.

1.2. FEATURES

Some exceptional features of your T802 Paramagnetic Oxygen Analyzer are:

- Non-depleting, paramagnetic sensor for O_2 specific measurement:
 - Virtually no cross-sensitivities
 - Rapid response times
 - No consumable parts
 - Consistent performance over time
 - No susceptibility to CO_2 poisoning (unlike electromechanical O_2 sensors)
- Microprocessor controlled for versatility
- LCD Graphical User Interface with capacitive touch screen
- Multi-tasking software for viewing of test variables during operation
- Continuous self checking with alarms
- Bi-directional USB, RS-232, and 10BaseT/100BaseT Ethernet ports for remote operation (optional RS-485)
- Front panel USB ports for peripheral devices
- Digital status outputs to indicate instrument operating condition
- Adaptive signal filtering to optimize response time
- Internal data logging with 1 min to 365-day multiple average
- Remote operation when used with Teledyne API's APICOM software
- Temperature and Pressure Compensation
- Ranges, 0-1% to 0-100.0%, user adjustable

HAZARD
Strong Oxidizer

OXYGEN IS A STRONG OXIDIZER.



This is a general purpose instrument designed for usage in nonhazardous areas. Ensure that all safety precautions related combustible gases are followed.

Before working with the casing open, be sure to turn off power to the analyzer, 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 tubing. Otherwise, poisoning, fire or explosion may be caused due to gas leakage, etc.

1.3. OPTIONS

Table 1-1 presents the options available with the T802 analyzer. For assistance with ordering, please contact the Sales department of Teledyne API at:

PHONE (toll free, North America)	800-324-5190
FAX:	858-657-9816
PHONE (Direct):	858-657-9800
E-MAIL:	api-sales@teledyne.com
WEB SITE	www.teledyne-api.com

Table 1-1. Analyzer Options

Option	Option Number	Description/Notes	Reference
Pumps		Pumps meet all typical AC power supply standards while exhibiting same pneumatic performance.	
	10A	External Pump 100V - 120V @ 60 Hz	N/A
	10B	External Pump 220V - 240V @ 50 Hz	N/A
	10C	External Pump 220V - 240V @ 60 Hz	N/A
	10D	External Pump 100V – 120V @ 50 Hz	N/A
	10E	External Pump 100V @ 60 Hz	N/A
	14	Internal Pump	N/A
	13	High Voltage Internal Pump 240V @ 50Hz	N/A
Rack Mount Kits		Options for mounting the analyzer in standard 19" racks	
	20A	Rack mount brackets with 26 in. chassis slides	N/A
	20B	Rack mount brackets with 24 in. chassis slides	N/A
	21	Rack mount brackets only (compatible with carrying strap, Option 29)	N/A
	23	Rack mount for external pump pack (no slides)	N/A

Option	Option Number	Description/Notes	Reference
Carrying Strap/Handle	Side-mounted strap for hand-carrying analyzer		
29	Extends from "flat" position to accommodate hand for carrying. Recesses to 9mm (3/8") dimension for storage. Can be used with rack mount brackets, Option 21. Cannot be used with rack mount slides.		N/A
CAUTION - GENERAL SAFETY HAZARD			
 THE T802 WEIGHS ABOUT 28 POUNDS (12.7 KG). TAKE CARE TO AVOID PERSONAL INJURY WHEN LIFTING/CARRYING THE ANALYZER. ALSO, DISCONNECT ALL CABLES AND TUBING FROM THE ANALYZER BEFORE MOVING IT.			
Analog Inputs w/USB port		Used for connecting external voltage signals from other instrumentation (such as meteorological instruments).	
64B	Also can be used for logging these signals in the analyzer's internal DAS. (See Option 64A for USB port only).		Sections 3.3.1.2 and 5.9.8
Current Loop Analog Outputs		Adds isolated voltage-to-current conversion circuitry to the analyzer's analog outputs.	
41	Can be configured for 0-20 mA or 4-20 mA. May be ordered separately for any of the analog outputs. Can be installed at the factory or retrofitted in the field.		Section 3.3.1.4
Parts Kits		Spare parts and expendables	
42A	Expendables Kit for analyzer with a pump, includes a recommended set of expendables for one year of operation.		Appendix B
42D	Expendables Kit for analyzer without a pump, includes a recommended set of expendables for one year of operation.		Appendix B
Communication Cables		For remote serial, network and Internet communication with the analyzer.	
	Type	Description	
60A	RS-232	Shielded, straight-through DB-9F to DB-25M cable, about 1.8 m long. Used to interface with older computers or code activated switches with DB-25 serial connectors.	
60B	RS-232	Shielded, straight-through DB-9F to DB-9F cable of about 1.8 m length.	Sections 3.3.1.8 and 6
60C	Ethernet	Patch cable, 2 meters long, used for Internet and LAN communications.	
60D	USB	Cable for direct connection between instrument (rear panel USB port) and personal computer.	
Concentration Alarm Relay		Issues warning when gas concentration exceeds limits set by user.	
61	Four (4) "dry contact" relays on the rear panel of the instrument. This relay option is different from and in addition to the "Contact Closures" that come standard on all TAPI instruments.		Section 3.3.1.7
RS-232 Multidrop		Enables communications between host computer and up to eight analyzers.	
62	Multidrop card seated on the analyzer's CPU card. Each instrument in the multidrop network requires this card and a communications cable (Option 60B).		Section 3.3.1.8

Option	Option Number	Description/Notes	Reference
USB COM Port			
	64A	Separate option if instrument not configured with Option 64B (analog inputs). Disabled when using Multidrop or RS-485 communication.	Sections 3.3.1.8 and 6.4
Second Gas Sensor			
	67A	Carbon Dioxide (CO ₂) Sensor 0-20%	Sections 9.5, 12.2, 12.2.1 and 12.3.1
Special Features	Built in features, software activated		
N/A		Maintenance Mode Switch , located inside the instrument, places the analyzer in maintenance mode where it can continue sampling, yet ignore calibration, diagnostic, and reset instrument commands. This feature is of particular use for instruments connected to Multidrop or Hessen protocol networks. Call Technical Support for activation.	N/A
N/A		Second Language Switch activates an alternate set of display messages in a language other than the instrument's default language. Call Technical Support for a specially programmed Disk on Module containing the second language.	N/A
N/A		Dilution Ratio Option allows the user 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. Call Technical Support for activation.	Sections 3.4.3.2 and 5.4.4

2. SPECIFICATIONS, APPROVALS & COMPLIANCE

2.1. SPECIFICATIONS

Table 2-1: T802 Specifications

PARAMETER	SPECIFICATION
O₂ Sensor	
Ranges	Min: 0-1% Full scale Max: 0-100% Full scale (user selectable)
Zero Noise ¹	< 0.02% (RMS)
Span Noise ¹	< 0.05% of reading (RMS)
Lower Detectable Limit ²	< 0.04%
Zero Drift ³	< ±0.02%/24 hours; < ±0.05%/7 days
Span Drift	< ±0.1%/7 days
Accuracy	< ±0.1%
Linearity	< ±0.1%
Temperature Coefficient	< ±0.01%/degree C
CO₂ Sensor Option	
Ranges	Min: 0-1% Full scale Max: 0-20% Full scale (user selectable; dual ranges and auto ranging supported)
Zero Noise ¹	< 0.02% (RMS)
Span Noise ¹	< 0.1% of reading (RMS)
Lower Detectable Limit ²	< 0.04%
Zero Drift	< ±0.02%/24 hours; < ±0.05%/7 days
Span Drift	< ±0.1%/7 days
Accuracy	< ±(1.5% of range +2% of reading)
Temperature Coefficient	< ±0.01%/degree C
Rise and Fall Time	<60 seconds to 95%
Flow Rate	120ml ±20ml/min
Humidity Range	0-95% RH
Pressure Range	25-31 in HG
AC Power	100V – 120V 60 Hz (77W); 220V – 240 V 50 Hz (80W)
Analog Output Ranges	All Outputs: 0.1 V, 1 V, 5 V or 10 V Three outputs convertible to 4-20 mA isolated current loop. All Ranges with 5% under/over-range
Recorder Offset	± 10%
Analog Output Resolution	1 part in 4096 of selected full-scale voltage
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
Alarm outputs	2 opto-isolated alarms outputs with user settable alarm limits

¹ As defined by the USEPA.

² Defined as twice the Zero Noise level by the USEPA.

³ Note: Zero Drift is typically <± 0.1% O₂ during the first 24 hours of operation.

2.2. APPROVALS AND CERTIFICATIONS

The Teledyne API Model T802 Paramagnet Oxygen Analyzer was tested and certified for Safety and Electromagnetic Compatibility (EMC). This section presents the compliance statements for those requirements and directives.

2.2.1. SAFETY

IEC 61010-1:2001, Safety requirements for electrical equipment for measurement, control, and laboratory use.

CE: 2006/95/EC, Low-Voltage Directive

North American:

cNEMKO (Canada): CAN/CSA-C22.2 No. 61010-1-04
NEMKO-CCL (US): UL No. 61010-1 (2nd Edition)

2.2.2. EMC

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

EN 55011 (CISPR 11), Group 1, Class A Emissions

FCC 47 CFR Part 15B, Class A Emissions

CE: 2004/108/EC, Electromagnetic Compatibility Directive

2.2.3. OTHER TYPE CERTIFICATIONS

For additional certifications, please contact Technical Support:

Toll-free Phone: 800-324-5190

Phone: 858-657-9800

Fax: 858-657-9816

Email: sda_techsupport@teledyne.com

3. GETTING STARTED

This section addresses the procedures for unpacking the instrument and inspecting for damage, presents clearance specifications for proper ventilation, introduces the instrument layout, then presents the procedures for getting started: making electrical and pneumatic connections, and conducting an initial calibration check.

3.1. UNPACKING THE T802 ANALYZER



CAUTION GENERAL SAFETY HAZARD

To avoid personal injury, always use two persons to lift and carry the T802.



CAUTION – AVOID WARRANTY INVALIDATION

Printed circuit assemblies (PCAs) are sensitive to electro-static discharges too small to be felt by the human nervous system. Damage resulting from failure to use ESD protection when working with electronic assemblies will void the instrument warranty.

See *A Primer on Electro-Static Discharge* in this manual for more information on preventing ESD damage.



CAUTION!

Do not operate this instrument until removing dust plugs from SAMPLE and EXHAUST ports on the rear panel!

Note

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

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

Included with your analyzer is a printed record of the final performance characterization performed on your instrument at the factory.

This record, *Final Test and Validation Data Sheet*, PN 068350000, is an important quality assurance and calibration record for this instrument. It should be placed in the quality records file for this instrument.

1. Carefully remove the top cover of the analyzer and check for internal shipping damage as follows:
 - a) Remove the locking screw located in the top, center of the Front panel;
 - b) Remove the two flat head, Phillips screws on the sides of the instrument (one per side towards the rear);
 - c) Slide the cover backwards until it clears the analyzer's front bezel;
 - d) Lift the cover straight up.
2. Inspect the interior of the instrument to make sure all circuit boards and other components are in good shape and properly seated.
3. Check that the connectors of the various internal wiring harnesses and pneumatic hoses are firmly and properly seated.
4. Verify that all of the optional hardware ordered with the unit has been installed. These are listed on the paperwork accompanying the analyzer.

3.1.1. VENTILATION CLEARANCE

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

Table 3-1: Ventilation Clearance

AREA	MINIMUM REQUIRED CLEARANCE
Back of the instrument	4 in.
Sides of the instrument	1 in.
Above and below the instrument	1 in.

Various rack mount kits are available for this analyzer. See Table 1-1 of this manual for more information.

3.2. INSTRUMENT LAYOUT

Instrument layout shows front panel and display, rear panel connectors, and internal chassis layout.

3.2.1. FRONT PANEL

Figure 3-1 shows the analyzer's front panel layout, followed by a close-up of the display screen in Figure 3-2, which is described in Table 3-3. The two USB ports on the front panel are provided for the connection of peripheral devices:

- plug-in mouse (not included) to be used as an alternative to the touchscreen interface
- thumb drive (not included) to download updates to instruction software (contact TAPI Technical Support for information).

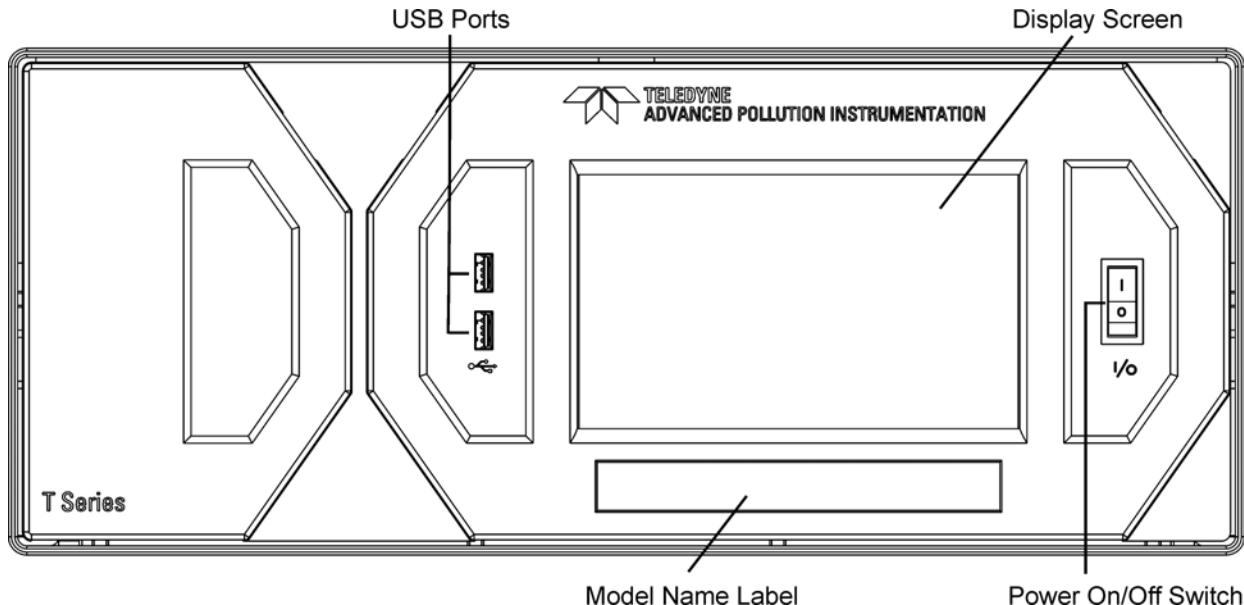


Figure 3-1: Front Panel Layout



Figure 3-2. Display Screen and Touch Control

The front panel liquid crystal display screen includes touch control. Upon analyzer start-up, the screen shows a splash screen and other initialization indicators before the main display appears, similar to Figure 3-2 above (may or may not display a Fault alarm). The LEDs on the display screen indicate the Sample, Calibration and Fault states; also on the screen is the gas concentration field (Conc), which displays real-time readouts for the primary gas and for the secondary gas if installed. The display screen also shows what mode the analyzer is currently in, as well as messages and data (Param). Along the bottom of the screen is a row of touch control buttons; only those that are currently applicable will have a label. Table 3-2 provides detailed information for each component of the screen.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Do not use hard-surfaced instruments such as pens to operate the control buttons.

Table 3-2. Display Screen and Touch Control Description

Field	Description/Function			
Status	LEDs indicating the states of Sample, Calibration and Fault, as follows:			
	Name	Color	State	Definition
	SAMPLE	Green	Off On Blinking	Unit is not operating in sample mode, DAS is disabled. Sample Mode active; Front Panel Display being updated; DAS data being stored. Unit is operating in sample mode, front panel display being updated, DAS hold-off mode is ON, DAS disabled
	CAL	Yellow	Off On Blinking	Auto Cal disabled Auto Cal enabled Unit is in calibration mode
	FAULT	Red	Off Blinking	No warnings exist Warnings exist
Conc	Displays the actual concentration of the sample gas currently being measured by the analyzer in the currently selected units of measure			
Mode	Displays the name of the analyzer's current operating mode			
Param	Displays a variety of informational messages such as warning messages, operational data, test function values and response messages during interactive tasks.			
Control Buttons	Displays dynamic, context sensitive labels on each button, which is blank when inactive until applicable.			

Figure 3-3 shows how the front panel display is mapped to the menu charts illustrated in this manual. The Mode, Param (parameters), and Conc (gas concentration) fields in the display screen are represented across the top row of each menu chart. The eight touch control buttons along the bottom of the display screen are represented in the bottom row of each menu chart.

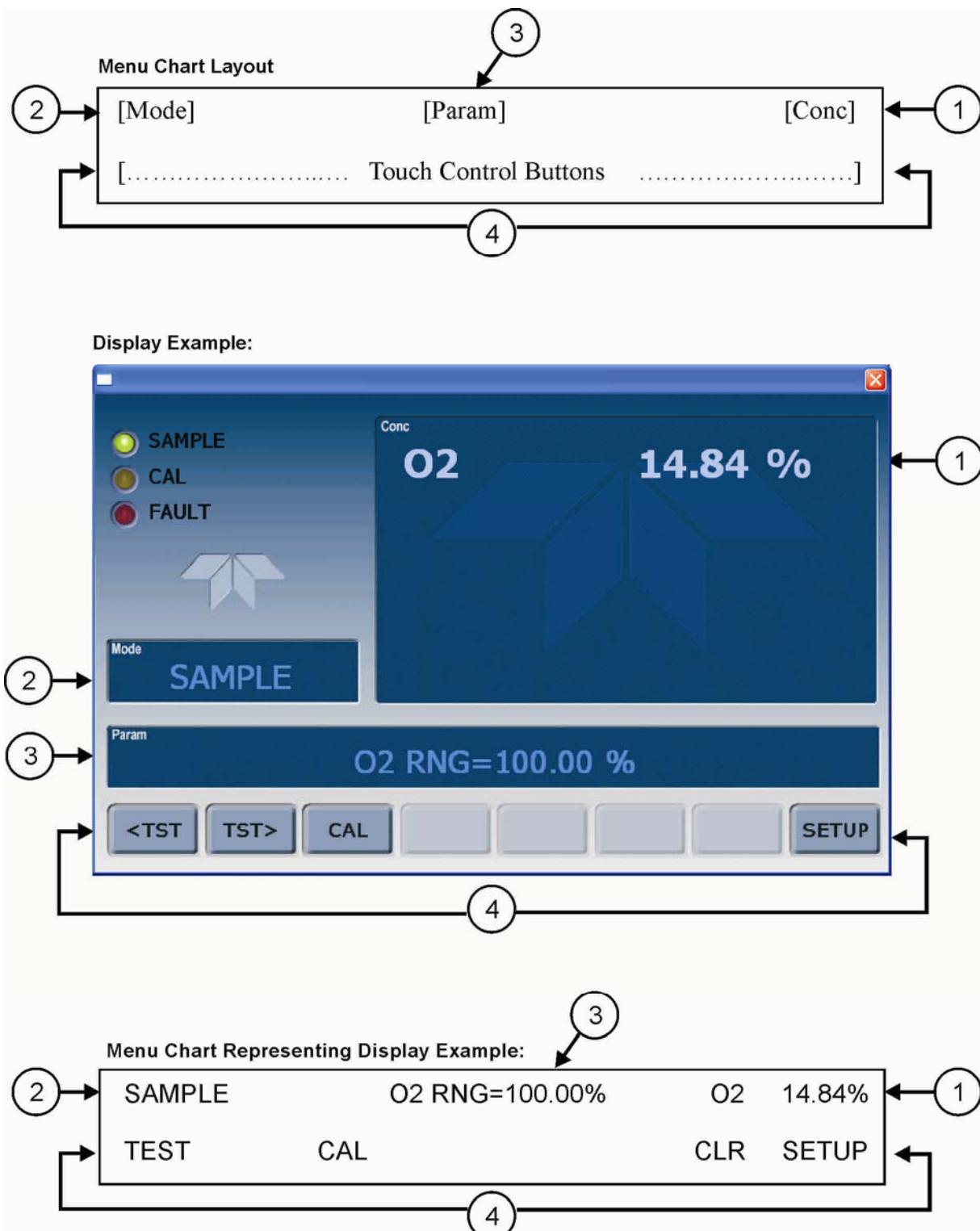


Figure 3-3.: Display/Touch Control Screen Mapped to Menu Charts

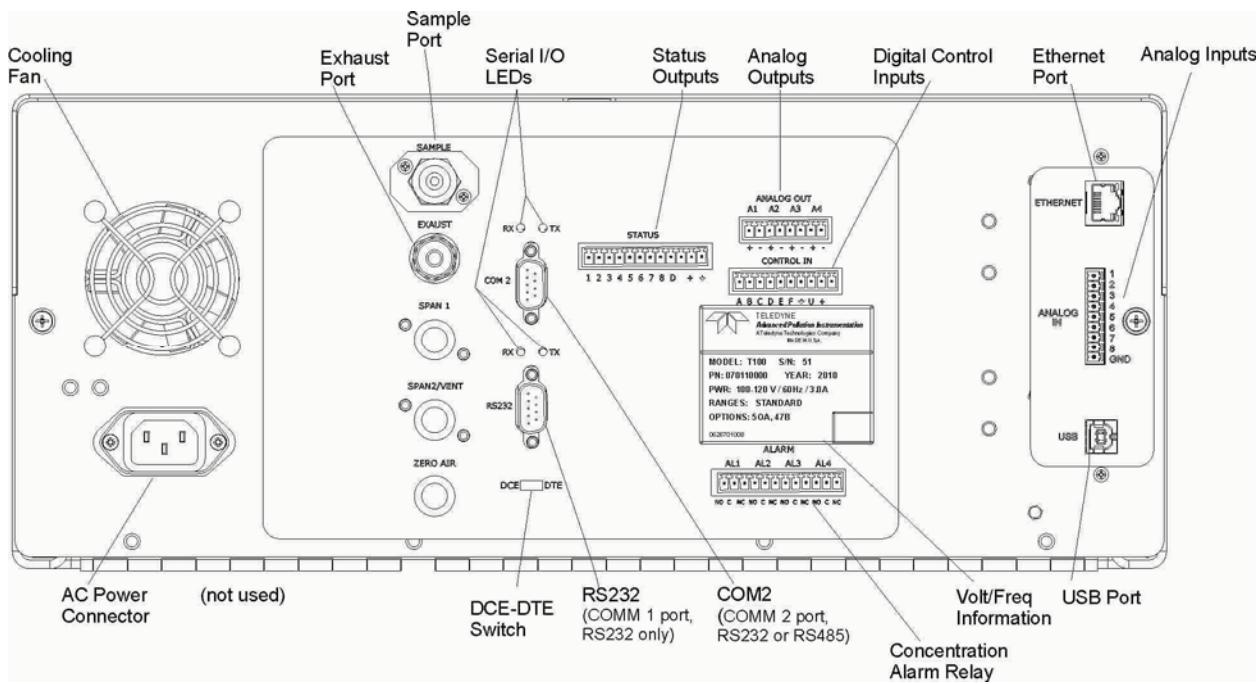


Figure 3-4: Rear Panel Layout

Table 3-3. Rear Panel Component Descriptions

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/Volt/Freq information 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 on the when blinking.
COM 2	Serial communications port for RS-232 or RS-485.
RS-232	Serial communications port for RS-232 only.
DCE DTE	Switch to select either data terminal equipment or data communication equipment during RS-232 communication.
STATUS	For outputs to devices such as Programmable Logic Controllers (PLCs).
ANALOG OUT	For voltage or current loop outputs to a strip chart recorder and/or a data logger.
CONTROL IN	For remotely activating the zero and span calibration modes.
ALARM	Option for concentration alarms and system warnings.
ETHERNET	Connector for network or Internet remote communication, using Ethernet cable
ANALOG IN	Option for external voltage signals from other instrumentation and for logging these signals
USB	Option for direct connection to personal computer, using USB com cable.

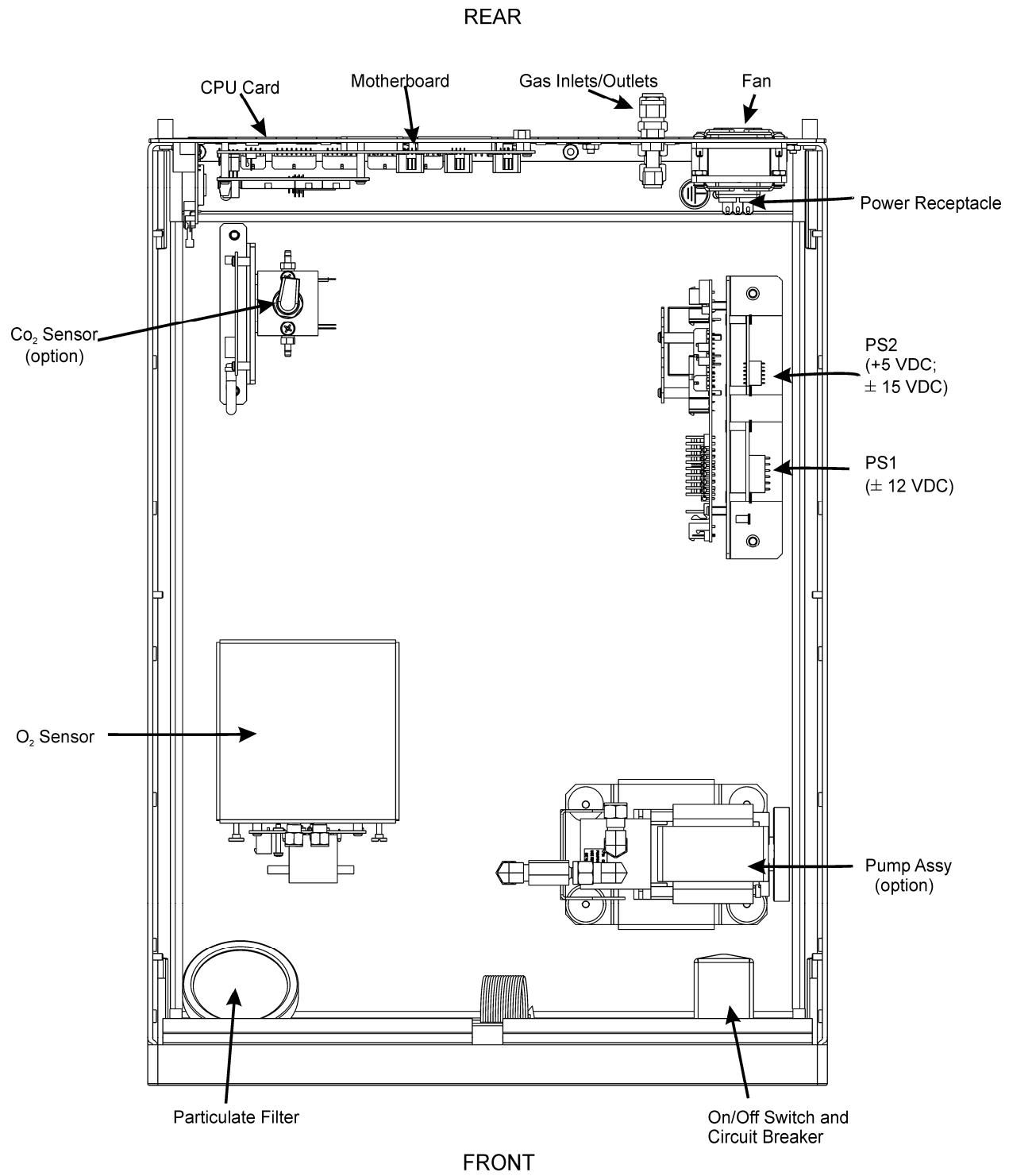


Figure 3-5: Internal Layout

3.3. CONNECTIONS AND SETUP

This section presents the electrical (Section 3.3.1) and pneumatic (Section 3.3.2) connections for setup and preparing for instrument operation.

3.3.1. ELECTRICAL CONNECTIONS

Note

To maintain compliance with EMC standards, it is required that the cable length be no greater than 3 meters for all I/O connections, which include Analog In, Analog Out, Status Out, Control In, Ethernet/LAN, USB, RS-232, and RS-485.

This section presents the electrical connections for AC power and communications.

3.3.1.1. CONNECTING POWER



WARNING - ELECTRICAL SHOCK HAZARD

- High Voltages are present inside the analyzers case.
- Turn OFF analyzer power before disconnecting or connecting PCAs, wiring harnesses or electrical subassemblies.
- Power connection must have functioning ground connection.
- Do not defeat the ground wire on power plug.
- Do not operate with cover off.

Attach the power cord to the analyzer and plug it into a power outlet capable of carrying at least 10 A current at your AC voltage and that it is equipped with a functioning earth ground.



**CAUTION
GENERAL SAFETY HAZARD**

The T802 analyzer can be configured for both 100-130 V and 210-240 V at either 47 or 63 Hz.

To avoid damage to your analyzer, make sure that the AC power voltage matches the voltage indicated on the Analyzer's serial number label tag (See Figure 3-4) before plugging the T802 into line power.

3.3.1.2. ANALOG INPUTS (OPTION 64) CONNECTIONS

The Analog In connector is used for connecting external voltage signals from other instrumentation (such as meteorological instruments) and for logging these signals in the analyzer's internal DAS. The input voltage range for each analog input is 0-10 VDC, and the input impedance is nominally 20kΩ in parallel with 0.1μF.

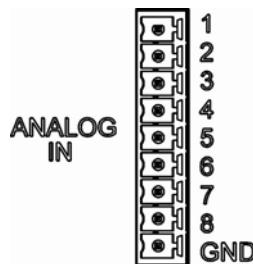


Figure 3-6: Analog In Connector

Pin assignments for the Analog In connector are presented in Table 3-4.

Table 3-4. Analog Input Pin Assignments

PIN	DESCRIPTION	DAS PARAMETER ¹
1	Analog input # 1	AIN 1
2	Analog input # 2	AIN 2
3	Analog input # 3	AIN 3
4	Analog input # 4	AIN 4
5	Analog input # 5	AIN 5
6	Analog input # 6	AIN 6
7	Analog input # 7	AIN 7
8	Analog input # 8	AIN 8
GND	Analog input Ground	N/A

¹ See Section 7 for details on setting up the DAS.

3.3.1.3. ANALOG OUTPUT CONNECTIONS

The T802 is equipped with several analog output channels accessible through the ANALOG OUT connector on the rear panel of the instrument. The standard configuration for these outputs is VDC. An optional current loop output is available for each (Section 3.3.1.4).

When the instrument is in its default configuration, channels A1 and A2 output a signal that is proportional to the O₂ concentration of the sample gas. Either can be used for connecting the analog output signal to a chart recorder or for interfacing with a data logger.

If the optional CO₂ sensor is installed, A3 outputs a signal proportional to the CO₂ concentration of the sample gas.

Channel A4 is special. It can be set by the user (see Section 5.9.6) to output any one of the parameters accessible through the <TST TST> buttons of the unit's Sample display.

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.

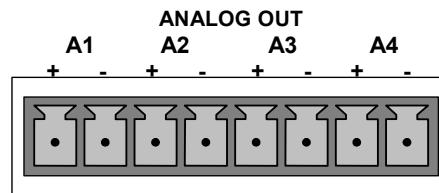


Figure 3-7: Analog Output Connector

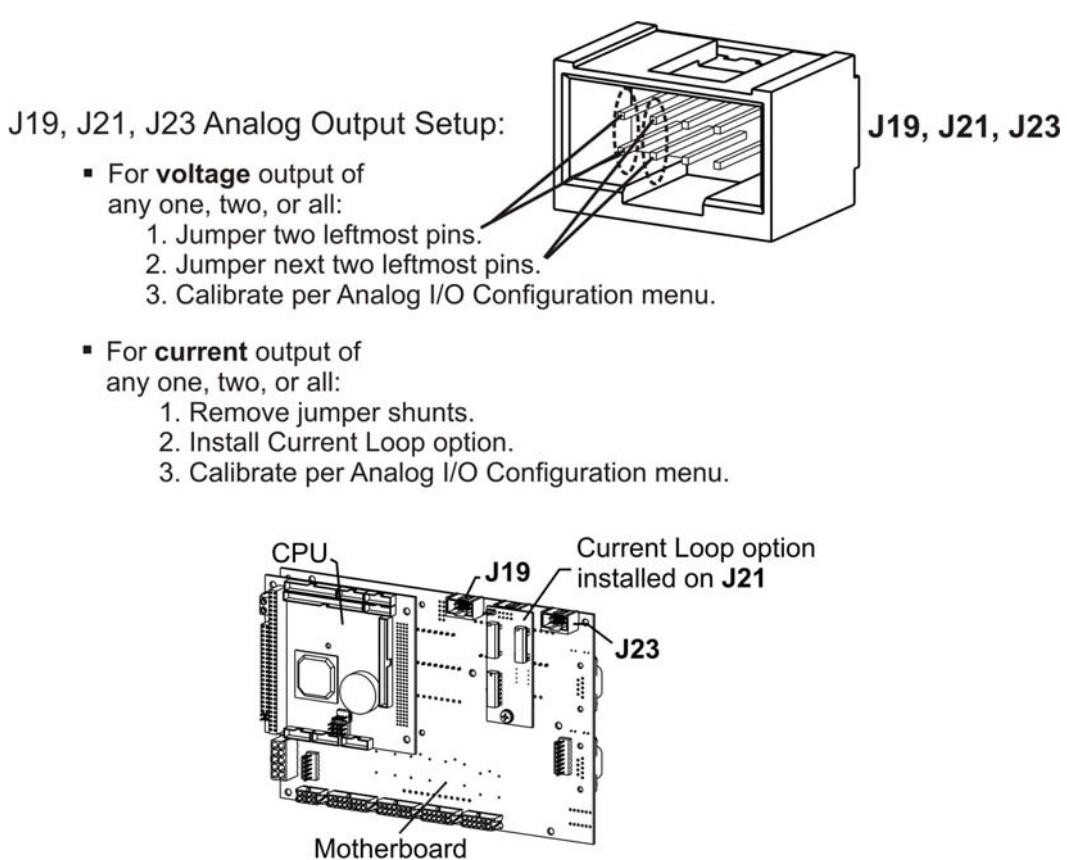
Table 3-5: Analog Output Pin-Outs

PIN	ANALOG OUTPUT	VOLTAGE SIGNAL	CURRENT SIGNAL
1	A1	V Out	I Out +
2		Ground	I Out -
3	A2	V Out	I Out +
4		Ground	I Out -
5	A3 (Only used if CO ₂ sensor is installed)	V Out	I Out +
6		Ground	I Out -
7	A4	V Out	NA
8		Ground	NA

3.3.1.4. CURRENT LOOP ANALOG OUTPUTS (OPTION 41) SETUP

This option adds isolated, voltage-to-current conversion circuitry to the analyzer's analog outputs. 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 of the analyzer. This option converts the DC voltage analog output to a current signal with 0-20 mA output current. The outputs 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 3-8 provides installation instructions and illustrates a sample combination of one current output and two voltage outputs configuration. The section following this provides instructions for converting current loop analog outputs to standard 0-to-5 VDC outputs. Information on calibrating or adjusting these outputs can be found in Section 5.9.3.7.



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 3-8: Current Loop Option Installed

CONVERTING CURRENT LOOP ANALOG OUTPUTS TO STANDARD VOLTAGE OUTPUTS



CAUTION

Servicing or handling of circuit components requires electrostatic discharge (ESD) protection, i.e. ESD grounding straps, mats and containers. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty. See Section 0 for more information on preventing ESD damage.

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

1. Turn off power to the analyzer.
2. If a recording device was connected to the output being modified, disconnect it.
3. Remove the top cover as follows:

- a) Remove the set screw located at the top center of the rear panel
- b) Remove the screws fastening the top cover to the unit (two per side).
- c) Slide cover back.
- d) 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 3-8).
 - a) Each connector, J19, J21 and J23, requires two shunts: Place one shunt on the two left-most pins.
 - b) Place the second shunt on the two pins next to it (refer to Figure 3-8 for an example).
6. Reattach the top case to the analyzer.
7. The analyzer is now ready to have a voltage-sensing, recording device attached to that output.

3.3.1.5. CONNECTING THE STATUS OUTPUTS

The status outputs report analyzer conditions via optically isolated NPN transistors, which sink up to 50 mA of DC current. These outputs can be used to interface with devices that accept logic-level digital inputs, such as programmable logic controllers (PLCs). Each status bit is an open collector output that can withstand up to 40 VDC. All of the emitters of these transistors are tied together and connected at Pin D.

Note

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

At 50 mA, the transistor will drop approximately 1.2V from its collector to emitter.

The status outputs are accessed via a 12-pin connector on the analyzer's rear panel labeled STATUS (see Figure 3-4). Pin-outs for this connector are:

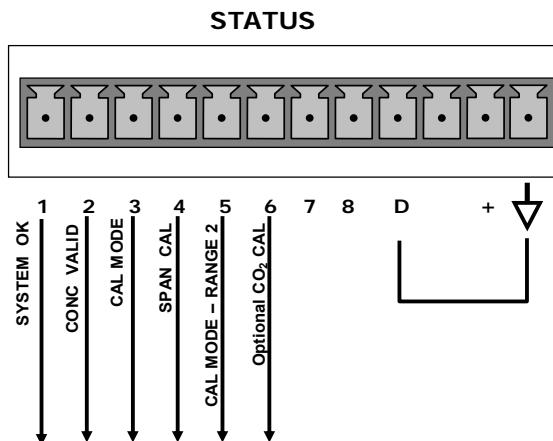


Figure 3-9: Status Output Connector

Table 3-6: Status Output Signals

Rear Panel Label	Status Definition	Condition
1	SYSTEM OK	ON if no faults are present.
2	CONC VALID	OFF any time the HOLD OFF feature is active, such as during calibration or when any faults exist invalidating the O ₂ measurement. ON if concentration measurement is valid.
3	CAL MODE	ON whenever the instrument is being calibrated. The Mode field
4	SPAN CAL	ON whenever the instrument's SPAN point is being calibrated.
5	RANGE2 CAL	ON if unit is in high range of either the DUAL or AUTO range modes.
6	CO ₂ CAL	If this analyzer is equipped with an optional CO ₂ sensor, this Output is ON when that sensor is in calibration mode. Otherwise this output is unused.
7 & 8	SPARE	
D	EMITTER BUS	The emitters of the transistors on Pins 1-8 are bussed together.
+	DC POWER	+ 5 VDC, 300 mA source (combined rating with Control Output, if used).
↓	Digital Ground	The ground level from the analyzer's internal DC power supplies

3.3.1.6. CONNECTING THE CONTROL INPUTS

If you wish to use the analyzer to remotely activate the zero and span calibration modes, several digital control inputs are provided through a 10-pin connector labeled **CONTROL IN** on the analyzer's rear panel.

There are two methods for energizing the control inputs. The internal +5V available from the pin labeled "+" is the most convenient method (Figure 3-10, left). However, if full isolation is required, an external 5 VDC power supply should be used (Figure 3-10, right).

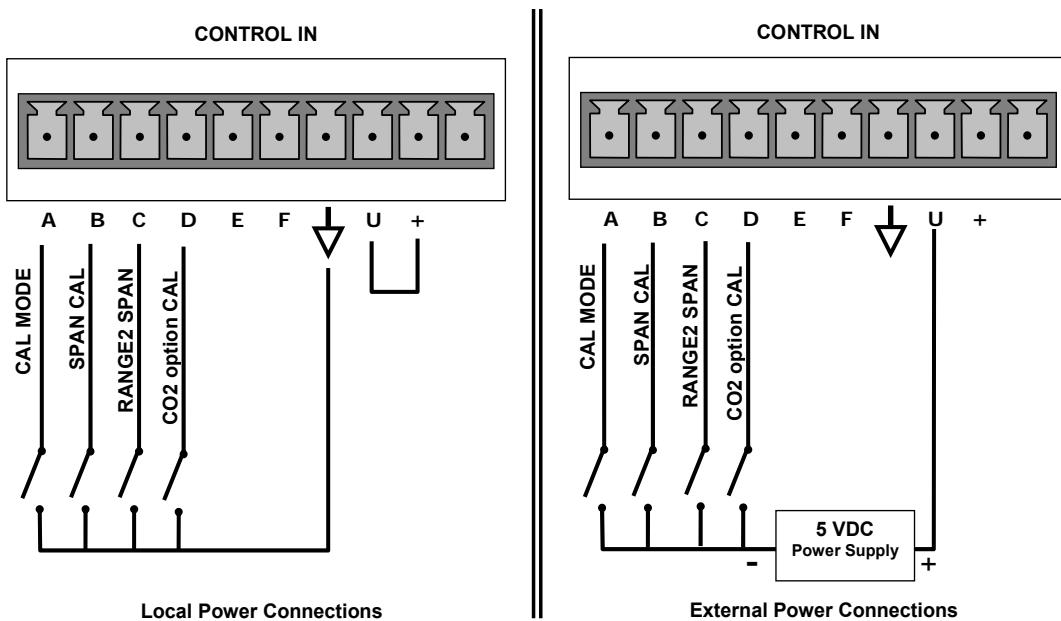


Figure 3-10: Control Input Connector

Table 3-7: Control Input Signals

Input #	Status Definition	ON Condition
A	CAL MODE	The analyzer is placed in Calibration mode. The mode field of the display will read O2 CAL R or O2 CAL ZR
B	REMOTE SPAN CAL	The analyzer is placed in span calibration mode as part of performing a low span (midpoint) calibration. The mode field of the display will read O2 CAL SR . If not active, it will be in ZERO MODE.
C	RANGE2 CAL	The analyzer is placed in span calibration mode as part of performing a High Span calibration.
D	CO2 CAL	ONLY available if the optional CO ₂ is installed. Initiates calibration of the CO ₂ sensor CO2 CAL R or CO2 CAL ZR
E & F	SPARE	
▽	Digital Ground	The ground level from the analyzer's internal DC power supplies (same as chassis ground)
U	External Power input	Input pin for +5 VDC required to activate Pins A – F.
+	5 VDC output	Internally generated 5V DC power. To activate inputs A – F, place a jumper between this pin and the "U" pin. The maximum amperage through this port is 300 mA (combined with the analog output supply, if used).

3.3.1.7. CONCENTRATION ALARM RELAY (OPTION 61)

The Teledyne API T-Series analyzers have an option for four (4) "dry contact" relays on the rear panel of the instrument. This relay option is different from and in addition to the "Contact Closures" that come standard on all TAPI instruments. The relays have three pins that have connections on the rear panel (refer Figure 3-11). They are a Common (C), a Normally Open (NO), and a Normally Closed (NC) pin.

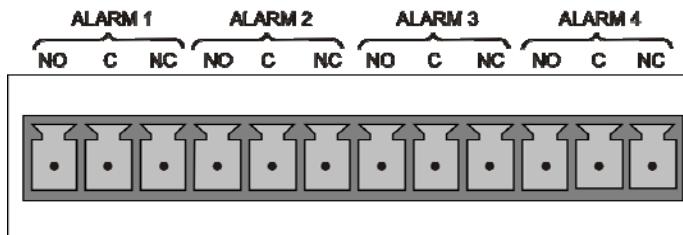


Figure 3-11: Concentration Alarm Relay

Alarm 1 "System OK 2"

Alarm 2 "Conc 1"

Alarm 3 "Conc 2"

Alarm 4 "Range Bit"

"ALARM 1" RELAY

Alarm 1 which is "System OK 2" (system OK 1, is the status bit) is in the energized state when the instrument is "OK" & there are no warnings. If there is a warning active or if the instrument is put into the "DIAG" mode, Alarm 1 will change states. This alarm has "reverse logic" meaning that if you put a meter across the Common & Normally Closed pins on the connector you will find that it is OPEN when the instrument is OK. This is so that if the instrument should turn off or lose power, it will change states & you can record this with a data logger or other recording device.

"ALARM 2" RELAY & "ALARM 3" RELAY

The "Alarm 2 Relay" on the rear panel, is associated with the "Concentration Alarm 1" set point in the software & the "Alarm 3 Relay" on the rear panel is associated with the "Concentration Alarm 2" set point in the software.

Alarm 2 Relay O₂ Alarm 1 = xxx %

Alarm 3 Relay O₂ Alarm 2 = xxx %

Alarm 2 Relay CO₂ Alarm 1 = xxx % (If CO₂ option is present)

Alarm 3 Relay CO₂ Alarm 2 = xxx % (If CO₂ option is present)

The Alarm 2 Relay will be turned on any time the concentration set-point is exceeded & will return to its normal state when the concentration value goes back below the concentration set-point.

Even though the relay on the rear panel is a NON-Latching alarm & resets when the concentration goes back below the alarm set point, the warning on the front panel of the instrument will remain latched until it is cleared. You can clear the warning on the front panel by either pushing the CLR button on the front panel or through the serial port.

The software for this instrument is flexible enough to allow you to configure the alarms so that you can have 2 alarm levels for each gas.

O₂ Alarm 1 = 20 %

O₂ Alarm 2 = 100 %

CO₂ Alarm 1 = 20 %

CO₂ Alarm 2 = 100 %

In this example, O₂ Alarm 1 & CO₂ Alarm 1 will both be associated with the “Alarm 2” relay on the rear panel. This allows you to have multiple alarm levels for individual gases.

A more likely configuration for this would be to put one gas on the “Alarm 1” relay & the other gas on the “Alarm 2” relay.

O₂ Alarm 1 = 20 %
O₂ Alarm 2 = Disabled
CO₂ Alarm 1 = Disabled
CO₂ Alarm 2 = 80 %

“ALARM 4” RELAY

This relay is connected to the “range bit”. If the instrument is configured for “Auto Range” & the instrument goes up into the high range, it will turn this relay on.

3.3.1.8. CONNECTING THE COMMUNICATION INTERFACES

The T-Series analyzers are equipped with connectors for remote communications interfaces: Ethernet, USB, RS-232, optional RS-232 Multidrop, and optional RS-485. In addition to using the appropriate cables (Table 1-1 describes the cable options, 60A through 60D), each type of communication method must be configured using the SETUP>COMM menu (Section 5.7).

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.

Configuration: Section 6.3

USB OPTION CONNECTION

For direct communication between the analyzer and a personal computer (PC), connect a USB cable between the analyzer and desktop or laptop USB ports. (If this option is installed, the COM2 port can only be used for RS232 multidrop communication). USB driver download is required.

Configuration: Section 6.4

RS-232 CONNECTION

For **RS-232** communications with data terminal equipment (**DTE**) or with data communication equipment (**DCE**) connect the applicable cable option (Table 1-1: either a DB9-female-to-DB25-male cable, Option 60A, or a DB9-female-to-DB9-female cable, Option 60B) from the analyzer’s rear panel RS-232 port to the device. Adjust the DCE-DTE switch (Figure 3-4) to select DTE or DCE as appropriate.

Configuration: Section 6.1 (and Section 6.5.2 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 before using.

Received from the factory, the analyzer is set up to emulate a DCE or modem, with Pin 3 of the DB-9 connector designated for receiving data and Pin 2 designated for sending data..

- **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

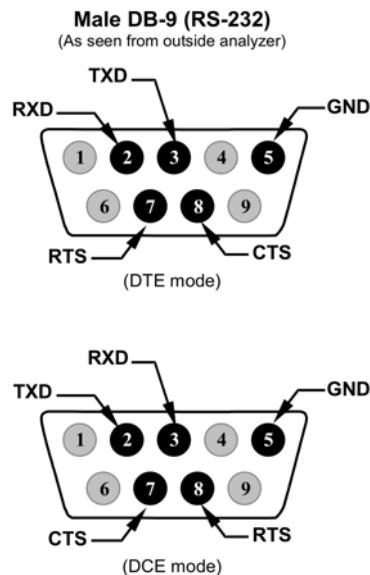


Figure 3-12: Default Pin Assignments, Rear Panel COM Port Connectors

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 3-12).

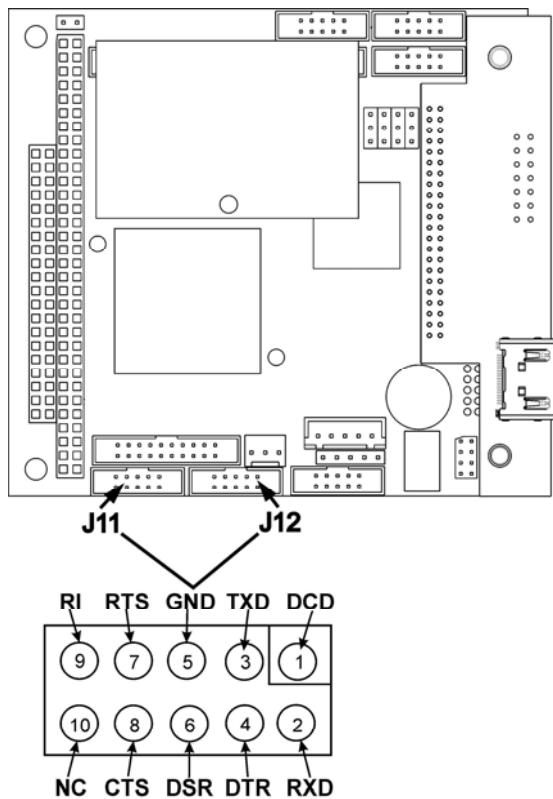


Figure 3-13. CPU Connector Pin-Outs for RS-232 Mode

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, use the small switch on the rear panel to switch it between DTE and DCE modes
- If both LEDs are still not illuminated, make sure the cable is properly constructed.

RS-232 MULTIDROP OPTION CONNECTION

When the RS-232 Multidrop option is installed, connection adjustments and configuration through the menu system are required. This section provides instructions for 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. Refer to Section 13 for more information on preventing ESD damage.

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 3-14. This shunt must be removed from all instruments except that designated as last in the multidrop chain, which must remain terminated. This requires powering off and opening each instrument and making the following adjustments:

1. With **NO power** to the instrument, remove its top cover and lay the rear panel open for access to the Multidrop/LVDS PCA, which is seated on the CPU.
2. On the Multidrop/LVDS PCA's JP2 connector, remove the shunt that jumpers Pins 21 ↔ 22 as indicated in Figure 3-14. (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 3-14):
 - J3 on the Multidrop/LVDS PCA to the CPU's COM1 connector
(Note that the CPU's COM2 connector is not used in Multidrop)
 - J4 on the Multidrop/LVDS PCA to J12 on the motherboard
 - J1 on the Multidrop/LVDS PCS to the front panel LCD

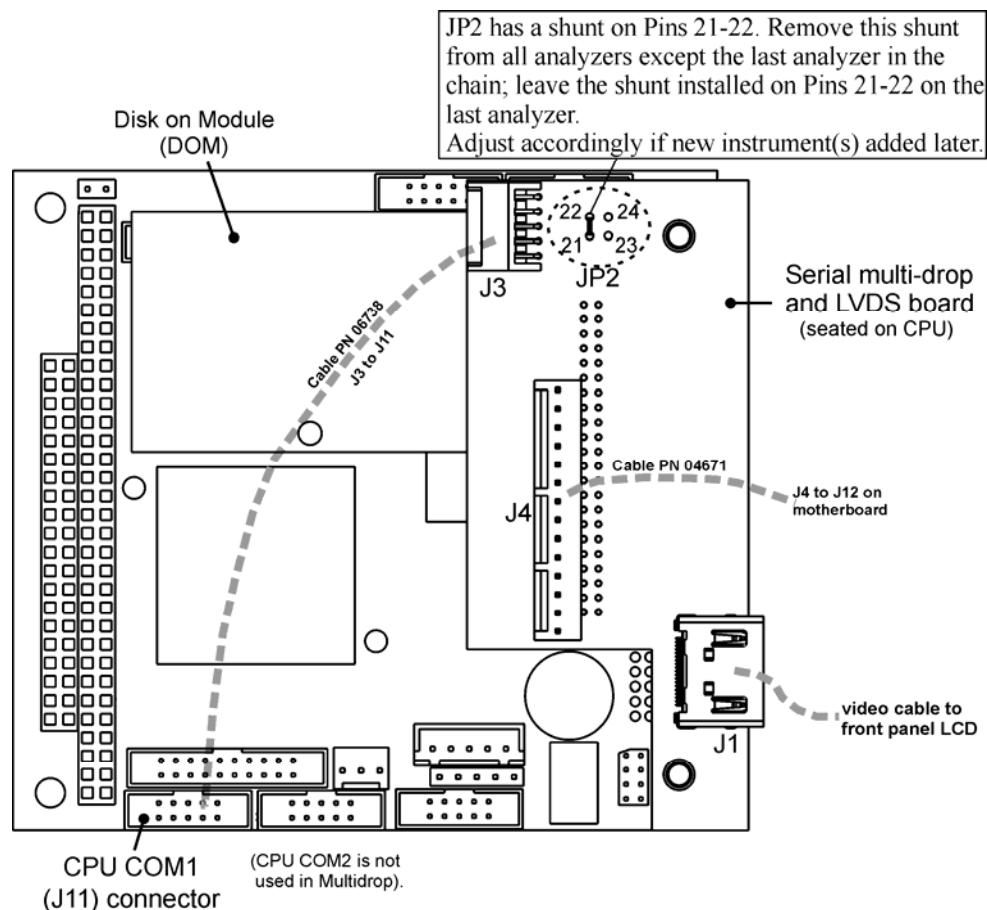


Figure 3-14: Jumper and Cables for Multidrop Mode

(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 3-15 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 Table 1-1, "Communication Cables" and the preceding subsection, "RS-232 Connection").

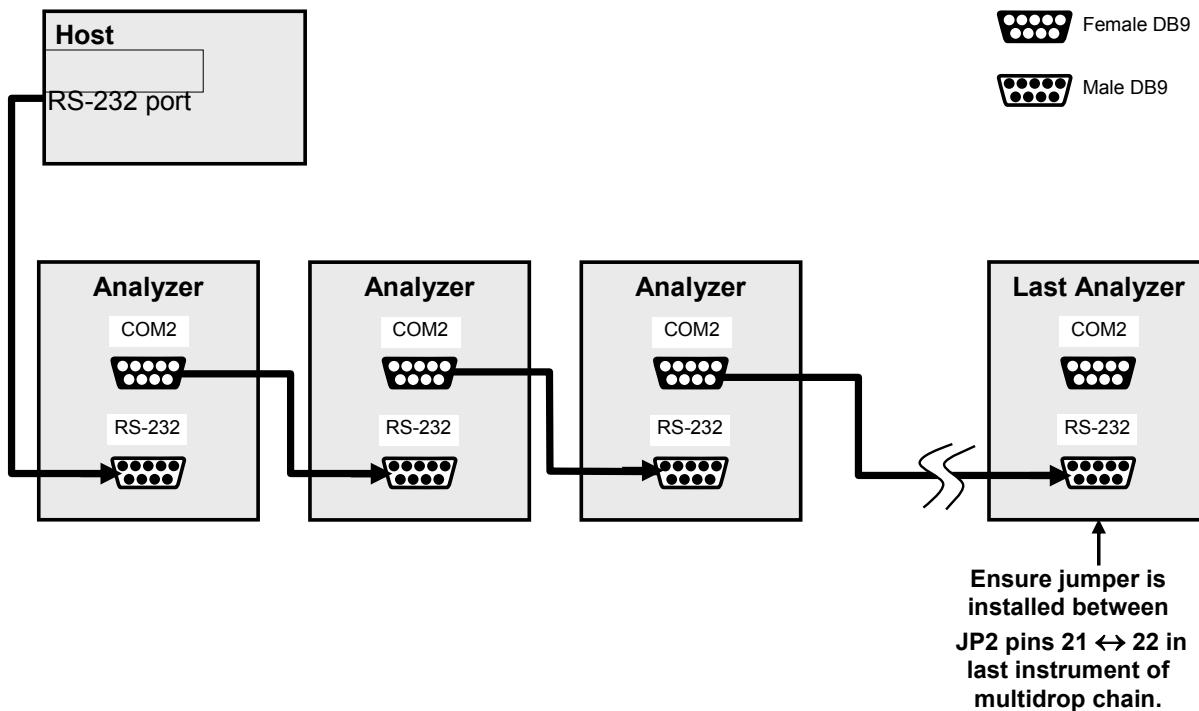


Figure 3-15: RS-232-Multidrop PCA Host/Analyzer Interconnect Diagram

7. BEFORE communicating from the host, power on the instruments and check that the Machine ID is unique for each (Section 5.7.16.5.2.9).
 - a. In the SETUP Mode menu go to SETUP>MORE>COMM>ID. The default ID is typically the model number or "0".
 - b. to change the identification number, press the button below the digit to be changed.
 - c. Press/select ENTER to accept the new ID for that instrument.
8. Next, in the SETUP>MORE>COMM>COM1 menu (do not use the COM2 menu for multidrop), edit the COM1 MODE parameter as follows: press/select EDIT and set only QUIET MODE, COMPUTER MODE, and MULTIDROP MODE to ON. Do not change any other settings.
9. Press/select ENTER to accept the changed settings, and ensure that COM1 MODE now shows 35.
10. Press/select SET> to go to the COM1 BAUD RATE menu and ensure it reads the same for all instruments (edit as needed so that all instruments are set at the same baud rate).

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.

Note

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

RS-485 CONNECTION

As delivered from the factory, **COM2** is configured for RS-232 communications. This port can be reconfigured for operation as a non-isolated, half-duplex RS-485 port. Using COM2 for RS-485 communication will disable the USB port. To reconfigure this port for RS-485 communication, please contact the factory.

3.3.2. PNEUMATIC CONNECTIONS

This section presents information about gases and pneumatic connections.

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.

3.3.2.1. CALIBRATION GASES

ZERO GAS

Zero gas is similar in chemical composition to the earth's atmosphere but scrubbed of all components that might affect the analyzers readings. Teledyne API recommends using pure N₂ when calibrating the zero point of your O₂ sensor.

CAUTION GENERAL SAFETY HAZARD



Rapid release of pure N₂ gas into an enclosed space can displace oxygen, and therefore represents an asphyxiation hazard. This may happen with few warning symptoms.

Do not vent calibration gases into enclosed areas.

3.3.2.2. SPAN GAS

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

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 (see Table 3-8).

Table 3-8: NISTSRMs Available for Traceability of O₂ Calibration Gases

NIST-SRM	Type	Nominal Concentration
2657a	O ₂ in N ₂	2%
2658a	O ₂ in N ₂	10%
2659a	O ₂ in N ₂	21%
2619a ¹	CO ₂ in N ₂	0.5%
2620a ¹	CO ₂ in N ₂	1%
2622a ¹	CO ₂ in N ₂	2%
2624a ¹	CO ₂ in N ₂	3%
2744b ¹	CO ₂ in N ₂	7%
2745 ¹	CO ₂ in N ₂	16%

¹ Used to calibrate optional CO₂ sensor.

3.3.2.3. INTERFERENTS

It should be noted that other gases also react to magnetic influences and will be detected by the T802's paramagnetic sensor. Usually this influence is extremely minor and can be disregarded; however, several gases, such as Nitrogen dioxide (NO₂) and Nitric oxide (NO), have strong enough paramagnetic properties to be of concern.

If the Sample Gas to be measured contains high levels of these gases, the gases used for both the zero point calibration and the span calibration should contain the same components in the same proportion in order to cancel any interference effects. Performing calibrations with O₂ mixed in N₂ in such applications, could induce significant errors into the O₂ measurements.

3.3.2.4. BASIC PNEUMATIC CONNECTIONS

See Figure 3-4 for the location and descriptions of the various pneumatic inlets/outlets referred to in this section.

See Section 3.3.2 for information regarding the pneumatic setup of T802 analyzer.

IMPORTANT

IMPACT ON READINGS OR DATA

Sample and calibration gases should only come into contact with Stainless Steel, PTFE (Teflon) tubing, glass or electroless nickel.

ATTENTION**COULD DAMAGE INSTRUMENT AND VOID WARRANTY**

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


CAUTION
GENERAL SAFETY HAZARD

The exhaust from the analyzer's internal or customer supplied external pump **MUST** be vented outside the immediate area or shelter surrounding the instrument.

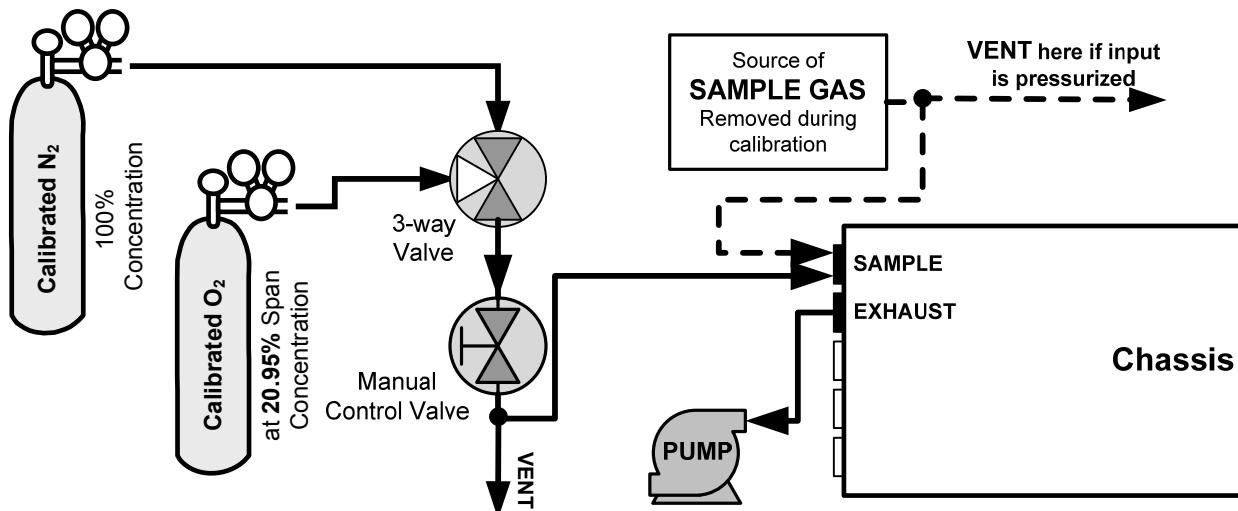


Figure 3-16: Pneumatic Connections—Basic Configuration—Using Bottled Span Gas

3.3.2.5. SAMPLE GAS SOURCE

Attach a sample inlet line to the SAMPLE inlet port. The SAMPLE input line should not be more than two (2) meters long.

- 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. Please refer to Figure 3-16.

3.3.2.6. CALIBRATION GAS SOURCES

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

Note

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

3.3.2.7. INPUT GAS VENTING

The span gas, zero air supply and sample gas line MUST be vented (Figure 3-16) for two reasons: in order to ensure that the gases input do not exceed the maximum inlet pressure of the analyzer, and to prevent back diffusion and pressure effects. These vents should be:

- At least 0.2m long
- No more than 2m long and
- Vented outside the shelter or immediate area surrounding the instrument

3.3.2.8. EXHAUST OUTLET

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

- PTEF tubing; minimum O.D 1/4"
- A maximum of 10 meters long
- Vented outside the T802 analyzer's enclosure, preferably outside the shelter or at least into a well-ventilated area.

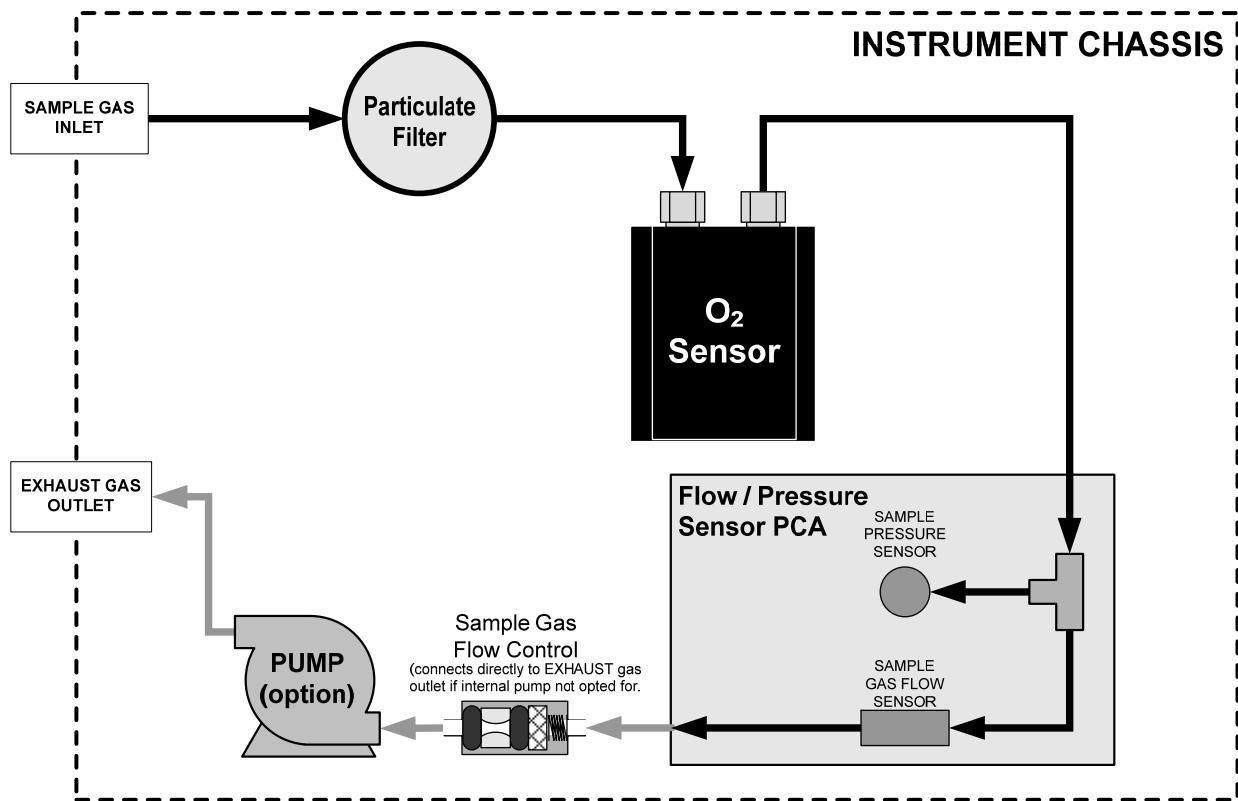


Figure 3-17: T802 Internal Gas Flow (Basic Configuration)

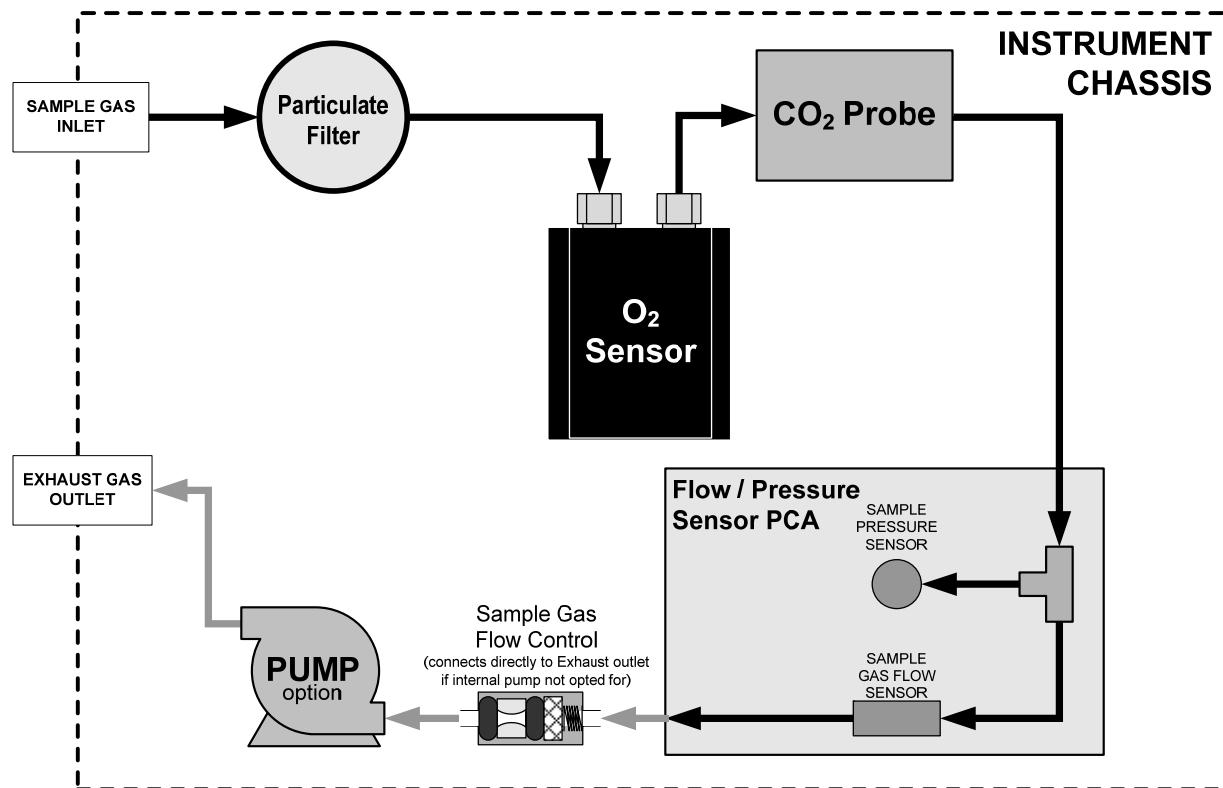


Figure 3-18: T802 – Internal Gas Flow with CO₂ Sensor Option

IMPORTANT

Leak Check:

Run a leak check once the appropriate pneumatic connections have been made; check all pneumatic fittings for leaks using the procedures defined in Section 10.3.3.

3.4. STARTUP, FUNCTIONAL CHECKS, AND INITIAL 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.

If you are unfamiliar with the theory of operation, we recommend that you read Section 12. For information on navigating the analyzer's software menus, see the menu trees described in Appendix A.1.

3.4.1. STARTUP

After the electrical and pneumatic connections are made, an initial functional check is in order. Turn on the instrument. The pump and exhaust fan should start immediately. The display will show a splash screen and other information during the initialization process while the CPU loads the operating systems, the firmware, and the configuration data.

The analyzer should automatically switch to Sample Mode after completing the boot-up sequence and start monitoring O₂ gas. However, there is a warm-up period of about 60 minutes before reliable gas measurements can be taken. During the warm-up period, the front panel display may behave as described in Table 3-9.

Table 3-9: Front Panel Display during System Warm-Up

FIELD	COLOR	BEHAVIOR	SIGNIFICANCE
Conc (Concentration)	N/A	Displays current, compensated H ₂ S concentration	This is normal operation, but deemed inaccurate during the warm-up period.
Mode	N/A	Displays blinking "SAMPLE"	Instrument is in sample mode but is still in the process of warming up.
Param (Parameters)	N/A	Displays menus, parameters, and messages.	Use any warning messages as a means of diagnosing problems.
STATUS LEDS			
Sample	Green	On	Unit is operating in sample mode; front panel display is being updated.
Cal	Yellow	Off	The instrument's calibration is not enabled.
Fault	Red	Blinking	The analyzer is warming up and hence out of specification for a fault-free reading. Various warning messages appear in the Param field.

3.4.1.1. WARNING MESSAGES

Because internal temperatures and other conditions may be outside the specified limits during the analyzer's warm-up period, the software will suppress most warning conditions for 30 minutes after power up. If warning messages persist after the 60-minute warm up period, investigate their cause using the troubleshooting guidelines in Section 11.

To view and clear warning messages, press:

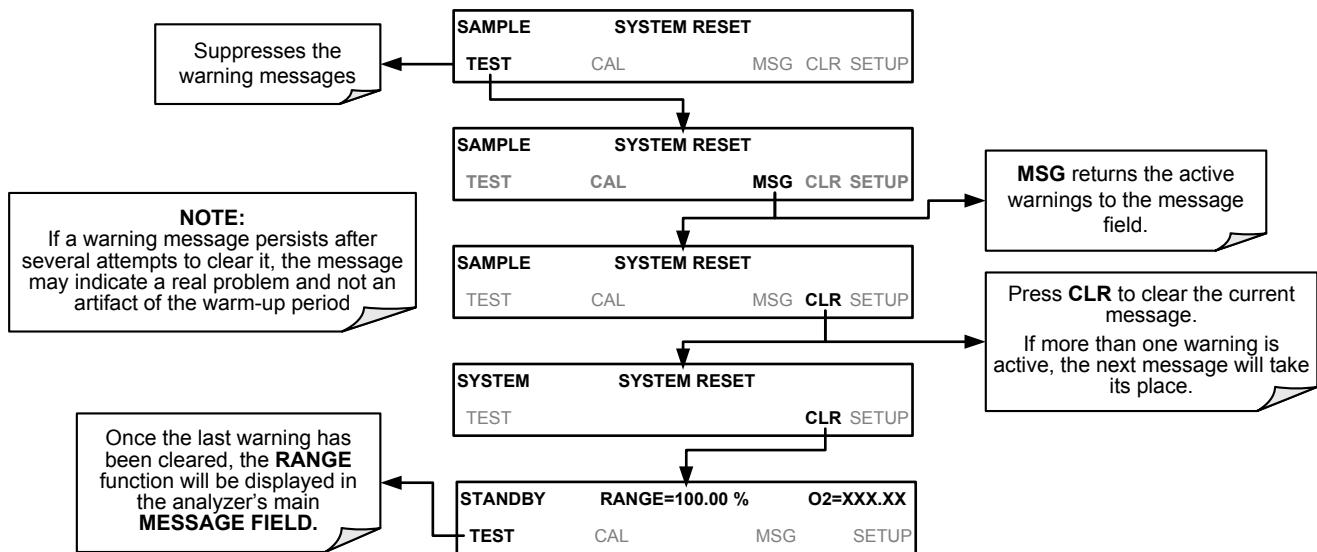


Figure 3-19: Viewing and Clearing T802 WARNING Messages

Table 3-10 lists brief descriptions of the warning messages that may occur during startup.

Table 3-10: Warning Messages

MESSAGE	MEANING
ANALOG CAL WARNING	The instrument's A/D circuitry or one of its analog outputs is not calibrated.
BOX TEMP WARN	The temperature inside the chassis is outside the specified limits.
CANNOT DYN SPAN³	Remote span calibration failed while the dynamic span feature was set to turned on
CANNOT DYN ZERO⁴	Remote zero calibration failed while the dynamic zero feature was set to turned on
CO₂ ALRM1 WARNING^{1,2}	Concentration alarm 1 is enabled and the measured CO ₂ level is \geq the set point.
CO₂ ALRM2 WARNING^{1,2}	Concentration alarm 2 is enabled and the measured CO ₂ level is \geq the set point.
CO₂ CELL TEMP WARN¹	CO ₂ sensor cell temperature outside of warning limits.
CONFIG INITIALIZED	Configuration storage was reset to factory configuration or erased.
DATA INITIALIZED	DAS data storage was erased.
O₂ ALRM1 WARNING²	Concentration alarm 1 is enabled and the measured O ₂ level is \geq the set point.
O₂ ALRM2 WARNING²	Concentration alarm 2 is enabled and the measured O ₂ level is \geq the set point.
O₂ CELL TEMP WARN	O ₂ sensor cell temperature outside of warning limits.
REAR BOARD NOT DET	The CPU is unable to communicate with the motherboard.
RELAY BOARD WARN	The firmware is unable to communicate with the relay board.
SAMPLE FLOW WARN	The flow rate of the sample gas is outside the specified limits.
SAMPLE PRESS WARN	Sample gas pressure outside of operational parameters.
SYSTEM RESET⁵	The analyzer was rebooted or the CPU was reset.

¹ Only enabled when the optional CO₂ Sensor is installed.

² Alarm warnings only present when optional concentration alarm relay package is installed.

³ Clears the next time successful span calibration is performed.

⁴ Clears the next time successful zero calibration is performed.

⁵ Does not clear after power up.

3.4.2. FUNCTIONAL CHECKS

After the analyzer's components have warmed up for at least 60 minutes, verify that the software properly supports any hardware options that were installed. For information on navigating through the analyzer's software menus, see the menu trees described in Appendix A.1.

Check to make sure that the analyzer is functioning within allowable operating parameters. Appendix C includes a list of test functions viewable from the analyzer's front panel as well as their expected values. These functions are also useful tools for diagnosing performance problems with your analyzer (see Section 11.1.2).

The enclosed Final Test and Validation Data Sheet (PN 068350000) lists these values before the instrument left the factory. Remember until the unit has completed its warm up these parameters may not have stabilized.

If your local area network (LAN) is running a dynamic host configuration protocol (DHCP) software package, the Ethernet will automatically configure its interface with your LAN. However, it is a good idea to check these settings to

make sure that the DHCP has successfully downloaded the appropriate network settings from your network server (see Section 6.3.1).

If your network is not running DHCP see your network administrator or configure the Ethernet interface manually (see Section 6.3.2).

3.4.3. INITIAL CALIBRATION

To perform the following calibration you must have sources for zero air and span gas available for input into the SAMPLE port on the back of the analyzer. See Section 3.3.2 for instructions for connecting these gas sources.

The initial calibration should be carried out using the same reporting range set up as used during the analyzer's factory calibration. This will allow you to compare your calibration results to the factory calibration as listed on the *Final Test and Validation Data Sheet*.

If both available DAS parameters for a specific gas type are being reported via the instrument's analog outputs e.g. **CONC1** and **CONC2** when the **DUAL** range mode is activated, separate calibrations should be carried out for each parameter.

- Use the **RNG1** button when calibrating for **CONC1** (equivalent to **LOW RANGE**).
- Use the **RNG2** button when calibrating for **CONC2** (equivalent to **HIGH RANGE**).

The calibration procedures assume:

- that the zero point and span gases have been adjusted for known interferents (Section 3.3.2.3)
- that the calibration gas will be supplied through the SAMPLE gas inlet on the back of the analyzer (see Figure 3-4), and;
- that the pneumatic setup matches that described in Section 3.3.2.4.

Perform the following outline of procedures for each sensor:

1. Verify the Reporting Range settings as presented in Section 3.4.3.1 While it is possible to perform the following procedure with any range setting we recommend that you perform this initial checkout using the following reporting range settings:
 - Mode Setting: **SNGL**
 - Analog Output Reporting Range: **20.95%** (default displays 100.00%)
2. If the Dilution Ratio Option is enabled on your T802, perform the Dilution Ratio set up as presented in Section 3.4.3.2.
3. Set the expected Span Gas Concentration for O₂ as presented in Section 3.4.3.3. This should be 80% of concentration range for which the analyzer's analog output range is set.
4. Perform the Zero/Span point calibration presented in Section 3.4.3.4.

The basic analyzer is now ready for operation. However, if your T802 is equipped with the optional CO₂ sensor, this sensor should be calibrated during installation

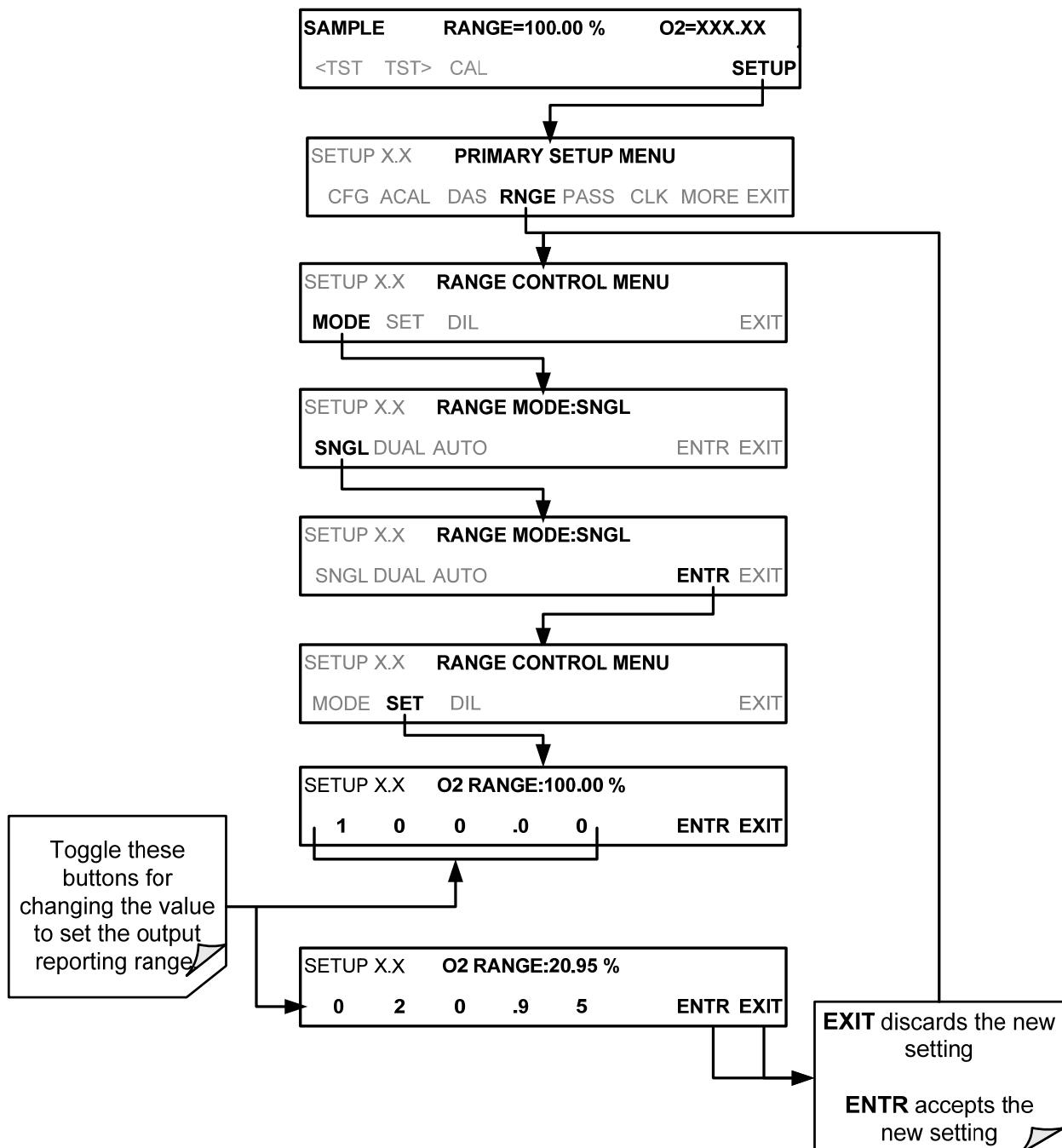
of the instrument to finish readying the analyzer for operation. See Section 9.5 for instructions.

Note

Once you have completed the above set-up procedures, please fill out the Quality Questionnaire that was shipped with your unit and return it to Teledyne API. This information is vital to our efforts in continuously improving our service and our products. THANK YOU.

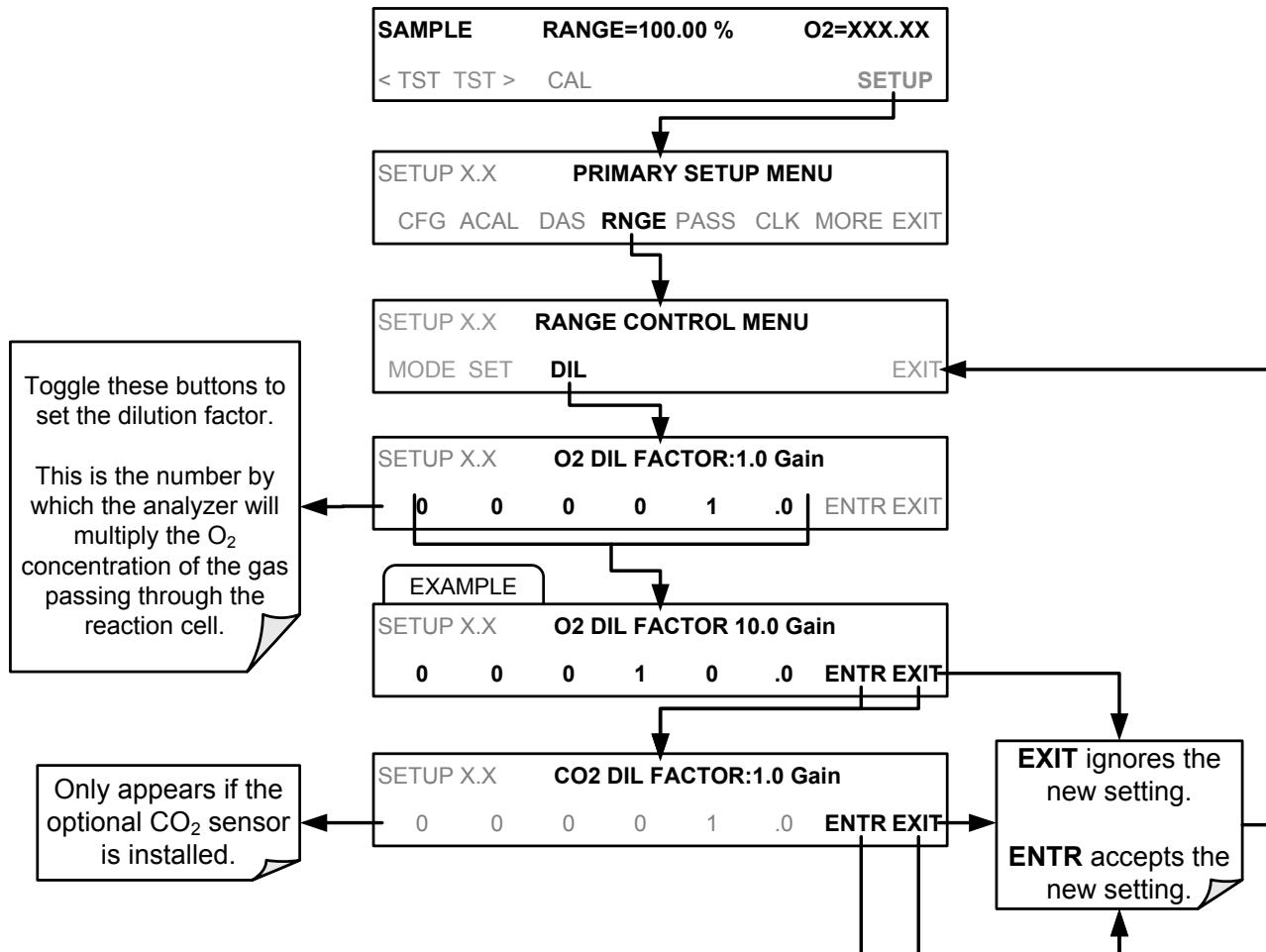
Verify/change these settings by pressing:

3.4.3.1. REPORTING RANGE SETTINGS



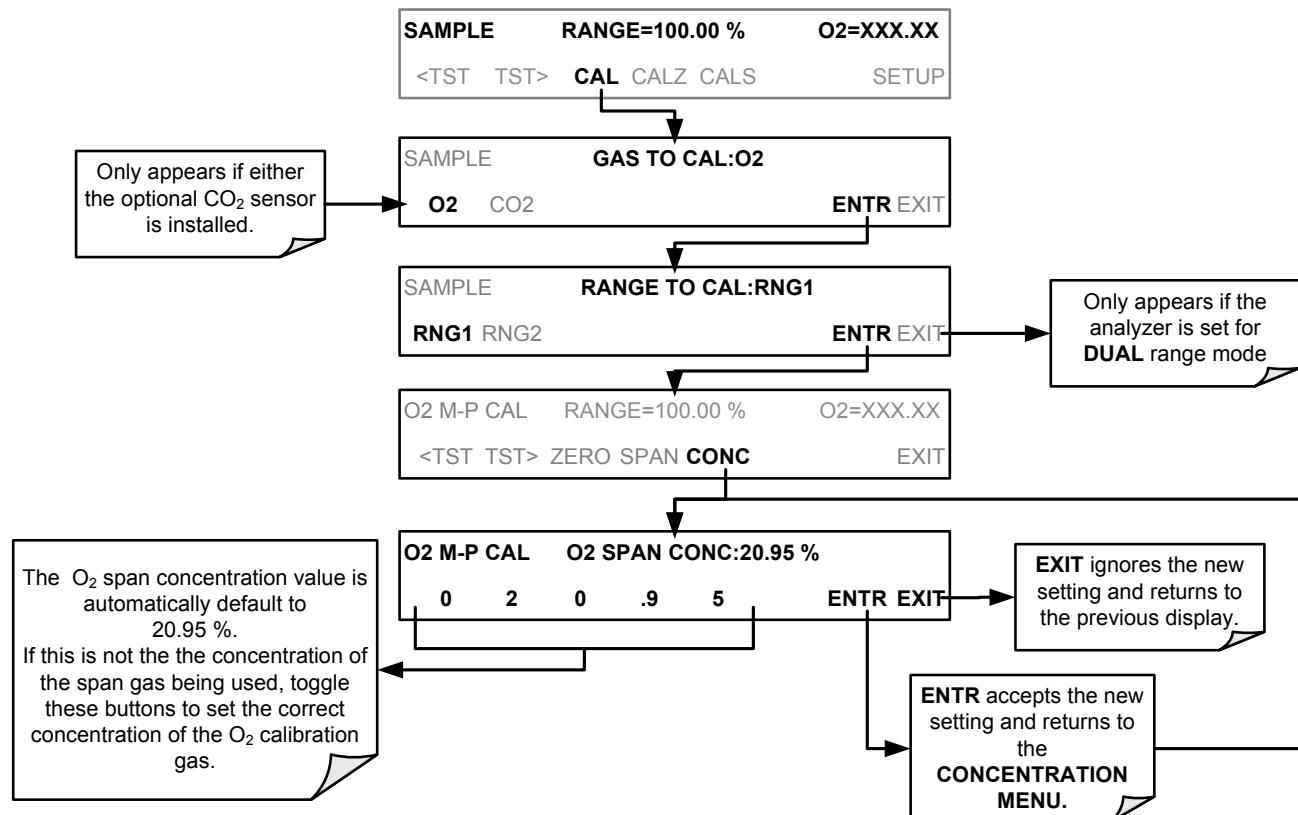
3.4.3.2. DILUTION RATIO (OPTION) SET UP

If the dilution ratio option is enabled on your T802 and your application involves diluting the sample gas before it enters the analyzer, set the dilution ratio as follows:



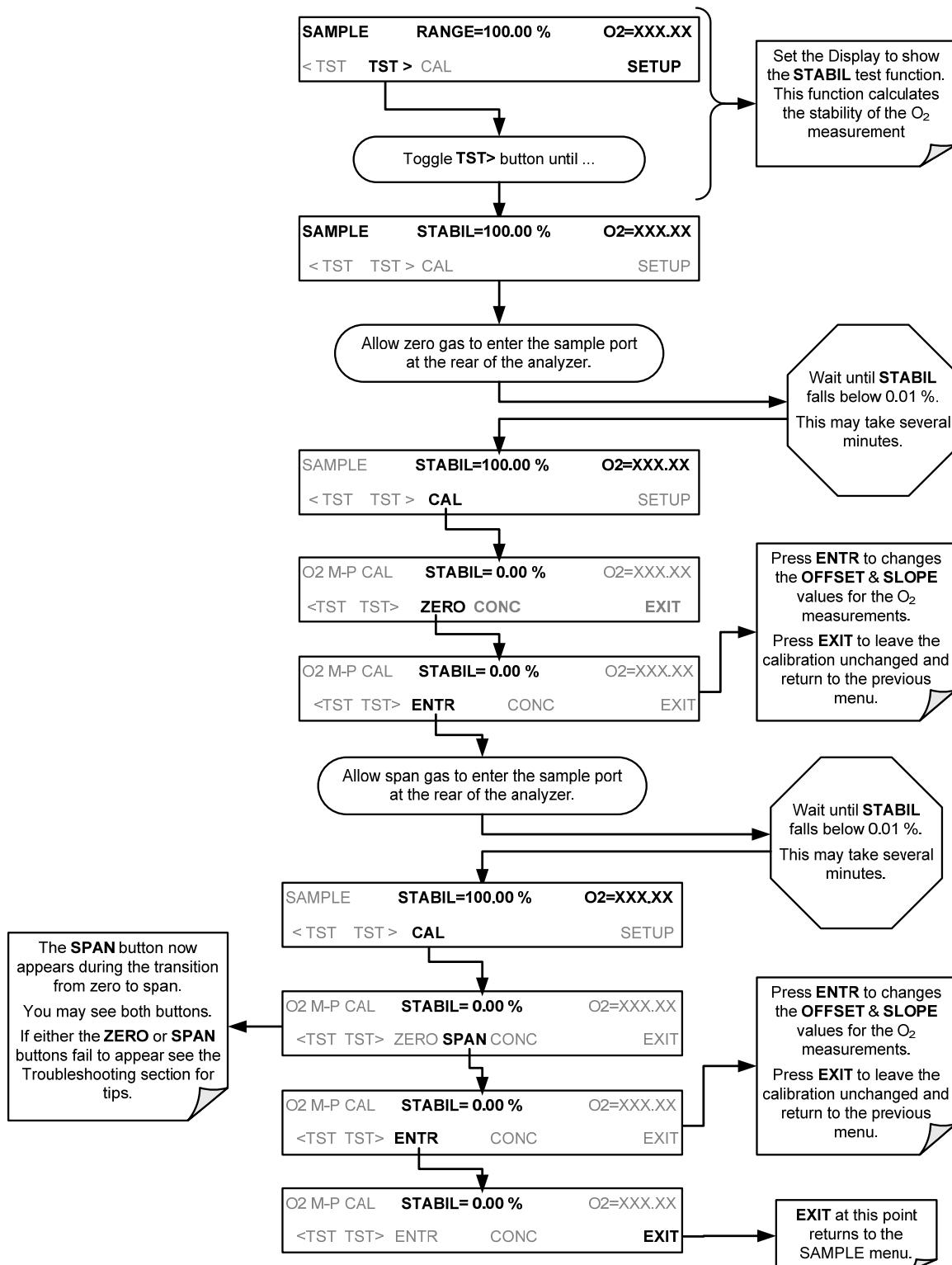
3.4.3.3. SET O₂ SPAN GAS CONCENTRATION

Set the expected O₂ span gas concentration. This should be 80% of concentration range for which the analyzer's analog output range is set.



3.4.3.4. ZERO/SPAN CALIBRATION

To perform the zero/span calibration procedure, press:



The CO₂ sensor assembly itself does not have any serviceable parts and is enclosed in an insulated canister.

SECTION II

OPERATING INSTRUCTIONS

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4. BASIC OPERATION

The T802 analyzer is a computer-controlled analyzer with a dynamic menu interface that allows all major operations to be controlled from the front panel touchscreen through these user-friendly menus. (A complete set of menu trees is located in Appendix A of this manual)

This section includes Step-by-Step instructions for using the display/touchscreen to set up and operate the analyzer's basic O₂ measurement features and functional modes.

4.1. OVERVIEW OF OPERATING MODES

The T802 software has a variety of operating modes. Most commonly, the analyzer will be operating in **Sample Mode**. In this mode a continuous read-out of the gas concentration is displayed on the front panel. SAMPLE mode is used to:

- perform calibrations
- run test functions
- read and clear warning messages
- output analog data (when enabled)

The next most commonly used operating mode is **SETUP** mode, which is used to:

- perform certain configuration operations, such as programming the DAS system or the configurable analog output channels
- set up the analyzer's serial communication channels (RS-232, RS-485, Ethernet)
- perform various diagnostic tests during troubleshooting



Figure 4-1: Front Panel Touchscreen and Display

The mode field of the front panel display indicates to the user which operating mode the unit is currently running.

In addition to **SAMPLE** and **SETUP**, other modes the analyzer can be operated in are:

Table 4-1: Analyzer Operating Modes

MODE	EXPLANATION
SAMPLE	Sampling normally, flashing text indicates adaptive filter is on.
SAMPLE A	Indicates that unit is in Sample Mode while AUTOCAL feature is active.
O2 M-P CAL	This is the basic calibration mode of the instrument and is activated by pressing the CAL key.
SETUP [X.X]	SETUP mode is being used to configure the analyzer. The gas measurement will continue during this process. The revision of the T802 firmware being run will appear after the word " SETUP ".
CAL O₂ Z[type]^{2 & 3}	Unit is performing O ₂ ZERO calibration procedure.
CAL O₂ S[type]^{2 & 3}	Unit is performing O ₂ SPAN calibration procedure
CAL CO₂ Z[type]^{2 & 3}	Unit is performing CO ₂ ZERO calibration procedure (when the optional CO ₂ sensor is installed).
CAL CO₂ S[type]^{2 & 3}	Unit is performing CO ₂ SPAN calibration procedure (when the optional CO ₂ sensor is installed).
DIAG Mode	One of the analyzer's diagnostic modes is active (Section 5.9).
[type:]	
² M: initiated manually by the user via the front panel touchscreen.	
³ R: initiated remotely through the COM ports or digital control inputs.	

4.2. SAMPLE MODE

This is the analyzer's standard operating mode. In this mode the instrument is analyzing the gas in the sample chamber, calculating O₂ concentration and reporting this information to the user via the front panel display, the analog outputs and, if set up properly, the RS-232/485/Ethernet ports.

A variety of **TEST** functions are available for viewing at the front panel whenever the analyzer is at the **MAIN MENU**. These functions provide information about the various functional parameters related to the analyzers operation and its measurement of gas concentrations. This information is particularly useful when troubleshooting a performance problem (see Section 11.1.2).

To view these **TEST** functions, press,

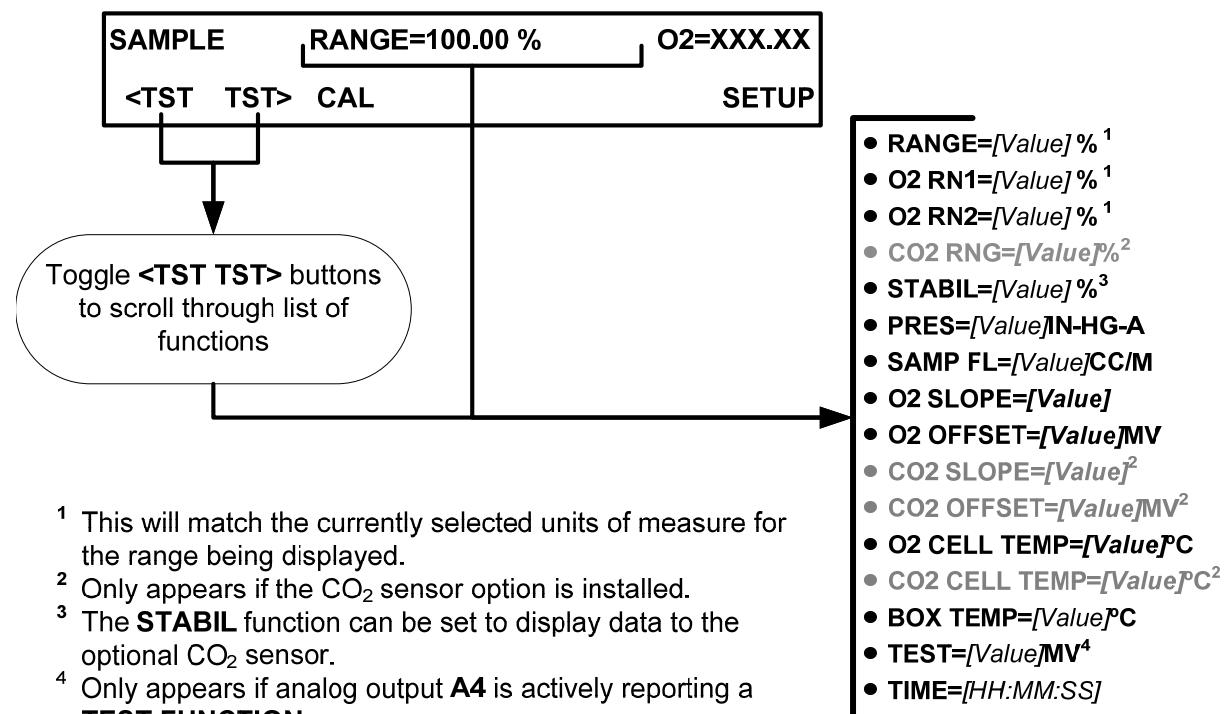


Figure 4-2: Viewing Test Functions

Note A value of "Warnings" displayed for any of the TEST functions indicates an out-of-range reading or the analyzer's inability to calculate it.

Note All pressure measurements are represented in terms of absolute pressure. Absolute, atmospheric pressure is 29.92 in-Hg-A at sea level. It decreases about 1 in-Hg per 300 m gain in altitude. A variety of factors such as air conditioning and passing storms can cause changes in the absolute atmospheric pressure.

Table 4-2: Test Functions Defined

PARAMETER	DISPLAY TITLE	UNITS	MEANING
Range	RANGE RANGE1 RANGE2	%	The full scale limit at which the reporting range of the analyzer is currently set. THIS IS NOT the Physical Range of the instrument. See Section 5.4.1 for more information.
CO ₂ Range ¹	CO2 RANGE	%	The range setting for the optional CO ₂ Sensor
Stability	STABIL	%	Standard deviation of O ₂ concentration readings. Data points are recorded every ten seconds using the last 25 data points. This function can be reset to show O ₂ or CO ₂ stability in instruments with those sensor options installed.
Sample Pressure	PRES	In-Hg-A	The absolute pressure of the Sample gas as measured by a pressure sensor located inside the sample chamber.
Sample Flow	SAMPLE FL	cm ³ /min	Sample mass flow rate as measured by the flow rate sensor in the sample gas stream.
O ₂ Sensor Slope	O2 SLOPE	-	O ₂ slope, computed during zero/span calibration.
O ₂ Sensor Offset	O2 OFFSET	-	O ₂ offset, computed during zero/span calibration.
Box Temperature	BOX TEMP	°C	The temperature inside the analyzer chassis.
O ₂ Cell Temperature	O2 CELL TEMP	°C	The current temperature of the O ₂ sensor measurement cell.
CO ₂ Cell Temperature ¹	CO2 CELL TEMP	°C	The current temperature of the CO ₂ sensor measurement cell.
CO ₂ Sensor Slope ¹	CO2 SLOPE	-	CO ₂ slope, computed during zero/span calibration.
CO ₂ Sensor Offset ¹	CO2 OFFSET	-	CO ₂ offset, computed during zero/span calibration.
Current Time	TIME	-	The current time. This is used to create a time stamp on DAS readings, and by the AUTOCAL feature to trigger calibration events.

¹ Only appears when the optional CO₂ sensor is installed.

4.3. CALIBRATION MODE

The T802 will switch into calibration mode when the user touches the CAL button. In this mode the user can, in conjunction with introducing zero or span gases of known concentrations into the analyzer, cause it to adjust and recalculate the slope (gain) and offset of its measurement range. This mode is also used to check the current calibration status of the instrument.

For more information about setting up and performing standard calibration operations or checks, see Section 9, Calibration Procedures.

Note

It is recommended that span calibration be performed at 80% of full scale of the analyzer's currently selected reporting range.

EXAMPLES:

If the reporting range is set for 0 to 50%, an appropriate span point would be 40%.

If the reporting range is set for 0 to 100%, an appropriate span point would be 80%.

4.4. SETUP MODE

The **SETUP** mode contains a variety of choices that are used to configure the analyzer's hardware and software features, perform diagnostic procedures, gather information on the instrument's performance and configure or access data from the internal data acquisition system (DAS). **SETUP** mode has a Primary and a Secondary setup menu.

Note	Any changes made to a variable during one of the SETUP procedures are not acknowledged by the instrument until the ENTR button is pressed. If the EXIT button is pressed before the ENTR button, the analyzer will beep to notify the user that the newly entered value has been lost.
	Setup Mode can be protected by password security through the SETUP>PASS menu (Section 5.5) to prevent unauthorized or inadvertent configuration adjustments.

4.4.1. PRIMARY SETUP MENU

For a visual representation of the software menu trees, refer to Appendix A-1.

The areas accessible under the **SETUP** mode are shown below:

Table 6-4: Primary Setup Mode Features and Functions

MODE OR FEATURE	MENU ITEM	DESCRIPTION	MANUAL SECTION
Analyzer Configuration	CFG	Lists key hardware and software configuration information	5.1
Auto Cal Feature	ACAL	(Special configuration; consult factory).	11.9
Internal Data Acquisition	DAS	Used to set up the DAS system and view recorded data	7
Analog Output Reporting Range Configuration	RNGE	Used to configure the output signals generated by the instruments Analog outputs.	5.4
Calibration Password Security	PASS	Turns the calibration password feature ON/OFF	5.5
Internal Clock Configuration	CLK	Used to Set or adjust the instrument's internal clock	5.6
Advanced SETUP features	MORE	This button accesses the instrument's secondary setup menu	See Table 6-5

4.4.2. SECONDARY SETUP MENU (SETUP>MORE)

Table 6-5: Secondary Setup Mode Features and Functions

MODE OR FEATURE	MENU ITEM	DESCRIPTION	MANUAL SECTION
External Communication Channel Configuration	COM	Used to set up and operate the analyzer's various external I/O channels including RS-232, RS-485, modem communication and/or Ethernet access.	5.7
System Status Variables	VARS	Used to view various variables related to the instruments current operational status <ul style="list-style-type: none"> Changes made to any variable will not be recorded in the instrument's memory until the ENTR key is pressed. Pressing the EXIT key ignores the new setting. 	5.8
System Diagnostic Features and Analog Output Configuration	DIAG	Used to access a variety of functions that configure, test or diagnose problems with a variety of the analyzer's basic systems. Most notably, the menus to configure the output signals generated by the instruments Analog outputs, are located here.	5.9
Alarm Limit Configuration ¹	ALRM	Used to turn the instrument's two alarms on and off as well as set the trigger limits for each.	5.10

¹ Alarm warnings only present when optional concentration alarm relay package is installed.

5. SETUP MENU

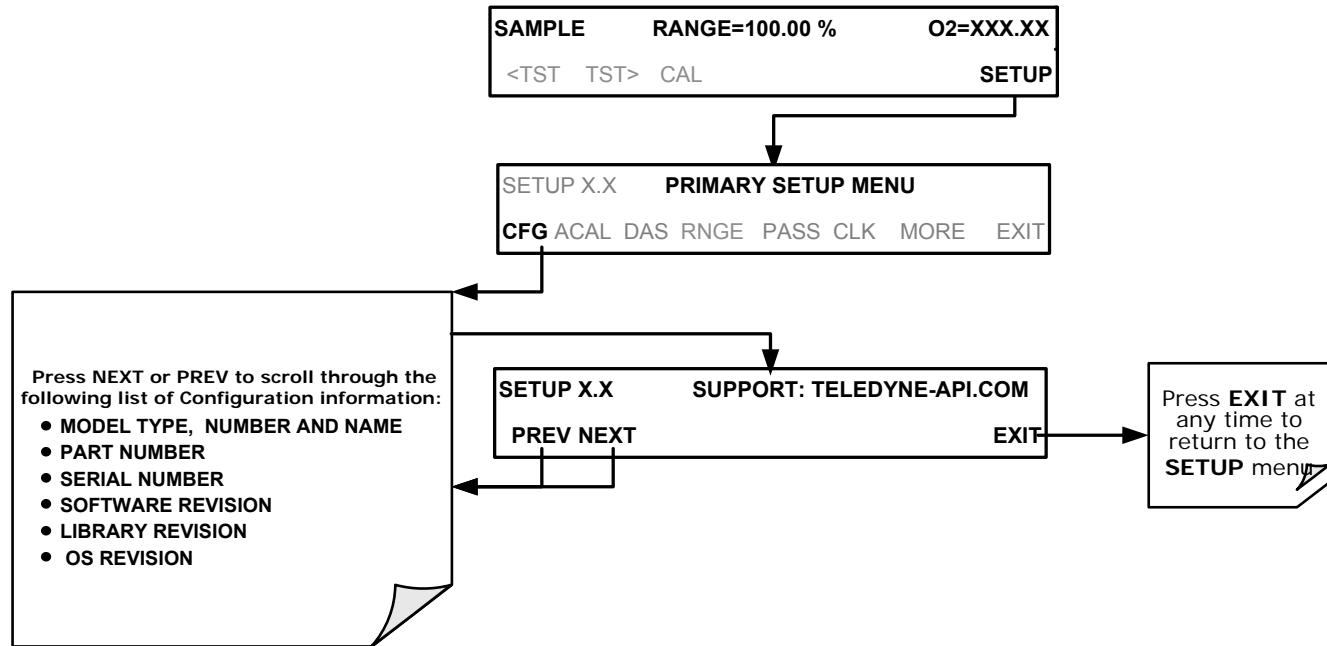
The SETUP menu is used to set instrument parameters for performing configuration, calibration, reporting and diagnostics operations.

5.1. SETUP → CFG: CONFIGURATION INFORMATION

Pressing the **CFG** key displays the instrument's configuration information. This display lists the analyzer model, serial number, firmware revision, software library revision, CPU type and other information.

- Special instrument or software features or installed options may also be listed here.
- Use this information to identify the software and hardware installed in your T802 analyzer when contacting Technical Support.

To access the configuration table, press:



5.2. SETUP → ACAL: [NOT USED]

ACAL on the primary SETUP menu is a special configuration. Contact factory.

5.3. SETUP → DAS: INTERNAL DATA ACQUISITION SYSTEM

Use the SETUP>DAS menu to capture and record data. Refer to Section 7 for configuration and operation details.

5.4. SETUP → RANGE: ANALOG OUTPUT REPORTING RANGE CONFIGURATION

5.4.1. PHYSICAL RANGE VERSUS ANALOG OUTPUT REPORTING RANGES

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.

Note

Both the DAS values stored in the CPU's memory and the concentration values reported on the front panel are unaffected by the settings chosen for the reporting range(s) of the instrument.

5.4.2. ANALOG OUTPUT RANGES FOR O₂ CONCENTRATION

The analyzer has several active analog output signals accessible through a connector on the rear panel (see Figure 3-4).

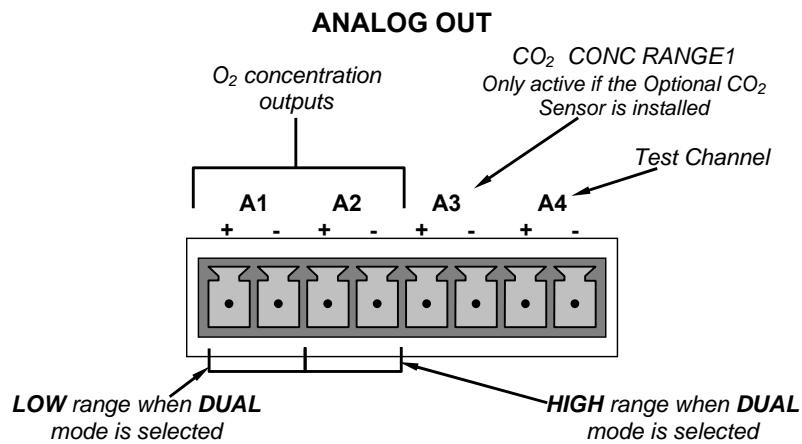


Figure 5-1: Analog Output Connector Pin Out

All three outputs can be configured either at the factory or by the user for full scale outputs of 0.1 VDC, 1VDC, 5VDC or 10VDC.

Additionally **A1** and **A2** may be equipped with optional 0-20 mA current loop drivers and configured for any current output within that range (e.g. 0-20, 2-20, 4-20, etc.). The user may also adjust the signal level and scaling of the actual output voltage or current to match the input requirements of the recorder or data logger (See Section 5.9.5).

The **A1** and **A2** channels output a signal that is proportional to the O₂ concentration of the sample gas. Several modes are available which allow them to operate independently or be slaved together (See Section 5.4.3).

EXAMPLE:

A1 OUTPUT: Output Signal = 0-5 VDC representing 0-100 % concentration values

A2 OUTPUT: Output Signal = 0 – 10 VDC representing 0-22 % concentration values.

Output **A3** is only active if the CO₂ sensor option is installed. In this case a signal representing the currently measured CO₂ concentration is output on this channel.

The output, labeled **A4** is special. It can be set by the user (See Section 5.9.6) to output several of the test functions accessible via the <TST TST> menu buttons.

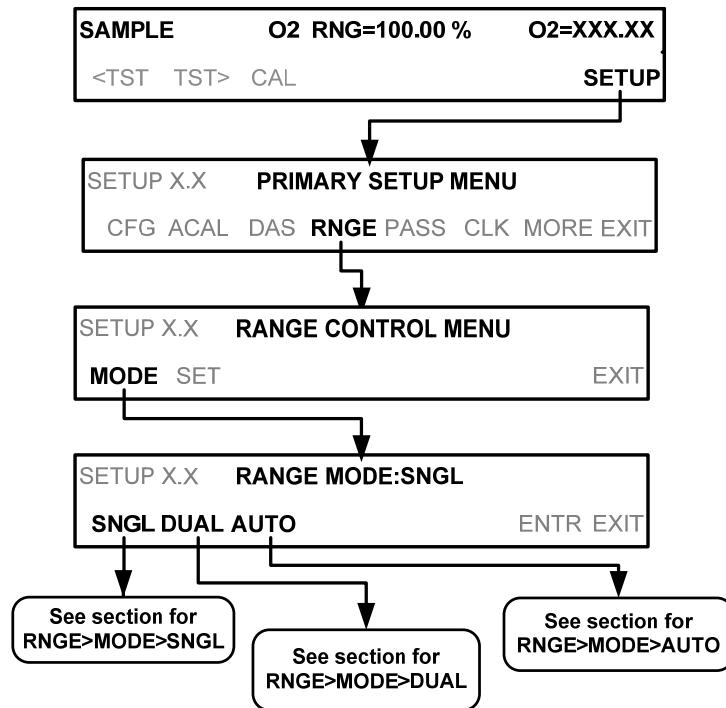
5.4.3. REPORTING RANGE MODES

The T802 provides three analog output range modes to choose from.

- Single range (SNGL) mode sets a single maximum range for the analog output. If single range is selected both outputs are slaved together and will represent the same measurement span (e.g. 0-20 %), however their electronic signal levels may be configured for different ranges (e.g. 0-10 VDC vs. 0.1 VDC).
- Dual range (DUAL) allows the A1 and A2 outputs to be configured with different measurement spans as well as separate electronic signal levels.
- Auto range (AUTO) mode gives the analyzer the ability to output data via a low range and high range. When this mode is selected the analyzer will automatically switch between the two ranges dynamically as the concentration value fluctuates.

Range status is also output via the external digital I/O status outputs (See Section 3.3.1.5).

To select the Analog Output Range Type press:



Upper span limit setting for the individual range modes are shared. Resetting the span limit in one mode also resets the span limit for the corresponding range in the other modes as follows:

<u>SNGL</u>	↔	<u>DUAL</u>	↔	<u>AUTO</u>
Range		Range1	↔	Low Range
		Range2	↔	High Range

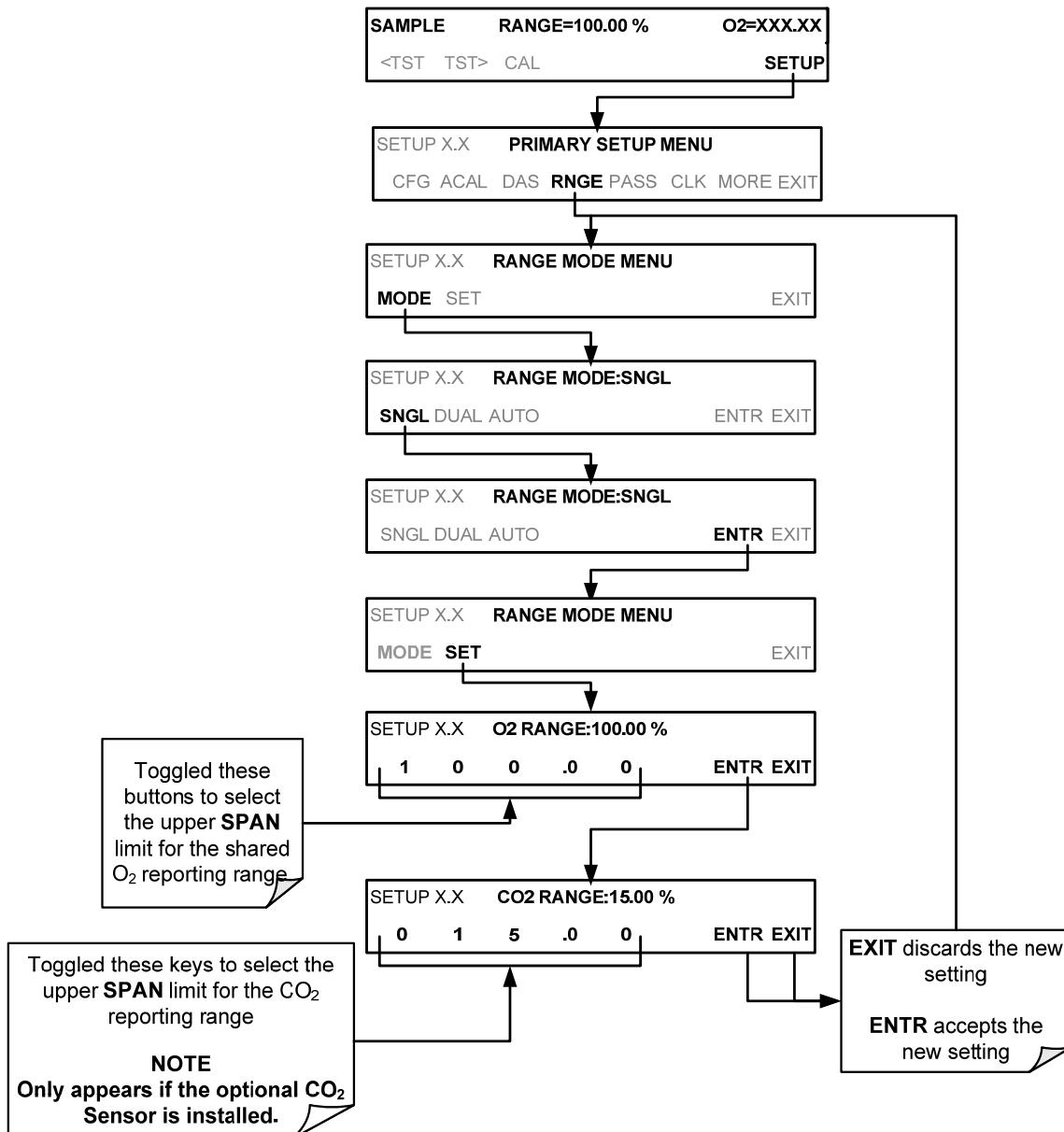
5.4.3.1. R^{NGE} → M^{ODE} → S^{NGL}: CONFIGURING THE T802 ANALYZER FOR SINGLE RANGE MODE

Single Range Mode (S^{NGL}) is the default reporting range mode for the analyzer.

When the single range mode is selected (S^{NGL}), all analog O₂ concentration outputs (**A1 and A2**) are slaved together and set to the same reporting range limits (e.g. 0- 22.00 %). The span limit of this reporting range can be set to any value within the physical range of the analyzer.

Although both outputs share the same concentration reporting range, the electronic signal ranges of the analog outputs may still be configured for different values (e.g. 0-5 VDC, 0-10 VDC, etc; see Section 5.9.3.1)

To select S^{NGL} range mode and to set the upper limit of the range, press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

5.4.3.2. RANGE → MODE → DUAL: CONFIGURING THE T802 ANALYZER FOR DUAL RANGE MODE

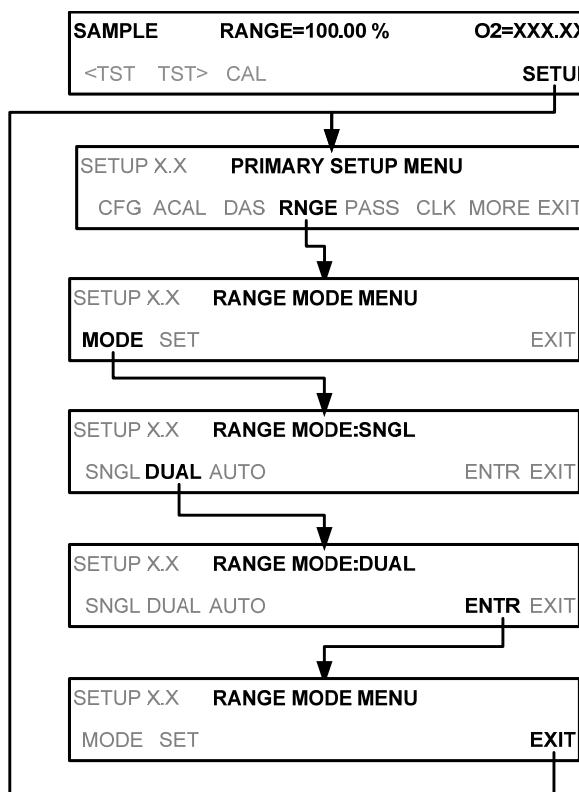
Selecting the **DUAL** range mode allows the **A1** and **A2** outputs to be configured with different reporting ranges. The analyzer software calls these two ranges **RNG1** (low) and **RNG2** (high).

- The O2L RANGE 1 setting corresponds with the analog output labeled A1 on the rear panel of the instrument.
- The O2H RANGE 2 setting corresponds with the A2 output.

In **DUAL** range mode the **RANGE** test function displayed on the front panel will be replaced by two separate functions:

- O2 RN1: The range setting for the A1 output.
- O2 rn2: The range setting for the A2 output.

To select the **DUAL** range mode press following keystroke sequence



When the instrument's range mode is set to Dual the concentration field in the upper right hand corner of the display alternates between displaying the low range value and the high range value. The concentration that would be displayed, is identified as follows: **"O2L"** = **LOW** (or **A1**) and **"O2H"** = **HIGH** (or **A2**).

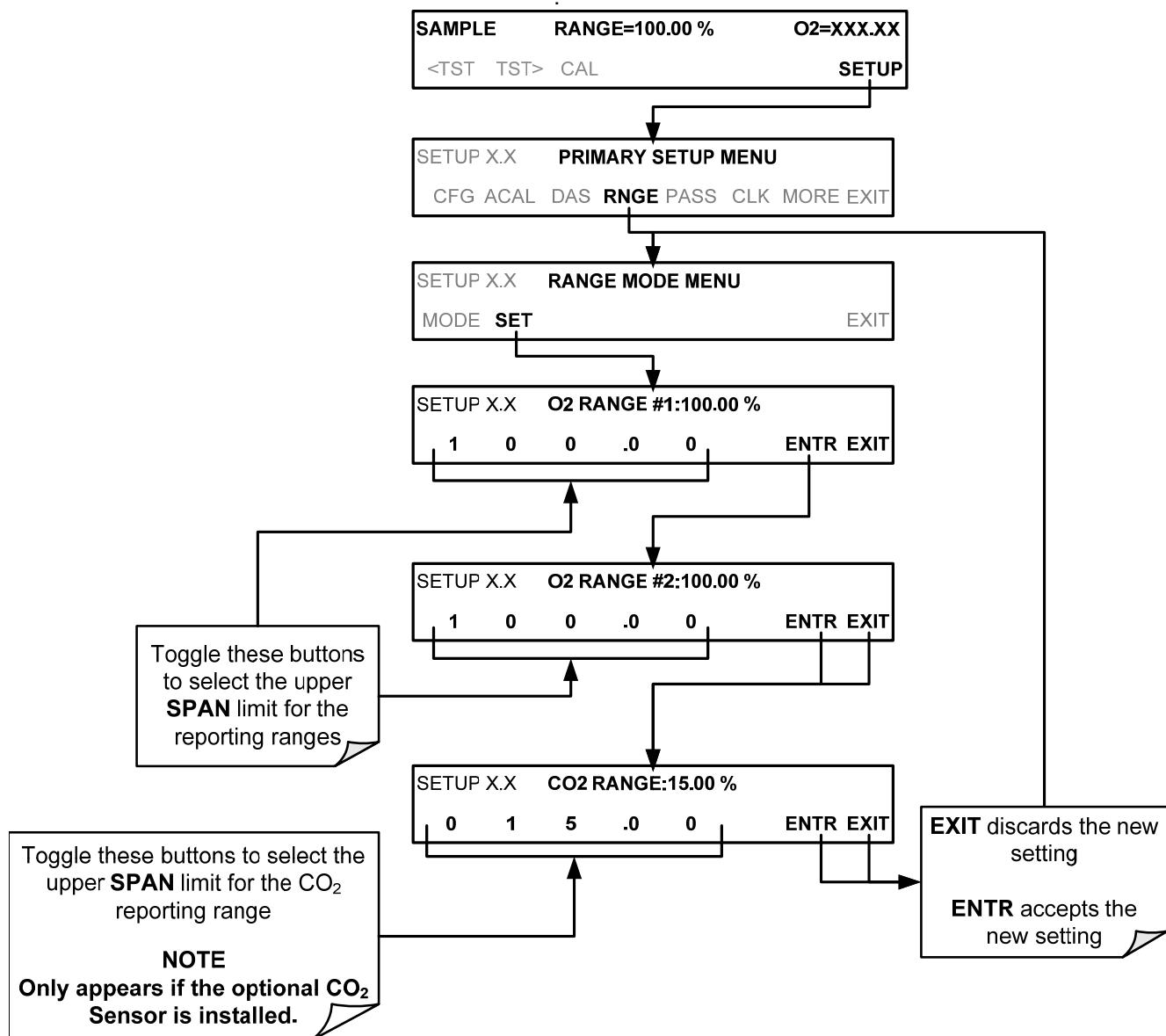
Note

In DUAL range mode O2L and O2H have separate slopes and offsets for computing O₂ concentrations. The two ranges must be independently calibrated.

Note

If the optional CO₂ sensor is installed, the concentration field of the T802's display will report a value labeled, "CO₂ RANGE:". Only one test function is available (CO₂ RNG) which reflects the range setting for C2L and only this value is reported via the analyzer's Analog Outputs (Output A3).

To set the upper range limit for each independent reporting range, press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

5.4.3.3. **RNGE → MODE → AUTO: CONFIGURING THE T802 ANALYZER FOR AUTO RANGE MODE**

In **AUTO** range mode, the analyzer automatically switches the reporting range between two user-defined ranges (low and high).

- The unit will switch from low range to high range when the O₂ concentration exceeds 98% of the low range span.
- The unit will return from high range back to low range once the O₂ concentration falls below 75% of the low range span.

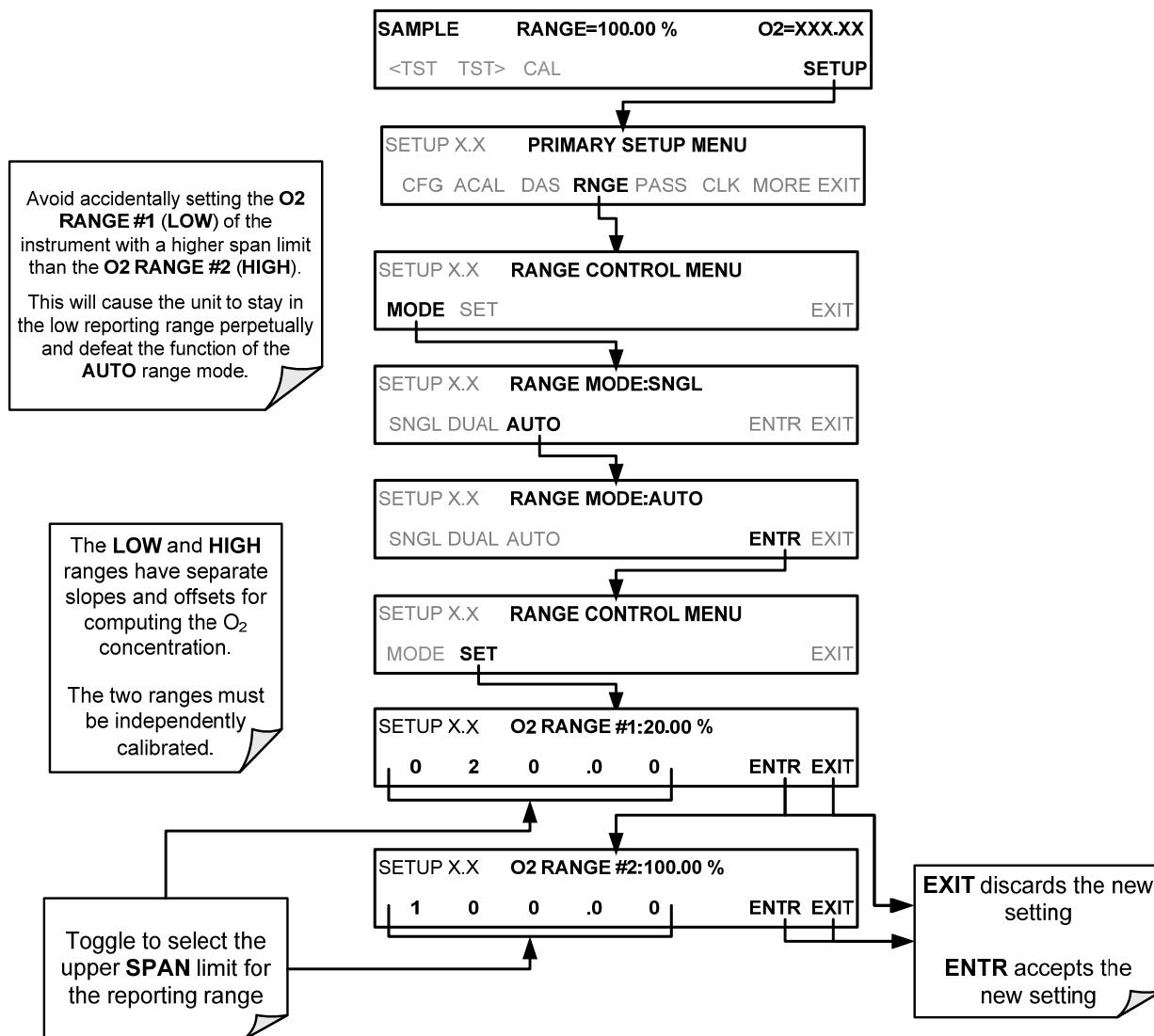
In **AUTO** Range mode the instrument reports the same data in the same range on both the **A1** and **A2** outputs and automatically switches both outputs between ranges as described above.

Also the **RANGE** test function displayed on the front panel will be replaced by two separate functions:

- **O2 RNG1:** The **LOW** range setting for all analog outputs.
- **O2 RNG2:** The **HIGH** range setting for all analog outputs.

The high/low range status is also reported through the external, digital status bits (See Section 3.3.1.5).

To set individual ranges press the following keystroke sequence.



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

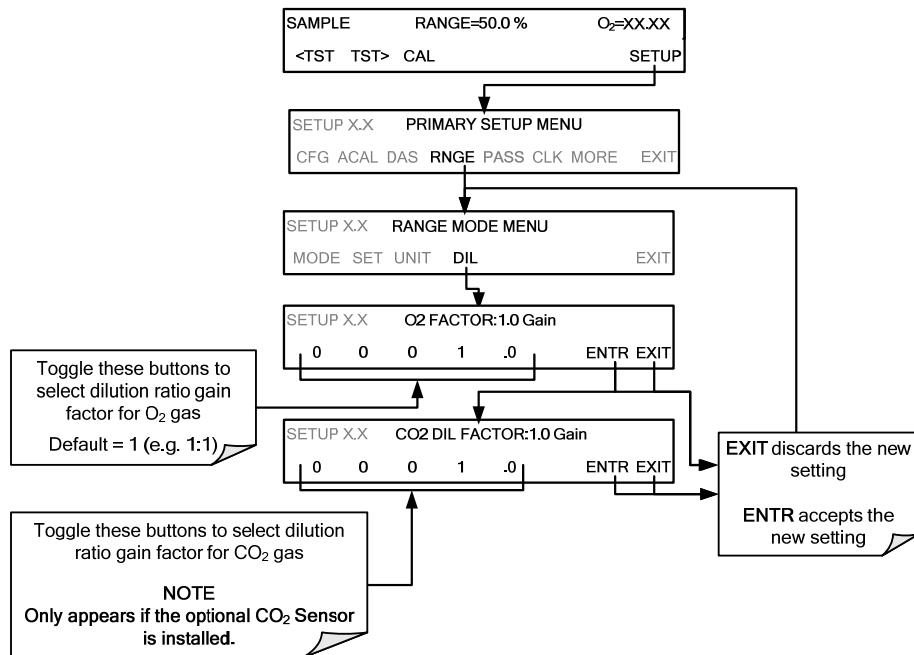
5.4.4. SETUP →RNGE → DIL: USING THE OPTIONAL DILUTION RATIO FEATURE

This feature is a optional software utility that allows the user to compensate for any dilution of the sample gas that may occur before it enters the sample inlet. Typically this occurs in continuous emission monitoring (CEM) applications where the sampling method used to remove the gas from the stack, dilutes the sample.

To set up and use the dilution ratio option:

1. In the DIAG menu, use the 929 password and navigate to Factory Options and enable the Dilution Ratio feature. (Press ENTER to save setting, and then return to SETUP menu).
2. Select the reporting range mode and set the reporting range upper limit (see Section 5.4.3).

3. Ensure that the upper span limit entered for the reporting range is the maximum expected concentration of the non-diluted gas.
4. Set the dilution factor as a gain (e.g., a value of 20 means 20 parts diluent and 1 part of sample gas):



5. Calibrate the analyzer.

- Make sure that the calibration span gas is either supplied through the same dilution system as the sample gas or has an appropriately lower actual concentration.

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

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

5.5. SETUP → PASS: PASSWORD FEATURE

The menu system provides password protection of the calibration and setup functions to prevent unauthorized adjustments. When the passwords have been enabled in the PASS menu item, the system will prompt the user for a password anytime a password-protected function (e.g., SETUP) is selected. This allows normal operation of the instrument, but requires the password (101) to access to the menus under SETUP. When PASSWORD is disabled (SETUP>PASS>OFF), any operator can enter the Primary Setup (SETUP) and Secondary Setup (SETUP>MORE) menus. Whether PASSWORD is enabled or disabled, a

password (default 818) is required to enter the VARS or DIAG menus in the SETUP>MORE menu.

Table 5-1: Password Levels

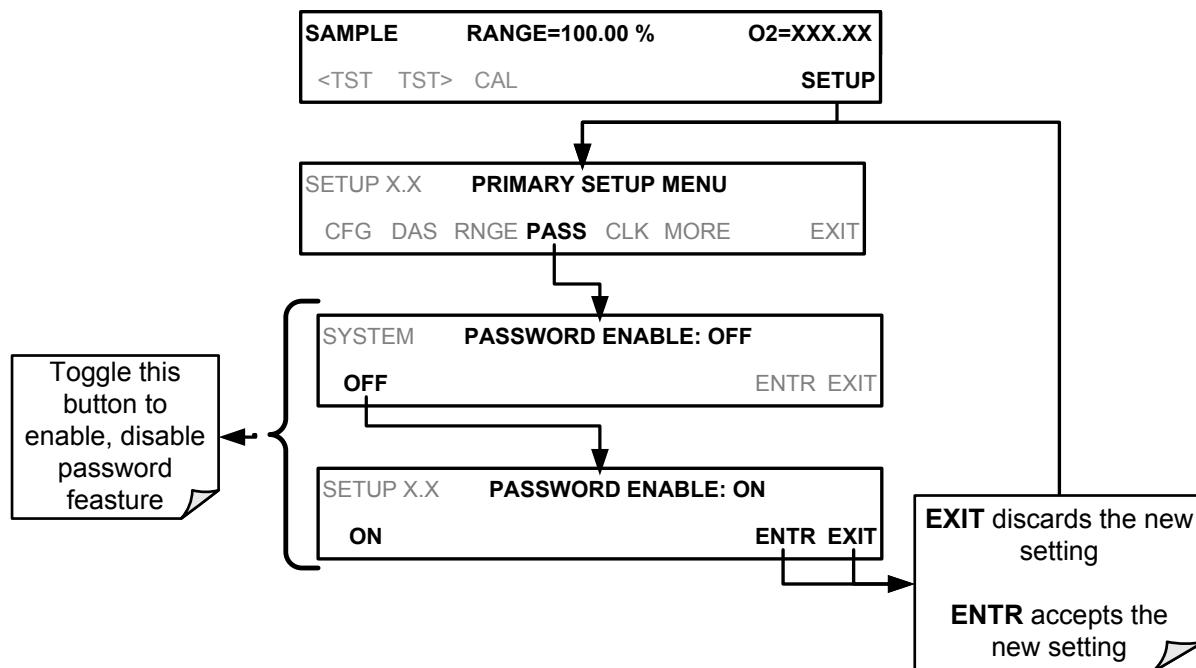
PASSWORD	LEVEL	MENU ACCESS ALLOWED
Null (000)	Operation	All functions of the main menu (top level, or Primary, menu)
101	Configuration/Maintenance	Access to Primary and Secondary SETUP Menus when PASSWORD is enabled
818	Configuration/Maintenance	Access to Secondary SETUP Submenus VARS and DIAG whether PASSWORD is enabled or disabled.

IMPORTANT

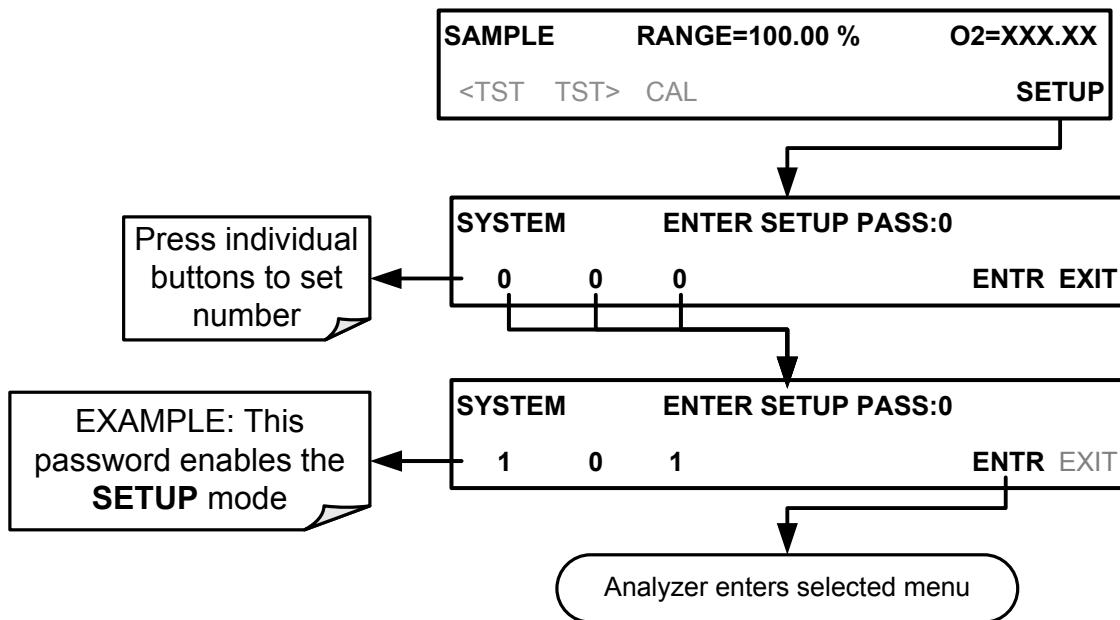
IMPACT ON READINGS OR DATA

There are more VARS available when using the password, 929, for configuration. Use caution when pressing any buttons while in this setup. Any changes made may alter the performance of the instrument or cause the instrument to not function properly. To discard an accidental change to a setup parameter, press EXIT.

To enable or disable passwords, press:



Example: If all passwords are enabled, the following keypad sequence would be required to enter the **SETUP** menu:

**Note**

When **PASSWORD ENABLE** is set to **OFF**, the instrument still prompts for a password when entering the **VARS** and **DIAG** menus, but it displays the default password (818). Press **ENTR** to continue.

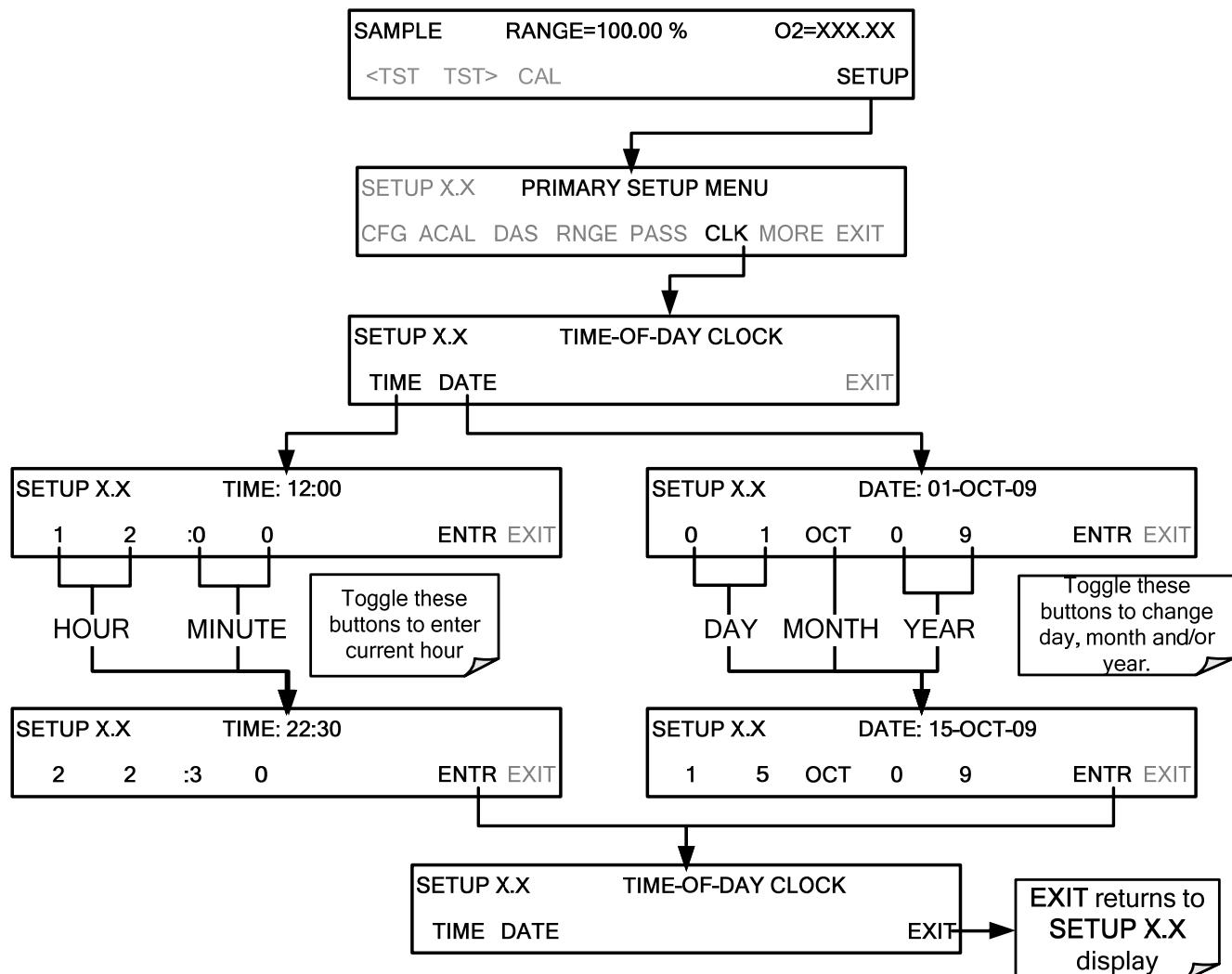
5.6. SETUP → CLK: SETTING THE T802 ANALYZER'S INTERNAL CLOCK

The analyzer has an internal clock for setting the time and day; its speed can be adjusted to compensate for faster or slower CPU clocks. Press SETUP>CLK to access the clock.

5.6.1. SETTING THE INTERNAL CLOCK'S TIME AND DAY

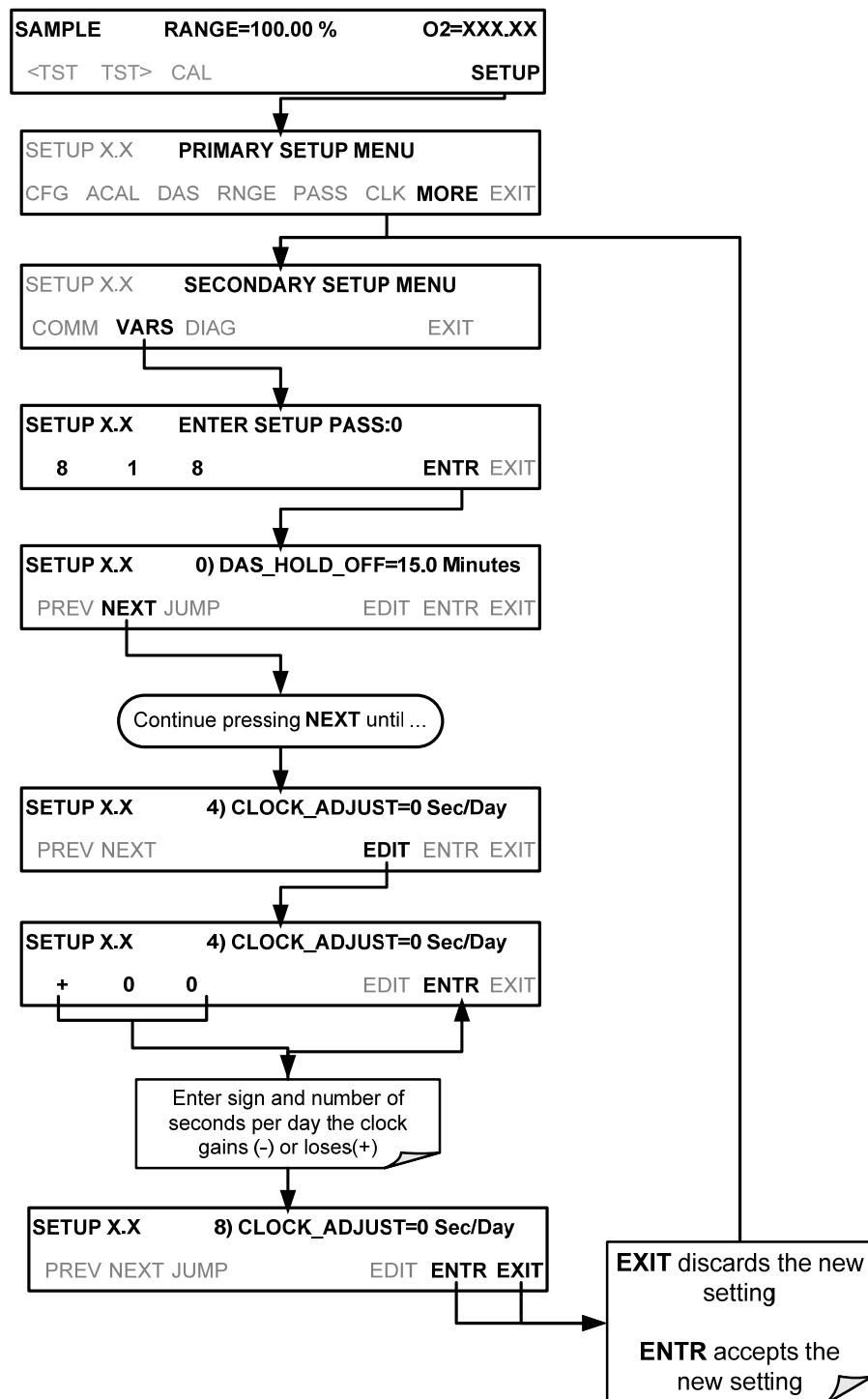
The T802 has a time of day clock that supports the time of day TEST function, the time stamps for the DAS feature and most COM port messages.

To set the clock's time and day, press:



5.6.2. ADJUSTING THE INTERNAL CLOCK'S SPEED

In order to compensate for CPU clocks that run faster or slower, you can adjust a variable called **CLOCK_ADJ** to speed up or slow down the clock by a fixed amount every day. The **CLOCK_ADJUST** variable is accessed via the **VARS** submenu: To change the value of this variable, press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

5.7. SETUP → MORE→ COMM: COMMUNICATION PORTS

This section introduces the communications setup menu; Section 6 provides the setup instructions and operation information. To arrive at the communications menu, press SETUP>MORE>COMM.

5.7.1. ID (MACHINE IDENTIFICATION)

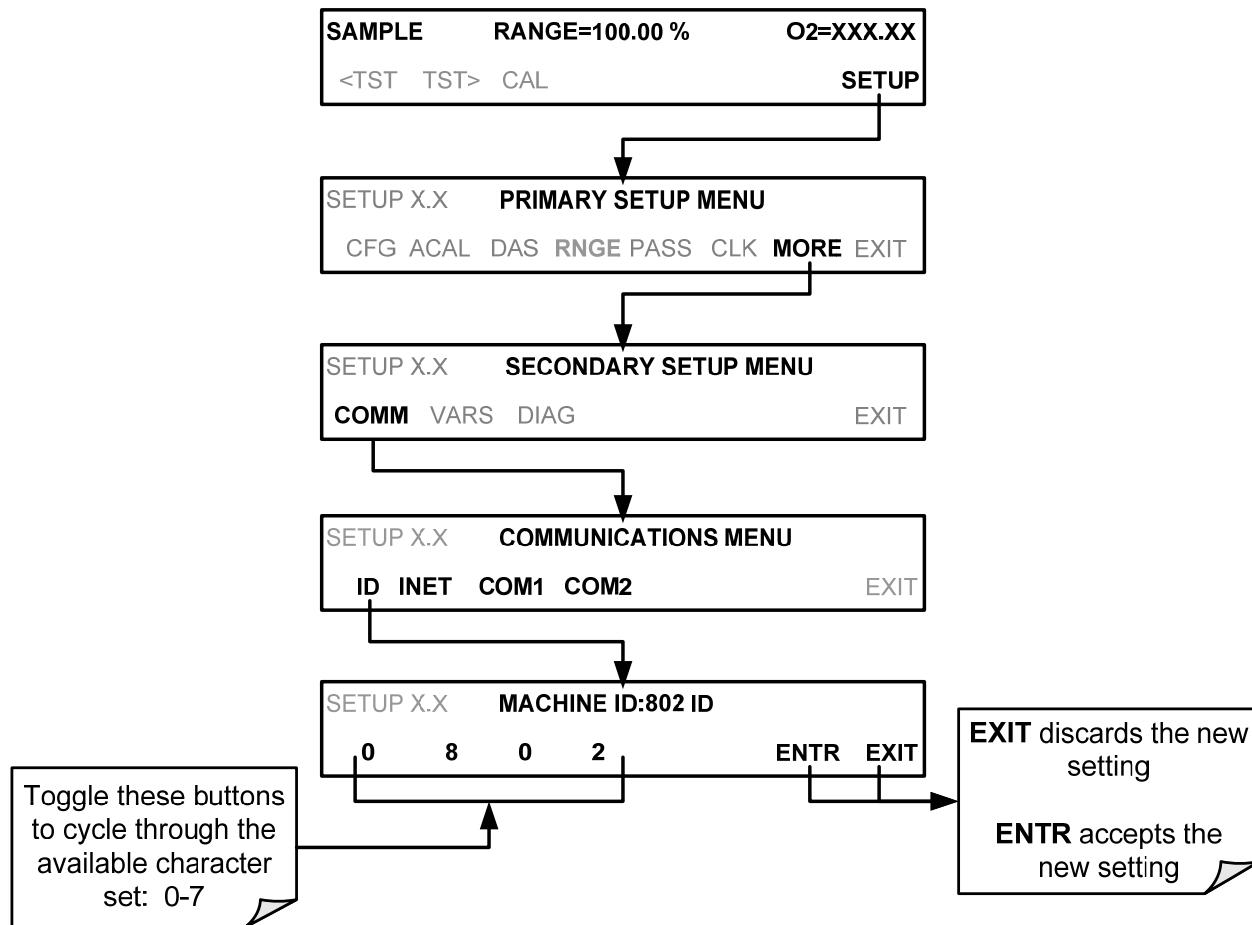
Each type of Teledyne API's analyzer is configured with a default **ID** code. The default **ID** code for the T802 analyzers is typically **802**, but could also be **0**.

The **ID** number is only important if more than one analyzer is connected to the same communications channel such as when several analyzers are:

- on the same Ethernet LAN (Section 6.5.1)
- in an RS-232 multidrop chain (Section 3.3.1.8)
- when applying MODBUS protocol (Section 6.5.1).
- when applying HESSEN protocol (Section 6.5.2)

If two analyzers of the same model type are used on one channel, the **ID** codes of one or both of the instruments needs to be changed.

To edit the instrument's ID code, press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

The ID can also be used for to identify any one of several analyzers attached to the same network but situated in different physical locations, e.g., by location number, company asset number, etc.).

5.7.2. INET (ETHERNET)

Use SETUP>COMM>INET to configure Ethernet communications, whether manually or via DHCP. Please see Section 6.3 for configuration details.

5.7.3. COM1[COM2] (MODE, BAUDE RATE AND TEST PORT)

Use the SETUP>COMM>COM1[COM2] menus to:

- configure communication modes (Section 6.2.1)
- view/set the baud rate (Section 6.2.2)
- test the connections of the com ports (Section 6.2.3).

Configuring COM1 or COM2 requires setting the DCE DTE switch on the rear panel. Section 6.1 provides DCE DTE information.

5.8. SETUP → MORE → VARS: INTERNAL VARIABLES (VARS)

The T802 has several user adjustable software variables, which define certain operational parameters. Usually, these variables are automatically set by the instrument's firmware, but can be manually redefined through the **VARS** menu.

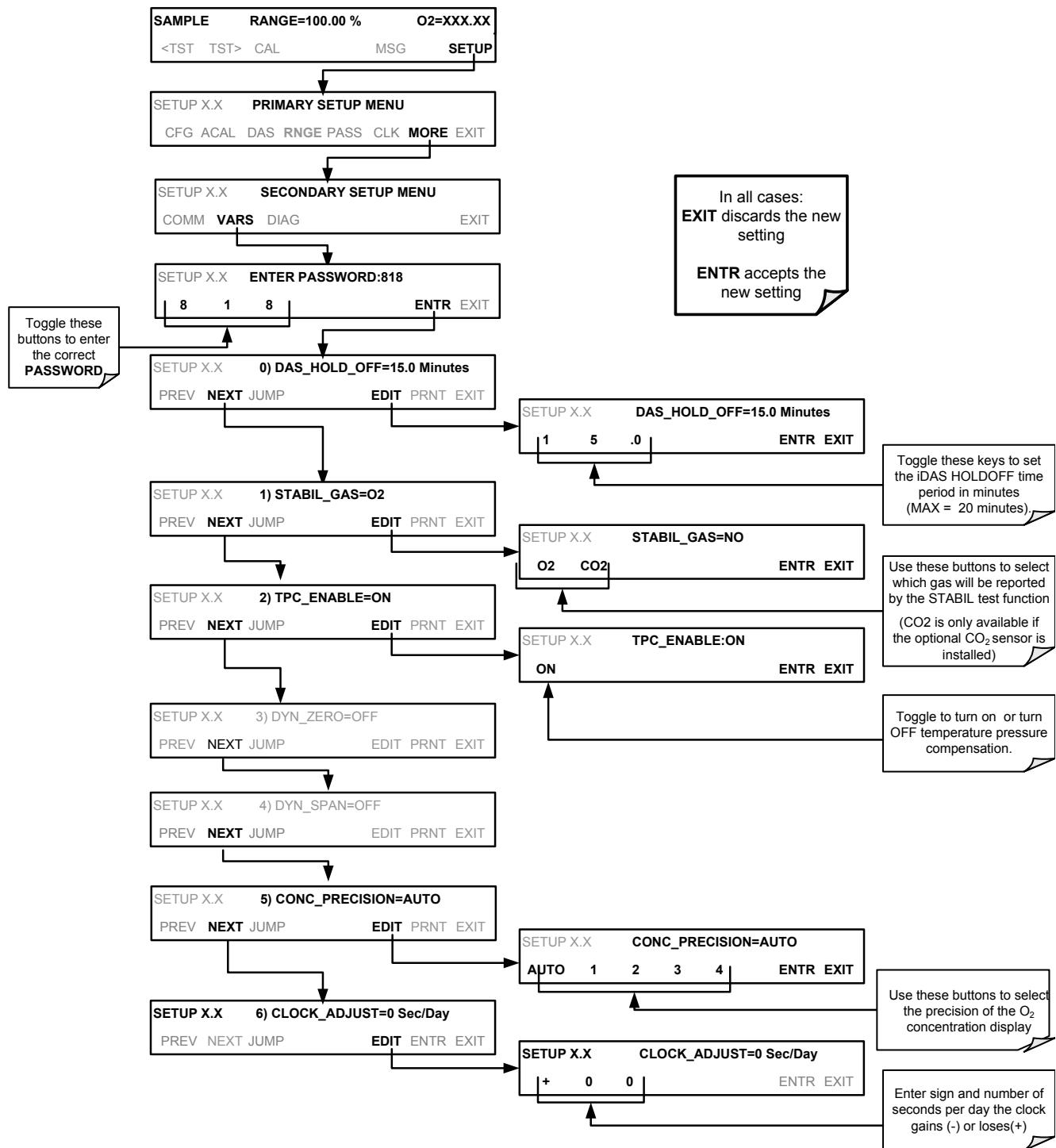
The following table lists all variables that are available within the 818 password protected level. See Appendix A2 for a detailed listing of all of the T802 variables that are accessible through the remote interface.

Table 5-2: Variable Names (VARS)

NO.	VARIABLE	DESCRIPTION	ALLOWED SETTINGS	VARS Default settings
0	DAS_HOLD_OFF	Changes the internal Data Acquisition System (DAS) HOLD OFF timer: No data are stored in the DAS channels during situations when the software considers the data to be questionable such as during warm up or just after the instrument returns from one of its calibration modes to SAMPLE Mode.	May be set for intervals between 0.5 – 20 min	15 min.
1	STABIL_GAS¹	Selects which gas measurement is displayed when the STABIL test function is selected.	O ₂ ; CO ₂	O2
2	TPC_ENABLE	NOTE: It is strongly recommended that this variable NOT be changed. ON enables, OFF disables temperature and pressure compensation	ON, OFF	ON
3	DYN_ZERO Special configuration; consult factory	[Automatically adjusts offset and slope of the O ₂ response when performing a zero point calibration during an AutoCal.]	[ON, OFF]	[OFF]
4	DYN_SPAN Special configuration; consult factory	[Automatically adjusts offset and slope of the O ₂ response when performing a zero point calibration during an AutoCal.]	[ON, OFF]	[OFF]
5	CONC_PRECISION	Allows the user to set the number of significant digits to the right of the decimal point display of concentration and stability values.	AUTO, 1, 2, 3, 4	AUTO
6	CLOCK_ADJ	Adjusts the speed of the analyzer's clock. Choose the + sign if the clock is too slow, choose the - sign if the clock is too fast.	-60 to +60 s/day	0 sec
7	SERVICE_CLEAR	Pressing the OFF button to display SERVICE_CLEAR:ON, followed by pressing ENTR resets the service interval timer and returns this Var back to its default setting, ready for the next reset.	ON, OFF	OFF
8	TIME_SINCE_SVC	Displays time in hours since last service (restarted by the SERVICE_CLEAR Variable).	0-50,000	0
9	SVC_INTERVAL	Sets the interval in hours between service reminders.	0-100,000	0

¹ This VAR only appears if the optional CO₂ sensor is installed.

To access and navigate the **VARS** menu, use the following key sequence.



5.9. SETUP → MORE → DIAG: DIAGNOSTICS FUNCTIONS

A series of diagnostic tools is grouped together under the **SETUP**→**MORE**→**DIAG** menu. These tools can be used in a variety of troubleshooting and diagnostic procedures and are referred to in many places of the maintenance and trouble-shooting sections of this manual.

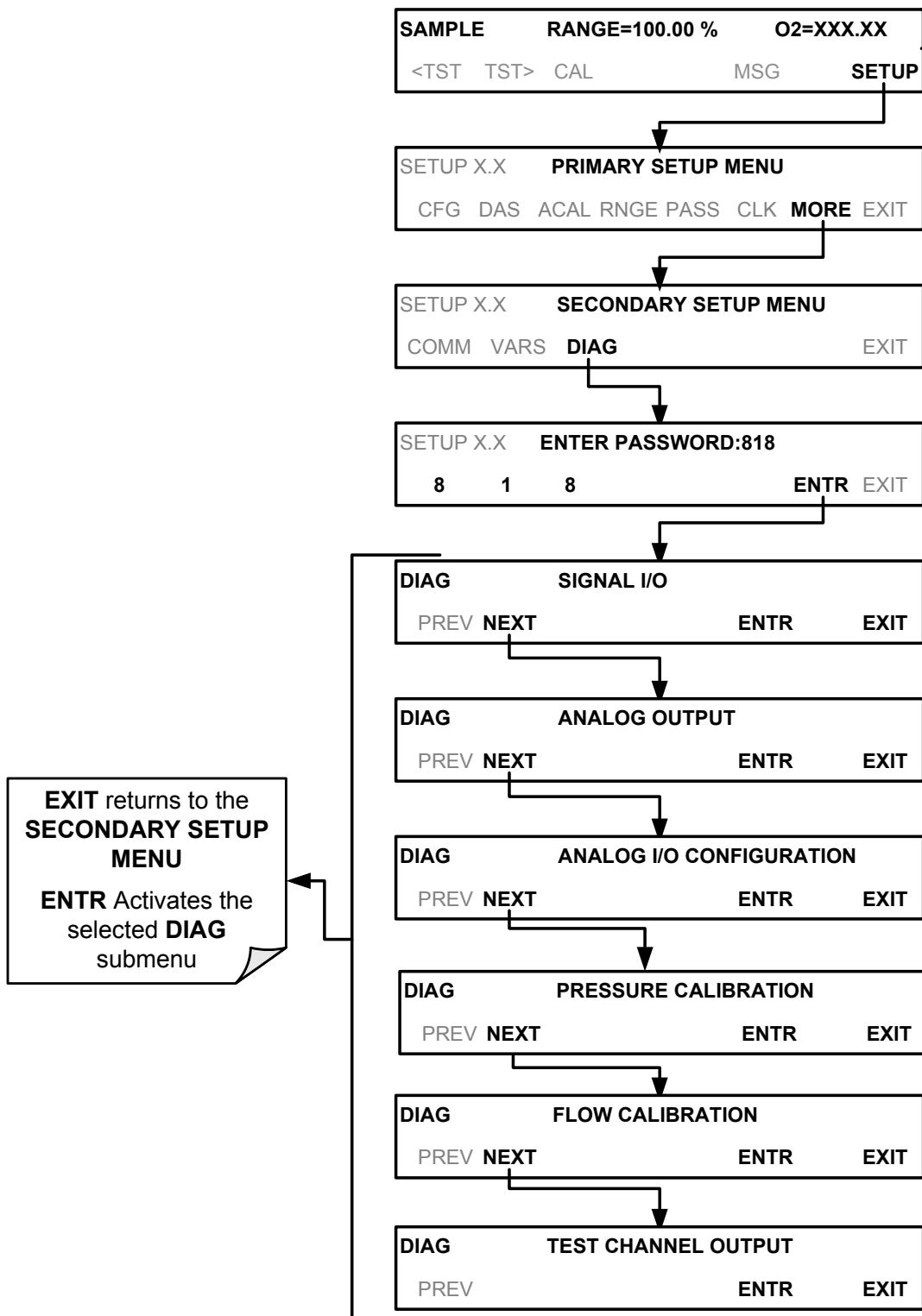
The various operating modes available under the **DIAG** menu are:

Table 5-3: Diagnostic Mode (DIAG) Functions

DIAG SUBMENU	SUBMENU FUNCTION	Front Panel Mode Indicator	MANUAL SECTION
SIGNAL I/O	Allows observation of all digital and analog signals in the instrument. Allows certain digital signals such as heaters to be toggled ON and OFF . These parameters are dependent on firmware revision, (see Appendix A).	DIAG I/O	11.1.3
ANALOG OUTPUT	When entered, the analyzer performs an analog output step test. This can be used to calibrate a chart recorder or to test the analog output accuracy.	DIAG AOUT	11.6.9.2
ANALOG I/O CONFIGURATION	This submenu allows the user to configure the analyzer's analog output channels, including choosing what parameter will be output on each channel. Instructions that appear here allow adjustment and calibration of the voltage signals associated with each output as well as calibration of the analog to digital converter circuitry on the motherboard.	DIAG AIO	5.9.3
PRESSURE CALIBRATION¹	This function is used to calibrate the Sample Pressure sensor.	DIAG PCAL	9.4.1
FLOW CALIBRATION¹	This function is used to calibrate the sample gas flow.	DIAG FCAL	9.4.2
TEST CHAN OUTPUT	Selects one of the available test channel signals to output over the A4 analog output channel.	DIAG TCHN	5.9.6

¹ These settings are retained after exiting **DIAG** mode.

To access the **DIAG** functions press the following menu sequence:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

5.9.1. SIGNAL I/O

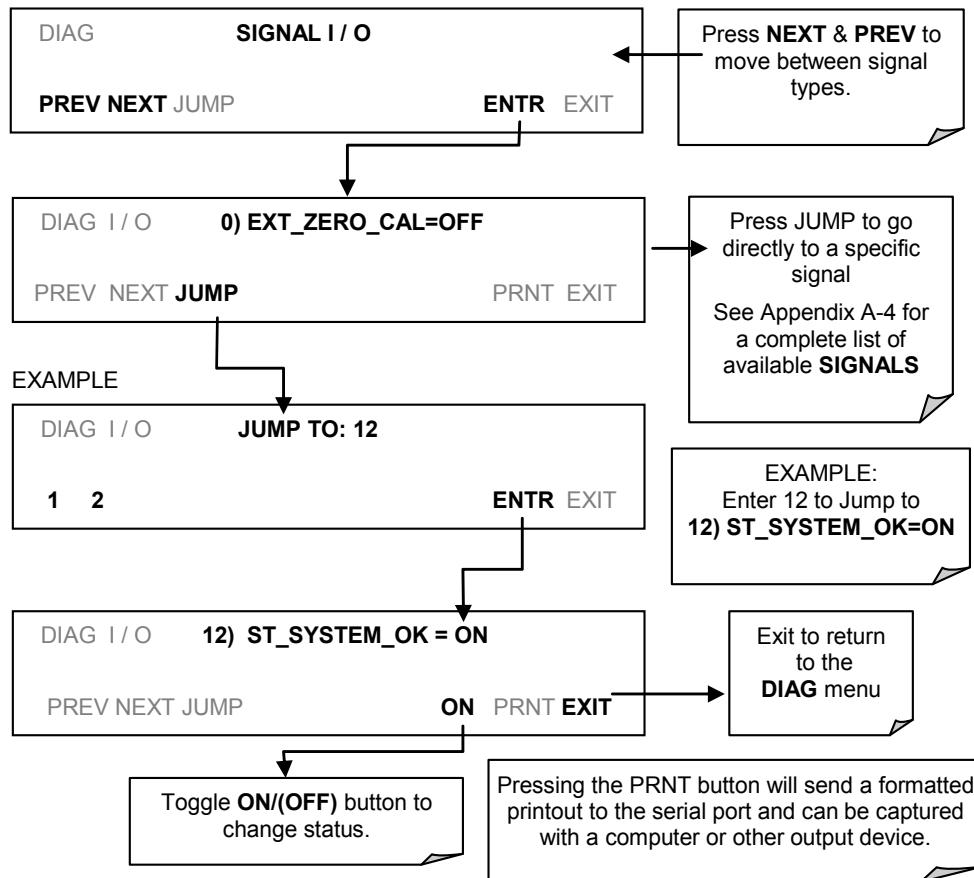
The signal I/O diagnostic mode allows a user to review and change the digital and analog input/output functions of the analyzer. It can also be used for troubleshooting purposes (Section 11.1.3). Refer to Appendix A for a complete list of the parameters available for review under this menu.

IMPORTANT

IMPACT ON READINGS OR DATA

Any changes of signal I/O settings will remain in effect only until the signal I/O menu is exited. Exceptions are the ozone generator override and the flow sensor calibration, which remain as entered when exiting.

Access the Signal I/O test mode from the DIAG Menu and press **ENTR** to access its parameters:



5.9.2. ANALOG OUTPUT

The T802 analyzer comes equipped with four analog outputs.

- The first two outputs (**A1 & A2**) carry analog signals that represent the currently measured concentration of O₂ (see Section 5.4.2).
- The third output (**A3**) is only active if the analyzer is equipped with the optional CO₂.
- The fourth output (**A4**) outputs a signal that can be set to represent the current value of one of several test functions (see Table 5-8).

5.9.3. ANALOG I/O CONFIGURATION

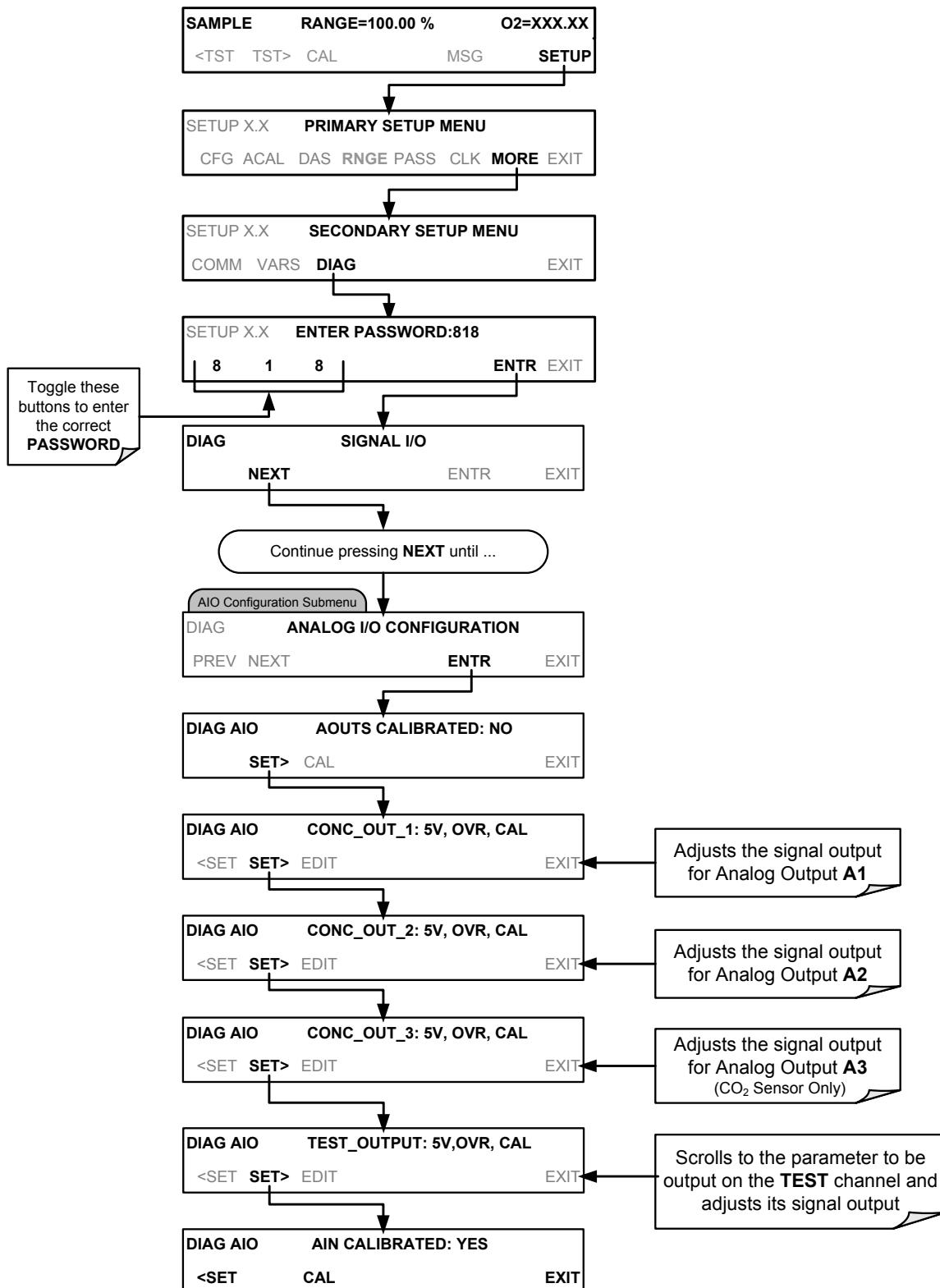
The following lists the analog I/O functions that are available in the T802 analyzer.

Table 5-4: DIAG - Analog I/O Functions

SUB MENU	FUNCTION
AOUT CALIBRATED	Initiates a calibration of the A1 , A2 , A3 and A4 analog output channels that determines the slope and offset inherent in the circuitry of each output. These values are stored in the memory and applied to the output signals by the CPU automatically.
CONC_OUT_1	Sets the basic electronic configuration of the A1 output (O ₂ Concentration). There are four options: <ul style="list-style-type: none"> • RANGE¹: Selects the signal type (voltage or current loop) and level of the output • REC_OFS: Allows them input of a DC offset to let the user manually adjust the output level • AUTO CAL: Enables / Disables the AOUT CALIBRATION Feature • CALIBRATED: Performs the same calibration as AOUT CALIBRATED, but on this one channel only.
CONC_OUT_2	<ul style="list-style-type: none"> • Same as for CONC_OUT_1 but for analog channel A2 but only if Auto or Dual range is selected (Oxygen high range, RNG2)
CONC_OUT_3	<ul style="list-style-type: none"> • Same as for CONC_OUT_1 but for analog channel A3 but only if the optional CO₂ sensor is installed.
TEST OUTPUT	<ul style="list-style-type: none"> • Same as for CONC_OUT_1 but for analog channel A4 (TEST CHANNEL)
AIN CALIBRATED	Initiates a calibration of the A-to-D Converter circuit located on the Motherboard.
XIN1 . XIN8	For each of 8 external analog inputs channels, shows the gain, offset, engineering units, and whether the channel is to show up as a Test function.

¹ Any changes made to **RANGE** or **REC_OFS** require recalibration of this output.

To access the **ANALOG I/O CONFIGURATION** sub menu, press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

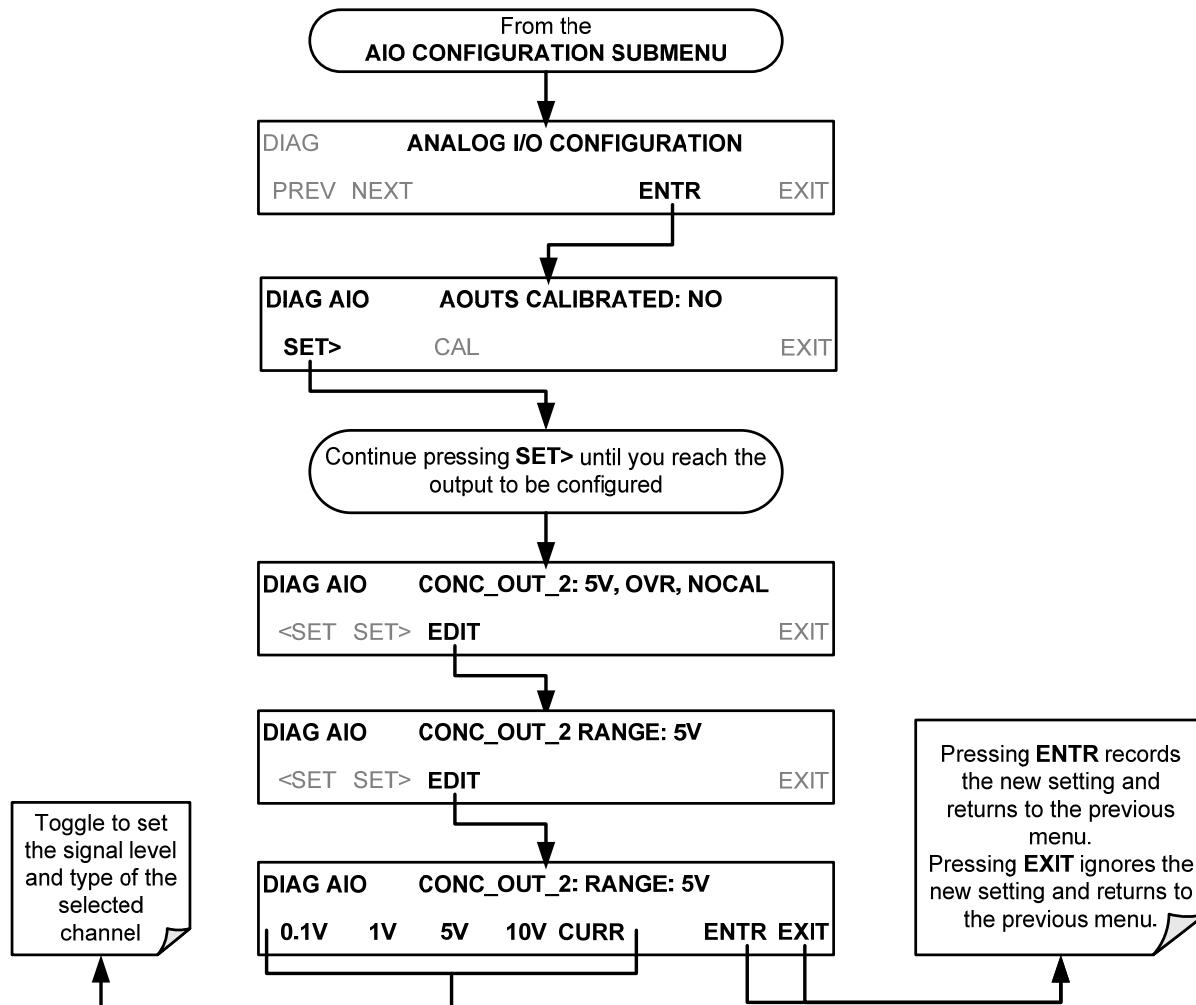
5.9.3.1. ANALOG OUTPUT VOLTAGE / CURRENT RANGE SELECTION

In its standard configuration the analog outputs are set to output a 0 – 5 VDC signals. Several other output ranges are available. Each range is usable from -5% to +5% of the rated span.

Table 5-5: Analog Output Voltage Range Min/Max

RANGE NAME	RANGE SPAN	MINIMUM OUTPUT	MAXIMUM OUTPUT
0.1V	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
<ul style="list-style-type: none">• The default offset for all VDC ranges is 0-5 VDC.			
CURR	0-20 mA	0 mA	20 mA
<ul style="list-style-type: none">• While these are the physical limits of the current loop modules, typical applications use 2-20 or 4-20 mA for the lower and upper limits. Please specify desired range when ordering this option.• The default offset for all current ranges is 0 mA.			

To change the output type and range, select the **ANALOG I/O CONFIGURATION** submenu (see Section 5.9.3) then press,



5.9.3.2. CALIBRATION OF THE ANALOG OUTPUTS

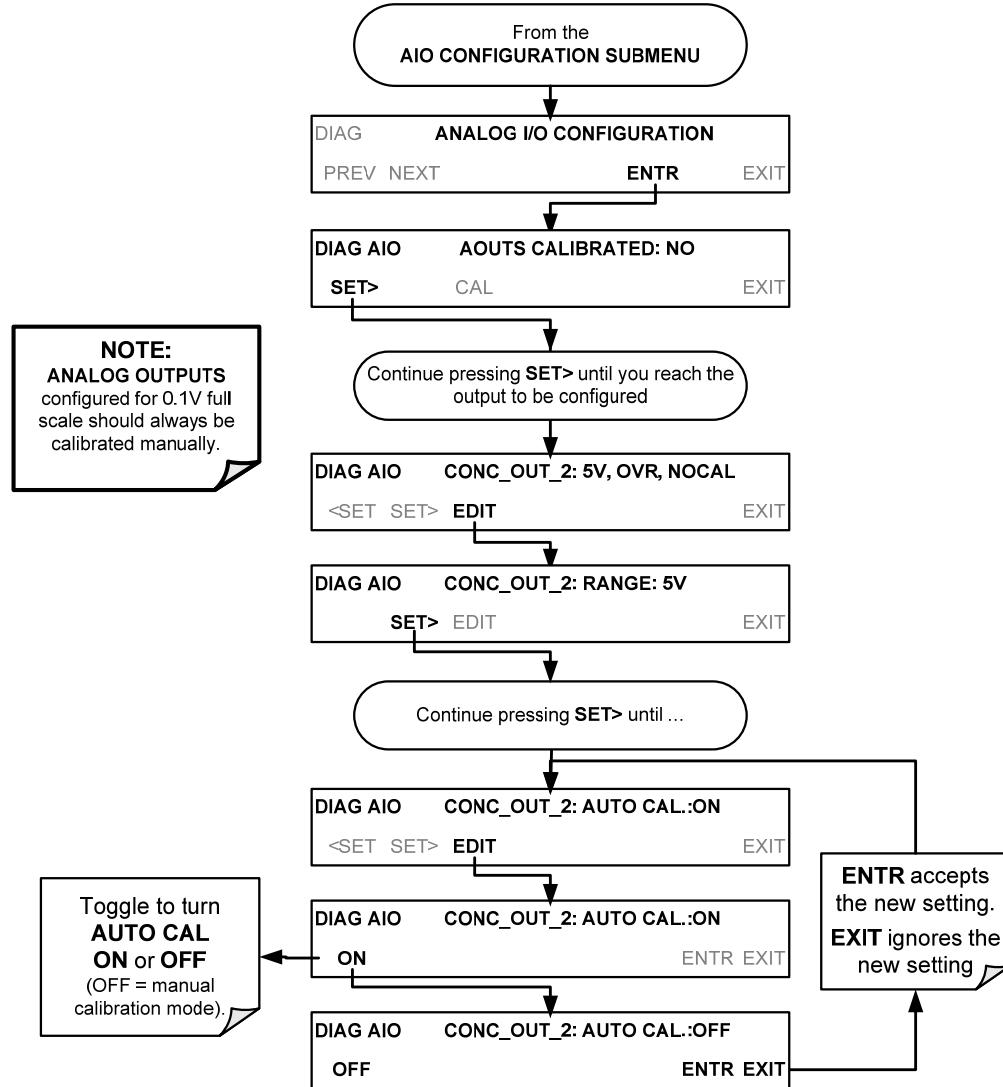
Analog output calibration should be carried out on first startup of the analyzer (performed in the factory as part of the configuration process) or whenever recalibration is required. The analog outputs can be calibrated automatically, either as a group or individually, or adjusted manually.

In its default mode, the instrument is configured for automatic calibration of all channels, which is useful for clearing any analog calibration warnings associated with channels that will not be used or connected to any input or recording device, e.g., data logger.

Manual calibration should be used for the 0.1V range or in cases where the outputs must be closely matched to the characteristics of the recording device. Manual calibration requires the AUTOCAL feature to be disabled.

5.9.3.3. ENABLING OR DISABLING THE AUTOCAL FOR AN INDIVIDUAL ANALOG OUTPUT

To enable or disable the AutoCal feature for an individual analog output, elect the **ANALOG I/O CONFIGURATION** submenu (see Section 5.9.3) then press:



5.9.3.4. AUTOMATIC GROUP CALIBRATION OF THE ANALOG OUTPUTS

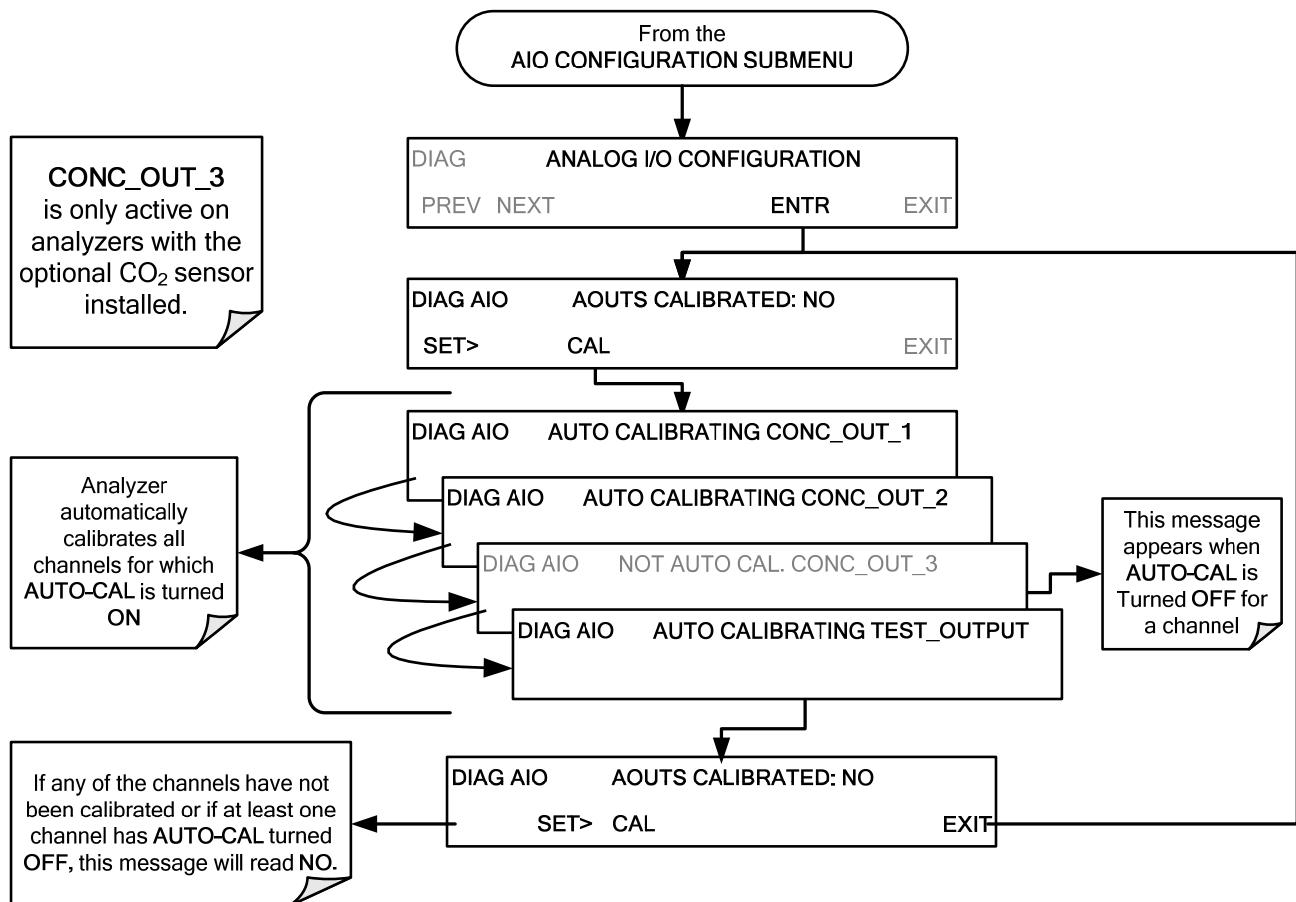
IMPORTANT

IMPACT ON READINGS OR DATA

Manual calibration should be used for any analog output set for a 0.1V output range or in cases where the outputs must be closely matched to the characteristics of the recording device.

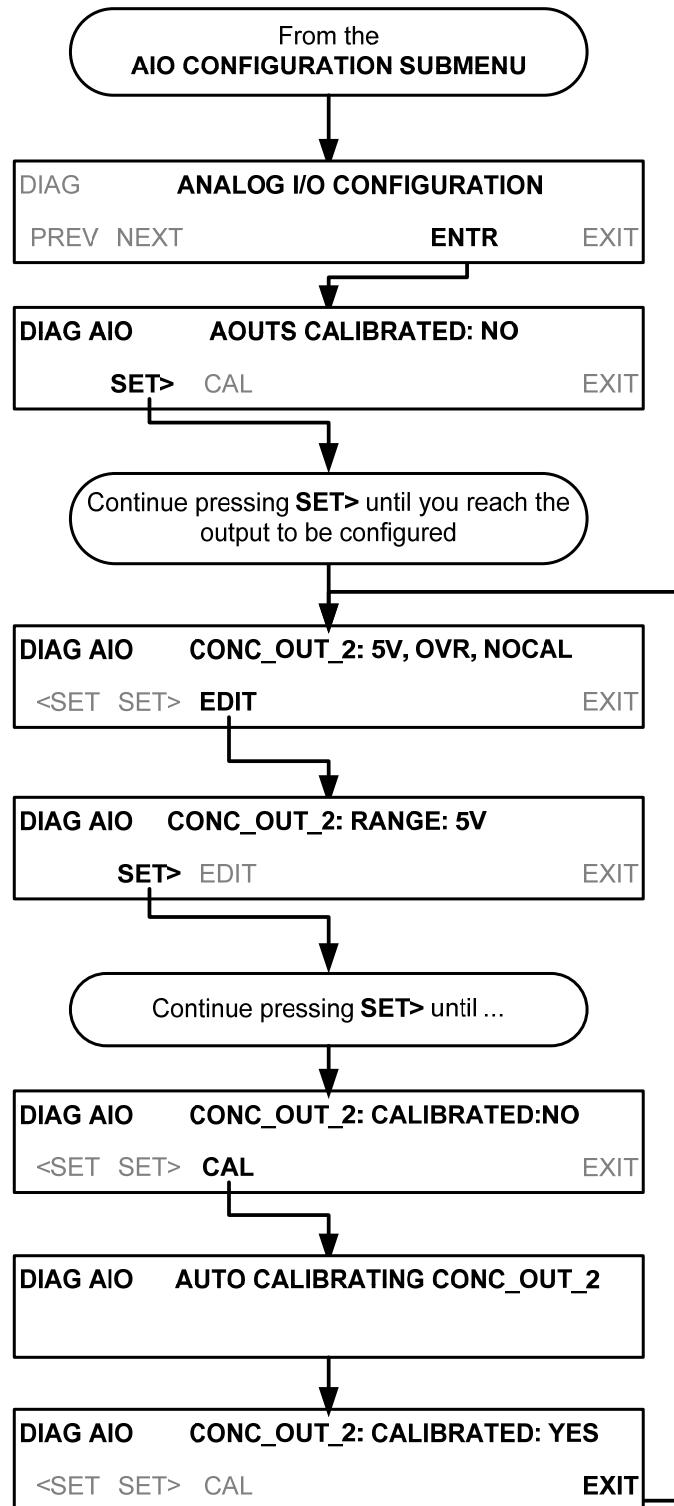
Before performing this procedure, ensure that the AUTO CAL for each analog output is enabled. (See Section 5.9.3.3).

To calibrate the outputs as a group with the AOUTS CALIBRATION command, select the ANALOG I/O CONFIGURATION submenu (see Section 5.9.3) then press:



5.9.3.5. AUTOMATIC INDIVIDUAL CALIBRATION OF THE ANALOG OUTPUTS

To use the **AUTO CAL** feature to initiate an automatic calibration for an individual analog output, select the **ANALOG I/O CONFIGURATION** submenu (see Section 5.9.3) then press:



5.9.3.6. MANUAL CALIBRATION OF THE ANALOG OUTPUTS CONFIGURED FOR VOLTAGE RANGES

For highest accuracy, the voltages of the analog outputs can be manually calibrated.

Note

The menu for manually adjusting the analog output signal level will only appear if the AUTO-CAL feature is turned off for the channel being adjusted (See Section 5.9.3.3).

Calibration is performed with a voltmeter connected across the output terminals and by changing the actual output signal level using the front panel keys in 100, 10 or 1 count increments. See Figure 3-7 for pin assignments and diagram of the analog output connector.

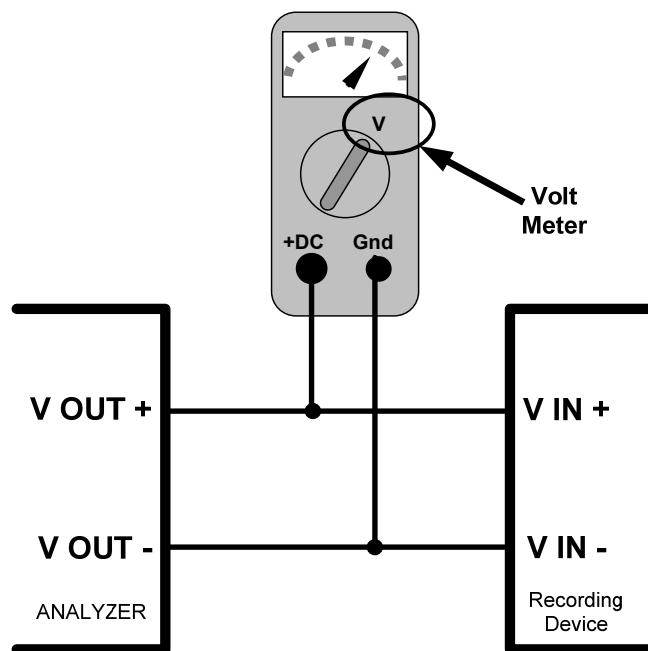
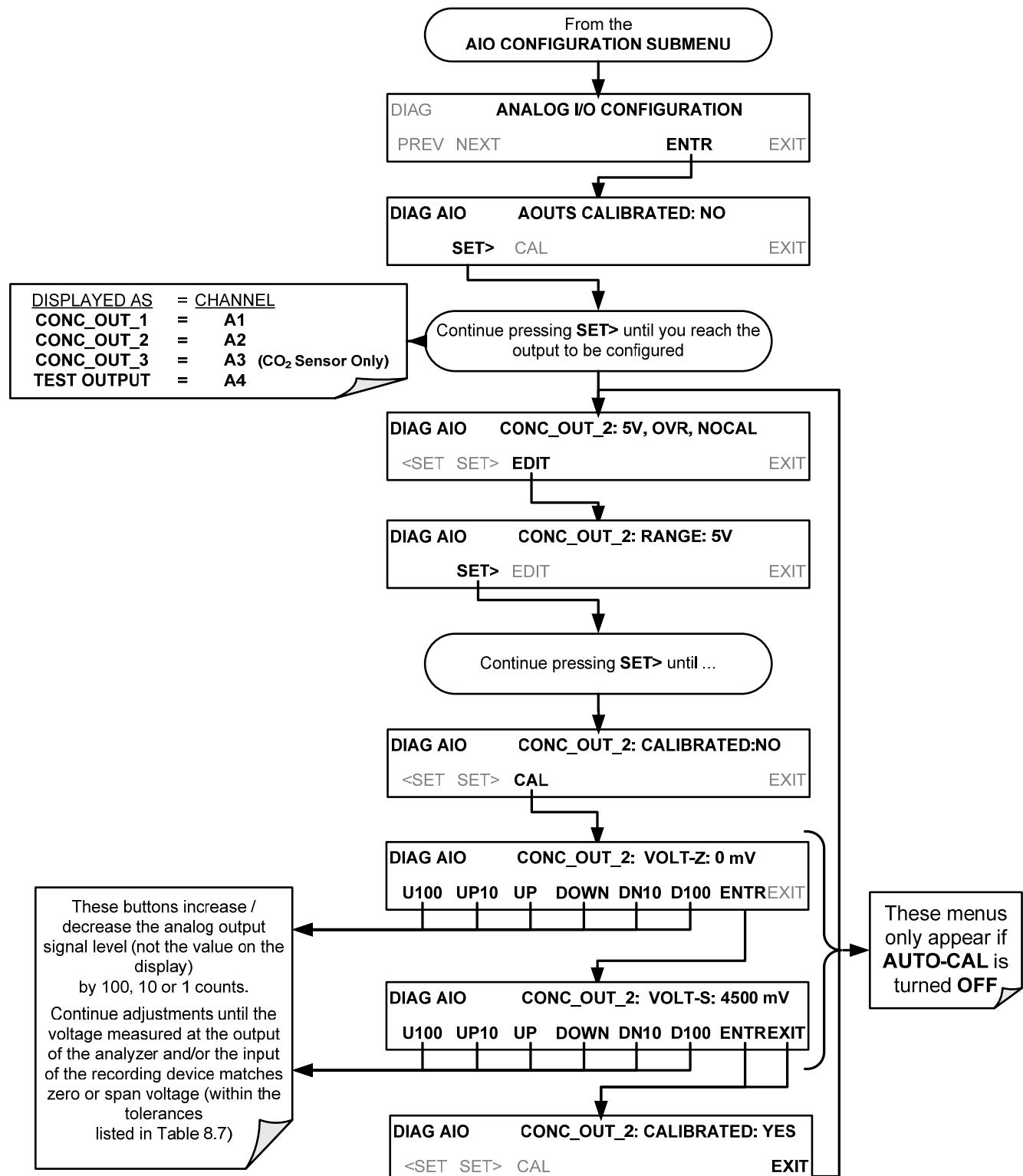


Figure 5-2: Setup for Checking / Calibrating DCV Analog Output Signal Levels

Table 5-6: Voltage Tolerances for the TEST CHANNEL Calibration

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

To adjust the signal levels of an analog output channel manually, select the ANALOG I/O CONFIGURATION submenu (see Section 5.9.3) then press:



5.9.3.7. MANUAL ADJUSTMENT OF CURRENT LOOP OPTION OUTPUT SPAN AND OFFSET

A current loop option may be purchased for the **A1**, **A2** and **A3** analog outputs of the analyzer. This option places circuitry in series with the output of the A-to-D converter on the motherboard that changes the normal DC voltage output to a 0-20 milliamp signal (See Section 3.3.1.4).

- The outputs can be ordered scaled to any set of limits within that 0-20 mA range, however most current loop applications call for either 0-20 mA or 4-20 mA range spans.
- All current loop outputs have a + 5% over range. Ranges whose lower limit is set above 1 mA also have a -5 under range.

To switch an analog output from voltage to current loop, follow the instructions in Section 5.9.3.1 (select **CURR** from the list of options on the “Output Range” menu).

Adjustment of 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 3-7 for pin assignments and diagram of the analog output connector.

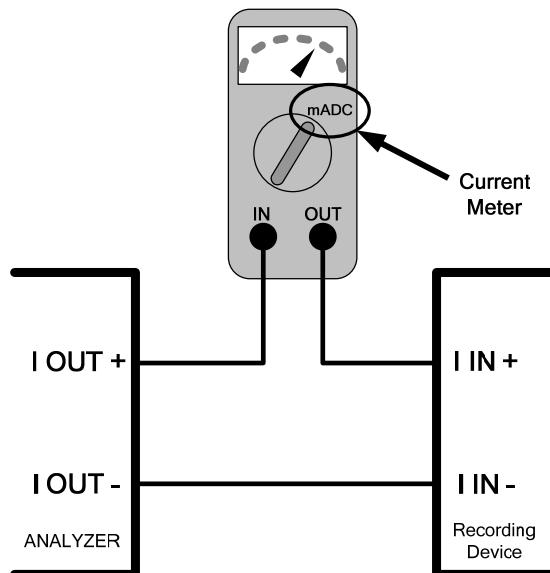


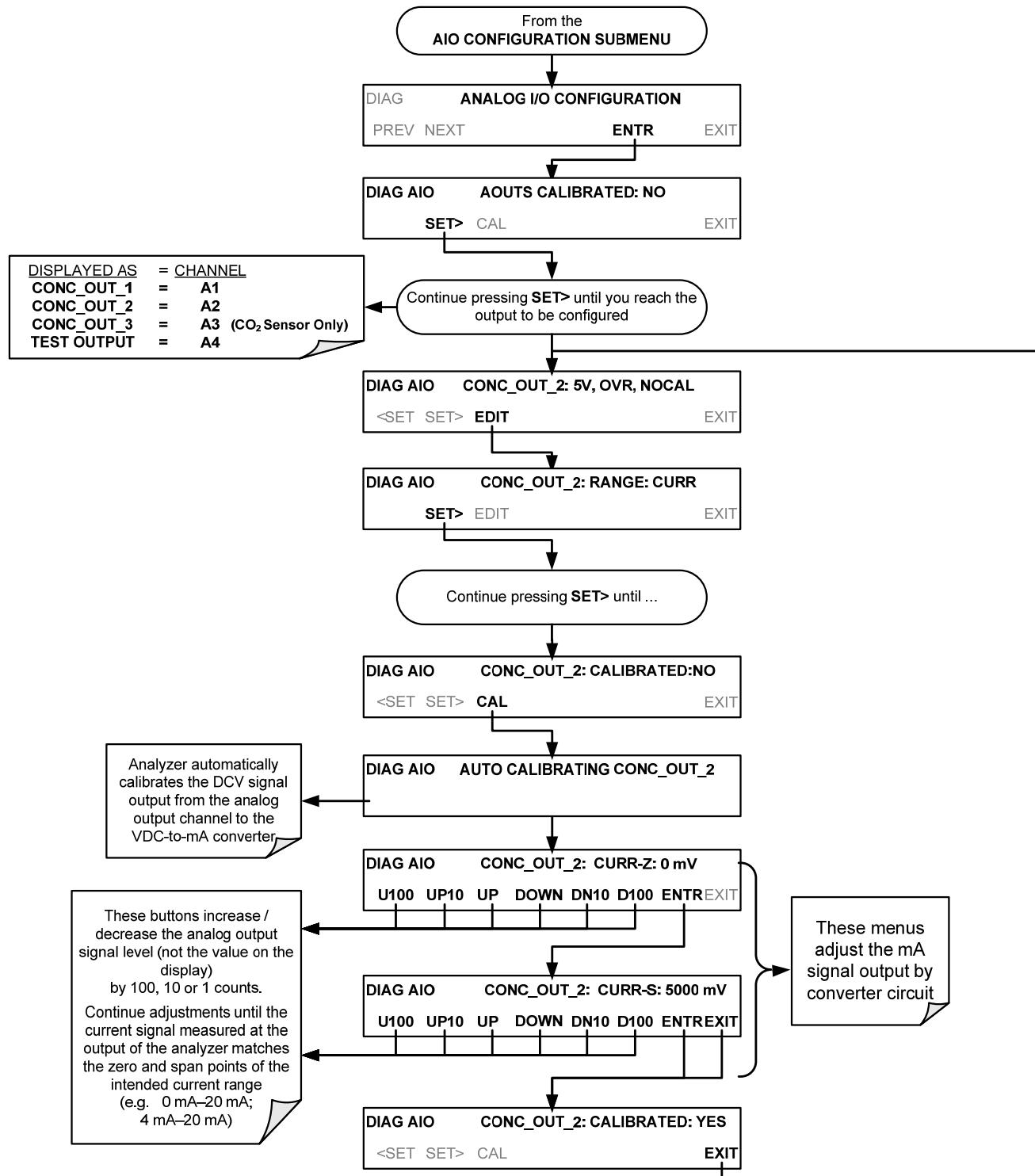
Figure 5-3: Setup for Checking / Calibration Current Output Signal Levels Using an Ammeter



CAUTION - GENERAL SAFETY HAZARD

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

To adjust the zero and span signal levels of the current outputs, select the **ANALOG I/O CONFIGURATION** submenu (see Section 5.9.3) then press:



An alternative 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 3-7 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.

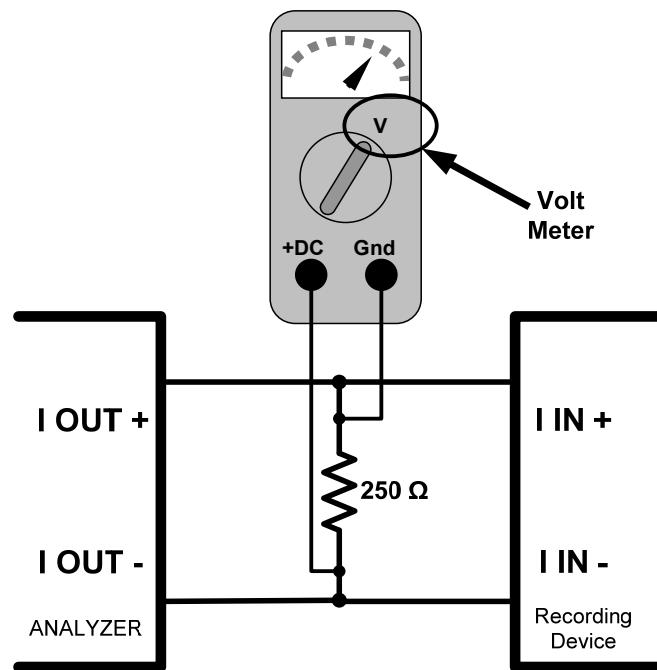


Figure 5-4: Alternative Setup Using 250Ω Resistor for Checking Current Output Signal Levels

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

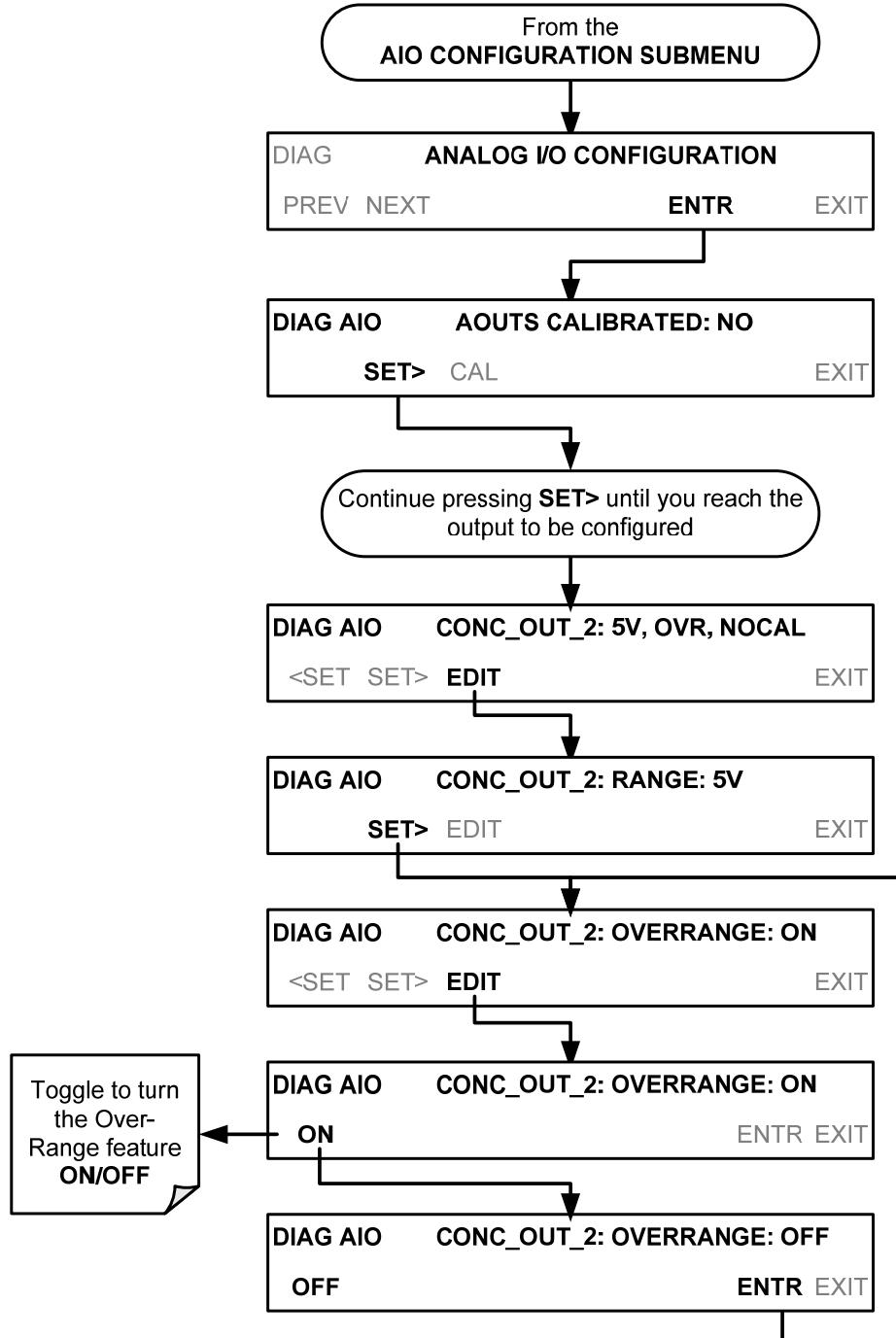
Table 5-7: Current Loop Output Check

% 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

5.9.4. TURNING AN ANALOG OUTPUT OVER-RANGE FEATURE ON/OFF

In its default configuration, a $\pm 5\%$ over-range is available on each of the T802's analog outputs. This over-range can be disabled if your recording device is sensitive to excess voltage or current.

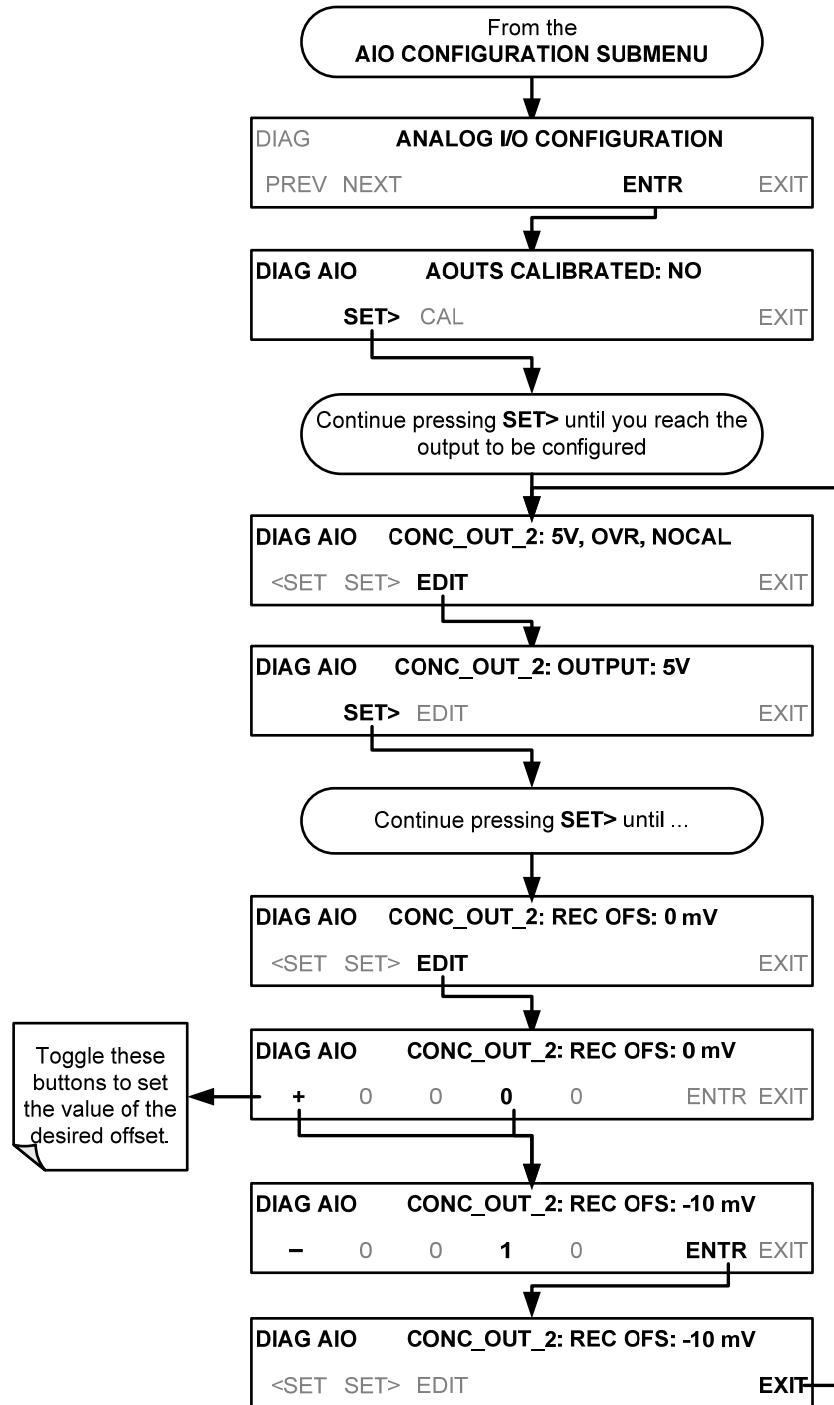
To turn the over-range feature on or off, select the **ANALOG I/O CONFIGURATION** submenu (see Section 5.9.3) then press:



5.9.5. ADDING A RECORDER OFFSET TO AN ANALOG OUTPUT

Some analog signal recorders require that the zero signal be significantly different from the baseline of the recorder in order to record slightly negative readings from noise around the zero point. This can be achieved in the T802 by defining a zero offset, a small voltage (e.g., 10% of span).

To add a zero offset to a specific analog output channel, select the **ANALOG I/O CONFIGURATION** submenu (see Section 5.9.3) then press:



5.9.6. SELECTING A TEST CHANNEL FUNCTION FOR OUTPUT A4

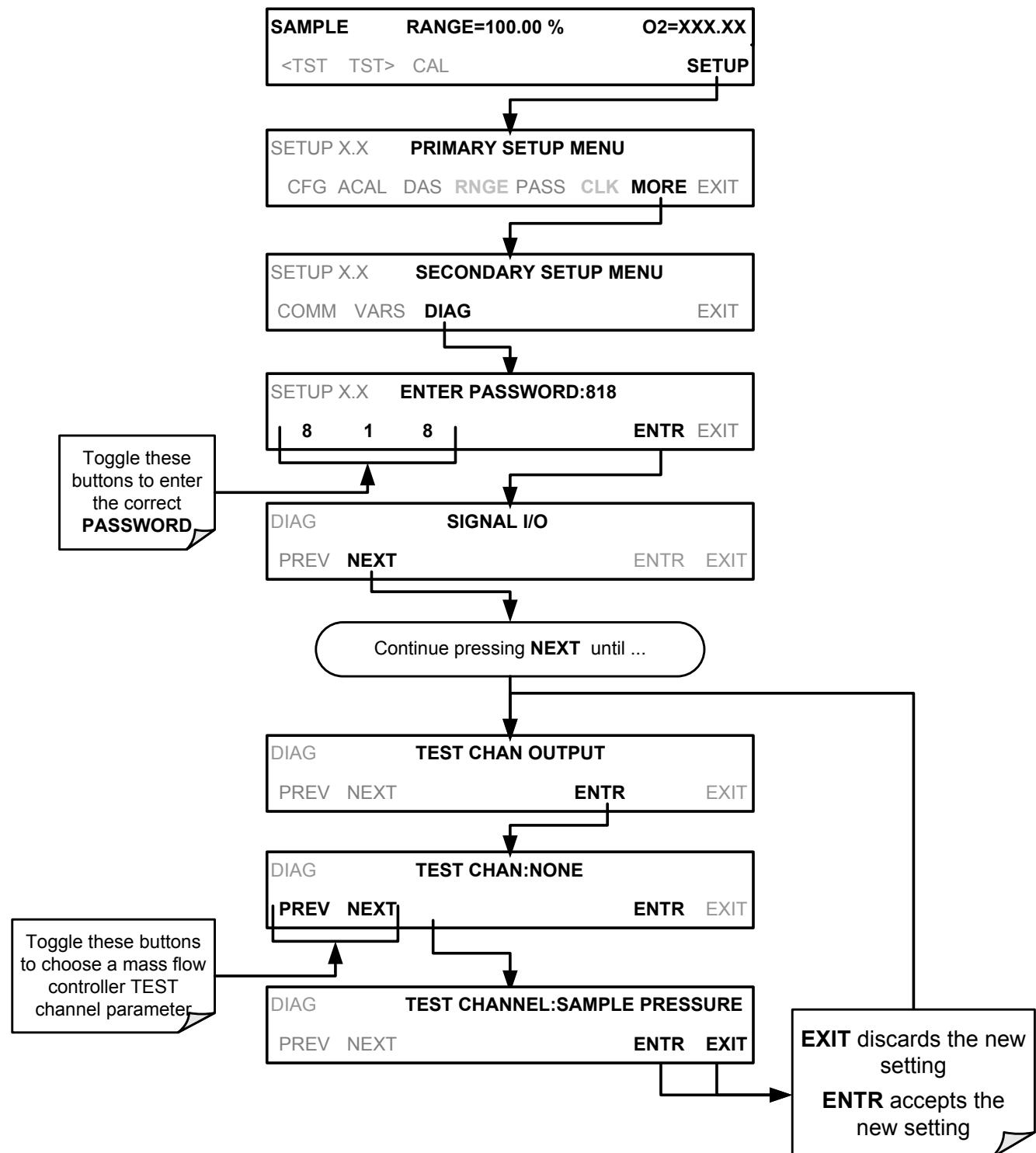
The test functions available to be reported are:

Table 5-8: Test Channels Functions available on the T802's Analog Output

TEST CHANNEL	DESCRIPTION	ZERO	FULL SCALE
NONE	Test Channel is turned off		
SAMPLE PRESSURE	The absolute pressure of the Sample gas as measured by a pressure sensor located inside the sample chamber.	0 "Hg	40 "Hg
SAMPLE FLOW	Sample mass flow rate as measured by the flow rate sensor in the sample gas stream.	0 cm ³ /m	1000 cm ³ /m
O₂ CELL TEMP	The temperature of the gas inside the O ₂ sensor sample chamber.	0°C	70°C
CO₂ CELL TEMP	The temperature of the gas inside the optional CO ₂ sensor sample chamber.	0°C	70°C
CHASSIS TEMP	The temperature inside the analyzer chassis.	0°C	70°C

Once a function is selected, the instrument not only begins to output a signal on the analog output, but also adds **TEST** to the list of test functions viewable via the front panel display.

To activate the **TEST** Channel and select a function (in this example **SAMPLE PRESSURE**), press:

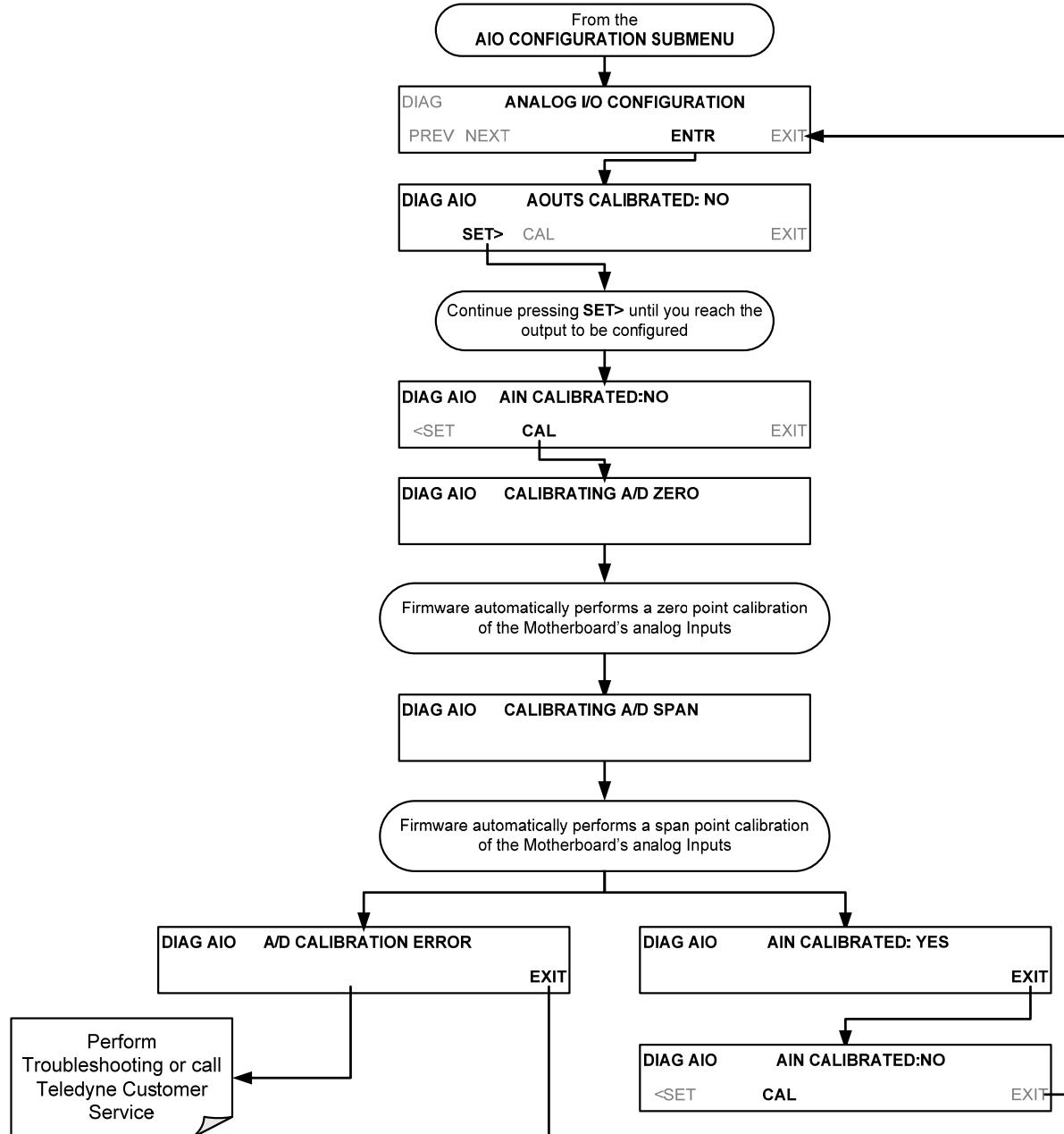


(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

5.9.7. AIN CALIBRATION

This is the sub-menu to conduct a calibration of the T802 analyzer's analog inputs. This calibration should only be necessary after major repair such as a replacement of CPU, motherboard or power supplies.

To perform an analog input calibration, select the **ANALOG I/O CONFIGURATION** submenu (see Section 5.9.3) then press:

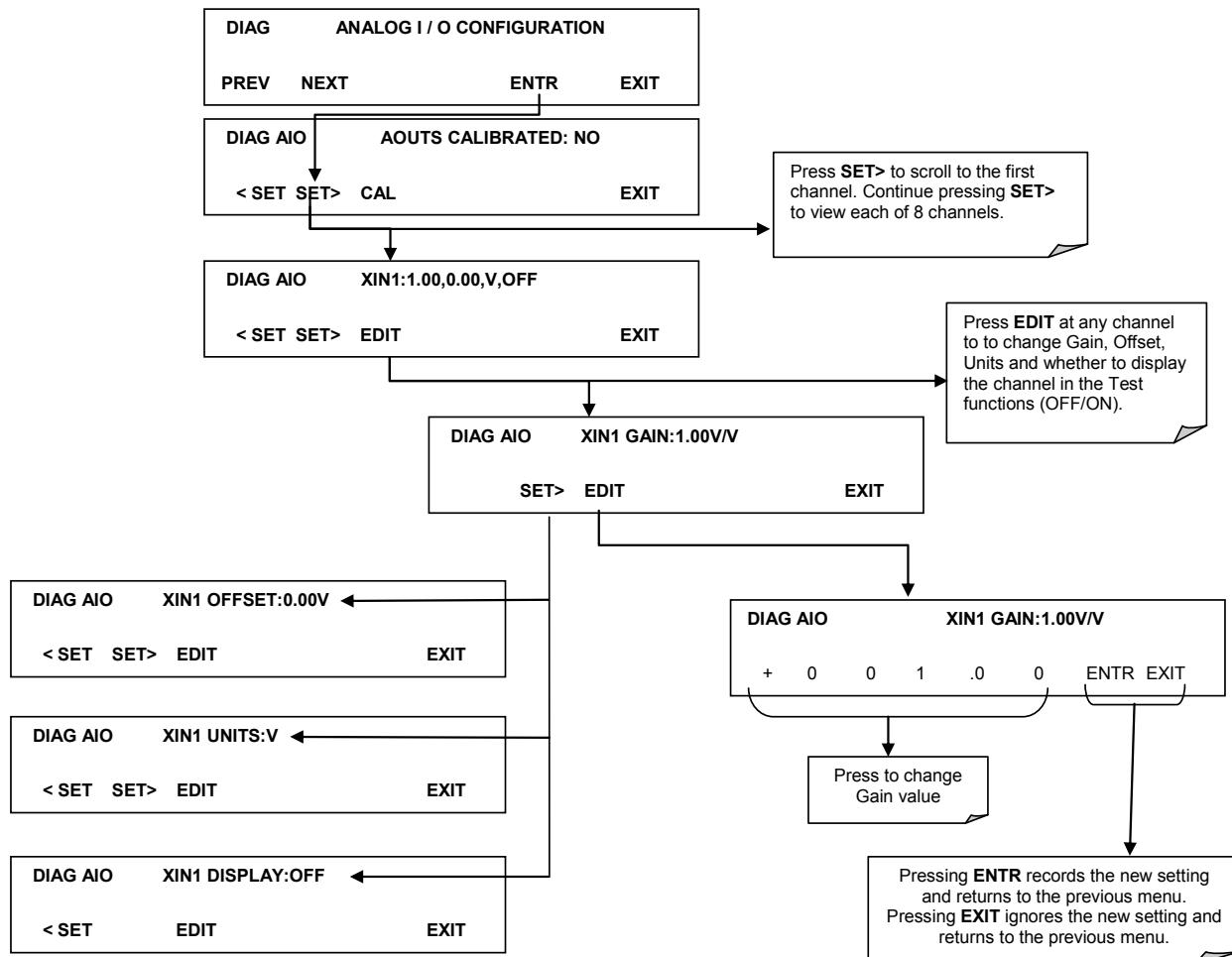


5.9.8. ANALOG INPUTS (XIN1...XIN8) OPTION CONFIGURATION

To configure the analyzer's optional analog inputs, define for each channel:

- gain (number of units represented by 1 volt)
- offset (volts)
- engineering units to be represented in volts (each press of the touchscreen button scrolls the list of alphanumeric characters from A-Z and 0-9)
- whether to display the channel in the Test functions

To adjust settings for the Analog Inputs option parameters press:



5.10. SETUP →MORE → ALRM: USING THE GAS CONCENTRATION ALARMS (OPTION 61)

The T802 includes two O₂ concentration alarms. Each alarm has a user settable limit, and is associated with an opto-isolated TTL relay accessible via the status output connector on the instrument's back panel (See Section 3.3.1.5). If the O₂ concentration measured by the instrument rises above that limit, the alarm's status output relay is closed.

The default settings for **ALM1** and **ALM2** are:

Table 5-9: O₂ Concentration Alarm Default Settings

ALARM	STATUS	LIMIT SET POINT ¹
O2 ALARM1	Disabled	10.00 %
O2 ALARM2	Disabled	30.0 %
CO2 ALARM1 ¹	Disabled	5.000 % ¹
CO2 ALARM2 ¹	Disabled	10.00 % ¹

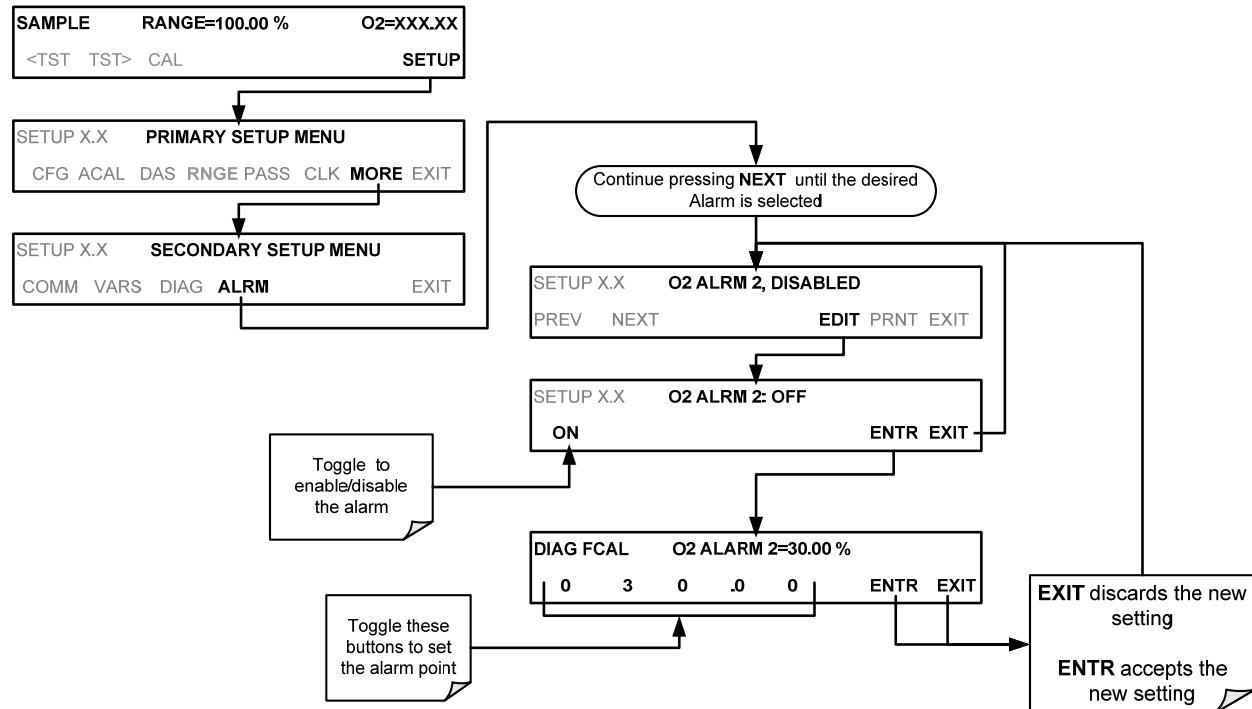
¹ Only available if the optional CO₂ sensor is installed.

Note

To prevent the concentration alarms from activating during span calibration operations make sure to press **CAL** button prior to introducing span gas into the analyzer..

5.10.1. SETTING THE T802 OPTION 61 CONCENTRATION ALARM LIMITS

To enable either of the O₂ concentration alarms and set the Limit points, press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

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6. COMMUNICATIONS SETUP AND OPERATION

This instrument's rear panel connections include an Ethernet port, a USB port (option) and two serial communication (COM) ports labeled **RS232**, which is the COM1 port, and **COM2** (see Figure 3-2). Both COM ports operate similarly and give the user the ability to communicate with, issue commands to, and receive data from the analyzer through an external computer system or terminal. Connection instructions were provided in Section 3.3.1.8.

This section provides pertinent information regarding communication equipment, describes the instrument's communications modes, presents configuration instructions for the communications ports, and provides instructions for their use, including communications protocol. Data acquisition is presented in Section 7. By default, both COM ports operate on the RS-232 protocol.

6.1. DATA TERMINAL/COMMUNICATION EQUIPMENT (DTE DCE)

RS-232 was developed for allowing communications between data terminal equipment (DTE) and data communication equipment (DCE). Basic data terminals always fall into the DTE category whereas modems are always considered DCE devices.

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

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

A switch located below the serial ports on the rear panel allows the user to switch between DTE (for use with data terminals) or DCE (for use with modems). Since computers can be either DTE or DCE, check your computer to determine which mode to use.

6.2. COMMUNICATION MODES, BAUD RATE AND PORT TESTING

Use the SETUP>MORE>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/or port testing for correct connection. If using a USB option communication connection, setup requires USB driver download and configuring a few settings for (Section 6.4).

6.2.1. COM PORT COMMUNICATION MODES

Each of the analyzer's serial ports can be configured to operate in a number of different modes, listed in Table 6-1. As modes are selected, the analyzer sums the mode ID numbers and displays this combined number on the front panel display. For example, if Quiet mode (01), computer mode (02) and Multi-Drop-Enabled mode (32) are selected, the analyzer would display a combined **MODE ID** of **35**.

Table 6-1: COM Port Communication Modes

MODE ¹	ID	DESCRIPTION
QUIET	1	Quiet mode suppresses any feedback from the analyzer (such as warning messages) to the remote device and is typically used when the port is communicating with a computer program where such intermittent messages might cause communication problems. Such feedback is still available but a command must be issued to receive them.
COMPUTER	2	Computer mode inhibits echoing of typed characters and is used when the port is communicating with a computer operated control program.
HESSEN PROTOCOL	16	The Hessen communications protocol is used in some European countries. TELEDYNE API PN 02252 contains more information on this protocol.
E, 8, 1	8192	When turned on this mode switches the COM port settings from • NO PARITY ; 8 data bits; 1 stop bit to EVEN PARITY ; 8 data bits; 1 stop bit.
E, 7, 1	2048	When turned on this mode switches the COM port settings from • NO PARITY ; 8 DATA BITS ; 1 stop bit to EVEN PARITY ; 7 DATA BITS ; 1 stop bit.
RS-485	1024	Configures the COM2 Port for RS-485 communication. RS-485 mode has precedence over multidrop mode if both are enabled.
SECURITY	4	When enabled, the serial port requires a password before it will respond (see Section 8.4). The only command that is active is the help screen (? CR).
MULTIDROP PROTOCOL	32	Multidrop protocol allows a multi-instrument configuration on a single communications channel. Multidrop requires the use of instrument IDs.
ENABLE MODEM	64	Enables to send a modem initialization string at power-up. Asserts certain lines in the RS-232 port to enable the modem to communicate.
ERROR CHECKING ²	128	Fixes certain types of parity errors at certain Hessen protocol installations.
XON/XOFF HANDSHAKE ²	256	Disables XON/XOFF data flow control also known as software handshaking.
HARDWARE HANDSHAKE	8	Enables CTS/RTS style hardwired transmission handshaking. This style of data transmission handshaking is commonly used with modems or terminal emulation protocols as well as by Teledyne Instrument's APICOM software.
HARDWARE FIFO	512	Disables the HARDWARE FIFO (First In – First Out), When FIFO is enabled it improves data transfer rate for that COM port.
COMMAND PROMPT	4096	Enables a command prompt when in terminal mode.

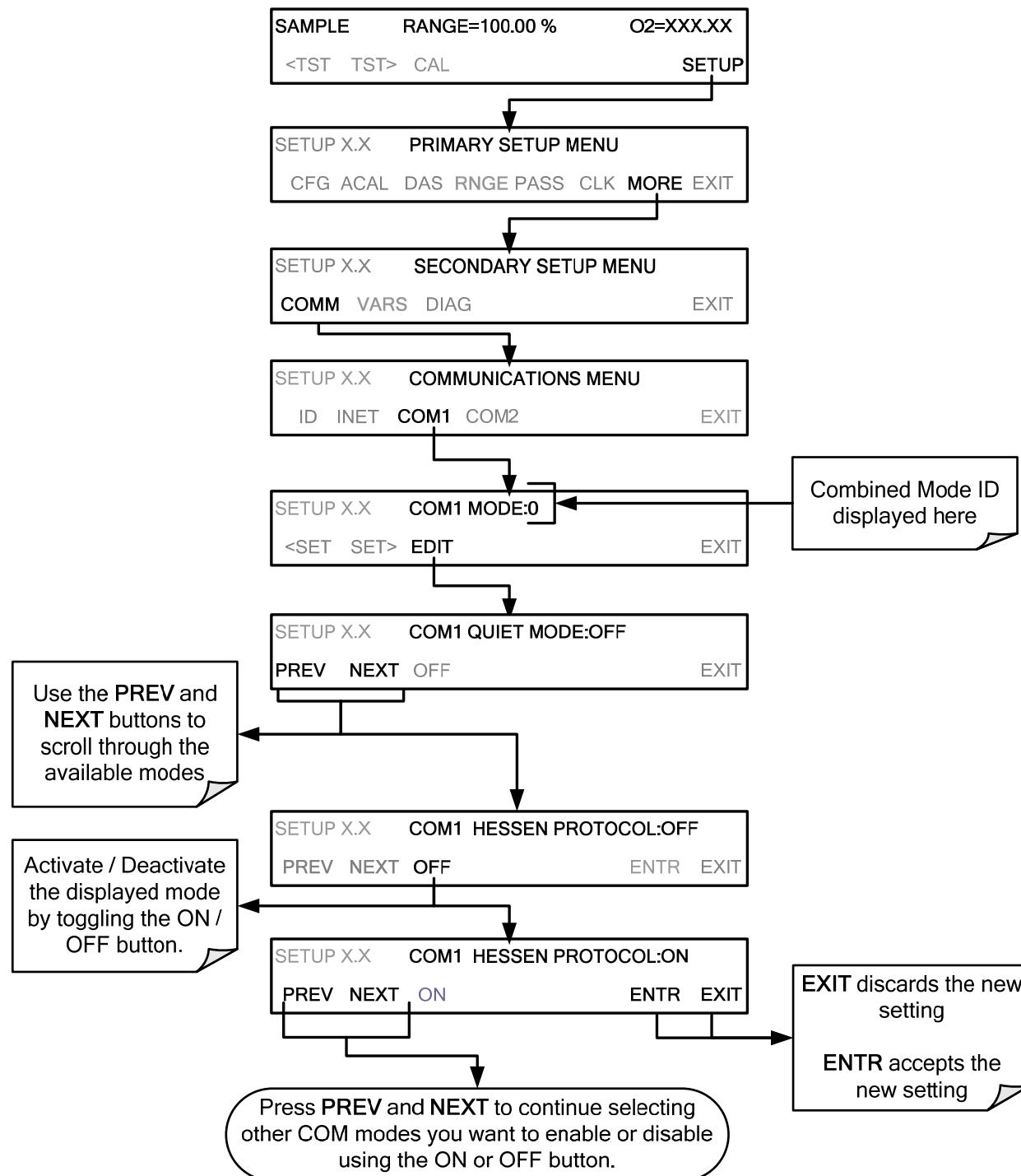
¹ Modes are listed in the order in which they appear in the
SETUP → MORE → COM → COM[1 OR 2] → MODE menu

² The default setting for this feature is **ON**. Do not disable unless instructed to by Teledyne API Technical Support personnel.

Note

Communication Modes for each COM port must be configured independently.

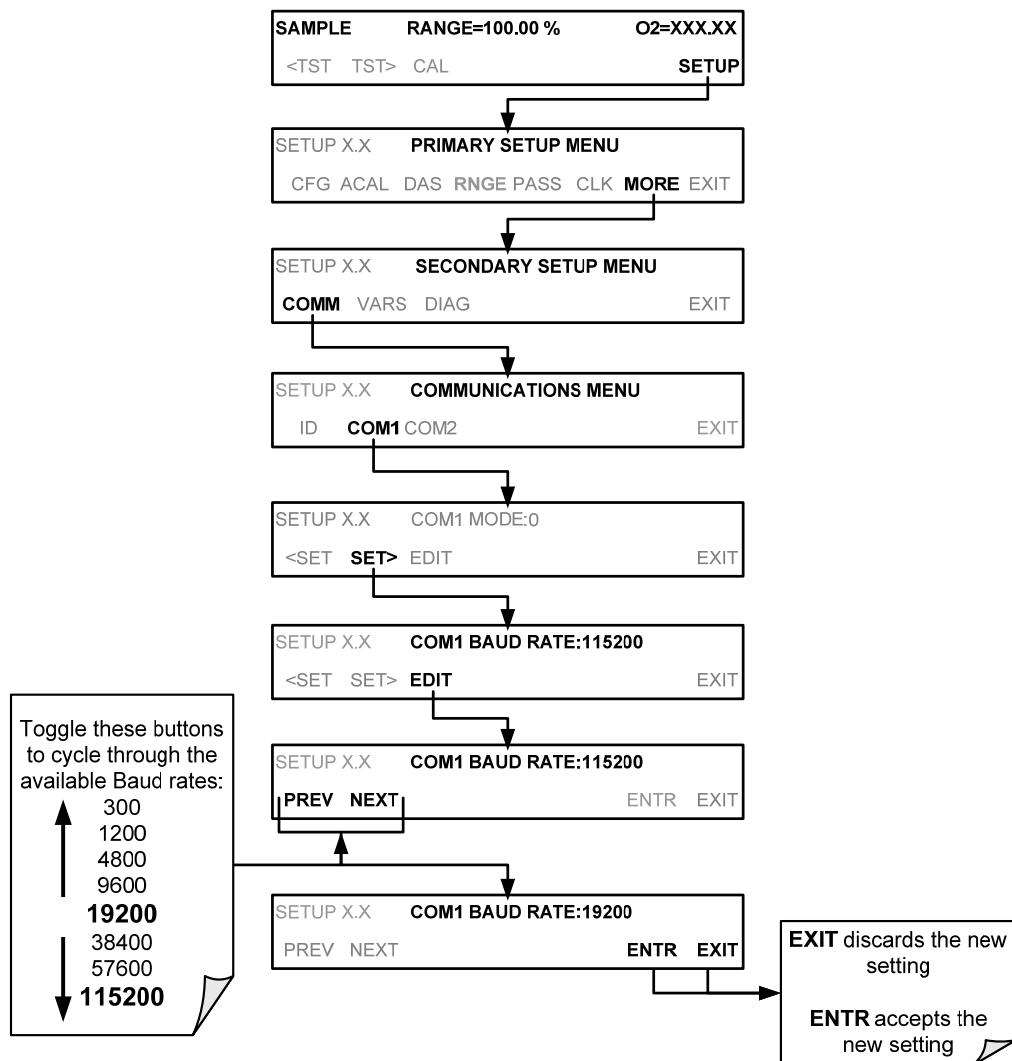
Press the following button sequence to select communication modes for one of the COM Ports, such as the following example where **HESSEN** is enabled:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

6.2.2. COM PORT BAUD RATE

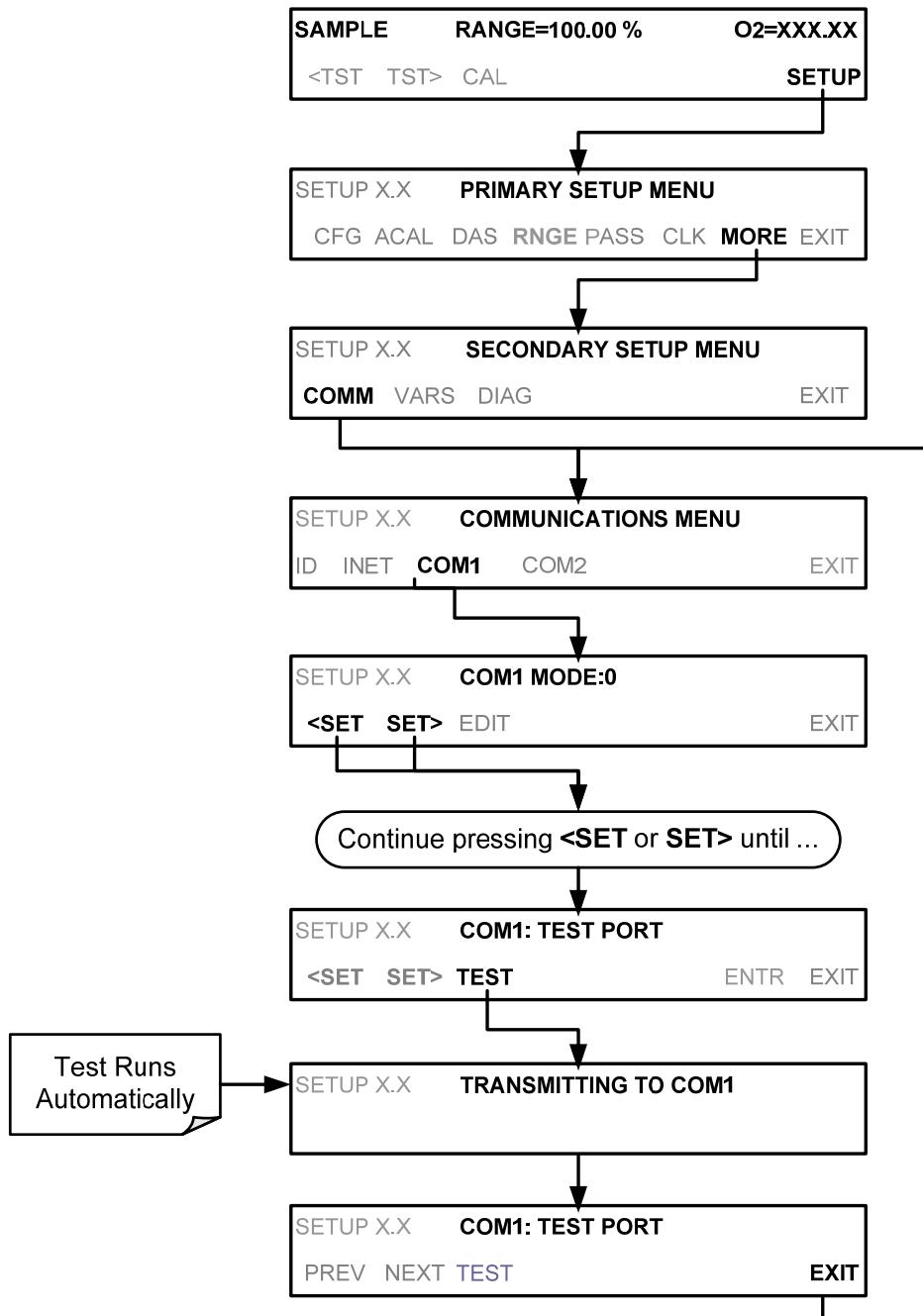
To select the baud rate of either of the COM Ports, go to SETUP>MORE>COMM and select either COM1 or COM2 as follows:



6.2.3. COM PORT TESTING

The serial ports can be tested for correct connection and output in the **COM** menu. This test sends a string of 256 'w' characters to the selected COM port. While the test is running, the red LED on the rear panel of the analyzer should flicker.

To initiate the test press the following menu sequence.



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

6.3. REMOTE ACCESS VIA THE ETHERNET

For network or Internet communication, 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 Internet to the analyzer using APICOM, terminal emulators or other programs.

The Ethernet cable connector on the rear panel has two LEDs indicating the Ethernet's current operating status.

Table 6-2: Ethernet Status Indicators

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

The analyzer is shipped with DHCP enabled by default. This allows the instrument to be connected to a network or router with a DHCP server. The instrument will automatically be assigned an IP address by the DHCP server. This configuration is useful for quickly getting an instrument up and running on a network. However, for permanent Ethernet connections, a static IP address should be used. Section 6.3.2 details how to configure the instrument with a static IP address.

6.3.1. CONFIGURING THE ETHERNET INTERFACE USING DHCP

The Ethernet for your T802 uses Dynamic Host Configuration Protocol (DHCP) to configure its interface with your LAN automatically. This requires that your network servers also be running DHCP. The analyzer will do this the first time you turn the instrument on after it has been physically connected to your network.

Note

Check the INET settings the first time you power up your analyzer after it has been physically connected to the LAN/Internet to make sure that the DHCP has successfully downloaded the appropriate information from your network server(s). The Ethernet configuration properties (Table 6-3) are viewable via the analyzer's front panel display.

Table 6-3: LAN/Internet Configuration Properties

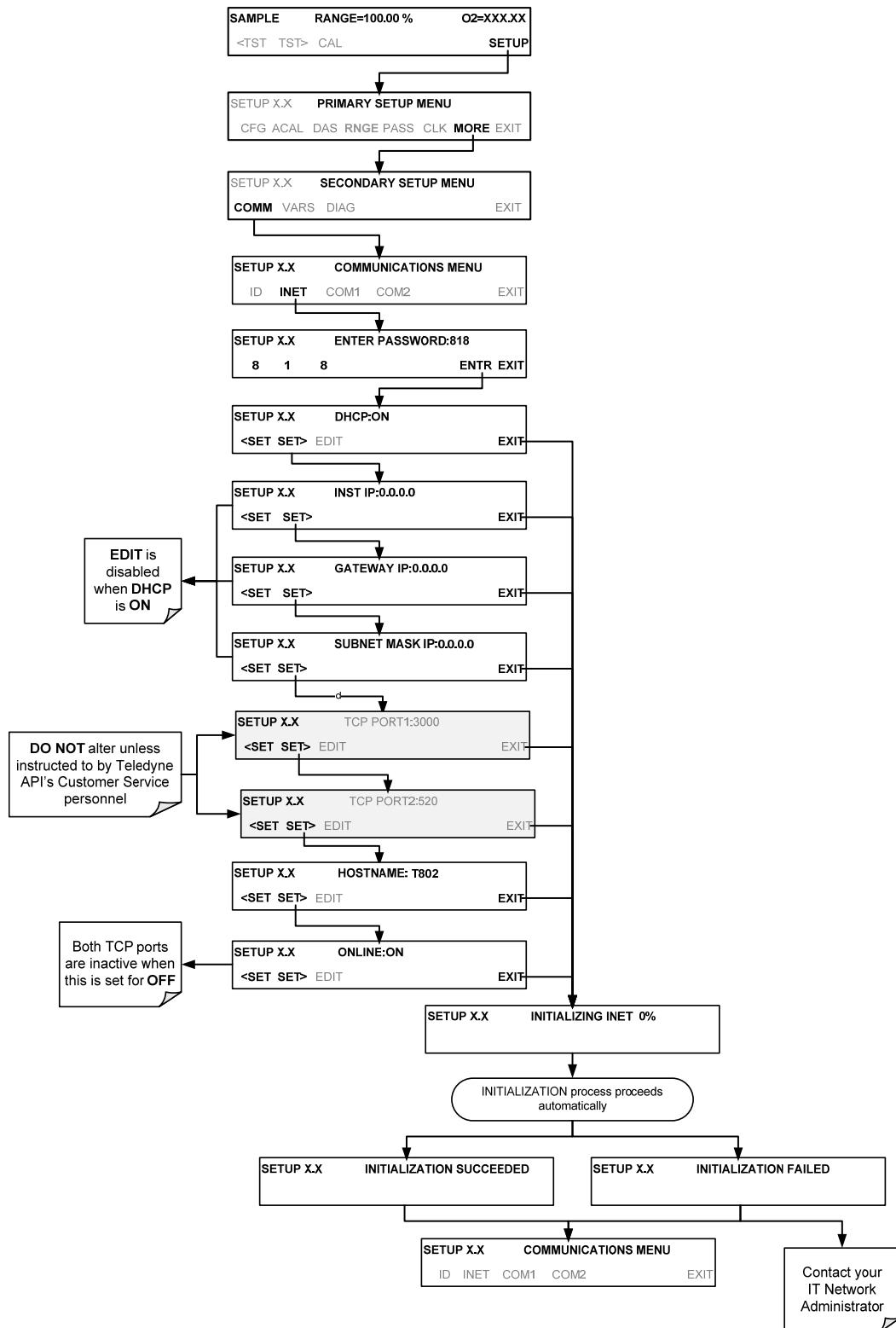
PROPERTY	DEFAULT STATE	DESCRIPTION
DHCP	ON	This displays whether the DHCP is turned ON or OFF. Press EDIT and toggle ON for automatic configuration after first consulting network administrator.
INSTRUMENT IP ADDRESS		This string of four packets of 1 to 3 numbers each (e.g. 192.168.76.55.) is the address of the analyzer itself.
GATEWAY IP ADDRESS	0.0.0.0	Can only be edited when DHCP is set to OFF. 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 to access the Internet.
SUBNET MASK	0.0.0.0	Can only be edited when DHCP is set to OFF. Also a string of four packets of 1 to 3 numbers each (e.g. 255.255.252.0) that 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.
TCP PORT¹	3000	This number defines the terminal control port by which the instrument is addressed by terminal emulation software, such as Internet or Teledyne API's APICOM.
HOST NAME	T802	The name by which your analyzer will appear when addressed from other computers on the LAN or via the Internet. To change, see Section 6.3.2.1.

¹ Do not change the setting for this property unless instructed to by Teledyne API's Technical Support personnel.

Note

If the gateway IP, instrument IP and the subnet mask are all zeroes (e.g. "0.0.0.0"), the DHCP was not successful in which case you may have to configure the analyzer's Ethernet properties manually. See your network administrator.

To view the above properties listed in Table 6-3, press:



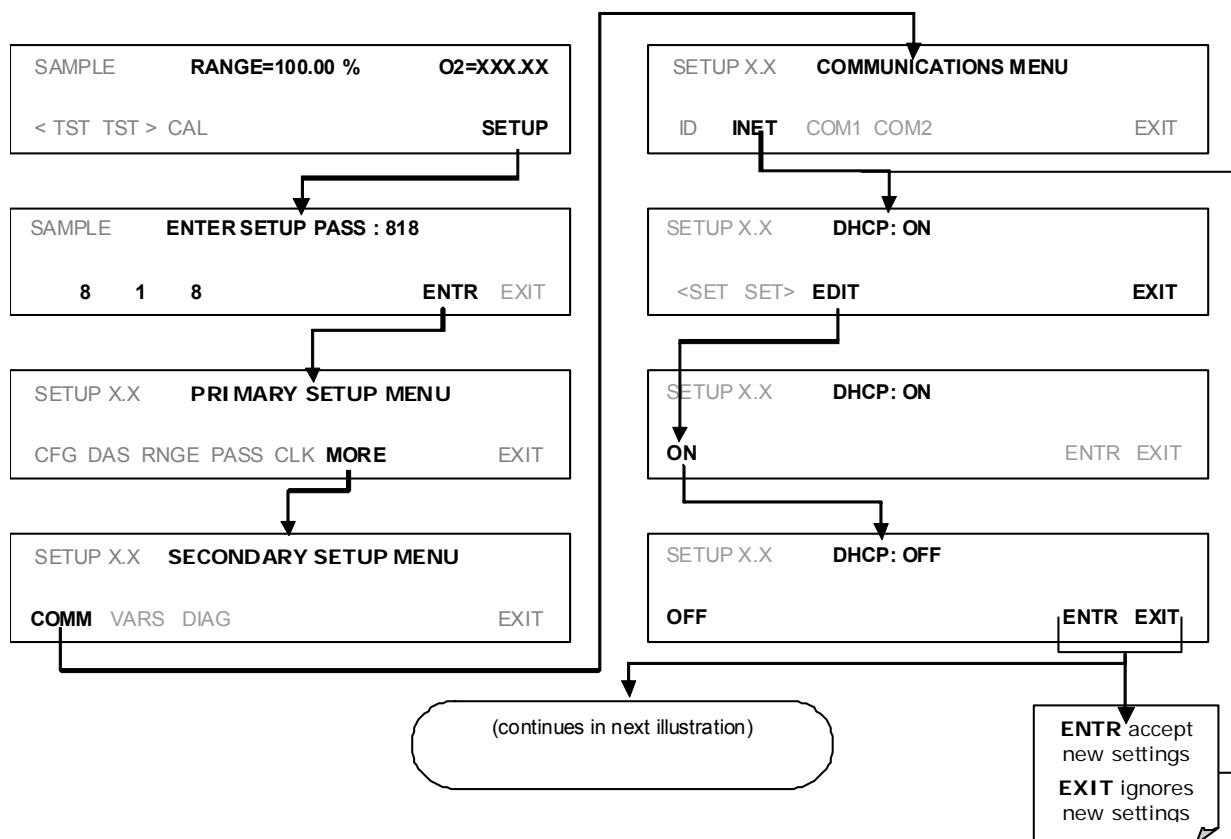
(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

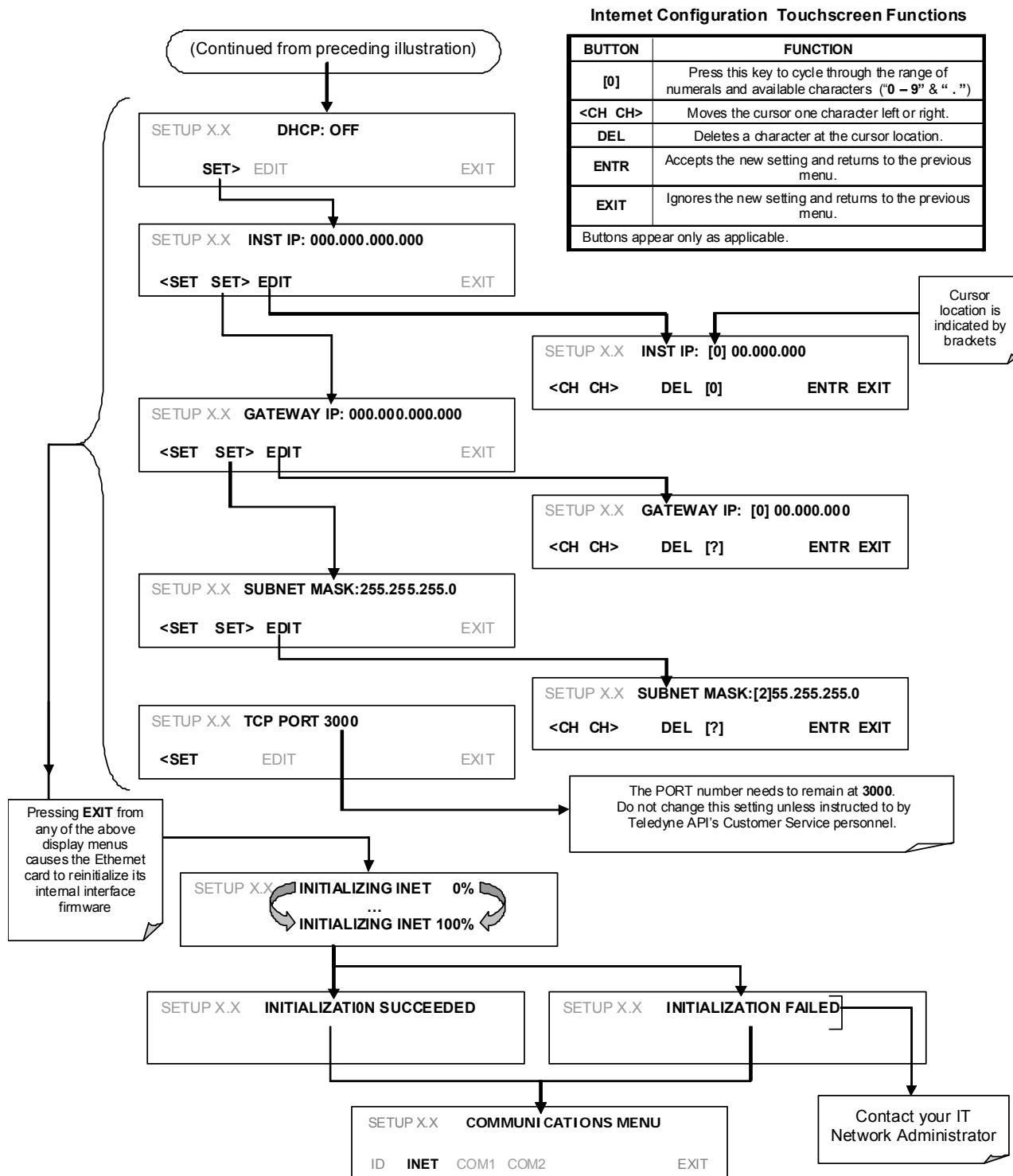
6.3.2. MANUALLY CONFIGURING THE NETWORK IP ADDRESSES

There are several circumstances when you may need to configure the interface settings of the analyzer's Ethernet card manually:

- your LAN is not running a DHCP software package
- the DHCP software is unable to initialize the analyzer's interface
- you wish to create a static IP (recommended)

1. Connect a cable from the analyzer's Ethernet port to a Local Area Network (LAN) or Internet port.
2. Access Ethernet configuration through: SETUP>MORE>COMM>INET.
3. Follow the setup sequence as shown in the illustrations that follow, and edit the Instrument and Gateway IP addresses and Subnet Mask to the desired settings. (From the computer, enter the same information through an application such as HyperTerminal).



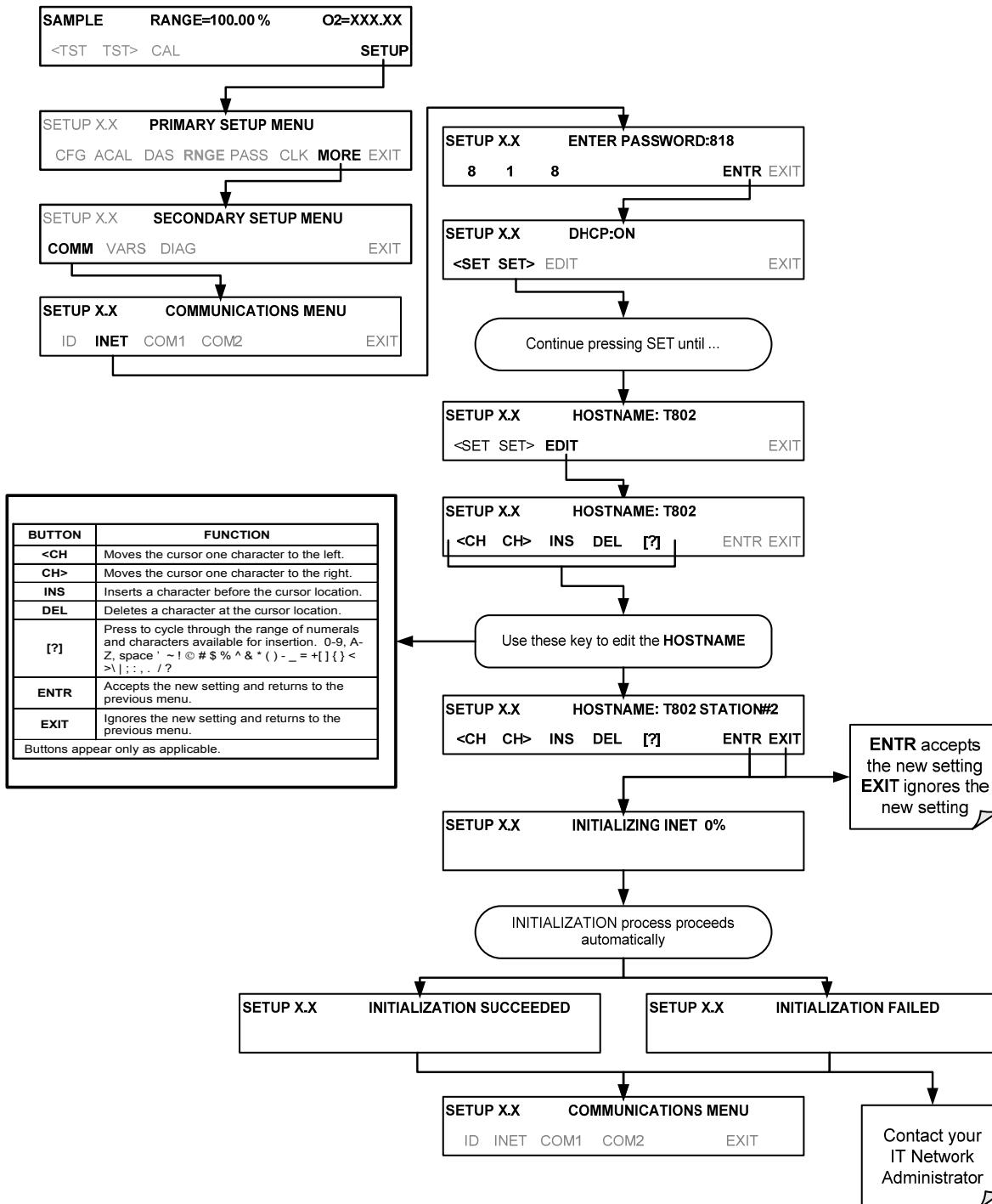


6.3.2.1. CHANGING THE ANALYZER'S HOSTNAME

The **HOSTNAME** is the name by which the analyzer appears on your network.

- The default name for all Teledyne API T802 analyzers is **T802**.

To change this name (particularly if you have more than one T802 analyzer on your network), press:

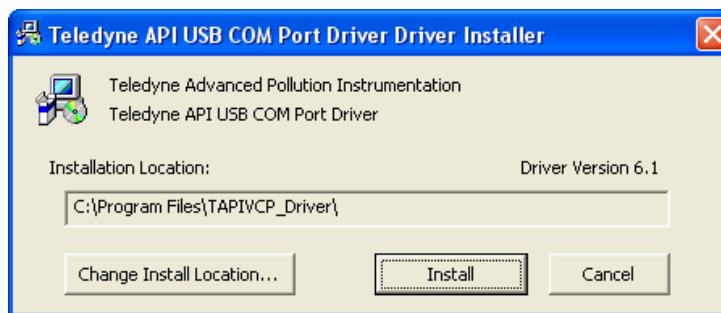


(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

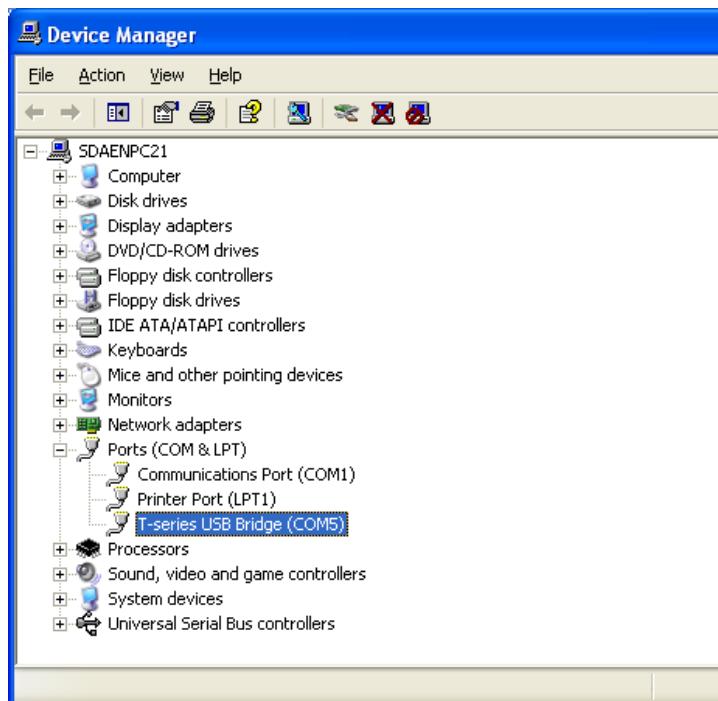
6.4. USB PORT FOR REMOTE ACCESS

The analyzer can be operated through a personal computer by downloading the TAPI USB driver and directly connecting their respective USB ports.

1. Install the Teledyne T-Series USB driver on your computer, downloadable from the Teledyne API website under Help Center>Software Downloads (www.teledyne-api.com/software).
2. Run the installer file: "TAPIVCPInstaller.exe"



3. Connect the USB cable between the USB ports on your personal computer and your analyzer. The USB cable should be a Type A – Type B cable, commonly used as a USB printer cable.
4. Determine the Windows XP Com Port number that was automatically assigned to the USB connection. (Start → Control Panel → System → Hardware → Device Manager). This is the com port that should be set in the communications software, such as APICOM or Hyperterminal.

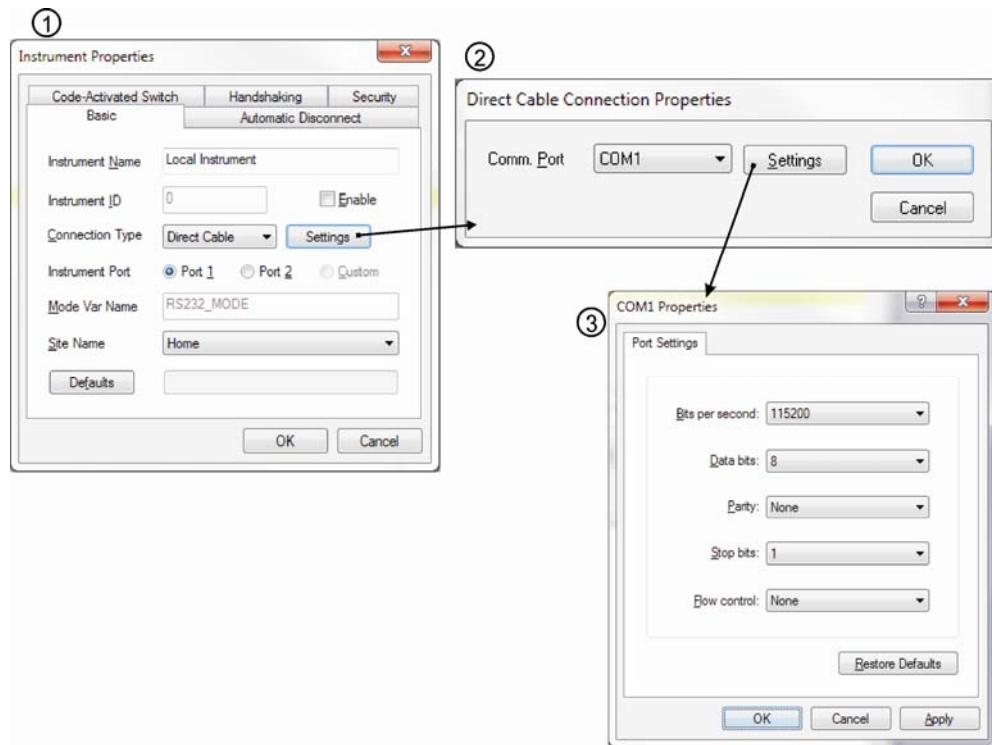


Refer to the Quick Start (*Direct Cable Connection*) section of the Teledyne APICOM Manual, PN 07463.

5. In the instrument's SETUP>MORE>COMM>COM2 menu, make the following settings:

Baud Rate: 115200			
COM2 Mode Settings:			
Quiet Mode	ON	SECURITY MODE	OFF
Computer Mode	ON	MULTIDROP MODE	OFF
MODBUS RTU	OFF	ENABLE MODEM	OFF
MODBUS ASCII	OFF	ERROR CHECKING	ON
E,8,1 MODE	OFF	XON/XOFF HANDSHAKE	OFF
E,7,1 MODE	OFF	HARDWARE HANDSHAKE	OFF
RS-485 MODE	OFF	HARDWARE FIFO	ON
		COMMAND PROMPT	OFF

6. Next, configure your communications software, such as APICOM. Use the COM port determined in Step 4 and the baud rate set in Step 5. The figures below show how these parameters would be configured in the Instrument Properties window in APICOM when configuring a new instrument. See the APICOM manual (PN 07463) for more details.



Note

- **USB configuration requires that the baud rates of the instrument and the PC match; check the PC baud rate and change if needed.**
- **Using the USB port disallows use of the rear panel COM2 port except for multidrop communication.**

6.5. COMMUNICATIONS PROTOCOLS

This section presents MODBUS and HESSEN information.

6.5.1. MODBUS SETUP

The following set of instructions assumes that the user is familiar with MODBUS communications, and provides minimal information to get started. For additional instruction, please refer to the Teledyne API MODBUS manual, PN 06276. Also refer to www.modbus.org for MODBUS communication protocols.

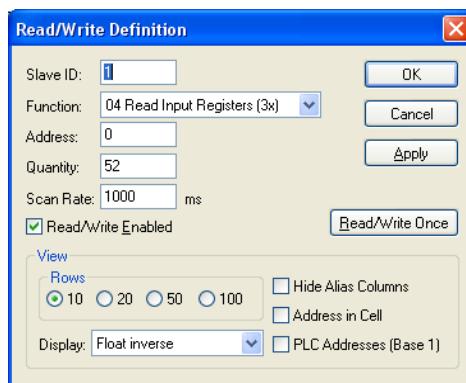
Minimum Requirements

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

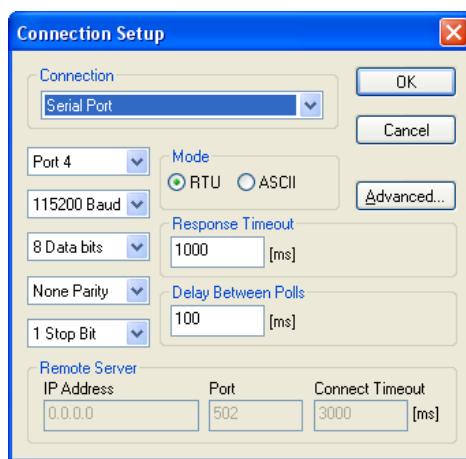
Actions

Set Com Mode parameters	Comm	Ethernet: Using the front panel menu, go to SETUP – MORE – COMM – INET; scroll through the INET submenu until you reach TCP PORT 2 (the standard setting is 502), then continue to TCP PORT 2 MODBUS TCP/IP; press EDIT and toggle the menu button to change the setting to ON, then press ENTR. (Change Machine ID if needed: see “Slave ID”). USB/RS232: Using the front panel menu, go to SETUP – MORE – COMM – COM2 – EDIT; scroll through the COM2 EDIT submenu until the display shows COM2 MODBUS RTU: OFF (press OFF to change the setting to ON. Scroll NEXT to COM2 MODBUS ASCII and ensure it is set to OFF. Press ENTR to keep the new settings. (If RTU is not available with your communications equipment, set the COM2 MODBUS ASCII setting to ON and ensure that COM2 MODBUS RTU is set to OFF. Press ENTR to keep the new settings).
Reboot analyzer		For the settings to take effect, power down the analyzer, wait 5 seconds, and power up the analyzer.
Make appropriate cable connections		Connect your analyzer either: <ul style="list-style-type: none"> via its Ethernet or USB port to a PC (this may require a USB-to-RS232 adapter for your PC; if so, also install the software driver from the CD supplied with the adapter, and reboot the computer if required), or via its COM2 port to a null modem (this may require a null modem adapter or cable).
Specify MODBUS software settings (examples used here are for MODBUS Poll software)		<ol style="list-style-type: none"> Click Setup / [Read / Write Definition] /. <ul style="list-style-type: none"> In the Read/Write Definition window (see example that follows) select a Function (what you wish to read from the analyzer). Input Quantity (based on your firmware’s register map). In the View section of the Read/Write Definition window select a Display (typically Float Inverse). Click OK. Next, click Connection/Connect. <ul style="list-style-type: none"> In the Connection Setup window (see example that follows), select the options based on your computer. Press OK.
Read the MODBUS Poll Register		Use the Register Map to find the test parameter names for the values displayed (see example that follows). If desired, assign an alias for each.

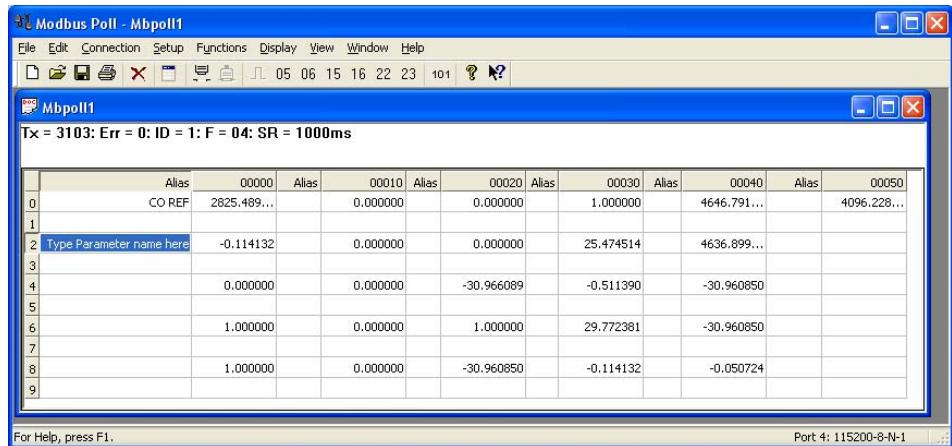
Example Read/Write Definition window:



Example Connection Setup window:



Example MODBUS Poll window:



6.5.2. HESSEN

The Hessen protocol is a multidrop protocol, in which several remote instruments are connected via a common communications channel to a host computer. The remote instruments are regarded as slaves of the host computer. The remote instruments are unaware that they are connected to a multidrop bus and never initiate Hessen protocol messages. They only respond to commands from the host computer and only when they receive a command containing their own unique ID number.

The Hessen protocol is designed to accomplish two things: to obtain the status of remote instruments, including the concentrations of all the gases measured; and to place remote instruments into zero or span calibration or measure mode. API's implementation supports both of these principal features.

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

Note	The following sections describe the basics for setting up your instrument to operate over a Hessen Protocol network. For more detailed information as well as a list of host computer commands and examples of command and response message syntax, download the <i>Manual Addendum for Hessen Protocol</i> from the Teledyne API web site: http://www.teledyne-api.com/manuals/.
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6.5.2.1. HESSEN COM PORT CONFIGURATION

Hessen protocol requires the communication parameters of the T802's COM ports to be set differently than the standard configuration as shown in the table below.

Table 6-4: RS-232 Communication Parameters for Hessen Protocol

PARAMETER	STANDARD	HESSEN
Baud Rate	300 – 115200	1200
Data Bits	8	7
Stop Bits	1	2
Parity	None	Even
Duplex	Full	Half

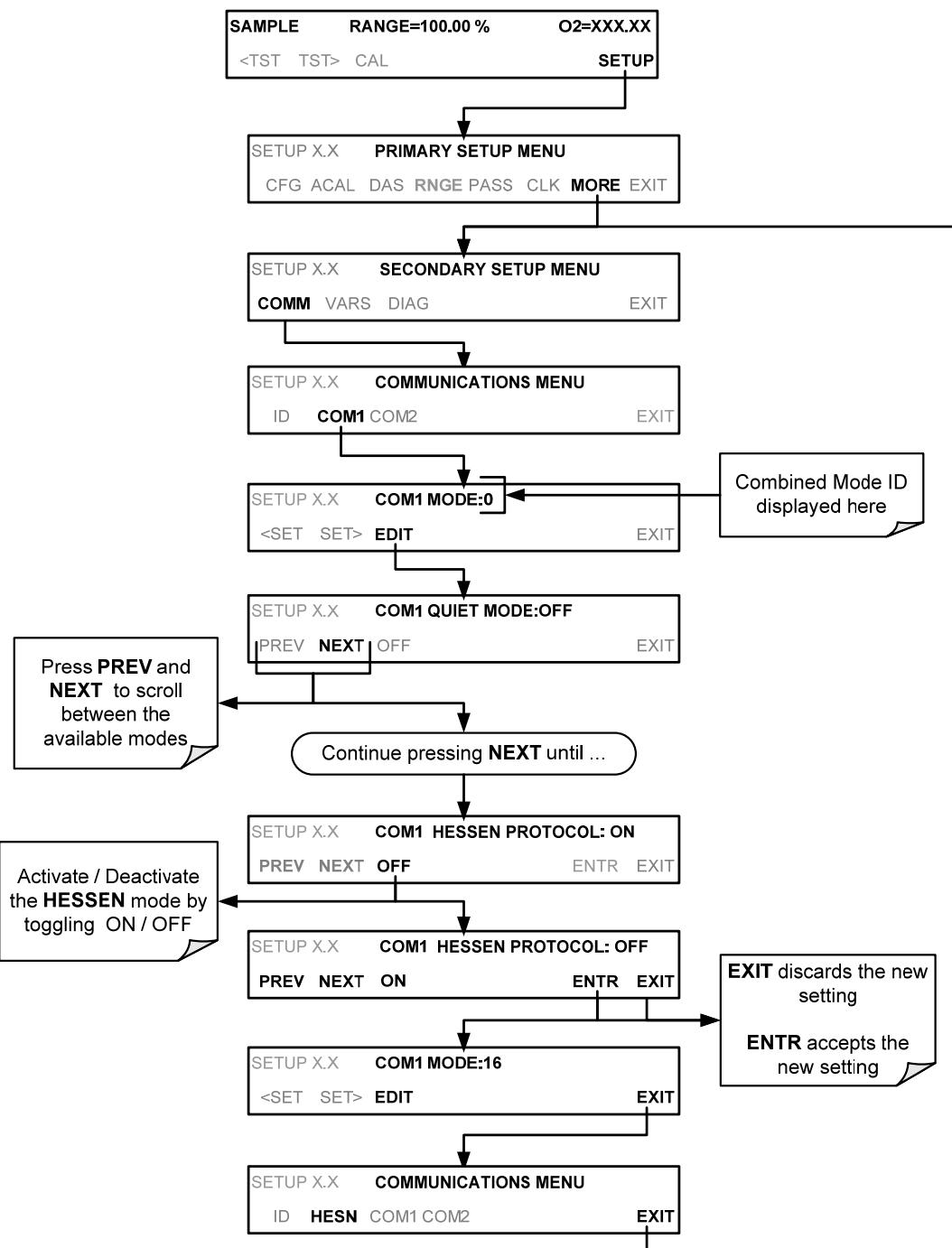
To change the baud rate of the T802's COM ports, See Section 6.2.2.

To change the rest of the COM port parameters listed in the table above, see Section 6.2 and Table 6-1.

Note	Make sure that the communication parameters of the host computer are also properly set.
	In addition, rather than issuing commands to the instrument in rapid succession, bear in mind that the instrument software has a 200 ms latency period before it responds to commands issued by the host computer.

6.5.2.2. ACTIVATING HESSEN PROTOCOL

Once the COM port has been properly configured, the next step in configuring the T802 to operate over a Hessen protocol network is to activate the Hessen mode for COM ports and configure the communication parameters for the port(s) appropriately. Press:



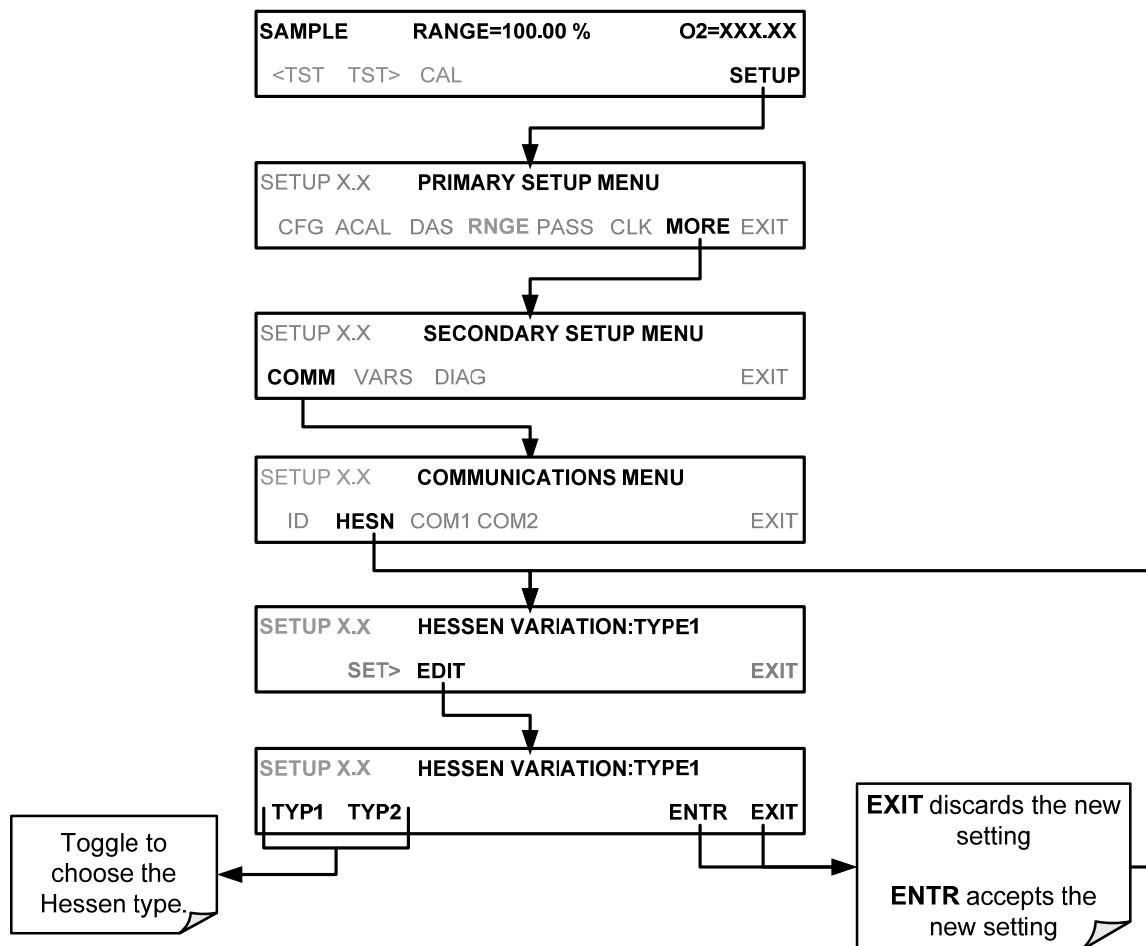
(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

6.5.2.3. SELECTING A HESSEN PROTOCOL TYPE

Currently there are two versions of Hessen Protocol in use. The original implementation, referred to as **TYPE 1**, and a more recently released version, **TYPE 2** that has more flexibility when operating with instruments that can measure more than one type of gas.

For more specific information about the difference between **TYPE 1** and **TYPE 2** download the *Manual Addendum for Hessen Protocol* from the Teledyne API web site: <http://www.teledyne-api.com/manuals/>.

To select a Hessen Protocol Type press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

Note

While Hessen Protocol Mode can be activated independently for COM1 and COM2, The TYPE selection affects both ports.

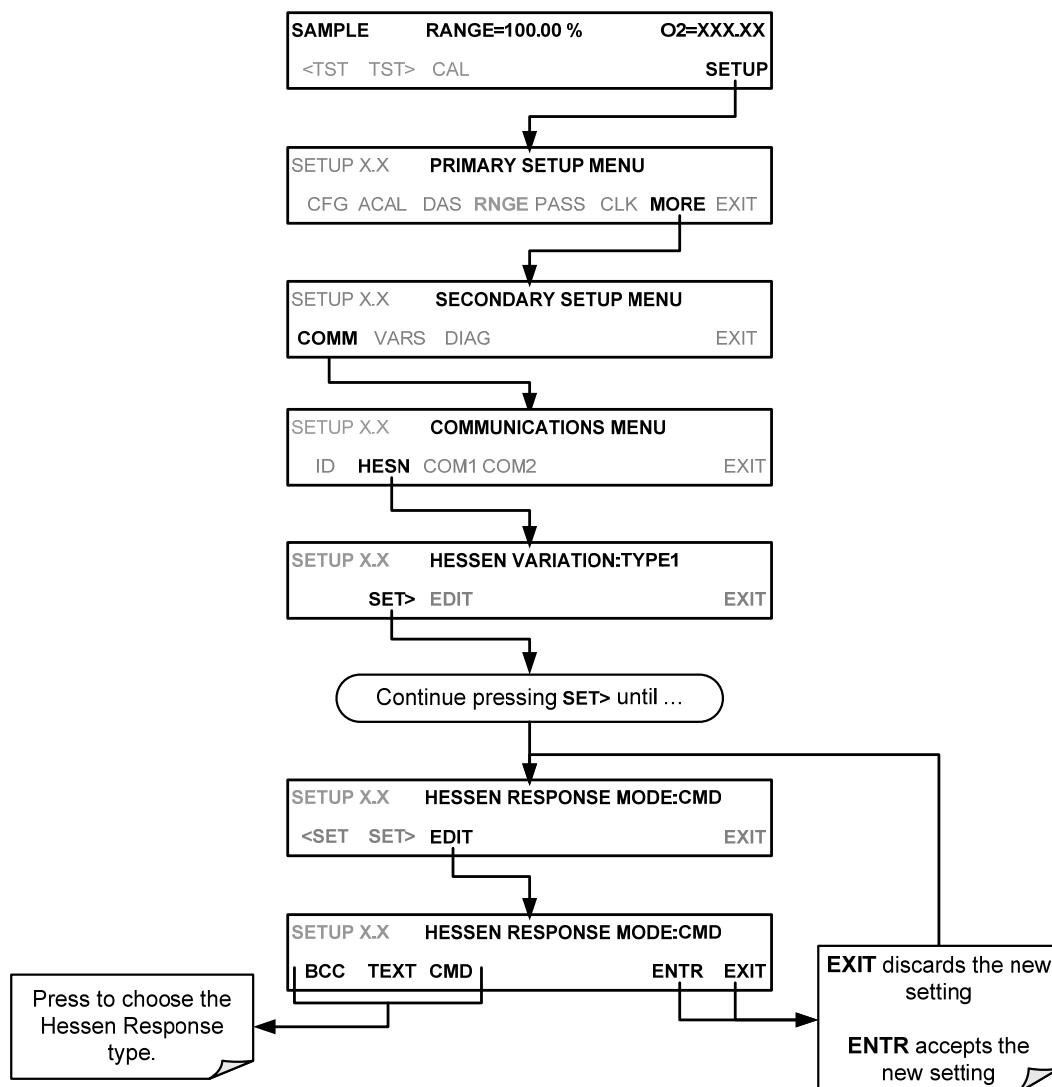
6.5.2.4. SETTING THE HESSEN PROTOCOL RESPONSE MODE

The Teledyne API implementation of Hessen Protocol allows the user to choose one of several different modes of response for the analyzer.

Table 6-5: Teledyne API 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.

To Select a Hessen response mode, press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

6.5.2.5. GAS LIST ENTRY FORMAT AND DEFINITIONS

The T802 analyzer keeps a list of available gas types. Each entry in this list is of the following format.

[GAS TYPE],[RANGE],[GAS ID],[REPORTED]

WHERE:

GAS TYPE = The type of gas being reported (e.g. O₂, CO₂).

RANGE = The concentration range for this entry in the gas list. This feature permits the user to select which concentration range will be used for this gas list entry. The T802 analyzer has two ranges: **RANGE1** or LOW and **RANGE2** or HIGH (See Section 5.4.1).

- 0 -The HESSEN protocol to use whatever range is currently active.
- 1 -The HESSEN protocol will always use **RANGE1** for this gas list entry
- 2 -The HESSEN protocol will always use **RANGE2** for this gas list entry
- 3 -Not applicable to the T802 analyzer.

GAS ID = An identification number assigned to a specific gas. In the case of the T802 analyzer in its base configuration, there is only one gas O₂, and its default GAS ID is 110. This ID number should not be modified.

REPORT = States whether this list entry is to be reported or not reported whenever this gas type or instrument is polled by the HESSEN network. If the list entry is not to be reported this field will be blank.

The T802 analyzer is a single gas instrument that measures O₂. Thus the default gas list entry would be:

O2, 0, 110, REPORTED

No default gas list entry exists for CO₂. If the optional CO₂ sensor is installed, the following gas list entry should be added: **CO2, 0, 111, REPORTED**

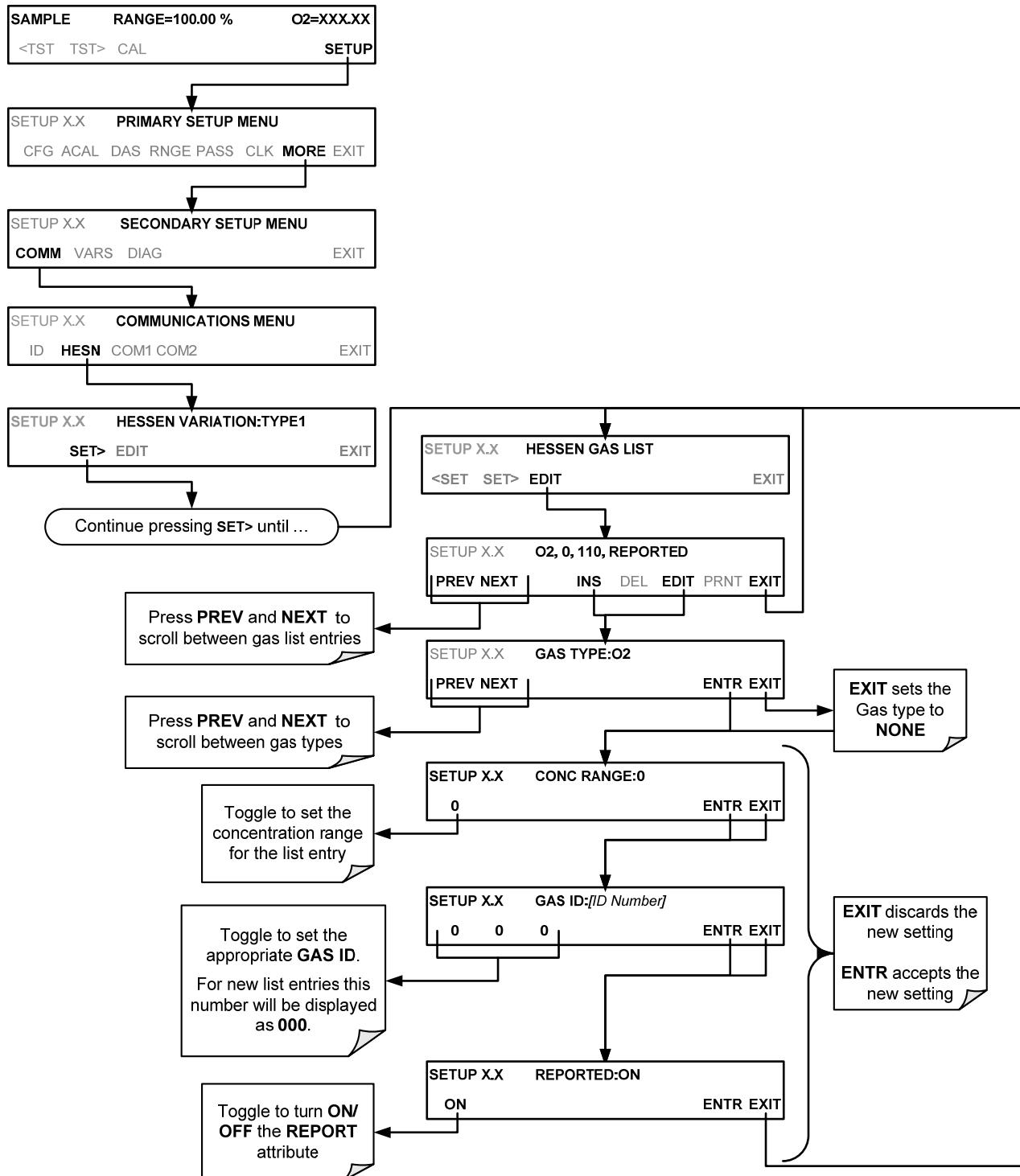
These default settings cause the instrument to report the concentration value of the currently active range. If you wish to have just concentration values stored for a specific range, this list entry should be edited or additional entries should be added (see Section 6.5.2.6).

EXAMPLE:

Changing the above O₂ gas list entry to read **O2, 2, 110, REPORTED** while **RANGE2** (HIGH) range was active would cause only the last O₂ reading to be recorded.

6.5.2.6. EDITING OR ADDING HESSEN GAS LIST ENTRIES

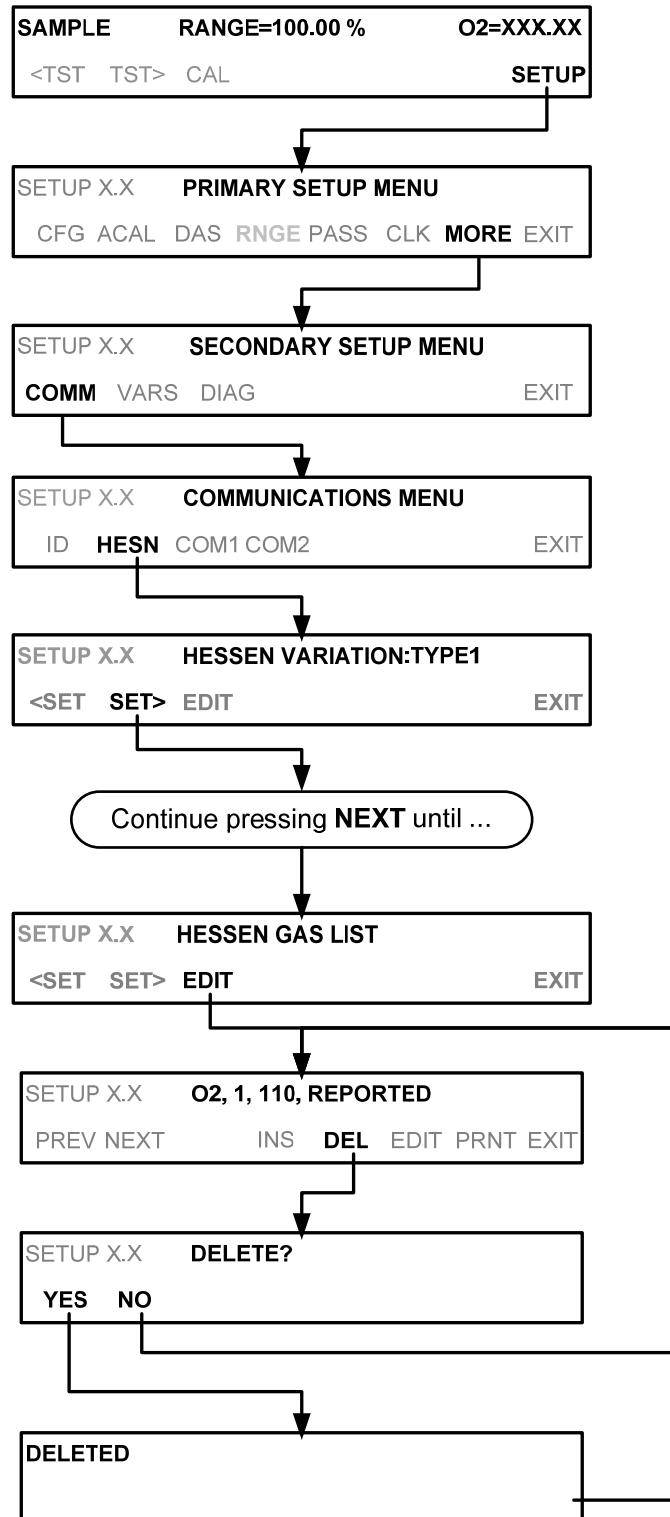
To add or edit an entry to the Hessen Gas List, press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

6.5.2.7. DELETING HESSEN GAS LIST ENTRIES

To delete an entry from the Hessen Gas list, press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

6.5.2.8. SETTING HESSEN PROTOCOL STATUS FLAGS

Teledyne API's implementation of Hessen protocols includes a set of status bits that the instrument includes in responses to inform the host computer of its condition. Each bit can be assigned to one operational and warning message flag. The default settings for these bit/flags are:

Table 6-6: Default Hessen Status Flag Assignments

STATUS FLAG NAME	DEFAULT BIT ASSIGNMENT
WARNING FLAGS¹	
SAMPLE FLOW WARNING	0001
INVALID CONC (The instrument's front panel display will show the concentration as "Warnings")	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 2²
O2 CELL TEMP WARN	ANALOG CAL WARNING
CO2 CELL TEMP WARN	CAL MP O2
SAMPLE PRESS WARN	CAL MP CO2
RELAY BOARD WARN	REAR BOARD NOT DET
CANNOT DYN SPAN	SYSTEM RESET
CANNOT DYN ZERO	CO2 CONC ALARM 1²
O2 CONC ALARM 1²	CO2 CONC ALARM 2²

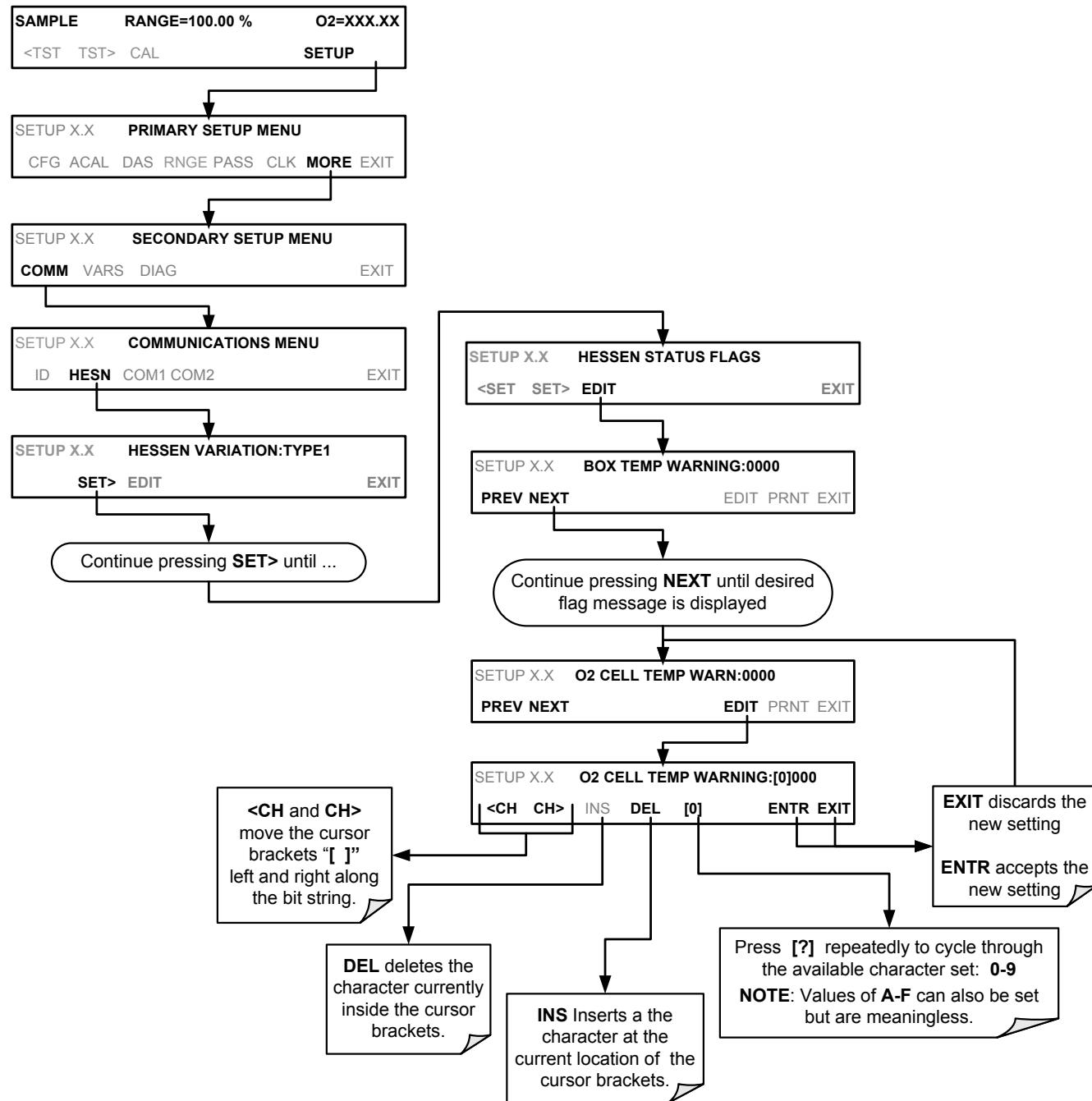
¹ These status flags are standard for all instruments and should probably not be modified.

² Only applicable if the analyzer is equipped with an alarm option.

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. *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.*

⁴ While these units are assigned flags, they are not applicable in the T802 which reports in % when measuring O₂ and when reporting CO₂.

To assign or reset the status flag bit assignments, press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

6.5.2.9. INSTRUMENT ID

Each instrument on a Hessen Protocol network must have a unique ID code. If more than one T802 analyzer is on the Hessen network, you will have to change this code for all but one of the T802 analyzer's on the Hessen network (see Section 5.7.1). The default **ID** code for the T802 analyzers is either **"0"** or **802**.

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7. DATA ACQUISITION SYSTEM (DAS) & APICOM

The T802 analyzer contains a flexible and powerful, internal data acquisition system (DAS) that enables the analyzer to store concentration and calibration data as well as a host of diagnostic parameters. The DAS is capable of capturing several months worth of data depending on how it is configured. The data are stored in non-volatile memory and are retained even when the instrument is powered off. Data are stored in plain text format for easy retrieval and use in common data analysis programs (such as spreadsheet-type programs).

The DAS is designed to be flexible; users have full control over the type, length and reporting time of the data. The DAS permits users to access stored data through the instrument's front panel or its communication ports.

The principle use of the DAS is logging data for trend analysis and predictive diagnostics, which can assist in identifying possible problems before they affect the functionality of the analyzer. The secondary use is for data analysis, documentation and archival in electronic format.

To support the DAS functionality, Teledyne API offers APICOM, a program that provides a visual interface for remote or local setup, configuration and data retrieval of the DAS. The APICOM manual (included with the program), contains a more detailed description of the DAS structure and configuration, which is briefly described here.

The T802 includes a basic DAS configuration, which is enabled by default. New data channels are also enabled by default, but each channel may be turned off for later or occasional use.

Note

The DAS can be disabled only by disabling or deleting its individual data channels.

The green SAMPLE LED on the instrument front panel, which indicates the analyzer status, also indicates certain aspects of the DAS status:

Table 7-1: Front Panel LED Status Indicators for DAS

LED STATE	DAS STATUS
steady off	System is in calibration mode. Data logging can be enabled or disabled for this mode. Calibration data are typically stored at the end of calibration periods, concentration data are typically not sampled, diagnostic data should be collected.
blinking	Instrument is in hold-off mode, a short period after the system exits calibrations. DAS channels can be enabled or disabled for this period. Concentration data are typically disabled whereas diagnostic should be collected.
steady on	Sampling normally.

IMPORTANT**IMPACT ON READINGS OR DATA**

DAS operation is suspended whenever its configuration is edited using the analyzer's front panel and therefore data may be lost. To prevent such data loss, it is recommended to use the APICOM graphical user interface for DAS changes. Please be aware that all stored data will be erased if the analyzer's disk-on-module or CPU board is replaced or if the configuration data stored there is reset..

7.1. DAS STRUCTURE

The DAS is designed around the feature of a “record”. A record is a single data point. The type of data recorded in a record is defined by two properties:

- **PARAMETER** type that defines the kind of data to be stored (e.g. the average of gas concentrations measured with three digits of precision). See Section 7.1.4.3.
- A **TRIGGER** event that defines when the record is made (e.g. timer; every time a calibration is performed, etc.). See Section 7.1.4.2

The specific **PARAMETER** and **TRIGGER** events that describe an individual record are defined in a construct called a **DATA CHANNEL**. Each data channel relates one or more parameters with a specific trigger event and various other operational characteristics related to the records being made (e.g. the channel's name, number of records to be made, time period between records, whether or not the record is exported via the analyzer's RS-232 port, etc.).

7.1.1. DAS CHANNELS

The key to the flexibility of the DAS is its ability to store a large number of combinations of triggering events and data parameters in the form of data channels. Users may create up to 50 data channels and each channel can contain one or more parameters. For each channel, the following are selected:

- One triggering event is selected
- Up to 50 data parameters, which can be shared between channels.
- Several other properties that define the structure of the channel and allow the user to make operational decisions regarding the channel.

Table 7-2: DAS Data Channel Properties

PROPERTY	DESCRIPTION	DEFAULT SETTING	SETTING RANGE
NAME	The name of the data channel.	“NONE”	Up to 6 letters or digits ¹
TRIGGERING EVENT	The event that triggers the data channel to measure and store the datum	ATIMER	Any available event (see Appendix A-5).
NUMBER AND LIST OF PARAMETERS	A User-configurable list of data types to be recorded in any given channel.	1 (PMTDET)	Any available parameter (see Appendix A-5).
REPORT PERIOD	The amount of time between each channel data point.	000:01:00 (1 hour)	000:00:01 to 366:23:59 (Days:Hours:Minutes)
NUMBER OF RECORDS	The number of reports that will be stored in the data file. Once the limit is exceeded, the oldest data is over-written.	100	1 to 30,000 (max), limited by available storage space. ²
RS-232 REPORT	Enables the analyzer to automatically report channel values to the RS-232 ports.	OFF	OFF or ON
CHANNEL ENABLED	Enables or disables the channel. Allows a channel to be temporarily turned off without deleting it.	ON	OFF or ON
CAL HOLD OFF	Disables sampling of data parameters while instrument is in calibration mode. ³	OFF	OFF or ON

¹ More with APICOM, but only the first six are displayed on the front panel).

² For information regarding the maximum number of channels, parameters, and records and how to calculate the file size for each data channel, refer to the DAS manual downloadable from the TAPI website at <http://www.teledyne-api.com/manuals/> under Special Manuals.

³ When enabled records are not recorded until the DAS HOLDOFF period is passed after calibration mode. DAS HOLDOFF SET in the **VARS** menu (see Section 5.8.)

7.1.2. DEFAULT DAS CHANNELS

CONC: Samples O₂ concentration at one minute intervals and stores an average every hour with a time and date stamp. Readings during calibration and calibration **HOLD OFF** are not included in the data. By default, the last 800 hourly averages are stored.

PNUMTC: Collects sample flow and sample pressure data at five-minute intervals and stores an average once a day with a time and date stamp. This data is useful for monitoring the condition of the pump and critical flow orifice (sample flow) and the sample filter (clogging indicated by a drop in sample pressure) over time to predict when maintenance will be required. The last 360 daily averages (about 1 year) are stored.

CALDAT: Data channel logs new slope and offset of O₂ measurements each time a zero or span calibration is performed and the result changes the value of the slope (triggering event: **SLPCHG**). The O₂ stability (to evaluate if the calibration value was stable) as well as the converter efficiency (for trend reference) are also stored.

- This data channel will store data from the last 200 calibrations and can be used to document analyzer calibration; it also is useful for detecting trends in slope and offset (instrument response) when performing predictive diagnostics as part of a regular maintenance schedule.

- The CALDAT channel collects data based on events (e.g. a calibration operation) rather than a timed interval and therefore does not represent any specific length of time. As with all data channels, a date and time stamp is recorded for every logged data point.

DETAILED: Samples six different parameters related to the operating status of the analyzer's optical sensors. For each parameter:

- A value is logged once every minute;
- An average of the last 60 readings is calculated once every minute (60 seconds).
- The last 480 averages are stored (20 days).

This channel is useful for diagnosing problems that cause the instruments measurements to drift slowly over time

FAST: Almost identical to **DETAIL** except that for each parameter:

- Samples are taken once per minute and reported once per minute, in effect causing the instrument to record an instantaneous reading of each parameter every minute.
- The last 360 readings for each parameter are recorded/reported.

This channel is useful for diagnosing transients; spikes and noise problems.

These default Data Channels can be used as they are, or they can be customized from the front panel to fit a specific application. They can also be deleted to make room for custom user-programmed Data Channels.

Appendix A-5 lists the firmware-specific DAS configuration in plain-text format. This text file either can be loaded into APICOM and then modified and uploaded to the instrument, or can be copied and pasted into a terminal program to be sent to the analyzer.

IMPORTANT

IMPACT ON READINGS OR DATA

Sending a DAS configuration to the analyzer through its COM ports will replace the existing configuration and will delete all stored data. Back up any existing data and the DAS configuration before uploading new settings.

Triggering Events and Data Parameters/Functions for these default channels are:

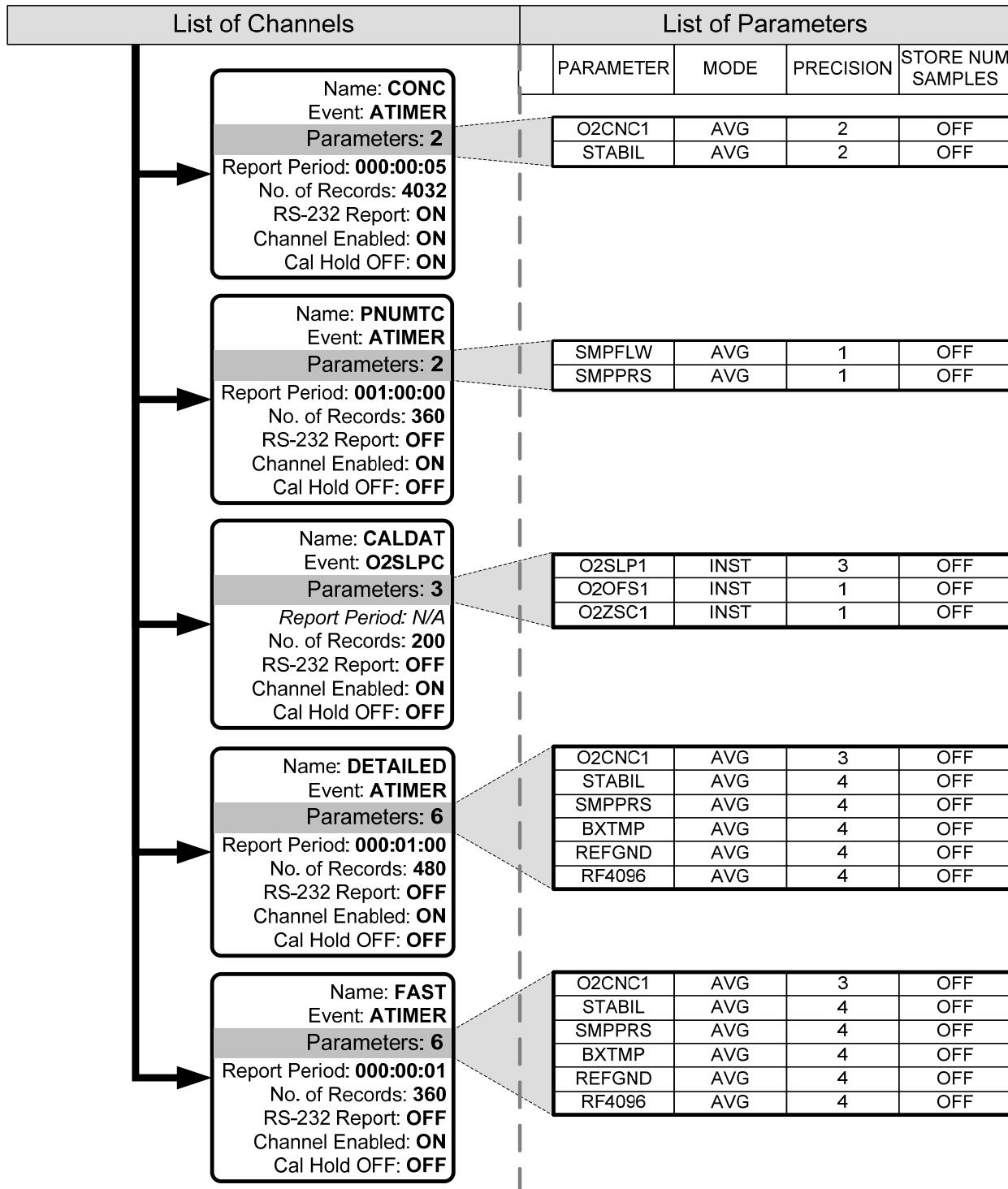
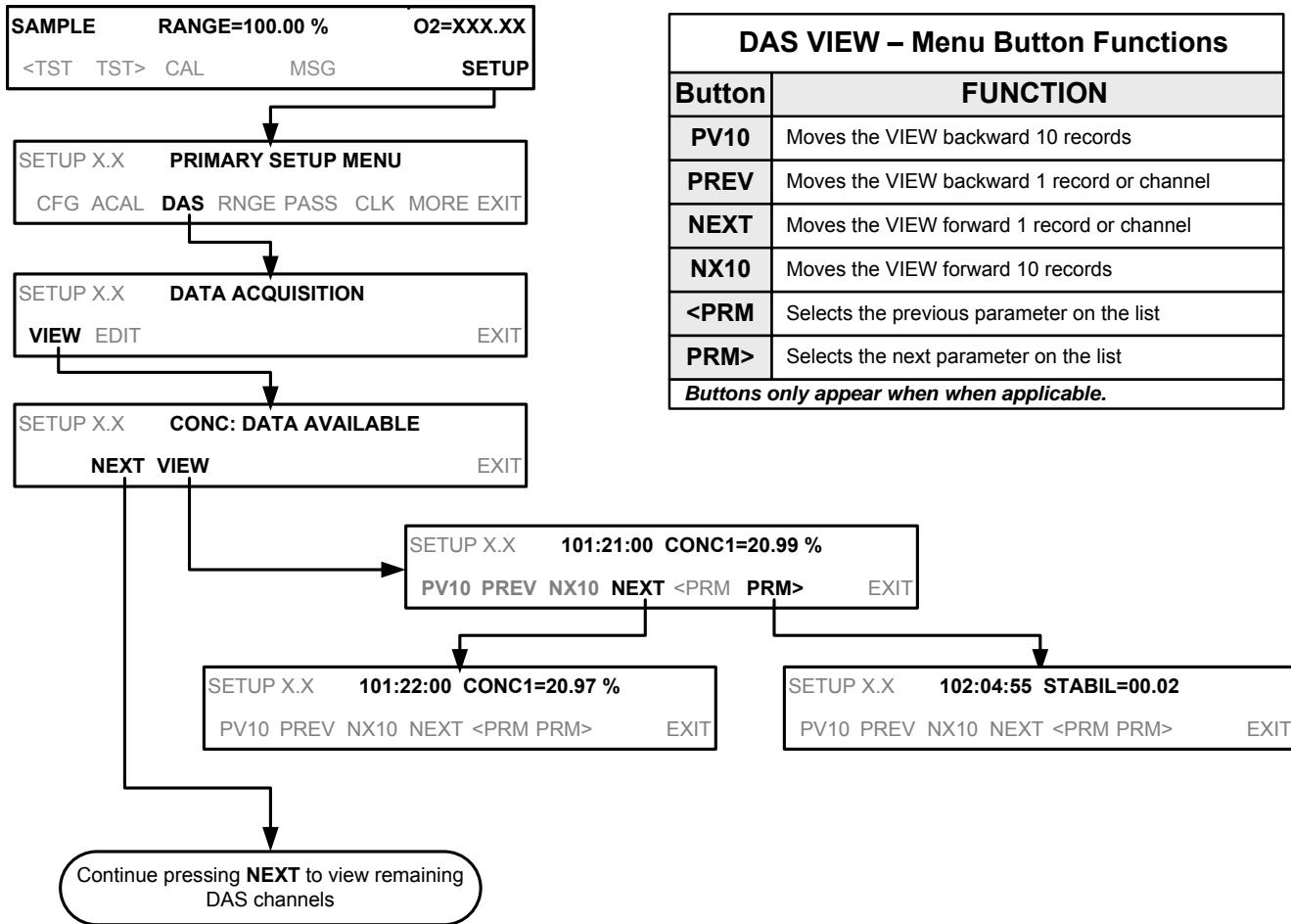


Figure 7-1: Default DAS Channel Setup

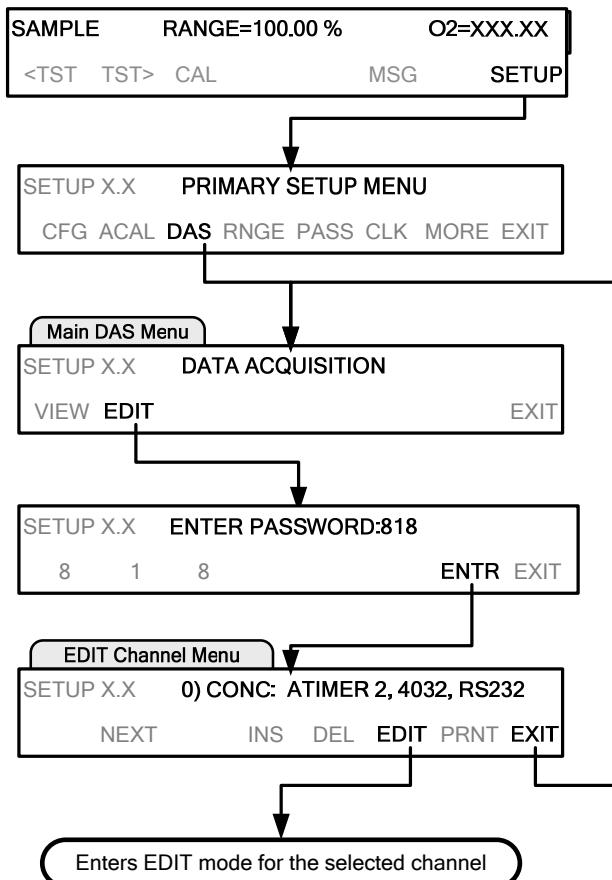
7.1.3. SETUP →DAS →VIEW: VIEWING DAS CHANNELS AND INDIVIDUAL RECORDS

DAS data and settings can be viewed on the front panel through the following keystroke sequence.



7.1.4. SETUP →DAS →EDIT: ACCESSING THE DAS EDIT MODE

DAS configuration is most conveniently done through the APICOM remote control program. The following list of key strokes shows how to edit using the front panel.



DAS EDIT - Touchscreen Functions	
Button	FUNCTION
PREV	Selects the previous data channel in the list
NEXT	Selects the next data channel in the list
INS	Inserts a new data channel into the list BEFORE the selected channel
DEL	Deletes the currently selected data channel
EDIT	Enters EDIT mode
PRINT	Exports the configuration of all data channels to the RS-232 interface

Buttons only appear when applicable.

When editing the data channels, the top line of the display indicates some of the configuration parameters.

For example, the display line:

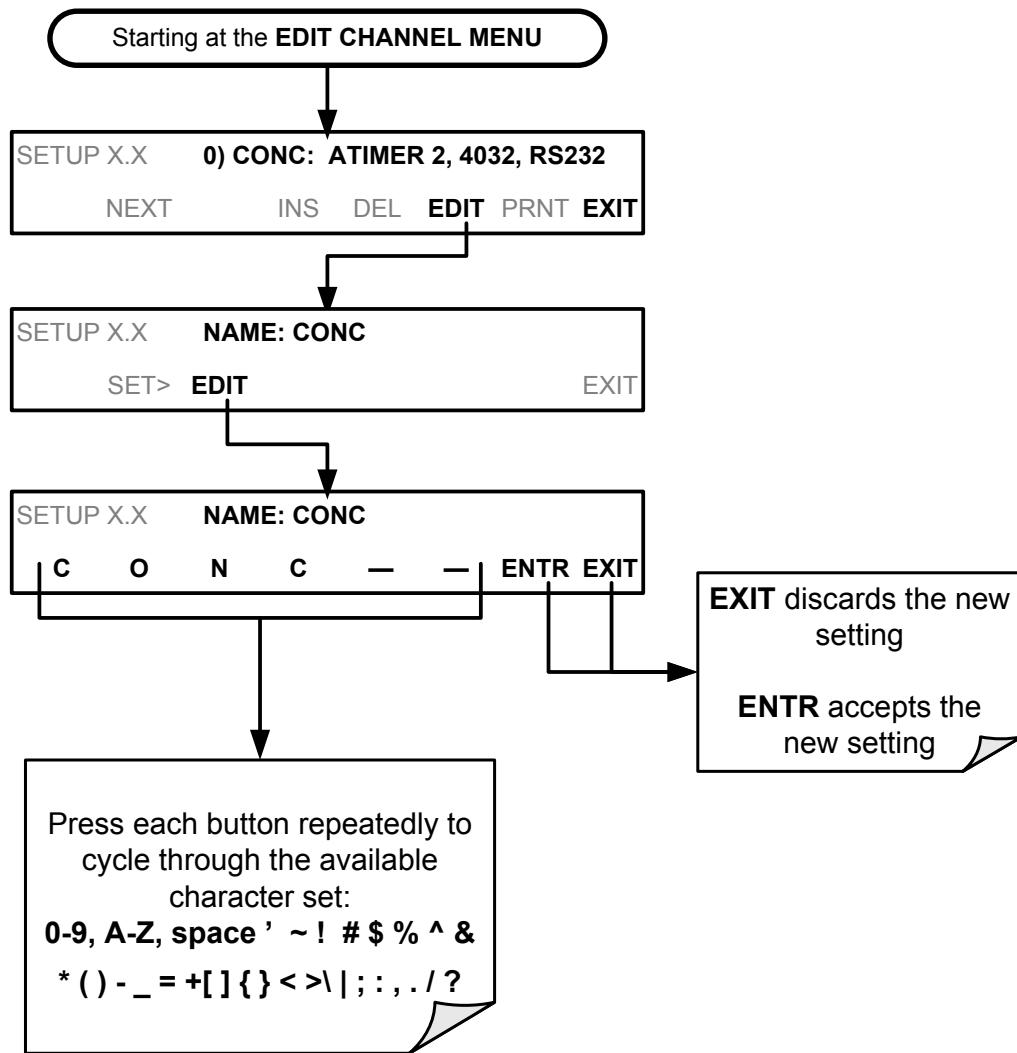
0) CONC: ATIMER, 2, 4032, RS232

Translates to the following configuration:

0 Channel No.
CONC Channel Name
ATIMER Trigger Event
2 Parameters – number of parameters included in this channel
4032 Event – number of data points this channel is set up to store
RS-232 Port via which values automatically reported

7.1.4.1. EDITING DAS DATA CHANNEL NAMES

To edit the name of a DAS data channel, follow the instruction shown in Section 7.1.4 then press:



7.1.4.2. EDITING DAS TRIGGERING EVENTS

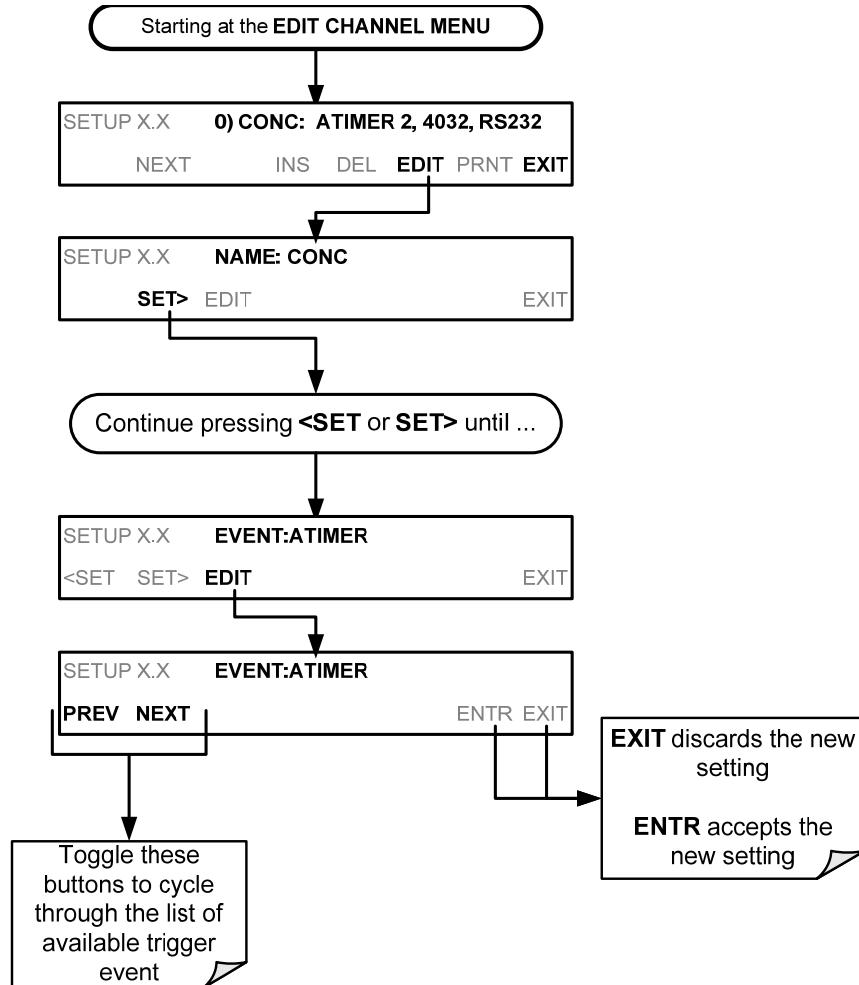
Triggering events define when and how the DAS records a measurement of any given data channel. The most commonly used triggering events are:

ATIMER: Sampling at regular intervals specified by an automatic timer. Most trending information is usually stored at such regular intervals, which can be instantaneous or averaged.

EXITZR, EXITSP, and O2SLPC (exit zero, exit span, O₂ slope change): Sampling at the end of (irregularly occurring) calibrations or when the response slope changes. These triggering events create instantaneous data points, e.g., for the new slope and offset (concentration response) values at the end of a calibration. Zero and slope values are valuable to monitor response drift and to document when the instrument was calibrated.

WARNINGS: Some data may be useful when stored if one of several warning messages appears such as **O2TMPW** (O₂ sensor temperature warning). This is helpful for trouble-shooting by monitoring when a particular warning occurred.

To edit the list of data parameters associated with a specific data channel, follow the instruction shown in Section 7.1.4 then press:



Note

DAS Trigger Events are firmware specific; a list of trigger events can be found in Appendix A-5 of this manual.

7.1.4.3. EDITING DAS PARAMETERS

Data parameters are types of data that may be measured and stored by the DAS. For each Teledyne API analyzer model, the list of available data parameters is different, fully defined and not customizable. Appendix A-5 lists firmware specific data parameters for the T802. DAS parameters include things like O₂ concentration measurements, temperatures of the various heaters placed around the analyzer, pressures and flows of the pneumatic subsystem and other

diagnostic measurements as well as calibration data such as stability, slope and offset.

Most data parameters have associated measurement units, such as mV, ppb, cm³/min, etc., although some parameters have no units (e.g. **SLOPE**). With the exception of concentration readings, none of these units of measure can be changed.

Note	DAS does not keep track of the units (i.e. %) of each concentration value; therefore, DAS data files may contain concentrations data recorded in more than one type of unit if the units of measure was changed during data acquisition.
-------------	---

Each data parameter has user-configurable functions that define how the data are recorded:

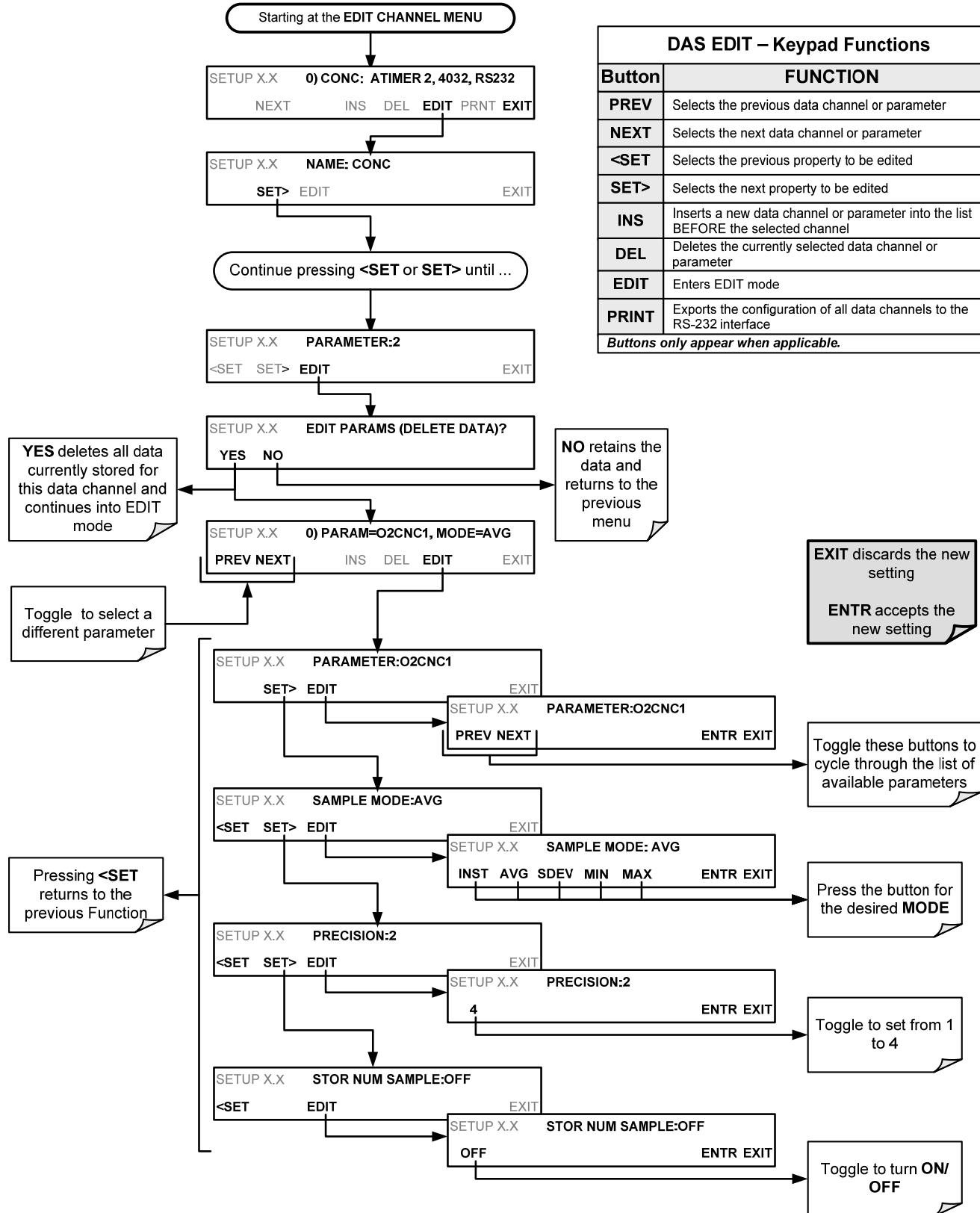
Table 7-3: DAS Data Parameter Functions

FUNCTION	EFFECT
PARAMETER	Instrument-specific parameter name.
SAMPLE MODE	INST: Records instantaneous reading. AVG: Records average reading during reporting interval. SDEV: Records the standard deviation of the data points recorded during the reporting interval. MIN: Records minimum (instantaneous) reading during reporting interval. MAX: Records maximum (instantaneous) reading during reporting interval.
PRECISION	0 to 4: Sets the number of digits to the right decimal point for each record. Example: Setting 4 ; “ 399.9865 % ” Setting 0 ; “ 400 % ”
STORE NUM. SAMPLES	OFF: Stores only the average (default). ON: Stores the average and the number of samples used to compute the value of the parameter. This property is only useful when the AVG sample mode is used. Note that the number of samples is the same for all parameters in one channel and needs to be specified only for one of the parameters in that channel.

Users can build a channel by selecting desired parameters from the available choices.

Data channels can be edited individually from the front panel without affecting other data channels. However, when editing a data channel, such as during adding, deleting or editing parameters, all data for that particular channel will be lost, because the DAS can store only data of one format (number of parameter columns etc.) for any given channel. In addition, a DAS configuration can only be uploaded remotely as an entire set of channels. Hence, remote update of the DAS will always delete all current channels and stored data.

To modify, add or delete a parameter, follow the instruction shown in Section 7.1.4 then press:



Note

When the STORE NUM SAMPLES feature is turned on, the instrument will store the number of measurements that were used to compute the AVG, SDEV, MIN or MAX value but not the actual measurements themselves.

7.1.4.4. EDITING SAMPLE PERIOD AND REPORT PERIOD

The DAS defines two principal time periods by which sample readings are taken and permanently recorded:

SAMPLE PERIOD: Determines how often DAS temporarily records a sample reading of the parameter in volatile memory. **SAMPLE PERIOD** is only used when the DAS parameter's sample mode is set for **AVG, SDEV, MIN or MAX**

The **SAMPLE PERIOD** is set to one minute by default and generally cannot be accessed from the standard DAS front panel menu, but is available via the instrument's communication ports by using APICOM or the analyzer's standard serial data protocol.

REPORT PERIOD: Sets how often the sample readings stored in volatile memory are processed, (e.g. average, minimum or maximum are calculated); the results stored permanently in the instrument's Disk-on-Module as well as transmitted via the analyzer's communication ports. The Report Period may be set from the front panel. If the **INST** sample mode is selected, the instrument stores and reports an instantaneous reading of the selected parameter at the end of the chosen report period.

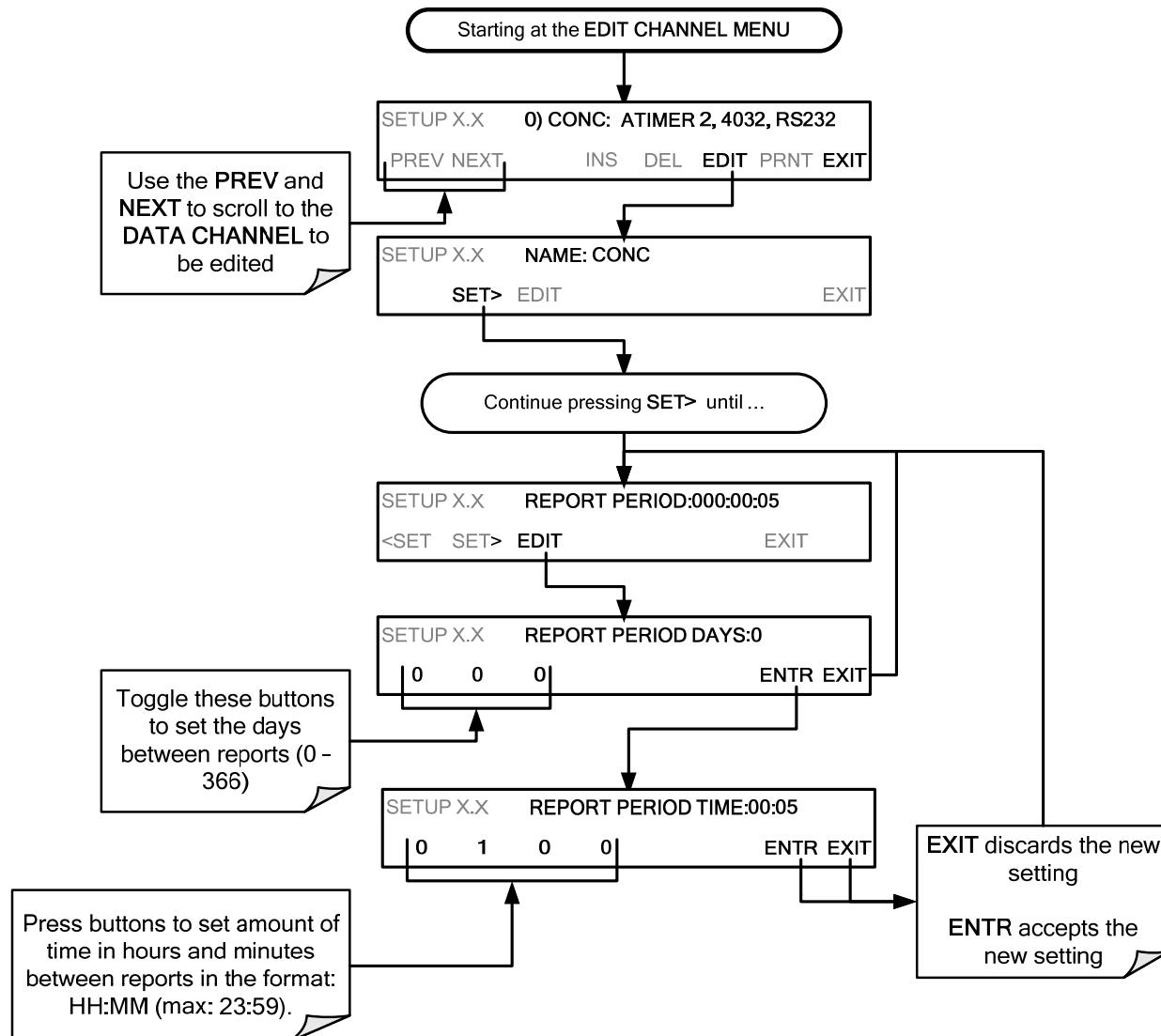
Note

In AVG, SDEV, MIN or MAX sample modes (Table 7-3), the settings for the Sample Period and the Report Period determine the number of data points used each time the parameters are calculated, stored and reported to the COMM ports.

The actual sample readings are not stored past the end of the chosen report period.

When the STORE NUM SAMPLES feature is turned on, the instrument will store the number of measurements that were used to compute the AVG, SDEV, MIN or MAX value but not the actual measurements themselves.

To define the **REPORT PERIOD**, follow the instruction shown in Section 7.1.4 then press:



The **SAMPLE PERIOD** and **REPORT PERIOD** intervals are synchronized to the beginning and end of the appropriate interval of the instrument's internal clock.

If SAMPLE Period were set for one minute, the first reading would occur at the beginning of the next full minute according to the instrument's internal clock.

If the Report period were set for one hour, the first report activity would occur at the beginning of the next full hour according to the instrument's internal clock.

EXAMPLE:

Given the above settings, if DAS were activated at 7:57:35 the first sample would occur at 7:58 and the first report would be calculated at 8:00 consisting of data points for 7:58, 7:59 and 8:00. During the next hour (from 8:01 to 9:00), the instrument will take a sample reading every minute and include 60 sample readings.

7.1.4.5. REPORT PERIODS IN PROGRESS WHEN INSTRUMENT IS POWERED OFF

If the instrument is powered off in the middle of a **REPORT PERIOD**, the samples accumulated so far during that period are lost. Once the instrument is turned back on, the DAS begins taking samples and temporarily storing them in volatile memory as part of a new **REPORT PERIOD**. At the end of this **REPORT PERIOD**, only the sample readings taken since the instrument was turned back on will be included in any **AVG**, **SDEV**, **MIN** or **MAX** calculation.

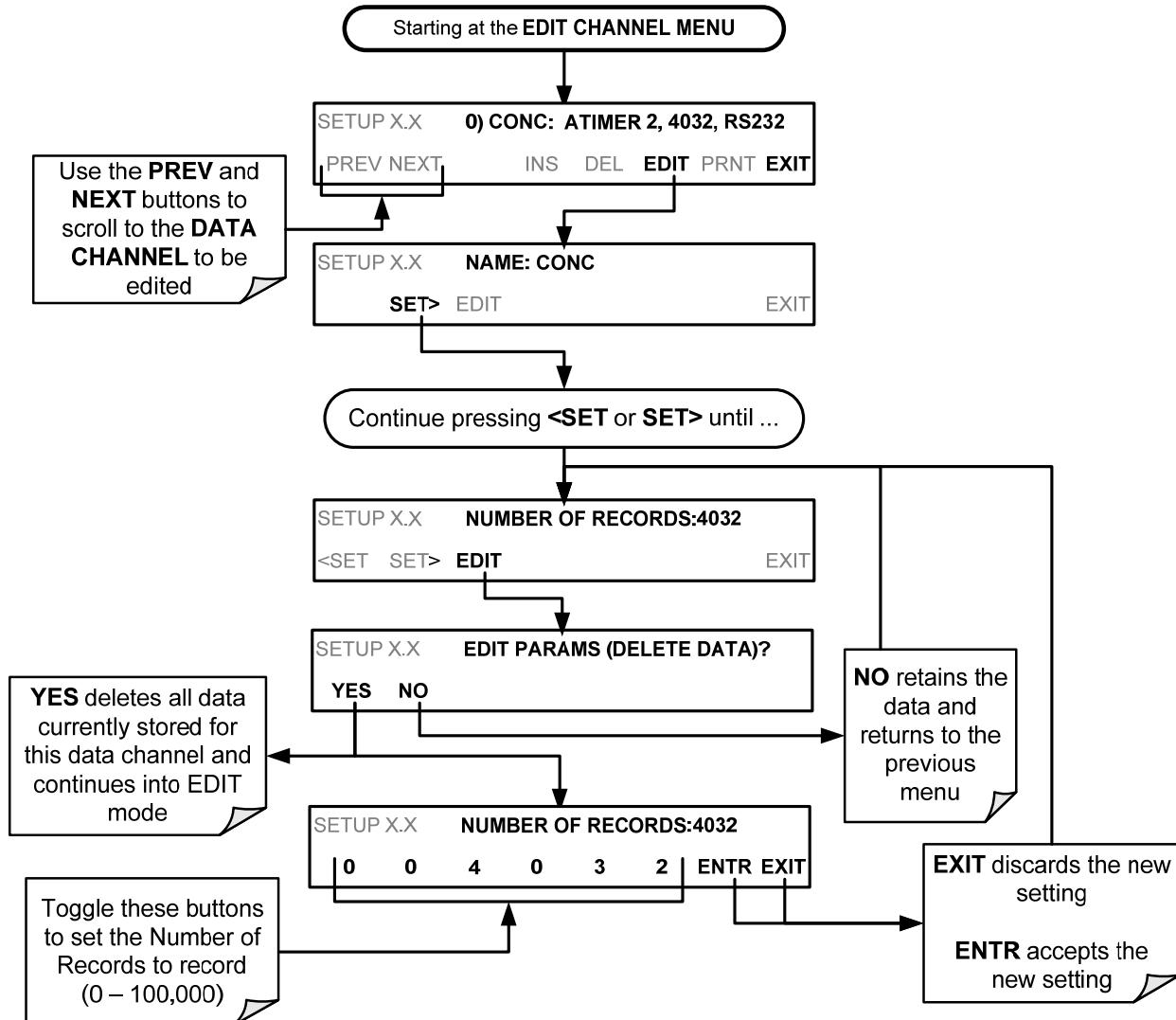
Also, the **STORE NUM SAMPLE** feature will report the number of sample readings taken since the instrument was restarted.

7.1.4.6. EDITING THE NUMBER OF RECORDS

The number of data records in the DAS is limited by the total number of parameters and channels and other settings in the DAS configuration. Every additional data channel, parameter, number of samples setting etc. will reduce the maximum amount of data points somewhat. In general, however, the maximum data capacity is divided amongst all channels (max: 20) and parameters (max: 50 per channel).

The DAS will check the amount of available data space and prevent the user from specifying too many records at any given point. If, for example, the DAS memory space can accommodate 375 more data records, the **ENTR** key will disappear when trying to specify more than that number of records. This check for memory space may also make an upload of a DAS configuration with APICOM or a terminal program fail, if the combined number of records would be exceeded. In this case, it is suggested to either try to determine what the maximum number of records available is using the front panel interface or use trial-and-error in designing the DAS script or calculate the number of records using the DAS or APICOM manuals.

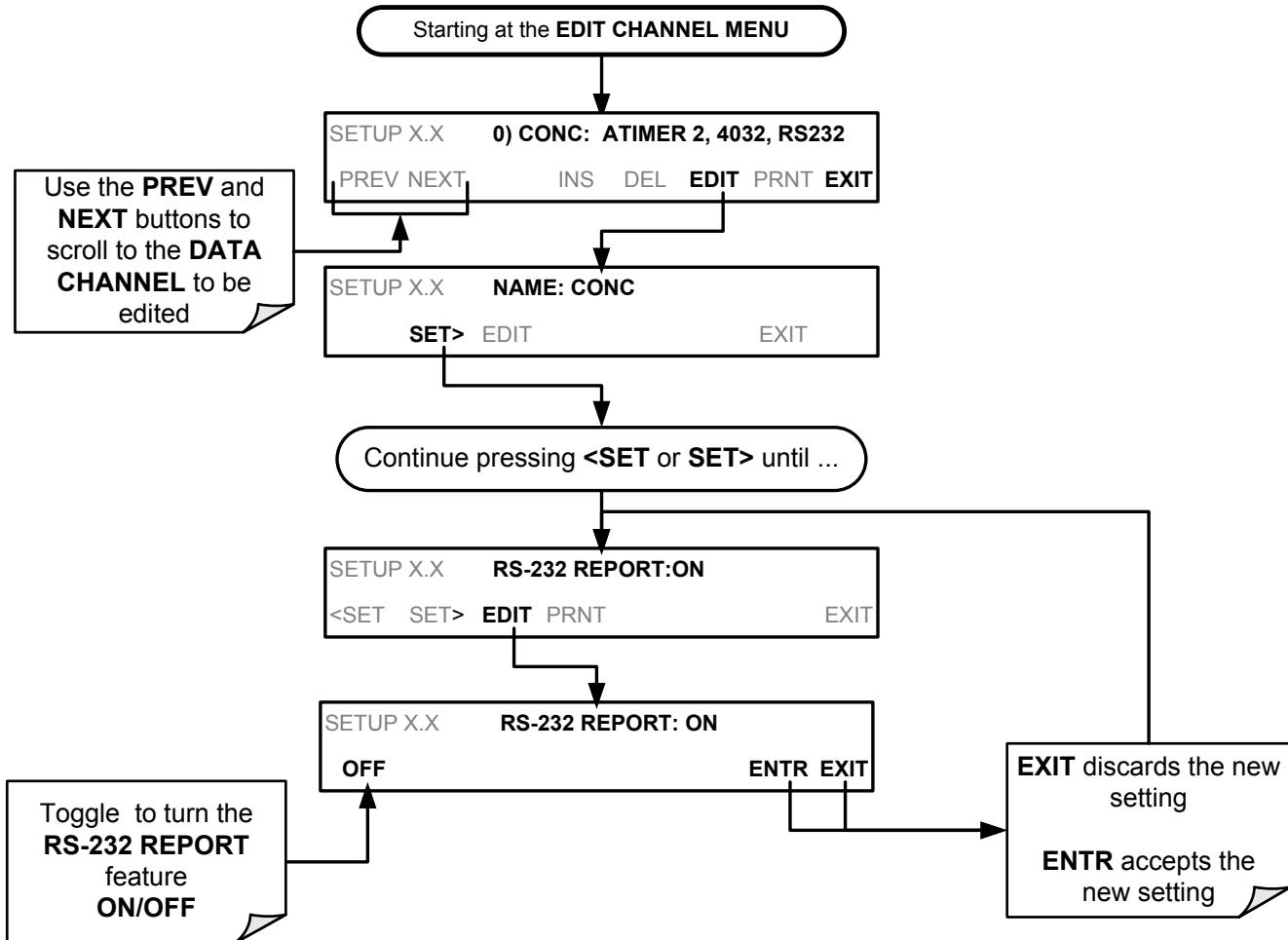
To set the **NUMBER OF RECORDS**, follow the instruction shown in Section 7.1.4 then press:



7.1.4.7. RS-232 REPORT FUNCTION

The DAS can automatically report data to the communications ports, where they can be captured with a terminal emulation program or simply viewed by the user using the APICOM software.

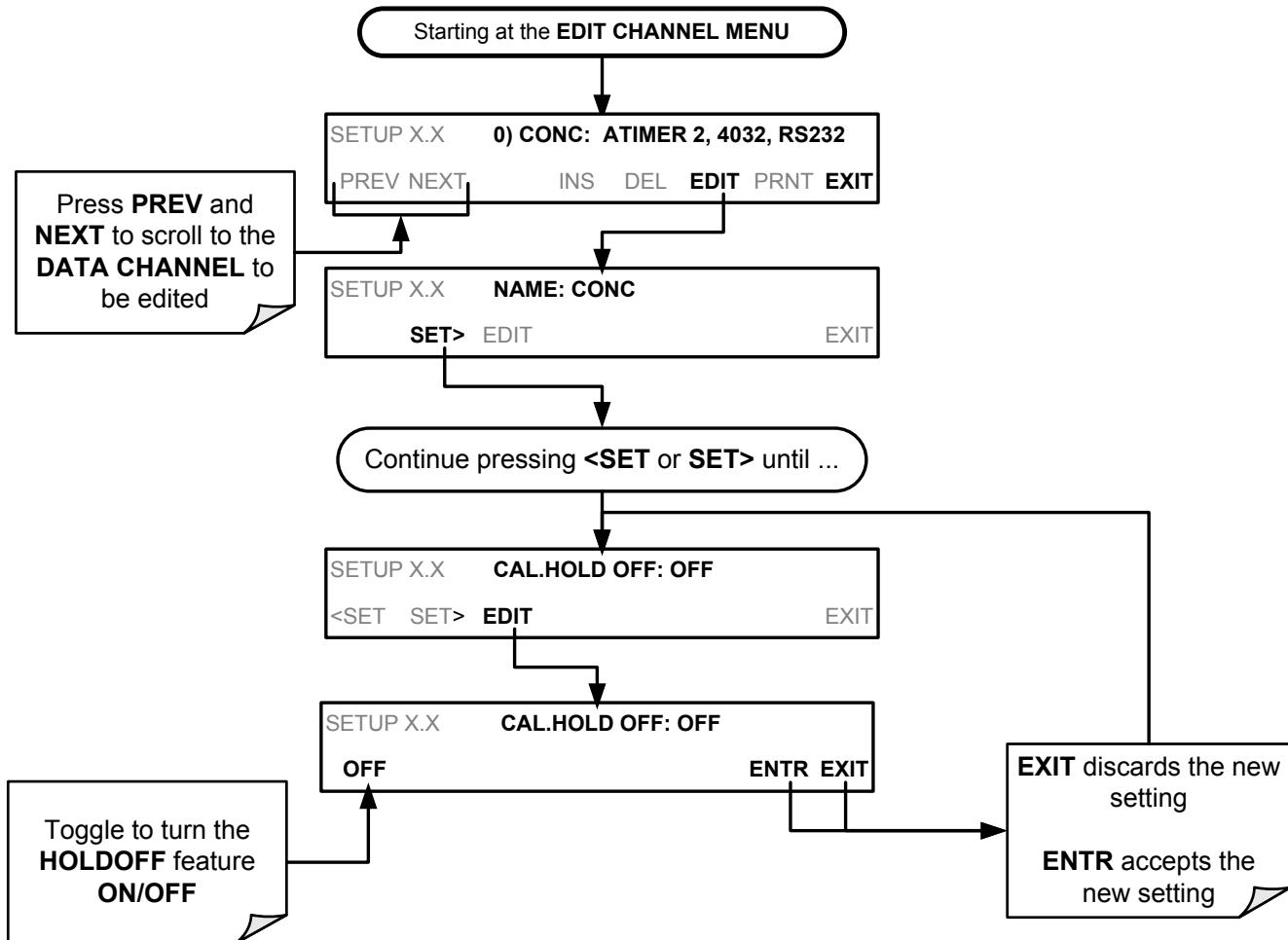
To enable automatic **COM** port reporting, follow the instruction shown in Section 7.1.4 then press:



7.1.4.8. ENABLING / DISABLING THE HOLD OFF FEATURE

The DAS **HOLD OFF** feature prevents data collection during calibration operations.

To enable or disable the **HOLD OFF**, follow the instruction shown in Section 7.1.4 then press:



HOLD OFF also prevents DAS measurements from being made at certain times when the quality of the analyzer's O₂ measurements may be suspect (e.g. while the instrument is warming up). In this case, the length of time that the **HOLD OFF** feature is active, is determined by the value of the internal variable (VARS), **DAS_HOLD OFF**.

To set the length of the **DAS_HOLD OFF** period, see Section 11.1.3.

7.1.4.9. THE COMPACT REPORT FEATURE

When enabled, this option avoids unnecessary line breaks on all RS-232 reports. Instead of reporting each parameter in one channel on a separate line, up to five parameters are reported in one line.

The **COMPACT DATA REPORT** generally cannot be accessed from the standard DAS front panel menu, but is available via the instrument's communication ports by using APICOM or the analyzer's standard serial data protocol.

7.1.4.10. THE STARTING DATE FEATURE

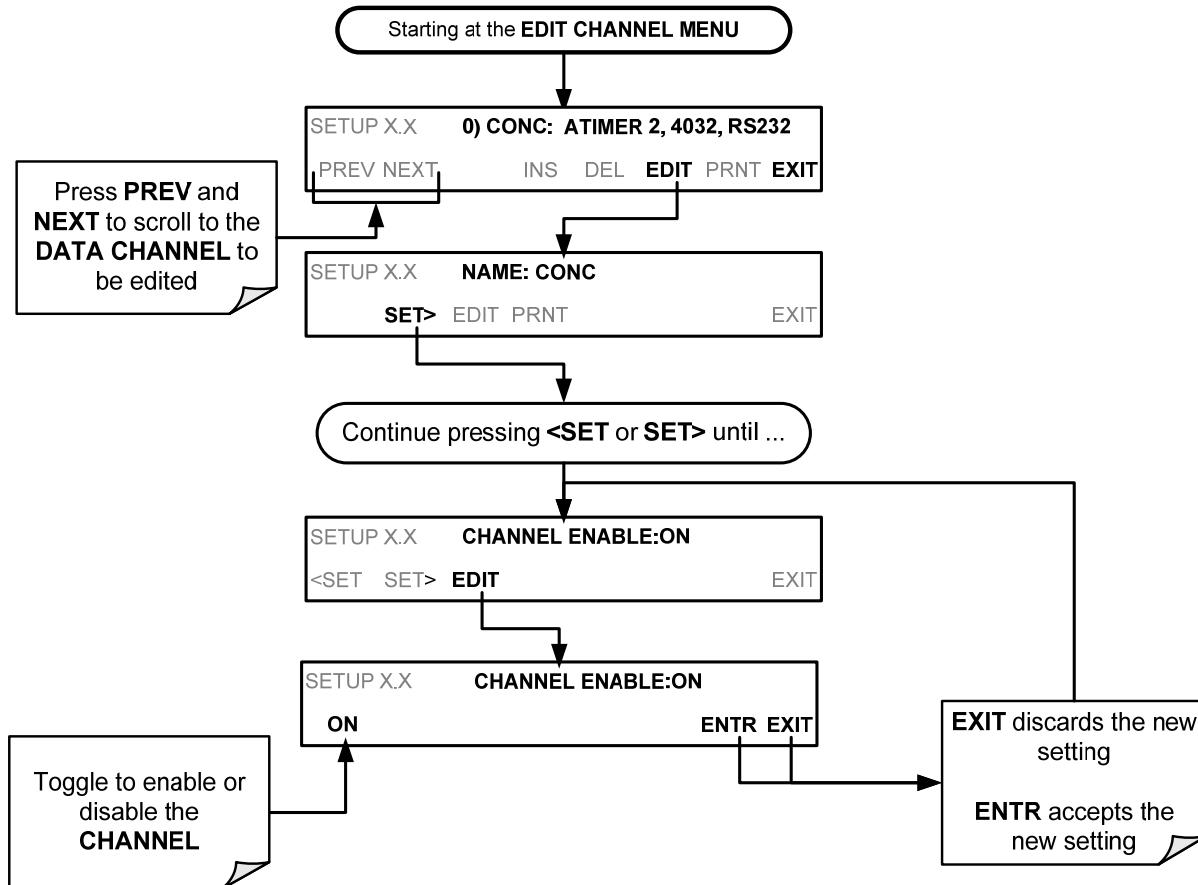
This option allows specifying a starting date for any given channel when the user wants to start data acquisition only after a certain time and date. If the **STARTING DATE** is in the past (the default condition), the DAS ignores this setting and begins recording data as defined by the **REPORT PERIOD** setting.

The **STARTING DATE** generally cannot be accessed from the standard DAS front panel menu, but is available via the instrument's communication ports by using APICOM or the analyzer's standard serial data protocol.

7.1.4.11. DISABLING/ENABLING DATA CHANNELS

Data channels can be temporarily disabled, which can reduce the read/write wear on the disk-on-module.

To disable a data channel, follow the instruction shown in Section 7.1.4 then press:



7.2. REMOTE DAS CONFIGURATION

The DAS can be configured and operated remotely via either the APICOM interface or a terminal emulation program. (Refer to Section 8 of this manual for details on remote operation of the T802 analyzer).

7.2.1. DAS CONFIGURATION VIA APICOM

Figure 7-2 shows an example of APICOM's main interface, which emulates the look and functionality of the instrument's actual front panel. Figure 7-3. shows an example of APICOM being used to remotely configure the DAS feature.

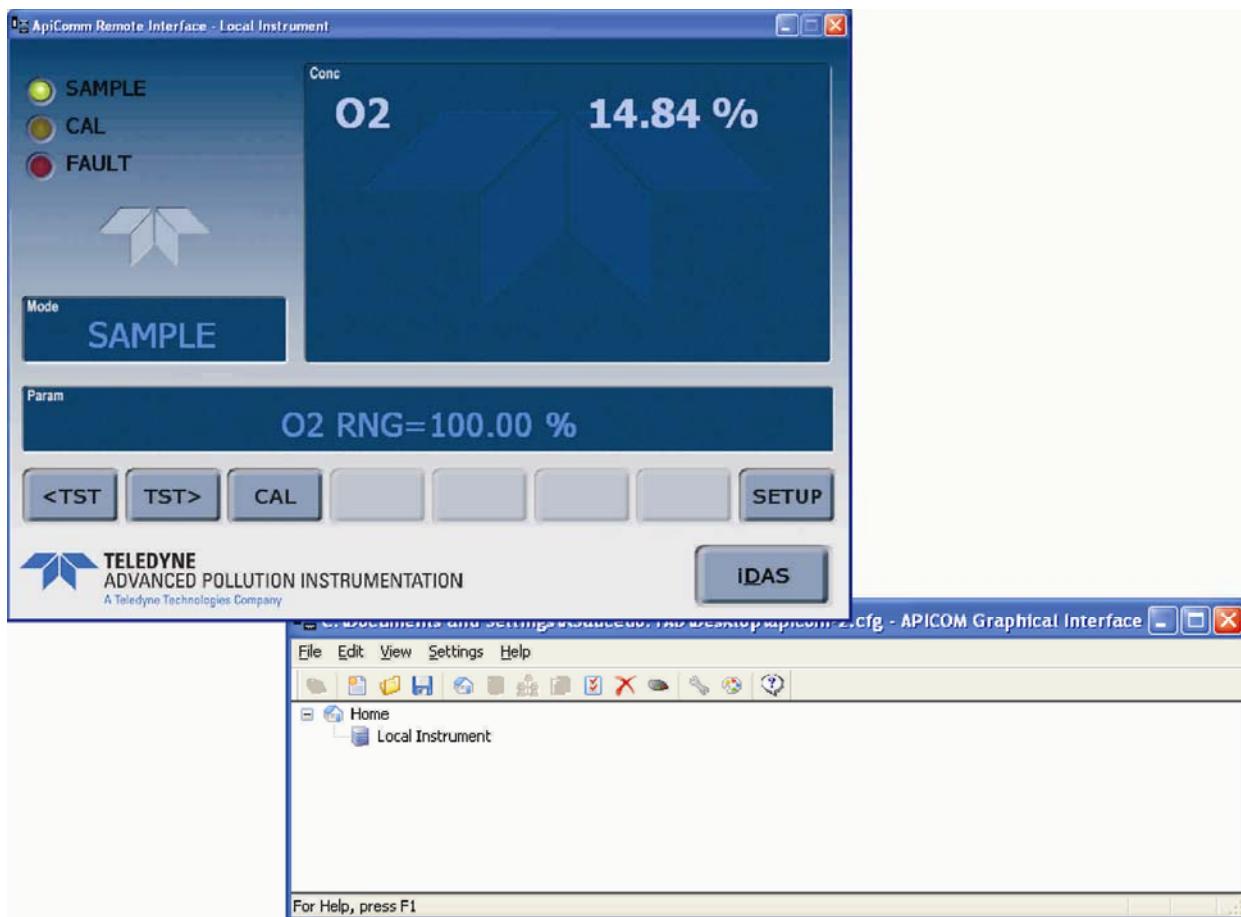


Figure 7-2: APICOM Remote Control Program Interface

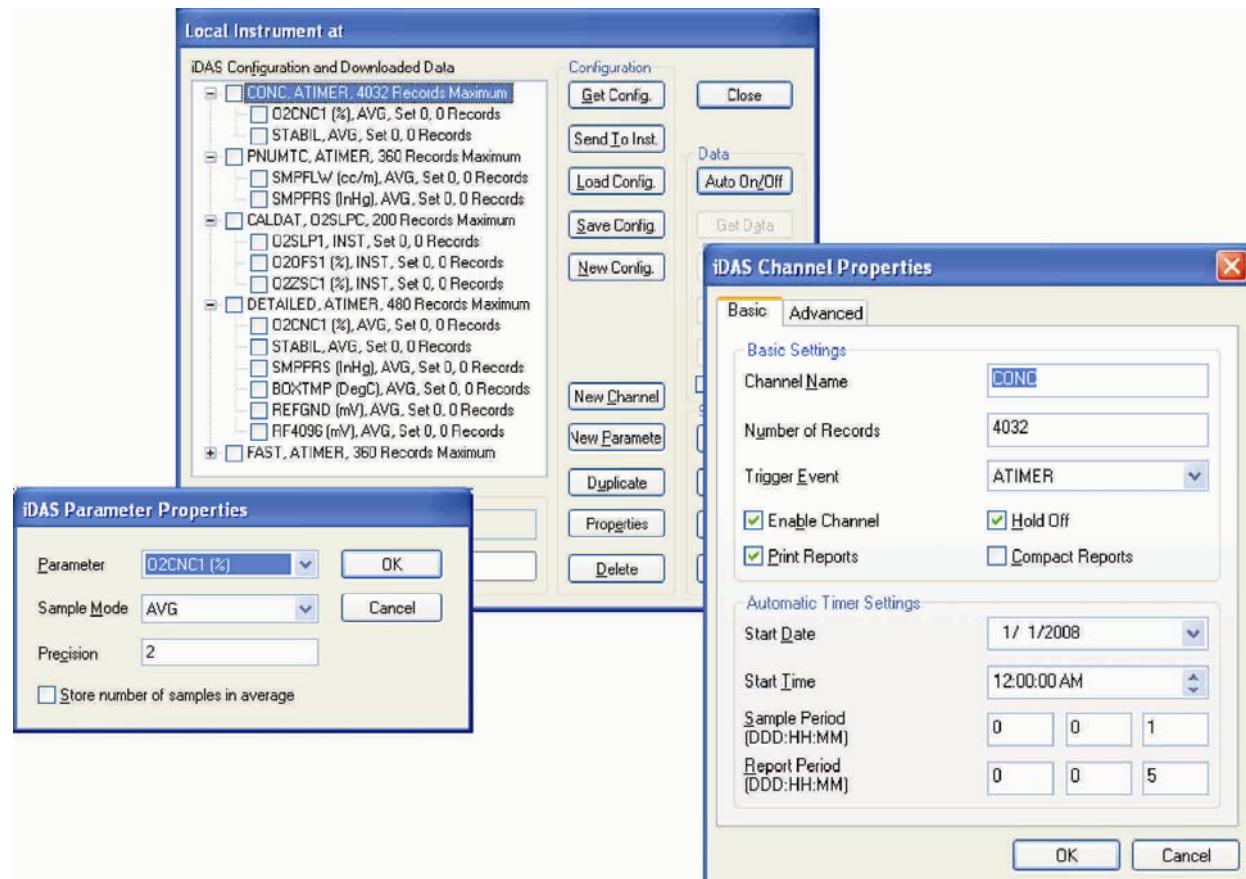


Figure 7-3: APICOM User Interface for Configuring the DAS

Once a DAS configuration is created or edited, it is conveniently saved to your computer and can be uploaded to any instrument; it can be stored on a computer for later review, alteration or documentation and archival. Refer to the APICOM manual for details on these procedures. The APICOM user manual (Teledyne API PN 058130000) is included in the APICOM installation file, which can be downloaded at <http://www.teledyne-api.com/manuals/>.

IMPORTANT

IMPACT ON READINGS OR DATA

Avoid losing data and saved configurations: All data, parameters and channels will be replaced when uploading a DAS configuration script to the analyzer through its communication ports. Back up data and the original DAS configuration before attempting any DAS changes.

7.2.2. DAS CONFIGURATION VIA TERMINAL EMULATION PROGRAMS

Although Teledyne API recommends the use of APICOM, the DAS can also be accessed and configured through a terminal emulation program such as HyperTerminal (see Figure 7-4 for example). It is best to start by downloading the default DAS configuration, getting familiar with its command structure and syntax conventions, and then altering a copy of the original file offline before uploading the new configuration.

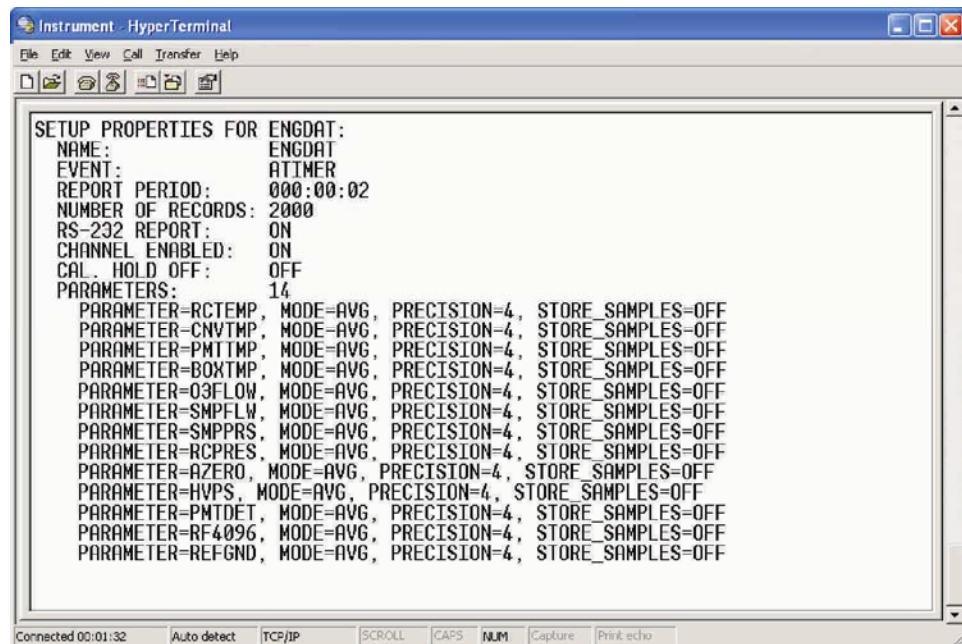


Figure 7-4: DAS Configuration through a Terminal Emulation Program

See Section for configuration commands and their strict syntax. Commands can be pasted in from of an existing text file, which was first edited offline and then uploaded through a specific transfer procedure.

IMPORTANT

IMPACT ON READINGS OR DATA

Whereas the editing, adding and deleting of DAS channels and parameters of one channel through the front-panel control buttons can be done without affecting the other channels, uploading a DAS configuration script to the analyzer through its communication ports will erase all data, parameters and channels by replacing them with the new DAS configuration. Backup of data and the original DAS configuration is advised before attempting any DAS changes.

8. REMOTE OPERATION

This section provides information needed when using external digital and serial I/O for remote operation. It assumes that the electrical connections have been made as described in Section 3.3.1.

Your analyzer can be remotely configured, calibrated or queried for stored data through the serial ports, via either **Computer mode** (using a personal computer) or **Interactive mode** (using a terminal emulation program).

8.1. COMPUTER MODE

Computer Mode is used when the analyzer is connected to a computer with a dedicated interface program such as APICOM.

8.1.1. REMOTE CONTROL VIA APICOM

APICOM is an easy-to-use, yet powerful interface program that allows the user to access and control any of Teledyne API's main line of ambient and stack-gas instruments from a remote connection through direct cable, modem or Ethernet. Running APICOM, a user can:

- Establish a link from a remote location to the T802 through direct cable connection via RS-232 modem or Ethernet.
- View the instrument's front panel and remotely access all functions that could be accessed when standing in front of the instrument.
- Remotely edit system parameters and set points.
- Download, view, graph and save data for predictive diagnostics or data analysis.
- Check on system parameters for trouble-shooting and quality control.

APICOM is very helpful for initial setup, data analysis, maintenance, and troubleshooting. Figure 7-2 shows examples of APICOM's main interface, which emulates the look and functionality of the instruments actual front panel. APICOM is included free of cost with the analyzer and the latest versions can also be downloaded at <http://www.teledyne-api.com/software/>.

8.2. INTERACTIVE MODE

Interactive mode is used with a terminal emulation programs or a “dumb” computer terminal.

8.2.1. REMOTE CONTROL VIA A TERMINAL EMULATION PROGRAM

Start a terminal emulation programs such as HyperTerminal. All configuration commands must be created following a strict syntax or be pasted in from a text file, which was edited offline and then uploaded through a specific transfer procedure. The commands that are used to operate the analyzer in this mode are listed in Table 8-1 and in Appendix A.

8.2.1.1. HELP COMMANDS IN INTERACTIVE MODE

Table 8-1: Terminal Mode Software Commands

COMMAND	Function
Control-T	Switches the analyzer to terminal mode (echo, edit). If mode flags 1 & 2 are OFF, the interface can be used in interactive mode with a terminal emulation program.
Control-C	Switches the analyzer to computer mode (no echo, no edit).
CR (carriage return)	A carriage return is required after each command line is typed into the terminal/computer. The command will not be sent to the analyzer to be executed until this is done. On personal computers, this is achieved by pressing the ENTER key.
BS (backspace)	Erases one character to the left of the cursor location.
ESC (escape)	Erases the entire command line.
?[ID] CR	This command prints a complete list of available commands along with the definitions of their functionality to the display device of the terminal or computer being used. The ID number of the analyzer is only necessary if multiple analyzers are on the same communications line, such as the multi-drop setup.
Control-P	Restarts the listing of commands.

8.2.1.2. COMMAND SYNTAX

Commands are not case-sensitive and all arguments within one command (i.e. ID numbers, keywords, data values, etc.) must be separated with a space character.

All Commands follow the syntax:

X [ID] COMMAND <CR>

Where

X is the command type (one letter; refer to Table 8-2) that defines the type of command. Allowed designators are listed in Appendix A-6.

[ID] is the machine identification number (Section 5.7.1). Example: the Command “? 700” followed by a carriage return would print the list of available commands for the revision of software currently installed in the instrument assigned ID Number 700.

COMMAND is the command designator: This string is the name of the command being issued (LIST, ABORT, NAME, EXIT, etc.). Some commands may have additional arguments that define how the command is to

be executed. Press ? <CR> or refer to Appendix A-6 for a list of available command designators

<CR> is a carriage return. All commands must be terminated by a carriage return (usually achieved by pressing the ENTER key on a computer).

Table 8-2: Teledyne API Serial I/O Command Types

COMMAND	COMMAND TYPE
C	Calibration
D	Diagnostic
L	Logon
T	Test measurement
V	Variable
W	Warning

8.2.1.3. DATA TYPES

Data types consist of integers, hexadecimal integers, floating-point numbers, Boolean expressions and text strings.

Integer data: Used to indicate integral quantities such as a number of records, a filter length, etc.

- They consist of an optional plus or minus sign, followed by one or more digits.
- For example, +1, -12, 123 are all valid integers.

Hexadecimal integer data: Used for the same purposes as integers.

- They consist of the two characters “0x,” followed by one or more hexadecimal digits (0-9, A-F, a-f), which is the ‘C’ programming language convention.
- No plus or minus sign is permitted.
- For example, 0x1, 0x12, 0x1234abcd are all valid hexadecimal integers.

Floating-point number: Used to specify continuously variable values such as temperature set points, time intervals, warning limits, voltages, etc.

- They consist of an optional plus or minus sign, followed by zero or more digits, an optional decimal point and zero or more digits.
- At least one digit must appear before or after the decimal point.
- Scientific notation is not permitted.
- For example, +1.0, 1234.5678, -0.1, 1 are all valid floating-point numbers.

Boolean expressions: Used to specify the value of variables or I/O signals that may assume only two values.

- They are denoted by the keywords **ON** and **OFF**.

Text strings: Used to represent data that cannot be easily represented by other data types, such as data channel names, which may contain letters and numbers.

- They consist of a quotation mark, followed by one or more printable characters, including spaces, letters, numbers, and symbols, and a final quotation mark.
- For example, “a”, “1”, “123abc”, and “()[]<>” are all valid text strings.
- It is not possible to include a quotation mark character within a text string.

Some commands allow you to access variables, messages, and other items. When using these commands, you must type the entire name of the item; you cannot abbreviate any names.

8.2.1.4. STATUS REPORTING

Reporting of status messages as an audit trail is one of the three principal uses for the RS-232 interface (the other two being the command line interface for controlling the instrument and the download of data in electronic format). You can effectively disable the reporting feature by setting the interface to quiet mode (Section 6.2.1, Table 6-1).

Status reports include warning messages, calibration and diagnostic status messages. Refer to Appendix A-3 for a list of the possible messages.

8.2.1.5. GENERAL MESSAGE FORMAT

All messages from the instrument (including those in response to a command line request) are in the format:

X DDD:HH:MM [ID] MESSAGE<CRLF>

Where:

X is a command type designator, a single character indicating the message type, as shown in the Table 8-2.

DDD:HH:MM is the time stamp, the date and time when the message was issued. It consists of the Day-of-year (DDD) as a number from 1 to 366, the hour of the day (HH) as a number from 00 to 23, and the minute (MM) as a number from 00 to 59.

[ID] is the analyzer ID, a number with 1 to 4 digits.

MESSAGE is the message content that may contain warning messages, test measurements, variable values, etc.

<CRLF> is a carriage return line feed pair, which terminates the message.

The uniform nature of the output messages makes it easy for a host computer to parse them into an easy structure. Keep in mind that the front panel display does not give any information on the time a message was issued, hence it is useful to log such messages for trouble-shooting and reference purposes. Terminal emulation programs such as HyperTerminal can capture these messages to text files for later review.

8.3. REMOTE ACCESS BY MODEM

The T802 can be connected to a modem for remote access. This requires a cable between the analyzer's COM port and the modem, typically a DB-9F to DB-25M cable (available from Teledyne API with PN WR0000024).

Once the cable has been connected, check to make sure:

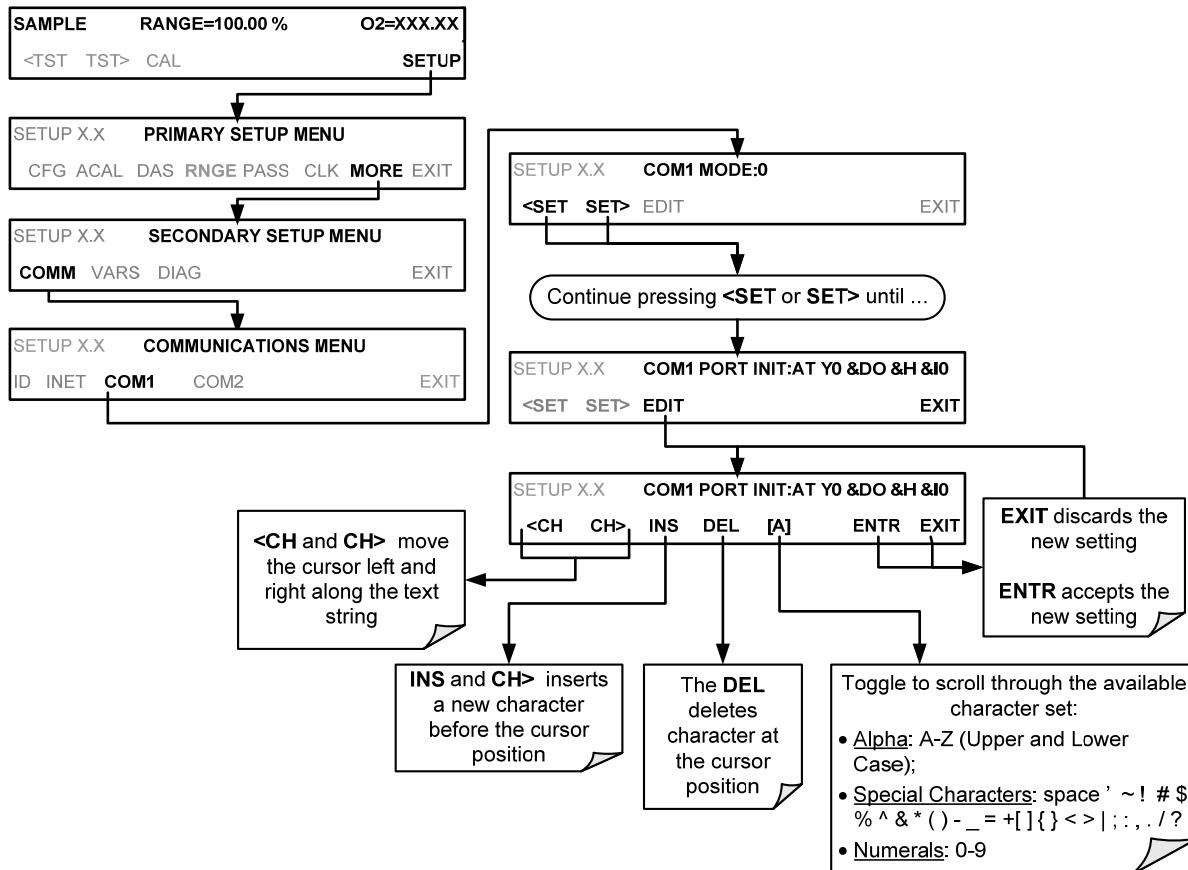
- The DTE-DCE switch on the rear panel is in the DCE position.
- The T802 COM port is set for a baud rate that is compatible with the modem,
- The Modem is designed to operate with an 8-bit word length with one stop bit.
- The MODEM ENABLE communication mode is turned on (Mode 64, see Section 6.2.1).

Once this is completed, the appropriate setup command line for your modem can be entered into the analyzer. The default setting for this feature is

AT Y0 &D0 &H0 &I0 S0=2 &B0 &N6 &M0 E0 Q1 &W0

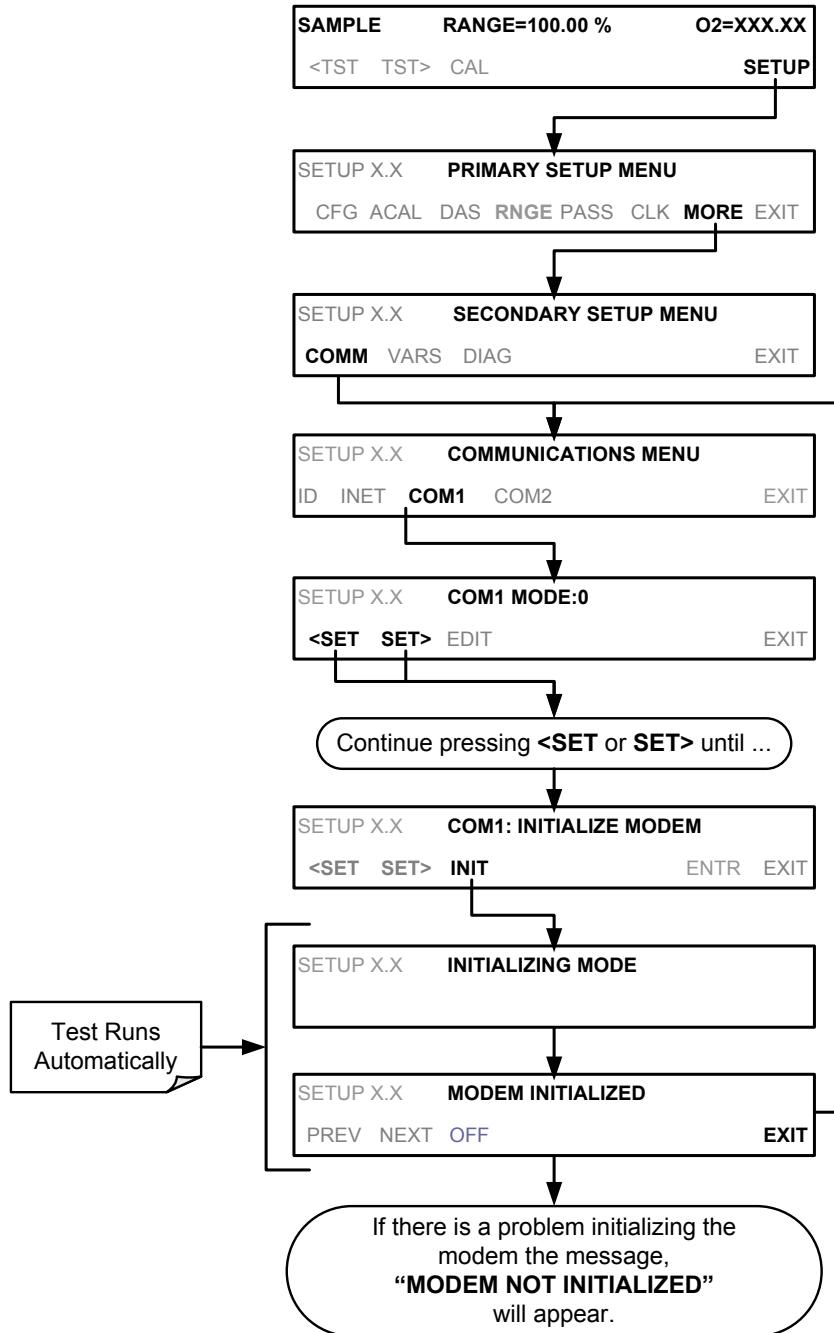
This string can be altered to match your modem's initialization and can be up to 100 characters long.

To change this setting press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

To initialize the modem press:



(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

8.4. COM PORT PASSWORD SECURITY

In order to provide security for remote access of the T802, a **LOGON** feature can be enabled to require a password before the instrument will accept commands. This is done by turning on the **SECURITY MODE** (Mode 4, Section 6.2.1).

Once the **SECURITY MODE** is enabled, the following items apply.

- A password is required before the port will respond or pass on commands.
- If the port is inactive for one hour, it will automatically logoff, which can also be achieved with the LOGOFF command.
- Three unsuccessful attempts to log on with an incorrect password will cause subsequent logins to be disabled for 1 hour, even if the correct password is used.
- If not logged on, the only active command is the '?' request for the help screen.
- The following messages will be returned at logon:
 - LOGON SUCCESSFUL - Correct password given
 - LOGON FAILED - Password not given or incorrect
 - LOGOFF SUCCESSFUL - Connection terminated successfully

To log on to the T802 analyzer with **SECURITY MODE** feature enabled, type:

LOGON 940331

Note

940331 is the default password.

To change the default password, use the variable **RS-232_PASS** issued as follows:

V RS-232_PASS=NNNNNN

Where N is any numeral between 0 and 9.

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9. CALIBRATION PROCEDURES

This section contains a variety of information regarding the various methods for calibrating a T802 as well as other supporting information

This section is organized as follows:

Section 9.1 – Before Calibration

This section contains general information you should know before calibrating the analyzer.

SECTION 9.2 – Manual Calibration Checks and Calibration

This section describes the procedure for checking the calibration of the T802 and calibrating the instrument. Also included are instructions for selecting the reporting range to be calibrated when the T802 analyzer is set to operate in either the DUAL or AUTO reporting range modes.

SECTION 9.3 – Assessing Calibration Quality

This section describes how to judge the effectiveness of a recently performed calibration.

SECTION 9.4 – Calibration of the T802’s Electronic Subsystems

This section describes how to perform calibrations of the T802’s electronic systems, including:

- adjusting the analyzers internal flow sensor
- adjusting the analyzers internal pressure sensor

SECTION 9.5 – Calibration of the Optional CO₂ Sensor

This section describes how to perform calibrations of the optional CO₂ Sensor.

Note

Throughout this Section are various diagrams showing pneumatic connections between the T802 and various other pieces of equipment such as calibrators and zero air sources. These diagrams are only intended to be schematic representations of these connections and do not reflect actual physical locations of equipment and fitting location or orientation. Contact your regional EPA or other appropriate governing agency for more detailed recommendations..

9.1. BEFORE CALIBRATION

The calibration procedures in this section assume that the range mode, analog range and units of measure have already been selected for the analyzer. If this has not been done, please do so before continuing (see Section 5.4 for instructions).

Note

If any problems occur while performing the following calibration procedures, refer to Section 11 for troubleshooting tips.

9.1.1. REQUIRED EQUIPMENT, SUPPLIES, AND EXPENDABLES

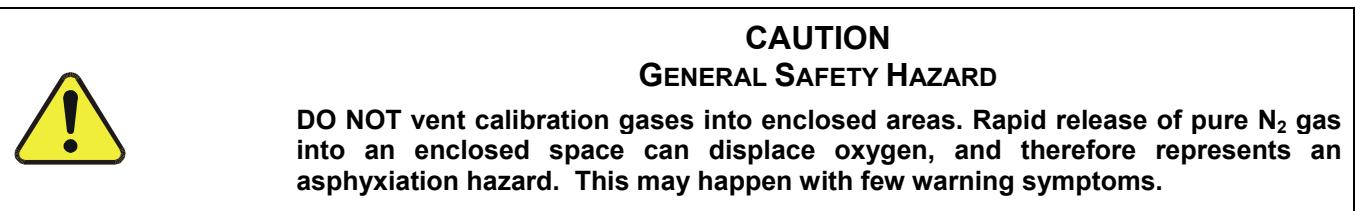
Calibration of the T802 analyzer requires a certain amount of equipment and supplies. These include, but are not limited to, the following:

- Zero-air source.
- Span gas source.
- Gas lines - All Gas lines should be Stainless Steel, PTFE (Teflon), glass or electroless nickel.
- A recording device such as a strip-chart recorder and/or data logger (optional). For electronic documentation, the internal data acquisition system can be used.

9.1.2. CALIBRATION GASES

9.1.2.1. ZERO AIR

A gas that is similar in chemical composition to the earth's atmosphere but scrubbed of all components that might affect the analyzers readings. Teledyne API recommends using pure N₂ when calibrating the zero point of your O₂ or optional CO₂ sensor options.



9.1.2.2. 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.

Table 9-1: NISTSRM's Available for Traceability of O₂ Calibration Gases

NIST-SRM	Type	Nominal Concentration
2657a	O ₂ in N ₂	2%
2658a	O ₂ in N ₂	10 %
2659a	O ₂ in N ₂	21%
2619a ¹	CO ₂ in N ₂	0.5%
2620a ¹	CO ₂ in N ₂	1%
2622a ¹	CO ₂ in N ₂	2%
2624a ¹	CO ₂ in N ₂	3%
2744b ¹	CO ₂ in N ₂	7%
2745 ¹	CO ₂ in N ₂	16%

¹ Used to calibrate optional CO₂ sensor.

Note

For span point calibration it is generally a good idea to use 80% of the reporting range for that channel. For instance, if the reporting range of the instrument is set for 5%, the proper span gas would be 4%.

9.1.3. DATA RECORDING DEVICES

A strip chart recorder, data acquisition system or digital data acquisition system should be used to record data from the serial or analog outputs of the T802.

- 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 T802 provides an internal data acquisition system (DAS), which is described in detail in Section 7 APICOM, a remote control program, is also provided as a convenient and powerful tool for data handling, download, storage, quick check and plotting (see Section 8.1.1).

9.2. MANUAL CALIBRATION CHECKS AND CALIBRATION

IMPORTANT

IMPACT ON READINGS OR DATA

ZERO/SPAN CALIBRATION CHECKS VS. ZERO/SPAN CALIBRATION

Pressing the ENTR button during the following procedure resets the stored values for OFFSET and SLOPE and alters the instrument's Calibration. This should ONLY BE DONE during an actual calibration of the T802.

NEVER press the ENTR button if you are only *checking* calibration.

9.2.1. SETUP FOR BASIC CALIBRATION CHECKS AND CALIBRATION

Connect the Sources of Zero Air and Span Gas as shown below.

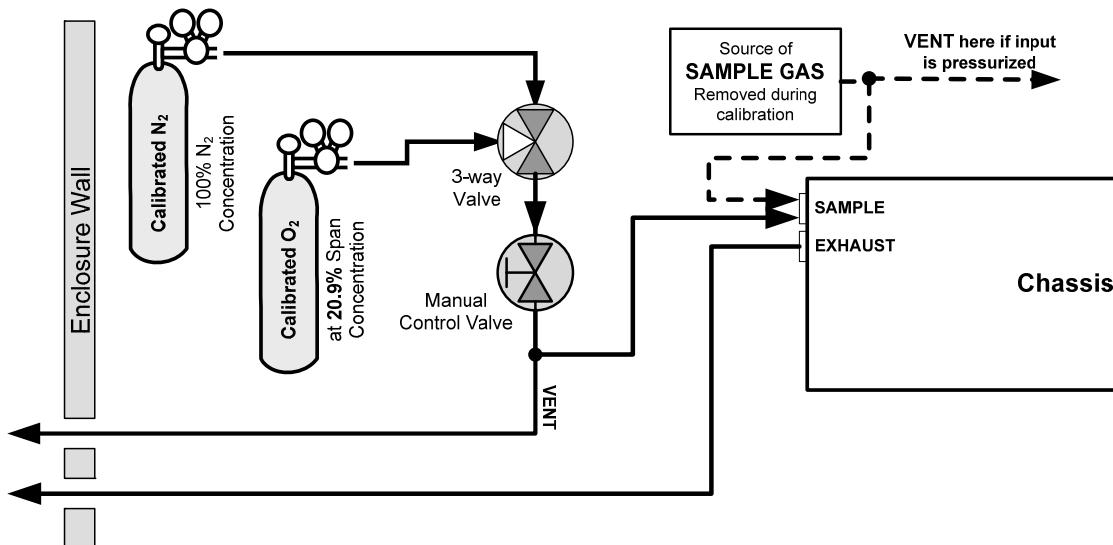
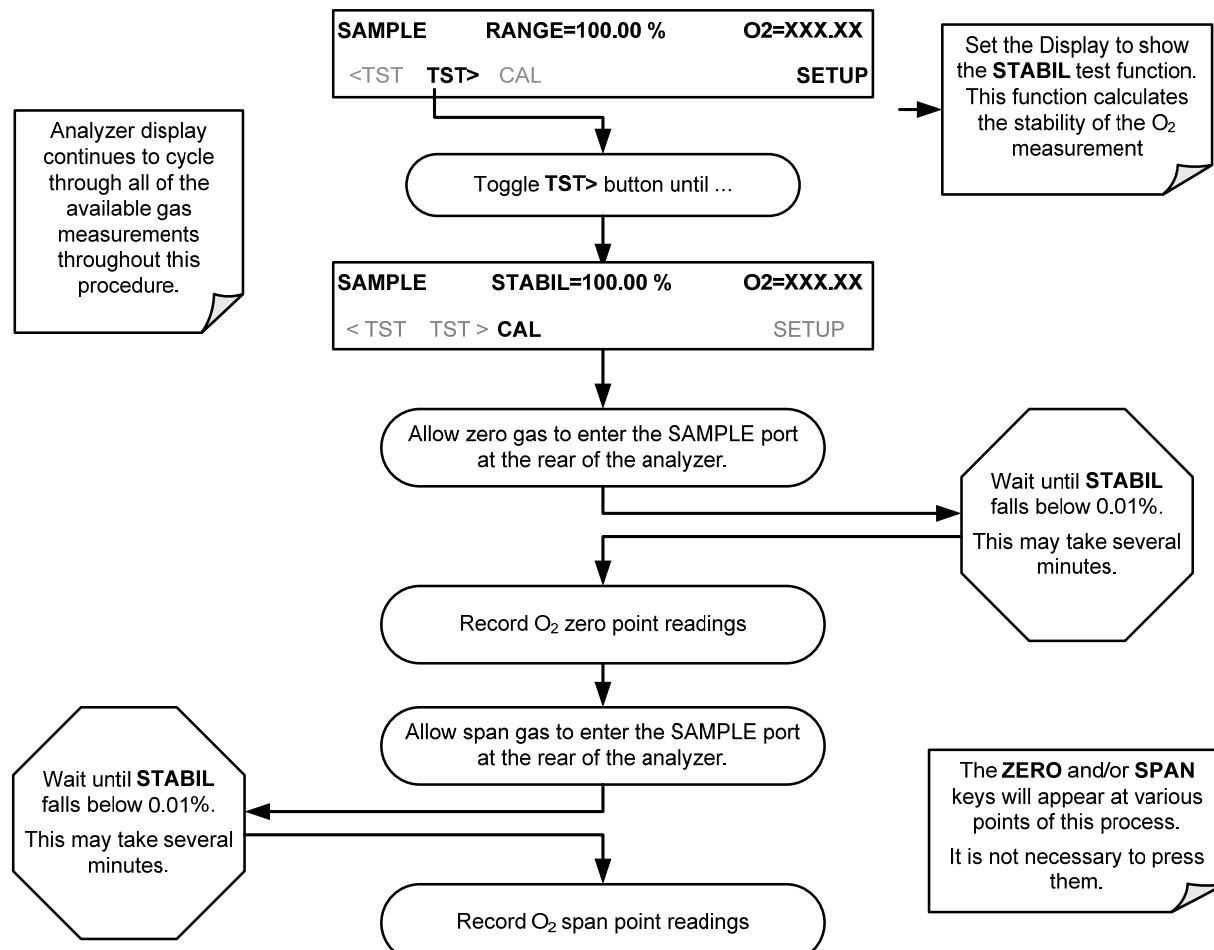


Figure 9-1: Pneumatic Connections—Basic Configuration—Using Bottled Span Gas

9.2.2. PERFORMING A BASIC MANUAL CALIBRATION CHECK



Note

If the **ZERO** or **SPAN** menu buttons are not displayed, the measurement made during this cal check is out of the allowable range allowed for a reliable calibration. See Section 11 for troubleshooting tips.

9.2.3. PERFORMING A BASIC MANUAL CALIBRATION

The following section describes the basic method for manually calibrating the T802.

If the analyzer's reporting range is set for the **DUAL** or **AUTO** range modes, a step will appear for selecting which range is to be calibrated: **RNG1** (LOW) or **RNG2** (HIGH).

Each of these two ranges **MUST** be calibrated separately.

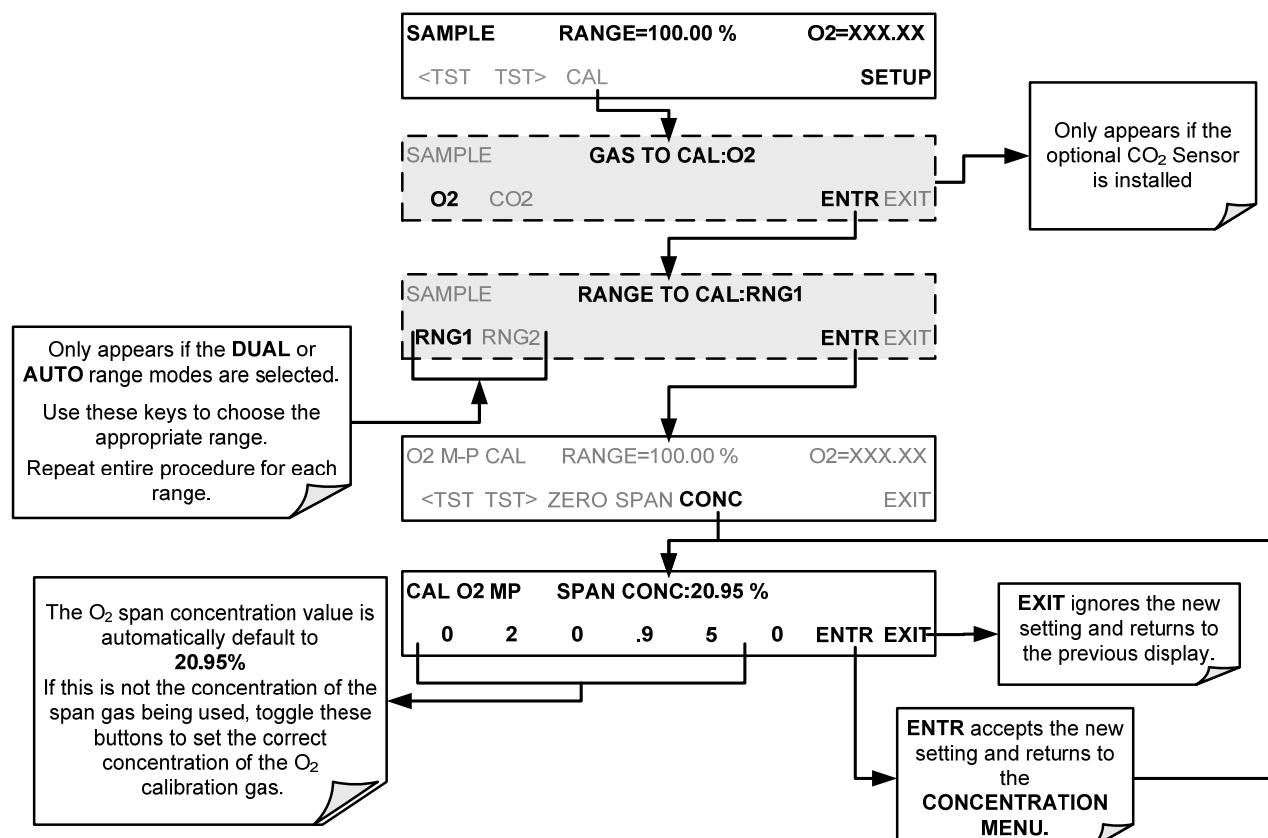
9.2.3.1. SETTING THE EXPECTED SPAN GAS CONCENTRATION

Note

When setting expected concentration values, consider impurities in your span gas.

The expected O₂ span gas concentration should be 80% of the reporting range of the instrument (see Section 5.4.1)

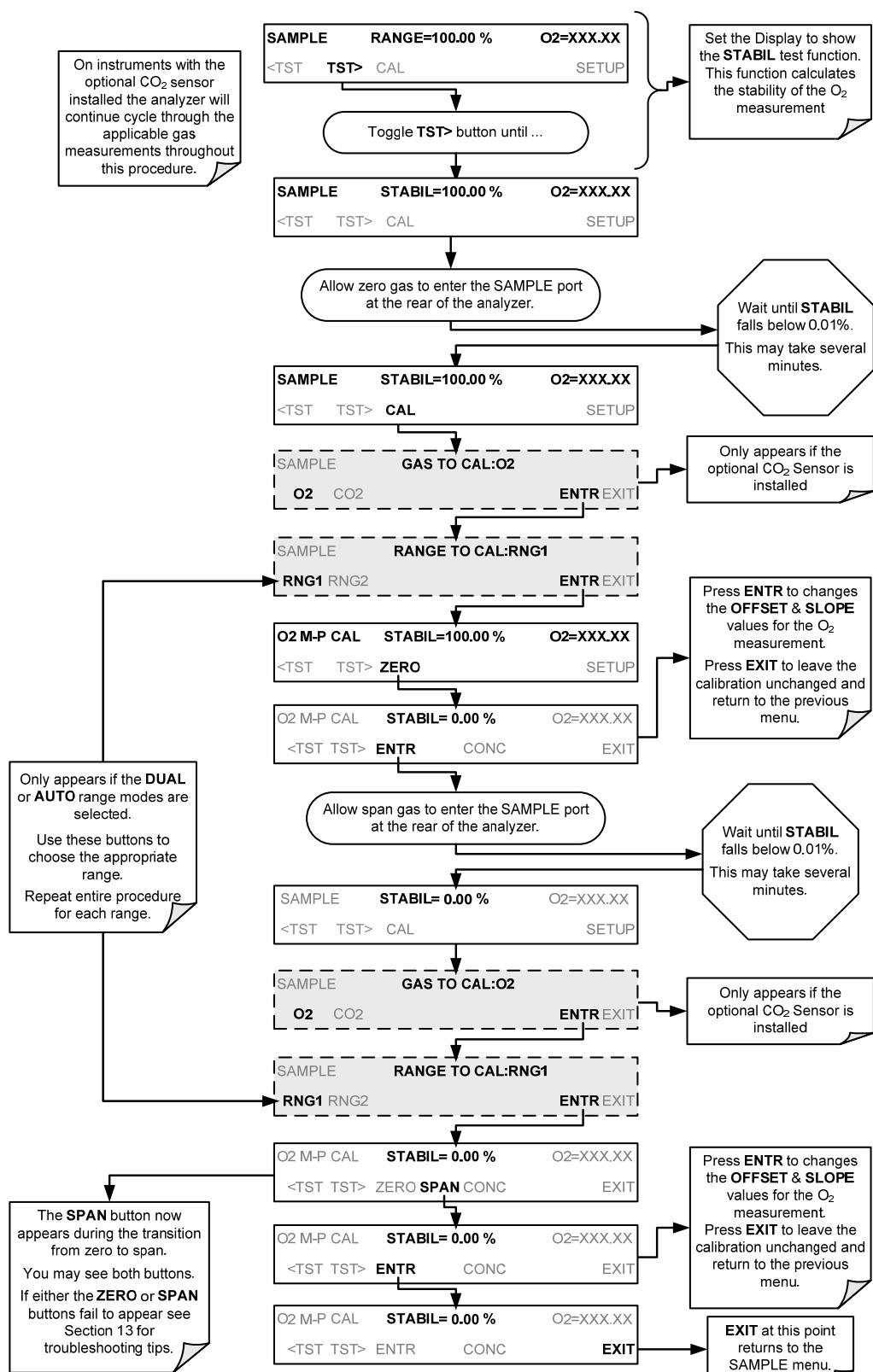
The default factory setting is 20.95 %. To set the span gas concentration, press:



Note

For this Initial Calibration it is important to independently verify the PRECISE Concentration Value of the SPAN gas. If the source of the Span Gas is from a calibrated bottle, use the exact concentration value printed on the bottle.

9.2.3.2. ZERO/SPAN POINT CALIBRATION PROCEDURE



9.3. ASSESSING CALIBRATION QUALITY

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

To perform this quality evaluation, you will need to record the values of both test functions (Section 3.4.2 or Appendix A-3), all of which are automatically stored in the DAS channel **CALDAT** for data analysis, documentation and archival.

Make sure that these parameters are within the limits listed below and frequently compare them to those values on the *Final Test and Checkout Sheet* (PN 068350000) that came attached to your manual, which should not be significantly different. If they are, refer to troubleshooting in Section 11.

Table 9-2: 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

These values should not be significantly different from the values recorded on the Teledyne API *Final Test and Validation Data Sheet* that was shipped with your instrument.

If they are, refer to troubleshooting in Section 11.

The default DAS configuration records all calibration values in channel **CALDAT** as well as all calibration check (zero and span) values in its internal memory.

- Up to 200 data points are stored for up 4 years of data (on weekly calibration checks) and a lifetime history of monthly calibrations.
- Review these data to see if the zero and span responses change over time.
- These channels also store the STABIL value (standard deviation of O₂ concentration) to evaluate if the analyzer response has properly leveled off during the calibration procedure

If your instrument has a CO₂ sensor option installed this should be calibrated as well.

9.4. CALIBRATION OF THE T802'S ELECTRONIC SUBSYSTEMS

9.4.1. PRESSURE CALIBRATION

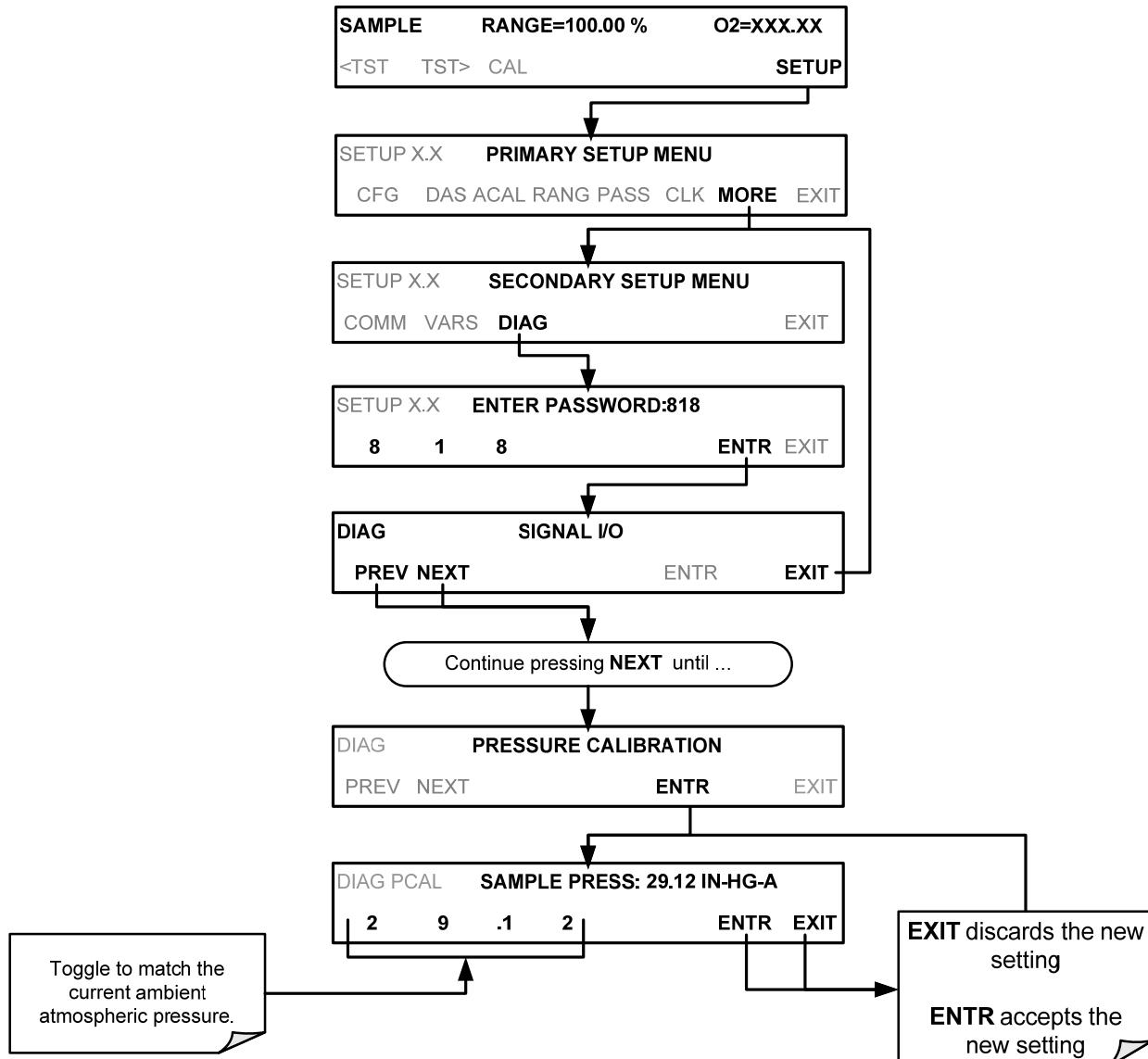
A sensor at the exit of the sample chamber continuously measures the pressure of the sample gas. This data is used to compensate the final O₂ concentration calculation for changes in atmospheric pressure and is stored in the CPU's memory as the test function PRES (also viewable via the front panel).

To carry out this adjustment, the current ambient atmospheric pressure must be known.

Before performing the following pressure calibration, ensure that the pressure being measured by the analyzer's internal sensor is equal to ambient atmospheric pressure by disconnecting:

- The sample gas pump and;
- The sample gas-line vent from the sample gas inlet on the instrument's rear panel.

To cause the analyzer to measure and record a value for PRES, press.

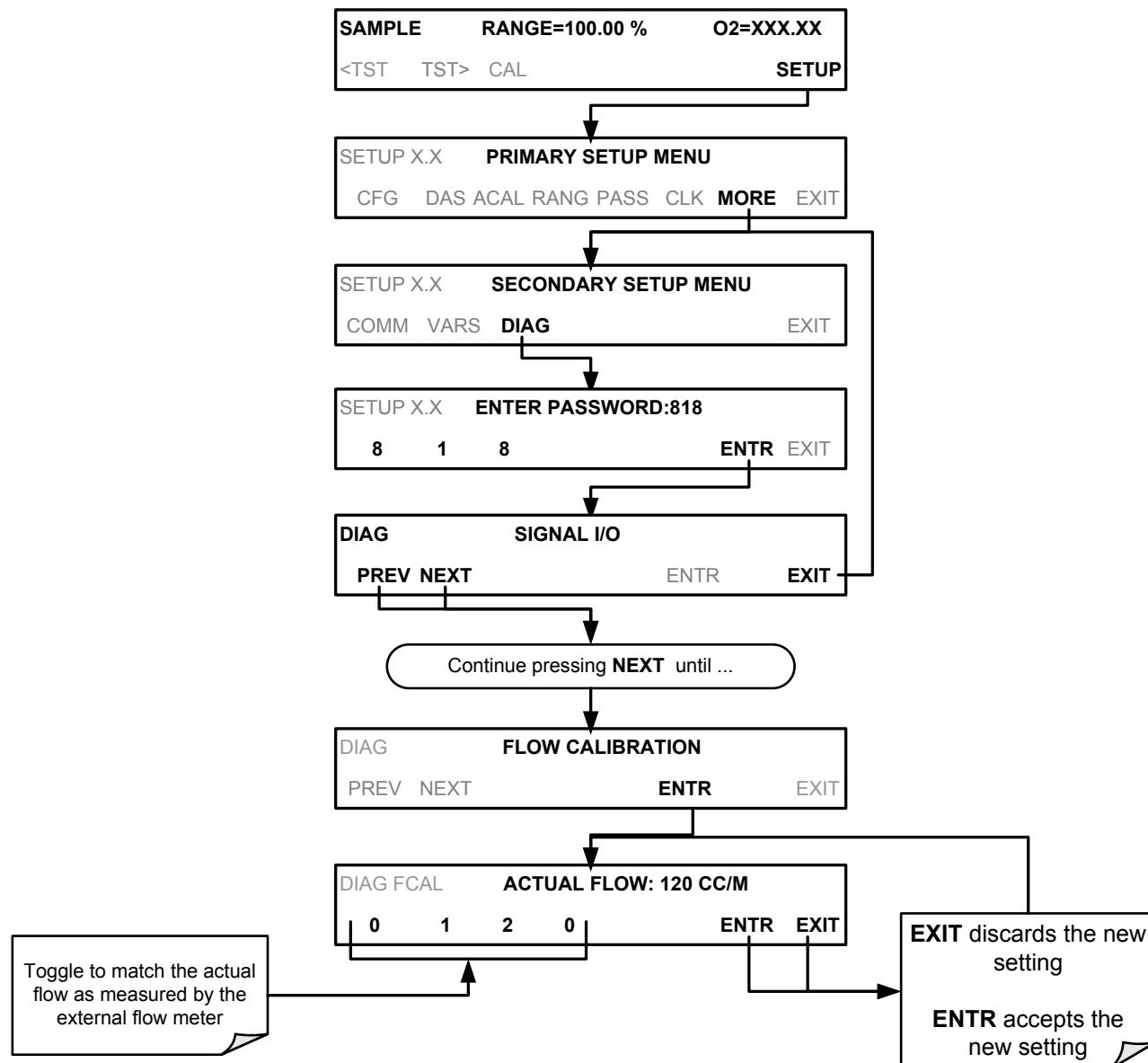


(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

9.4.2. FLOW CALIBRATION

The flow calibration allows the user to adjust the values of the sample flow rates as they are displayed on the front panel and reported through COM ports to match the actual flow rate measured at the sample inlet. This does not change the hardware measurement of the flow sensors, only the software-calculated values.

To carry out this adjustment, connect an external, sufficiently accurate flow meter to the sample inlet. Once the flow meter is attached and is measuring actual gas flow, press:



9.5. CALIBRATION OF THE OPTIONAL CO₂ SENSOR

9.5.1. CO₂ CALIBRATION SETUP

The pneumatic connections for calibrating are as follows

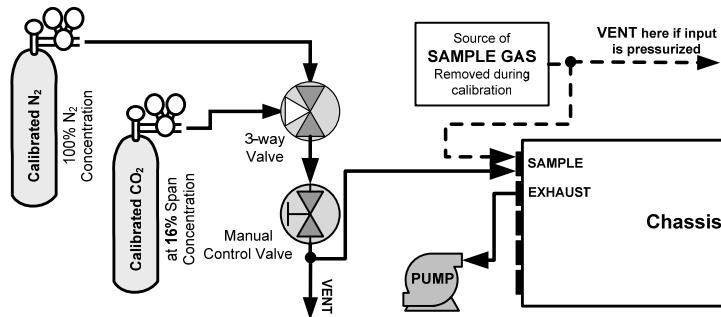


Figure 9-2: CO₂ Sensor Calibration Set Up

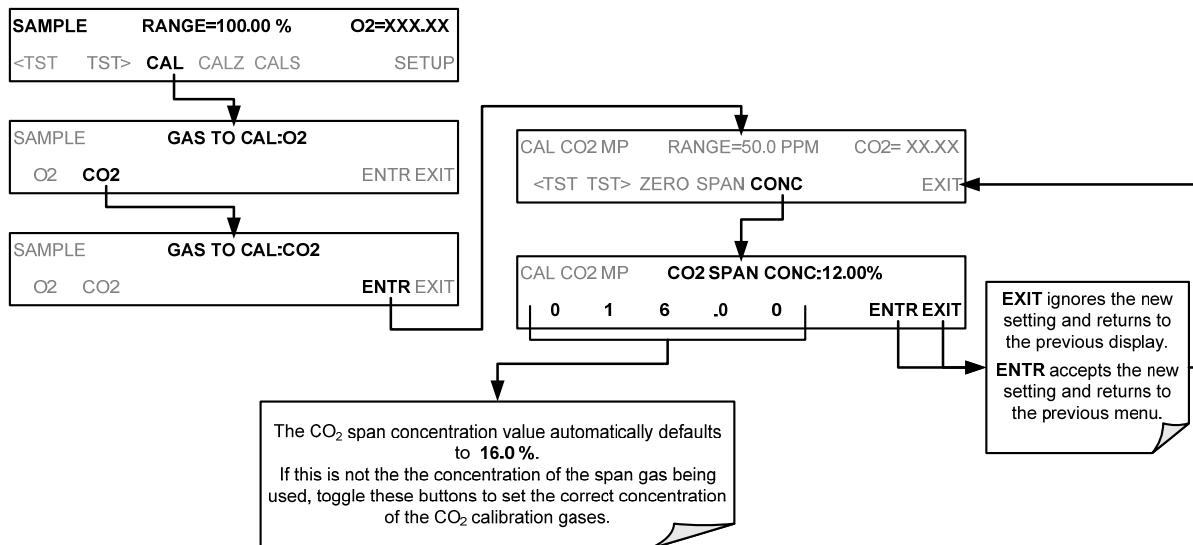
CO₂ SENSOR ZERO GAS: Teledyne API recommends using pure N₂ when calibrating the zero point of your CO₂ sensor option.

CO₂ SENSOR SPAN GAS: Teledyne API recommends using 16% CO₂ in N₂ when calibrating the span point of your CO₂ sensor option (Table 3-8).

9.5.2. SET CO₂ SPAN GAS CONCENTRATION

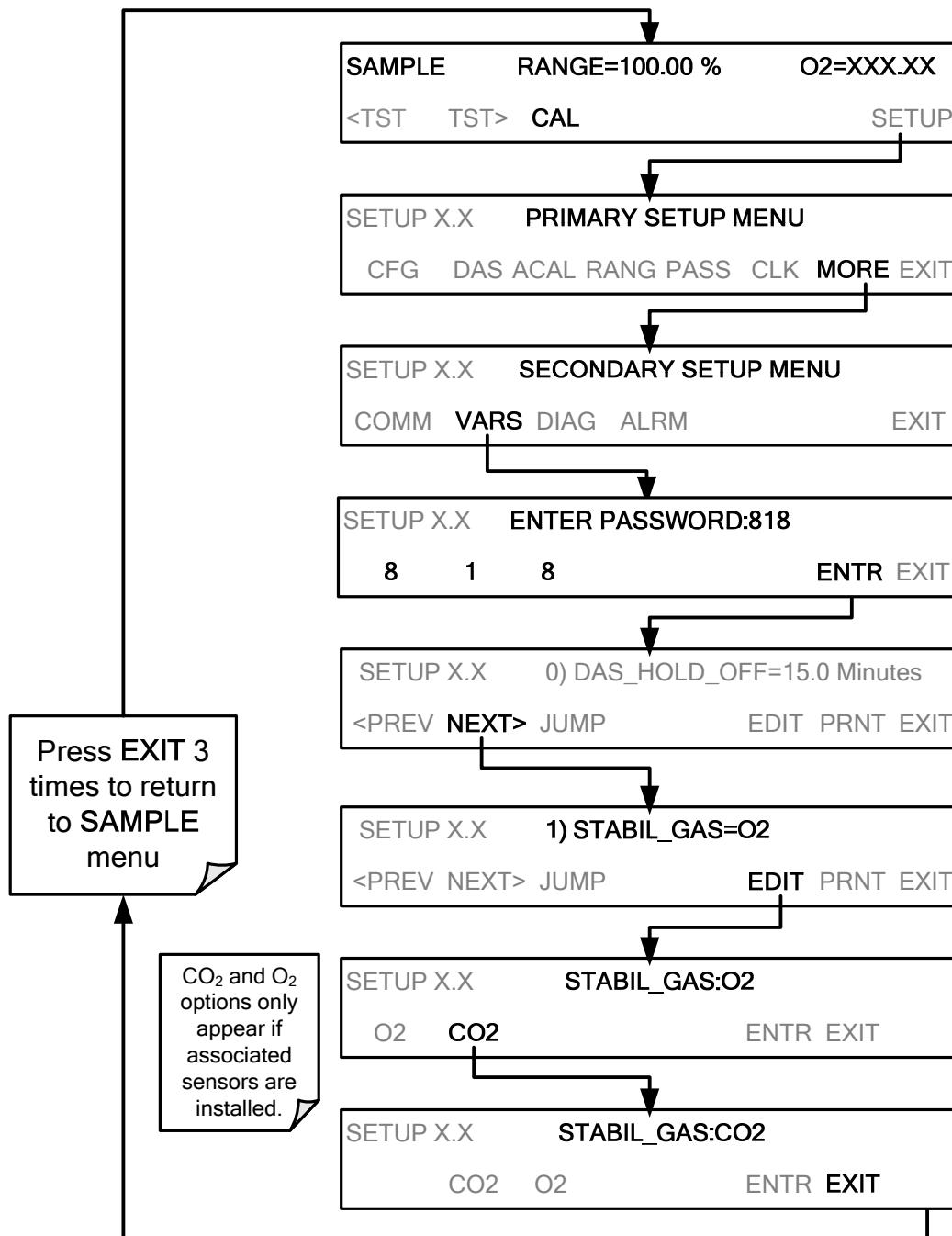
Set the expected CO₂ span gas concentration.

This should be equal to the percent concentration of the CO₂ span gas of the selected reporting range (default factory setting = 16%).



9.5.3. ACTIVATE CO₂ SENSOR STABILITY FUNCTION

To change the stability test function from O₂ concentration to the CO₂ sensor output, press:



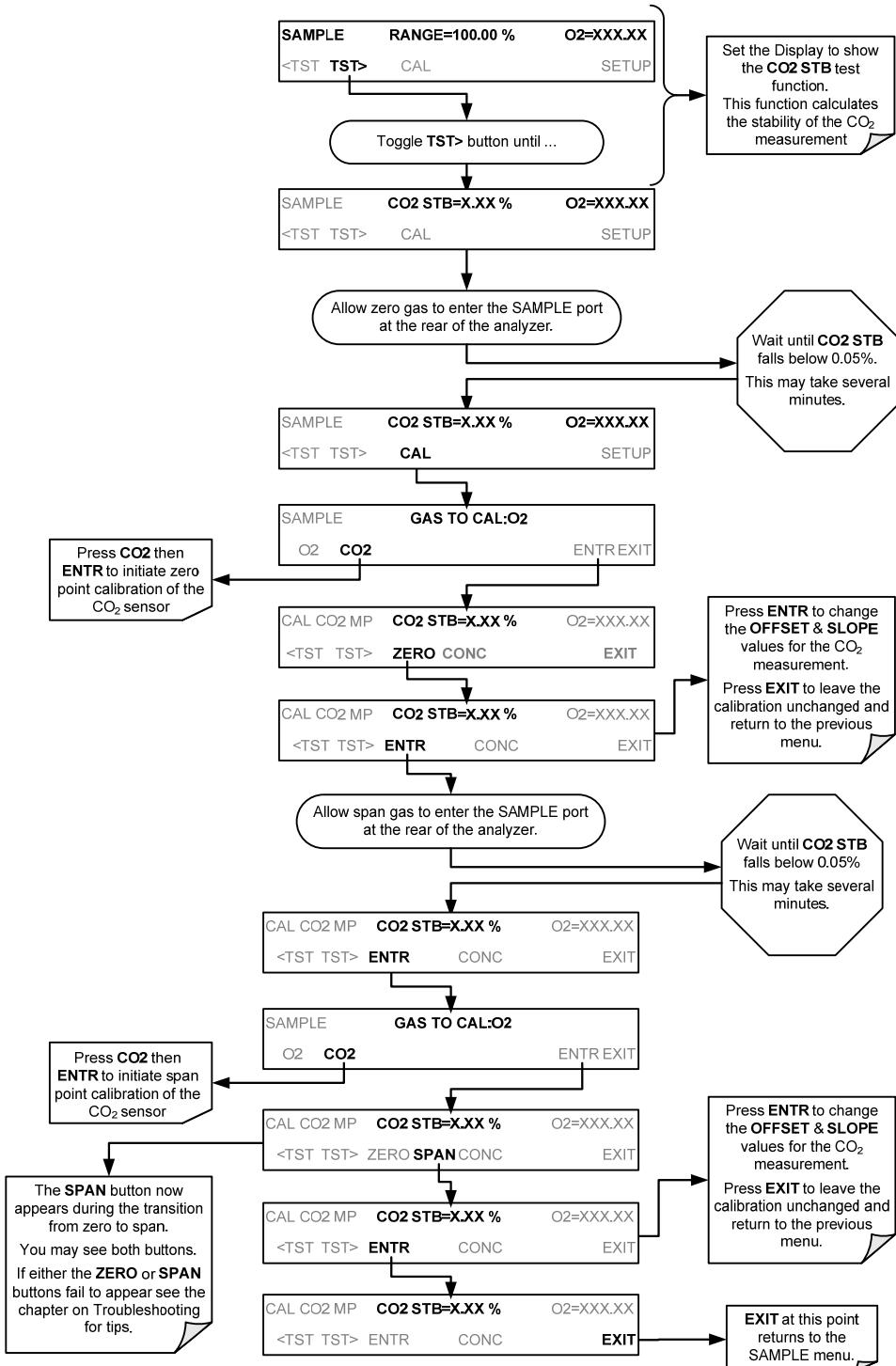
NOTE

Use the same procedure to reset the STB test function to O₂ when the CO₂ calibration procedure is complete.

(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

9.5.4. CO₂ ZERO/SPAN CALIBRATION:

To perform the zero/span calibration procedure:



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PART III
—
MAINTENANCE AND SERVICE

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10. MAINTENANCE SCHEDULE & PROCEDURES

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. Repairs and troubleshooting are covered in Section 11 of this manual.

10.1. MAINTENANCE SCHEDULE

Table 10-1 shows a typical maintenance schedule for the analyzer. Please note that in certain environments (i.e. dusty, very high ambient pollutant levels) some maintenance procedures may need to be performed more often than shown.

Note

A Span and Zero Calibration Check (see CAL CHECK REQ'D Column of Table 10-1) must be performed following certain of the maintenance procedure listed below.

HAZARD

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

GENERAL SAFETY HAZARD



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



CAUTION
QUALIFIED PERSONNEL

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

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Table 10-1. T802 Maintenance Schedule

ITEM	ACTION	FREQ	CAL CHECK REQ'D.	MANUAL	DATE PERFORMED									
Particulate Filter	Replace	Weekly or as needed	No	10.3.1										
Verify Test Functions	Record and analyze	Weekly or after any Maintenance or Repair	No	11.1.2										
Pump Diaphragm	Replace	Annually	Yes	10.3.2										
Perform Flow Check	Check Flow	Annually	No	10.3.4										
Perform Leak Check	Verify Leak Tight	Annually or after any Maintenance or Repair	No	10.3.3										
Pneumatic lines	Examine and clean	As needed	Yes if cleaned											
Chassis	Wipe down	As needed	Only if cover removed											

Table 10-2: T802 Test Function Record

FUNCTION	OPERATING MODE*	DATE RECORDED									
STABIL	O2 ZERO CAL										
PRES	SAMPLE										
O2SLOPE	SPAN CAL										
O2 OFFSET	ZERO CAL										

10.2. PREDICTIVE DIAGNOSTICS

The Test Functions can be used to predict failures by looking at how their values change over time. Initially it may be useful to compare the state of these Test Functions to the values recorded on the printed record of the final calibration performed on your instrument at the factory. Table 10-3 can be used as a basis for taking action as these values change with time. The internal data acquisition system (DAS) is a convenient way to record and track these changes. Use APICOM to download and review this data from a remote location.

Table 10-3: Predictive uses for Test Functions

FUNCTION	CONDITION	BEHAVIOR	INTERPRETATION
STABIL	O ₂ Zero Cal	Increasing	<ul style="list-style-type: none"> Pneumatic Leaks – instrument & sample system
PRES	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

10.3. MAINTENANCE PROCEDURES

The following procedures are to be performed periodically as part of the standard maintenance of the T802.

10.3.1. 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. Do not touch any part of the housing, filter element, PTFE retaining ring, glass cover and the o-ring.

To change the filter:

1. Turn OFF the analyzer to prevent drawing debris into the instrument.
2. Open the T802's hinged front panel and unscrew the knurled retaining ring on the filter assembly.

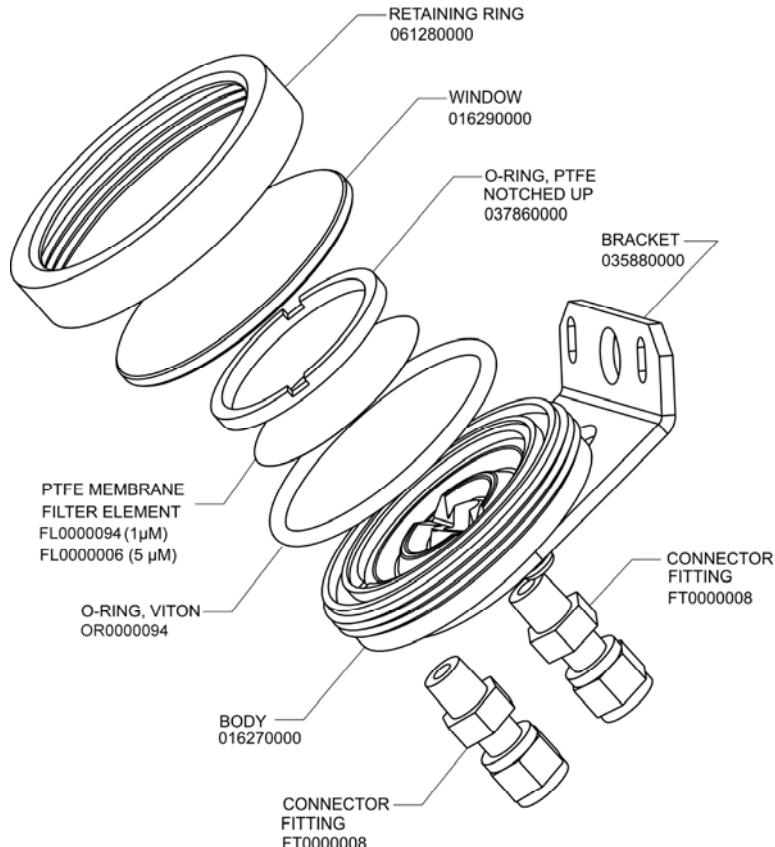


Figure 10-1: Sample Particulate Filter Assembly

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

10.3.2. REBUILDING THE SAMPLE PUMP

The diaphragm in the sample pump periodically wears out and must be replaced. A sample rebuild kit is available – see Appendix B of this manual 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.

10.3.3. PERFORMING LEAK CHECKS



HAZARD STRONG OXIDIZER

OXYGEN IS A STRONG OXIDIZER.

ONLY Perform Leak Checks using N₂ gas and after thoroughly purging the analyzer's internal pneumatics.

Leaks are the most common cause of analyzer malfunction; Section 10.3.3.1 presents a simple leak check procedure. Section 10.3.3.2 details a more thorough procedure.

10.3.3.1. 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 following. In the **TEST** menu, note the SAMPLE PRESSURE reading.
4. If the reading is < 10 in-Hg, the pump is in good condition and there are no large leaks.
5. Check the sample gas flow. If the flow is <10 cm³/min and stable, there are no large leaks in the instrument's pneumatics.

10.3.3.2. PRESSURE LEAK CHECK

If you can't locate the leak by the above procedure, use the following procedure. Obtain a leak checker similar to the Teledyne API PN 01960, which contains a small pump, shut-off valve and pressure gauge. Alternatively, a convenient source of low-pressure gas is a tank of span gas, with the two-stage regulator adjusted to less than 15 psi with a shutoff valve and pressure gauge.



CAUTION
GENERAL SAFETY HAZARD

Do not use bubble solution with vacuum applied to the analyzer. The solution may contaminate the instrument. Do not exceed 15 PSI pressure.

1. Turn OFF power to the instrument.
2. Install a leak checker or tank of gas as described above on the SAMPLE inlet at the rear panel.
3. Remove the instrument cover and locate the inlet side of the sample pump. Remove the flow assembly from the pump and plug it with the appropriate gas-tight fitting.
4. Pressurize the instrument with the leak checker, allowing enough time to fully pressurize the instrument through the critical flow orifice. Do not exceed 15 psi pressure. Check each fitting with soap bubble solution, looking for bubbles. Once the fittings have been wetted with soap solution, do not re-apply vacuum, as it will suck soap solution into the instrument and contaminate it. Wipe down and thoroughly dry all parts first.
5. Once the leak has been located and repaired, the leak-down rate should be < 1 in-Hg (0.4 psi) in 5 minutes after the pressure is shut off.

10.3.4. PERFORMING A SAMPLE FLOW CHECK



HAZARD
STRONG OXIDIZER

ONLY Perform Leak Checks using N₂ gas and after thoroughly purging the analyzer's internal pneumatics.



CAUTION
GENERAL SAFETY HAZARD

Always use a separate calibrated flow meter capable of measuring flows in the 0 – 1000 cm³/min range to measure the gas flow rate though the analyzer.

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

1. Attach the Flow Meter to the SAMPLE inlet port on the rear panel (Figure 3-4). Ensure that the inlet to the Flow Meter is at atmospheric pressure.
2. Sample flow should be 120 cm³/min ± 10%.
3. Once an accurate measurement has been recorded by the method described above, adjust the analyzer's internal flow sensors (See Section 9.4.2).

Low flows indicate blockage somewhere in the pneumatic pathway, typically a plugged sintered filter or critical flow orifice in one of the analyzer's flow control assemblies. High flows indicate leaks downstream of the Flow Control Assembly.

10.3.5. CLEANING THE OPTICAL BENCH

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.

10.3.6. CLEANING EXTERIOR SURFACES OF THE T802

If necessary, the exterior surfaces of the T802 can be cleaned with a clean damp cloth. Do NOT submerge any part of the instrument and do NOT use any cleaning solution.

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11. TROUBLESHOOTING AND SERVICE

This section describes a variety of methods for identifying the source of performance problems with the analyzer. Also included here are procedures that are used to repair the instrument.

HAZARD
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.

QUALIFIED PERSONNEL ONLY



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

CAUTION

RISK OF ELECTRICAL SHOCK



- Some operations need to be carried out with the instrument open and running.
- Exercise caution to avoid electrical shocks and electrostatic or mechanical damage to the analyzer.
- Do not drop tools into the analyzer or leave them after your procedures.
- Do not shorten or touch electric connections with metallic tools while operating inside the analyzer.
- Use common sense when operating inside a running analyzer.

11.1. GENERAL TROUBLESHOOTING

The T802 paramagnetic O₂ analyzer has been designed so that problems can be rapidly detected, evaluated and repaired. During operation, it continuously performs diagnostic tests and provides the ability to evaluate its key operating parameters without disturbing monitoring operations.

A systematic approach to troubleshooting will generally consist of the following five steps:

1. Note any **WARNING MESSAGES** and take corrective action as necessary.
2. Examine the values of all TEST functions and compare them to factory values. Note any major deviations from the factory values and take corrective action.
3. Use the internal electronic status LEDs to determine whether the electronic communication channels are operating properly.

Verify that the DC power supplies are operating properly by checking the voltage test points on the relay PCA.

Note that the analyzer's DC power wiring is color-coded and these colors match the color of the corresponding test points on the relay PCA.

4. **SUSPECT A LEAK FIRST!**

Technical Support data indicate that the majority of all problems are eventually traced to leaks in the internal pneumatics of the analyzer or the diluent gas and source gases delivery systems.

Check for gas flow problems such as clogged or blocked internal/external gas lines, damaged seals, punctured gas lines, a damaged / malfunctioning pumps, etc.

5. Follow the procedures defined in Section 11.6 to confirm that the analyzer's vital functions are working (power supplies, CPU, relay PCA, keyboard, etc.).

See Figure 3-5 for the general layout of components and sub-assemblies in the analyzer.

See the wiring interconnect diagram and interconnect list in Appendix D.

11.1.1. FAULT DIAGNOSIS WITH WARNING MESSAGES

The most common and/or serious instrument failures will result in a warning message being displayed on the front panel. Table 11-1 lists warning messages, along with their meaning and recommended corrective action.

It should be noted that if more than two or three warning messages occur at the same time, it is often an indication that some fundamental analyzer sub-system (power supply, relay board, motherboard) has failed rather than indication of the specific failures referenced by the warnings. In this case, it is recommended that proper operation of power supplies (See Section 11.6.2), the relay board (See Section 11.6.5), and the A/D Board (See Section 11.6.9.1) be confirmed before addressing the specific warning messages.

The analyzer will alert the user that a Warning Message is active by flashing the FAULT LED, displaying the Warning message in the Param field along with the **CLR** button (press to clear Warning message). The **MSG** button displays if there is more than one warning in queue or if you are in the TEST menu and have not yet cleared the message. The following display/touchscreen examples provide an illustration of each:



Top: the CLR button is available to clear the warning message displayed in the Param field.

Bottom: the MSG button indicates that at least one warning message has not yet been cleared.

The analyzer will also alert the user via the Serial I/O COM port(s).

To view or clear the various warning messages press:

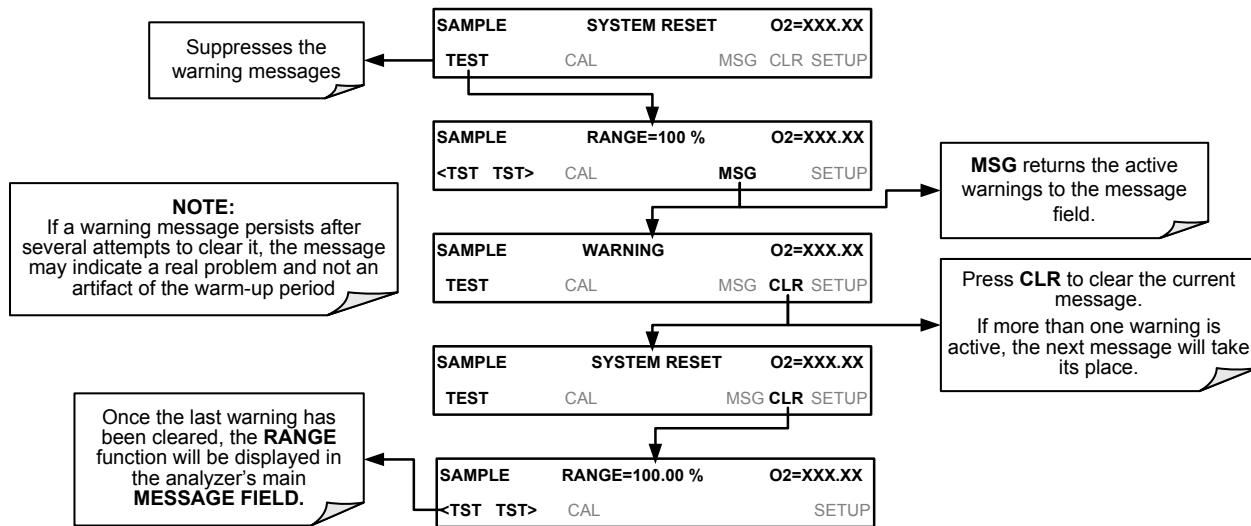


Figure 11-1: Viewing and Clearing Warning Messages

Table 11-1: Warning Messages - Indicated Failures

WARNING MESSAGE	FAULT CONDITION	POSSIBLE CAUSES
O ₂ CELL TEMP WARN	The O ₂ cell temp is controlled at 50 ± 2 °C.	Bad heater Bad temperature sensor Bad relay controlling the heater Entire relay board is malfunctioning I ² C bus malfunction
BOX TEMP WARNING	Box Temp is < 8 °C or > 50 °C.	NOTE: Box temperature typically runs ~7°C warmer than ambient temperature. Poor/blocked ventilation to the analyzer. Stopped exhaust-fan Ambient temperature outside of specified range
CANNOT DYN SPAN	Dynamic Span operation failed	Measured concentration value is too high or low. Concentration slope value to high or too low
CANNOT DYN ZERO	Dynamic Zero operation failed	Measured concentration value is too high. Concentration offset value to high.
CONFIG INITIALIZED	Configuration and Calibration data reset to original Factory state.	Failed disk on module User erased data
DATA INITIALIZED	Data Storage in DAS was erased	Failed Disk on Module User cleared data
REAR BOARD NOT DET	Motherboard not detected on power up.	Warning only appears on serial I/O COM port(s) Front panel display will be frozen, blank or will not respond. Massive failure of mother board

WARNING MESSAGE	FAULT CONDITION	POSSIBLE CAUSES
RELAY BOARD WARN	The CPU cannot communicate with the Relay Board.	I ² C bus failure Failed relay board Loose connectors/wiring
SAMPLE FLOW WARN	Sample flow rate is < 80 cm ³ /min or > 180 cm ³ /min	Failed sample pump Blocked sample inlet/gas line Dirty particulate filter Leak downstream of critical flow orifice Failed flow sensor/circuitry
SAMPLE PRES WARN	Sample Pressure is <15 in-Hg or > 35 in-Hg Normally 29.92 in-Hg at sea level decreasing at 1 in-Hg per 1000 ft of altitude (with no flow – pump disconnected).	If sample pressure is < 15in-Hg: Blocked particulate filter Blocked sample inlet/gas line Failed pressure sensor/circuitry If sample pressure is > 35 in-Hg: Pressurized sample gas. Install vent Blocked vent line on pressurized sample/zero/span gas supply Bad pressure sensor/circuitry
SYSTEM RESET	The computer has rebooted.	This message occurs at power on. If you have not cycled the power on your instrument: Failed +5 VDC power, Fatal error caused software to restart Loose connector/wiring

11.1.2. FAULT DIAGNOSIS WITH TEST FUNCTIONS

In addition to being useful as predictive diagnostic tools, the test functions viewable from the front panel can be used to isolate and identify many operational problems when combined with a thorough understanding of the analyzer's theory of operation (see Section 12).

The acceptable ranges for these test functions are listed in the "Nominal Range" column of the analyzer *Final Test and Validation Data Sheet* (PN 068350000) shipped with the instrument. Values outside these acceptable ranges indicate a failure of one or more of the analyzer's subsystems. Functions whose values are still within the acceptable range but have significantly changed from the measurement recorded on the factory data sheet may also indicate a failure.

Note

A worksheet has been provided in Appendix C to assist in recording the value of these test functions. This worksheet also includes expected values for the various test functions.

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

Table 11-2: Test Functions - Indicated Failures

TEST FUNCTIONS (As Displayed)	INDICATED FAILURE(S)
TIME	Time of day clock is too fast or slow To adjust See Section 5.6. Battery in clock chip on CPU board may be dead.
RANGE	Incorrectly configured measurement range(s) could cause response problems with a Data logger or chart recorder attached to one of the analog output. If the Range selected is too small, the recording device will over range. If the Range is too big, the device will show minimal or no apparent change in readings.
STABIL	Indicates noise level of instrument or concentration of sample gas (See Section 11.3 for causes).
PRES	See Table 11-1 for SAMPLE PRES WARN
SAMPLE FL	Check for gas flow problems (see Section 11.3).
O2 CELL TEMP	Temperatures outside of the specified range or oscillating temperatures are cause for concern
BOX TEMP	If the box temperature is out of range, check fan in the power supply module. Areas to the side and rear of instrument should allow adequate ventilation. See Table 11-1 for BOX TEMP WARNING .
O2 SLOPE	Values outside range indicate Contamination of the zero air or span gas supply Instrument is miscalibrated Blocked gas flow Bad/incorrect span gas concentration due.
O2 OFFSET	Values outside range indicate contamination of the zero air supply

11.1.3. **DIAG → SIGNAL I/O: USING THE DIAGNOSTIC SIGNAL I/O FUNCTION**

The signal I/O diagnostic mode allows access to the digital and analog I/O in the analyzer. Some of the digital signals can be controlled through the keyboard. These signals, combined with a thorough understanding of the instruments Theory of Operation (found in Section 12), 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. The following flowchart shows an example of how to use the Signal I/O menu to view the raw voltage of an input signal or to control the state of an output voltage or control signal.

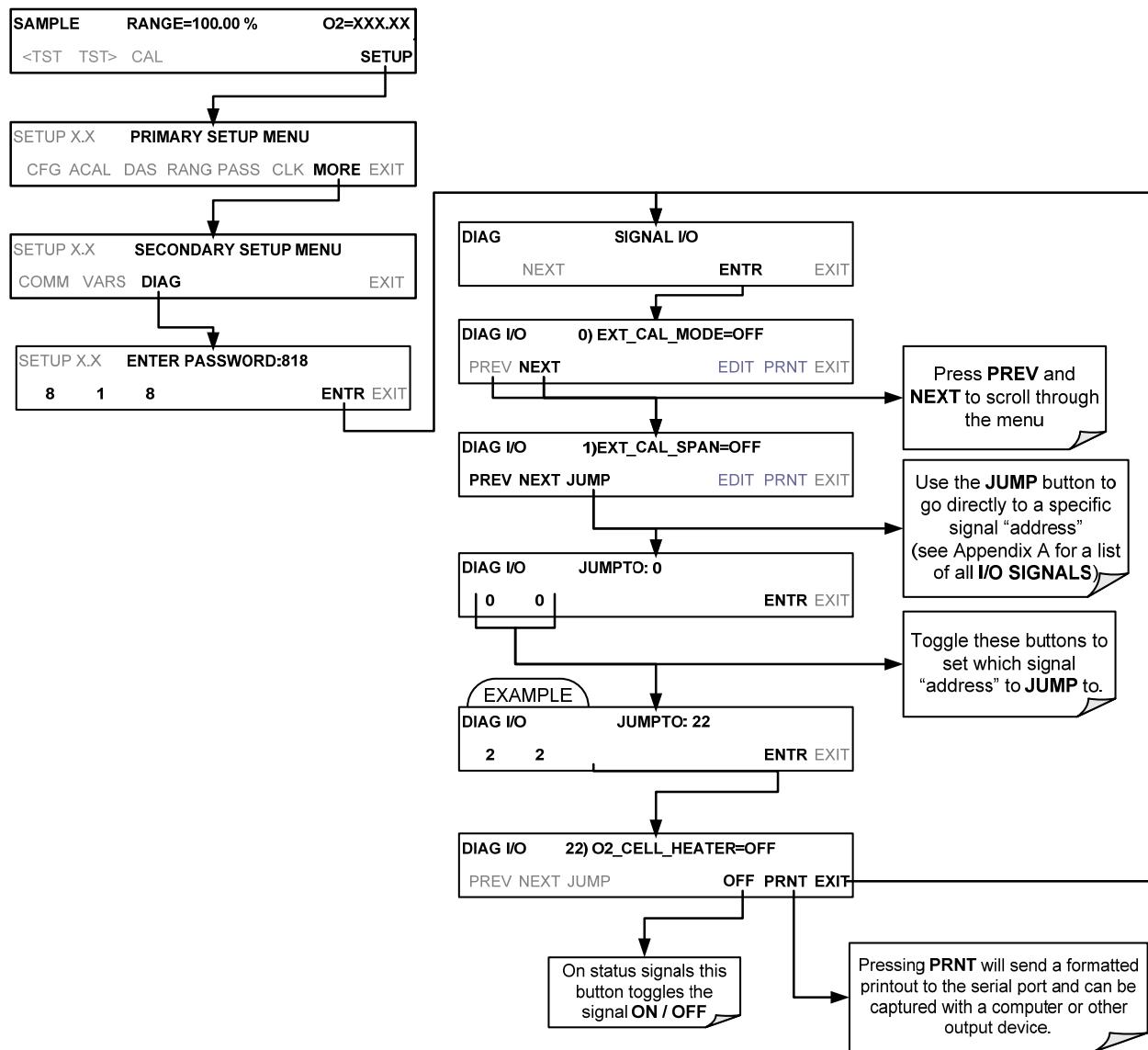


Figure 11-2: Example of Signal I/O Function

(The ACAL submenu in the Primary Setup Menu is a special configuration; consult factory).

Note

Any I/O signals changed while in the signal I/O menu will remain in effect ONLY until signal I/O menu is exited. The Analyzer regains control of these signals upon exit.

11.2. USING THE INTERNAL ELECTRONIC STATUS LEDS

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

11.2.1. CPU STATUS INDICATOR

DS5, a red LED, that is located on upper portion of the motherboard, just to the right of the CPU board, flashes when the CPU is running the main program loop. After power-up, approximately 30 to 60 seconds, DS5 should flash on and off. If characters are written to the front panel display but DS5 does not flash, then the program files have become corrupted. If after 30 – 60 seconds neither the DS5 is flashing or no characters have been written to the front panel display, then the CPU is bad and must be replaced.

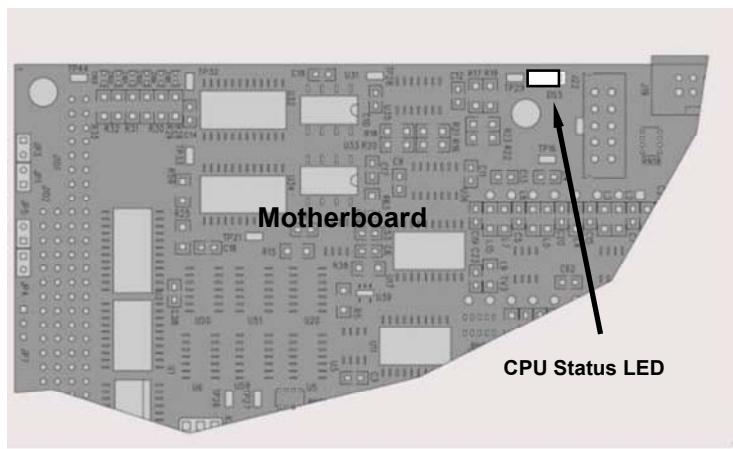


Figure 11-3: CPU Status Indicator

11.2.2. RELAY PCA STATUS INDICATORS

There are sixteen status indicator LEDs located on the Relay PCA. Some are not used on this model.

11.2.2.1. I²C BUS WATCHDOG STATUS LEDS

The most important is D1 (which indicates the health of the I²C bus).

Table 11-3: Relay PCA Watchdog LED Failure Indications

LED	Function	Fault Status	Indicated Failure(s)
D1 (Red)	I ² C bus Health (Watchdog Circuit)	Continuously ON or Continuously OFF	Failed/Halted CPU Faulty Motherboard, Keyboard or Relay PCA Faulty Connectors/Wiring between Motherboard, Keyboard or Relay PCA Failed/Faulty +5 VDC Power Supply (PS1)

If D1 is blinking, then the other LEDs can be used in conjunction with **DIAG** Menu Signal I/O to identify hardware failures of the relays and switches on the Relay PCA.

11.2.2.2. RELAY PCA STATUS LED S

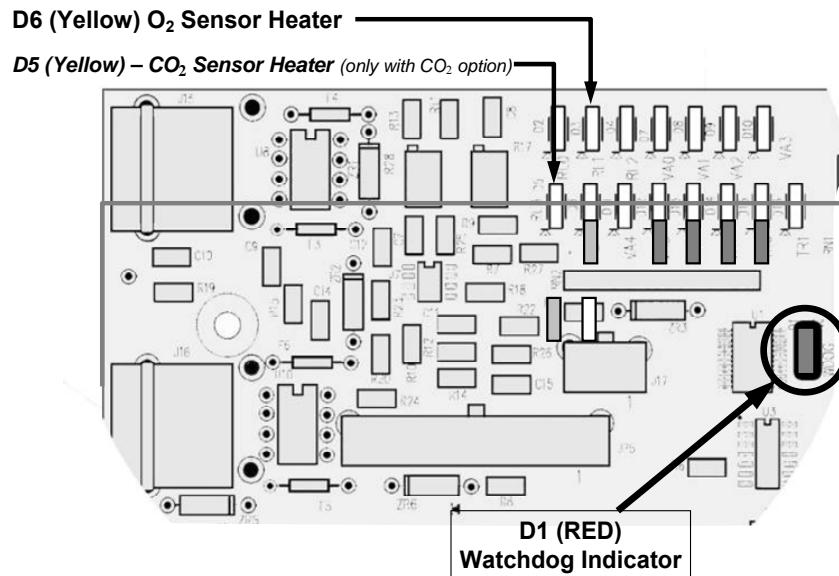


Figure 11-4: Relay PCA Status LEDS Used for Troubleshooting

Table 11-4: Relay PCA Status LED Failure Indications

LED	Color	Function	Status When LED Lit (Energized State)	Status When LED Unlit (Default State)
D1	Red	Watchdog Circuit	Cycles ON/OFF every 3 Seconds under direct control of the analyzer's CPU.	
D2-D4		SPARE		
D5 ¹	Yellow	CO ₂ Sensor Cell heater	Heating	Not Heating
D6	Yellow	O ₂ Sensor heater	Heating	Not Heating
D7 ²	Green			
D8 ²	Green			
D9 ²	Green			
D10 ²	Green			
D11 - 16		SPARE		

¹ Only active when the optional CO₂ sensor is installed
² Not Used

11.3. GAS FLOW PROBLEMS

When troubleshooting flow problems, it is a good idea to first confirm that the actual flow and not the analyzer's flow sensor and software are in error, or the flow meter is in error. Use an independent flow meter to perform a flow check as described in Section 10.3.4. If this test shows the flow to be correct, check the pressure sensors as described in Section 11.6.8.

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

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

When troubleshooting flow problems, it is crucial to confirm the actual flow rate without relying on the analyzer's flow display. The use of an independent, external flow meter to perform a flow check as described in Section 10.3.4 is essential.

The flow diagrams found in a variety of locations within this manual depicting the T802 in its standard configuration and with options installed, can help in trouble-shooting flow problems. For your convenience the diagrams are collected here.

11.3.1. T802 INTERNAL GAS FLOW DIAGRAMS

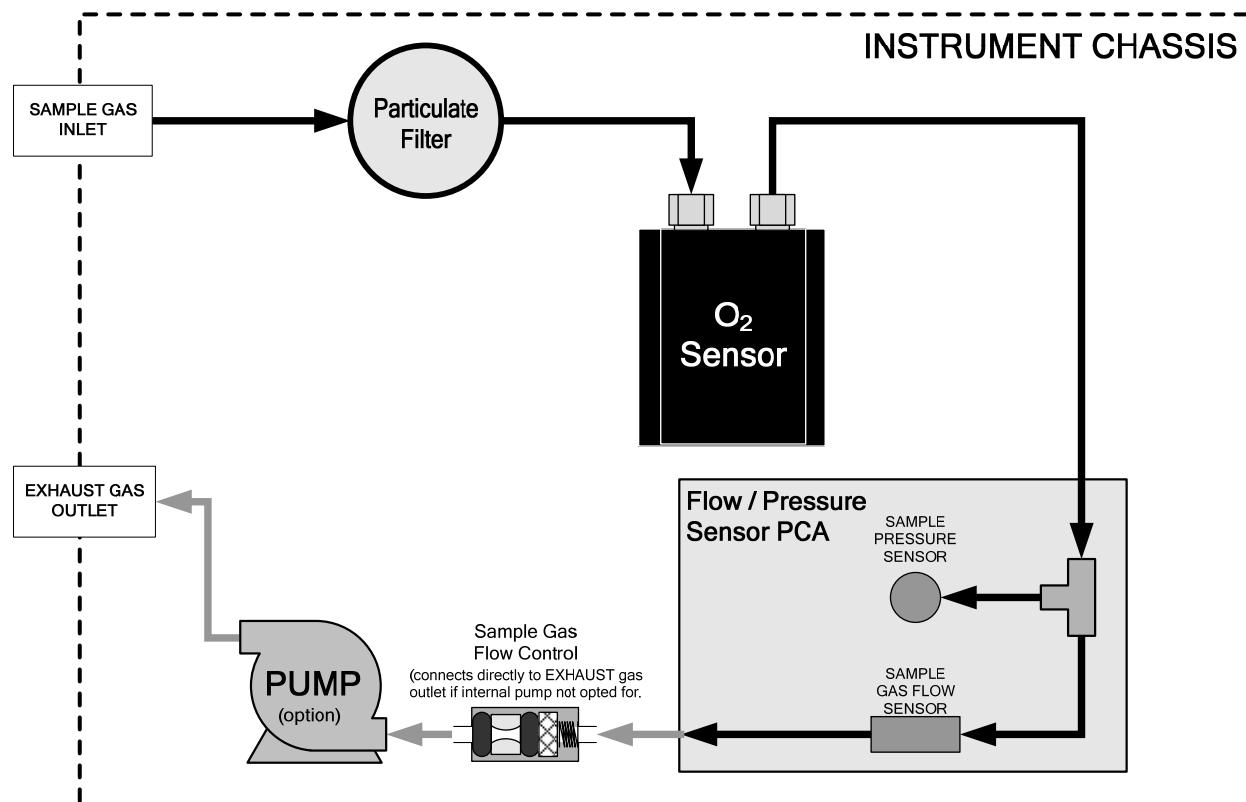


Figure 11-5: T802– Basic Internal Gas Flow

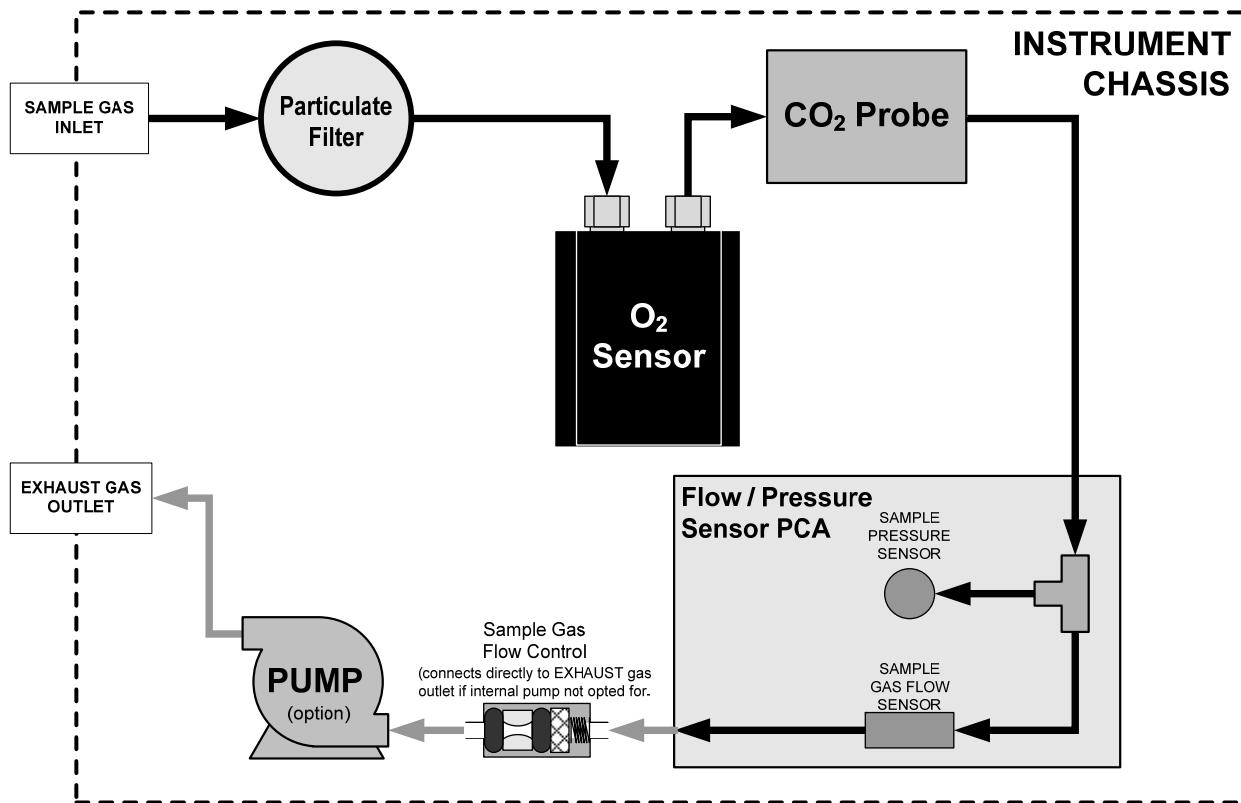


Figure 11-6: T802 – Internal Pneumatics with CO₂ Sensor Option 67

11.3.2. TYPICAL SAMPLE GAS FLOW PROBLEMS

11.3.2.1. FLOW IS ZERO

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

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

1. If AC power is being supplied to the pump, but it is not turning, replace the pump.
2. If the pump is operating but the unit reports no gas flow, perform a flow check as described in Section 10.3.4.
3. If no independent flow meter is available:
 - Disconnect the gas lines from both the sample inlet and the exhaust outlet on the rear panel of the instrument.
 - Make sure that the unit is in basic SAMPLE Mode.
 - Place a finger over a Sample inlet on the rear panel of the instrument.
 - If gas is flowing through the analyzer, you will feel a vacuum suction at the inlet.

4. If gas flows through the instrument when it is disconnected from its sources of zero air, span gas or sample gas, the flow problem is most likely not internal to the analyzer. Check to ensure that:
 - All calibrators/generators are turned on and working correctly.
 - Gas bottles are not empty or low.
 - Valves, regulators and gas lines are not clogged or dirty.

11.3.2.2. LOW FLOW

1. Check if the pump diaphragm is in good condition. If not, rebuild the pump (See Section 10.3.2). Check the Spare Parts List for information on pump rebuilding kits.
2. Check for leaks as described in Section 10.3.3. Repair the leaking fitting, line and re-check.
3. Check for the sample filter and the orifice filter for dirt. Replace filters (See 10.3.1).
4. Check for partially plugged pneumatic lines. Clean or replace them.
5. Check for plugged or dirty critical flow orifices. Replace them.

11.3.2.3. HIGH FLOW

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

11.3.2.4. DISPLAYED FLOW WARNINGS

This warning means that there is inadequate gas flow. There are four conditions that might cause this:

- A leak upstream or downstream of the flow sensor
- A flow obstruction upstream or downstream of the flow sensor
- Bad Flow Sensor Board
- Bad pump

To determine which condition is causing the flow problem, view the sample pressure and sample flow functions on the front panel display. If the sample pressure is reading abnormally low, then the cause is likely a flow obstruction upstream of the flow sensor. First, check the sample filter and make sure it is not plugged and then systematically check all the other components upstream of the orifice to ensure that they are not obstructed.

If the sample pressure is reading normal but the sample flow is reading low, then it is likely that the pump diaphragm is worn or there is an obstruction downstream of the flow sensor.

11.3.2.5. ACTUAL FLOW DOES NOT MATCH DISPLAYED FLOW

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 as described in Section 10.3.4.

11.3.2.6. SAMPLE PUMP

The sample pump should start immediately after the front panel power switch is turned ON. With the SAMPLE inlet plugged the test function PRES should read about 10"-Hg for a pump in good condition. Readings above 10" Hg indicate that the pump needs rebuilding. If the test function SAMP FL is greater than 10 cm³/min there is a leak in the pneumatic lines.

11.4. CALIBRATION PROBLEMS

11.4.1. 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.

11.4.2. 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 10.3.3. 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.

11.4.3. 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 ~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.

11.4.4. 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.

11.5. OTHER PERFORMANCE PROBLEMS

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

11.5.1. TEMPERATURE PROBLEMS

Individual control loops are used to maintain the set point of the absorption bench, filter wheel and IR photo-detector temperatures. If any of these temperatures are out of range or are poorly controlled, the T802 will perform poorly.

11.5.1.1. BOX TEMPERATURE

The box temperature sensor is mounted to the motherboard and cannot be disconnected to check its resistance. Rather check the **BOX TEMP** signal using the SIGNAL I/O function under the **DIAG** Menu (See Section 5.9). This parameter will vary with ambient temperature, but at ~30°C (6-7° above room temperature) the signal should be ~1450 mV.

11.6. SUBSYSTEM CHECKOUT

Section 10 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. This describes how to determine individually determine if a certain component or subsystem is actually the cause of the problem being investigated.

11.6.1. AC MAINS CONFIGURATION

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

1. The Sample Pump is running.
2. If incorrect power is suspected, check that the correct voltage and frequency is present at the line input on the rear panel.
 - If the unit is set for 230 VAC and is plugged into 115VAC, or 100VAC the sample pump will not start, and the heaters will not come up to temperature.
 - If the unit is set for 115 or 100 VAC and is plugged into a 230 VAC circuit, the circuit breaker built into the ON/OFF Switch on the Front Panel will trip to the OFF position immediately after power is switched on.

11.6.2. DC POWER SUPPLY

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

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

Table 11-5: DC Power Test Point and Wiring Color Codes

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

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

Table 11-6: DC Power Supply Acceptable Levels

POWER SUPPLY ASSY	VOLTAGE	CHECK RELAY BOARD TEST POINTS				MIN V	MAX V		
		FROM TEST POINT		TO TEST POINT					
		NAME	#	NAME	#				
PS1	+5	Dgnd	1	+5	2	4.85	5.25		
PS1	+15	Agnd	3	+15	4	13.5	16V		
PS1	-15	Agnd	3	-15V	5	-13.5V	-16V		
PS1	Agnd	Agnd	3	Dgnd	1	-0.05	0.05		
PS1	Chassis	Dgnd	1	Chassis	N/A	-0.05	0.05		
PS2	+12	+12V Ret	6	+12V	7	11.75	12.5		
PS2	Dgnd	+12V Ret	6	Dgnd	1	-0.05	0.05		

11.6.3. 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.

11.6.4. TOUCHSCREEN INTERFACE

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

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

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

11.6.5. LCD DISPLAY MODULE

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

11.6.6. RELAY BOARD

The relay board PCA (04135) can be most easily checked by observing the condition of the its status LEDs on the relay board, as described in Section 12.5.4.1, and the associated output when toggled on and off through signal I/O function in the diagnostic menu, See Section 11.1.3.

1. If the front panel display responds to key presses and D1 on the relay board is NOT flashing then either the wiring between the Keyboard and the relay board is bad, or the relay board is bad.
2. If D1 on the relay board is flashing and the status indicator for the output in question (heater power etc.) toggles properly using the signal I/O function, then the associated control device on the relay board is bad. (Several of the control devices are in sockets and can be easily replaced).

11.6.7. SENSOR ASSEMBLY

The paramagnetic O₂ sensor of your T802 analyzer has no user serviceable parts

11.6.8. PRESSURE/FLOW SENSOR ASSEMBLY

The pressure/flow sensor PCA can be checked with a Voltmeter using the following procedure which, assumes that the wiring is intact, and that the motherboard and the power supplies are operating properly:

1. For Pressure related problems:
 - Measure the voltage across C1 it should be 5 ± 0.25 VDC.
 - If not then the board is bad.
 - Measure the voltage across TP4 and TP1.
 - With the sample pump disabled it should be 4500 mV ± 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.
2. For flow related problems:
 - Measure the voltage across TP2 and TP1 it should be 10 ± 0.25 VDC.
 - If not then the board is bad.
 - With flow stopped (sample inlet blocked) the voltage should be approximately $1V$.
 - If the voltage is incorrect, the flow sensor is bad, the board is bad or there is a leak upstream of the sensor.

11.6.9. MOTHERBOARD

11.6.9.1. A/D FUNCTIONS

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

1. Use the Signal I/O function (See Section 11.1.3 and Appendix A) to view the value of REF_4096_MV and REF_GND.
 - If both are within 3 mV of nominal (4096 and 0), and are stable, ± 0.2 mV then the basic A/D is functioning properly. If not then the motherboard is bad.
2. Choose a parameter in the Signal I/O function such as SAMPLE_PRESSURE or SAMPLE_FLOW.
 - Compare these voltages at their origin (see interconnect drawing PN 06407 and interconnect list PN 06294 in Appendix D) with the voltage displayed through the signal I/O function.
 - If the wiring is intact but there is a large difference between the measured and displayed voltage (± 10 mV) then the motherboard is bad.

11.6.9.2. ANALOG OUTPUTS: CURRENT LOOP

To verify that the analog outputs with the optional current mode output are working properly, connect a 250 ohm resistor across the outputs and use a voltmeter to measure the output as described in Section 5.9.3.6.

For each step the output should be within 1% of the nominal value listed in the table below.

Table 11-7: Analog Output Test Function - Nominal Values Current Outputs

STEP	%	OUTPUT RANGE			
		2 -20		4 -20	
		NOMINAL OUTPUT VALUES			
STEP	%	CURRENT	V(250 OHMS)	CURRENT	V(250 OHMS)
1	0	2 mA	0.5V	4	1
2	20	5.6	1.4	7.2	1.8
3	40	9.2	2.3	10.4	2.6
4	60	12.8	3.2	13.6	3.4
5	80	16.4	4.1	16.8	4.2
6	100	20	5	20	5

11.6.9.3. STATUS OUTPUTS

The procedure below can be used to test the Status outputs:

1. Connect a jumper between the “D” pin and the “▽” pin on the status output connector.
2. Connect a 1000 ohm resistor between the “+” pin and the pin for the status output that is being tested.
3. Connect a voltmeter between the “▽” pin and the pin of the output being tested (see table below).

Under the **DIAG→ SIGNAL I/O** menu (See Section 11.1.3), scroll through the inputs and outputs until you get to the output in question. 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.

Table 11-8: Status Outputs Check

PIN (LEFT TO RIGHT)	STATUS
1	SYSTEM OK
2	CONC VALID
3	O ₂ ZERO CAL
4	O ₂ SPAN CAL
5	ZERO CAL RNG2
6	CO ₂ ZERO CAL
7	SPARE
8	SPARE

11.6.10. CPU

There are two major types of failures associated with the CPU board: complete failure and a failure associated with the Disk-On-Module (DOM) on the CPU board. 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.

11.6.11. RS-232 COMMUNICATIONS

11.6.11.1. GENERAL RS-232 TROUBLESHOOTING

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

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

1. Incorrect cabling and connectors. See Section 3.3.1.8 for connector and pin-out information.
2. The BAUD rate and protocol are incorrectly configured. See Section 6.2.2.
3. If a modem is being used, additional configuration and wiring rules must be observed. See Section 8.3
4. Incorrect setting of the DTE – DCE switch is set correctly. See Section 6.1.
5. Verify that cable (03596) that connects the serial COM ports of the CPU to J12 of the motherboard is properly seated

11.6.11.2. TROUBLESHOOTING ANALYZER/MODEM OR TERMINAL OPERATION

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 make sure the DTE-DCE is in the correct position as described in Section 6.1.
3. Check to make sure the set up command is correct (See Section 8.3)
4. Verify that the Ready to Send (RTS) signal is at logic high. The T802 sets pin 7 (RTS) to greater than 3 volts to enable modem transmission.
5. Make sure the BAUD rate, word length, and stop bit settings between modem and analyzer match, See Section 8.3.
6. Use the RS-232 test function to send “w” characters to the modem, terminal or computer; See Section 8.3.
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. Make sure that the communications software or terminal emulation software is functioning properly.

Further help with serial communications is available in a separate manual “RS-232 Programming Notes” Teledyne API PN 013500000.

11.6.12. OPTIONAL CO₂ SENSOR

There are Two LEDs located on the CO₂ sensor PCA.

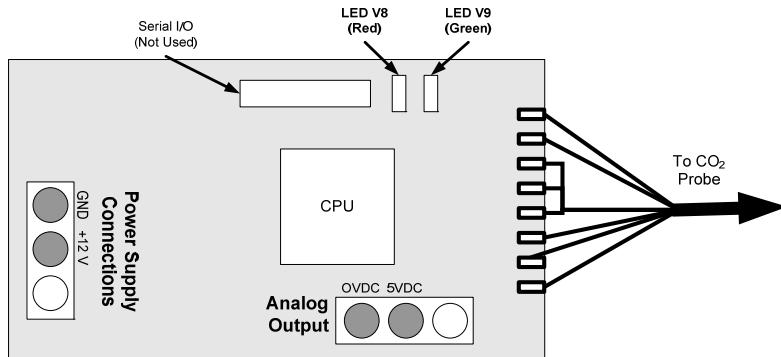


Figure 11-7: Location of Diagnostic LEDs on CO₂ Sensor PCA

- 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.

11.7. REPAIR PROCEDURES

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

11.7.1. 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 10.3.4.

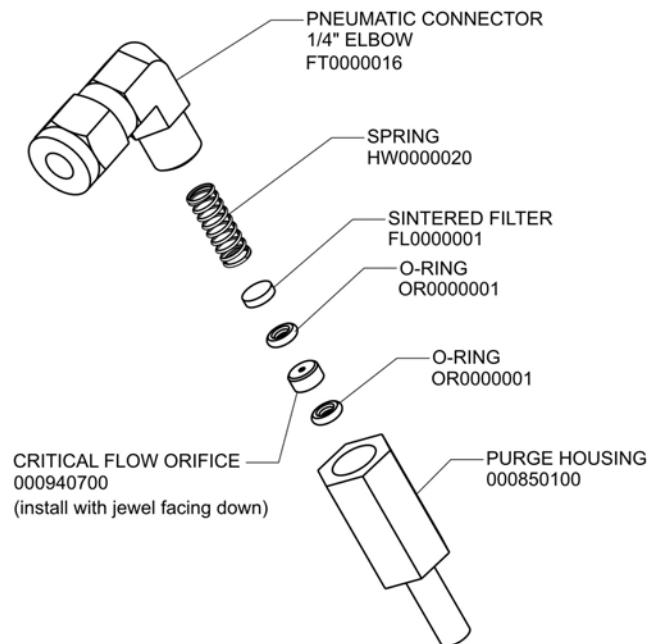


Figure 11-8: Critical Flow Restrictor Assembly / Disassembly

11.7.2. 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. Refer to Section 13 for more information on preventing ESD damage.

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

1. Document all analyzer parameters that may have been changed, such as range, auto-cal, analog output, serial port and other settings before replacing the DOM

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

11.8. FAQ'S

The following is a list from the Teledyne API's Technical Support Department of the most commonly asked questions relating to the Model T802 O₂ Analyzer.

QUESTION	ANSWER
Why does the ENTR button sometimes disappear on the Front Panel Display?	During certain types of adjustments or configuration operations, the ENTR button will disappear if you select a setting that is nonsensical (such as trying to set the 24-hour clock to 25:00:00) or out of the allowable range for that parameter (such as selecting a DAS HOLD OFF period of more than 20 minutes). Once you adjust the setting in question to an allowable value, the ENTR button will re-appear.
Why is the ZERO or SPAN button not displayed during calibration?	The instrument disables these buttons when the expected span or zero value entered by the users is too different from the gas concentration actual measured value. This is to prevent the accidental recalibration of the analyzer to an out-of-range response curve. EXAMPLE: The span set point is 16% but gas concentration being measured is only 5%.
How do I enter or change the value of my Span Gas?	Press the CONC button found under the CAL button of the main SAMPLE display menus to enter the expected CO ₂ span concentration. See Section 9.2.3.1 or for more information.
Why does the analyzer not respond to span gas	Section 11.4 has some possible answers to this question.
What shall I do if the concentration on the instrument's front panel display does not match the value recorded or displayed on my data logger even if both instruments are properly calibrated?	This most commonly occurs for one of the following reasons: - A difference in circuit ground between the analyzer and the data logger - A wiring problem or a scale problem with the input to the data logger. The analog outputs can be manually adjusted to compensate for either or both of these effects, see Section 5.9.5; - The analog outputs are not calibrated, which can happen after a firmware upgrade. - Both the electronic scale and offset of the analog outputs can be adjusted (Section 5.9.3.2). Alternately, use the data logger itself as the metering device during calibrations procedures.

QUESTION	ANSWER
How do I perform a leak check?	See Section 10.3.3.
How do I measure the sample flow?	Sample flow is measured by attaching a calibrated rotameter, wet test meter, or other flow-measuring device to the sample inlet port when the instrument is operating. The sample flow should be 120 cm ³ /min ±10%. See Section 9.4.2.
What is the averaging time for this instrument?	The default averaging time, optimized for ambient pollution monitoring, is 60 seconds for stable concentrations and 10 seconds for rapidly changing concentrations; See 12.5.9 for more information.

11.9. TECHNICAL ASSISTANCE

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

**Teledyne API, Technical Support,
9480 Carroll Park Drive
San Diego, California 92121-5201USA**

Phone: 800-324-5190 (toll free in North America)

Phone: 858-657-9800 (direct)

Fax: 858-657-9816

Email: sda_techsupport@teledyne.com

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

Before you contact Teledyne API's Technical Support, fill out the problem report form in Appendix C, which is also available online for electronic submission at <http://www.teledyne-api.com/forms/>

12. PRINCIPLES OF OPERATION

The T802 parametric oxygen analyzer is a microprocessor-controlled analyzer that determines the percent 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.

Calibration of the instrument is performed in software and does not require physical adjustments to the instrument. During calibration the microprocessor measures the current state of the O₂ Sensor output and various other physical parameters of the instrument and stores them in memory. The microprocessor uses these calibration values, measurements made on the sample gas along with data regarding the current temperature and pressure of the gas to calculate a final O₂ concentration.

The optional CO₂ sensor allows the T802 to measure both O₂ and CO₂ simultaneously. This option includes a CO₂ sensor probe, a Logic PCA that conditions the probe output and issues a 0-5 VDC signal to the analyzer's CPU that is used to compute the CO₂ concentration. The T802 receives this input, scales it based on the values of the **CO2_SLOPE** and **CO2_OFFSET** Recorded during calibration (see Section 9.5).

12.1. PARAMAGNETIC OXYGEN MEASUREMENT

12.1.1. 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.

12.1.2. PRINCIPLE OF MEASUREMENT

The type of paramagnetic sensor used in the T802 analyzer is called a magneto-mechanical sensor. This type of sensor 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.

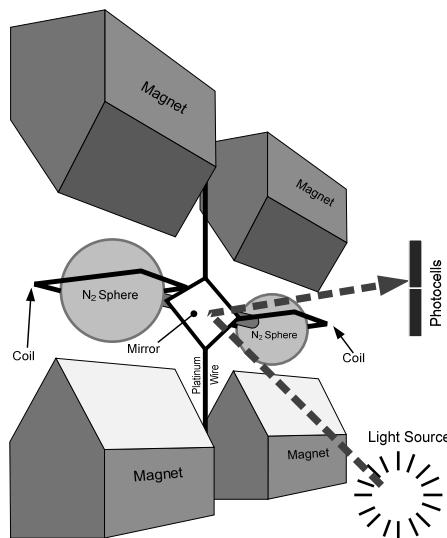


Figure 12-1: Paramagnetic O₂ Sensor Design

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.

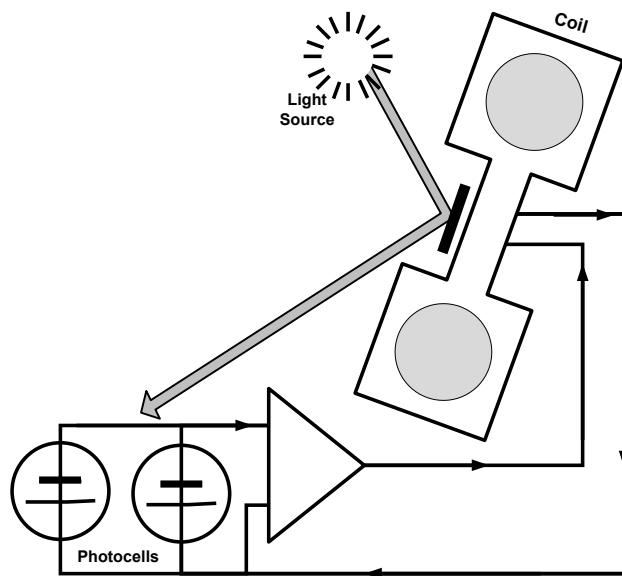


Figure 12-2: Paramagnetic O₂ Sensor Block Diagram

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.

12.2. 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.

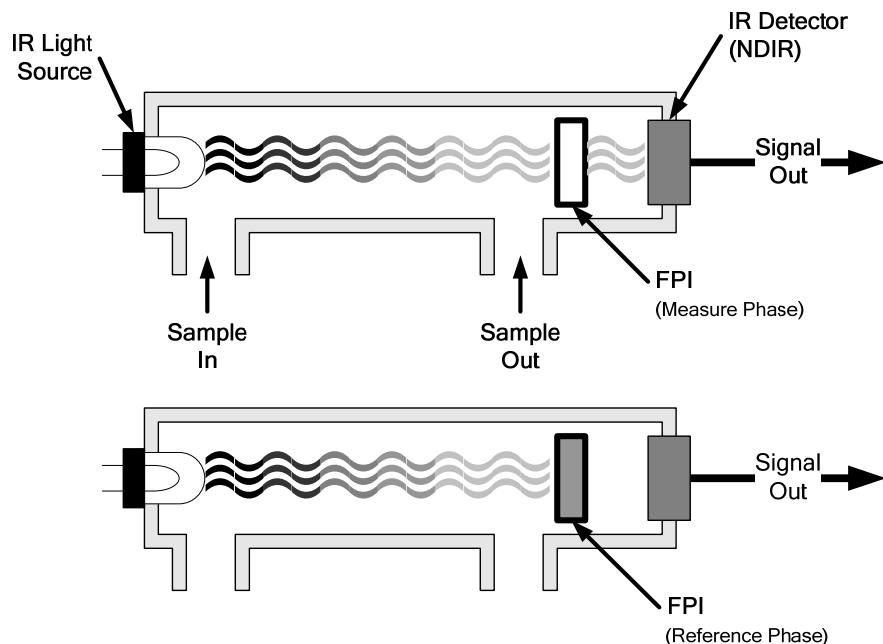


Figure 12-3: CO₂ Sensor Theory of Operation

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.

12.2.1. OPERATION WITHIN THE T802 ANALYZER

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 is displayed in the upper right-hand corner, alternating with O₂ concentration.
- Test functions for CO₂ slope and offset are viewable from the front panel along with the analyzer's other test functions.
- CO₂ sensor calibration is performed via the front panel CAL function and is performed in a nearly identical manner as the standard O₂ calibration. See Section 9.5 for more details.
- Stability of the CO₂ sensor can be viewed via the front panel (see Section 9.5.3).

The CO₂ concentration range is 0-20%. See Section 9.5.1 for information on calibrating the CO₂.

12.3. PNEUMATIC OPERATION



CAUTION GENERAL SAFETY HAZARD

IT IS IMPORTANT THAT THE SAMPLE AIRFLOW SYSTEM IS BOTH LEAK-TIGHT AND NOT PRESSURIZED OVER AMBIENT PRESSURE.

Regular leak checks should be performed on the analyzer as described in the maintenance schedule, 10.1.

Procedures for correctly performing leak checks can be found in Section 10.3.3

In pneumatic operation an internal pump evacuates the sample chamber creating a small vacuum that draws sample gas into the analyzer. Normally the analyzer is operated with its inlet near ambient pressure either because the sample is directly drawn at the inlet or a small vent is installed at the inlet. There are several advantages to this “pull through” configuration.

- First the pumping process heats and compresses the sample air complicating the measurement process. Both heat and pressure affect the accuracy of paramagnetic O₂ measurements.
- Additionally, certain physical parts of the pump itself are made of materials that might chemically react with the sample gas.

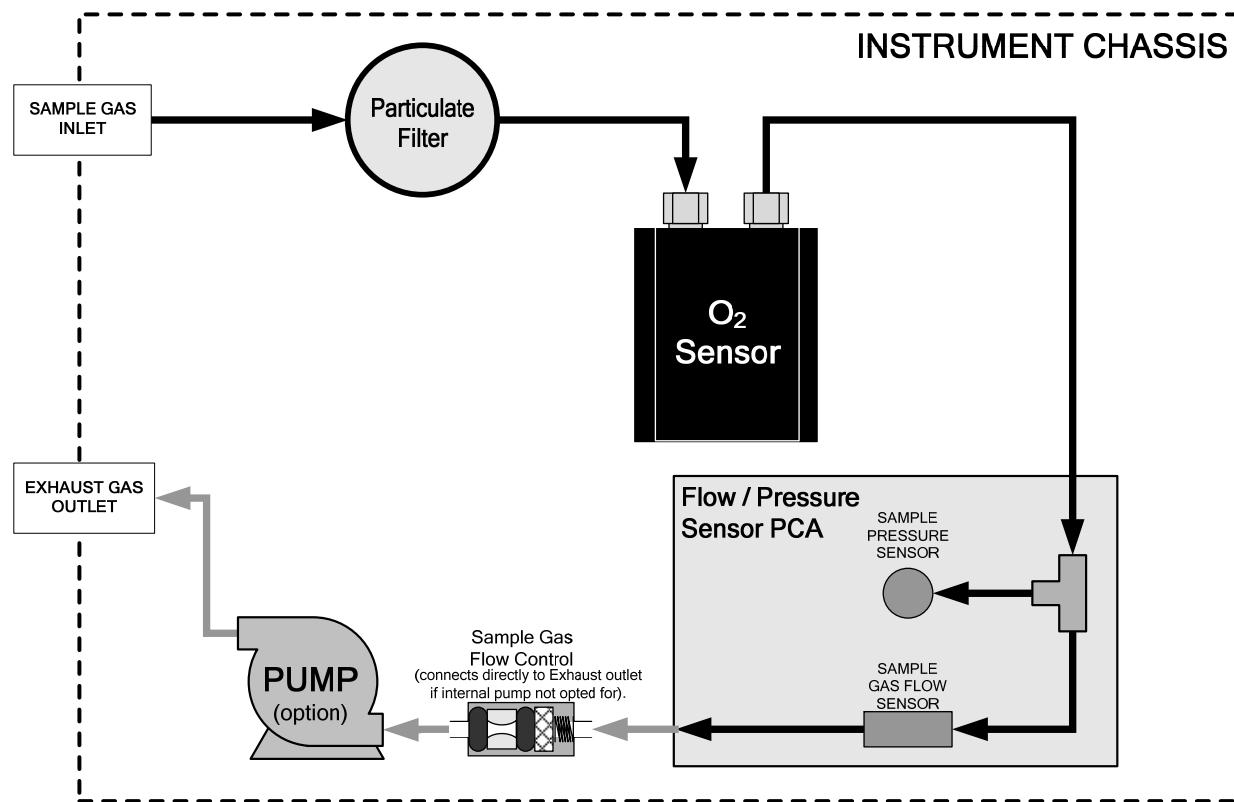


Figure 12-4: T802 – Internal Pneumatic Flow – Basic Configuration

12.3.1. PNEUMATIC OPERATION OF THE CO₂ SENSOR

Pneumatically, the CO₂ sensor 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

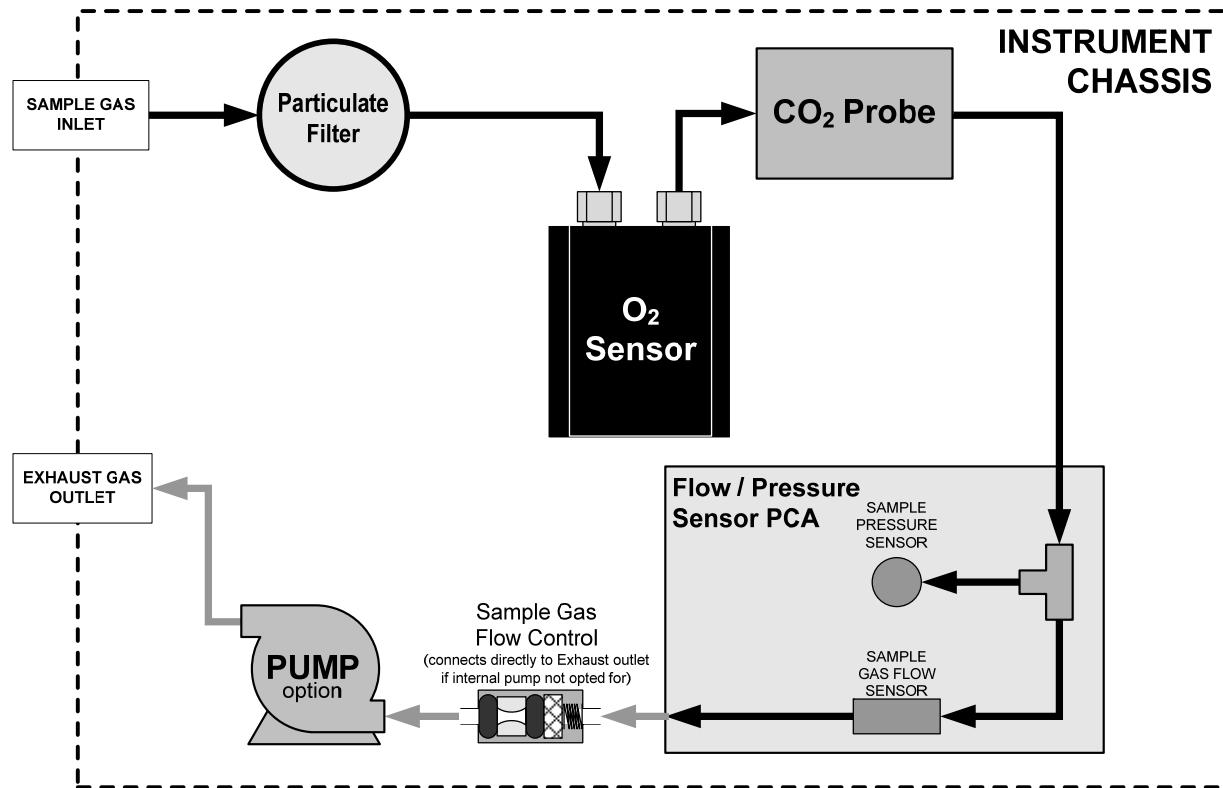


Figure 12-5: T802 – Internal Pneumatic Flow with CO₂ Sensor Option

12.4. 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. These assemblies consist of:

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

12.4.1. CRITICAL FLOW ORIFICE

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

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

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

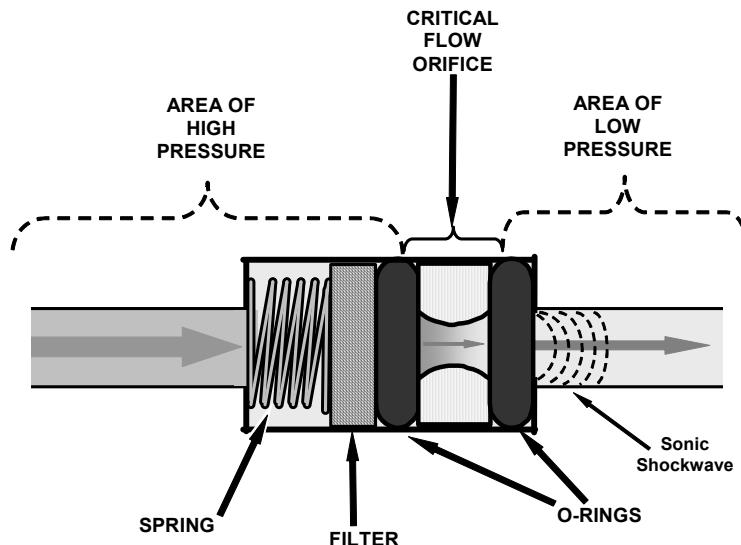


Figure 12-6: Flow Control Assembly & Critical Flow Orifice

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.

12.4.2. PARTICULATE FILTER

The T802 Analyzer comes equipped with a 47 mm diameter, Teflon, particulate filter with a 1 micron pore size. The filter is accessible through the front panel, which folds down to allow access, and should be changed according to the suggested maintenance schedule described in

12.4.3. PNEUMATIC SENSORS

12.4.3.1. SAMPLE PRESSURE SENSOR

An absolute value pressure transducer plumbed to the outlet of the sample chamber is used to measure sample pressure. The output of the sensor is used to

compensate the concentration measurement for changes in ambient air pressure. This sensor is mounted to a printed circuit board with the sample flow sensor on the sample chamber; see the following section and Figure 3-5.

12.4.3.2. 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 with the Sample Pressure sensor on the sample chamber; see the previous section and Figure 3-5.

12.5. ELECTRONIC OPERATION

12.5.1. OVERVIEW

Figure 10-9 shows a block diagram of the major electronic components of the T802.

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

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

Data is 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.

A variety of sensors report the physical and operational status of the analyzer's major components, again through the signal processing capabilities of the motherboard. These status reports are used as data for the O₂ concentration calculation and as trigger events for certain control commands issued by the CPU. They are stored in memory by the CPU and in most cases can be viewed but the user via the front panel display.

The CPU communicates with the user and the outside world in a variety of manners:

- Through the analyzer's keyboard and vacuum fluorescent display over a clocked, digital, serial I/O bus (using a protocol called I2C);
- RS-232 & RS-485 Serial I/O channels;
- Via an optional Ethernet communications card;
- Various DCV and DCA analog outputs, and
- Several sets of Digital I/O channels.

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

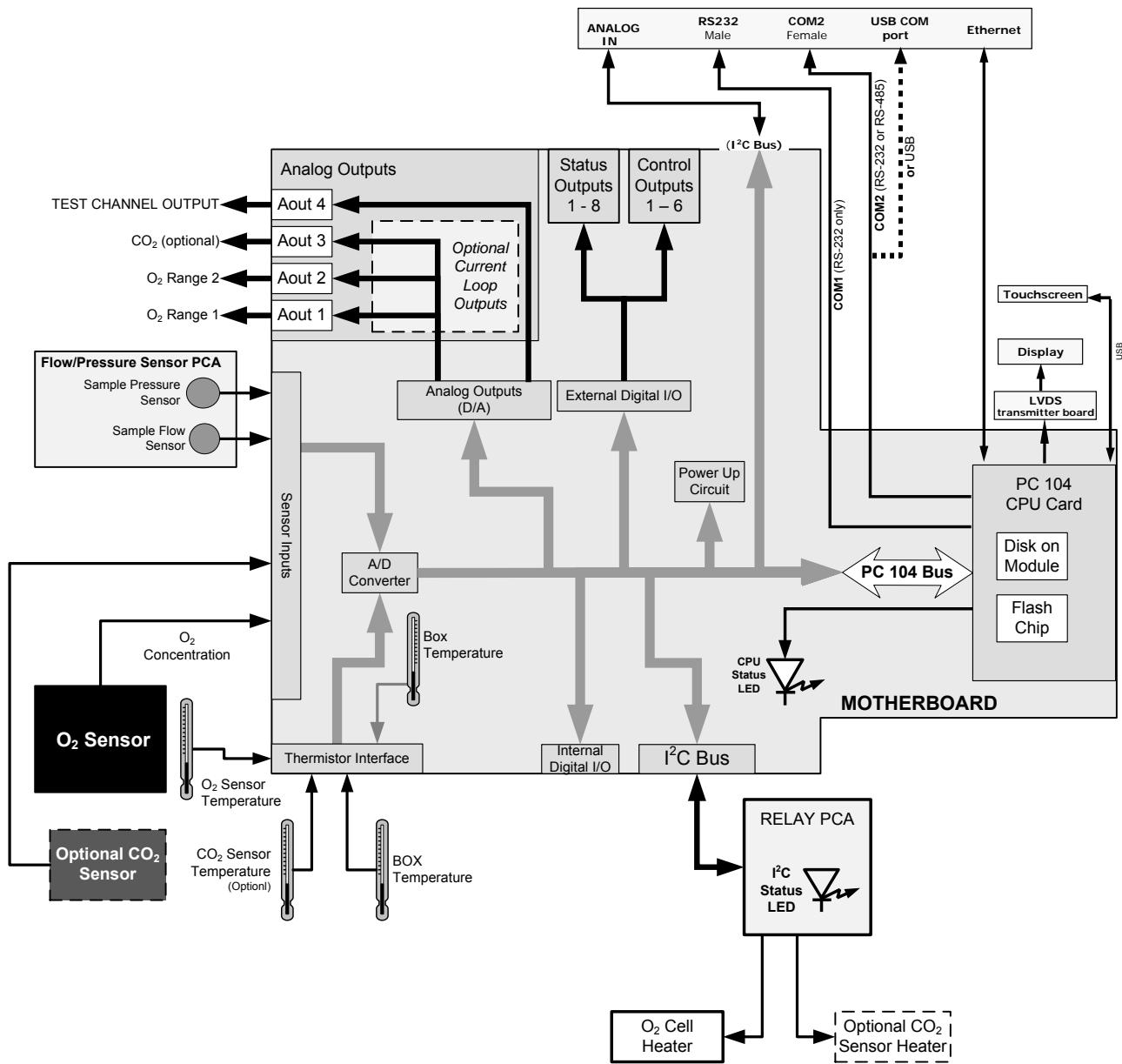


Figure 12-7: T802 Electronic Block Diagram

12.5.2. ELECTRONIC OPERATION OF THE CO₂ SENSOR

The CO₂ 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.

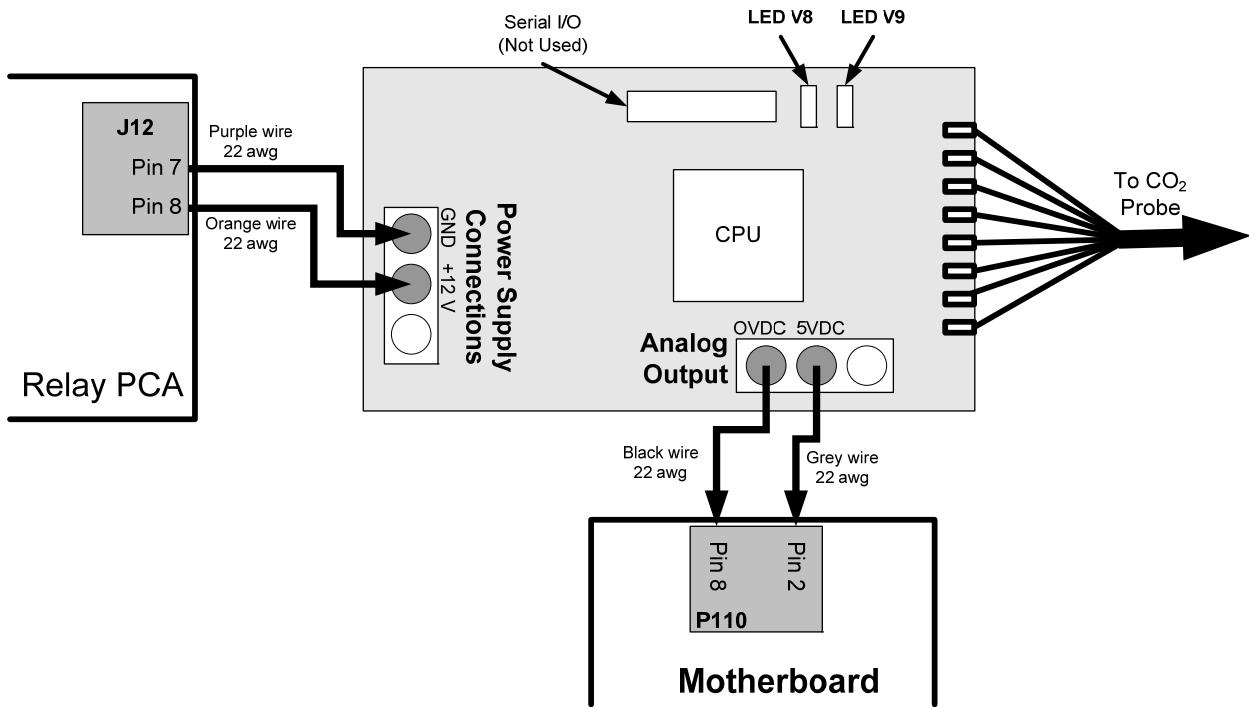


Figure 12-8: CO₂ Sensor Option PCA Layout and Electronic Connections

12.5.3. 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.

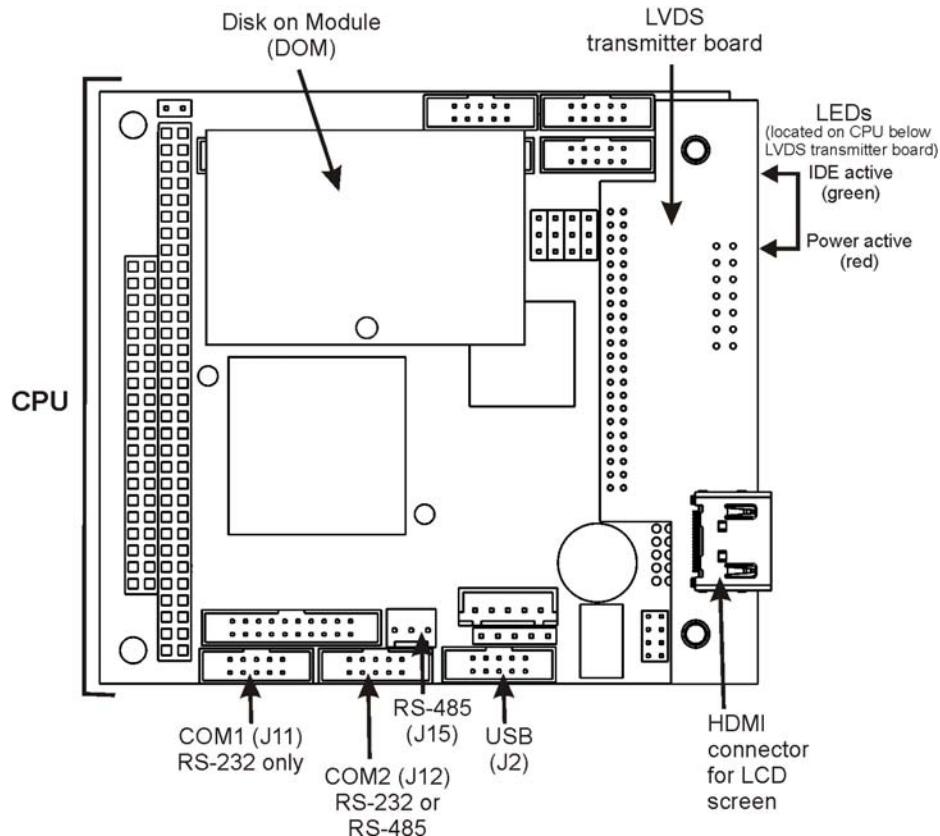


Figure 12-9. CPU Card

The CPU includes two types of non-volatile data storage: an embedded 2MB flash chip and a Disk on Module (DOM).

12.5.3.1. 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.

12.5.4. 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.

The relay PCA is located in the right-rear quadrant of the analyzer and is mounted vertically on the backside of the same bracket as the instrument's DC power supplies.

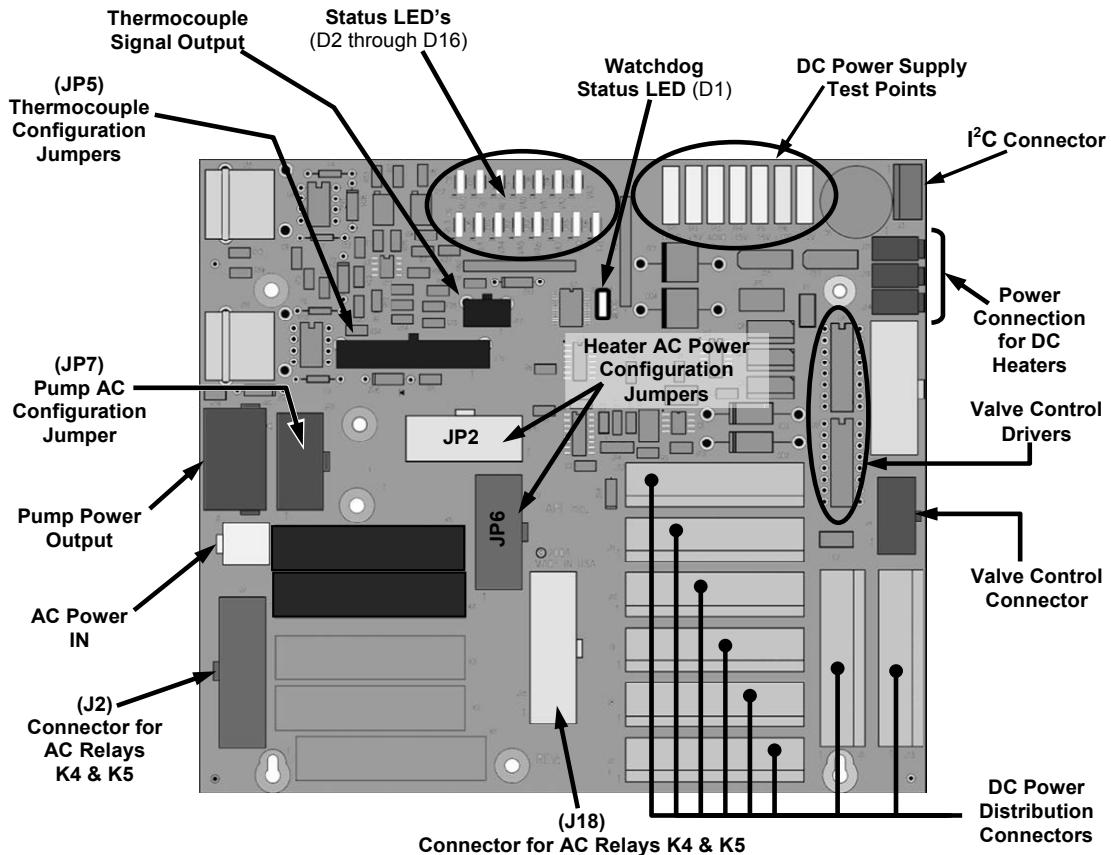


Figure 12-10: Relay PCA Layout (PN 04135)

CAUTION
ELECTRICAL SHOCK HAZARD

Only those relays actually required by the configuration of the T802 are populated.



A protective retainer plate is installed over the AC power relays to keep them securely seated in their sockets and prevent accidental contact with those sockets that are not populated (see Figure 12-11).

Never remove this retainer while the instrument is plugged in and turned on. The contacts of the AC relay sockets beneath the shield carry high AC voltages even when no relays are present.

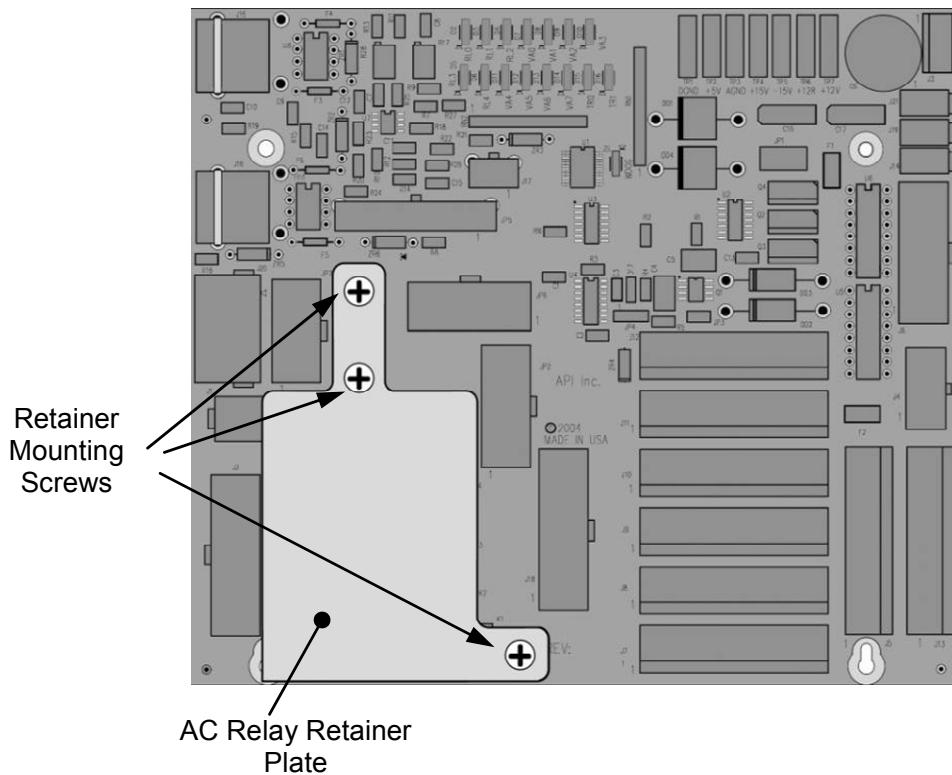


Figure 12-11: Relay PCA with AC Relay Retainer in Place

12.5.4.1. STATUS LEDs

LEDs located on the Analyzer's relay PCA, show the current status of various control functions performed by the relay PCA. The three that are used in the T802 are described in Table 12-1, and their locations are illustrated in Figure 12-12.

Table 12-1: Relay PCA Status LEDs

LED	Color	Function	Status When LED Lit (Energized State)	Status When LED Unlit (Default State)
D1	Red	Watchdog Circuit	Cycles ON/OFF every 3 Seconds under direct control of the analyzer's CPU.	
D2-D4				SPARE
D5 ¹	Yellow	CO ₂ Sensor Cell heater	Heating	Not Heating
D6	Yellow	O ₂ Sensor heater	Heating	Not Heating
D7 ²	Green			
D8 ²	Green			
D9 ²	Green			
D10 ²	Green			
D11 - 16				SPARE

¹ Only active when the optional CO₂ sensor is installed

² Not Used.

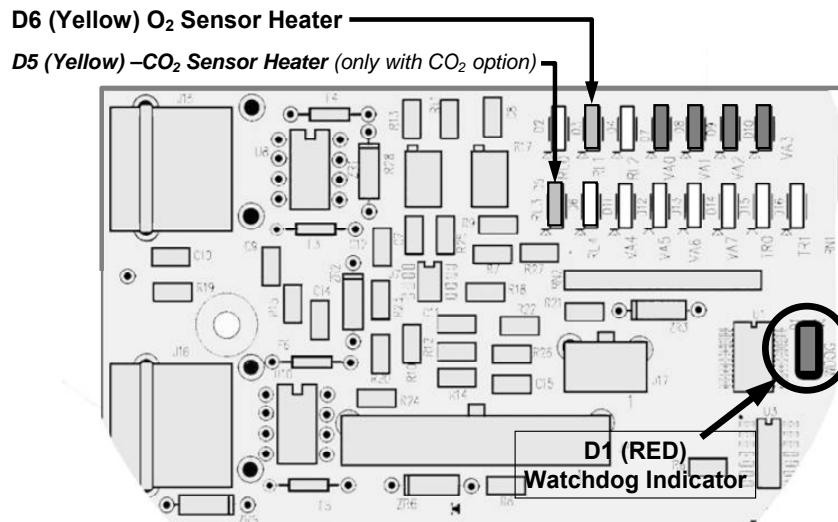


Figure 12-12: Status LED Locations – Relay PCA

12.5.4.2. WATCHDOG CIRCUITRY

The most important of the status LEDs on the relay board is the red I²C Bus 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.

12.5.5. HEATER CONTROL

12.5.5.1. 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.

12.5.6. MOTHERBOARD

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

12.5.6.1. A TO D CONVERSION

Analog signals, such as the voltages received from the analyzer's various sensors, are converted into digital signals that the CPU can understand and manipulate by the analog to digital converter (A/D). Under the control of the CPU, this

functional block selects a particular signal input (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.

See Section 5.9.3.2 for instructions on performing this calibration.

12.5.6.2. SENSOR INPUTS

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

12.5.6.3. 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.

12.5.6.4. 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). This information is stored by the CPU and can be viewed by the user for troubleshooting purposes via the front panel display (See Section 11.1.2).

12.5.6.5. 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.

12.5.6.6. EXTERNAL DIGITAL I/O

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

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).

CONTROL INPUTS

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.

12.5.6.7. 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 is then fed to the keyboard/display interface and finally onto the relay board.

12.5.6.8. POWER UP CIRCUIT

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

12.5.6.9. 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. As illustrated in Figure 12-13, power enters the analyzer through a standard IEC 320 power receptacle located on the rear panel of the instrument. From there it is routed through the On/Off switch located 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.



CAUTION GENERAL SAFETY HAZARD

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

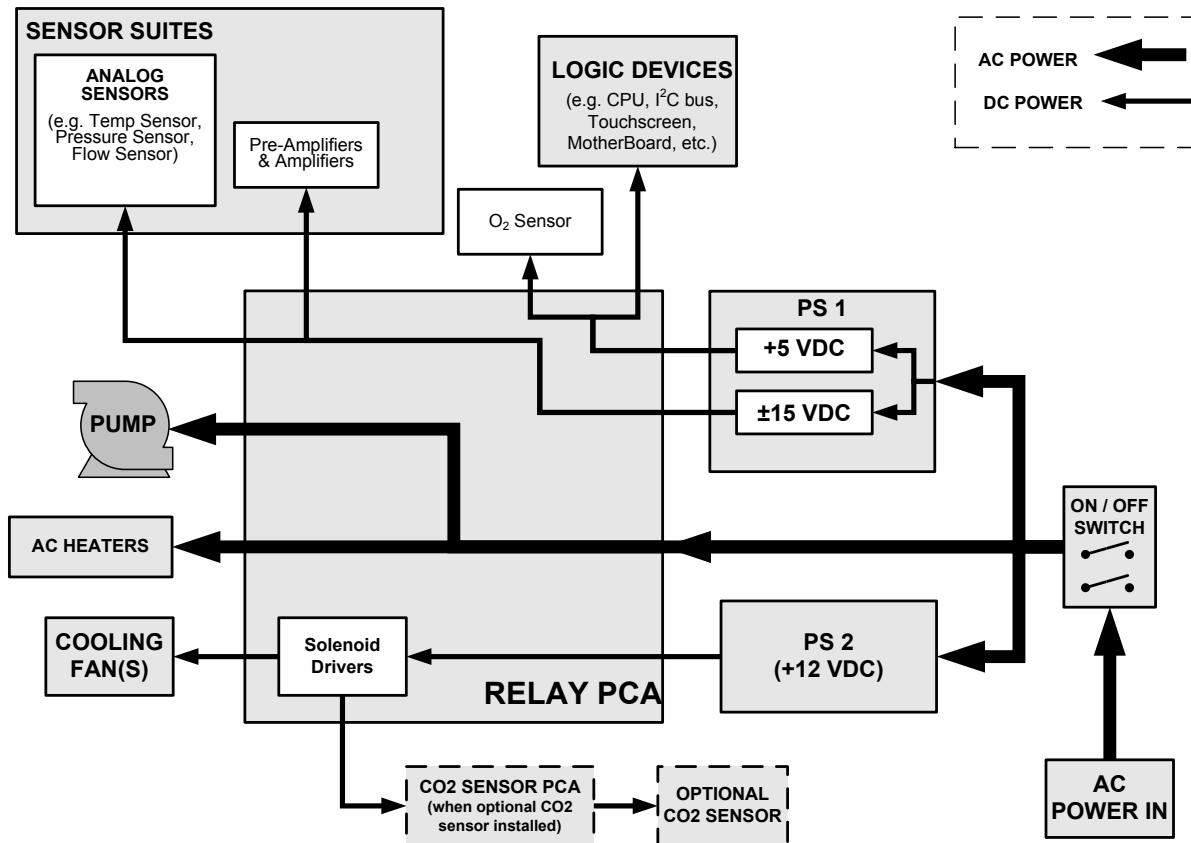


Figure 12-13: Power Distribution Block Diagram

12.5.7. FRONT PANEL TOUCH SCREEN/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.

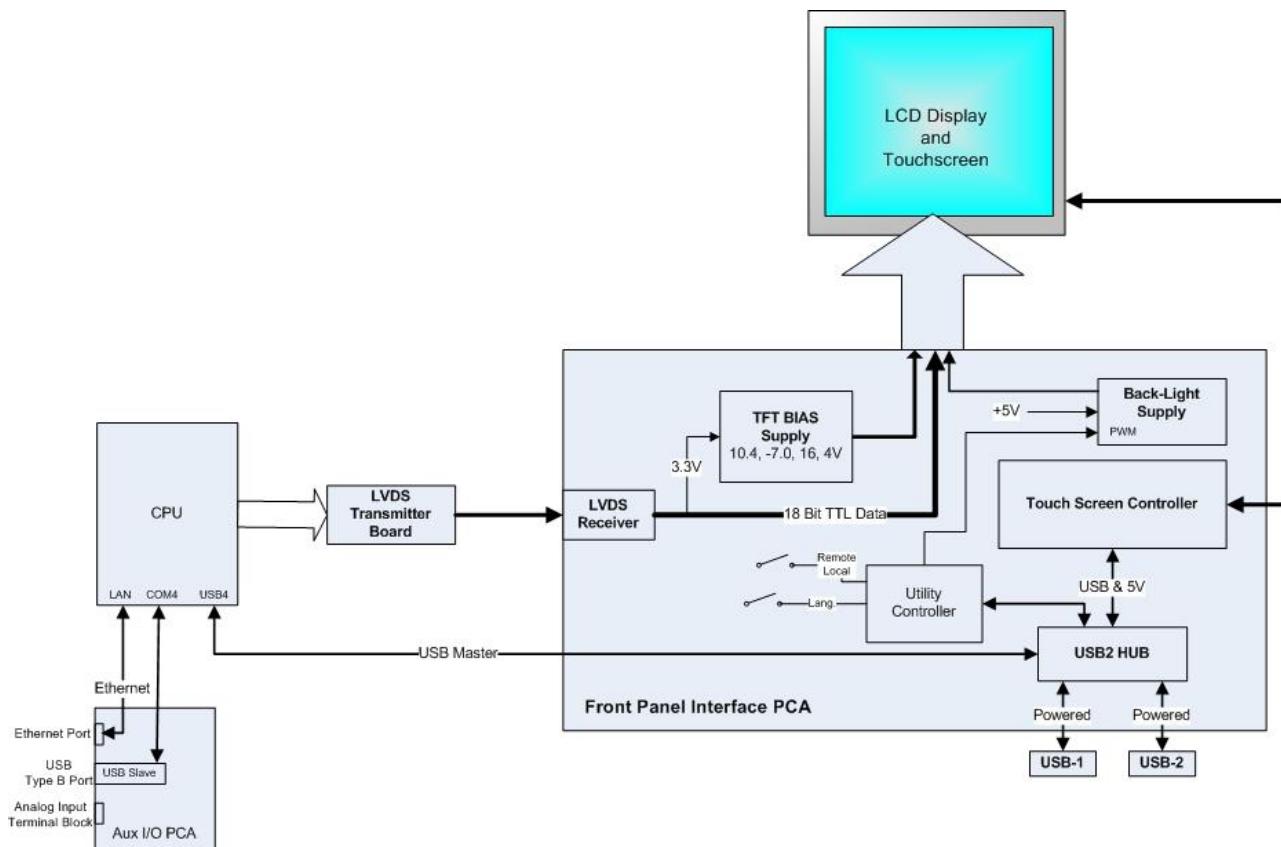


Figure 12-14: Front Panel and Display Interface Block Diagram

12.5.7.1. 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..

12.5.7.2. FRONT PANEL TOUCH SCREEN/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

12.5.8. SOFTWARE OPERATION

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

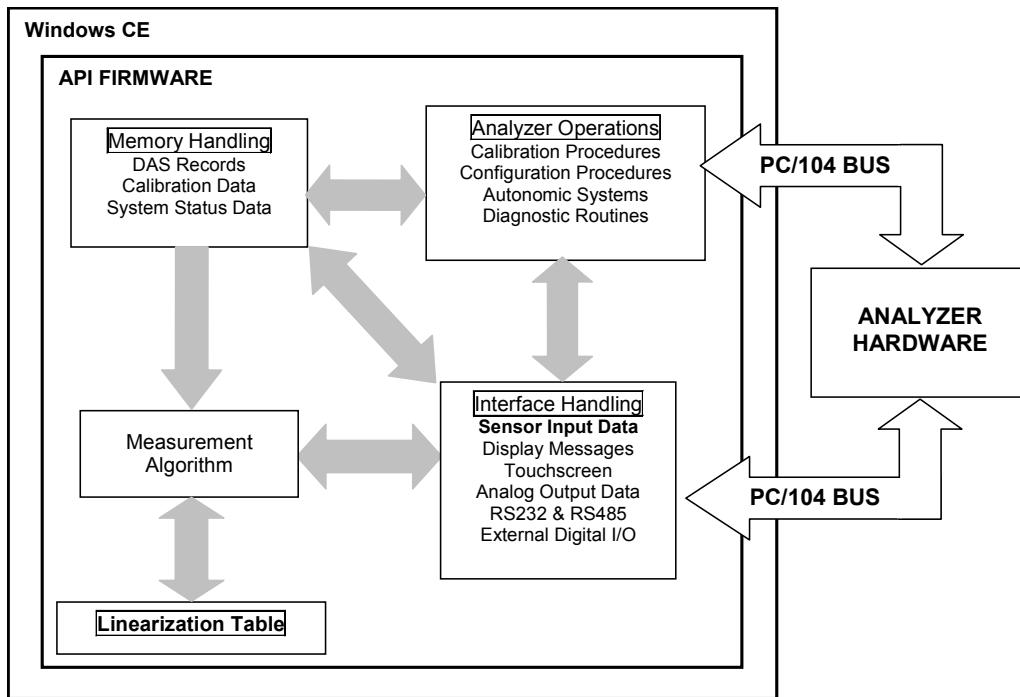


Figure 12-15: Basic Software Operation

12.5.9. 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).

12.5.10. 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.

The instrument slope and offset values recorded during the last calibration are available for viewing from the front panel (See Section 3.4.2)

12.5.11. 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 which 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.

12.5.12. INTERNAL DATA ACQUISITION SYSTEM (DAS)

The DAS is designed to implement predictive diagnostics that stores trending data for users to anticipate when an instrument will require service. Large amounts of data can be stored in non-volatile memory and retrieved in plain text format for further processing with common data analysis programs. The DAS has a consistent user interface in all Teledyne API analyzers. New data parameters and triggering events can be added to the instrument as needed.

Depending on the sampling frequency and the number of data parameters the DAS can store several months of data, which are retained even when the instrument is powered off or a new firmware is installed. The DAS permits users to access the data through the instrument's front panel or the remote interface. The latter can automatically download stored data for further processing. For information on using the DAS, refer to Section 7

13. A PRIMER ON ELECTRO-STATIC DISCHARGE

Teledyne API considers the prevention of damage caused by the discharge of static electricity to be extremely important part of making sure that your analyzer continues to provide reliable service for a long time. This section describes how static electricity occurs, why it is so dangerous to electronic components and assemblies as well as how to prevent that damage from occurring.

13.1. HOW STATIC CHARGES ARE CREATED

Modern electronic devices such as the types used in the various electronic assemblies of your analyzer, are very small, require very little power and operate very quickly. Unfortunately, the same characteristics that allow them to do these things also make them very susceptible to damage from the discharge of static electricity. Controlling electrostatic discharge begins with understanding how electro-static charges occur in the first place.

Static electricity is the result of something called triboelectric charging which happens whenever the atoms of the surface layers of two materials rub against each other. As the atoms of the two surfaces move together and separate, some electrons from one surface are retained by the other.

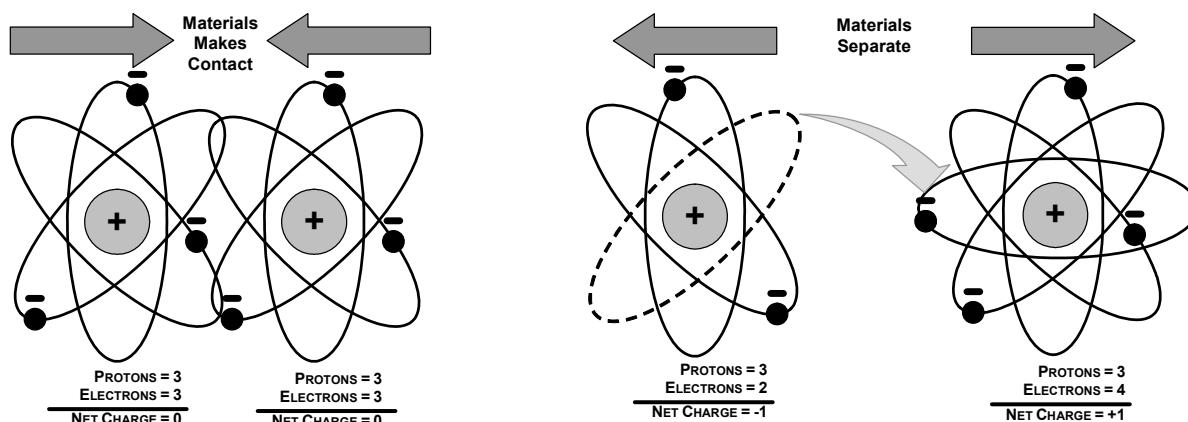


Figure 13-1: Triboelectric Charging

If one of the surfaces is a poor conductor or even a good conductor that is not grounded, the resulting positive or negative charge cannot bleed off and becomes trapped in place, or static. The most common example of triboelectric charging happens when someone wearing leather or rubber soled shoes walks across a nylon carpet or linoleum tiled floor. With each step, electrons change places and the resulting electro-static charge builds up, quickly reaching significant levels. Pushing an epoxy printed circuit board across a workbench, using a plastic handled screwdriver or even the constant jostling of Styrofoam™ pellets during shipment can also build hefty static charges

Table 13-1: Static Generation Voltages for Typical Activities

MEANS OF GENERATION	65-90% RH	10-25% RH
Walking across nylon carpet	1,500V	35,000V
Walking across vinyl tile	250V	12,000V
Worker at bench	100V	6,000V
Poly bag picked up from bench	1,200V	20,000V
Moving around in a chair padded with urethane foam	1,500V	18,000V

13.2. HOW ELECTRO-STATIC CHARGES CAUSE DAMAGE

Damage to components occurs when these static charges come into contact with an electronic device. Current flows as the charge moves along the conductive circuitry of the device and the typically very high voltage levels of the charge overheat the delicate traces of the integrated circuits, melting them or even vaporizing parts of them. When examined by microscope the damage caused by electro-static discharge looks a lot like tiny bomb craters littered across the landscape of the component's circuitry.

A quick comparison of the values in Table 13-1 with the those shown in Table 13-2, listing device susceptibility levels, shows why *Semiconductor Reliability News* estimates that approximately 60% of device failures are the result of damage due to electro-static discharge.

Table 13-2: Sensitivity of Electronic Devices to Damage by ESD

DEVICE	DAMAGE SUSCEPTIBILITY VOLTAGE RANGE	
	DAMAGE BEGINS OCCURRING AT	CATASTROPHIC DAMAGE AT
MOSFET	10	100
VMOS	30	1800
NMOS	60	100
GaAsFET	60	2000
EPROM	100	100
JFET	140	7000
SAW	150	500
Op-AMP	190	2500
CMOS	200	3000
Schottky Diodes	300	2500
Film Resistors	300	3000
This Film Resistors	300	7000
ECL	500	500
SCR	500	1000
Schottky TTL	500	2500

Potentially damaging electro-static discharges can occur:

- Any time a charged surface (including the human body) discharges to a device. Even simple contact of a finger to the leads of a sensitive device or assembly can allow enough discharge to cause damage. A similar discharge can occur from a charged conductive object, such as a metallic tool or fixture.
- When static charges accumulated on a sensitive device discharges from the device to another surface such as packaging materials, work surfaces, machine surfaces or other device. In some cases, charged device discharges can be the most destructive.
- A typical example of this is the simple act of installing an electronic assembly into the connector or wiring harness of the equipment in which it is to function. If the assembly is carrying a static charge, as it is connected to ground a discharge will occur.
- Whenever a sensitive device is moved into the field of an existing electrostatic field, a charge may be induced on the device in effect discharging the field onto the device. If the device is then momentarily grounded while within the electrostatic field or removed from the region of the electrostatic field and grounded somewhere else, a second discharge will occur as the charge is transferred from the device to ground.

13.3. COMMON MYTHS ABOUT ESD DAMAGE

- **I didn't feel a shock so there was no electro-static discharge:** The human nervous system isn't able to feel a static discharge of less than 3500 volts. Most devices are damaged by discharge levels much lower than that.
- **I didn't touch it so there was no electro-static discharge:** Electro Static charges are fields whose lines of force can extend several inches or sometimes even feet away from the surface bearing the charge.
- **It still works so there was no damage:** Sometimes the damage caused by electro-static discharge can completely sever a circuit trace causing the device to fail immediately. More likely, the trace will be only partially occluded by the damage causing degraded performance of the device or worse, weakening the trace. This weakened circuit may seem to function fine for a short time, but even the very low voltage and current levels of the device's normal operating levels will eat away at the defect over time causing the device to fail well before its designed lifetime is reached.
 - These latent failures are often the most costly since the failure of the equipment in which the damaged device is installed causes down time, lost data, lost productivity, as well as possible failure and damage to other pieces of equipment or property.
- **Static Charges can't build up on a conductive surface:** There are two errors in this statement.
 - Conductive devices can build static charges if they are not grounded. The charge will be equalized across the entire device, but without access to earth ground, they are still trapped and can still build to high enough levels to cause damage when they are discharged.

- A charge can be induced onto the conductive surface and/or discharge triggered in the presence of a charged field such as a large static charge clinging to the surface of a nylon jacket of someone walking up to a workbench.
- **As long as my analyzer is properly installed, it is safe from damage caused by static discharges:** It is true that when properly installed the chassis ground of your analyzer is tied to earth ground and its electronic components are prevented from building static electric charges themselves. This does not prevent discharges from static fields built up on other things, like you and your clothing, from discharging through the instrument and damaging it.

13.4. BASIC PRINCIPLES OF STATIC CONTROL

It is impossible to stop the creation of instantaneous static electric charges. It is not, however difficult to prevent those charges from building to dangerous levels or prevent damage due to electro-static discharge from occurring.

13.4.1. GENERAL RULES

Only handle or work on all electronic assemblies at a properly set up ESD station. Setting up an ESD safe workstation need not be complicated. A protective mat properly tied to ground and a wrist strap are all that is needed to create a basic anti-ESD workstation.

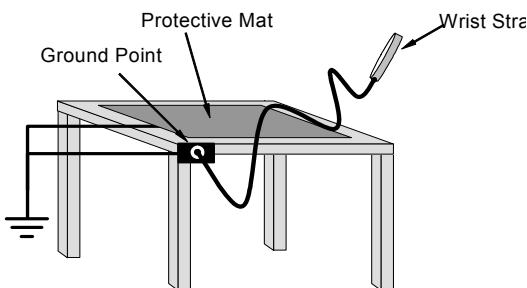


Figure 13-2: Basic Anti-ESD Workbench

For technicians that work in the field, special lightweight and portable anti-ESD kits are available from most suppliers of ESD protection gear. These include everything needed to create a temporary anti-ESD work area anywhere.

- Always wear an Anti-ESD wrist strap when working on the electronic assemblies of your **analyzer**. An anti-ESD wrist strap keeps the person wearing it at or near the same potential as other grounded objects in the work area and allows static charges to dissipate before they can build to dangerous levels. Anti-ESD wrist straps terminated with alligator clips are available for use in work areas where there is no available grounded plug.
- Also, anti-ESD wrist straps include a current limiting resistor (usually around one meg-ohm) that protects you should you accidentally short yourself to the instrument's power supply.

- **Simply touching a grounded piece of metal is insufficient.** While this may temporarily bleed off static charges present at the time, once you stop touching the grounded metal new static charges will immediately begin to rebuild. In some conditions, a charge large enough to damage a component can rebuild in just a few seconds.
- **Always store sensitive components and assemblies in anti-ESD storage bags or bins:** Even when you are not working on them, store all devices and assemblies in a closed anti-Static bag or bin. This will prevent induced charges from building up on the device or assembly and nearby static fields from discharging through it.
- **Use metallic anti-ESD bags for storing and shipping ESD sensitive components and assemblies rather than pink-poly bags.** The famous, pink-poly bags are made of a plastic that is impregnated with a liquid (similar to liquid laundry detergent) which very slowly sweats onto the surface of the plastic creating a slightly conductive layer over the surface of the bag.
 - While this layer may equalize any charges that occur across the whole bag, it does not prevent the build up of static charges. If laying on a conductive, grounded surface, these bags will allow charges to bleed away but the very charges that build up on the surface of the bag itself can be transferred through the bag by induction onto the circuits of your ESD sensitive device. Also, the liquid impregnating the plastic is eventually used up after which the bag is as useless for preventing damage from ESD as any ordinary plastic bag.
 - Anti-Static bags made of plastic impregnated with metal (usually silvery in color) provide all of the charge equalizing abilities of the pink-poly bags but also, when properly sealed, create a Faraday cage that completely isolates the contents from discharges and the inductive transfer of static charges.
 - Storage bins made of plastic impregnated with carbon (usually black in color) are also excellent at dissipating static charges and isolating their contents from field effects and discharges.
- **Never use ordinary plastic adhesive tape near an ESD sensitive device or to close an anti-ESD bag.** The act of pulling a piece of standard plastic adhesive tape, such as Scotch® tape, from its roll will generate a static charge of several thousand or even tens of thousands of volts on the tape itself and an associated field effect that can discharge through or be induced upon items up to a foot away.

13.4.2. BASIC ANTI-ESD PROCEDURES FOR ANALYZER REPAIR AND MAINTENANCE

13.4.2.1. WORKING AT THE INSTRUMENT RACK

When working on the analyzer while it is in the instrument rack and plugged into a properly grounded power supply

1. Attach your anti-ESD wrist strap to ground before doing anything else.
 - Use a wrist strap terminated with an alligator clip and attach it to a bare metal portion of the instrument chassis.
 - This will safely connect you to the same ground level to which the instrument and all of its components are connected.
2. Pause for a second or two to allow any static charges to bleed away.
3. Open the casing of the analyzer and begin work. Up to this point, the closed metal casing of your analyzer has isolated the components and assemblies inside from any conducted or induced static charges.
4. If you must remove a component from the instrument, do not lay it down on a non-ESD preventative surface where static charges may lie in wait.
5. Only disconnect your wrist strap after you have finished work and closed the case of the analyzer.

13.4.2.2. WORKING AT AN ANTI-ESD WORK BENCH

When working on an instrument or an electronic assembly while it is resting on a anti-ESD workbench

1. Plug your anti-ESD wrist strap into the grounded receptacle of the work station before touching any items on the work station and while standing at least a foot or so away. This will allow any charges you are carrying to bleed away through the ground connection of the workstation and prevent discharges due to field effects and induction from occurring.
2. Pause for a second or two to allow any static charges to bleed away.
3. Only open any anti-ESD storage bins or bags containing sensitive devices or assemblies after you have plugged your wrist strap into the workstation.
 - Lay the bag or bin on the workbench surface.
 - Before opening the container, wait several seconds for any static charges on the outside surface of the container to be bled away by the workstation's grounded protective mat.
4. Do not pick up tools that may be carrying static charges while also touching or holding an ESD sensitive Device.
 - Only lay tools or ESD-sensitive devices and assemblies on the conductive surface of your workstation. Never lay them down on any non-ESD preventative surface.
5. Place any static sensitive devices or assemblies in anti-static storage bags or bins and close the bag or bin before unplugging your wrist strap.
6. Disconnecting your wrist strap is always the last action taken before leaving the workbench.

13.4.2.3. TRANSFERRING COMPONENTS FROM RACK TO BENCH AND BACK

When transferring a sensitive device from an installed Teledyne API analyzer to an Anti-ESD workbench or back:

1. Follow the instructions listed above for working at the instrument rack and workstation.
2. Never carry the component or assembly without placing it in an anti-ESD bag or bin.
3. Before using the bag or container allow any surface charges on it to dissipate:
 - If you are at the instrument rack, hold the bag in one hand while your wrist strap is connected to a ground point.
 - If you are at an anti-ESD workbench, lay the container down on the conductive work surface.
 - In either case wait several seconds.
4. Place the item in the container.
5. Seal the container. If using a bag, fold the end over and fastening it with anti-ESD tape.
 - Folding the open end over isolates the component(s) inside from the effects of static fields.
 - Leaving the bag open or simply stapling it shut without folding it closed prevents the bag from forming a complete protective envelope around the device.
6. Once you have arrived at your destination, allow any surface charges that may have built up on the bag or bin during travel to dissipate:
 - Connect your wrist strap to ground.
 - If you are at the instrument rack, hold the bag in one hand while your wrist strap is connected to a ground point.
 - If you are at a anti-ESD workbench, lay the container down on the conductive work surface
 - In either case wait several seconds
7. Open the container.

13.4.2.4. OPENING SHIPMENTS FROM TELEDYNE API'S TECHNICAL SUPPORT

Packing materials such as bubble pack and Styrofoam pellets are extremely efficient generators of static electric charges. To prevent damage from ESD, Teledyne API ships all electronic components and assemblies in properly sealed ant-ESD containers.

Static charges will build up on the outer surface of the anti-ESD container during shipping as the packing materials vibrate and rub against each other. To prevent these static charges from damaging the components or assemblies being shipped make sure that you:

Always unpack shipments from Teledyne API Technical Support by:

1. Opening the outer shipping box away from the anti-ESD work area
2. Carry the still sealed ant-ESD bag, tube or bin to the anti-ESD work area
3. Follow steps 6 and 7 of Opening Shipments from Teledyne API's Technical Support above when opening the anti-ESD container at the work station
4. Reserve the anti-ESD container or bag to use when packing electronic components or assemblies to be returned to Teledyne API

13.4.2.5. PACKING COMPONENTS FOR RETURN TO TELEDYNE API TECHNICAL SUPPORT

Always pack electronic components and assemblies to be sent to Teledyne API Technical Support in anti-ESD bins, tubes or bags.

CAUTION – ESD HAZARD



- **DO NOT** use pink-poly bags.
- **NEVER** allow any standard plastic packaging materials to touch the electronic component/assembly directly. This includes, but is not limited to, plastic bubble-pack, Styrofoam peanuts, open cell foam, closed cell foam, and adhesive tape
- **DO NOT** use standard adhesive tape as a sealer. Use **ONLY** anti-ESD tape

Never carry the component or assembly without placing it in an anti-ESD bag or bin.

1. Before using the bag or container allow any surface charges on it to dissipate:
 - If you are at the instrument rack, hold the bag in one hand while your wrist strap is connected to a ground point.
 - If you are at an anti-ESD workbench, lay the container down on the conductive work surface.
 - In either case wait several seconds.
2. Place the item in the container.
3. Seal the container. If using a bag, fold the end over and fastening it with anti-ESD tape.
 - Folding the open end over isolates the component(s) inside from the effects of static fields.
 - Leaving the bag open or simply stapling it shut without folding it closed prevents the bag from forming a complete protective envelope around the device.

Note

If you do not already have an adequate supply of anti-ESD bags or containers available, Teledyne API's Technical Support department will supply them (see Section 11.9 for contact information). Follow the instructions listed above for working at the instrument rack and workstation.

GLOSSARY

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

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>
CE	<i>Converter Efficiency</i> , the percentage of light energy that is actually converted into electricity
CEM	<i>Continuous Emission Monitoring</i>

Chemical formulas that may be included in this document:

CO ₂	carbon dioxide
C ₃ H ₈	propane
CH ₄	methane
H ₂ O	water vapor
HC	general abbreviation for hydrocarbon
HNO ₃	nitric acid
H ₂ S	hydrogen sulfide
NO	nitric oxide
NO ₂	nitrogen dioxide
NO _x	nitrogen oxides, here defined as the sum of NO and NO ₂
NO _y	nitrogen oxides, often called odd nitrogen: the sum of NO _x plus other compounds such as HNO ₃ (definitions vary widely and may include nitrate (NO ₃), PAN, N ₂ O and other compounds as well)
NH ₃	ammonia
O ₂	molecular oxygen
O ₃	ozone
SO ₂	sulfur dioxide
cm ³	metric abbreviation for <i>cubic centimeter</i> (replaces the obsolete abbreviation "cc")
CPU	<i>Central Processing Unit</i>

Term	Description/Definition
DAC	<i>Digital-to-Analog Converter</i>
DAS	<i>Data Acquisition System</i>
DCE	<i>Data Communication Equipment</i>
DHCP	<i>Dynamic Host Configuration Protocol</i> . A protocol used by LAN or Internet servers to automatically set up the interface protocols between themselves and any other addressable device connected to the network
DIAG	<i>Diagnostics</i> , the diagnostic settings of the analyzer.
DOM	<i>Disk On Module</i> , a 44-pin IDE flash drive with up to 128MB storage capacity for instrument's firmware, configuration settings and data
DOS	<i>Disk Operating System</i>
DRAM	<i>Dynamic Random Access Memory</i>
DR-DOS	<i>Digital Research DOS</i>
DTE	<i>Data Terminal Equipment</i>
EEPROM	<i>Electrically Erasable Programmable Read-Only Memory</i> also referred to as a FLASH chip or drive
ESD	<i>Electro-Static Discharge</i>
ETEST	<i>Electrical Test</i>
Ethernet	a standardized (IEEE 802.3) computer networking technology for local area networks (LANs), facilitating communication and sharing resources
FEP	<i>Fluorinated Ethylene Propylene</i> polymer, one of the polymers that Du Pont markets as <i>Teflon</i> ®
Flash	non-volatile, solid-state memory
FPI	<i>Fabry-Perot Interferometer</i> : a special light filter typically made of a transparent plate with two reflecting surfaces or two parallel, highly reflective mirrors
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>

Term	Description/Definition
LED	<i>Light Emitting Diode</i>
LPM	<i>Liters Per Minute</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>
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

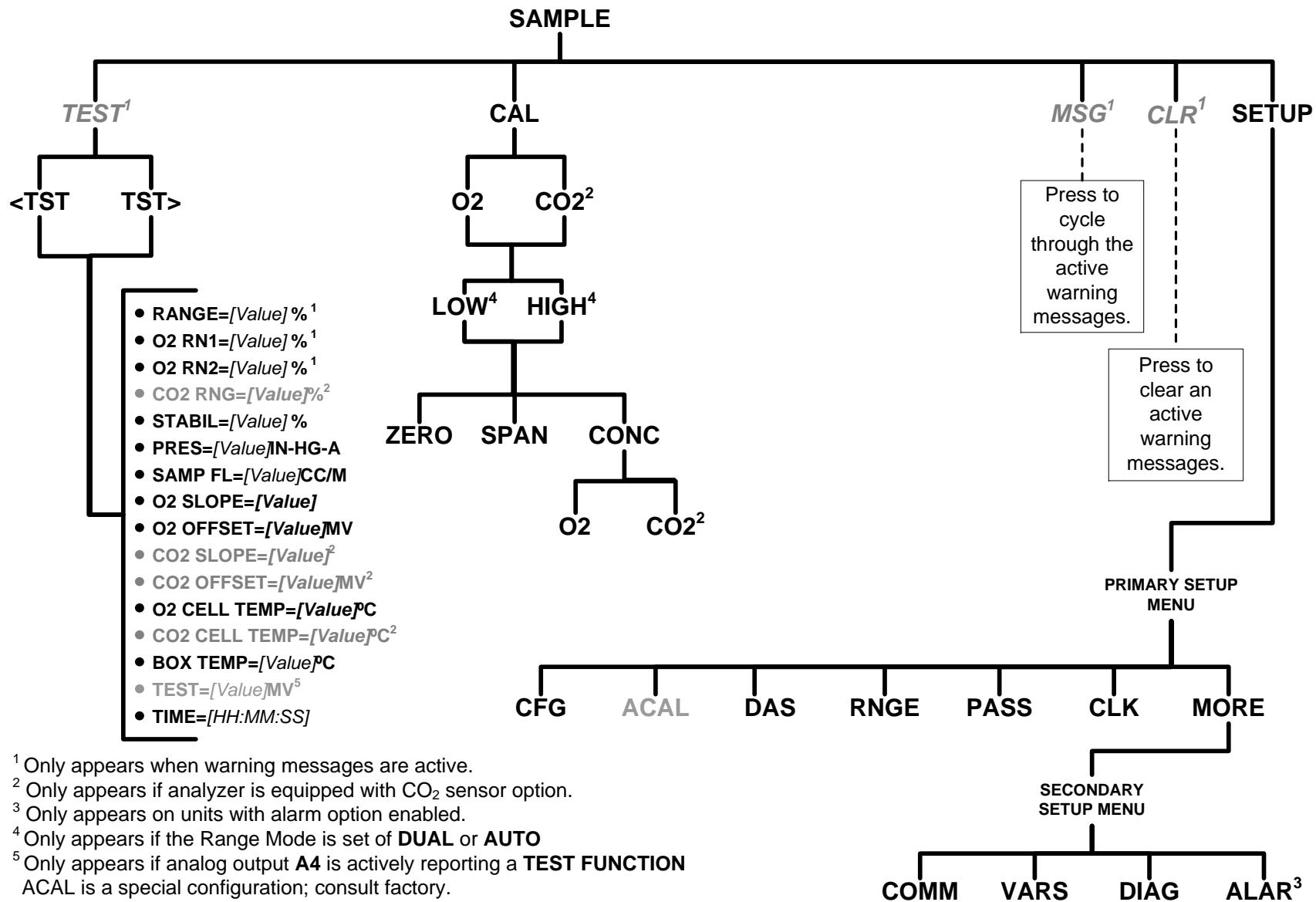
Term	Description/Definition
RS-485	specification and standard describing a binary serial communication method among multiple devices at a data rate faster than RS-232 with a much longer distance between the host and the furthest device
SAROAD	<i>Storage and Retrieval of Aerometric Data</i>
SLAMS	<i>State 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 – Version Specific Software Documentation

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APPENDIX A-1: Software Menu Trees, Software Versions 1.0.3 (T-Series)/A.3 (E-Series)



¹ Only appears when warning messages are active.

² Only appears if analyzer is equipped with CO₂ sensor option.

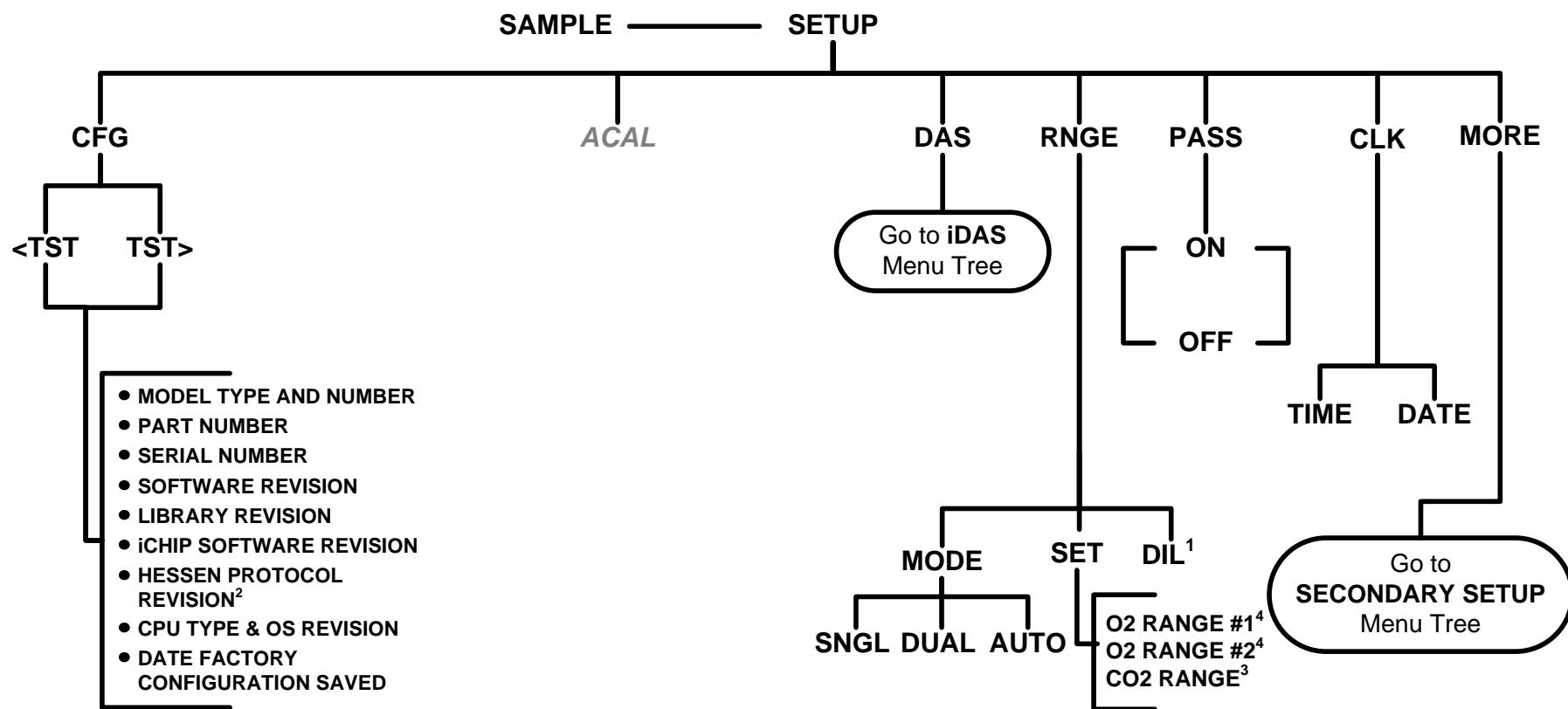
³ Only appears on units with alarm option enabled.

⁴ Only appears if the Range Mode is set of **DUAL** or **AUTO**

⁵ Only appears if analog output **A4** is actively reporting a **TEST FUNCTION**

ACAL is a special configuration; consult factory.

Figure A-1: Basic Sample Display Menu



¹ Only appears if Dilution option is active.

² Only appears if Hessen protocol is active.

³ CO₂ mode only appears if analyzer is equipped with the related sensor option.

⁴ Only appears if the **DUAL** or **AUTO** range modes are selected.

ACAL is a special configuration; consult factory.

Figure A-2: Primary Setup Menu (Except DAS)

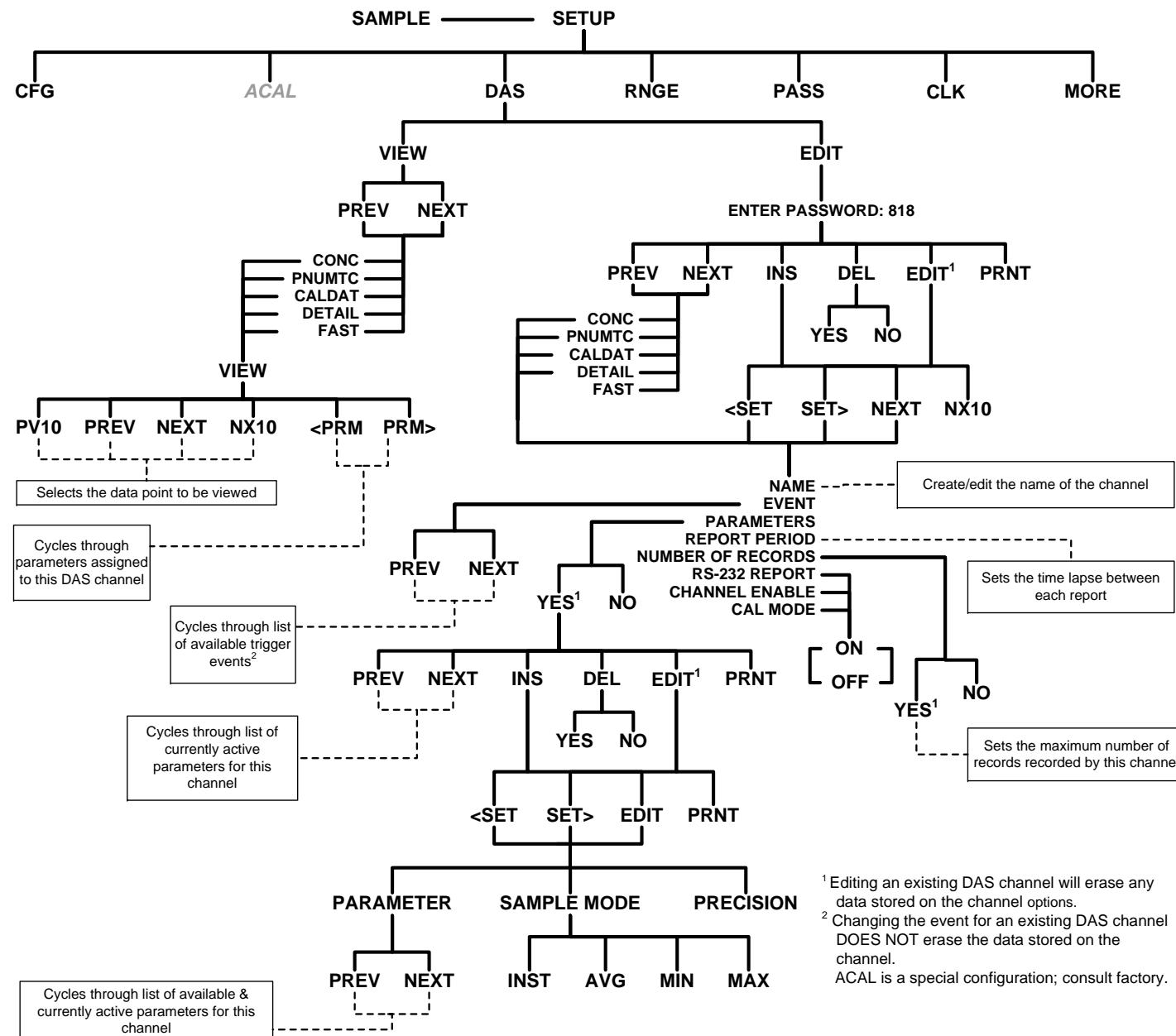
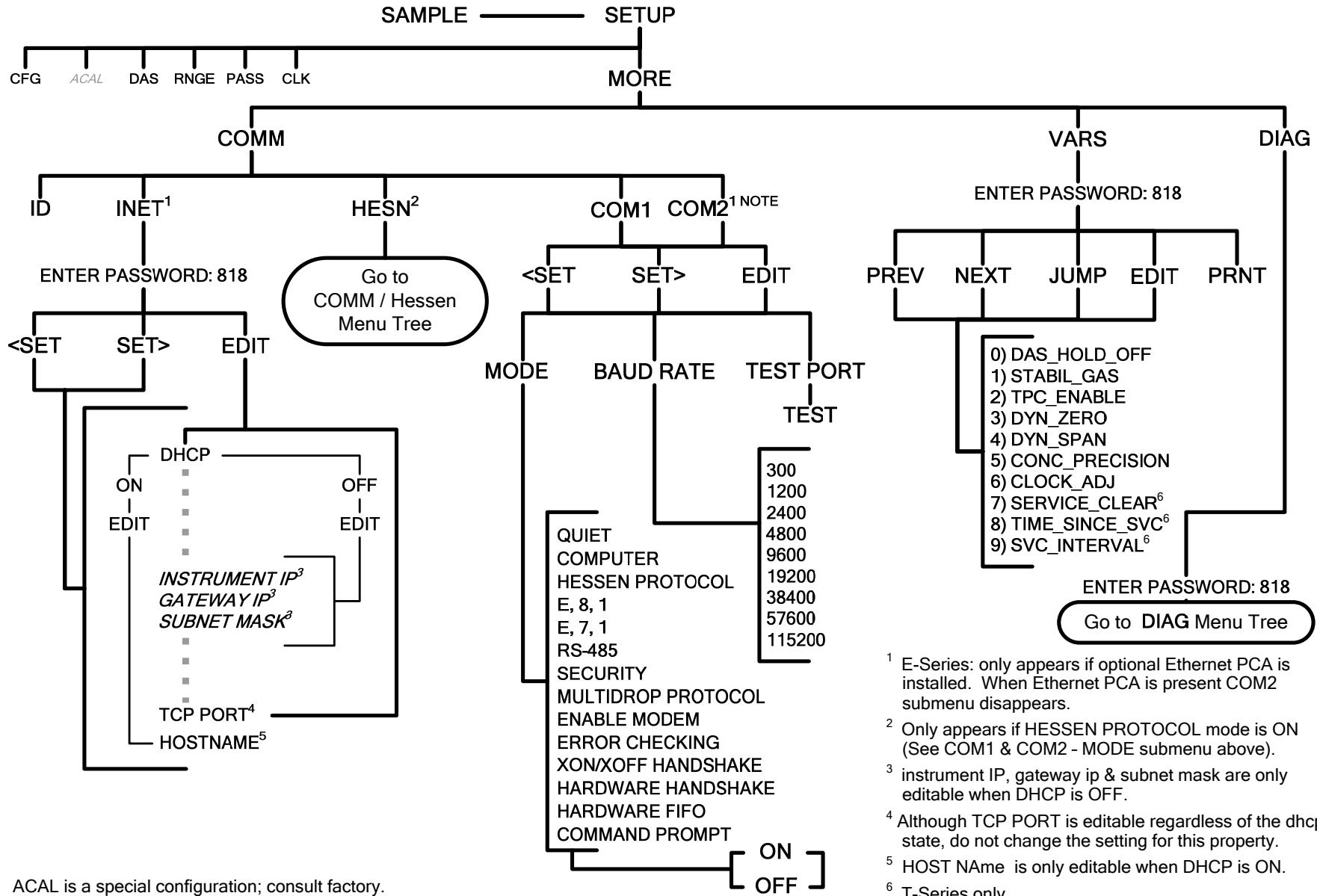


Figure A-4: Primary Setup Menu (DAS)



¹ E-Series: only appears if optional Ethernet PCA is installed. When Ethernet PCA is present COM2 submenu disappears.

² Only appears if HESSEN PROTOCOL mode is ON (See COM1 & COM2 - MODE submenu above).

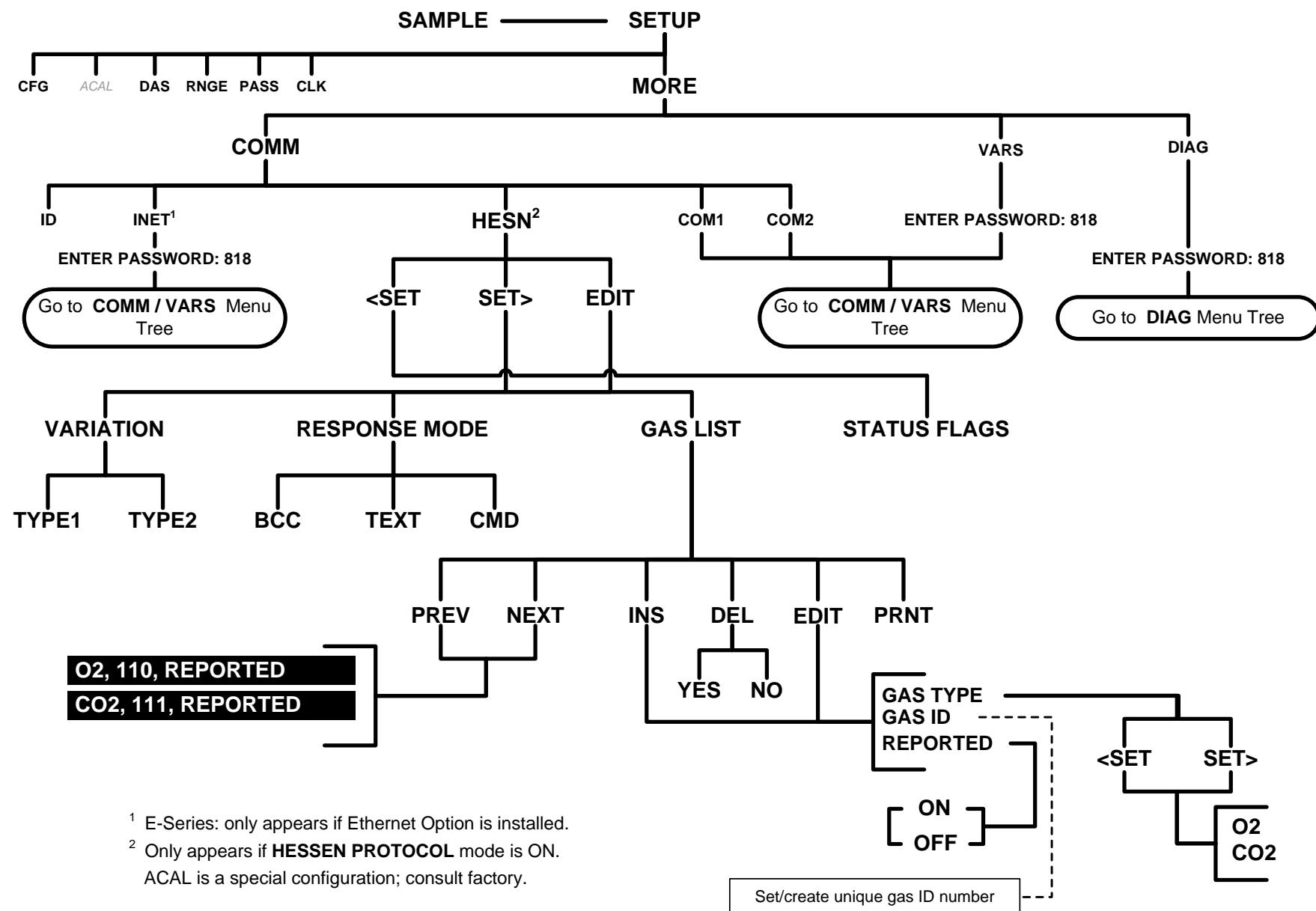
³ instrument IP, gateway ip & subnet mask are only editable when DHCP is OFF.

⁴ Although TCP PORT is editable regardless of the dhcp state, do not change the setting for this property.

⁵ HOST NAME is only editable when DHCP is ON.

⁶ T-Series only.

Figure A-5: Secondary Setup Menu (COMM & VARS)

**Figure A-6: Secondary Setup Menu - HESSEN Submenu**

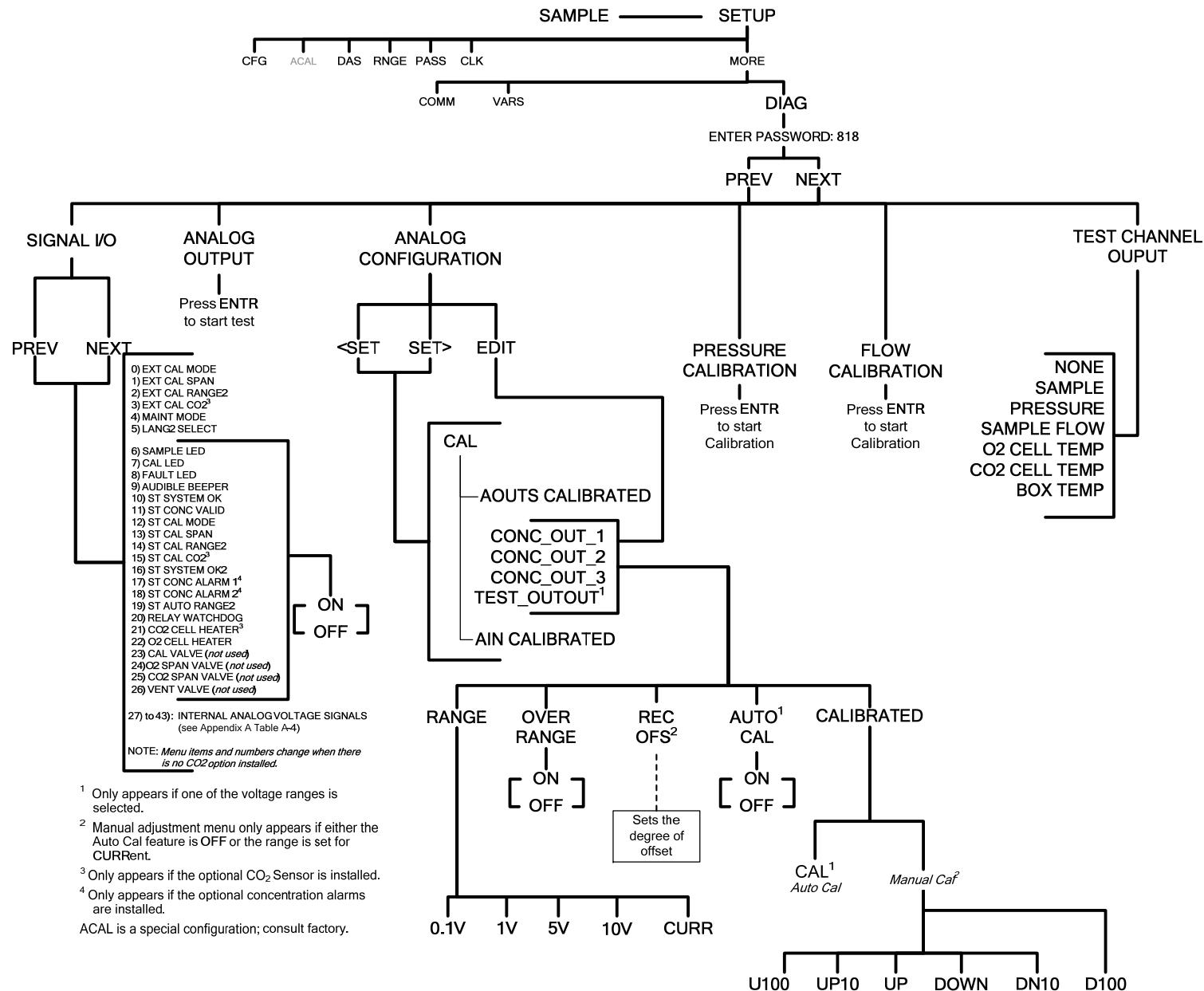


Figure A-7: Secondary Setup Menu (DIAG)

APPENDIX A-2: Setup Variables For Serial I/O, Software Versions 1.0.3 (T-Series)/A.3 (E-Series)**Table A-1: Setup Variables**

Setup Variable	Numeric Units	Default Value	Value Range	Description
Low Access Level Setup Variables (818 password)				
DAS_HOLD_OFF	Minutes	15	0.5–20	Duration of DAS hold off period.
STABIL_GAS	—	O2 ⁵ CO2 ⁴	O2 ³ , CO2 ¹	Selects gas for stability measurement. Enclose value in double quotes ("") when setting from the RS-232 interface.
TPC_ENABLE	—	ON	OFF, ON	ON enables temperature and pressure compensation; OFF disables it.
DYN_ZERO	—	OFF	OFF, ON	ON enables contact closure dynamic zero; OFF disables it.
DYN_SPAN	—	OFF	OFF, ON	ON enables contact closure dynamic span; OFF disables it.
CONC_PRECISION	—	AUTO	AUTO, 0, 1, 2, 3, 4	Number of digits to display to the right of the decimal point for concentrations on the display. Enclose value in double quotes ("") when setting from the RS-232 interface.
CLOCK_ADJ	Sec./Day	0	-60–60	Time-of-day clock speed adjustment.
SERVICE_CLEAR ⁸	—	OFF	OFF ON	ON resets the service interval timer.
TIME_SINCE_SVC ⁸	Hours	0	0–500000	Time since last service.
SVC_INTERVAL ⁸	Hours	0	0–100000	Sets the interval between service reminders.
Medium Access Level Setup Variables (929 password)				
DAYLIGHTSAVING_ENABLE ⁸	—	ON	OFF, ON	Enables/disables automatic Daylight Savings Time change.
LANGUAGE_SELECT	—	ENGL	ENGL, SECD, EXTN	Selects the language to use for the user interface. Enclose value in double quotes ("") when setting from the RS-232 interface.
MAINT_TIMEOUT	Hours	2	0.1–100	Time until automatically switching out of software-controlled maintenance mode.
LATCH_WARNINGS ⁸	—	ON	ON, OFF	ON enables latching warning messages; OFF disables latching.
CONV_TIME	—	33 MS	33 MS, 66 MS, 133 MS, 266 MS, 533 MS, 1 SEC, 2 SEC	Conversion time for O ₂ and CO ₂ detector channels. Enclose value in double quotes ("") when setting from the RS-232 interface.

Setup Variable	Numeric Units	Default Value	Value Range	Description
NEG_CONC_SUPPRESS	—	OFF	OFF, ON	ON pegs negative concentrations at zero; OFF permits negative concentrations
O2_DWELL ³	Seconds	1	0.1–30	Dwell time before taking each sample.
O2_FILT_ADAPT ³	—	ON	ON, OFF	ON enables O ₂ adaptive filter; OFF disables it.
O2_FILT_SIZE ³	Samples	60	1–500	O ₂ moving average filter size in normal mode.
O2_FILT_ASIZE ³	Samples	10	1–500	O ₂ moving average filter size in adaptive mode.
O2_FILT_DELTA ³	%	2	0.1–100	Absolute change in O ₂ concentration to shorten filter.
O2_FILT_PCT ³	%	2	0.1–100	Relative change in O ₂ concentration to shorten filter.
O2_FILT_DELAY ³	Seconds	20	0–300	Delay before leaving O ₂ adaptive filter mode.
O2_DIL_FACTOR ³	—	1	0.1–1000	Dilution factor for O ₂ . Used only if is dilution enabled with FACTORY_OPT variable.
O2_CELL_SET ³	°C	50	30–70	O ₂ sensor cell temperature set point and warning limits.
		Warnings: 45–55		
O2_CELL_CYCLE ³	Seconds	10	0.5–30	O ₂ cell temperature control cycle period.
O2_CELL_PROP ³	—	1	0–10	O ₂ cell PID temperature control proportional coefficient.
O2_CELL_INTEG ³	—	0.1	0–10	O ₂ cell PID temperature control integral coefficient.
O2_CELL_DERIV ³	—	0 (disabled)	0–10	O ₂ cell PID temperature control derivative coefficient.
O2_STD_CELL_TEMP ³	°K	323	1–500	Standard O ₂ cell temperature for temperature compensation.
O2_STD_CELL_PRESS ³	"Hg	28.50	1.00–50.00	Standard O ₂ cell pressure for pressure compensation.
CO2_DWELL ¹	Seconds	1	0.1–30	Dwell time before taking each sample.
CO2_FILT_ADAPT ¹	—	ON	ON, OFF	ON enables CO ₂ adaptive filter; OFF disables it.
CO2_FILT_SIZE ¹	Samples	48	1–300	CO ₂ moving average filter size in normal mode.
CO2_FILT_ASIZE ¹	Samples	12	1–300	CO ₂ moving average filter size in adaptive mode.
CO2_FILT_DELTA ¹	%	2	0.1–10	Absolute change in CO ₂ concentration to shorten filter.
CO2_FILT_PCT ¹	%	10	0.1–100	Relative change in CO ₂ concentration to shorten filter.
CO2_FILT_DELAY ¹	Seconds	90	0–300	Delay before leaving CO ₂ adaptive filter mode.

Setup Variable	Numeric Units	Default Value	Value Range	Description
CO2_DIL_FACTOR ¹	—	1	0.1–1000	Dilution factor for CO ₂ . Used only if is dilution enabled with FACTORY_OPT variable.
CO2_CELL_SET ¹	°C	50	30–70	CO ₂ sensor cell temperature set point and warning limits.
		Warnings: 45–55		
CO2_CELL_CYCLE ¹	Seconds	10	0.5–30	CO ₂ cell temperature control cycle period.
CO2_CELL_PROP ¹	—	1	0–10	CO ₂ cell PID temperature control proportional coefficient.
CO2_CELL_INTEG ¹	—	0.1	0–10	CO ₂ cell PID temperature control integral coefficient.
CO2_CELL_DERIV ¹	—	0 (disabled)	0–10	CO ₂ cell PID temperature control derivative coefficient.
CO2_STD_CELL_TEMP ¹	°K	323	1–500	Standard CO ₂ cell temperature for temperature compensation.
CO2_STD_CELL_PRESS ¹	"Hg	28.50	1.00–50.00	Standard CO ₂ cell pressure for pressure compensation.
O2_TARG_SPAN1 ³	%	20.95	0.1–100	Target O ₂ concentration during span calibration of range 1.
O2_SLOPE1 ³	—	1	0.5–2	O ₂ slope for range 1.
O2_OFFSET1 ³	%	0	-10–10	O ₂ offset for range 1.
CO2_TARG_SPAN1 ¹	%	12	0.1–1000	Target CO ₂ concentration during span calibration of range 1.
CO2_SLOPE1 ¹	—	1	0.5–5	CO ₂ slope for range 1.
CO2_OFFSET1 ¹	%	0	-10–10	CO ₂ offset for range 1.
O2_TARG_SPAN2 ⁵	%	20.95	0.1–100	Target O ₂ concentration during span calibration of range 2.
O2_SLOPE2 ⁵	—	1	0.5–2	O ₂ slope for range 2.
O2_OFFSET2 ⁵	%	0	-10–10	O ₂ offset for range 2.
CO2_TARG_SPAN2 ⁴	%	12	0.1–1000	Target CO ₂ concentration during span calibration of range 2.
CO2_SLOPE2 ⁴	—	1	0.5–5	CO ₂ slope for range 2.
CO2_OFFSET2 ⁴	%	0	-10–10	CO ₂ offset for range 2.
RANGE_MODE	—	SNGL	SNGL, DUAL, AUTO	Range control mode. Enclose value in double quotes ("") when setting from the RS-232 interface.
CONC_RANGE1	%	100	0.1–500	D/A concentration range 1
CONC_RANGE2	%	100	0.1–500	D/A concentration range 2
CONC_RANGE3 ²	%	15	0.1–500	D/A concentration range 3

Setup Variable	Numeric Units	Default Value	Value Range	Description
SAMP_FLOW_SET	cc/m	120	0–6000	Sample flow set point for flow calculation and warning limits.
		Warnings: 80–180		
SAMP_FLOW_SLOPE	—	1	0.5–1.5	Sample flow slope correction factor (adjusted flow = measured flow x slope).
SAMP_PRESS_SET	"Hg	29.92	0–100	Sample pressure set point for pressure compensation and warning limits.
		Warnings: 15–35		
BOX_SET	°C	30	5–60	Box temperature warning limits. Set point is not used.
		Warnings: 8–50		
RS232_MODE	BitFlag	0	0–65535	<p>RS-232 COM1 mode flags. Add values to combine flags.</p> <p>1 = quiet mode 2 = computer mode 4 = enable security 8 = enable hardware handshaking 16 = enable Hessen protocol ⁸ 32 = enable multi-drop 64 = enable modem 128 = ignore RS-232 line errors 256 = disable XON / XOFF support 512 = disable hardware FIFOs 1024 = enable RS-485 mode 2048 = even parity, 7 data bits, 1 stop bit 4096 = enable command prompt 8192 = even parity, 8 data bits, 1 stop bit 16384 = enable dedicated MODBUS ASCII protocol 32678 = enable dedicated MODBUS RTU or TCP protocol</p>
BAUD_RATE	—	115200	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	RS-232 COM1 baud rate. Enclose value in double quotes ("") when setting from the RS-232 interface.

Setup Variable	Numeric Units	Default Value	Value Range	Description
MODEM_INIT	—	"AT Y0 &D0 &H0 &I0 S0=2 &B0 &N6 &M0 E0 Q1 &W0"	Any character in the allowed character set. Up to 100 characters long.	RS-232 COM1 modem initialization string. Sent verbatim plus carriage return to modem on power up or manually. Enclose value in double quotes ("") when setting from the RS-232 interface.
RS232_MODE2	BitFlag	0	0–65535	RS-232 COM2 mode flags. (<i>Same settings as RS232_MODE</i> .)
BAUD_RATE2	—	19200	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	RS-232 COM2 baud rate. Enclose value in double quotes ("") when setting from the RS-232 interface.
MODEM_INIT2	—	"AT Y0 &D0 &H0 &I0 S0=2 &B0 &N6 &M0 E0 Q1 &W0"	Any character in the allowed character set. Up to 100 characters long.	RS-232 COM2 modem initialization string. Sent verbatim plus carriage return to modem on power up or manually. Enclose value in double quotes ("") when setting from the RS-232 interface.
RS232_PASS	Password	940331	0–999999	RS-232 log on password.
MACHINE_ID	ID	802	0–9999	Unique ID number for instrument.
COMMAND_PROMPT	—	"Cmd> "	Any character in the allowed character set. Up to 100 characters long.	RS-232 interface command prompt. Displayed only if enabled with <i>RS232_MODE</i> variable. Enclose value in double quotes ("") when setting from the RS-232 interface.
TEST_CHAN_ID	—	NONE	NONE, SAMPLE PRESSURE, , SAMPLE FLOW, O2 CELL TEMP ³ , CO2 CELL TEMP ¹ , CHASSIS TEMP	Diagnostic analog output ID. Enclose value in double quotes ("") when setting from the RS-232 interface.

Setup Variable	Numeric Units	Default Value	Value Range	Description
REMOTE_CAL_MODE	—	O2 RANGE1 ⁵ CO2 RANGE1 ⁴	O2 RANGE1 ³ , O2 RANGE2 ⁵ , CO2 RANGE1 ¹ , CO2 RANGE2 ⁴	Range to calibrate during contact-closure and Hessen calibration. Enclose value in double quotes ("") when setting from the RS-232 interface.
PASS_ENABLE	—	OFF	OFF, ON	ON enables passwords; OFF disables them.
STABIL_FREQ	Seconds	10	1–300	Stability measurement sampling frequency.
STABIL_SAMPLES	Samples	25	2–40	Number of samples in concentration stability reading.
SERIAL_NUMBER	—	“00000000”	Any character in the allowed character set. Up to 100 characters long.	Unique serial number for instrument. Enclose value in double quotes ("") when setting from the RS-232 interface.
DISP_INTENSITY	—	HIGH	HIGH, MED, LOW, DIM	Front panel display intensity. Enclose value in double quotes ("") when setting from the RS-232 interface.
I2C_RESET_ENABLE	—	ON	OFF, ON	I ² C bus automatic reset enable.

Setup Variable	Numeric Units	Default Value	Value Range	Description
CLOCK_FORMAT	—	"TIME=%H:%M:%S"	Any character in the allowed character set. Up to 100 characters long.	<p>Time-of-day clock format flags. Enclose value in double quotes ("") when setting from the RS-232 interface.</p> <p>"%a" = Abbreviated weekday name.</p> <p>"%b" = Abbreviated month name.</p> <p>"%d" = Day of month as decimal number (01 – 31).</p> <p>"%H" = Hour in 24-hour format (00 – 23).</p> <p>"%I" = Hour in 12-hour format (01 – 12).</p> <p>"%j" = Day of year as decimal number (001 – 366).</p> <p>"%m" = Month as decimal number (01 – 12).</p> <p>"%M" = Minute as decimal number (00 – 59).</p> <p>"%p" = A.M./P.M. indicator for 12-hour clock.</p> <p>"%S" = Second as decimal number (00 – 59).</p> <p>"%w" = Weekday as decimal number (0 – 6; Sunday is 0).</p> <p>"%y" = Year without century, as decimal number (00 – 99).</p> <p>"%Y" = Year with century, as decimal number.</p> <p>"%" = Percent sign.</p>
ALARM_TRIGGER	Cycles	3	1–100	Number of times concentration must exceed limit to trigger alarm.

Setup Variable	Numeric Units	Default Value	Value Range	Description
FACTORY_OPT	BitFlag	0	0–0x7fffffff	<p>Factory option flags. Add values to combine flags.</p> <p>1 = enable dilution factor 2 = display units in concentration field 4 = enable software-controlled maintenance mode 8 = enable switch-controlled maintenance mode 16 = enable concentration alarms 32 = enable Internet option⁷ 16384 = enable external analog inputs⁶</p>

¹ T-Series/E-Series: 801, 803, or 802 with CO₂ option.
² T-Series/E-Series: 802 with CO₂ option or 803.
³ T-Series/E-Series: 802 or 803.
⁴ T-Series/E-Series: 801 or 803.
⁵ T-Series/E-Series: 802 only.
⁶ T-Series external analog input option.
⁷ E Series internet option.
⁸ T-Series only

APPENDIX A-3: Warnings and Test Measurements, Software Versions 1.0.3 (T-Series)/A.3 (E-Series)**Table A-2: Warning Messages**

Name ¹	Message Text	Description
Warnings		
WSYSRES	SYSTEM RESET	Instrument was power-cycled or the CPU was reset.
WDATAINIT	DATA INITIALIZED	Data storage was erased.
WCONFIGINIT	CONFIG INITIALIZED	Configuration storage was reset to factory configuration or erased.
WO2ALARM1 ³	O2 ALARM 1 WARN	O ₂ concentration alarm limit #1 exceeded
WO2ALARM2 ³	O2 ALARM 2 WARN	O ₂ concentration alarm limit #2 exceeded
WCO2ALARM1 ²	CO2 ALARM 1 WARN	CO ₂ concentration alarm limit #1 exceeded
WCO2ALARM2 ²	CO2 ALARM 2 WARN	CO ₂ concentration alarm limit #2 exceeded
WSAMPFLOW	SAMPLE FLOW WARN	Sample flow outside of warning limits specified by <i>SAMP_FLOW_SET</i> variable.
WSAMPPRESS	SAMPLE PRESS WARN	Sample pressure outside of warning limits specified by <i>SAMP_PRESS_SET</i> variable.
WBOXTEMP	BOX TEMP WARNING	Chassis temperature outside of warning limits specified by <i>BOX_SET</i> variable.
WO2CELLTEMP ³	O2 CELL TEMP WARN	O ₂ sensor cell temperature outside of warning limits specified by <i>O2_CELL_SET</i> variable.
WCO2CELLTEMP ²	CO2 CELL TEMP WARN	CO ₂ sensor cell temperature outside of warning limits specified by <i>CO2_CELL_SET</i> variable.
WDYNZERO	CANNOT DYN ZERO	Contact closure zero calibration failed while <i>DYN_ZERO</i> was set to <i>ON</i> .
WDYNSPAN	CANNOT DYN SPAN	Contact closure span calibration failed while <i>DYN_SPAN</i> was set to <i>ON</i> .
WREARBOARD	REAR BOARD NOT DET	Rear board was not detected during power up.
WRELAYBOARD	RELAY BOARD WARN	Firmware is unable to communicate with the relay board.
WFRONTPANEL	FRONT PANEL WARN	Firmware is unable to communicate with the front panel.
WANALOGCAL	ANALOG CAL WARNING	The A/D or at least one D/A channel has not been calibrated.

¹ The name is used to request a message via the RS-232 interface, as in "T BOXTEMP".² T-Series/E-Series: 801, 803 or 802 with CO₂ option.³ T-Series/E-Series: 802 or 803.⁴ T-Series/E-Series: 801 or 803.⁵ T-Series/E-Series: 802 only.⁶ T-Series/E-Series: 803 only.⁷ T-Series/E-Series: 802 with CO₂ option.⁸ T-Series/E-Series: 801 or 802 without CO₂ option.¹⁰ External analog input option.

Table A-3: Test Measurements

Name ¹	Message Text	Description
Test Measurements		
O2RANGE ⁵ CO2RANGE ⁴	O2 RNG=500.0 % CO2 RNG = 500.0 %	D/A range in single or auto-range modes.
O2RANGE1 ⁵ CO2RANGE1 ⁴	O2 RN1=500.0 % CO2 RN1=500.0 %	D/A 1 range in independent range mode.
O2RANGE2 ⁵ CO2RANGE2 ⁴	O2 RN2=500.0 % CO2 RN2=500.0 %	D/A 2 range in independent range mode.
O2RANGE ⁶ CO2RANGE ⁷	O2 RNG=100 % CO2 RNG=100 %	D/A 3 range.
STABILITY	STABIL=0.0 % ⁸ O2 STB=0.0 % ² or CO2 STB=0.0 % ²	Concentration stability.
SAMPPRESS	PRES=29.9 IN-HG-A	Sample pressure.
SAMPFLOW	SAMP FL=100 CC/M	Sample flow rate.
O2SLOPE ³	O2 SLOPE=0.980	O ₂ slope, computed during zero/span calibration.
O2OFFSET ³	O2 OFST=1.79 %	O ₂ offset, computed during zero/span calibration.
CO2SLOPE ²	CO2 SLOPE=1.0000	CO ₂ slope, computed during zero/span calibration.
CO2OFFSET ²	CO2 OFST=0.00 %	CO ₂ offset, computed during zero/span calibration.
O2CELLTEMP ³	O2 CELL TEMP=50.2 C	O ₂ sensor cell temperature.
CO2CELLTEMP ²	CO2 CELL TEMP=50.2 C	CO ₂ sensor cell temperature.
BOXTEMP	BOX TEMP=35.5 C	Internal chassis temperature.
O2 ³	O2=0.00 %	O ₂ concentration.
CO2 ²	CO2=0.00 %	CO ₂ concentration.
TESTCHAN	TEST=3721.1 MV	Value output to <i>TEST_OUTPUT</i> analog output, selected with <i>TEST_CHAN_ID</i> variable.
XIN1 ¹⁰	AIN1=37.15 EU	External analog input 1 value in engineering units.
XIN2 ¹⁰	AIN2=37.15 EU	External analog input 2 value in engineering units.
XIN3 ¹⁰	AIN3=37.15 EU	External analog input 3 value in engineering units.
XIN4 ¹⁰	AIN4=37.15 EU	External analog input 4 value in engineering units.
XIN5 ¹⁰	AIN5=37.15 EU	External analog input 5 value in engineering units.
XIN6 ¹⁰	AIN6=37.15 EU	External analog input 6 value in engineering units.
XIN7 ¹⁰	AIN7=37.15 EU	External analog input 7 value in engineering units.
XIN8 ¹⁰	AIN8=37.15 EU	External analog input 8 value in engineering units.

Name ¹	Message Text	Description
Test Measurements		
CLOCKTIME	TIME=10:38:27	Current instrument time of day clock.
¹ The name is used to request a message via the RS-232 interface, as in "T BOXTEMP".		
² T-Series/E-Series: 801, 803, or 802 with CO ₂ option.		
³ T-Series/E-Series: 802 or 803.		
⁴ T-Series/E-Series: 801 or 803.		
⁵ T-Series/E-Series: 802 only.		
⁶ T-Series/E-Series: 803 only.		
⁷ T-Series/E-Series: 802 with CO ₂ option.		
⁸ T-Series/E-Series: 801 or 802 without CO ₂ option.		
¹⁰ External analog input option.		

APPENDIX A-4: Signal I/O Definitions, Software Versions 1.0.3 (T-Series)/A.3 (E-Series)**Table A-4: Signal I/O Definitions**

Signal Name	Bit or Channel Number	Description
Internal inputs, U7, J108, pins 9–16 = bits 0–7, default I/O address 322 hex		
	0–7	Spare
Internal outputs, U8, J108, pins 1–8 = bits 0–7, default I/O address 322 hex		
	0–5	Spare
I2C_RESET	6	1 = reset I ² C peripherals 0 = normal
I2C_DRV_RST	7	0 = hardware reset 8584 chip 1 = normal
Control inputs, U11, J1004, pins 1–6 = bits 0–5, default I/O address 321 hex		
EXT_CAL_MODE	0	0 = go into calibration mode 1 = exit calibration mode and go into measure mode
EXT_CAL_SPAN	1	0 = calibrate span 1 = calibrate zero
EXT_CAL_RANGE2	2	0 = calibrate range #2 1 = calibrate range #1
EXT_CAL_CO2 ¹	3	0 = calibrate CO ₂ 1 = calibrate O ₂
	4–5	Spare
	6–7	Always 1
Control inputs, U14, J1006, pins 1–6 = bits 0–5, default I/O address 325 hex		
	0–5	Spare
	6–7	Always 1
Control outputs, U17, J1008, pins 1–8 = bits 0–7, default I/O address 321 hex		
	0–7	Spare
Control outputs, U21, J1008, pins 9–12 = bits 0–3, default I/O address 325 hex		
	0–3	Spare
Alarm outputs, U21, J1009, pins 1–12 = bits 4–7, default I/O address 325 hex		
ST_SYSTEM_OK2, MB_RELAY_36 ³	4	1 = system OK 0 = any alarm condition or in diagnostics mode
		Controlled by MODBUS coil register
ST_CONC_ALARM_1, MB_RELAY_37 ³	5	1 = conc. limit 1 exceeded 0 = conc. OK
		Controlled by MODBUS coil register
ST_CONC_ALARM_2, MB_RELAY_38 ³	6	1 = conc. limit 2 exceeded 0 = conc. OK
		Controlled by MODBUS coil register
ST_AUTO_RANGE2, MB_RELAY_39 ³	7	1 = auto-range 2 in use 0 = auto-range 1 in use
		Controlled by MODBUS coil register

Signal Name	Bit or Channel Number	Description
A status outputs, U24, J1017, pins 1–8 = bits 0–7, default I/O address 323 hex		
ST_SYSTEM_OK	0	0 = system OK 1 = any alarm condition
ST_CONC_VALID	1	0 = conc. valid 1 = warnings or other conditions that affect validity of concentration
ST_CAL_MODE	2	0 = in calibration mode 1 = in measure mode
ST_CAL_SPAN	3	0 = calibrating span 1 = calibrating zero
ST_CAL_RANGE2	4	0 = calibrating range 2 1 = calibrating range 1
ST_CAL_CO2 ¹	5	0 = calibrating CO ₂ 1 = calibrating O ₂
	6–7	Spare
B status outputs, U27, J1018, pins 1–8 = bits 0–7, default I/O address 324 hex		
	0–7	Spare
Front panel I²C keyboard, default I²C address 4E hex		
MAINT_MODE	5 (input)	0 = maintenance mode 1 = normal mode
LANG2_SELECT	6 (input)	0 = select second language 1 = select first language (English)
SAMPLE_LED	8 (output)	0 = sample LED on 1 = off
CAL_LED	9 (output)	0 = cal. LED on 1 = off
FAULT_LED	10 (output)	0 = fault LED on 1 = off
AUDIBLE_BEEPER	14 (output)	0 = beeper on (for diagnostic testing only) 1 = off
Relay board digital output (PCF8575), default I²C address 44 hex		
RELAY_WATCHDOG	0	Alternate between 0 and 1 at least every 5 seconds to keep relay board active
	1–3	Spare
CO2_CELL_HEATER ²	4	0 = CO ₂ sensor cell heater on 1 = off
O2_CELL_HEATER ⁴	5	0 = O ₂ sensor cell heater on 1 = off
CAL_VALVE ⁶	6	0 = let cal. gas in 1 = let sample gas in
O2_SPAN_VALVE ^{4, 6}	7	0 = let O ₂ span gas in 1 = let zero gas in

Signal Name	Bit or Channel Number	Description
CO2_SPAN_VALVE ^{2,6}	8	0 = let CO ₂ span gas in 1 = let zero gas in
VENT_VALVE ⁶	9	0 = open vent valve 1 = close vent valve
	10–15	Spare
Rear board primary MUX analog inputs		
	0–3	Spare
	4	Temperature MUX
	5	Spare
O2_CONC_SENSOR ⁴	6	O ₂ concentration sensor
SAMPLE_PRESSURE	7	Sample pressure
	8	Spare
REF_4096_MV	9	4.096V reference from MAX6241
SAMPLE_FLOW	10	Sample flow rate
CO2_CONC_SENSOR ²	11	CO ₂ concentration sensor
	12–13	Spare (thermocouple input?)
	14	DAC MUX
REF_GND	15	Ground reference
Rear board temperature MUX analog inputs		
BOX_TEMP	0	Internal box temperature
	1	Spare
CO2_CELL_TEMP ²	2	CO ₂ sensor cell temperature
	3	Spare
O2_CELL_TEMP ⁴	4	O ₂ sensor cell temperature
	5–7	Spare
Rear board DAC MUX analog inputs		
DAC_CHAN_1	0	DAC channel 0 loopback
DAC_CHAN_2	1	DAC channel 1 loopback
DAC_CHAN_3	2	DAC channel 2 loopback
DAC_CHAN_4	3	DAC channel 3 loopback
Rear board analog outputs		
CONC_OUT_1, DATA_OUT_1	0	Concentration output #1, Data output #1
CONC_OUT_2, DATA_OUT_2	1	Concentration output #2, Data output #2
CONC_OUT_3 ¹ DATA_OUT_3	2	Concentration output #3, Data output #3
TEST_OUTPUT, DATA_OUT_4	3	Test measurement output, Data output #4

Signal Name	Bit or Channel Number	Description
External analog input board, default I²C address 5C hex		
XIN1 ⁷	0	External analog input 1
XIN2 ⁷	1	External analog input 2
XIN3 ⁷	2	External analog input 3
XIN4 ⁷	3	External analog input 4
XIN5 ⁷	4	External analog input 5
XIN6 ⁷	5	External analog input 6
XIN7 ⁷	6	External analog input 7
XIN8 ⁷	7	External analog input 8

¹ T-Series/E-Series: 803 or 802 with CO₂ option.
² T-Series/E-Series: 801 or 803.
³ MODBUS option.
⁴ T-Series/E-Series: 802 or 803.
⁵ future
⁶ Future valve option.
⁷ T-Series: External analog input option.

APPENDIX A-5: DAS Triggering Events, Parameters, Software Version s 1.0.3 (T-Series)/A.3 (E-Series)**Table A-5: DAS Trigger Events**

Name	Description
ATIMER	Automatic timer expired
EXO2ZR ³	Exit O ₂ zero calibration mode
EXO2SP ³	Exit O ₂ span calibration mode
EXO2MP ³	Exit O ₂ multi-point calibration mode
O2SLPC ³	O ₂ slope and offset recalculated
EXCO2Z ¹	Exit CO ₂ zero calibration mode
EXCO2S ¹	Exit CO ₂ span calibration mode
EXCO2M ¹	Exit CO ₂ multi-point calibration mode
CO2SLC ¹	CO ₂ slope and offset recalculated
EXITDG	Exit diagnostic mode
CONC1W	Concentration limit 1 exceeded
CONC2W	Concentration limit 2 exceeded
O2TMPW ³	O ₂ sensor cell temperature warning
CO2TMW ¹	CO ₂ sensor cell temperature warning
SFLOWW	Sample flow warning
SPRESW	Sample pressure warning
BTEMPW	Box temperature warning

¹ T-Series/E-Series: 801, 803 or 802 with CO₂ option.

² future.

³ T-Series/E-Series: 802 or 803.

Table A-6: DAS Parameters

Name	Description	Units
O2SLP1 ²	O ₂ slope for range #1	—
O2SLP2 ⁴	O ₂ slope for range #2	—
O2OFS1 ²	O ₂ offset for range #1	%
O2OFS2 ⁴	O ₂ offset for range #2	%
CO2SL1 ¹	CO ₂ slope for range #1	—
CO2SL2 ³	CO ₂ slope for range #2	—
CO2OF1 ¹	CO ₂ offset for range #1	%
CO2OF2 ³	CO ₂ offset for range #2	%
O2ZSC1 ²	O ₂ concentration for range #1 during zero/span calibration, just before computing new slope and offset	%
O2ZSC2 ⁴	O ₂ concentration for range #2 during zero/span calibration, just before computing new slope and offset	%
CO2ZS1 ¹	CO ₂ concentration for range #1 during zero/span calibration, just before computing new slope and offset	%
CO2ZS2 ³	CO ₂ concentration for range #2 during zero/span calibration, just before computing new slope and offset	%
O2CNC1 ²	O ₂ concentration for range #1	%
O2CNC2 ⁴	O ₂ concentration for range #2	%
CO2CN1 ¹	CO ₂ concentration for range #1	%
CO2CN2 ³	CO ₂ concentration for range #2	%
STABIL	Concentration stability #1	%
O2TEMP ²	O ₂ sensor cell temperature	°C
O2DUTY ²	O ₂ sensor cell temperature controller duty cycle	Fraction (0.0 = off, 1.0 = on full)
CO2TMP ¹	CO ₂ sensor cell temperature	°C
CO2DTY ¹	CO ₂ sensor cell temperature controller duty cycle	Fraction (0.0 = off, 1.0 = on full)
SMPFLW	Sample flow	cc/m
SMPPRS	Sample pressure	"Hg
BOXTMP	Internal box temperature	°C
REFGND	Ground reference (REF_GND)	mV
RF4096	4096 mV reference (REF_4096_MV)	mV

Name	Description	Units
XIN1 ⁵	External analog input 1 value	Volts
XIN1SLPE ⁵	External analog input 1 slope	eng unit / V
XIN1OFST ⁵	External analog input 1 value	eng unit
XIN2 ⁵	External analog input 2 value	Volts
XIN2SLPE ⁵	External analog input 2 slope	eng unit / V
XIN2OFST ⁵	External analog input 2 value	eng unit
XIN3 ⁵	External analog input 3 value	Volts
XIN3SLPE ⁵	External analog input 3 slope	eng unit / V
XIN3OFST ⁵	External analog input 3 value	eng unit
XIN4 ⁵	External analog input 4 value	Volts
XIN4SLPE ⁵	External analog input 4 slope	eng unit / V
XIN4OFST ⁵	External analog input 4 value	eng unit
XIN5 ⁵	External analog input 5 value	Volts
XIN5SLPE ⁵	External analog input 5 slope	eng unit / V
XIN5OFST ⁵	External analog input 5 value	eng unit
XIN6 ⁵	External analog input 6 value	Volts
XIN6SLPE ⁵	External analog input 6 slope	eng unit / V
XIN6OFST ⁵	External analog input 6 value	eng unit
XIN7 ⁵	External analog input 7 value	Volts
XIN7SLPE ⁵	External analog input 7 slope	eng unit / V
XIN7OFST ⁵	External analog input 7 value	eng unit
XIN8 ⁵	External analog input 8 value	Volts
XIN8SLPE ⁵	External analog input 8 slope	eng unit / V
XIN8OFST ⁵	External analog input 8 value	eng unit

¹ T-Series/E-Series: 801, 803 or 802 with CO₂ option.

² T-Series/E-Series: 802 or 803.

³ T-Series/E-Series: 801 or 803.

⁴ T-Series/E-Series: 802 only.

⁵ T-Series: External analog input option.

APPENDIX A-6: Terminal Command Designators, Software Versions 1.0.3 (T-Series)/A.3 (E-Series)**Table A-7: Terminal Command Designators**

COMMAND	ADDITIONAL COMMAND SYNTAX	DESCRIPTION
? [ID]		Display help screen and commands list
LOGON [ID]	password	Establish connection to instrument
LOGOFF [ID]		Terminate connection to instrument
T [ID]	SET ALL name hexmask	Display test(s)
	LIST [ALL name hexmask] [NAMES HEX]	Print test(s) to screen
	name	Print single test
	CLEAR ALL name hexmask	Disable test(s)
W [ID]	SET ALL name hexmask	Display warning(s)
	LIST [ALL name hexmask] [NAMES HEX]	Print warning(s)
	name	Clear single warning
	CLEAR ALL name hexmask	Clear warning(s)
C [ID]	ZERO LOWSPAN SPAN [1 2]	Enter calibration mode
	ASEQ number	Execute automatic sequence
	COMPUTE ZERO SPAN	Compute new slope/offset
	EXIT	Exit calibration mode
	ABORT	Abort calibration sequence
D [ID]	LIST	Print all I/O signals
	name[=value]	Examine or set I/O signal
	LIST NAMES	Print names of all diagnostic tests
	ENTER name	Execute diagnostic test
	EXIT	Exit diagnostic test
	RESET [DATA] [CONFIG] [exitcode]	Reset instrument
	PRINT ["name"] [SCRIPT]	Print DAS configuration
	RECORDS ["name"]	Print number of DAS records
	REPORT ["name"] [RECORDS=number] [FROM=<start date>][TO=<end date>][VERBOSE COMPACT HEX] (Print DAS records)(date format: MM/DD/YYYY(or YY) [HH:MM:SS])	Print DAS records
	CANCEL	Halt printing DAS records
V [ID]	LIST	Print setup variables
	name[=value [warn_low [warn_high]]]	Modify variable
	name="value"	Modify enumerated variable
	CONFIG	Print instrument configuration
	MAINT ON OFF	Enter/exit maintenance mode
	MODE	Print current instrument mode
	DASBEGIN [<data channel definitions>] DASEND	Upload DAS configuration
	CHANNELBEGIN propertylist CHANNELEND	Upload single DAS channel
	CHANNELDELETE ["name"]	Delete DAS channels

The command syntax follows the command type, separated by a space character. Strings in [brackets] are optional designators. The following key assignments also apply.

Table A-8: Terminal Key Assignments

TERMINAL KEY ASSIGNMENTS	
ESC	Abort line
CR (ENTER)	Execute command
Ctrl-C	Switch to computer mode
COMPUTER MODE KEY ASSIGNMENTS	
LF (line feed)	Execute command
Ctrl-T	Switch to terminal mode

APPENDIX A-7: MODBUS® Register Map, Software Versions 1.0.3 (T-Series)/A.3 (E-Series)

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 ⁴	O ₂ slope for range 1	—
2 ⁶	O ₂ slope for range 2	—
4 ⁴	O ₂ offset for range 1	%
6 ⁶	O ₂ offset for range 2	%
8 ⁴	O ₂ concentration for range 1 during zero/span calibration, just before computing new slope and offset	%
10 ⁶	O ₂ concentration for range 2 during zero/span calibration, just before computing new slope and offset	%
12 ⁴	O ₂ concentration for range 1	%
14 ⁶	O ₂ concentration for range 2	%
16 ⁴	O ₂ sensor cell temperature	°C
18 ⁴	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 ⁵	CO ₂ slope for range 2	—
104 ¹	CO ₂ offset for range 1	%
106 ⁵	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 ⁵	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 ⁵	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

MODBUS Register Address (dec., 0-based)	Description	Units
130 ⁷	External analog input 1 value	Volts
132 ⁷	External analog input 1 slope	eng unit /V
134 ⁷	External analog input 1 offset	eng unit
136 ⁷	External analog input 2 value	Volts
138 ⁷	External analog input 2 slope	eng unit /V
140 ⁷	External analog input 2 offset	eng unit
142 ⁷	External analog input 3 value	Volts
144 ⁷	External analog input 3 slope	eng unit /V
146 ⁷	External analog input 3 offset	eng unit
148 ⁷	External analog input 4 value	Volts
150 ⁷	External analog input 4 slope	eng unit /V
152 ⁷	External analog input 4 offset	eng unit
154 ⁷	External analog input 5 value	Volts
156 ⁷	External analog input 5 slope	eng unit /V
158 ⁷	External analog input 5 offset	eng unit
160 ⁷	External analog input 6 value	Volts
162 ⁷	External analog input 6 slope	eng unit /V
164 ⁷	External analog input 6 offset	eng unit
166 ⁷	External analog input 7 value	Volts
168 ⁷	External analog input 7 slope	eng unit /V
170 ⁷	External analog input 7 offset	eng unit
172 ⁷	External analog input 8 value	Volts
174 ⁷	External analog input 8 slope	eng unit /V
176 ⁷	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 ⁴	Maps to O2_TARG_SPAN1 variable; target conc. for range 1	%
2 ⁶	Maps to O2_TARG_SPAN2 variable; target conc. for range 2	%
100 ¹	Maps to CO2_TARG_SPAN1 variable; target conc. for range 1	%
102 ⁵	Maps to CO2_TARG_SPAN2 variable; target conc. for range 2	%

MODBUS Register Address (dec., 0-based)	Description	Units
MODBUS Discrete Input Registers (single-bit; read-only)		
0	Box temperature warning	
1 ⁴	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 ⁴	In O ₂ zero calibration mode	
13 ⁴	In O ₂ span calibration mode	
14 ⁴	In O ₂ multi-point calibration mode	
15	System is OK (same meaning as SYSTEM_OK 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 Register Address (dec., 0-based)	Description	Units
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 ^{3,4}	Triggers O ₂ zero calibration of range 1 (on enters cal.; off exits cal.)	
21 ^{3,4}	Triggers O ₂ span calibration of range 1 (on enters cal.; off exits cal.)	
22 ^{6,4}	Triggers O ₂ zero calibration of range 2 (on enters cal.; off exits cal.)	
23 ^{6,4}	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 ^{1,3}	Triggers CO ₂ span calibration of range 1 (on enters cal.; off exits cal.)	
26 ^{5,3}	Triggers CO ₂ zero calibration of range 2 (on enters cal.; off exits cal.)	
27 ^{5,3}	Triggers CO ₂ span calibration of range 2 (on enters cal.; off exits cal.)	

¹ T-Series/E-Series: 801, 803 or 802 with CO₂ option.

² future.

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

⁴ T-Series/E-Series: 802 or 803.

⁵ T-Series/E-Series: 801 or 803.

⁶ T-Series/E-Series: 802 only.

⁷ T-Series: External analog input option.

APPENDIX B - Spare Parts

Note Use of replacement parts other than those supplied by Teledyne Advanced Pollution Instrumentation (TAPI) may result in non-compliance with European standard EN 61010-1.

Note Due to the dynamic nature of part numbers, please refer to the TAPI Website at <http://www.teledyne-api.com> or call Customer Service at 800-324-5190 for more recent updates to part numbers.

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T80X Spare Parts List

(Ref: 072690000A DCN6431, 2012 April 12)

PARTNUMBER	DESCRIPTION
000940700	CD, ORIFICE, .005 YELLOW
001763500	ASSY, FLOW CTL, 110CC, 1/4" ELBOW-B
003290000	THERMISTOR, BASIC (VENDOR ASSY)(KB)
009690200	AKIT, TFE FLTR ELEM (FL19,100=1) 47mm
009690300	AKIT, TFE FLTR ELEM (FL19, 30=1) 47mm
016290000	WINDOW, SAMPLE FILTER, 47MM (KB)
016300800	ASSY, SAMPLE FILTER, 47MM, ANG BKT, 1UM
037860000	ORING, TEFLON, RETAINING RING, 47MM (KB)
040010000	ASSY, FAN REAR PANEL (B/F)
040030100	PCA, PRESS SENSORS (1X), w/FM4
042410500	ASSY, PUMP, INT
043420000	ASSY, HEATER/THERM, O2 SEN
045230200	PCA, RELAY CARD
055100200	ASSY, OPTION, PUMP, 240V *
058021100	PCA, MOTHERBD, GEN 5-ICOP
066970000	PCA, INTRF. LCD TOUCH SCRN, F/P
067240000	CPU, PC-104, VSX-6154E, ICOP *(KB)
067300000	PCA, AUX-I/O BD, ETHERNET, ANALOG & USB
067300100	PCA, AUX-I/O BOARD, ETHERNET
067300200	PCA, AUX-I/O BOARD, ETHERNET & USB
067900000	LCD MODULE, W/TOUCHSCREEN(KB)
068810000	PCA, LVDS TRANSMITTER BOARD
069500000	PCA, SERIAL & VIDEO INTERFACE BOARD
072150000	ASSY. TOUCHSCREEN CONTROL MODULE
072740000	MANUAL, T801, OPERATORS
072750000	MANUAL, T802, OPERATORS
072760000	MANUAL, T803, OPERATORS
073770100	DOM, w/SOFTWARE, STD, T801 *
073780100	DOM, w/SOFTWARE, STD, T802 *
073790100	DOM, w/SOFTWARE, STD, T803 *
CN0000073	POWER ENTRY, 120/60 (KB)
CN0000458	PLUG, 12, MC 1.5/12-ST-3.81 (KB)
CN0000520	PLUG, 10, MC 1.5/10-ST-3.81 (KB)
FL0000001	FILTER, SS (KB)
FM0000004	FLOWMETER (KB)
HE0000017	HTR, 12W/120V (50W/240V), CE AP (KB)
HW0000005	FOOT
HW0000020	SPRING
HW0000036	TFE TAPE, 1/4" (48 FT/ROLL)
HW0000101	ISOLATOR
HW0000453	SUPPORT, CIRCUIT BD, 3/16" ICOP
HW0000685	LATCH, MAGNETIC, FRONT PANEL
KIT000219	AKIT, 4-20MA CURRENT OUTPUT
KIT000253	ASSY & TEST, SPARE PS37
KIT000254	ASSY & TEST, SPARE PS38
OP0000030	OXYGEN TRANSDUCER, PARAMAGNETIC

T80X Spare Parts List

(Ref: 072690000A DCN6431, 2012 April 12)

OR0000001	ORING, 2-006VT *(KB)
OR0000094	ORING, 2-228V, 50 DURO VITON(KB)
PU0000022	REBUILD KIT, FOR PU20 & 04241 (KB)
RL0000015	RELAY, DPDT, (KB)
SW0000006	SWITCH, THERMAL, 60 C (KB)
SW0000025	SWITCH, POWER, CIRC BREAK, VDE/CE *(KB)
SW0000059	PRESSURE SENSOR, 0-15 PSIA, ALL SEN
WR0000008	POWER CORD, 10A(KB)

M802E Expendables Kit, PN06535A (DCN5390)	
--	--

M802E without a pump Expendables Kit	
---	--

Part Number	Description
006190600	AKIT, EXP, 802E W/O PUMP, 1UM <i>This kit contains the following items (labor incl.)</i>
009690300	AKIT, TFE FLTR ELEMENT, 47MM, 1UM (30)
FL0000001	FILTER, SS
HW0000020	SPRING
OR0000001	ORING, SAMPLE FLOW

M802E with a pump Expendables Kit	
--	--

Part Number	Description
006190500	AKIT, EXP, 802E W/ PUMP, 1UM <i>This kit contains the following items (labor incl.)</i>
009690300	AKIT, TFE FLTR ELEMENT, 47MM, 1UM (30)
FL0000001	FILTER, SS
HW0000020	SPRING
NOTE01-23	SERVICE NOTE, HOW TO REBUILD KNF PUMP
OR0000001	ORING, SAMPLE FLOW
PU0000022	REBUILD KIT, FOR PU20 & 04241 (KB)

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Appendix C
Warranty/Repair Questionnaire
T80X, M80XE
(06532C DCN 5798)



TELEDYNE
ADVANCED POLLUTION INSTRUMENTATION
A Teledyne Technologies Company

CUSTOMER: _____

PHONE: _____

CONTACT NAME: _____

FAX NO. _____

SITE ADDRESS: _____

MODEL TYPE: _____ SERIAL NO.: _____ FIRMWARE REVISION: _____

Are there any failure messages? _____

(Continue on back if necessary)

PLEASE COMPLETE THE FOLLOWING TABLE:

PARAMETER	RECORDED VALUE	ACCEPTABLE VALUE
O2 RANGE ¹	%	0-100%
O2 CELL TEMP ¹	°C	50 ± 5
O2 SLOPE ¹		1.0 ± 0.3
O2 OFFSET ¹		-10 to 10%
CO2 RANGE ¹	%	0 to 20%
CO2 CELL TEMP ¹	°C	50 ± 5
CO2 SLOPE ¹		1.0 ± 0.3
CO2 OFFSET ¹		-10 to 10%
STABIL	%	≤ 0.2% with zero air
PRESS	in-Hg-A	ambient ± 1
SAMPLE FLOW	cm ³ /min	120 ± 20
BOX TEMP	°C	ambient ± 5°C
<i>following values are under the signal i/o submenu</i>		
REF_4096_MV	mV	4096mV ±2 mV and Must be Stable
REF_GND	mV	0± 0.5 and Must be Stable

¹ Not all models are equipped with both an O₂ and a CO₂ sensor.

Cap the SAMPLE inlet and record the flow rate and pressure readings:

What is PRESS _____ in-Hg-A

What is the SAMPLE FLOW _____ cc/min

What are the failure symptoms? _____

What test have you done trying to solve the problem? _____

Appendix C

Warranty/Repair Questionnaire

T80X, M80XE

(06532C DCN 5798)



TELEDYNE

ADVANCED POLLUTION INSTRUMENTATION

A Teledyne Technologies Company

If possible, please include a portion of a strip chart pertaining to the problem. Circle pertinent data.

OTHER NOTES: _____

Thank you for providing this information. Your assistance enables Teledyne API to respond faster to the problem that you are encountering.

TELEDYNE API CUSTOMER SERVICE
EMAIL: api-customerservice@teledyne.com
PHONE: (858) 657-9800 TOLL FREE: (800) 324-5190 FAX: (858) 657-9816

APPENDIX D – Wire List and Electronic Schematics

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T80X Interconnect List

(Reference: 073800100A DCN6418)

Cable PN	Signal	FROM					TO		
		Assembly	PN	J/P	Pin	Assembly	PN	J/P	Pin
036490100	CBL ASSY, AC POWER								
AC Line						Power Switch	SW0000025		L
AC Neutral						Power Switch	SW0000025		N
Power Grnd	Power Entry	CN0000073				Shield			
Power Grnd	Power Entry	CN0000073				Chassis			
AC Line Switched	Power Switch	SW0000025		L	PS2 (+12)	PS0000038	SK2	1	
AC Neu Switched	Power Switch	SW0000025		N	PS2 (+12)	PS0000038	SK2	3	
Power Grnd	Power Entry	CN0000073			PS2 (+12)	PS0000038	SK2	2	
AC Line Switched	PS2 (+12)	PS0000038	SK2	1	PS1 (+5, ±15)	PS0000037	SK2	1	
AC Neu Switched	PS2 (+12)	PS0000038	SK2	3	PS1 (+5, ±15)	PS0000037	SK2	3	
Power Grnd	PS2 (+12)	PS0000038	SK2	2	PS1 (+5, ±15)	PS0000037	SK2	2	
AC Line Switched	PS1 (+5, ±15)	PS0000037	SK2	1	Relay Board	045230100	J1	1	
AC Neu Switched	PS1 (+5, ±15)	PS0000037	SK2	3	Relay Board	045230100	J1	3	
Power Grnd	PS1 (+5, ±15)	PS0000037	SK2	2	Relay Board	045230100	J1	2	
038290000	CBL ASSY, DC POWER TO MOTHERBOARD								
DGND	Relay Board	045230100	J7	1	Motherboard	058021100	J15	1	
+5V	Relay Board	045230100	J7	2	Motherboard	058021100	J15	2	
AGND	Relay Board	045230100	J7	3	Motherboard	058021100	J15	3	
+15V	Relay Board	045230100	J7	4	Motherboard	058021100	J15	4	
AGND	Relay Board	045230100	J7	5	Motherboard	058021100	J15	5	
-15V	Relay Board	045230100	J7	6	Motherboard	058021100	J15	6	
+12V RET	Relay Board	045230100	J7	7	Motherboard	058021100	J15	7	
+12V	Relay Board	045230100	J7	8	Motherboard	058021100	J15	8	
Chassis Gnd	Relay Board	045230100	J7	10	Motherboard	058021100	J15	9	
040230000	CBL, I2C, RELAY BOARD TO MOTHERBOARD								
I2C Serial Clock	Motherboard	058021100	P107	3	Relay Board	045230100	P3	1	
I2C Serial Data	Motherboard	058021100	P107	5	Relay Board	045230100	P3	2	
I2C Reset	Motherboard	058021100	P107	2	Relay Board	045230100	P3	4	
I2C Shield	Motherboard	058021100	P107	6	Relay Board	045230100	P3	5	
041050000	CBL, INTERFACE BOARD TO MOTHERBOARD								
Kbd Interrupt	LCD Interface PCA	066970000	J2	7	Motherboard	058021100	J106	1	
DGND	LCD Interface PCA	066970000	J2	2	Motherboard	058021100	J106	8	
SDA	LCD Interface PCA	066970000	J2	5	Motherboard	058021100	J106	2	
SCL	LCD Interface PCA	066970000	J2	6	Motherboard	058021100	J106	6	
Shld	LCD Interface PCA	066970000	J2	10	Motherboard	058021100	J106	5	
041760000	CBL, DC POWER TO RELAY BOARD								
DGND	Relay Board	045230100	P8	1	Power Supply Triple	PS0000037	J1	3	
+5V	Relay Board	045230100	P8	2	Power Supply Triple	PS0000037	J1	1	
+15V	Relay Board	045230100	P8	4	Power Supply Triple	PS0000037	J1	6	
AGND	Relay Board	045230100	P8	5	Power Supply Triple	PS0000037	J1	4	
-15V	Relay Board	045230100	P8	6	Power Supply Triple	PS0000037	J1	5	
+12V RET	Relay Board	045230100	P8	7	Power Supply Single	PS0000038	J1	3	
+12V	Relay Board	045230100	P8	8	Power Supply Single	PS0000038	J1	1	
046710000	CBL, MOTHERBOARD TO XMITTER BD (MULTIDROP OPTION)								
GND	Motherboard	058021100	P12	2	Xmitter bd w/Multidrop	069500000	J4	2	
RX0	Motherboard	058021100	P12	14	Xmitter bd w/Multidrop	069500000	J4	14	
RTS0	Motherboard	058021100	P12	13	Xmitter bd w/Multidrop	069500000	J4	13	
TX0	Motherboard	058021100	P12	12	Xmitter bd w/Multidrop	069500000	J4	12	
CTS0	Motherboard	058021100	P12	11	Xmitter bd w/Multidrop	069500000	J4	11	
RS-GND0	Motherboard	058021100	P12	10	Xmitter bd w/Multidrop	069500000	J4	10	
RTS1	Motherboard	058021100	P12	8	Xmitter bd w/Multidrop	069500000	J4	8	
CTS1/485-	Motherboard	058021100	P12	6	Xmitter bd w/Multidrop	069500000	J4	6	
RX1	Motherboard	058021100	P12	9	Xmitter bd w/Multidrop	069500000	J4	9	
TX1/485+	Motherboard	058021100	P12	7	Xmitter bd w/Multidrop	069500000	J4	7	
RS-GND1	Motherboard	058021100	P12	5	Xmitter bd w/Multidrop	069500000	J4	5	
RX1	Motherboard	058021100	P12	9	Xmitter bd w/Multidrop	069500000	J4	9	
TX1/485+	Motherboard	058021100	P12	7	Xmitter bd w/Multidrop	069500000	J4	7	
RS-GND1	Motherboard	058021100	P12	5	Xmitter bd w/Multidrop	069500000	J4	5	
063750000	CBL, CO2, O2 SENSOR THERM/HTR								
O2-L	Relay Board	045230100	P18	9	O2 sensor therm./htr	043420000	P1	4	
O2-N	Relay Board	045230100	P18	10	O2 sensor therm./htr	043420000	P1	2	
Shield	Relay Board	045230100	P18	12	O2 sensor therm./htr	043420000	P1		
O2TA	O2 sensor therm./htr	043420000	P1	3	Motherboard	058021100	P27	4	
O2TB	O2 sensor therm./htr	043420000	P1	1	Motherboard	058021100	P27	11	
CO2THA	CO2 sensor therm./htr	041920000	P1	2	Motherboard	058021100	P27	6	
CO2THB	CO2 sensor therm./htr	041920000	P1	1	Motherboard	058021100	P27	13	
CO2-11B	Relay Board	045230100	P18	1	CO2 Cell Heater	040400000	P1	4	
CO2-12B	Relay Board	045230100	P18	1	CO2 Cell Heater	040400000	P2	6	
CO2-11A	Relay Board	045230100	P18	2	CO2 Cell Heater	040400000	P3	3	
CO2TS1	Relay Board	045230100	P18	3	CO2 Cell Heater	040400000	P4	1	
CO2TS2	Relay Board	045230100	P18	4	CO2 Cell Heater	040400000	P5	2	
CO2-12A	Relay Board	045230100	P18	5	CO2 Cell Heater	040400000	P6	5	

T80X Interconnect List

(Reference: 073800100A DCN6418)

Cable PN	Signal	Assembly	FROM			Assembly	TO		
			PN	J/P	Pin		PN	J/P	Pin
066470000 CBL, CO2 & O2 SENSORS DC PWR									
O2 SIGNAL -	Motherboard	058021100	P109	7	O2 Sensor	OP0000030	P1	9	
O2 SIGNAL +	Motherboard	058021100	P109	1	O2 Sensor	OP0000030	P1	10	
Shield	Motherboard	058021100	P109	9					
DGND	O2 Sensor	OP0000030	P1	5	Relay Board	045230100	P5	1	
+5V	O2 Sensor	OP0000030	P1	6	Relay Board	045230100	P5	2	
+12V RET	CO2 Sensor	OP0000033	P1	GND	Relay Board	045230100	P5	7	
+12V	CO2 Sensor	OP0000033	P1	L	Relay Board	045230100	P5	8	
066830000 CBL, FLOW MODULE									
DGND	LCD Interface PCA	066970000	P14	8	Relay Board	045230100	P10	1	
+5V	LCD Interface PCA	066970000	P14	1	Relay Board	045230100	P10	2	
DGND	LCD Interface PCA	066970000	P14	2	Relay Board	045230100	P11	1	
+5V	LCD Interface PCA	066970000	P14	3	Relay Board	045230100	P11	2	
+12V RET	Relay Board	045230100	P11	7	Chassis fan	040010000	P1	1	
+12V	Relay Board	045230100	P11	8	Chassis fan	040010000	P1	2	
P/Flow Sensor AGND	Relay Board	045230100	P11	3	P/Flow Sensor board	040030100	P1	3	
P/Flow Sensor +15V	Relay Board	045230100	P11	4	P/Flow Sensor board	040030100	P1	6	
Pressure signal 1	P/Flow Sensor board	040030100	P1	2	Motherboard	058021100	P110	6	
Pressure signal 2	P/Flow Sensor board	040030100	P1	4	Motherboard	058021100	P110	5	
Flow signal 1	P/Flow Sensor board	040030100	P1	5	Motherboard	058021100	P110	4	
Shield	P/Flow Sensor board	040030100	P1	S	Motherboard	058021100	P110	12	
CO2+	CO2 Sensor	OP0000033	P1	V	Motherboard	058021100	P110	3	
CO2-	CO2 Sensor	OP0000033	P1	O	Motherboard	058021100	P110	9	
06737 CBL, I2C to AUX I/O (ANALOG IN OPTION)									
ATX-	Motherboard	058021100	J106	1	Aux I/O PCA	067300000	J2	1	
ATX+	Motherboard	058021100	J106	2	Aux I/O PCA	067300000	J2	2	
LED0	Motherboard	058021100	J106	3	Aux I/O PCA	067300000	J2	3	
ARX+	Motherboard	058021100	J106	4	Aux I/O PCA	067300000	J2	4	
ARX-	Motherboard	058021100	J106	5	Aux I/O PCA	067300000	J2	5	
LED0+	Motherboard	058021100	J106	6	Aux I/O PCA	067300000	J2	6	
LED1+	Motherboard	058021100	J106	8	Aux I/O PCA	067300000	J2	8	
06738 CBL, CPU COM to AUX I/O (MULTIDROP OPTION)									
RXD	CPU PCA	067240000	COM1	1	Xmitter bd w/Multidrop	069500000	J3	1	
DDC	CPU PCA	067240000	COM1	2	Xmitter bd w/Multidrop	069500000	J3	2	
DTR	CPU PCA	067240000	COM1	3	Xmitter bd w/Multidrop	069500000	J3	3	
TXD	CPU PCA	067240000	COM1	4	Xmitter bd w/Multidrop	069500000	J3	4	
DSR	CPU PCA	067240000	COM1	5	Xmitter bd w/Multidrop	069500000	J3	5	
GND	CPU PCA	067240000	COM1	6	Xmitter bd w/Multidrop	069500000	J3	6	
CTS	CPU PCA	067240000	COM1	7	Xmitter bd w/Multidrop	069500000	J3	7	
RTS	CPU PCA	067240000	COM1	8	Xmitter bd w/Multidrop	069500000	J3	8	
RI	CPU PCA	067240000	COM1	10	Xmitter bd w/Multidrop	069500000	J3	10	
06738 CBL, CPU COM to AUX I/O (USB OPTION)									
RXD	CPU PCA	067240000	COM1	1	Aux I/O PCA	0673000 or -02	J3	1	
DDC	CPU PCA	067240000	COM1	2	Aux I/O PCA	0673000 or -02	J3	2	
DTR	CPU PCA	067240000	COM1	3	Aux I/O PCA	0673000 or -02	J3	3	
TXD	CPU PCA	067240000	COM1	4	Aux I/O PCA	0673000 or -02	J3	4	
DSR	CPU PCA	067240000	COM1	5	Aux I/O PCA	0673000 or -02	J3	5	
GND	CPU PCA	067240000	COM1	6	Aux I/O PCA	0673000 or -02	J3	6	
CTS	CPU PCA	067240000	COM1	7	Aux I/O PCA	0673000 or -02	J3	7	
RTS	CPU PCA	067240000	COM1	8	Aux I/O PCA	0673000 or -02	J3	8	
RI	CPU PCA	067240000	COM1	10	Aux I/O PCA	0673000 or -02	J3	10	
06739 CBL, CPU ETHERNET TO AUX I/O									
ATX-	CPU PCA	067240000	LAN	1	Aux I/O PCA	06730XXXX	J2	1	
ATX+	CPU PCA	067240000	LAN	2	Aux I/O PCA	06730XXXX	J2	2	
LED0	CPU PCA	067240000	LAN	3	Aux I/O PCA	06730XXXX	J2	3	
ARX+	CPU PCA	067240000	LAN	4	Aux I/O PCA	06730XXXX	J2	4	
ARX-	CPU PCA	067240000	LAN	5	Aux I/O PCA	06730XXXX	J2	5	
LED0+	CPU PCA	067240000	LAN	6	Aux I/O PCA	06730XXXX	J2	6	
LED1	CPU PCA	067240000	LAN	7	Aux I/O PCA	06730XXXX	J2	7	
LED1+	CPU PCA	067240000	LAN	8	Aux I/O PCA	06730XXXX	J2	8	
06741 CBL, CPU USB TO FRONT PANEL									
GND	CPU PCA	067240000	USB	8	LCD Interface PCA	066970000	J9		
LUSBD3+	CPU PCA	067240000	USB	6	LCD Interface PCA	066970000	J9		
LUSBD3-	CPU PCA	067240000	USB	4	LCD Interface PCA	066970000	J9		
VCC	CPU PCA	067240000	USB	2	LCD Interface PCA	066970000	J9		
07482 CBL, HDMI, T-SERIES									
	LCD Interface PCA	066970000	J15		Transmitter PCA	068810000	J1		

