



TELEDYNE
ADVANCED POLLUTION INSTRUMENTATION
Everywhereyoulook™

MODEL T500U
CAPS NO₂ ANALYZER
Operation Manual

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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)!

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

Telephone: 800-324-5190

Email: sda_techsupport@teledyne.com

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

CONSIGNES DE SÉCURITÉ

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



AVERTISSEMENT : Risque de choc électrique



DANGER : Oxydant puissant



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



MISE EN GARDE : Surface chaude



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



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



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

MISE EN GARDE



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

NE JAMAIS utiliser un analyseur de gaz pour échantillonner des gaz combustibles!

WARRANTY

Warranty Policy (02024 G)

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 Invalidation



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

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ABOUT THIS MANUAL

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

Part No.	Rev	Name/Description
078340000	B	T500U Operation Manual (this manual)
080610000	B	Software Menu Trees, Appendix A
080670000	A	T500U Spare Parts List, Appendix B
080620000	A	T500U Repair Questionnaire, Appendix C
078480000	A	T500U Interconnect Diagram, Appendix D

Support information such as electrostatic discharge (ESD) prevention and various communications is presented in our manuals, which are available on the TAPI website <http://www.teledyne-api.com> in Help Center>Product Manuals, under Special Manuals.

Note

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

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REVISION HISTORY

This section provides information regarding changes to this manual.

T500U CAPS NO₂ Analyzer Manual PN 07834

Date	Rev	DCN	Change Summary
2014 July 01	B	6927	Update AREF behavior description; adjust lower limit Temperature alarm.
2014 April 21	A	5543	Initial Release

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TABLE OF CONTENTS

Safety Messages.....	iii
WARRANTY.....	v
About This Manual	vii
Revision History	ix
Table of Contents	xi
1. INTRODUCTION.....	19
2. SPECIFICATIONS, APPROVALS & COMPLIANCE.....	21
2.1. Specifications	21
2.2. EPA Equivalency Designation	22
2.3. Approvals and Certifications	22
1.1.1 Safety.....	22
1.1.2 EMC.....	22
3. GETTING STARTED.....	23
3.1. Unpacking	23
3.1.1. Installation Requirements.....	24
3.2. Instrument Layout	24
3.2.1. Front Panel	24
3.2.2. Rear Panel.....	26
3.2.3. Internal Chassis Layout.....	28
3.3. Connections and Setup.....	29
3.3.1. Electrical Connections	29
3.3.1.1. Connecting Power	29
3.3.1.2. Connecting Analog Inputs (AIN) Option	30
3.3.1.3. Connecting Analog Outputs	30
3.3.1.4. Current Loop Analog Outputs (Option 41) Setup	31
3.3.1.5. Connecting the Status Outputs	33
3.3.1.6. Connecting the Control Inputs.....	34
3.3.1.7. Concentration Alarm Relay (Option 61)	35
3.3.1.8. Connecting the Communications Interfaces	36
3.3.2. Pneumatic Connections.....	42
3.3.2.1. About Zero Air and Calibration (Span) Gas	44
3.3.2.2. Basic Connections from Calibrator, with and Without Span Gas.....	45
4. OVERVIEW OF OPERATING MODES.....	49
4.1. Sample Mode	50
4.1.1. Test Functions	50
4.1.2. Warning Messages.....	51
4.2. Calibration Mode	51
4.3. Setup Mode.....	52
4.3.1. Primary Setup Menu.....	52
4.3.2. Secondary Setup Menu (SETUP →MORE).....	53
5. STARTUP, FUNCTIONAL CHECKS, AND INITIAL CALIBRATION.....	55
5.1. Startup.....	55
5.1.1. Warning Messages.....	55
5.2. Functional Checks.....	56
5.3. Initial Calibration.....	58
5.3.1. Initial Calibration Procedure for T500U Analyzers without VALVE Options.....	59
5.3.1.1. Verifying the Reporting Range Settings	59
5.3.1.2. Verifying the Expected NO ₂ Span Gas Concentration	61
5.3.1.3. Initial Zero/Span Calibration Procedure	62
6. SETUP.....	63
6.1. CFG: Configuration Information	63

6.2. DAS: Internal Data Acquisition System.....	63
6.3. RNGE: Analog Output Reporting Range	63
6.3.1. Analog Output Ranges for NO ₂ Concentration.....	64
6.3.2. Analog Output Reporting Range Default Settings.....	65
6.3.3. SETUP → RNGE → MODE	65
6.3.3.1. SETUP → RNGE → MODE → SNGL: Single Range Mode Configuration ..	65
6.3.3.2. SETUP → RNGE → MODE → DUAL: Dual Range Mode Configuration	66
6.3.3.3. SETUP → RNGE → MODE → AUTO: Auto Range Mode Configuration.....	68
6.3.3.4. SETUP → RNGE → UNIT: Setting the Reporting Range Units of Measure	69
6.3.3.5. SETUP → RNGE → DIL: Using the Optional Dilution Ratio Feature.....	69
6.4. PASS: Password Protection	71
6.5. CLK: Clock, Setting time and Date	74
6.5.1. Setting the Time of Day	74
6.5.2. Adjusting the Internal Clock's Speed.....	75
6.6. MORE>COMM: Communications Ports	76
6.6.1. ID (Machine Identification).....	76
6.6.2. INET (Ethernet)	77
6.6.3. COM1[COM2] (Mode, Baud Rate and Test Port)	77
6.7. MORE>VARS: Variables Setup and Definition.....	77
6.8. MORE>DIAG: Diagnostics Functions	80
6.8.1. Signal I/O	81
6.8.2. Analog Output (DIAG AOUT)	82
6.8.3. Analog I/O Configuration (DIAG AIO).....	82
6.8.3.1. Analog Output Voltage / Current Range Selection.....	85
6.8.3.2. Calibration of the Analog Outputs	86
6.8.3.3. Enabling or Disabling the AutoCal for an Individual Analog Output.....	86
6.8.3.4. Automatic Group Calibration of the Analog Outputs	87
6.8.3.5. Automatic Individual Calibration of the Analog Outputs.....	89
6.8.3.6. Manual Calibration of the Analog Outputs Configured for Voltage Ranges..	90
6.8.3.7. Manual Adjustment of Current Loop Output Span and Offset	92
6.8.3.8. Turning the Analog Output Over-Range Feature On/Off	95
6.8.3.9. Adding a Recorder Offset to an Analog Output.....	96
6.8.3.10. AIN (Analog Inputs) Calibration.....	97
6.8.3.11. External Analog Inputs (XIN1...XIN8) Option Configuration	98
6.8.4. Test Chan Output (Selecting a Test Channel Function for Output A4).....	99
6.8.5. NO ₂ LED DISABLE.....	101
6.8.6. PUMP DISABLE	101
6.9. SETUP>MORE>AREF:.....	101
7. COMMUNICATIONS SETUP AND OPERATION.....	103
7.1. Data Terminal/Communication Equipment (DTE DEC).....	103
7.2. Communication Modes, Baud Rate and Port Testing.....	103
7.2.1. Communication Modes.....	104
7.2.2. Com Port Baud Rate	106
7.2.3. Com Port Testing.....	107
7.3. RS-232	108
7.4. RS-485 (Option).....	108
7.5. Ethernet.....	109
7.5.1. Configuring Ethernet Communication Manually (Static IP Address).....	109
7.5.2. Configuring Ethernet Communication Using Dynamic Host Configuration Protocol	
(DHCP)	111
7.5.2.1. Changing the Analyzer's HOSTNAME	113
7.6. USB Port for Remote Access.....	114
7.7. Communications Protocols	116
7.7.1. Hessen.....	116
7.7.1.1. Hessen Com Port Configuration.....	116
7.7.1.2. Activating Hessen Protocol	117

7.7.1.3. Selecting a Hessen Protocol Type	118
7.7.1.4. Setting the Hession Protocol Response Mode.....	119
7.7.1.5. Hessen Protocol Gas List Entry Format and Definitions	120
7.7.1.6. Setting Hessen Protocol Status Flags.....	121
7.7.2. MODBUS.....	122
8. DATA ACQUISITION SYSTEM (DAS) AND APICOM.....	125
8.1. DAS Structure	126
8.1.1. DAS Channels	126
8.1.1.1. Default DAS Channels	127
8.1.1.2. DAS Configuration Limits	128
8.1.2. Viewing DAS Data and Settings	129
8.1.3. Editing DAS Data Channels	130
8.1.3.1. Editing DAS Data Channel Names.....	131
8.1.3.2. Editing DAS Triggering Events	132
8.1.3.3. Editing DAS Parameters	132
8.1.3.4. Editing Sample Period and Report Period	135
8.1.3.5. Report Periods in Progress when Instrument Is Powered Off	137
8.1.3.6. Editing the Number of Records	137
8.1.3.7. RS-232 Report Function.....	139
8.1.3.8. HOLDOFF Feature	140
8.1.3.9. The Compact Report Feature.....	141
8.1.3.10. The Starting Date Feature.....	141
8.1.3.11. Disabling/Enabling Data Channels.....	141
8.2. Remote DAS Configuration.....	142
8.2.1. DAS Configuration via APICOM.....	142
8.2.2. DAS Configuration via Terminal Emulation Programs	142
9. REMOTE OPERATION	145
9.1. Computer Mode	145
9.2. Interactive Mode.....	145
9.2.1. Remote Control via a Terminal Emulation Program.....	145
9.2.1.1. Help Commands in Interactive Mode	146
9.2.1.2. Command Syntax	146
9.2.1.3. Data Types	147
9.2.1.4. Status Reporting.....	147
9.2.1.5. General Message Format.....	148
9.3. Remote Access by Modem	148
9.4. Password Security for Serial Remote Communications	151
10. CALIBRATION	153
10.1. Calibration Gases.....	153
10.1.1. Span Gas for Multipoint Calibration.....	153
10.1.2. NO ₂ Permeation Tubes	153
10.2. Data Recording Devices	154
10.3. Manual Calibration Checks and Calibration of the T500U in its Base Configuration	154
10.3.1. Setup for Basic Calibration Checks and Calibration	155
10.3.2. Performing a Basic Manual Calibration Check.....	156
10.3.3. Performing a Basic Manual Calibration	157
10.3.3.1. Setting the Expected Span Gas Concentration.....	157
10.3.3.2. Zero/Span Point Calibration Procedure	158
10.4. Manual Calibration with the Internal Span Gas Generator	159
10.4.1. Performing “Precision” Manual Calibration for Internal Span Gas (IZS) Generator Option	159
10.4.2. Setup for Calibration with the Internal Span Gas Generator.....	160
10.4.3. Performing a Manual Calibration Check with the Internal Span Gas Generator	161
10.4.4. Performing a Manual Calibration with the Internal Span Gas Generator.....	162
10.4.4.1. Setting the Expected Span Gas Concentration.....	162

10.4.5. Manual Calibration Checks with Valve Options Installed	163
10.4.6. Manual Calibration Using Valve Options	164
10.4.6.1. Setting the Expected Span Gas Concentration	164
10.4.6.2. Zero/Span Point Calibration Procedure for Valve Options	165
10.4.6.3. Use of Zero/Span Valve with Remote Contact Closure	166
10.5. Automatic Zero/Span Cal/Check (AutoCal)	166
10.5.1. SETUP → ACAL: Programming and AUTO CAL Sequence	169
10.6. Calibration Quality Analysis	172
11. MAINTENANCE	173
11.1. Maintenance Schedule	173
11.2. Predictive Diagnostics	174
11.3. Maintenance Procedures	175
11.3.1. Replacing the Sample Particulate Filter	175
11.3.2. Changing the Internal Span Gas Generator Permeation Tube	176
11.3.3. Checking for Pneumatic Leaks	177
11.3.3.1. Detailed Pressure Leak Check	177
11.3.3.2. Performing a Sample Flow Check	178
12. EPA PROTOCOL CALIBRATION	179
12.1. References Relating to NO ₂ Monitoring	179
13. TROUBLESHOOTING AND SERVICE	181
13.1. General Troubleshooting	182
13.1.1. Fault Diagnosis with WARNING Messages	182
13.1.2. Fault Diagnosis With Test Functions	185
13.1.3. DIAG → SIGNAL I/O: Using the Diagnostic Signal I/O Function	186
13.2. Using the Analog Output Test Channel	188
13.3. Using the Internal Electronic Status LEDs	188
13.3.1. CPU Status Indicator	188
13.3.2. Relay PCA Status LEDs	189
13.3.2.1. I ² C Bus Watchdog Status LEDs	189
13.3.2.2. Relay PCA Status LEDs	190
13.4. Calibration Problems	191
13.4.1. Negative Concentrations	191
13.4.2. No Response	191
13.4.3. Unstable Zero and Span	191
13.4.4. Inability to Span - No SPAN Button (CALS)	192
13.4.5. Inability to Zero - No ZERO Button (CALZ)	192
13.4.6. Non-Linear Response	193
13.4.7. Discrepancy Between Analog Output and Display	193
13.5. Other Performance Problems	194
13.5.1. Excessive Noise	194
13.5.2. Slow Response	194
13.5.3. AREF Warnings	195
13.6. Subsystem Checkout	196
13.6.1. AC Main Power	196
13.6.2. DC Power Supply	197
13.6.3. I ² C Bus	198
13.6.4. LCD/Display Module	198
13.6.5. Relay PCA	198
13.6.6. Motherboard	199
13.6.6.1. Test Channel / Analog Outputs Voltage	199
13.6.6.2. A/D Functions	199
13.6.6.3. Status Outputs	200
13.6.6.4. Control Inputs	201
13.6.7. CPU	202
13.6.8. RS-232 Communications	202

13.6.8.1. General RS-232 Troubleshooting.....	202
13.6.8.2. Troubleshooting Analyzer/Modem or Terminal Operation	203
13.6.9. Internal Span Gas Generator and Valve Options.....	203
13.6.10. Temperature Sensor.....	204
13.6.10.1. Box Temperature Sensor	204
13.7. Service Procedures.....	205
13.7.1. Disk-On-Module Replacement Procedure.....	206
13.7.2. Removing / Replacing the Relay PCA	207
13.8. Frequently Asked Questions	208
13.9. Technical Assistance	210
14. PRINCIPLES OF OPERATION.....	211
Glossary	213

LIST OF FIGURES

Figure 3-1:	Front Panel Layout.....	25
Figure 3-2:	Display Screen and Touch Control	25
Figure 3-3:	T500U Rear Panel.....	26
Figure 3-4:	Internal Layout.....	28
Figure 3-5:	Analog In Connector	30
Figure 3-6:	Analog Output Connector.....	31
Figure 3-7:	Current Loop Option Installed on the Motherboard.....	32
Figure 3-8:	Status Output Connector.....	33
Figure 3-9:	Energizing the Control Inputs.....	34
Figure 3-10:	Concentration Alarm Relay	35
Figure 3-11:	Rear Panel Connector Pin-Outs for RS-232 Mode	37
Figure 3-12:	Pin Assignments for J11, J12 Connectors on CPU Board.....	38
Figure 3-13:	Jumper and Cables for Multidrop Mode.....	40
Figure 3-14:	RS-232-Multidrop PCA Host/Analyzer Interconnect Diagram	41
Figure 3-15:	Gas Line Connections from Calibrator – Basic T500U Configuration.....	45
Figure 3-16:	T500U Pneumatics with Zero Span Valves Option.....	47
Figure 3-17:	T500U Pneumatics with Internal Zero Span Valves Option.....	48
Figure 4-1:	Front Panel Display	49
Figure 6-1:	Analog Output Connector Pin Out.....	64
Figure 6-2:	SETUP – COMM Menu	76
Figure 6-3:	COMM– Machine ID.....	77
Figure 6-4:	Accessing the DIAG Submenus.....	81
Figure 6-5:	Accessing the Analog I/O Configuration Submenus	84
Figure 6-6:	Setup for Checking / Calibrating DCV Analog Output Signal Levels	90
Figure 6-7:	Setup for Checking / Calibration Current Output Signal Levels Using an Ammeter	92
Figure 6-8:	Alternative Setup Using 250Ω Resistor for Checking Current Output Signal Levels.....	94
Figure 7-1:	COMM - LAN /Internet Manual Configuration	110
Figure 7-2:	COMM – LAN / Internet Automatic Configuration (DHCP)	112
Figure 8-1:	Example Default DAS Configuration in APICOM (Section 8.2.1) Interface	128
Figure 8-2:	DAS Configuration through a Terminal Emulation Program	143
Figure 10-1:	Set up for Manual Calibrations/Checks in Base Configuration w/Gas Dilution Calibrator	155
Figure 10-2:	Pneumatic Connections for T500U Precision Calibration when IZS Generator Present..	159
Figure 10-3:	Pneumatic Connections for Manual Calibration/Checks with the Internal Span Gas Generator.....	160

Figure 11-1: Replacing the Sample Filter	176
Figure 13-1. CLR and MSG Menu Buttons	183
Figure 13-2: Example of Signal I/O Function.....	187
Figure 13-3: CPU Status Indicator	188
Figure 13-4: Relay PCA Status LEDS Used for Troubleshooting	190
Figure 13-5: Location of DC Power Test Points on Relay PCA	197
Figure 13-6: Typical Set Up of Status Output Test.....	200
Figure 13-7: Relay PCA with AC Relay Retainer In Place	207
Figure 13-8: Relay PCA Mounting Screw Locations	207
Figure 14-1: T500U Optical Absorption Cell.....	212
Figure 14-2: Phase Shift Representation of Increased Concentration of NO ₂	212

LIST OF TABLES

Table 2-1: Specifications	21
Table 3-1: Ventilation Clearance Requirements	24
Table 3-2: Display Screen and Touch Control Description	26
Table 3-3: Rear Panel Description	27
Table 3-4: Analog Input Pin Assignments	30
Table 3-5: Analog Output Pin Assignments	31
Table 3-6: Status Output Pin Assignments	34
Table 3-7: Control Input Pin Assignments.....	35
Table 4-1: Analyzer Operating Modes.....	50
Table 4-2: Primary Setup Mode Features and Functions	52
Table 4-3: Secondary Setup Mode Features and Functions.....	53
Table 5-1: Possible Warning Messages at Start-Up	56
Table 5-2: Test Functions Defined	57
Table 6-1: Password Levels	71
Table 6-2: Variables (VARS)	78
Table 6-3: Diagnostic Mode (DIAG) Functions.....	80
Table 6-4: DIAG - Analog I/O Functions.....	83
Table 6-5: Analog Output Voltage Range Min/Max.....	85
Table 6-6: Voltage Tolerances for the TEST CHANNEL Calibration	90
Table 6-7: Current Loop Output Check	94
Table 6-8: Test Channels Functions available on the T500U's Analog Output	99
Table 7-1: COM port Communication Modes	104

Table 7-2:	Ethernet Status Indicators	109
Table 7-3:	LAN/Ethernet Default Configuration Properties	111
Table 7-4:	RS-232 Communication Parameters for Hessen Protocol	116
Table 7-5:	Teledyne API's Hessen Protocol Response Modes	119
Table 7-6:	Default Hessen Status Flag Assignments.....	121
Table 7-7:	MODBUS Setup Instructions.....	122
Table 8-1:	DAS Data Channel Properties	126
Table 8-2:	T500U Default DAS Channels	127
Table 8-3:	DAS Data Parameter Functions.....	133
Table 9-1:	Terminal Mode Software Commands.....	146
Table 9-2:	Teledyne API's Serial I/O Command Types.....	146
Table 10-1:	AUTOCAL Modes.....	166
Table 10-2:	AutoCal Attribute Setup Parameters.....	167
Table 10-3:	Example AutoCal Sequence	168
Table 10-4:	Calibration Data Quality Evaluation	172
Table 11-1:	T500U Maintenance Schedule.....	174
Table 11-2:	Predictive Uses for Test Functions	175
Table 13-1:	Front Panel Warning Messages.....	184
Table 13-2:	Test Functions - Indicated Failures.....	185
Table 13-3:	Relay PCA Watchdog LED Failure Indications	189
Table 13-4:	Relay PCA Status LED Failure Indications	190
Table 13-5:	DC Power Test Point and Wiring Color Codes	197
Table 13-6:	DC Power Supply Acceptable Levels.....	198
Table 13-7:	Analog Output Test Function - Nominal Values Voltage Outputs.....	199
Table 13-8:	Status Outputs Check	201
Table 13-9:	T500U Control Input Pin Assignments and Corresponding Signal I/O Functions	201

1. INTRODUCTION

Teledyne API's Model T500U CAPS NO₂ Analyzer uses Cavity-Attenuated Phase-Shift (CAPS) spectroscopy to render true measurement of nitrogen dioxide (NO₂). The T500U operates as an optical absorption spectrometer, wherein the absorbance (lost light) is directly proportional to both the path-length and the concentration of the absorbing gas (Beer-Lambert law), providing direct measurement of NO₂.

The T500U uses few components: an optical cell, a pair of highly reflective spherical mirrors centered at 450nm (strong NO₂ absorbance band), a light emitting diode (LED), and a vacuum photodiode detector. The LED is located behind a mirror at one end of the cell, and the detector behind the other mirror at the opposite end of the cell. The LED emits ultraviolet light (UV) into the cell; the light reflects back and forth between the two mirrors, building intensity and running a very long path length. The long path length extends the "time" or "life" of the photon, thus providing ample time to measure absorbance when NO₂ is present. Through the use of precisely timed data acquisition coupled with a proprietary algorithm the measured absorption is translated into a phase shift, from which the NO₂ concentration is calculated. The phase shift decreases as the NO₂ signal increases.

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

Economically, the CAPS method is less costly to operate than traditional analyzers in that it uses less power (~70W) and fewer components.

The section on Principles of Operation provides more detail on the behavior and technique of the CAPS method for NO₂ measurement.

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2. SPECIFICATIONS, APPROVALS & COMPLIANCE

2.1. SPECIFICATIONS

Table 2-1 below presents the T500U specifications.

Table 2-1: Specifications

Parameter	Description						
Range	Min: 0-5 ppb Max: 0-1 ppm NO ₂ (User-selectable)						
Measurement Units	ppb, ppm, µg/m ³ , mg/m ³ (User-selectable)						
Zero Noise	<0.020 ppb						
Span Noise	<0.2% of reading + 0.020 ppb						
Zero Drift	<0.1 ppb / 24 hours						
Span Drift	<0.5% of reading / 24 hours						
Lower Detectable Limit	0.04 ppb						
Lag Time	~8 seconds (limited by volumetric flow rate)						
Rise/ Fall Time	<30 Seconds to 95%						
Linearity	< 1% Full Scale						
Precision	0.5% of reading above 5 ppb						
Sample Flow Rate	900 cm ³ /min ±10%						
AC Power	<table border="1"> <thead> <tr> <th>Rating</th> <th>Typical Power Consumption</th> </tr> </thead> <tbody> <tr> <td>110 - 120 V~ 60 Hz 3.0 A</td> <td>80 W</td> </tr> <tr> <td>220 - 240 V~ 50 Hz 3.0 A</td> <td>80 W</td> </tr> </tbody> </table>	Rating	Typical Power Consumption	110 - 120 V~ 60 Hz 3.0 A	80 W	220 - 240 V~ 50 Hz 3.0 A	80 W
Rating	Typical Power Consumption						
110 - 120 V~ 60 Hz 3.0 A	80 W						
220 - 240 V~ 50 Hz 3.0 A	80 W						
Analog Output Ranges	10V, 5V, 1V, 0.1V (selectable)						
Analog Output Resolution	1 part in 4096 of selected full-scale voltage						
Communications							
Standard I/O	1 Ethernet: 10/100Base-T 2 RS-232 (300 – 115,200 baud) 2 USB device ports 8 opto-isolated digital outputs 6 opto-isolated digital inputs (3 defined, 3 spare) 4 analog outputs						
Optional I/O	1 USB com port 1 RS485 8 analog inputs (0-10V, 12-bit) 4 digital alarm outputs Multidrop RS232 3 4-20mA current outputs						
Operating Temperature	5-40 °C						
Humidity Range	0-95% RH, Non-Condensing						
Dimensions HxWxD	7" x 17" x 23.5" (178 x 432 x 597 mm) (19" rack mount, 5U, 24" deep)						
Weight	33 lbs (15 kg)						
Environmental Conditions	<ul style="list-style-type: none"> Installation Category (Over Voltage Category) II Pollution Degree 2 Intended for Indoor Use Only at Altitudes ≤ 2000m 						

2.2. EPA EQUIVALENCY DESIGNATION

Teledyne Advanced Pollution Instrumentation's Model T500U cavity attenuated phase shift spectroscopy nitrogen dioxide analyzer is officially designated as an equivalent method, EQNA-0514-212, for NO₂ measurement as defined in 40 CFR Part 53, when the T500U is operated under the following conditions:

- on any full scale range between 0-50 ppb and 0-1000 ppb
- with any range mode (Single, Dual, or Auto Range)
- with a sample particulate filter
- at any operating temperature from 5°C to 40°C
- with the software setting: Temperature and Pressure compensation ON
- in accordance with this T500U manual
- with or without any of the following options:
 - Zero/Span (Z/S) valves
 - internal Zero/Span (IZS) permeation oven
 - external communication and data monitoring interfaces

This analyzer is approved for use, with proper factory configuration (if applicable), on either 50 or 60 Hertz line frequency and nominal power line voltages of 115 VAC and 230 VAC, or similar voltages as specified in this manual.

2.3. APPROVALS AND CERTIFICATIONS

The Teledyne API Model T500U was designed, tested and certified for Safety and Electromagnetic Compatibility (EMC). This section presents the compliance statements for those requirements and directives. For additional certifications, please contact Technical Support by telephone at 1-800-324-5190 or by email at sda_techsupport@teledyne.com.

1.1.1 SAFETY

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

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

1.1.2 EMC

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

EN55011 (CISPR 11), Group 1, Class A Emissions

FCC 47 CFR Part 15B, Class A Emissions

CE: 2004/108/EC, Electromagnetic Compatibility Directive

3. GETTING STARTED

This section discusses unpacking, connecting, and initializing the instrument.

3.1. UNPACKING

The shipping crate contains:

- instrument
- power cord
- CD-ROM of manuals (and/or paper manual if special-ordered)

Verify that there is no apparent external shipping damage to the unit. 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, titled *Final Test and Validation Data Sheet (P/N 07853)*. It is an important quality assurance and calibration record and should be placed in the quality records file for this instrument.

With no power to the unit, carefully open the analyzer and check for internal shipping damage:

1. Remove the two screws on either side of the chassis toward the back.
2. Slide the cover backward until it clears the analyzer's front bezel.
3. Lift the cover straight up.
4. Check that all circuit boards and other components are in good shape and properly seated.
5. Ensure that the connectors of the various internal wiring harnesses and pneumatic hoses are firmly and properly seated.
6. Verify that all optional hardware ordered with the unit has been installed (listed on the paperwork accompanying the analyzer).



WARNING
ELECTRICAL SHOCK HAZARD

Never disconnect any electronic assemblies or subassemblies while the instrument is under power.

3.1.1. INSTALLATION REQUIREMENTS

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 Requirements

AREA	MINIMUM CLEARANCE
Back of the instrument	4 in (10 cm)
Top, Bottom, Sides of the instrument	1 in (2.5 cm)

Note

Ensure accessibility to rear panel for disconnecting power.

3.2. INSTRUMENT LAYOUT

This section illustrates 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 3-2. 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 (or flash) drive (not included) to download updates to software (contact TAPI Technical Support for information).

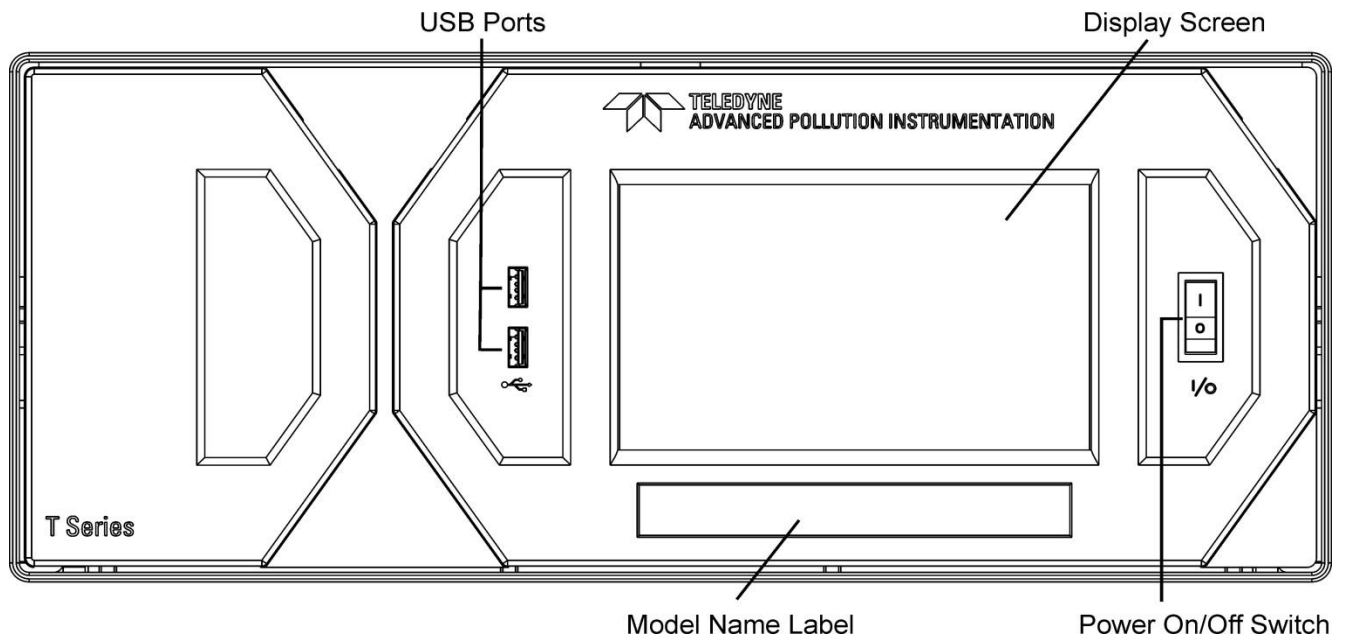


Figure 3-1: Front Panel Layout

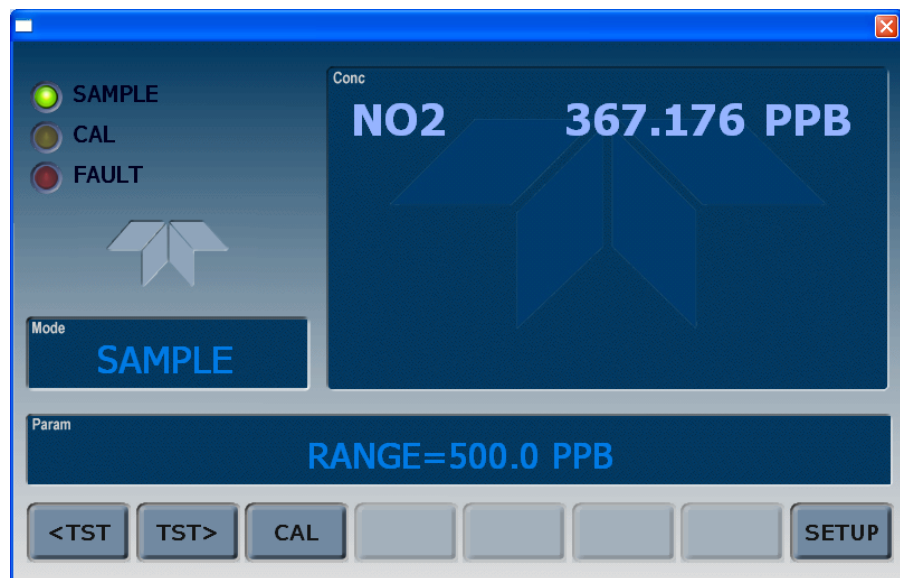


Figure 3-2: Display Screen and Touch Control

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	Unit is not operating in sample mode, DAS is disabled.
			On	Sample Mode active; Front Panel Display being updated; DAS data being stored.
			Blinking	Unit is operating in sample mode, front panel display being updated, DAS hold-off mode is ON, DAS disabled
CAL	Yellow	Off	Auto Cal disabled	
		On	Auto Cal enabled	
		Blinking	Unit is in calibration mode	
FAULT	Red	Off	No warnings exist	
		Blinking	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.			

3.2.2. REAR PANEL

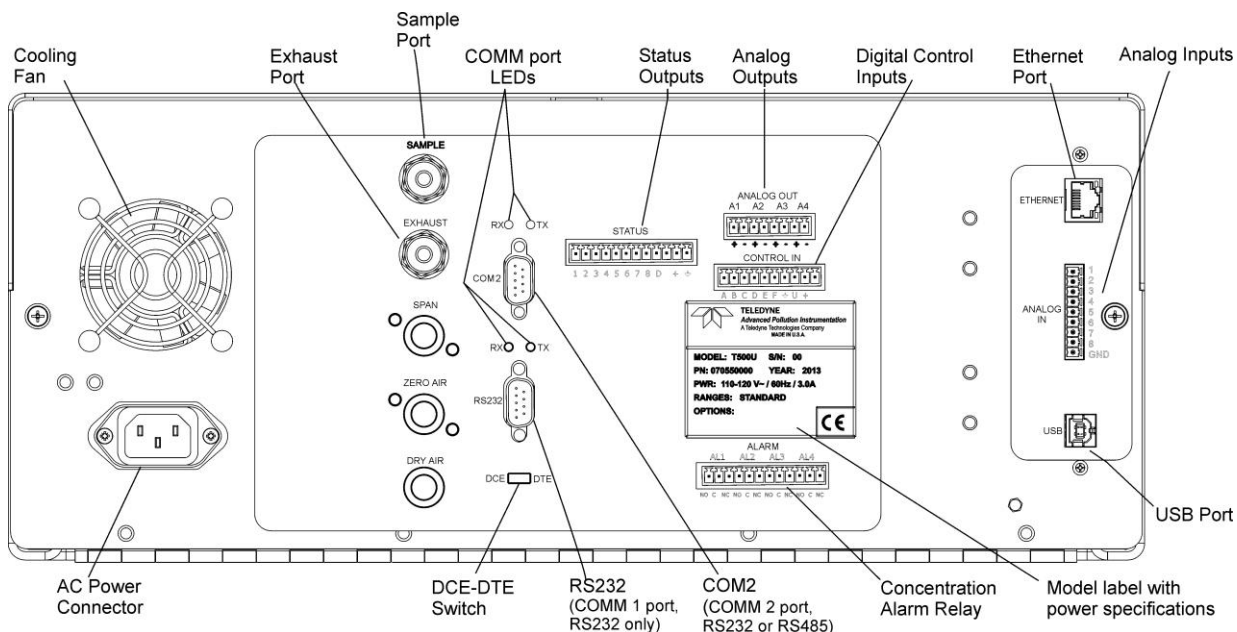



Figure 3-3: T500U Rear Panel

Table 3-3 provides a description of the rear panel components.

Table 3-3: Rear Panel Description

Component	Function
cooling fan	Pulls ambient air into chassis through side vents and exhausts through rear.
 AC power connector	Connector for three-prong cord to apply AC power to the analyzer. CAUTION! The cord's power specifications (specs) MUST comply with the power specs on the analyzer's rear panel Model label
Model/specs label	Identifies the analyzer model number and provides power specs
SAMPLE	Connect a gas line from the source of sample gas here. Calibration gases can also enter here on units without zero/span/shutoff valve options installed.
EXHAUST	Connect an exhaust gas line of not more than 10 meters long here that leads outside the shelter or immediate area surrounding the instrument. The line must be ¼" tubing or greater.
SPAN	On units with zero/span valve option installed, connect a gas line to the source of calibrated span gas here.
ZERO AIR	On units with zero/span valve option installed, but no zero air scrubber, attach a gas line to the source of zero air here. If a permeation oven, also known as internal zero/span valve (IZS), option is installed attach the zero air scrubber here.
DRY AIR	Not Used
RX TX	LEDs indicate receive (RX) and transmit (TX) activity when blinking.
COM 2	Serial communications port for RS-232 or RS-485 (RS-485).
RS-232	Serial communications port for RS-232 only.
DCE DTE	Switch to select either data terminal equipment or data communication equipment during RS-232 communication.
STATUS	For outputs to devices such as Programmable Logic Controllers (PLCs).
ANALOG OUT	(AOUT) 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	(AIN) Option for receiving and logging voltage signals from other instrumentation.
USB	Connector for direct connection to laptop computer, using USB cable.
Model Label	Includes voltage and frequency specifications

3.2.3. INTERNAL CHASSIS LAYOUT

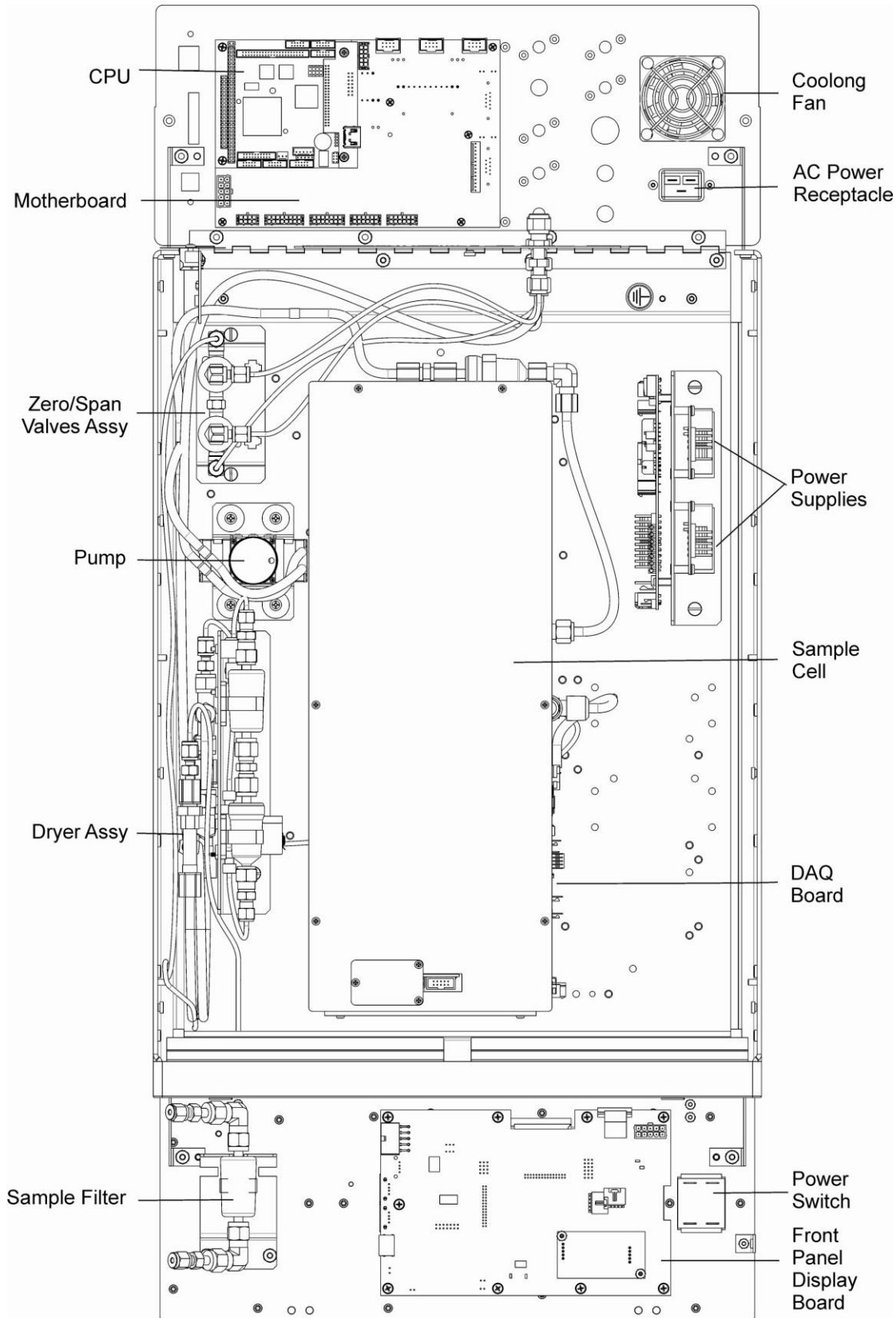


Figure 3-4: Internal Layout

3.3. CONNECTIONS AND SETUP

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



WARNING
ELECTRICAL SHOCK HAZARD

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



CAUTION
GENERAL SAFETY HAZARD

To avoid damage to your analyzer, ensure that the AC power voltage matches the voltage indicated on the analyzer's model/specs label located on the rear panel before plugging the T500U into line power.

3.3.1.1. CONNECTING POWER

Adhering to all safety and cautionary messages, attach the power cord between the analyzer's AC power connector and a power outlet capable of carrying at least the rated current at your AC voltage range; also ensure that it is equipped with a functioning earth ground.

3.3.1.2. CONNECTING ANALOG INPUTS (AIN) OPTION

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 data acquisition system (DAS). The input voltage range for each analog input is 0-10 VDC, and input impedance is nominally 20k Ω in parallel with 0.1 μ F.

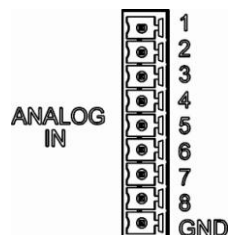


Figure 3-5: Analog In Connector

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 8 for details on setting up the DAS.

3.3.1.3. CONNECTING ANALOG OUTPUTS

The T500U is equipped with analog output channels (see rear panel ANALOG OUT connector, Figure 3-3).

Channels **A1** and **A2** output a signal proportional to the NO₂ concentration of the sample gas. Both the voltage and concentration range are configurable.

- The default analog output voltage setting of these channels is 0 to 5 VDC with a reporting range of 0 to 500 ppb.
- An optional Current Loop output is available (Section 3.3.1.4).

Channel **A3** is not used.

Channel **A4** can be set by the user to output any one of a variety of diagnostic test functions (see Section 6.8.4).

- The default analog output voltage setting of this channel is 0 to 5 VDC.
- See Section 6.8.4 for a list of available functions and their associated reporting range.
- There is no optional Current Loop output available for Channel A4.

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. Pin-outs for the analog output connector are:

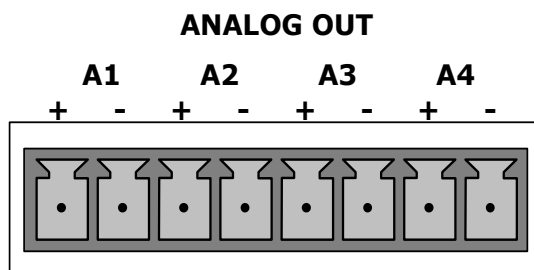


Figure 3-6: Analog Output Connector

Table 3-5: Analog Output Pin Assignments

PIN	ANALOG OUTPUT	SIGNAL	STANDARD VOLTAGE OUTPUT	CURRENT LOOP OPTION
1	A1	NO₂ Concentration*	V Out	I Out +
2			Ground	I Out -
3	A2	NO₂ Concentration*	V Out	I Out +
4			Ground	I Out -
3	A3	(Not Used)	V Out	I Out +
4			Ground	I Out -
7	A4	TEST CHANNEL	V Out	Not Available
8			Ground	Not Available

* See Section 6.8.3 for analog I/O functions and configuration.

To change the settings for the analog output channels, see Section 6.8.2.

3.3.1.4. CURRENT LOOP ANALOG OUTPUTS (OPTION 41) SETUP

This option converts the DC voltage analog output to a current signal with 0-20 mA output current. 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. 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.

Figure 3-7 provides installation instructions and illustrates a sample combination of one current output and two voltage outputs configuration.

To calibrate or adjust these outputs, see Section 6.8.3.7.

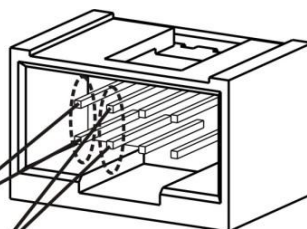


CAUTION – AVOID INVALIDATING WARRANTY

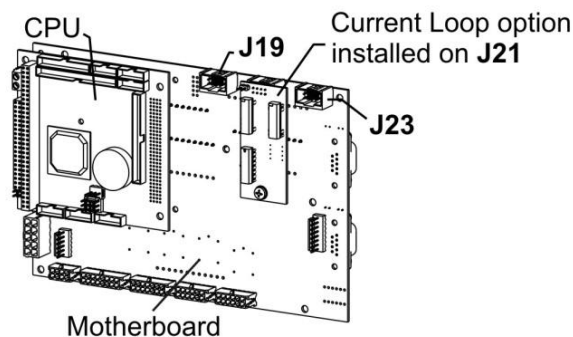
Servicing or handling of circuit components requires electrostatic discharge (ESD) protection, i.e. ESD grounding straps, mats and containers. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty. Please learn more about preventing ESD damage in our manual, *Fundamentals of ESD*, PN 04786, available on our website at <http://www.teledyne-api.com> in Help Center>Product Manuals, under Special Manuals.

J19, J21, J23 Analog Output Setup:

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



J19, J21, J23



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

Figure 3-7: Current Loop Option Installed on the Motherboard

Converting Current Loop Analog Outputs to Standard Voltage Outputs

This section provides instructions for converting current loop analog outputs to standard 0-to-5 VDC outputs. To convert an output configured for current loop operation to the standard 0 to 5 VDC output operation:

1. Turn off power to the analyzer.
2. If a recording device was connected to the output being modified, disconnect it.

3. Remove the top cover.
 - Remove the set screw located in the top, center of the rear panel.
 - Remove the screws fastening the top cover to the unit (one per side).
 - Slide the cover back and lift the cover straight up.
4. Remove the screw holding the current loop option to the motherboard.
5. Disconnect the current loop option PCA from the appropriate connector on the motherboard (see Figure 3-7).
6. Each connector, J19 and J23, requires two shunts. Place one shunt on the two leftmost pins and the second shunt on the two adjacent pins (see Figure 3-7).
7. Reattach the top cover to the analyzer.
8. Attach a voltage-sensing, recording device to that output.
9. Calibrate the analog output as described in Section 6.8.3.2.

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 available at pin D.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

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

The status outputs are accessed via a rear panel 12-pin connector labeled STATUS (Figure 3-8). Pin-outs for this connector are:

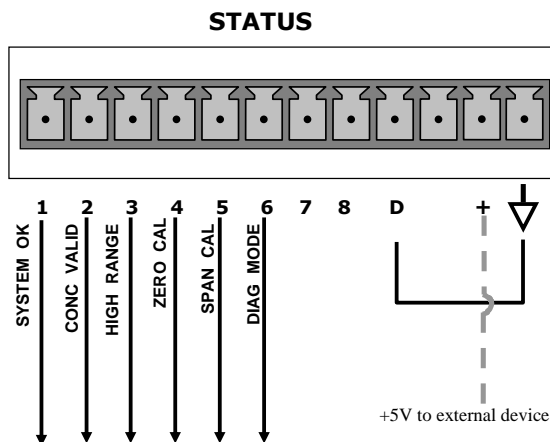


Figure 3-8: Status Output Connector

Table 3-6: Status Output Pin Assignments

OUTPUT #	STATUS DEFINITION	CONDITION
1	SYSTEM OK	On if no faults are present.
2	CONC VALID	On if NO ₂ concentration measurement is valid. If the NO ₂ concentration measurement is invalid, this bit is OFF.
3	HIGH RANGE	On if unit is in high range of DUAL or AUTO Range Modes.
4	ZERO CAL	On whenever the instrument is in CALZ mode.
5	SPAN CAL	On whenever the instrument is in CALS mode.
6	DIAG MODE	On whenever the instrument is in DIAGNOSTIC mode.
7-8	SPARE	
D	Emitter BUS	The emitters of the transistors on pins 1 to 8 are bussed together.
	SPARE	
+	DC Power	+ 5 VDC, 300 mA source maximum
↓	Digital Ground	The ground level from the analyzer's internal DC power supplies. This connection should be used as the ground return when +5VDC power is used.

3.3.1.6. CONNECTING THE CONTROL INPUTS

The 10-pin CONTROL IN connector provides three digital control inputs to remotely activate the zero and span calibration modes.

There are two methods for energizing the Control Inputs. The internal +5V available from the pin labeled “+” is the most convenient method however, to ensure that these inputs are truly isolated; a separate external 5 VDC power supply should be used.

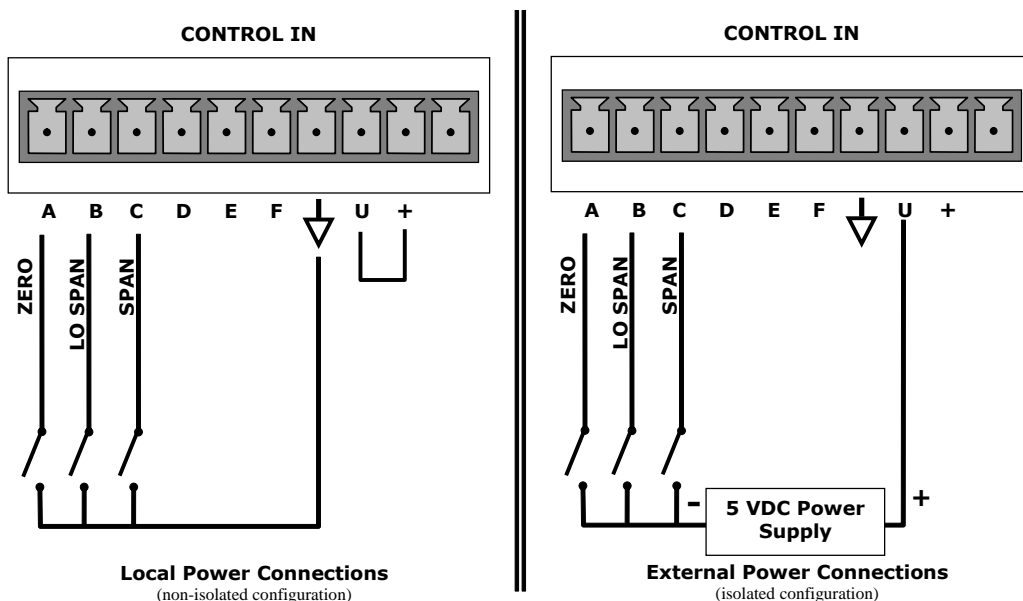



Figure 3-9: Energizing the Control Inputs

Table 3-7: Control Input Pin Assignments

Input #	Status Definition	ON Condition
A	REMOTE ZERO CAL	The Analyzer is placed in Zero Calibration mode. The mode field of the display will read ZERO CAL R.
B	REMOTE LOW SPAN CAL	The Analyzer is placed in Lo Span Calibration mode. The mode field of the display will read LO CAL R.
C	REMOTE SPAN CAL	The Analyzer is placed in Span Calibration mode. The mode field of the display will read SPAN CAL R.
D, E & F	Spare	
	Digital Ground	The ground level from the analyzer's internal DC Power Supplies (same as chassis ground).
U	External Power input	Input pin for +5 VDC required to activate pins A – F.
+	5 VDC output	Internally generated 5V DC power. To activate inputs A – F, place a jumper between this pin and the “U” pin. The maximum amperage through this port is 300 mA (combined with the analog output supply, if used).

3.3.1.7. CONCENTRATION ALARM RELAY (OPTION 61)

This option for four (4) “dry contact” relays is different from and in addition to the “Contact Closures” that come standard on all TAPI instruments. Each relay has 3 pins with connections on the rear panel (refer Figure 3-10): Common (C), Normally Open (NO), and Normally Closed (NC).

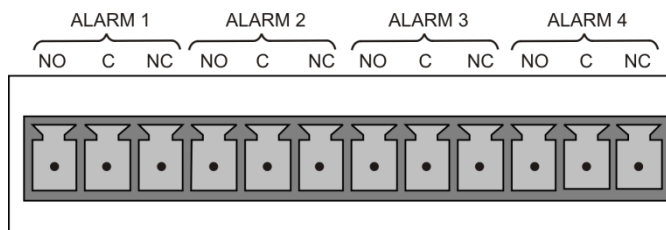


Figure 3-10: Concentration Alarm Relay

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” and 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 and you can record this with a data logger or other recording device.

“Alarm 2” Relay & “Alarm 3” Relay

The “Alarm 2 Relay” is associated with the “Concentration Alarm 1” set point in the software, and the “Alarm 3 Relay” is associated with the “Concentration Alarm 2” set point in the software.

Alarm 2 Relay NO₂ Alarm 1 = xxx PPM

Alarm 3 Relay NO₂ Alarm 2 = xxx PPM

The Alarm Relay activates any time the concentration set-point is exceeded, and will return to its normal state when the concentration value returns below the concentration set-point.

Even though the relay on the rear panel is a NON-Latching alarm & resets when the concentration falls below the alarm set point, the warning on the front panel display will remain latched until it is cleared: either push CLR on the front panel menu or clear the warning through the serial port.

“Alarm 4” Relay

This relay is connected to the “range bit”. If the instrument is configured for “Auto Range” and the instrument moves into the high range, it activates this relay.

3.3.1.8. CONNECTING THE COMMUNICATIONS INTERFACES

Connectors for remote communications interfaces are: **Ethernet, USB, RS-232, RS-232 Multidrop** and **RS-485** (each described here). In addition to using the appropriate cables, each type of communication method must be configured using the SETUP>COMM menu (see Section 6.6 for a brief description of the SETUP>COMM menu, and Section 7 for communications configuration).

Ethernet Connection

For network or Internet communication with the analyzer, connect an Ethernet cable from the analyzer’s rear panel ETHERNET interface connector to an Ethernet port. Although the analyzer is shipped with DHCP enabled by default (Section 7.5.2), it should be manually assigned a static IP address.

Configuration: (manual, i.e., static) Section 7.5.1.

USB Connection

The USB option can be used for direct communication between the analyzer and a PC; connect a USB cable between the analyzer and computer USB ports. This USB connection can only be used when the COM2 port is not in use except for RS-232 Multidrop communication.

Configuration: Section 7.6.

Note

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

RS-232 Connection

For **RS-232** communications with data terminal equipment (**DTE**) or with data communication equipment (**DCE**) connect either a DB9-female-to-DB9-female cable (Teledyne API part number WR000077) or a DB9-female-to-DB25-male cable (Option 60A), as applicable, from the analyzer's rear panel RS-232 port to the device. Adjust the rear panel DCE-DTE switch to select DTE or DCE as appropriate (Section 7.1).

Configuration: Section 7.3

IMPORTANT

IMPACT ON READINGS OR DATA

Cables that appear to be compatible because of matching connectors may incorporate internal wiring that makes the link inoperable. Check cables acquired from sources other than Teledyne API for pin assignments (Figure 3-11) before using.

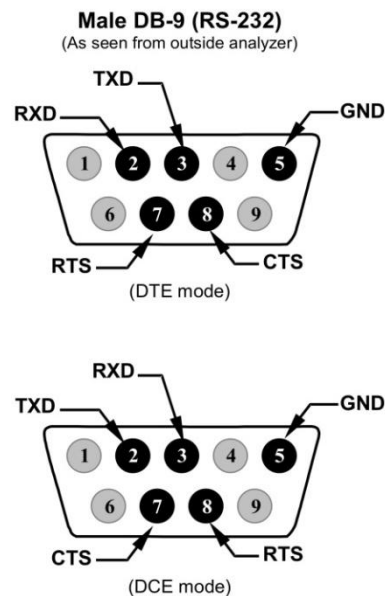


Figure 3-11: Rear Panel Connector Pin-Outs for RS-232 Mode

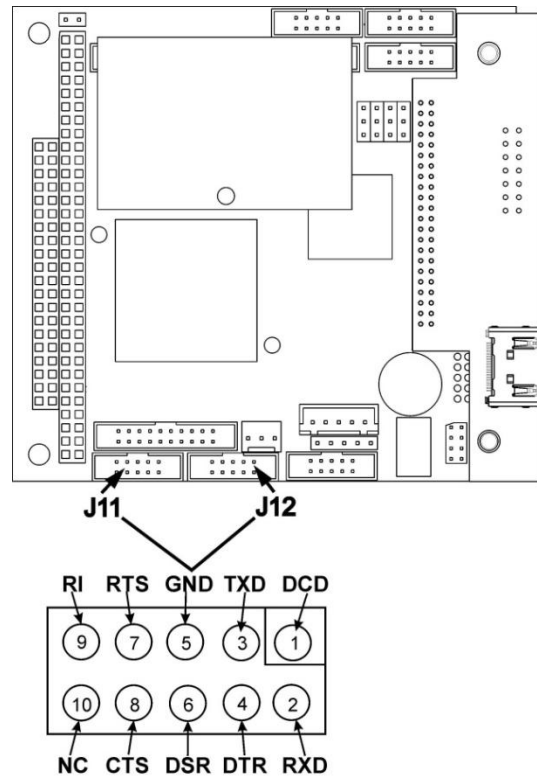


Figure 3-12: Pin Assignments for J11, J12 Connectors on CPU Board.

Teledyne API offers either of two mating cables, to select for your use:

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

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

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

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

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

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

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

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

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

RS-232 Multidrop (Option 62) Connection

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

Note

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

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Printed Circuit Assemblies (PCAs) are sensitive to electro-static discharges (ESD) 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. Please learn more about preventing ESD damage in our manual, *Fundamentals of ESD*, PN 04786, available on our website at <http://www.teledyne-api.com> in Help Center>Product Manuals, under Special Manuals.

In each instrument with the Multidrop option there is a shunt that jumpers two pins on the serial Multidrop and LVDS printed circuit assembly (PCA), as shown in Figure 3-13. This shunt must be removed from all instruments except that designated as last in the multidrop chain, which must remain terminated. This requires powering off and opening each instrument and making the following adjustments:

1. With **NO power** to the instrument, remove its top cover and lay the rear panel open for access to the Multidrop/LVDS PCA, which is seated on the CPU.
2. On the Multidrop/LVDS PCA's JP2 connector, remove the shunt that jumpers Pins 21 ↔ 22 as indicated in. (Do this for all but the last instrument in the chain where the shunt should remain at Pins 21 ↔ 22).
3. Check that the following cable connections are made in *all* instruments (again refer to Figure 3-13):
 - 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

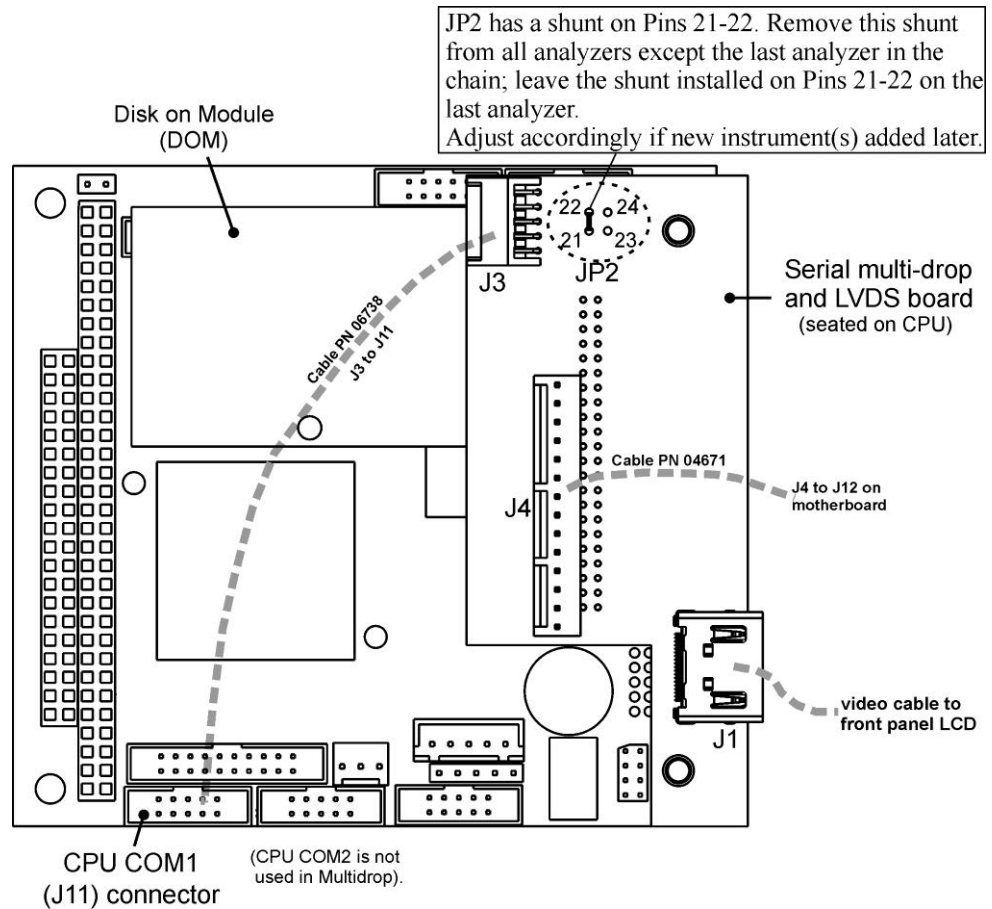


Figure 3-13: Jumper and Cables for Multidrop Mode

(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 3-14 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 Section 3.3.1.8: Connecting the Communications Interfaces, "RS-232 Connection").

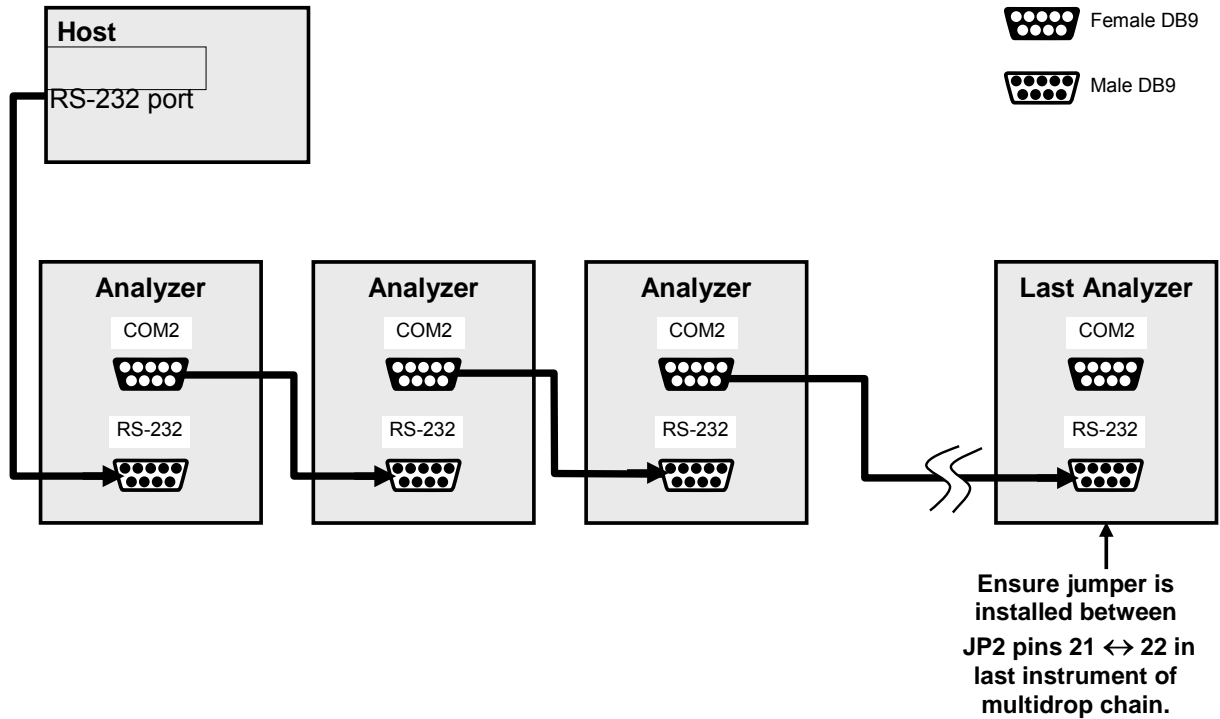


Figure 3-14: RS-232-Multidrop PCA Host/Analyzer Interconnect Diagram

7. BEFORE communicating from the host, power on the instruments and check that the Machine ID code is unique for each (Section 6.6.1).
 - 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

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

Note

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

RS-485 Connection (Option)

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 provides not only pneumatic connection information, but also important information about the gases required for accurate calibration (Section 3.3.2.1); it also illustrates the pneumatic layout for the analyzer, including valve option.

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

CAUTION – GENERAL SAFETY HAZARD



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

Remove the permeation tube when taking the analyzer out of operation (Section 11.3.2 provides removal instructions), and store in a sealed container (use original container that tube was shipped in).



CAUTION GENERAL SAFETY HAZARD

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

ATTENTION**-----
COULD DAMAGE INSTRUMENT AND VOID WARRANTY****Venting Pressurized Gas:**

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

- **at least 0.2m long**
- **no more than 2m long**
- **vented outside the shelter.**

Avoiding Introduction of Debris into Optical Cell:

Sudden, large changes in pressure can forcibly move debris past the filters (sample/exhaust) and into the optical cell. To avoid this, relieve pressure slowly when the system is under vacuum and/or pressure.

Dust Plugs:

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

IMPORTANT**-----
IMPACT ON READINGS OR DATA**

Sample and calibration gases should only come into contact with PTFE tubing.

IMPORTANT**-----
IMPACT ON READINGS OR DATA**

Run a leak check once the appropriate pneumatic connections have been made; check all pneumatic fittings for leaks using the procedures defined in Section 11.3.3.

3.3.2.1. ABOUT ZERO AIR AND CALIBRATION (SPAN) GAS

Zero air and span gas are required for accurate calibration.

Note

Zero air and span gases must be supplied at twice the instrument's specified gas flow rate. Therefore, the T500U zero and span gases should be supplied to their respective inlets in excess of 1800 cm³/min (~900 cm³/min x 2).

Zero Air

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

For the T500U this means zero air should be devoid of NO₂ and H₂O vapor.

- If your application is not a measurement in ambient air, the zero calibration gas should be matched to the composition of the gas being measured.
- Pure nitrogen (N₂) could be used as a zero gas for applications where NO₂ is measured in nitrogen.

Calibration (Span) Gas

Calibration gas is specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the desired reporting range. To measure NO₂ with the T500U analyzer, it is recommended that you use a span gas with a concentration equal to 80% of the measurement range for your application

EXAMPLE:

- If the application is to measure NO₂ in ambient air between 0 ppb and 500 ppb, an appropriate span gas would be 400 ppb.
- If the application is to measure NO₂ in ambient air between 0 ppb and 100 ppb, an appropriate span gas would be 80 ppb.

Cylinders of calibrated NO₂ gas traceable to NIST specifications (also referred to as EPA protocol calibration gases or Standard Reference Materials) are commercially available.

Note

TAPI recommends the use of NO₂ permeation tubes for performing routine calibration checks.

Span Gas for Multipoint Calibration

Some applications, such as EPA monitoring, require a multipoint calibration where span gases of different concentrations are needed. We recommend using an NO₂ gas of higher concentration combined with a gas dilution calibrator such as a Teledyne API Model T700. This type of calibrator mixes a high concentration gas with zero air to accurately produce span gas of the desired concentration. Linearity profiles can be automated with this model and run unattended overnight.

If a dynamic dilution system such as the Teledyne API Model T700 is used to dilute high concentration gas standards to low, ambient concentrations, ensure that the NO₂ concentration of the reference gas matches the dilution range of the calibrator.

Choose the NO₂ gas concentration so that the dynamic dilution system operates in its mid-range and not at the extremes of its dilution capabilities.

EXAMPLE:

- A dilution calibrator with 10-1000 dilution ratio will not be able to accurately dilute a 5000 ppm NO₂ gas to a final concentration of 500 ppb, as this would operate at the very extreme dilution setting.
- A 50 ppm NO₂ gas in nitrogen is much more suitable to calibrate the T500U analyzer (dilution ratio of 200, in the mid-range of the system's capabilities).

3.3.2.2. BASIC CONNECTIONS FROM CALIBRATOR, WITH AND WITHOUT SPAN GAS

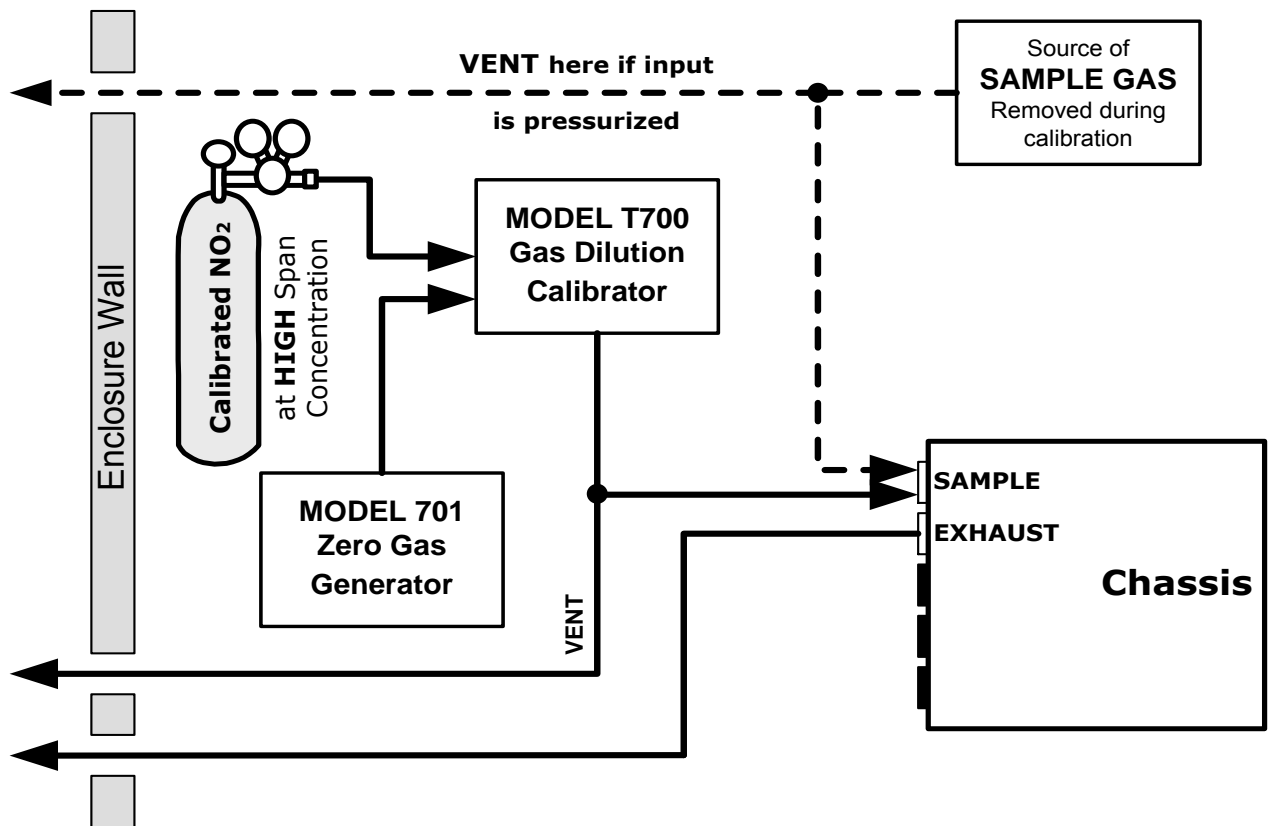


Figure 3-15: Gas Line Connections from Calibrator – Basic T500U Configuration

For the T500U analyzer in its basic configuration, attach the following pneumatic lines:

Sample Gas Source

Connect a sample gas line to the SAMPLE inlet

- Use PTFE tubing; minimum OD ¼”.
- Sample Gas pressure must not exceed ambient atmospheric pressure by more than 1.0 psig.
- Follow cautionary guidelines for pressurized manifold.

Calibration Gas Sources

- **CAL GAS & ZERO AIR SOURCES:** The source of calibration gas is also attached to the **SAMPLE** inlet, but only when a calibration operation is actually being performed.
 - Use PTFE tubing; minimum OD ¼”.

Venting

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

- Vented outside the shelter.
- Minimum OD ¼”.
- No less than 2 meters in length.
- No greater than 10 meters in length.

Exhaust Outlet

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

- Use PTFE tubing; minimum OD ¼”.
- No greater than 10 meters in length.
- Vented outside the shelter.

Note

Once the appropriate pneumatic connections have been made, check all pneumatic fittings for leaks using the procedures defined in Sections 11.3.3 (or 11.3.3.1 for detailed check if leak suspected).

Pneumatic Layouts

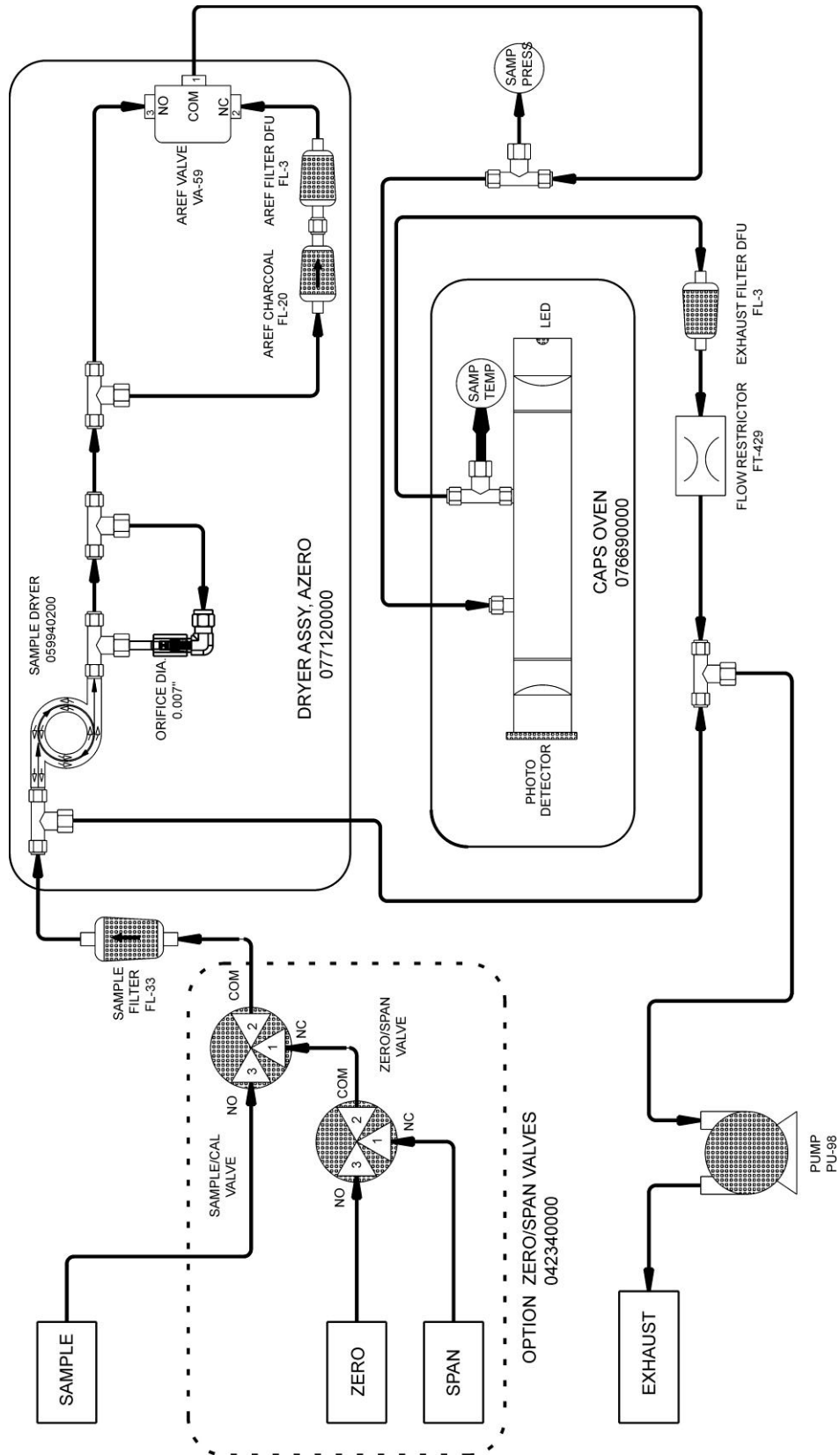


Figure 3-16: T500U Pneumatics with Zero Span Valves Option

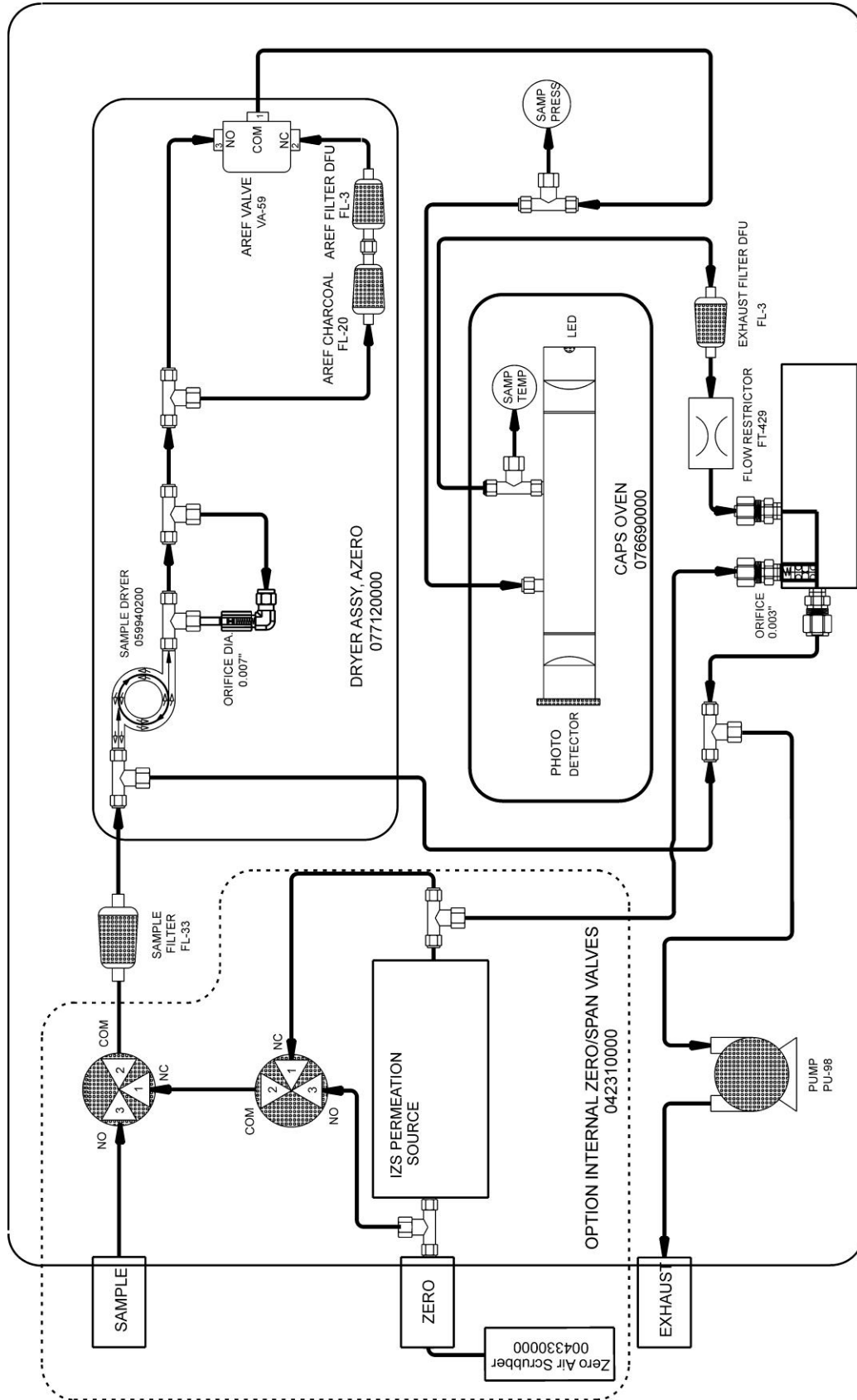


Figure 3-17: T500U Pneumatics with Internal Zero Span Valves Option

4. OVERVIEW OF OPERATING MODES

To assist in navigating the analyzer's software, a series of menu trees is available for reference in Appendix A of this manual.

Note

Some control buttons on the touch screen do not appear if they are not applicable to the operation at hand or if an invalid setting was input.

The T500U analyzer software has several operating modes, the most commonly used of which is the **SAMPLE** mode. In this mode, a continuous read-out of the NO₂ concentration can be viewed on the front panel and output as an analog voltage from rear panel terminals.

The second most commonly used operating mode is **SETUP**, which is used to configure the various subsystems, such as the Data Acquisition System (DAS), the reporting ranges, or the communication channels. **SETUP** mode is also used for performing various diagnostic tests during troubleshooting.

Figure 4-1 shows in the Mode field that the unit is operating in SAMPLE Mode.



Figure 4-1: Front Panel Display

Table 4-1 describes other operating modes

Table 4-1: Analyzer Operating Modes

MODE	EXPLANATION
DIAG	One of the analyzer's diagnostic modes is active.
AREF²	Periodically an internal valve activates diverting the sample gas through a charcoal scrubber. The auto reference value is measured during this period.
LO CAL A	Unit is performing LOW SPAN calibration initiated automatically by the analyzer's AUTOCAL feature
LO CAL R	Unit is performing LOW SPAN calibration initiated remotely through the COM ports or digital control inputs.
M-P CAL	This is the basic calibration mode of the instrument and is activated by pressing the CAL button.
SAMPLE	Sampling normally, flashing text indicates the adaptive filter has tripped due to a change in concentration.
SETUP	SETUP mode is being used to configure the analyzer. The gas measurement will continue during setup.
SAMPLE A¹	Indicates that unit is in SAMPLE mode and AUTOCAL feature is activated.
SPAN CAL A¹	Unit is performing SPAN calibration initiated automatically by the analyzer's AUTOCAL feature
SPAN CAL M¹	Unit is performing SPAN calibration initiated manually by the user.
SPAN CAL R¹	Unit is performing SPAN calibration initiated remotely through the COM ports or digital control inputs.
ZERO CAL A¹	Unit is performing ZERO calibration procedure initiated automatically by the AUTOCAL feature
ZERO CAL M¹	Unit is performing ZERO calibration procedure initiated manually by the user.
ZERO CAL R¹	Unit is performing ZERO calibration procedure initiated remotely through the COM ports or digital control inputs.
¹ Only appears on units with the Z/S or IZS valve option. ² Initial AREF (automatically runs 20 minutes after power up) and any manual AREF sets the AREF filter output value to the current reading.	

4.1. SAMPLE MODE

SAMPLE is the standard operating mode. In this mode, the instrument is continually calculating the NO₂ concentration. These values are displayed in the **CONC** field of the analyzer's front panel display during **SAMPLE** mode.

Also in this mode the **PARAM** field will display any warning messages (Section 4.1.2) as well as the test functions (Section 4.1.1), which provide information about the operational status of the analyzer.

4.1.1. TEST FUNCTIONS

TEST functions provide information about the various parameters related to the analyzer's operation and its measurement of gas concentration. Section 5.2 provides information about these functions.

4.1.2. WARNING MESSAGES

The most common and serious instrument failures will activate Warning Messages, which are displayed on the analyzer's Front Panel. A table of Warning Messages and their descriptions is presented in Table 5-1, Section 5.1.1.

4.2. CALIBRATION MODE

Note

Always perform Zero calibration *before* Span calibration.

Pressing the CAL button, switches the analyzer into calibration mode. 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.

Note

This mode is also used to check the current calibration status of the instrument.

If the instrument includes one of the available zero/span valve options, the SAMPLE mode display will also include CALZ and CALS buttons. Pressing either of these buttons also puts the instrument into calibration mode.

- The CALZ button is used to initiate a calibration of the analyzer's zero point using zero air.
- The CALS button is used to calibrate the span point of the analyzer's current reporting range using span gas.

Note

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

EXAMPLE:

If the reporting range is set for 0 to 500 ppb, an appropriate span point would be 400 ppb.

Due to their critical importance and complexity, calibration operations are described in in Section 10, which details setting up and performing standard calibration operations or checks.

For information on using the automatic calibrations feature (ACAL) in conjunction with the calibration valve options, see Sections 10.4.6 and 10.5.

IMPORTANT

IMPACT ON READINGS OR DATA

To avoid inadvertent adjustments to critical settings, activate calibration security by enabling password protection in the SETUP – PASS menu.

4.3. 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 instruments performance and configure or access data from the internal data acquisition system (DAS). For a visual representation of the software menu trees, refer to Appendix A.

SETUP Mode is divided between Primary and Secondary Setup menus and can be protected through password security through the SETUP>PASS menu (Section 6.4) to prevent unauthorized or inadvertent configuration adjustments.

4.3.1. PRIMARY SETUP MENU

The areas accessed and configured under the primary SETUP Mode menu are shown in Table 4-2.

Table 4-2: Primary Setup Mode Features and Functions

MODE OR FEATURE	CONTROL BUTTON LABEL	DESCRIPTION
Analyzer Configuration	CFG	Lists button hardware and software configuration information.
<i>Auto Cal Feature</i>	ACAL	<i>Used to set up and operate the AutoCal feature. (Only appears if the Zero/Span valve option is installed).</i>
Internal Data Acquisition (DAS)	DAS	Used to set up the DAS system and view recorded data.
Analog Output Reporting Range Configuration	RNGE	Used to configure the output signals generated by the instrument's analog outputs.
Calibration Password Security	PASS	Turns the calibration password feature ON/OFF.
Internal Clock Configuration	CLK	Used to set or adjust the instrument's internal clock.
(Advanced SETUP features)	MORE	Jumps to the secondary setup menu.

4.3.2. SECONDARY SETUP MENU (SETUP →MORE)

Table 4-3 presents advanced feature under the secondary SETUP Mode menu.

Table 4-3: Secondary Setup Mode Features and Functions

MODE OR FEATURE	CONTROL BUTTON LABEL	DESCRIPTION
External Communication Channel Configuration	COMM	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.
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 are not acknowledged and recorded in the instrument's memory until the ENTR button is pressed. • Pressing the EXIT button ignores the new setting. • If the EXIT button is pressed before the ENTR button, the analyzer will beep alerting the user that the newly entered value has been lost.
System Diagnostic Features and Analog Output Configuration	DIAG	Used to access a variety of functions that are used to configure, test or diagnose problems with a variety of the analyzer's basic systems. Most notably, the menus used to configure the output signals generated by the instruments' analog outputs are located here.
Auto Reference	AREF	Can be used to expedite the AREF loss measurement prior to conducting a Zero/Span calibration. Note that AREF is disabled during calibrations until the unit is placed back in SAMPLE mode. Also see Table 4-1.
Alarm option (if installed)	ALRM	Used to provide notice when concentration values are out of range. (Only appears if the Alarm option is installed).

IMPORTANT

IMPACT ON READINGS OR DATA

Any changes made to a variable during 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 make an audible signal before exiting the menu, alerting the user that the newly entered value had not been accepted.

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5. STARTUP, FUNCTIONAL CHECKS, AND INITIAL CALIBRATION

5.1. STARTUP

For accurate results, allow the monitor to run for at least 60 minutes to reach a stable operating temperature.

5.1.1. 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 45 minutes after power up. If warning messages persist after the 45 minutes warm up period is over, investigate their cause using the troubleshooting guidelines in Section 13.1.

To view and clear warning messages, press:

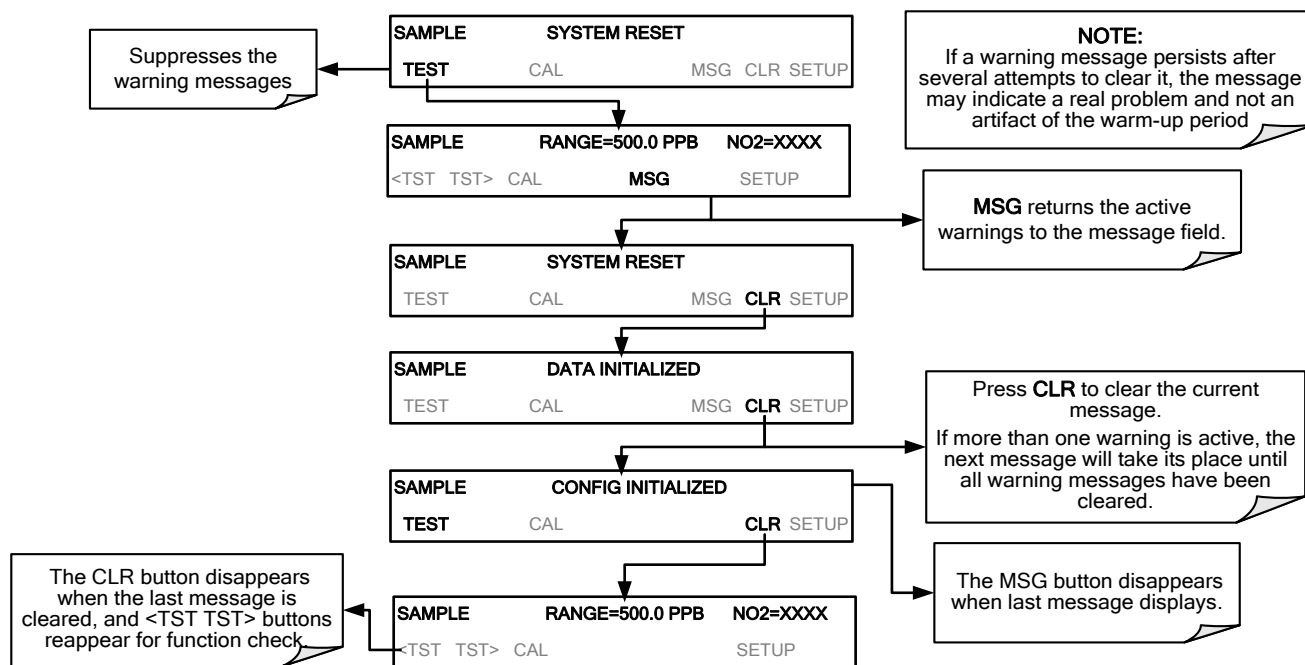


Table 5-1: Possible Warning Messages at Start-Up

Message Text	Description
SYSTEM SERVICE	System service interval has elapsed, per hours specified by <i>SVC_INTERVAL</i> variable.
SYSTEM RESET¹	Instrument was power-cycled or the CPU was reset.
CONFIG INITIALIZED	Configuration storage was reset to factory configuration or erased.
DATA INITIALIZED	Data storage was erased.
CANNOT DYN ZERO²	Contact closure zero calibration failed while <i>DYN_ZERO</i> was set to <i>ON</i> .
CANNOT DYN SPAN³	Contact closure span calibration failed while <i>DYN_SPAN</i> was set to <i>ON</i> .
NO₂ ALARM1 WARN⁴	NO ₂ concentration alarm limit #1 exceeded
NO₂ ALARM2 WARN⁴	NO ₂ concentration alarm limit #2 exceeded
MANIFOLD TEMP WARN⁴	Manifold temperature outside of warning limits.
IZS TEMP WARNING⁴	IZS Oven temperature outside of warning limits.
OVEN TEMP WARNING	Oven temperature outside of warning limits.
SAMPLE PRESS WARN⁶	Sample pressure outside of warning limits.
SAMPLE TEMP WARN	Sample temperature outside of warning limits.
BOX TEMP WARNING	Chassis temperature outside of warning limits.
AUTO REF WARNING⁵	AREF value outside of allowable limit.
REAR BOARD NOT DET	Rear board was not detected during power up.
RELAY BOARD WARN	Firmware is unable to communicate with the relay board.
FRONT PANEL WARN	Firmware is unable to communicate with the front panel.
INTERNAL PUMP OFF⁶	Internal pump is not running.
ANALOG CAL WARNING	The A/D or at least one D/A channel has not been calibrated.
¹ Cleared 45 minutes after power up. ² Cleared the next time successful zero calibration is performed. ³ Cleared the next time successful span calibration is performed. ⁴ Options Installed: Concentration alarm, Manifold, and Permeation Oven. ⁵ Applies when AREF is enabled (also see Table 4-1). ⁶ Pump stops running if sample pressure reaches 15 InHg; if that's not the case, see Troubleshooting Section 13.1.	

5.2. FUNCTIONAL CHECKS

After warm-up, verify that the software properly supports any hardware options that are installed and that the analyzer is functioning within allowable operating parameters (Appendix C shows the list of test functions and their expected values; the enclosed *Final Test and Validation Data sheet* lists these values as they appeared before the instrument left the factory).

These functions can also be used as diagnostic tools for troubleshooting a performance problem (see Section 13). To view the current values of these parameters on the analyzer's front panel press the button sequence illustrated as follows.

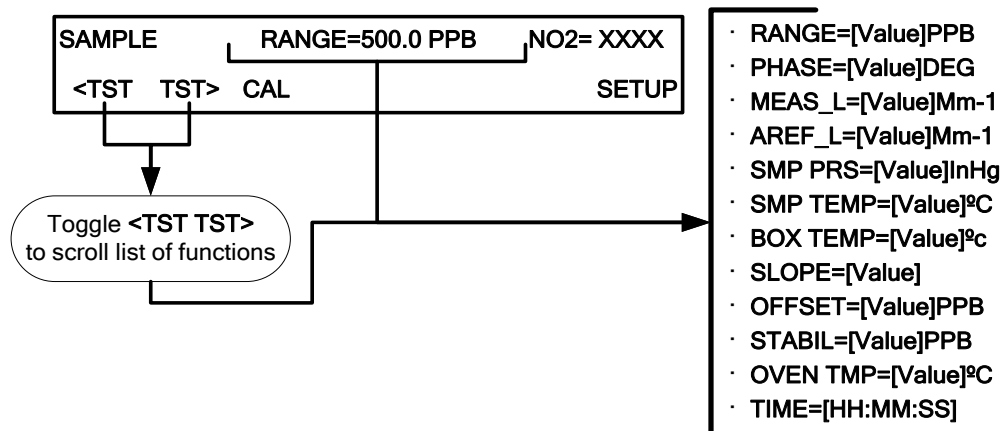


Table 5-2: Test Functions Defined

DISPLAY	PARAMETER	UNITS	DESCRIPTION
RANGE	RANGE	PPB PPM UGM MGM	The Full Scale limit at which the reporting range of the analyzer's ANALOG OUTPUTS is currently set. THIS IS NOT the Physical Range of the instrument. See Section 6.3 for more information.
PHASE	PHASE	DEG	Measurement phase value.
MEAS_L	MEASURE LOSS	Mm ⁻¹	Measurement loss value. (Mega (10 ⁶) per meter)
AREF_L	AUTOREF LOSS	Mm ⁻¹	Auto reference value (to null any baseline drift from the measurement). See Table 4-1.
SMP PRS	SAMPRESS	InHg	Sample pressure.
SMP TEMP	SAMPTEMP	°C	Sample temperature.
BOX TEMP	BOXTEMP	°C	Temperature inside the analyzer chassis.
SLOPE	SLOPE	n/a	The slope for current range, computed during span calibration.
OFFSET	OFFSET	PPB	The offset for current range, computed during zero calibration.
STABIL	STABILITY	PPB	The standard deviation of concentration STABILITY <ul style="list-style-type: none"> • Data points are recorded every ten seconds (default; this frequency can be changed in the STABIL_FREQ variable). • The calculation uses the last 25 data points (default; this number of samples can be changed in the STABIL_SAMPLES variable).
OVEN TMP	OVEN TEMP	°C	Oven temperature
TEST*	TESTCHAN	MV	*(When DIAG>TEST CHAN OUTPUT is configured for a test function). Displays the signal level of the Test Function that is currently being produced by the Analog Output Channel A4.
TIME	CLOCKTIME	HH:MM:SS	The current time. This is used to create a time stamp on DAS readings, and by the AutoCal feature to trigger calibration events.

IMPORTANT

IMPACT ON READINGS OR DATA

A value of “XXXX” displayed for any of the TEST functions indicates an out-of-range reading or the analyzer’s inability to calculate it. 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.

5.3. INITIAL CALIBRATION

This section provides the initial calibration procedures. To perform the following calibration, sources for zero air and calibration (span) gas are required for input into the inlet/outlet fittings on the back of the analyzer (see Section 3.3.2.1).

Note

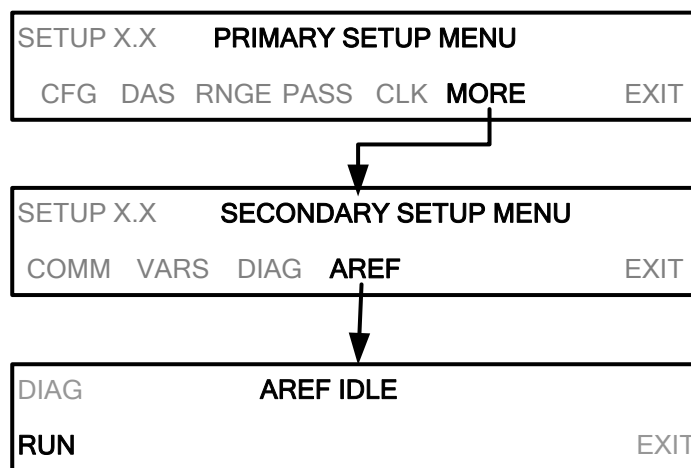
A start-up period of 4-5 hours is recommended prior to performing a calibration on the analyzer.

The method for performing an initial calibration for the T500U nitrogen dioxide analyzer differs slightly depending on whether valve options are installed.

- See Section 5.3.1 for instructions for initial calibration of the T500U analyzers in their base configuration.
- See Sections 10.4 and 10.4.6 for information regarding setup and calibration of T500U analyzers with Z/S Valve options.

In either case, any time an initial calibration is in order, e.g., starting the analyzer for the first time or after maintenance on the mirrors, conducting a manual AREF may be required (Auto Reference: reference loss measurement) However, note that the instrument is programmed to automatically run an AREF 20 minutes after power up. This expedites the AREF_L value to match current measurements. The AREF_L value is based on the average of the last four readings taken one hour apart. Repeat the process if large changes in the AREF_L value occur. Both the AREF_L and MEAS_L readings should be similar while sampling zero air.

To run a manual AREF, press SETUP>MORE>AREF>RUN:



Press RUN to run the AREF feature; message reads, AREF RUNNING, and the RUN button becomes the STOP button. Press EXIT to return to the Secondary Setup menu and allow the auto reference feature to complete its course.

5.3.1. INITIAL CALIBRATION PROCEDURE FOR T500U ANALYZERS WITHOUT VALVE OPTIONS

The following procedure assumes that:

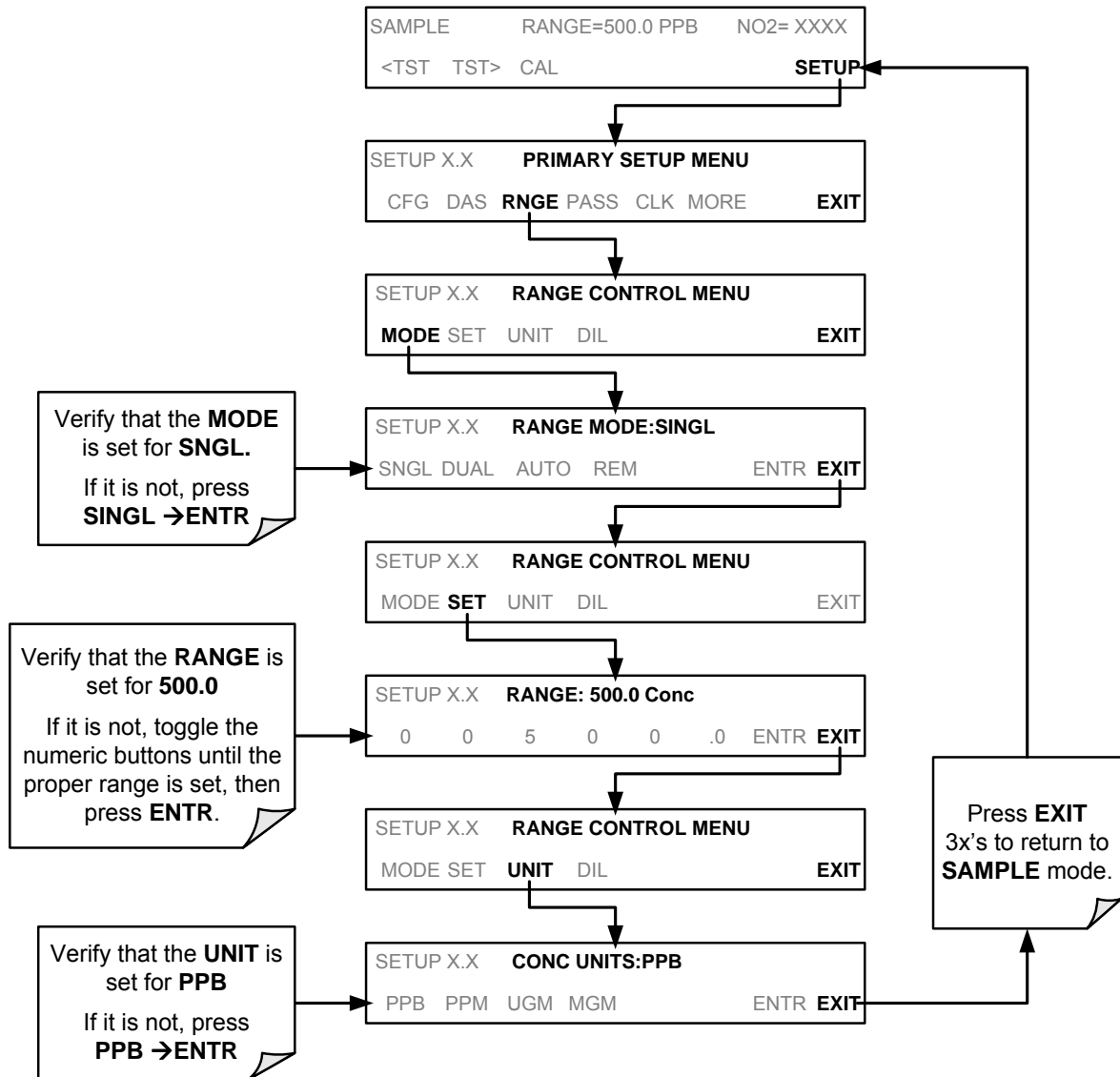
- The instrument DOES NOT have any of the available calibration valve or gas inlet options installed.
- Cal gas will be supplied through the SAMPLE gas inlet on the back of the analyzer, and
- The pneumatic setup matches that described in Section 3.3.2.2.

5.3.1.1. VERIFYING THE REPORTING RANGE SETTINGS

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:

- Unit of Measure: PPB
- Reporting Range: 500 ppb
- Mode Setting: SNGL

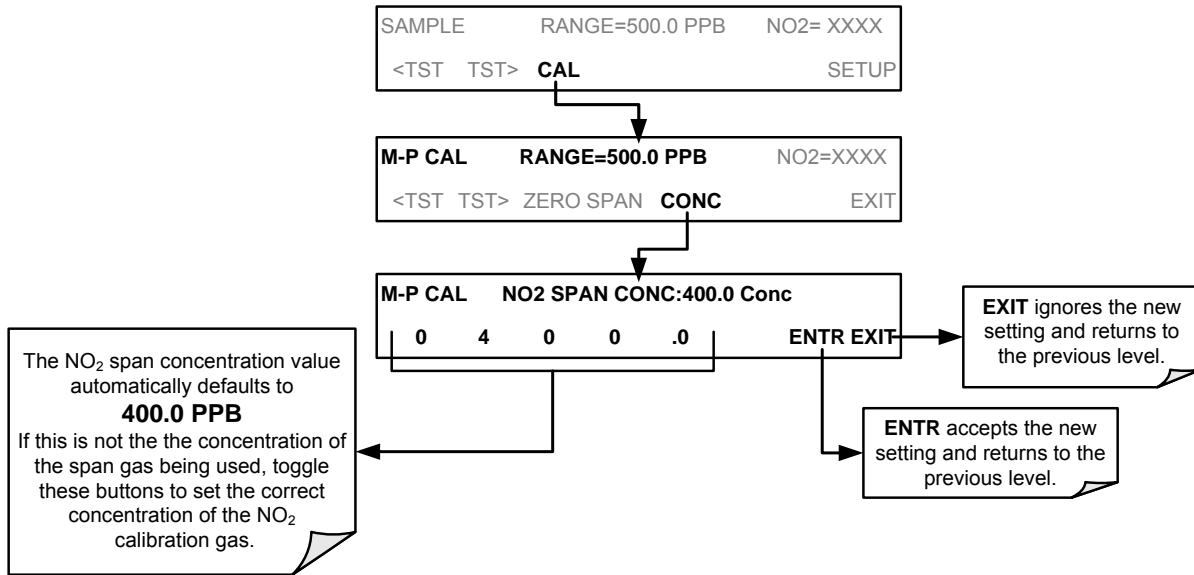
While these are the default settings for the T500U analyzer, it is recommended that you verify them before proceeding with the calibration procedure, by pressing the following menu button sequence:



5.3.1.2. VERIFYING THE EXPECTED NO₂ SPAN GAS CONCENTRATION

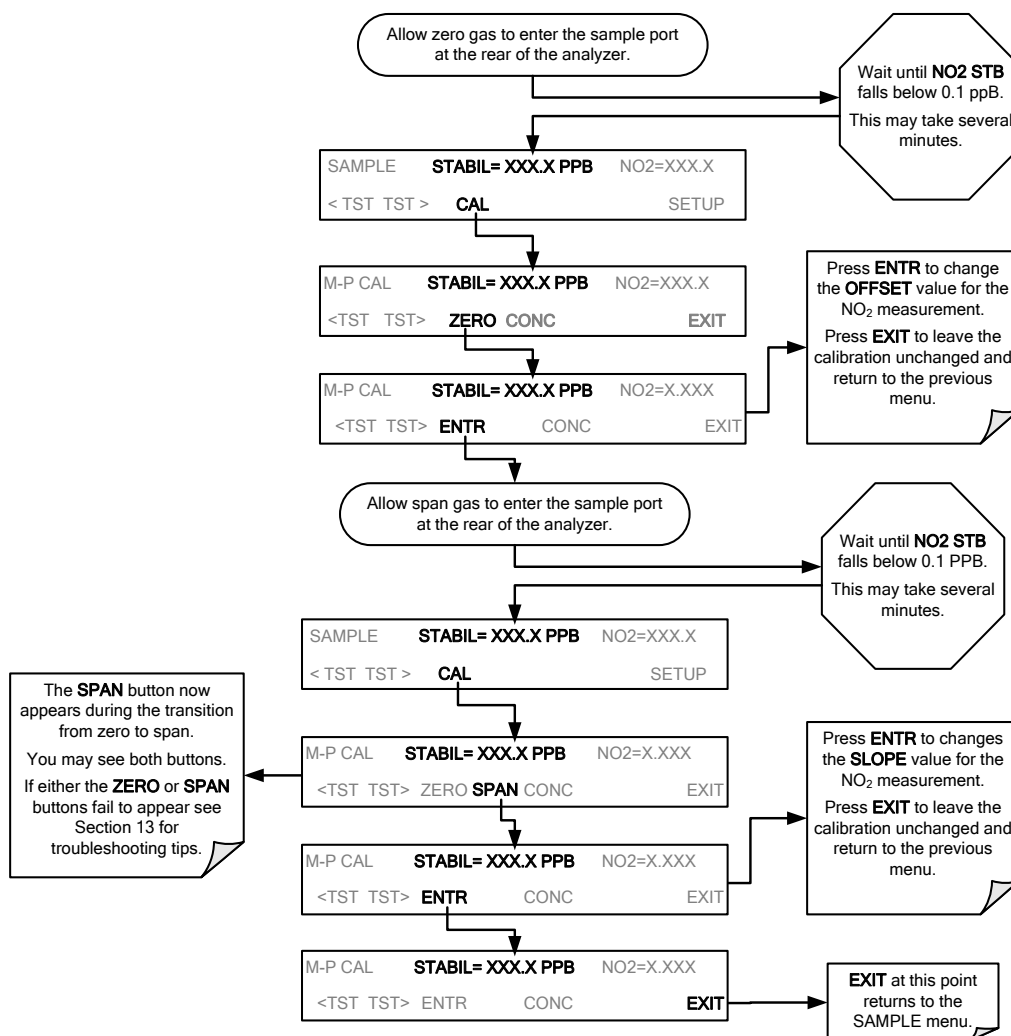
The NO₂ span concentration value automatically defaults to **400.0 PPB** and it is recommended that calibration gases of that concentration be used for the initial calibration of the unit.

To verify that the analyzer span setting is set for **400 PPB**, press:



5.3.1.3. INITIAL ZERO/SPAN CALIBRATION PROCEDURE

To perform an initial calibration, press:



The T500U analyzer is now ready for operation.

Note

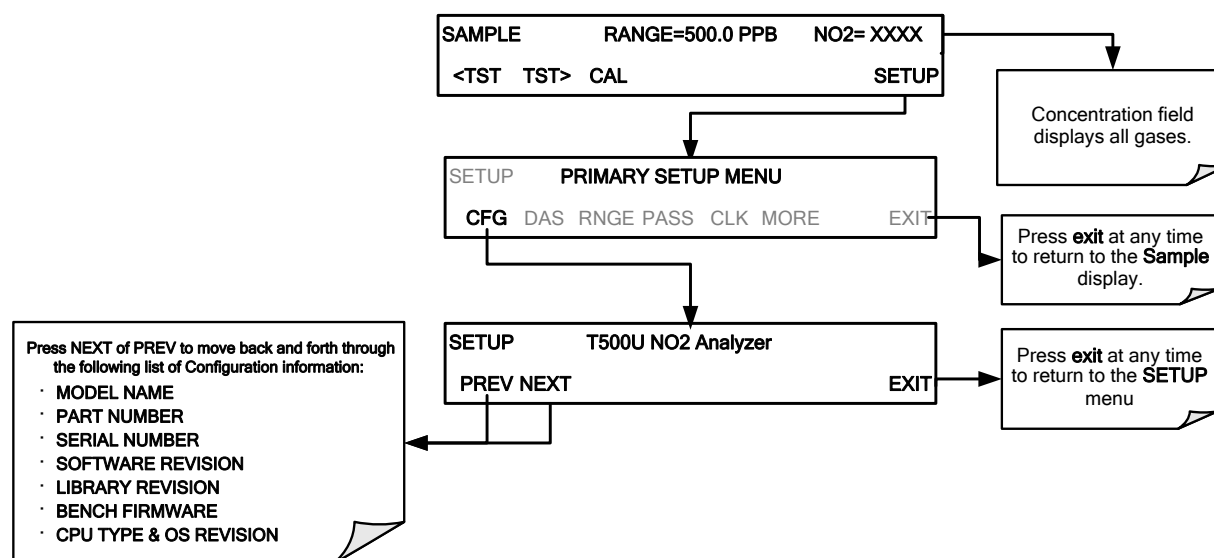
Once you have completed the above set-up procedures, please fill out the Quality Questionnaire that was shipped with your unit and return it to Teledyne API. This information is vital to our efforts in continuously improving our service and our products for you. **THANK YOU.**

6. SETUP

The SETUP menu provides access to the instrument parameter settings for performing configuration, calibration, reporting, and diagnostics operations.

6.1. CFG: CONFIGURATION INFORMATION

Pressing the CFG button displays the instrument configuration information. This display lists the analyzer model, serial number, firmware revision, software library revision, CPU type and other information. Use this information to identify the software and hardware when contacting Technical Support. Special instrument or software features or installed options may also be listed here.



6.2. DAS: INTERNAL DATA ACQUISITION SYSTEM

Use the SETUP>DAS menu to capture and record data. Refer to Section 8 for configuration and operation details.

6.3. RNGE: ANALOG OUTPUT REPORTING RANGE

Use the SETUP>RNGE menu to configure output reporting ranges, Single, Dual, and Auto.

6.3.1. ANALOG OUTPUT RANGES FOR NO₂ CONCENTRATION

The T500U has three active analog output signals via the rear panel connector..

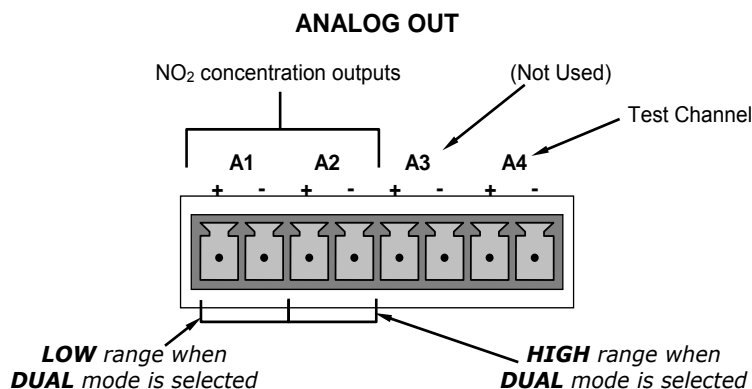


Figure 6-1: Analog Output Connector Pin Out

The outputs can be configured either at the factory or by the user for full scale outputs of 0.1 VDC, 1 VDC, 5 VDC or 10 VDC. Additionally **A1** and **A2** may be equipped with optional 0-20 mA DC 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 (Refer to Sections 6.9.4.3 and 6.9.4.5).

In its basic configuration, the **A1** and **A2** channels of the T500U output a signal that is proportional to the NO₂ concentration of the sample gas. Several operating modes are available which allow:

- Single range mode (**SNGL** Mode, refer to Section 6.7.4): Both outputs are slaved together and will represent the same concentration span (e.g. 0-500 ppb); however their electronic signal levels may be configured for different ranges (e.g. 0-10VDC vs. 0-0.1 VDC – Refer to Section 6.9.4).
- Dual range mode (**DUAL** mode, refer to Section 6.7.5): The two outputs can be configured for separate and independent concentration ranges as well as separate electronic signal levels.
- Auto range mode (**AUTO** mode, refer to Section 6.7.6) sets the analyzer to automatically switch the A1 and A2 analog outputs between two ranges (low and high) dynamically as the concentration value fluctuates.

EXAMPLE:

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

A2 OUTPUT: Output Signal = 0-10 VDC representing 0-500 ppb concentration values.

A4 OUTPUT: Test channel; e.g., Sample Pressure = 0-5V

Output **A3** is not available on the T500U Analyzer.

IMPORTANT

IMPACT ON READINGS OR DATA

The instrument does not remember upper range limits settings associated with the individual modes. Changes made to the range limits (e.g. 400 ppb → 600 ppb) when in one particular mode will alter the range limit settings for the other modes.

When switching between reporting range modes, ALWAYS check

and reset the upper range limits for the new mode selection.

6.3.2. ANALOG OUTPUT REPORTING RANGE DEFAULT SETTINGS

The default setting for these the reporting ranges of the analog output channels **A1**, **A2** and **A4** are:

- SNGL mode
- 0 to 500.0 ppb
- 0 to 5 VDC

6.3.3. SETUP → RNGE → MODE

Single range mode (**SNGL**) is the default range mode for reporting the NO₂ gas concentration outputs using the same range span (see Section 6.3.3.1).

Dual range mode (**DUAL**) allows the NO₂ analog outputs to be set with different reporting range spans (see Section 6.3.3.2).

Automatic range mode (**AUTO**) allows the analyzer to automatically switch the reporting range between two user upper span limits (designated **LOW** and **HIGH**) based on the actual concentrations being measured for each (see Section 6.3.3.3).

6.3.3.1. SETUP → RNGE → MODE → SNGL: SINGLE RANGE MODE CONFIGURATION

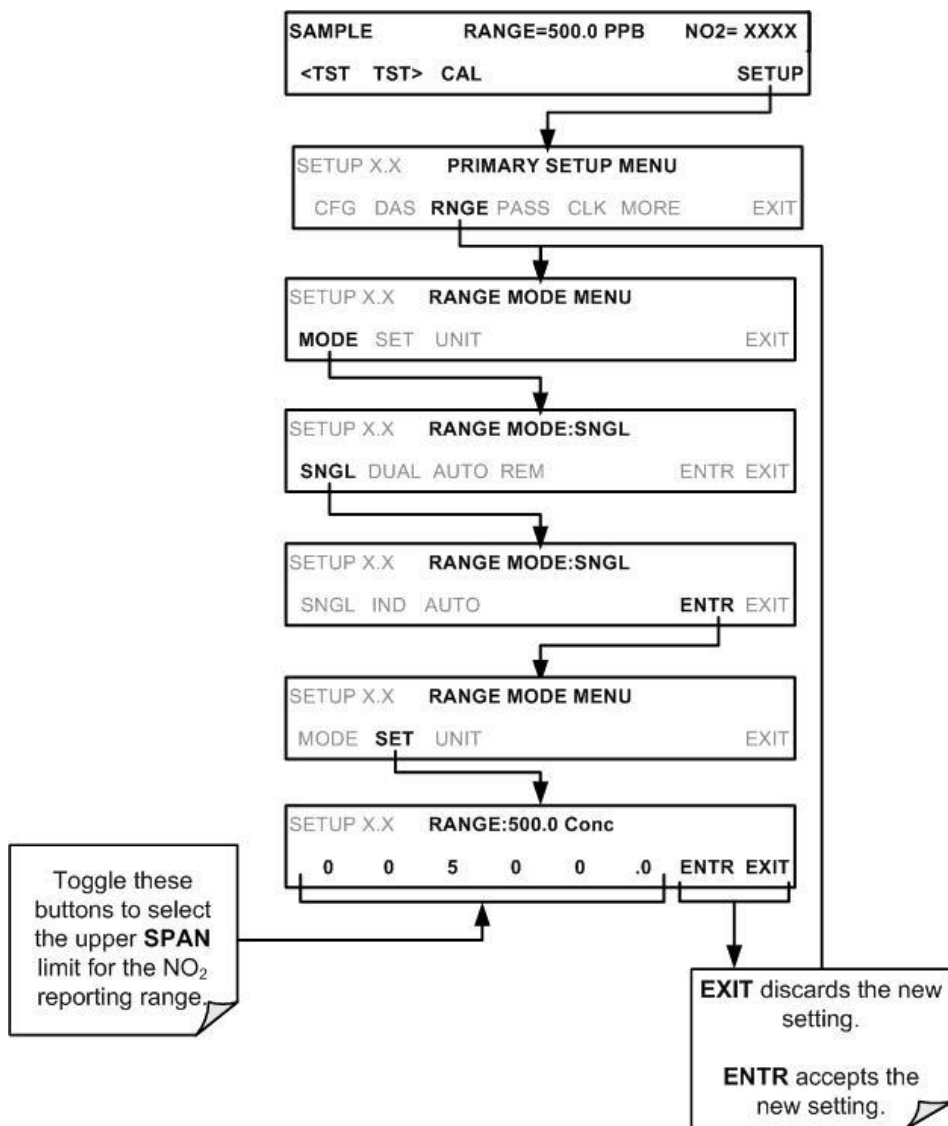
Note

Single Range is the default reporting range mode for the analyzer.

When the single range mode is selected (**SNGL**), all analog concentration outputs (**A1**, **A2**) are slaved together and set to the same reporting range limits (e.g. 500.0 ppb).

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 6.8.3.1).

To select **SNGL** range mode and to set the upper limit of the range, press:



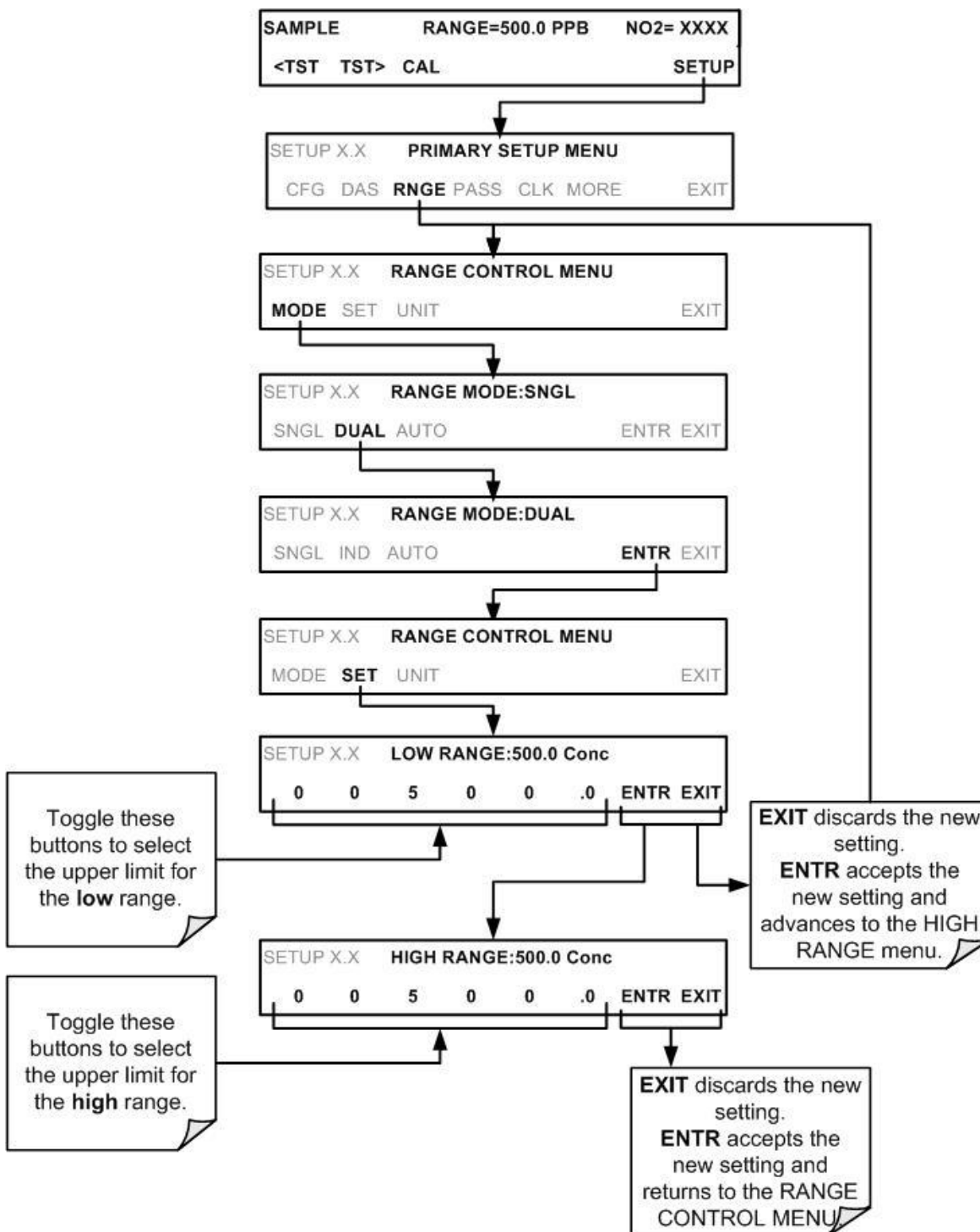
6.3.3.2. SETUP → RNGE → MODE → DUAL: DUAL RANGE MODE CONFIGURATION

Selecting Dual Range mode allows the **A1** and **A2** outputs to be configured with different reporting ranges. The analyzer software calls these two ranges low and high. The low range setting corresponds with the analog output labeled **A1** on the rear panel of the instrument. The high range setting corresponds with the **A2** output. While the software names these two ranges low and high, they do not have to be configured that way. For example: the low range can be set for a span of 0-150 ppb while the high range is set for 0-50 ppb.

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

- Range1: The range setting for the A1 output.
- Range2: The range setting for the A2 output.

To set the ranges press the following control button sequence:



IMPORTANT

IMPACT ON READINGS OR DATA

In DUAL range mode the LOW and HIGH ranges have separate slopes and offsets for computing NO₂ concentration. The two ranges must be independently calibrated.

6.3.3.3. SETUP → RNGE → MODE → AUTO: AUTO RANGE MODE CONFIGURATION

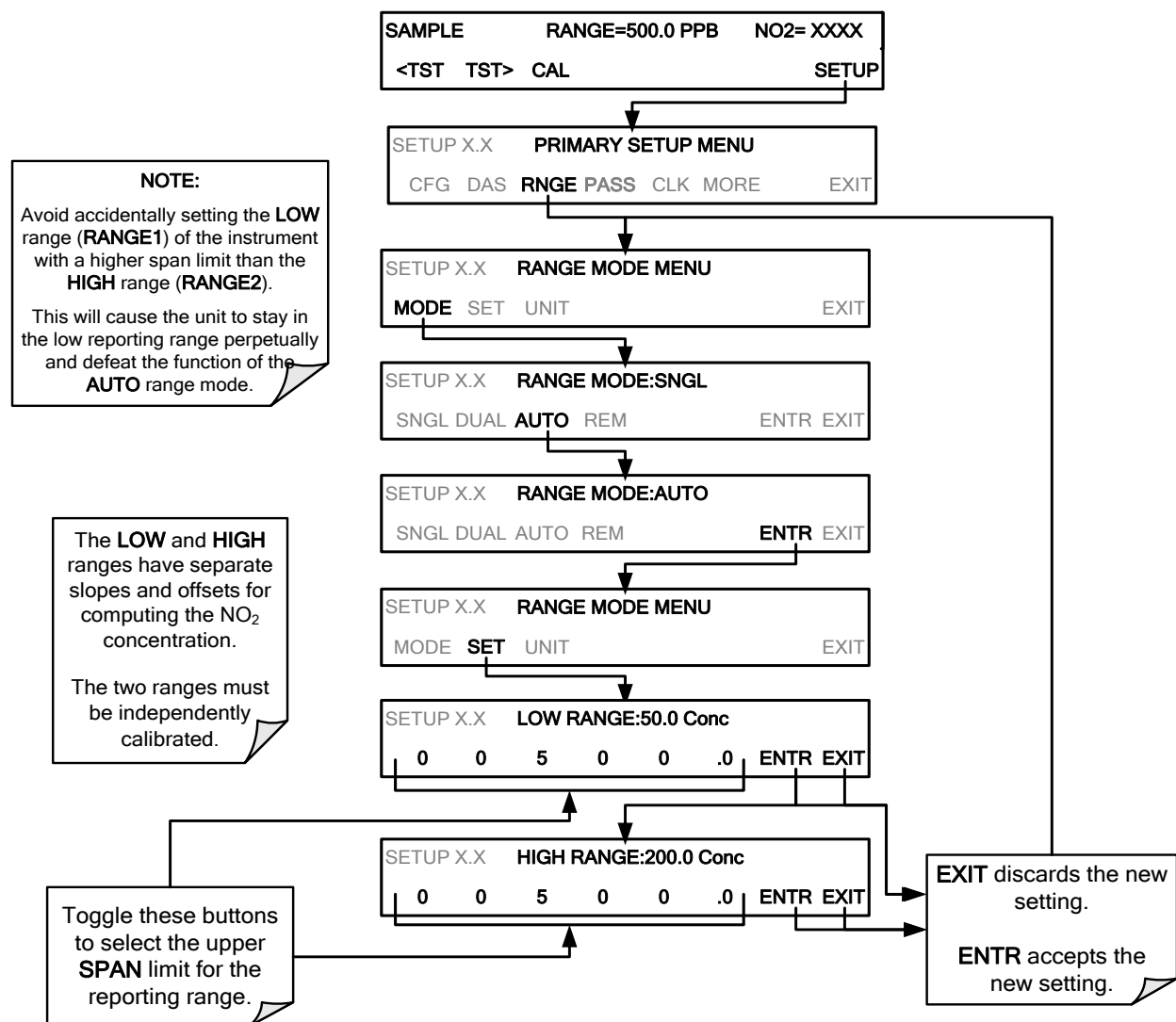
In **AUTO** range mode, the analyzer automatically switches the reporting range between two user-defined ranges (**LOW** and **HIGH**).

- The unit will switch from **LOW** range to **HIGH** range when the NO₂ concentration exceeds 98% of the low range span.
- The unit will return from **HIGH** range back to **LOW** range once the NO₂ concentration falls below 75% of the low range span.

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

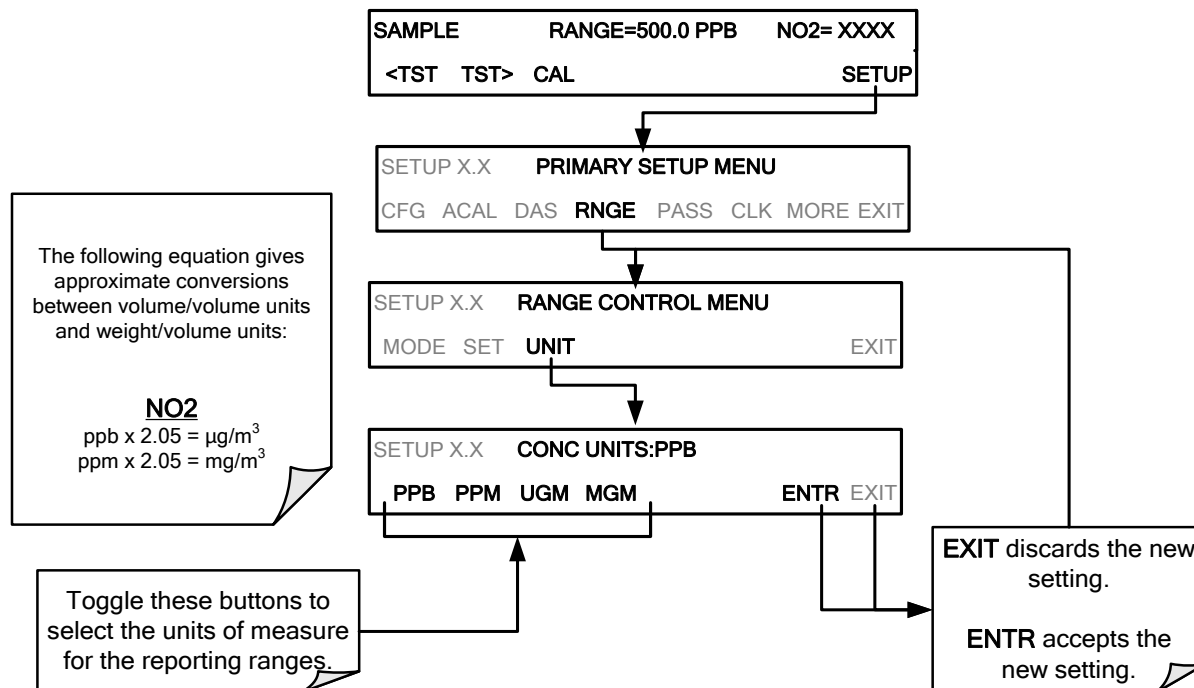
- RANGE1: The LOW range setting for all analog outputs.
- RANGE2: The HIGH range setting for all analog outputs.

The **LOW/HIGH** range status is also reported through the external, digital status bits (Section 3.3.1.4). To set individual ranges press the following menu sequence.



6.3.3.4. SETUP → RNGE → UNIT: SETTING THE REPORTING RANGE UNITS OF MEASURE

The T500U can display and report concentrations in ppb, ppm, ug/m³, mg/m³ units. Changing units affects all of the COM port values, and all of the display values for all reporting ranges. To change the units of measure press:



IMPORTANT

IMPACT ON READINGS OR DATA

Concentrations displayed in mg/m³ and ug/m³ use 0°C @ 760 mmHg for Standard Temperature and Pressure (STP).

Consult your local regulations for the STP used by your agency. (Example: US EPA uses 25°C as the reference temperature).

Once the Units of Measurement have been changed from volumetric (ppb or ppm) to mass units (ug/m³ or mg/m³) the analyzer **MUST** be recalibrated, as the “expected span values” previously in effect will no longer be valid.

Simply entering new expected span values without running the entire calibration routine is not sufficient. This will also counteract any discrepancies between STP definitions.

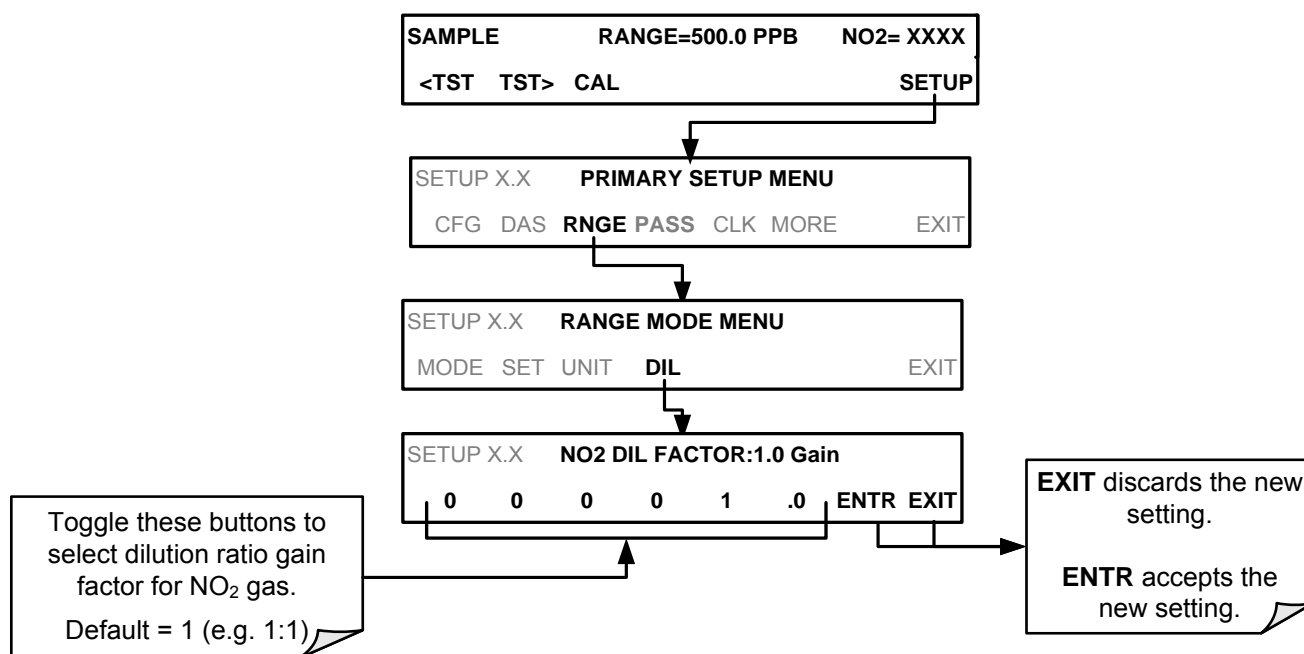
6.3.3.5. SETUP → RNGE → DIL: USING THE OPTIONAL DILUTION RATIO FEATURE

The dilution ratio feature is a software utility option designed for applications where the sample gas is diluted before being analyzed by the T500U. Typically this occurs in continuous emission monitoring (CEM) applications where the quality of gas in a smoke stack is being tested and the sampling method used to

remove the gas from the stack dilutes the gas. Once the degree of dilution is known, this feature allows the user to add an appropriate scaling factor to the analyzer's NO₂ concentration calculations so that the measurement range and concentration values displayed on the instrument's front panel display and reported via the instrument's various outputs reflect the undiluted values.

Using the Dilution Ratio option is a 4-step process:

1. Select the appropriate units of measure (see Section 6.3.3.4).
2. Select the reporting range mode and set the reporting range upper limit (see Section 6.3.3).
 - Ensure that the upper span limit entered for the reporting range is the maximum expected concentration of the **UNDILUTED** gas.
3. Set the dilution factor as a gain (e.g., a value of 20 means 20 parts diluent and 1 part of sample gas):



4. Calibrate the analyzer.
 - Ensure that the calibration span gas is either supplied through the same dilution system as the sample gas or has an appropriately lower actual concentration.

EXAMPLE: If the reporting range limit is set for 1 ppm and the dilution ratio of the sample gas is 20 gain, either:

- a span gas with the concentration of 1 ppm can be used if the span gas passes through the same dilution steps as the sample gas, or;
- a 0.05 ppm span gas must be used if the span gas **IS NOT** routed through the dilution system.

6.4. PASS: PASSWORD PROTECTION

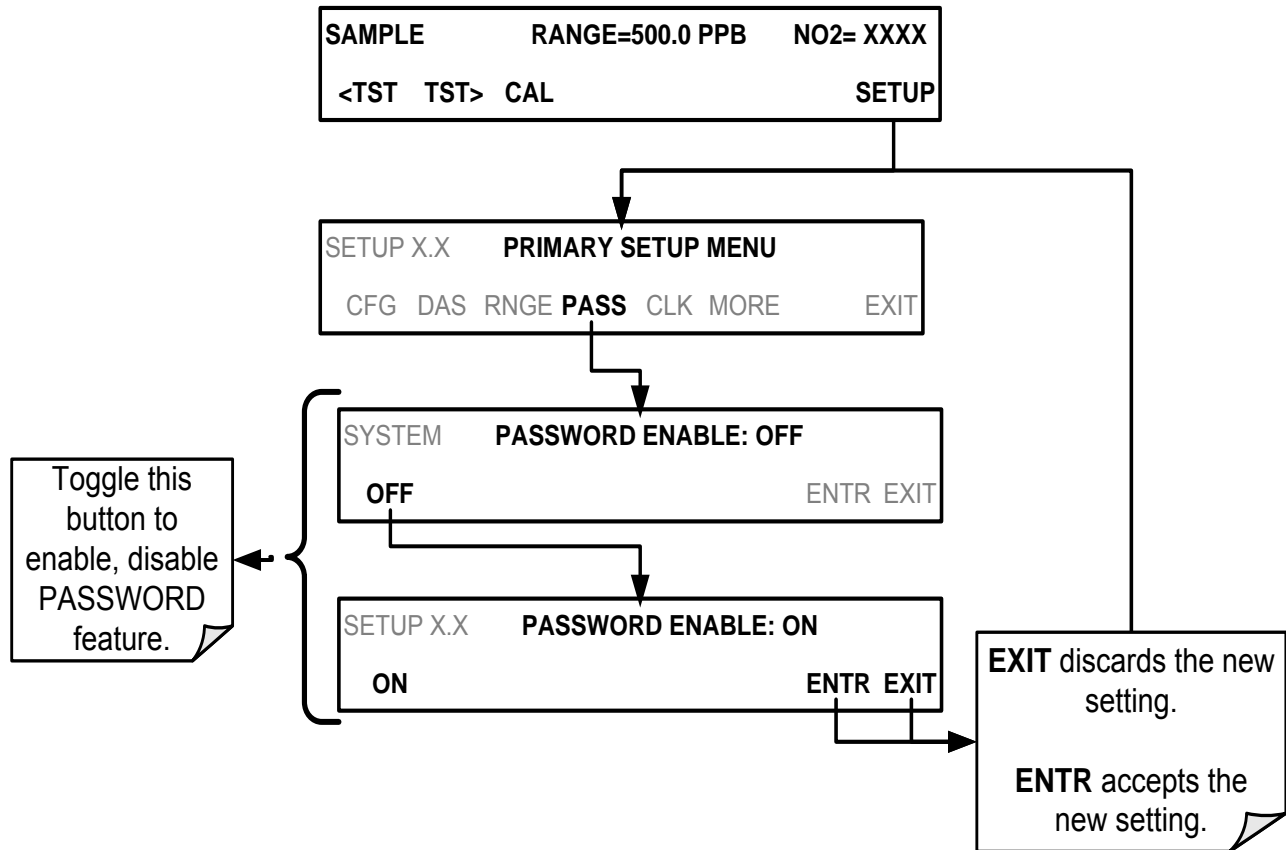
The T500U provides password protection of the calibration and setup functions to prevent unauthorized adjustments. When the passwords have been SETUP>PASS>ON), the system will prompt the user for a password anytime a password-protected function (e.g., SETUP>MORE>DIAG) is selected. This allows normal 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.

There are two levels of password protection above the “null” level, which correspond to operator, maintenance and configuration functions. Each level allows access to all of the functions in the previous level.

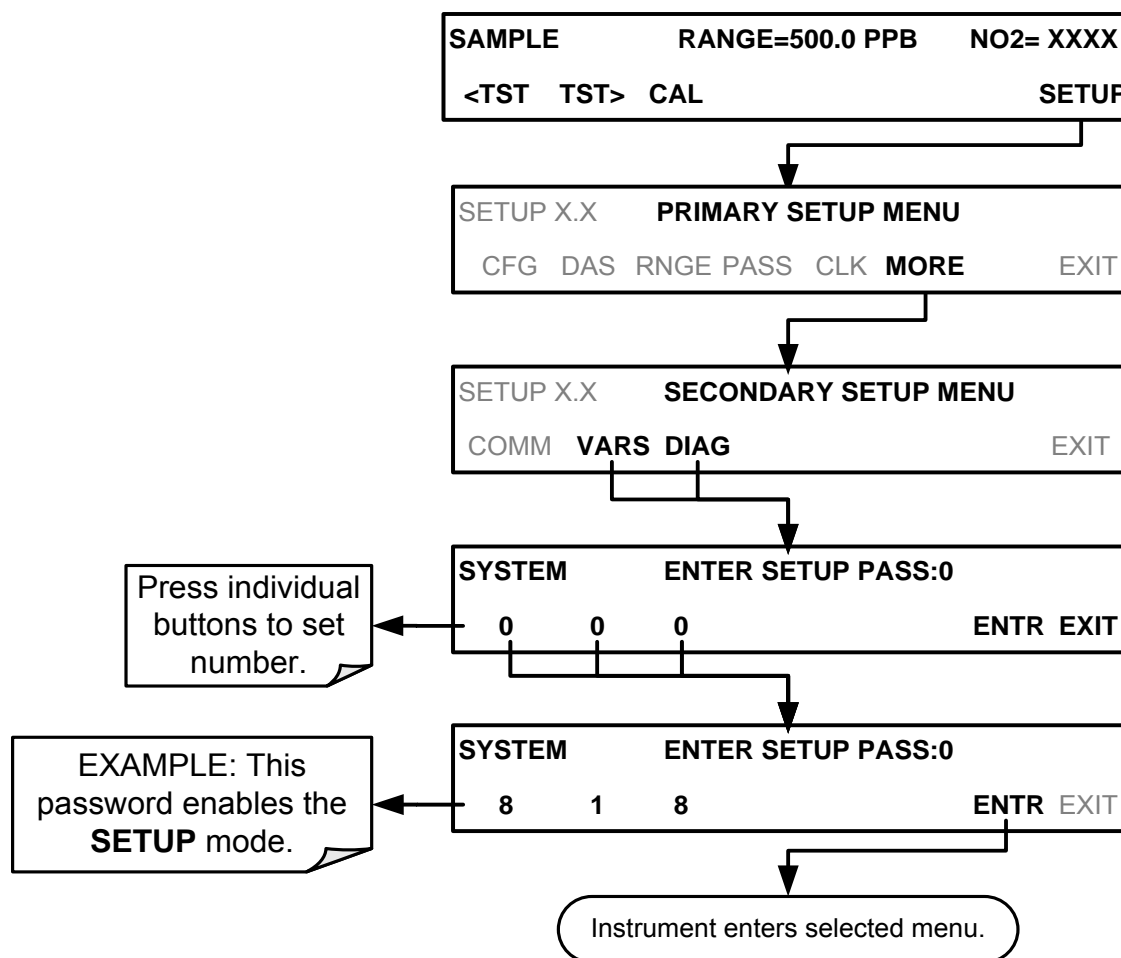
Table 6-1: Password Levels

PASSWORD	LEVEL	MENU ACCESS ALLOWED
Null (no password required)	Operation	Functions of the menu for general operation.
101	Configuration/Maintenance	Access to Primary Setup 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.

To enable passwords, press:



Example: If all passwords are enabled, the following touchscreen control sequence would be required to enter the **VARs** or **DIAG** submenus:

**Note**

The instrument still prompts for a password when entering the VARS and DIAG menus, even if passwords are disabled, but it displays the default password (818) upon entering these menus. In this case, only press ENTR to access the password-protected menus.

To disable the PASSWORD feature after it has been turned ON, the SETUP menu first requires a password; once the password has been input and the ENTR button pressed, the PRIMARY SETUP MENU appears, and now the PASS menu can be accessed, where pressing the ON button turns PASSWORD ENABLE back to OFF, and pressing the ENTR button accepts the change (Table 6-1).

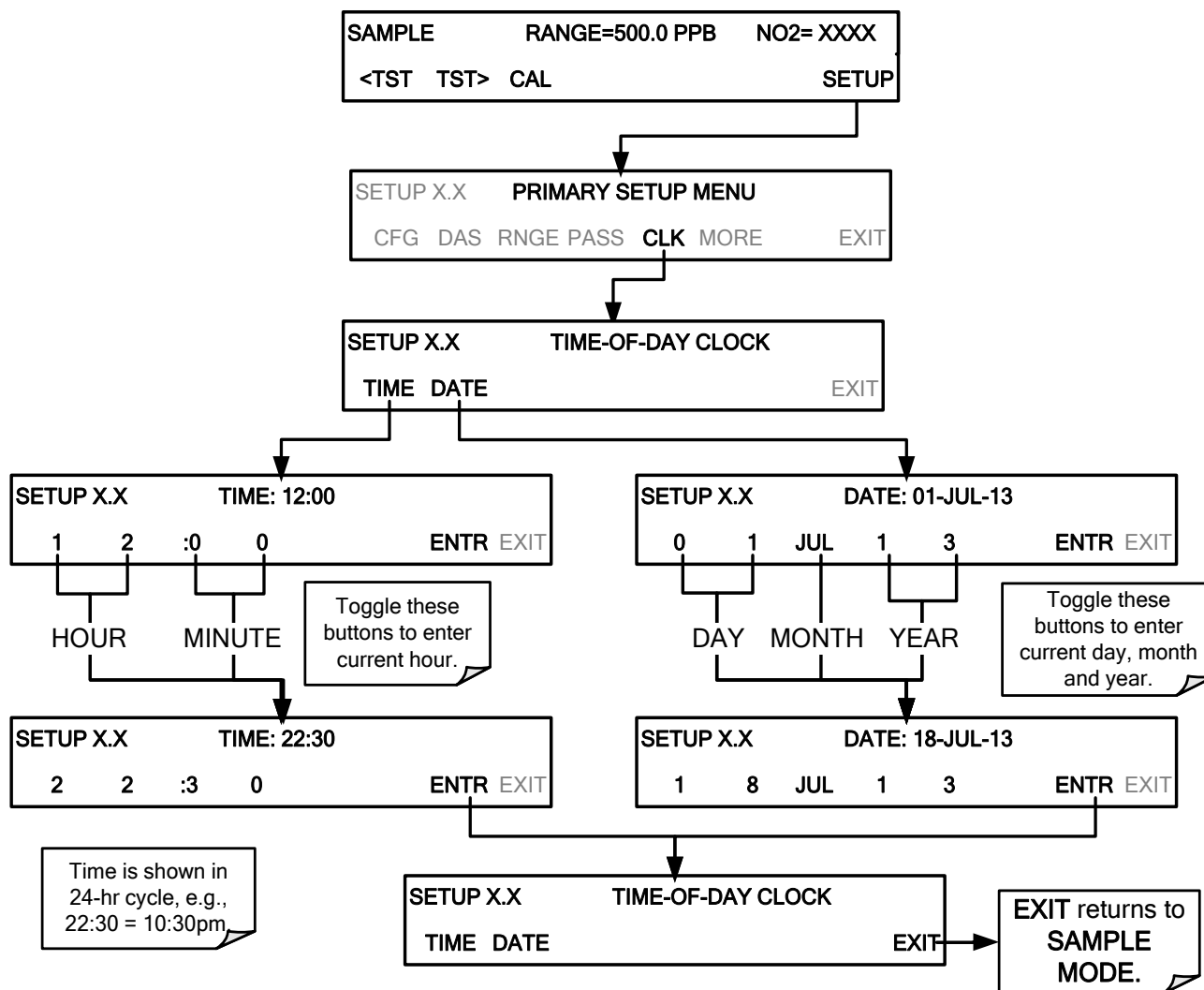
6.5. CLK: CLOCK, SETTING TIME AND DATE

Sets time and date of clock; its speed can be adjusted to compensate for faster or slower CPU clocks. Press SETUP>CLK to access the clock.

6.5.1. SETTING THE TIME OF DAY

The time-of-day feature of the internal clock supports the **DURATION** step of the automatic calibration (**ACAL**) sequence feature, has a built-in clock for the AutoCal timer, for the time TEST function, and for time stamps on COM port messages and on DAS data entries.

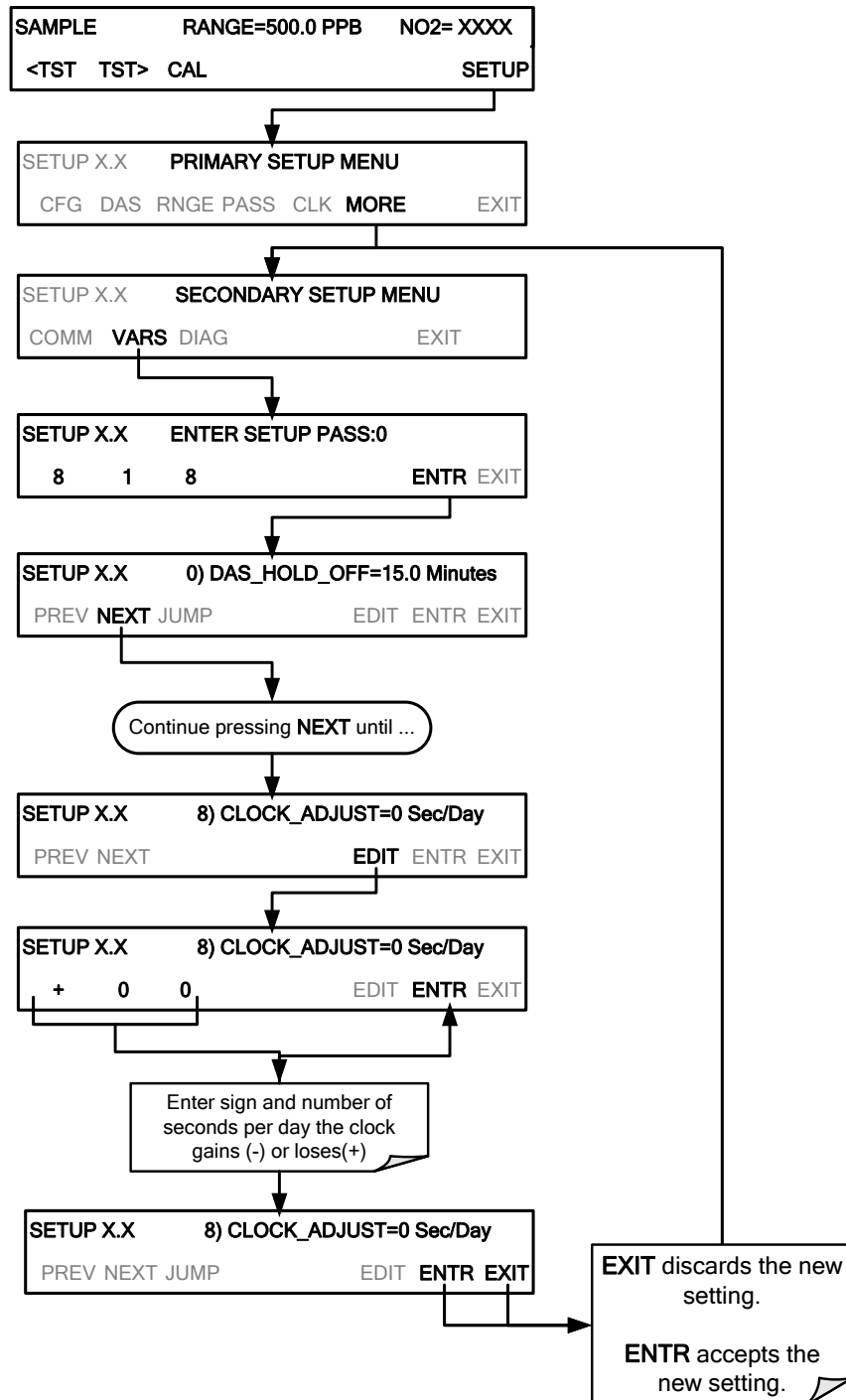
To set the clock's time and date, press:



6.5.2. ADJUSTING THE INTERNAL CLOCK'S SPEED

In order to compensate for CPU clocks that run fast or slow, you can adjust a variable called **CLOCK_ADJ** to speed up or slow down the clock by a fixed amount every day.

The **CLOCK_ADJ** variable is accessed via the **VARS** submenu: To change the value of this variable, press:



6.6. MORE>COMM: COMMUNICATIONS PORTS

This section introduces the communications setup menu; Section 7 provides the setup instructions and operation information.

Press SETUP>MORE>COMM to arrive at the communications menu.

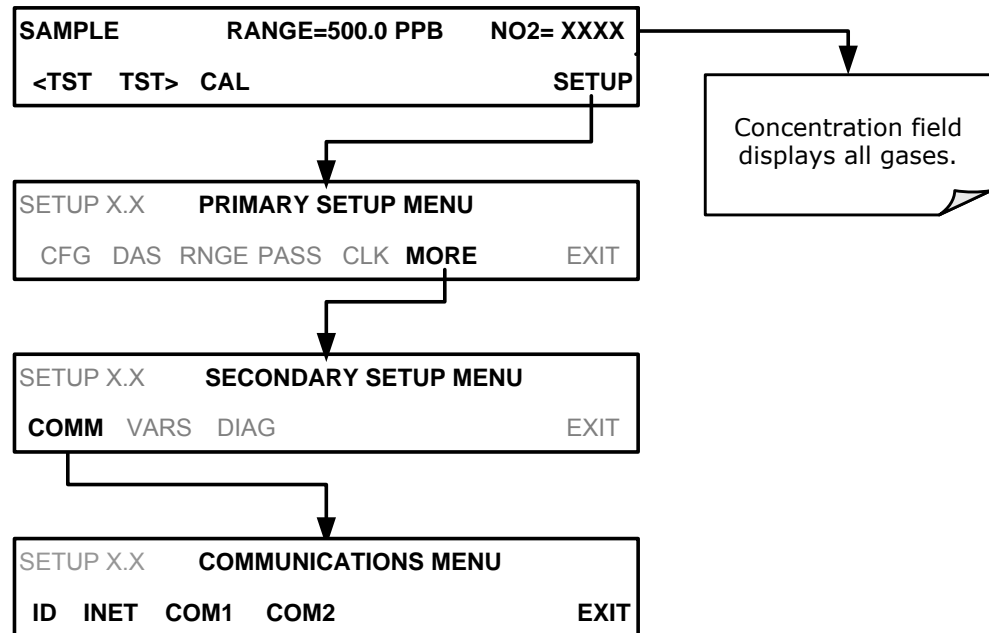


Figure 6-2. SETUP – COMM Menu

6.6.1. ID (MACHINE IDENTIFICATION)

In the SETUP>MORE>COMM menu press ID to display and/or change the Machine ID, which must be changed to a unique identifier (number) when more than one instrument of the same model is used:

- in an RS-232 multidrop configuration (Sections 3.3.1.8)
- on the same Ethernet LAN (Section 7.5)
- when applying MODBUS protocol (Section 7.7)

The default ID is either **0** or the same as the model number, e.g., **0500** for the Model T500U. Press any button(s) in the MACHINE ID menu (Figure 6-3) until the Machine ID in the Parameter field displays the desired identifier.

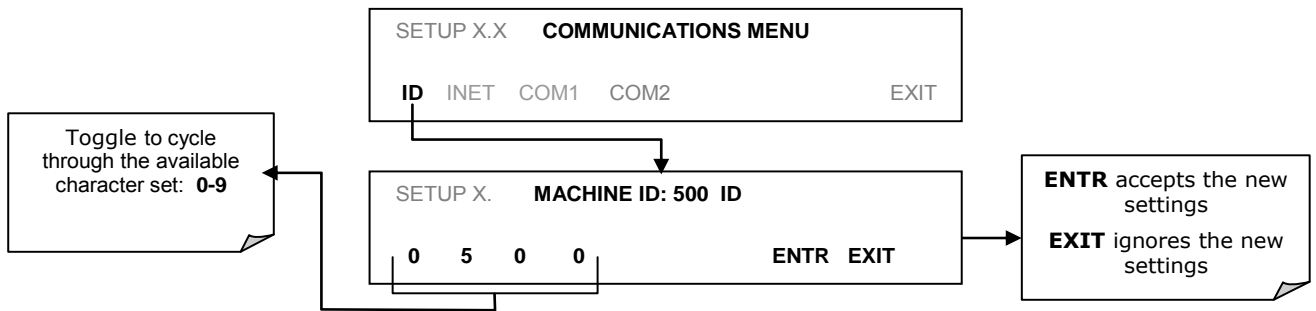


Figure 6-3. COMM– Machine ID

The ID can be any unique 4-digit number and can also be used to identify analyzers in any number of ways (e.g. location numbers, company asset number, etc.)

6.6.2. INET (ETHERNET)

Use `SETUP>COMM>INET` to configure Ethernet communications, whether manually or via DHCP. Please see Section 7.5.2 for configuration details.

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

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

- configure communication modes (Section 7.2.1)
- view/set the baud rate (Section 7.2.2)
- test the connections of the com ports (Section 7.2.3).

Configuring COM1 or COM2 requires setting the DCE DTE switch on the rear panel. Section 7.1 provides DCE DTE information.

6.7. MORE>VARS: VARIABLES SETUP AND DEFINITION

Use the `SETUP>MORE>VARS` menu to adjust the settings for software variables that define certain operational parameters.

Table 6-2 lists variables that are available within the 818 password protected level. See Appendix A for a detailed listing of the T500U variables that are accessible through the remote interface.

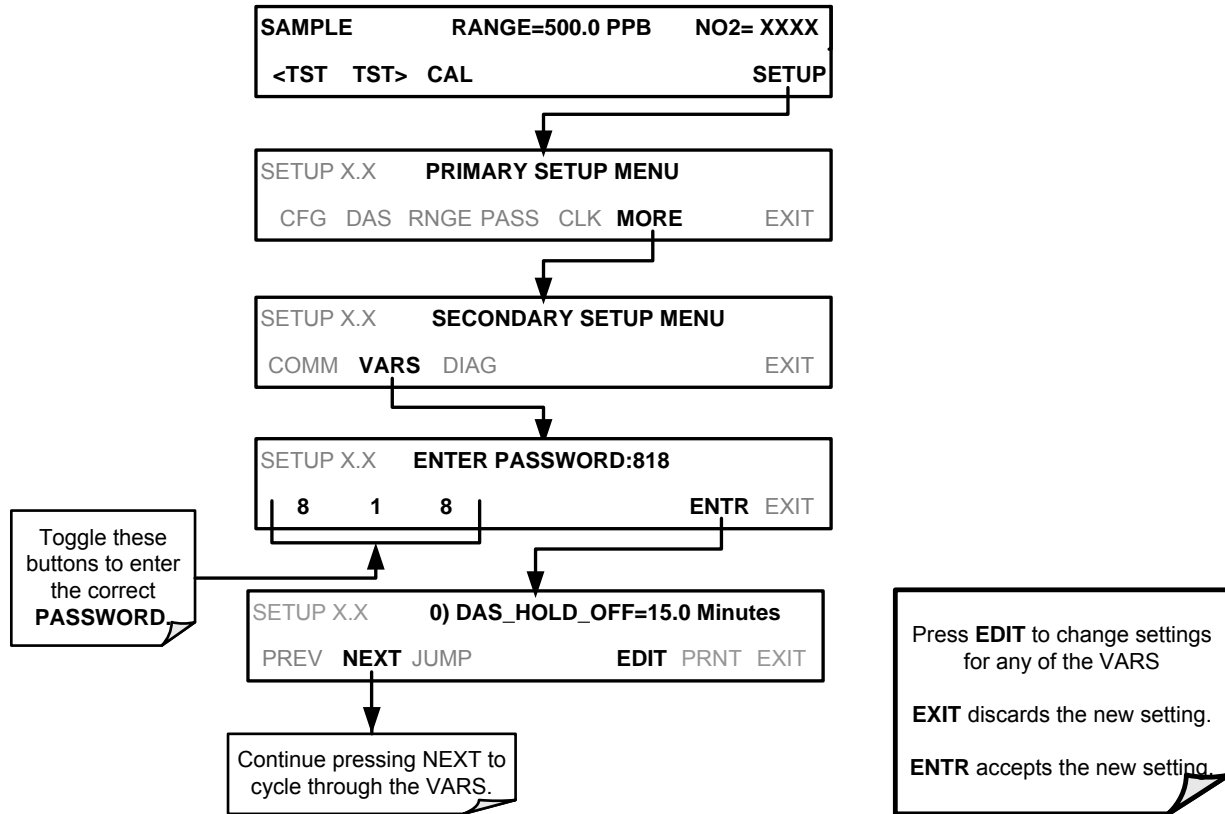
Table 6-2: Variables (VARS)

NO.	VARIABLE	DESCRIPTION	ALLOWED VALUES	VARS DEFAULT VALUES
0	DAS_HOLD_OFF	Changes the Internal Data Acquisition System (DAS) HOLDOFF timer: No data is stored in the DAS channels during situations when the software considers the data to be questionable such as during warm up of just after the instrument returns from one of its calibration mode to SAMPLE Mode.	May be set for intervals between 0.5 – 20 min	15 min.
1	CONC_PRECISION	Sets the number of significant digits to the right of the decimal point display of concentration and stability values.	AUTO, 1, 2, 3, 4	3
2	CLOCK_ADJ	Adjusts the speed of the analyzer's clock. Choose + sign if the clock is too slow; choose - sign if the clock is too fast.	-60 to +60 s/day	0 sec
3	SERVICE_CLEAR	Resets the service timer. Pressing OFF turns the setting to ON. ENTR resets the timer to 0 and returns the setting to OFF.	ON/OFF	OFF
4	TIME_SINCE_SVC	Displays number of hours since last service (since SERVICE_CLEAR was reset).	0-500000	0 Hrs
5	SVC_INTERVAL	Sets the number of hours between service reminders.	0-100000	0 Hrs

Note

There is a 2-sec latency period between the time a VARS value is changed and its storage into the analyzer's memory. DO NOT turn the analyzer off during this period or the new setting will be lost.

To access and navigate the **VARs** menu, use the following button sequence:



6.8. MORE>DIAG: DIAGNOSTICS FUNCTIONS

A series of diagnostic tools is grouped together under the **SETUP→MORE→DIAG** menu. The parameters are dependent on firmware revision (see Appendix A). These tools can be used in a variety of troubleshooting and diagnostic procedures and are referred to in many places of the maintenance and troubleshooting sections of this manual.

The various operating modes available under the **DIAG** menu, using password 818, are:

Table 6-3: Diagnostic Mode (DIAG) Functions

DIAG SUBMENU	SUBMENU FUNCTION	MANUAL SECTION
SIGNAL I/O	Allows observation of all digital and analog signals in the instrument. Allows certain digital signals such as valves and heaters to be toggled ON and OFF .	6.8.1, 13.1.3
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.	6.8.2, 13.6.6.1
ANALOG I/O CONFIGURATION	The signal levels of the instruments analog outputs may be calibrated (either individually or as a group). Various electronic parameters such as signal span, and offset are available for viewing and configuration.	6.8.3
TEST CHAN OUTPUT	Selects one of the available test channel signals to output over the A4 analog output channel.	6.8.4
NO2 LED DISABLE	Allows the user to turn off the LED without cycling instrument power.	6.8.5
PUMP DISABLE	Allows the user to turn off the internal pump without cycling instrument power.	6.8.6

To access the various **DIAG** submenus, press the following buttons:

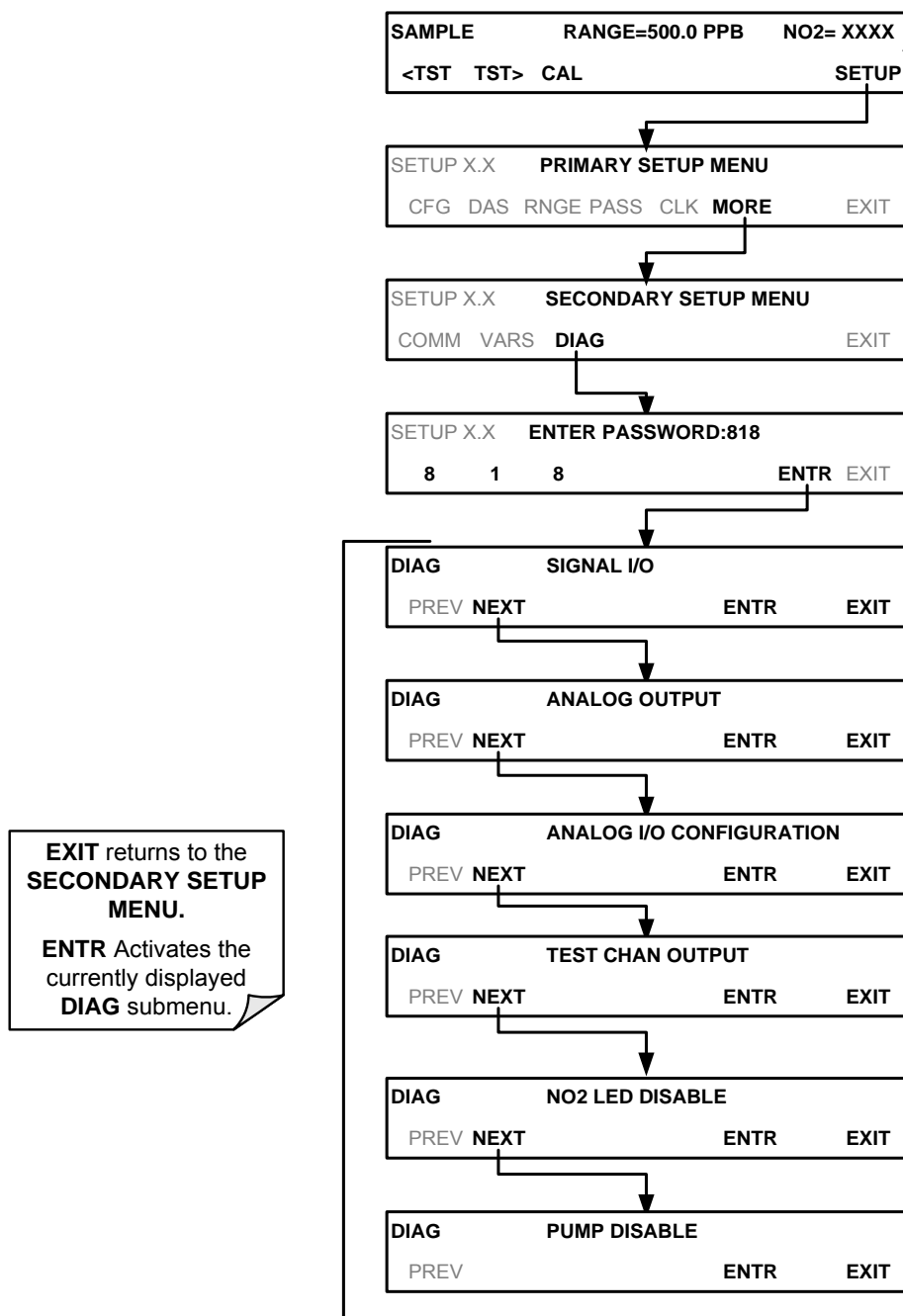
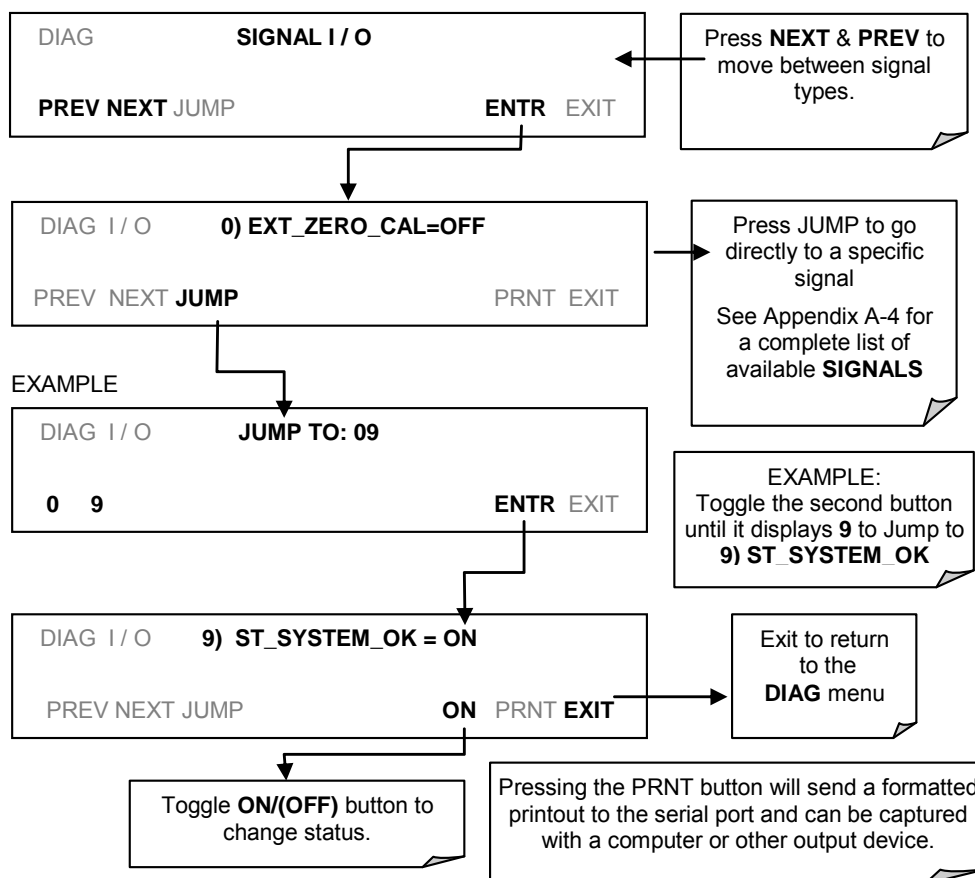


Figure 6-4: Accessing the DIAG Submenus

6.8.1. 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. Refer to Appendix A for a list of the parameters available for review under this menu.

Access the signal I/O test mode from the DIAG Menu (Figure 6-4), then press:



6.8.2. ANALOG OUTPUT (DIAG AOUT)

Analog Output (AOUT) is used to verify functionality and accuracy of the analog outputs. The test forces all analog output channels to produce signals ranging from 0% to 100% of the full scale range in 20% increments. This test is useful to verify the operation of the data logging/recording devices attached to the analyzer.

Section 13.6.6.1 presents instructions for use in troubleshooting and service.

6.8.3. ANALOG I/O CONFIGURATION (DIAG AIO)

The T500U analyzer comes equipped with three analog outputs (refer to Figure 3-6). The first two outputs, **A1 & A2** (**A3** is not used) carry analog signals that represent the currently measured NO₂ concentration, (see Section 6.3.1). The third, **A4**, outputs a signal that can be set to represent the current value of one of several test functions (see Table 6-8 in Section 6.8.4 Table 6-8).

The following table lists the analog I/O functions that are available in the T500U analyzer.

Table 6-4: DIAG - Analog I/O Functions

SUB MENU	FUNCTION	MANUAL SECTION
AOUT CALIBRATED	Initiates a calibration of the A1 , A2 , and A4 analog output channels that determines the slope and offset inherent in the circuitry of each output. These values are stored and applied to the output signals by the CPU automatically.	6.8.3.1
CONC_OUT_1	Sets the basic electronic configuration of the A1 output (NO ₂ Concentration). There are four options: <ul style="list-style-type: none"> • RANGE: 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. 	6.8.2
CONC_OUT_2	<ul style="list-style-type: none"> • Same as for CONC_OUT_1 but for analog channel A2 (NO Concentration) 	
TEST OUTPUT	<ul style="list-style-type: none"> • Same as for CONC_OUT_1 but for analog channel A4 (TEST CHANNEL) 	6.8.4
AIN CALIBRATED	Initiates a calibration of the A-to-D Converter circuit located on the Motherboard.	6.8.3.10
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.	6.8.3.11

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

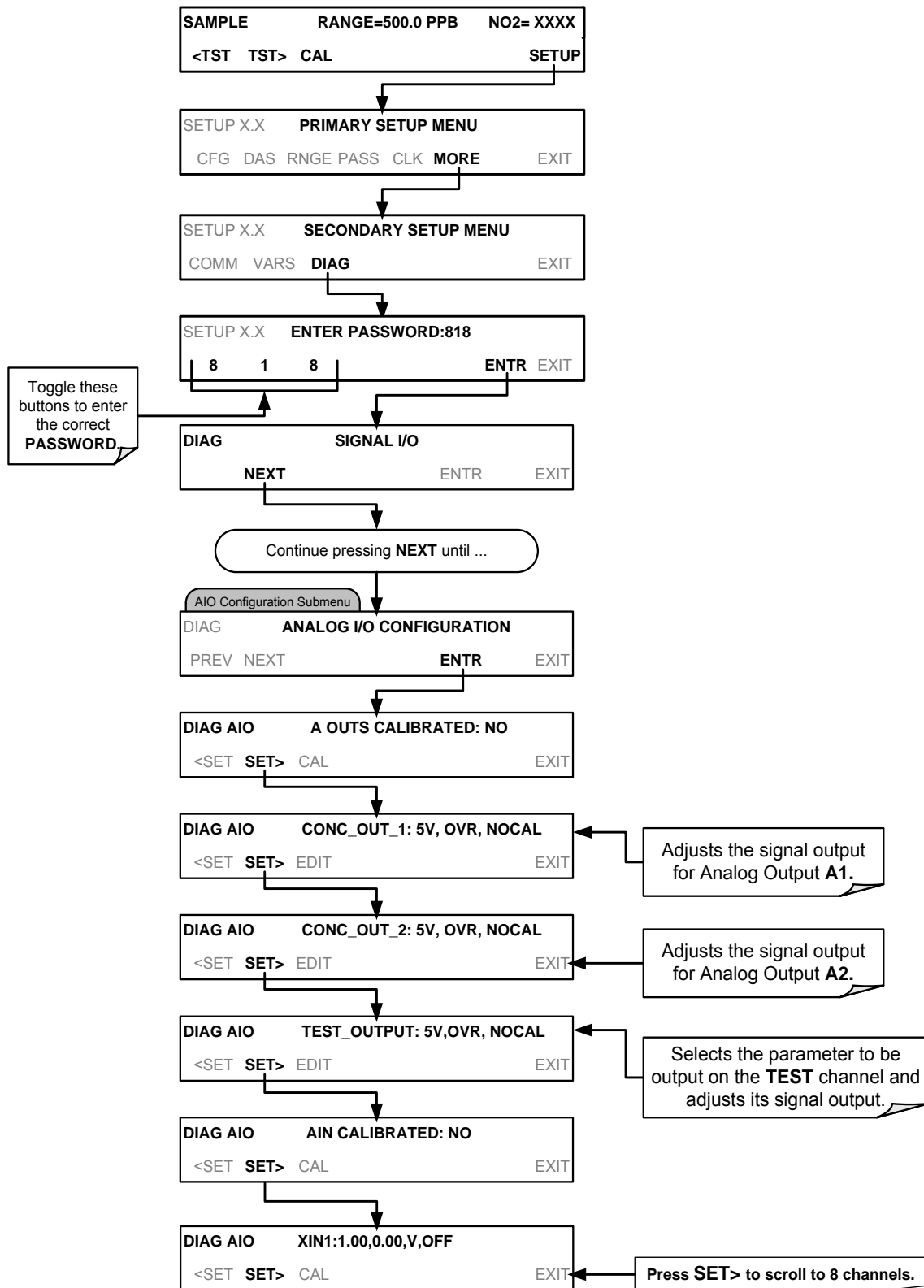


Figure 6-5: Accessing the Analog I/O Configuration Submenus

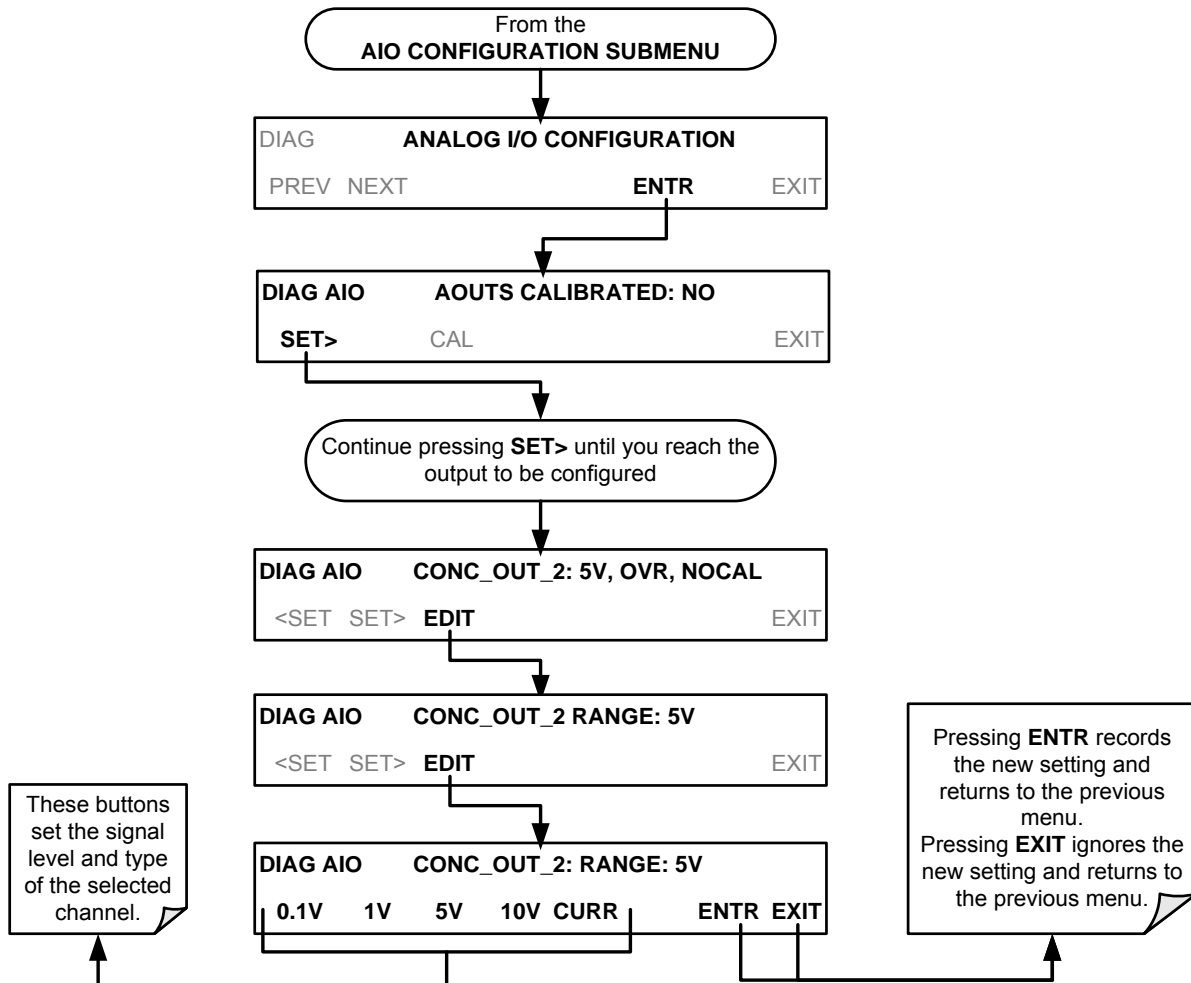
6.8.3.1. ANALOG OUTPUT VOLTAGE / CURRENT RANGE SELECTION

In its standard configuration the analog outputs are set to output a 0 – 5 VDC signals. Several other output ranges are available (see Table 6-5). Each range is usable from -5% to +5% of the rated span.

Table 6-5: 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
The default offset for all VDC ranges is 0-5 VDC.			
CURR	0-20 mA	0 mA	20 mA
While these are the physical limits of the current loop modules, typical applications use 2-20 mA or 4-20 mA for the lower and upper limits. 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 Figure 6-5) then press:



6.8.3.2. CALIBRATION OF THE ANALOG OUTPUTS

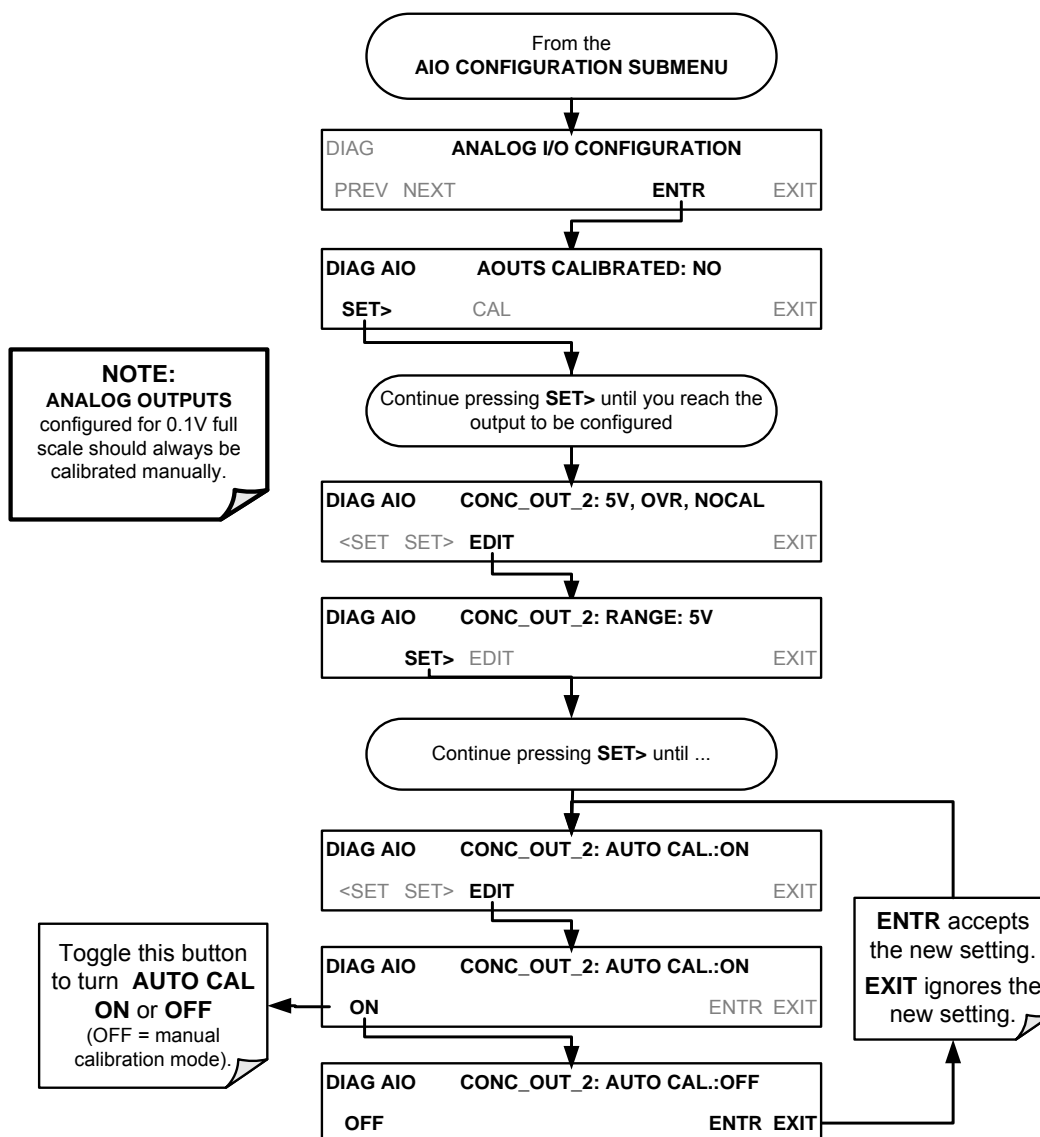
Analog output calibration should be carried out on first startup of the analyzer (performed in the factory as part of the configuration process) and whenever recalibration is required. The analog outputs can be calibrated automatically, either as a group or individually, or calibrated manually.

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. The AUTOCAL feature must be disabled first for manual calibration.

6.8.3.3. 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 Figure 6-5) then press:



6.8.3.4. AUTOMATIC GROUP CALIBRATION OF THE ANALOG OUTPUTS

IMPORTANT

IMPACT ON READINGS OR DATA

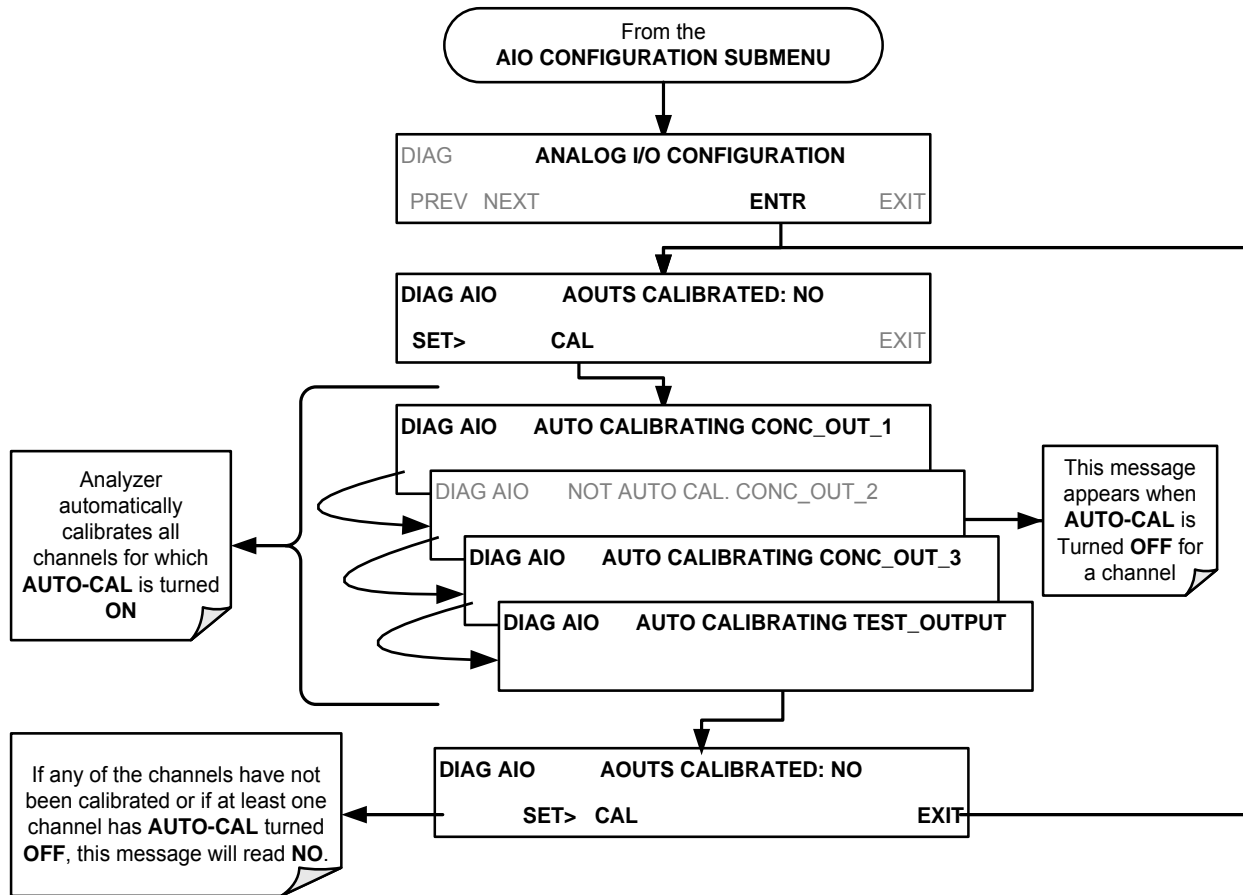
Manual calibration should be used for any analog output set for a 0.1V output range or in cases where the outputs must be closely matched to the characteristics of the recording device. (See Sections 6.8.3.2, 6.8.3.3, and 6.8.3.6).

IMPORTANT

IMPACT ON READINGS OR DATA

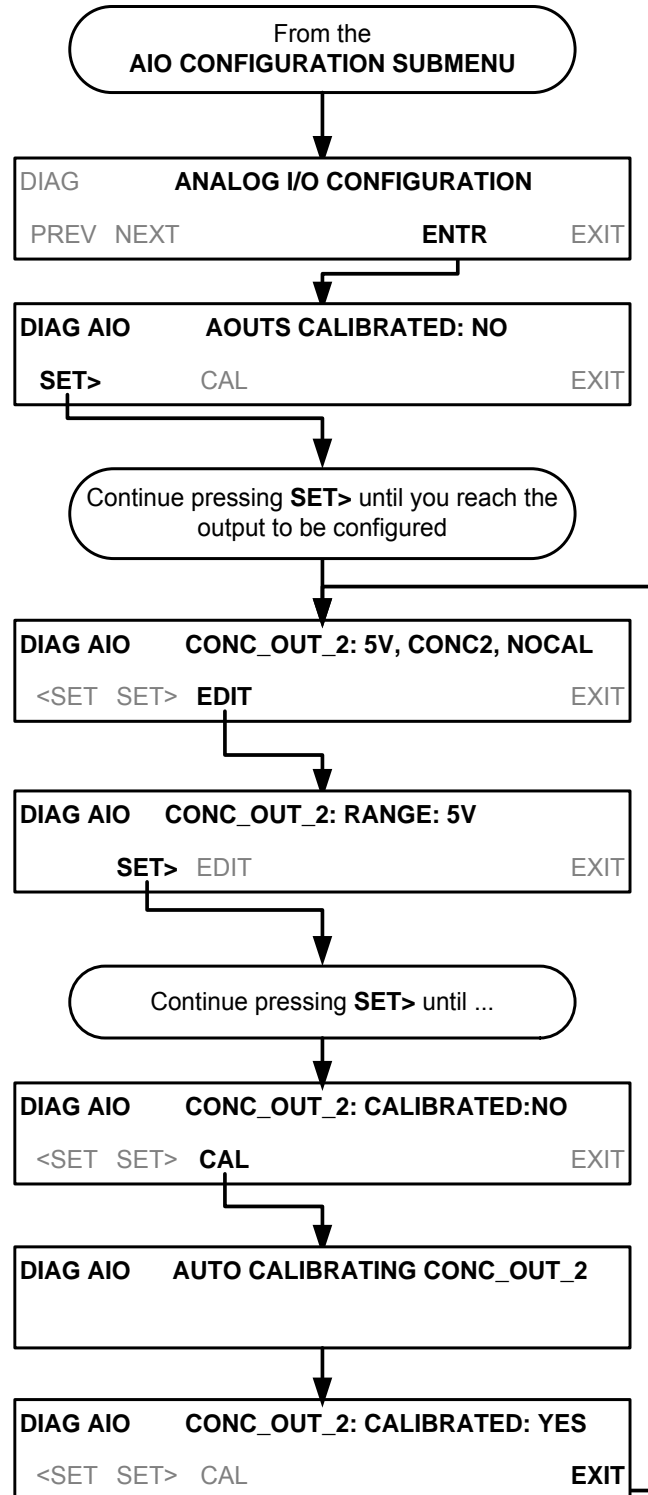
Before performing this procedure, ensure that the **AUTO CAL** for each analog output is enabled. (See Section 6.8.3.3).

To calibrate the outputs as a group with the **AOUTS CALIBRATION** command, select the **ANALOG I/O CONFIGURATION** submenu (see Figure 6-5) then press:



6.8.3.5. 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 Figure 6-5) then press:



6.8.3.6. 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 6.8.3.3).

Calibration is performed with a voltmeter connected across the output terminals and by changing the actual output signal level using the front panel buttons in 100, 10 or 1 count increments. See Figure 3-6 for pin assignments and diagram of the analog output connector.

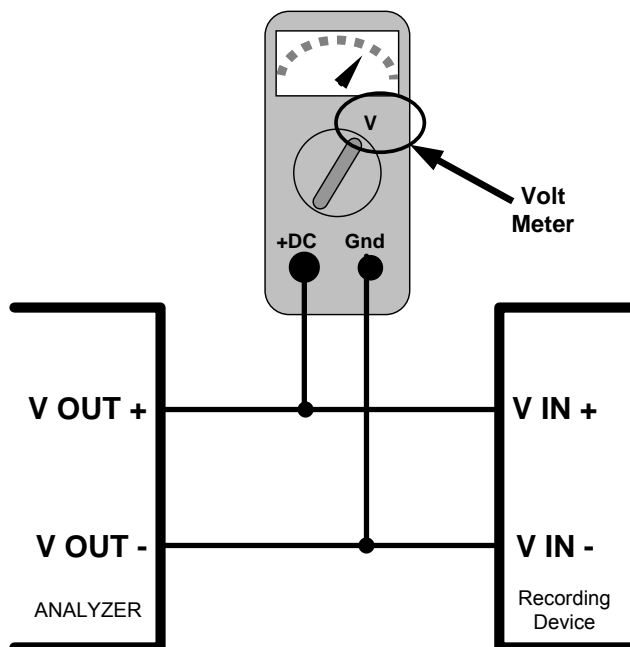
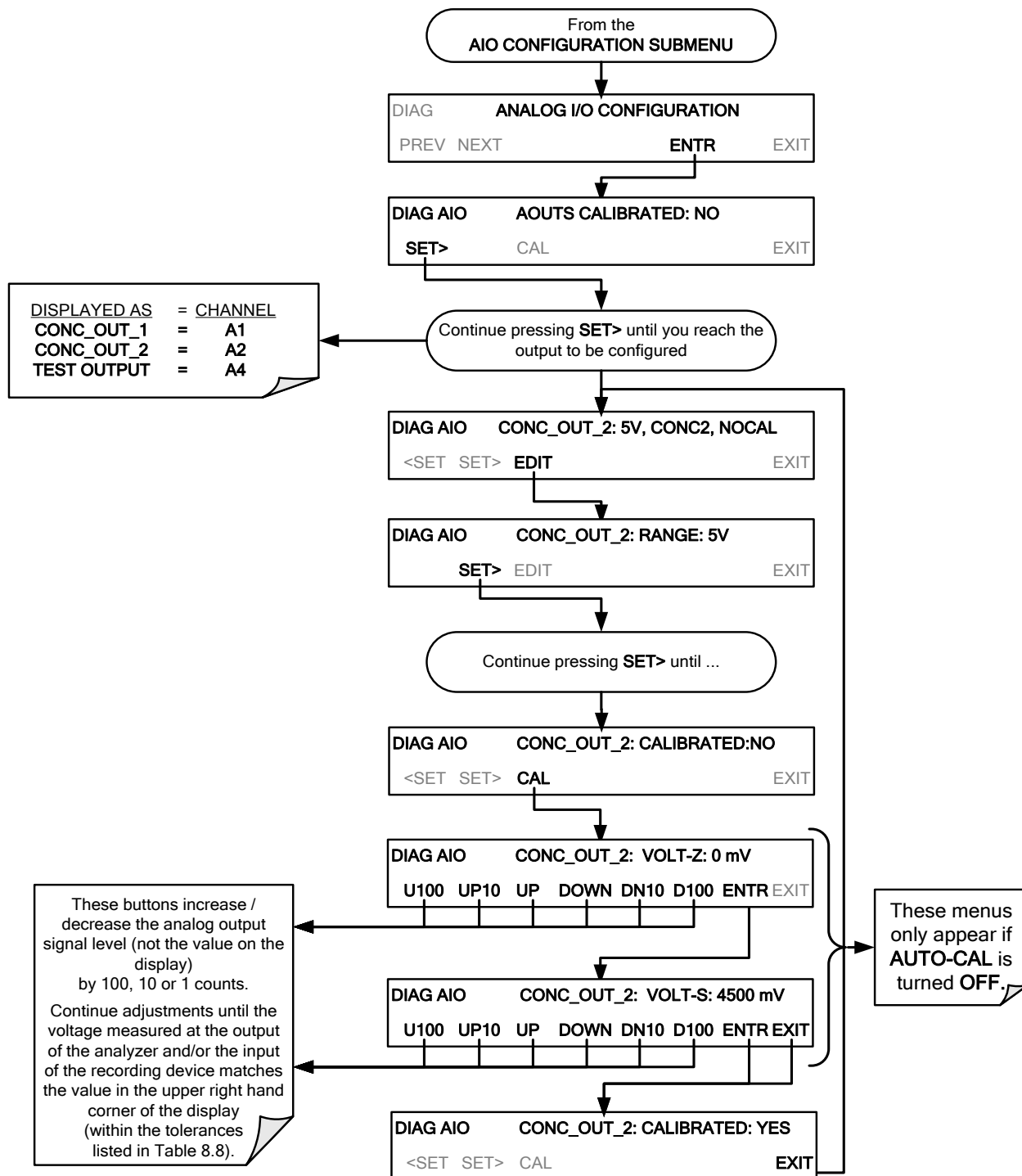


Figure 6-6: Setup for Checking / Calibrating DCV Analog Output Signal Levels

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

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

To adjust the signal levels of an analog output channel manually, select the **ANALOG I/O CONFIGURATION** submenu (see Figure 6-5) then press:



6.8.3.7. MANUAL ADJUSTMENT OF CURRENT LOOP OUTPUT SPAN AND OFFSET

A current loop option may be purchased for the **A1** and **A2** Analog outputs of the analyzer. This option places circuitry in series with the output of the D-to-A converter on the motherboard that changes the normal DC voltage output to a 0-20 milliamp signal (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 6.8.3.1 (select **CURR** from the list of options on the “Output Range” menu).

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

The software allows this adjustment to be made in 100, 10 or 1 count increments. Since the exact amount by which the current signal is changed per D-to-A count varies from output-to-output and instrument-to-instrument, you will need to measure the change in the signal levels with a separate, current meter placed in series with the output circuit. See Figure 3-6 for pin assignments and diagram of the analog output connector.

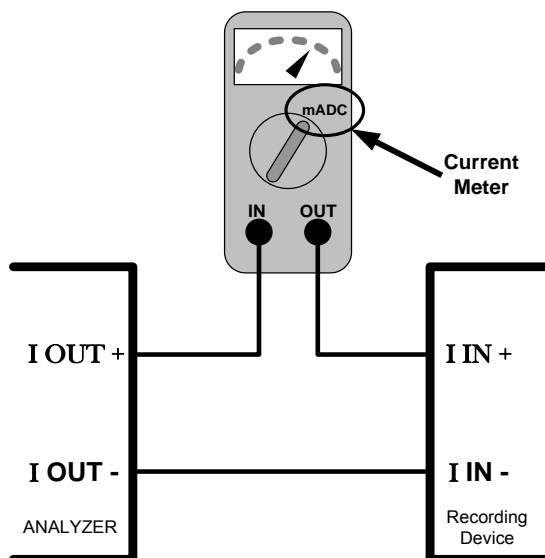


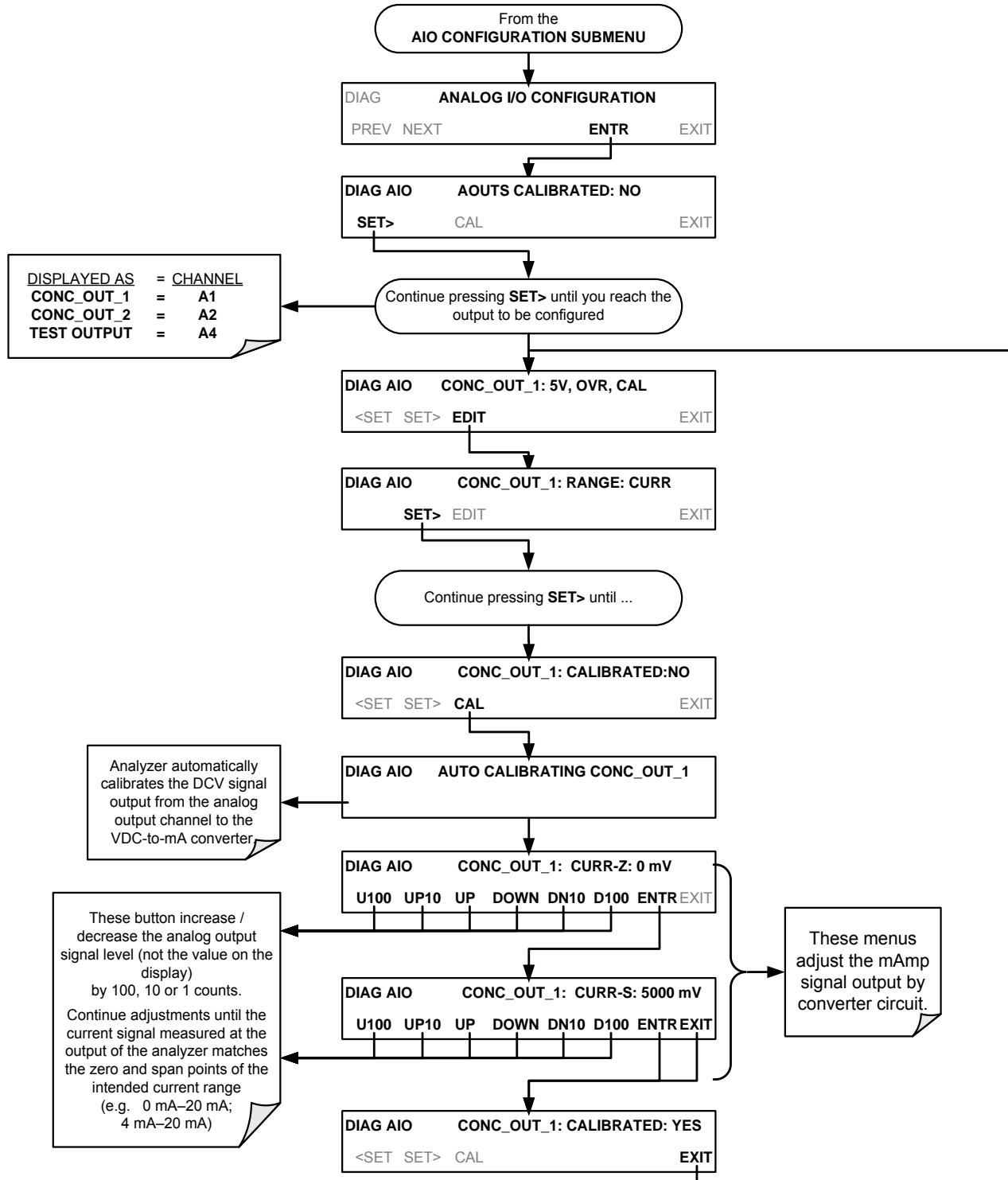
Figure 6-7: Setup for Checking / Calibration Current Output Signal Levels Using an Ammeter



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 Figure 6-5) then press:



An alternate method for measuring the output of the Current Loop converter is to connect a 250 ohm $\pm 1\%$ resistor across the current loop output in lieu of the current meter (see Figure 3-6 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.

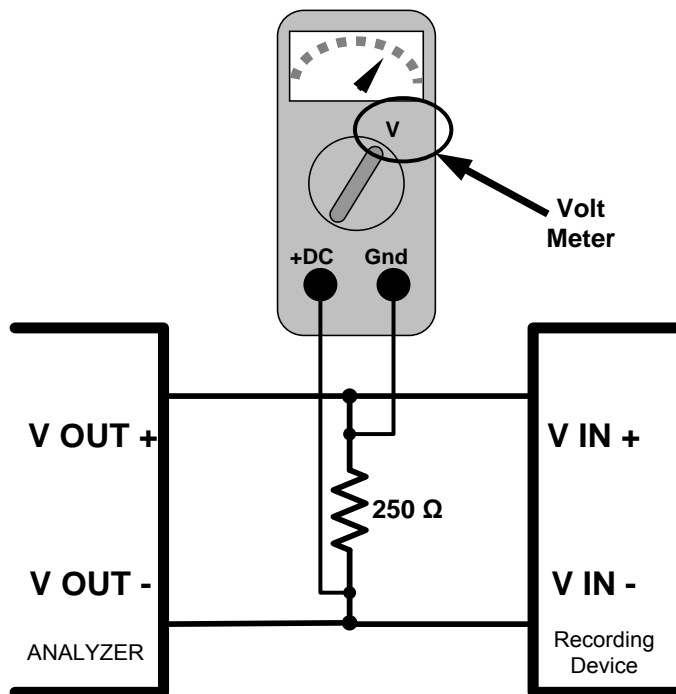


Figure 6-8: Alternative Setup Using 250Ω Resistor for Checking Current Output Signal Levels

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

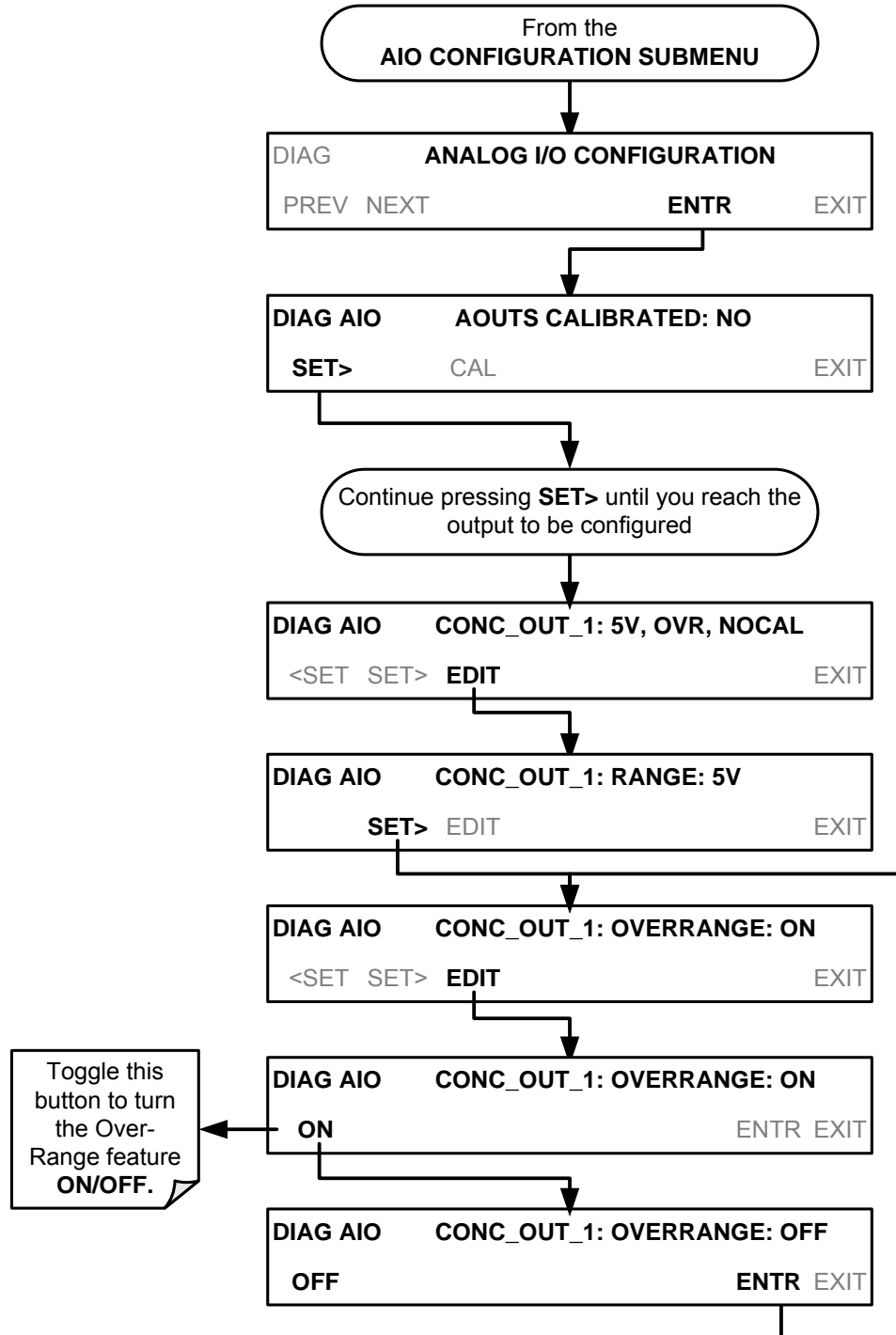
Table 6-7: Current Loop Output Check

% 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

6.8.3.8. TURNING THE ANALOG OUTPUT OVER-RANGE FEATURE ON/OFF

In its default configuration, a $\pm 5\%$ over-range is available on each of the T500U's analog outputs. This over-range can be disabled if your recording device is sensitive to excess voltage or current.

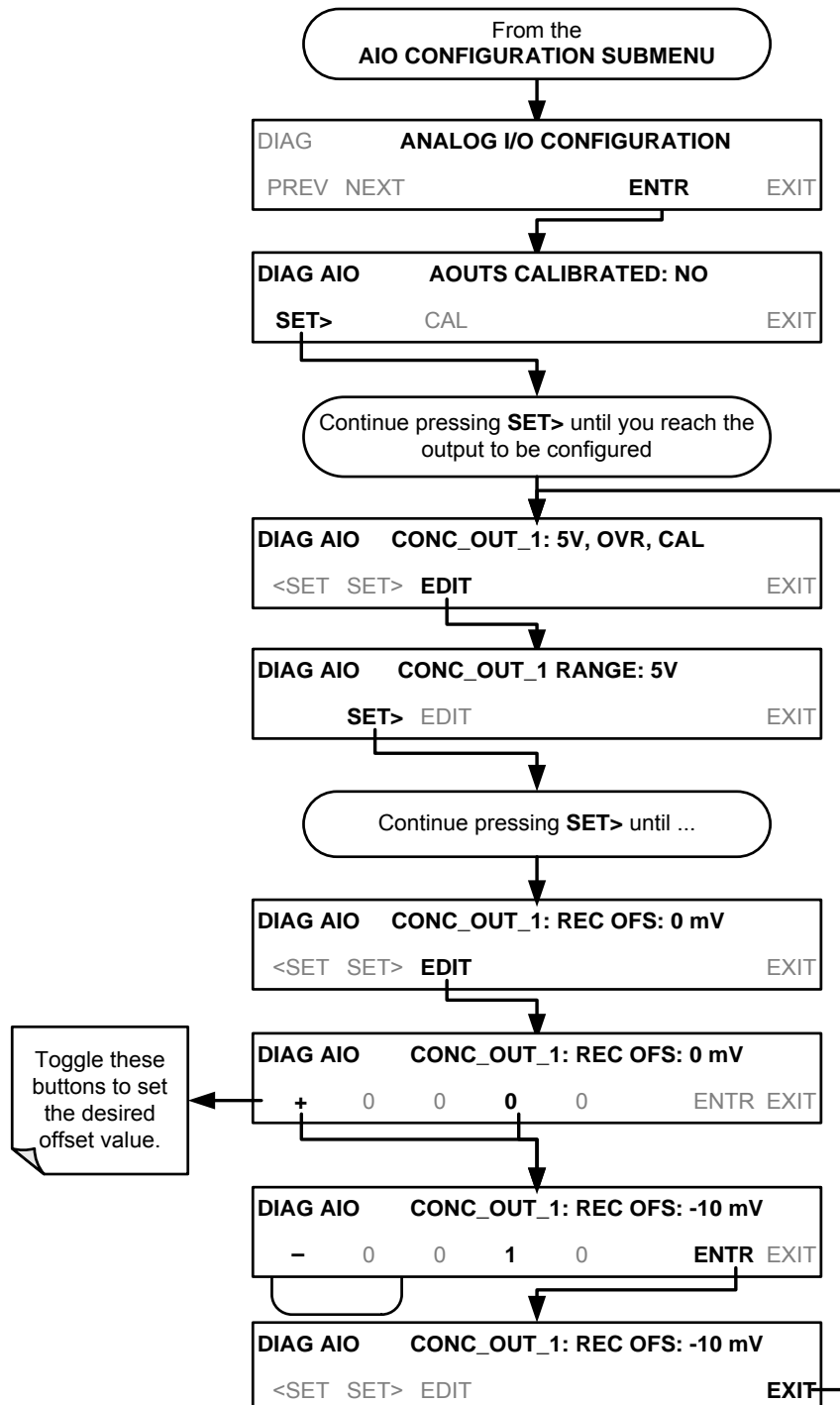
To turn the over-range feature on or off, select the **ANALOG I/O CONFIGURATION** submenu (see Figure 6-5) then press:



6.8.3.9. 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 T500U by defining a zero offset, a small voltage (e.g., 10% of span).

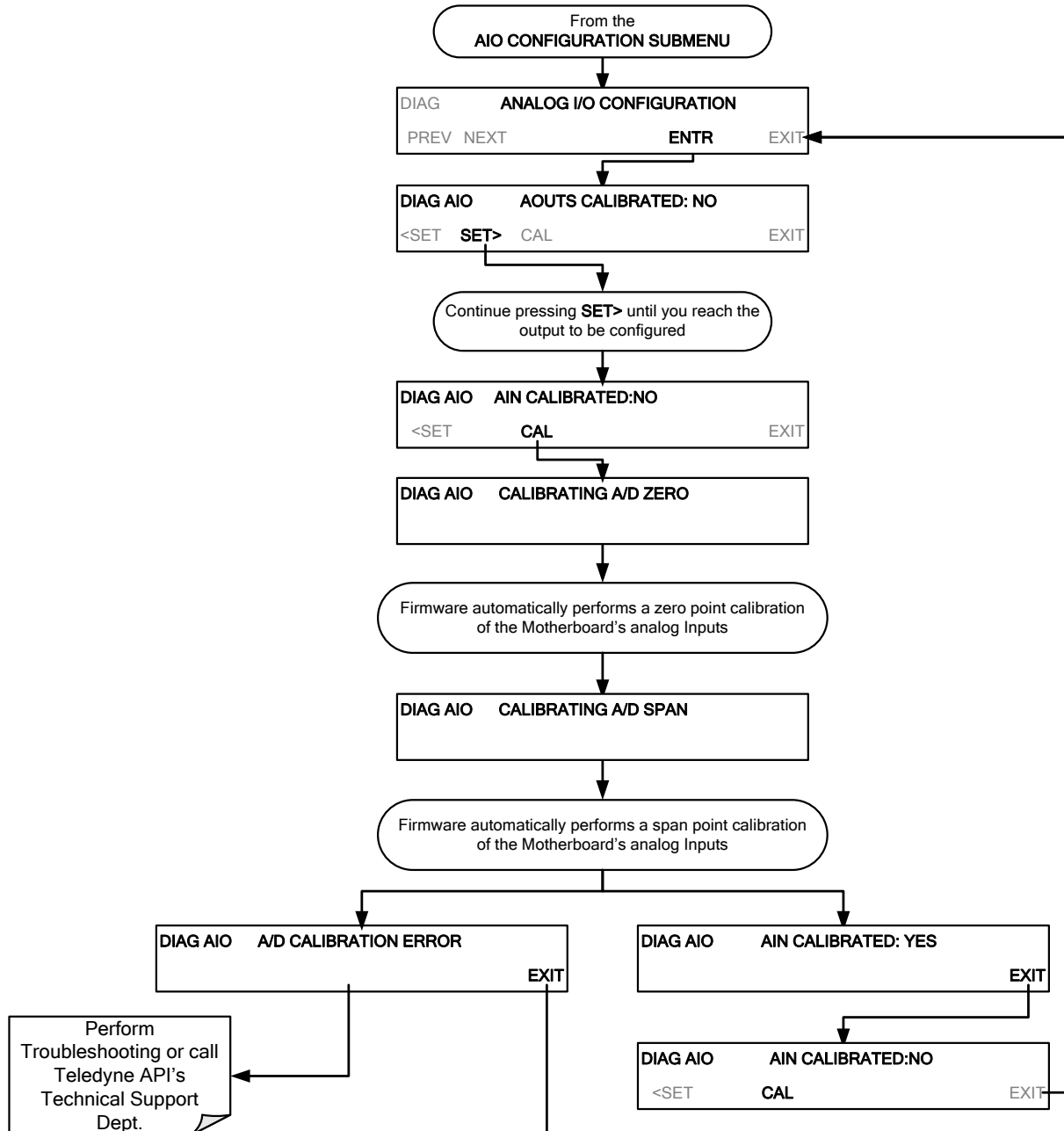
To add a zero offset to a specific analog output channel, select the **ANALOG I/O CONFIGURATION** submenu (see Figure 6-5) then press:



6.8.3.10. AIN (ANALOG INPUTS) CALIBRATION

This is the submenu to conduct a calibration of the T500U 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 Figure 6-5) then press:



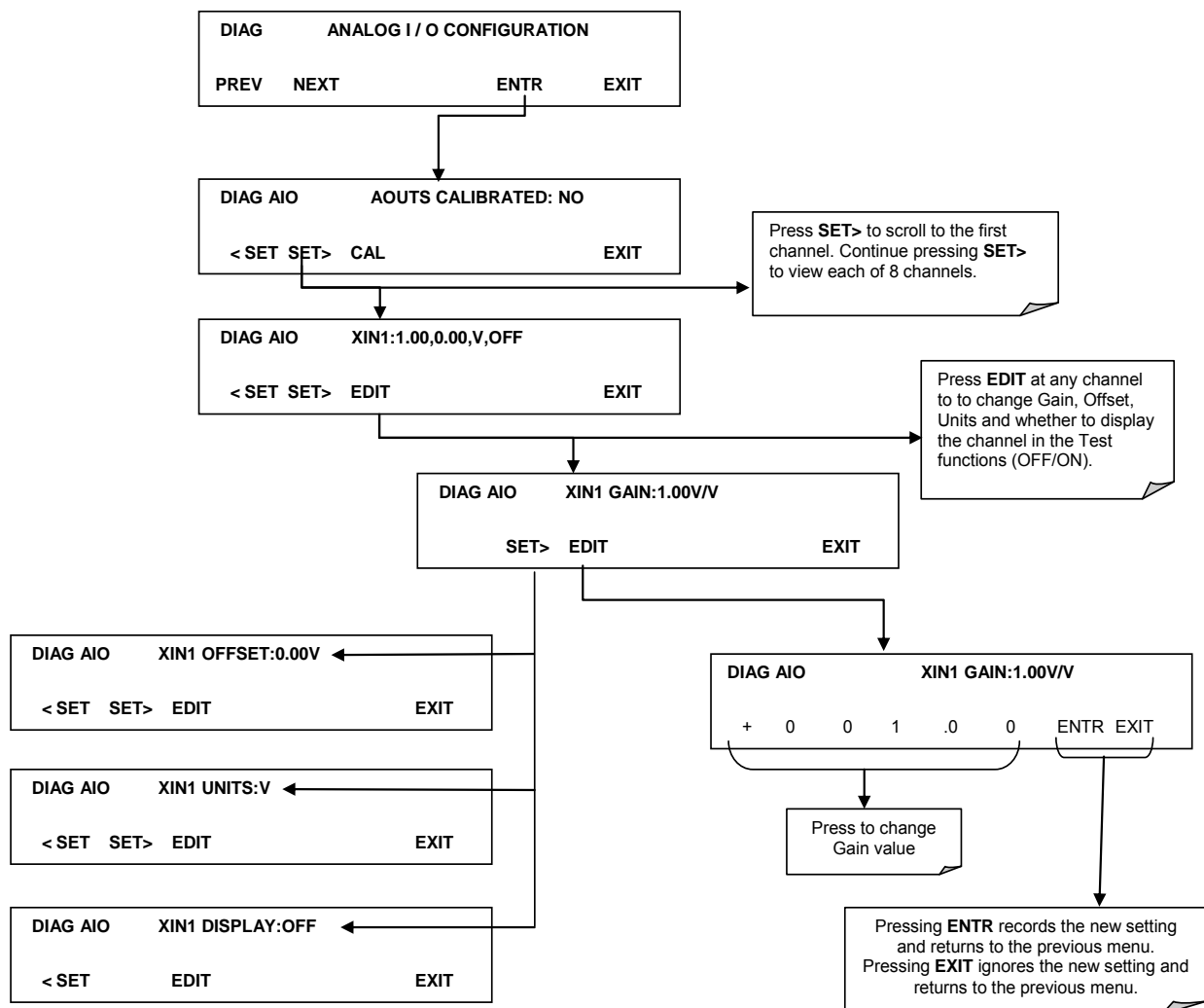
6.8.3.11. EXTERNAL ANALOG INPUTS (XIN1...XIN8) OPTION CONFIGURATION

To configure the analyzer's optional external 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

These parameters can also be captured in the internal Data Acquisition System (DAS); refer to Appendix A for Analog-In DAS parameters.

To adjust settings for the Analog Inputs option parameters press:



6.8.4. TEST CHAN OUTPUT (SELECTING A TEST CHANNEL FUNCTION FOR OUTPUT A4)

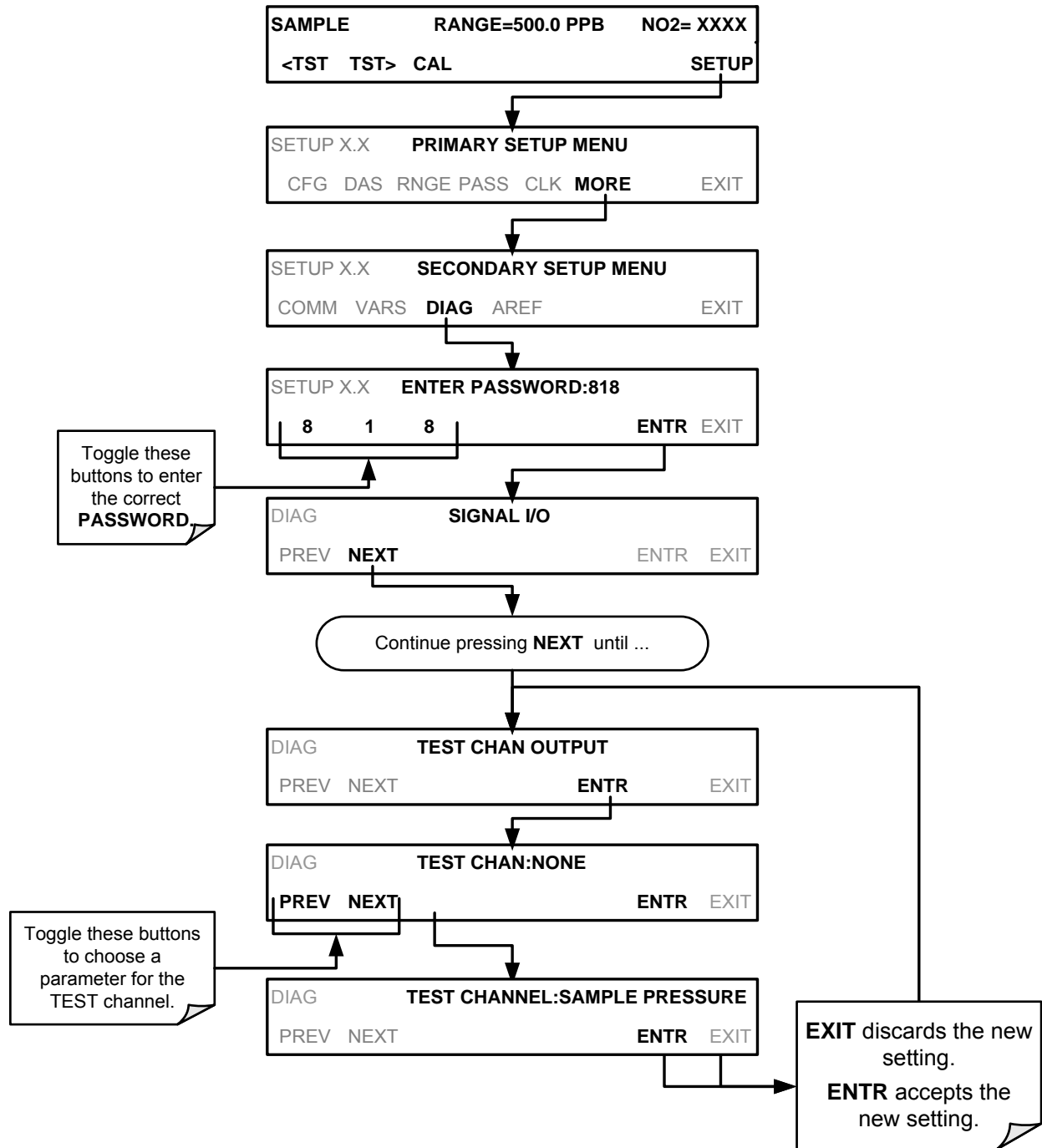
The test functions available to be reported are listed in Table 6-8:

Table 6-8: Test Channels Functions available on the T500U's Analog Output

TEST CHANNEL	DESCRIPTION	ZERO	FULL SCALE
NONE	<i>TEST CHANNEL IS TURNED OFF</i>		
SMP PRS	The pressure of the sample gas measured at the entrance of the Optical bench.	Ambient InHg-A	32 InHg-A
SMP TEMP	The temperature of the sample gas measured at the exhaust of the Optical bench.	0 °C	70 °C
MEASURED LOSS	Optical loss in the bench.	400-800 Mm-1	1800 Mm-1
OVEN TEMP	The temperature of the internal oven.	0 °C	70 °C
BOX TEMP	The temperature inside the chassis.	0 °C	70 °C
MANIFOLD TEMP	Option –Temperature of heated manifold.	0 °C	70 °C
IZS TEMP	The temperature inside the 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 in the front panel display.

To activate the **TEST** Channel and select a function, press:



6.8.5. NO₂ LED DISABLE

This feature is available if the LED is suspected of causing faulty readings (readings that don't make sense). Access NO₂ LED DISABLE in the SETUP>MORE>DIAG>... menu, and press ENTR, YES/NO to turn the LED ON or OFF.

6.8.6. PUMP DISABLE

This parameter in the DIAG menu is to turn the internal pump ON or OFF while keeping the instrument running. This is an important feature when maintenance is required where reading the front panel display is necessary, such as for the internal bench.

6.9. SETUP>MORE>AREF:

At 20 minutes after power up and periodically thereafter, the analyzer conducts a background measurement, known as an auto reference (AREF), whereby the sample is routed through an internal charcoal scrubber. This measurement accounts for drift in the baseline loss. A manual AREF is recommended prior to initial calibration (Section 5.3).

Please note that AREF becomes disabled during calibration if the instrument stays in calibration mode (CALZ or CALS) for longer than it would normally take to run a calibration. To ensure that AREF is enabled, return to SAMPLE mode after conducting a calibration.

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7. COMMUNICATIONS SETUP AND OPERATION

Communication 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 8.

7.1. DATA TERMINAL/COMMUNICATION EQUIPMENT (DTE DEC)

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

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

To allow the analyzer to be used with terminals (DTE), modems (DCE) and computers (which can be either), a switch mounted below the serial ports on the rear panel labeled **DCE DTE** (Figure 3-3) allows the user to set the RS-232 configuration for one of these two data devices. This switch exchanges the Receive and Transmit lines on RS-232 emulating a cross-over or null-modem cable. The switch has no effect on COM2.

7.2. 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 configuring the COM2 baud rate (Section 7.2.2).

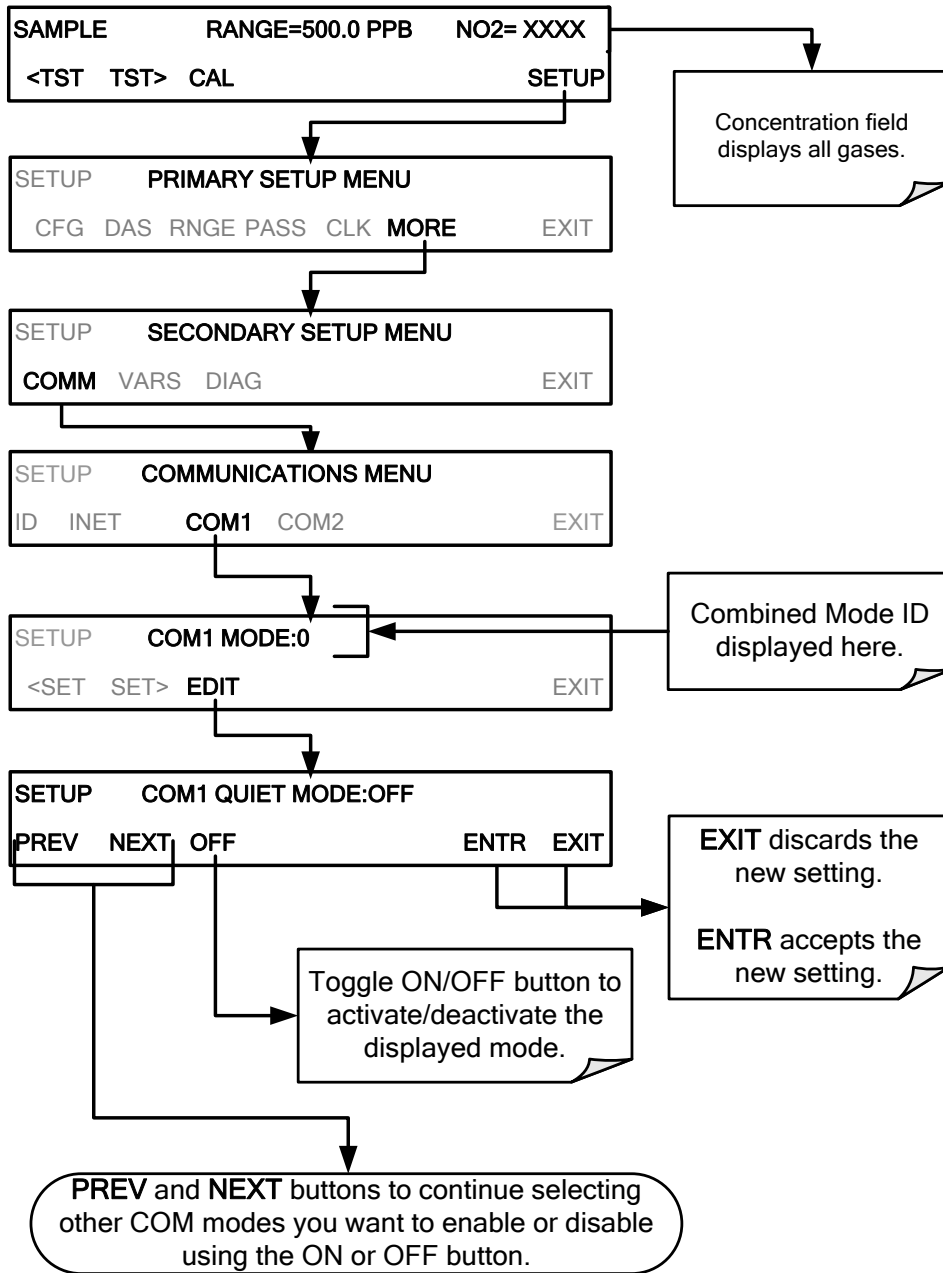
7.2.1. COMMUNICATION MODES

Each of the analyzer's serial ports can be configured to operate in a number of different modes, listed in Table 7-1. 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 7-1: COM port Communication Modes

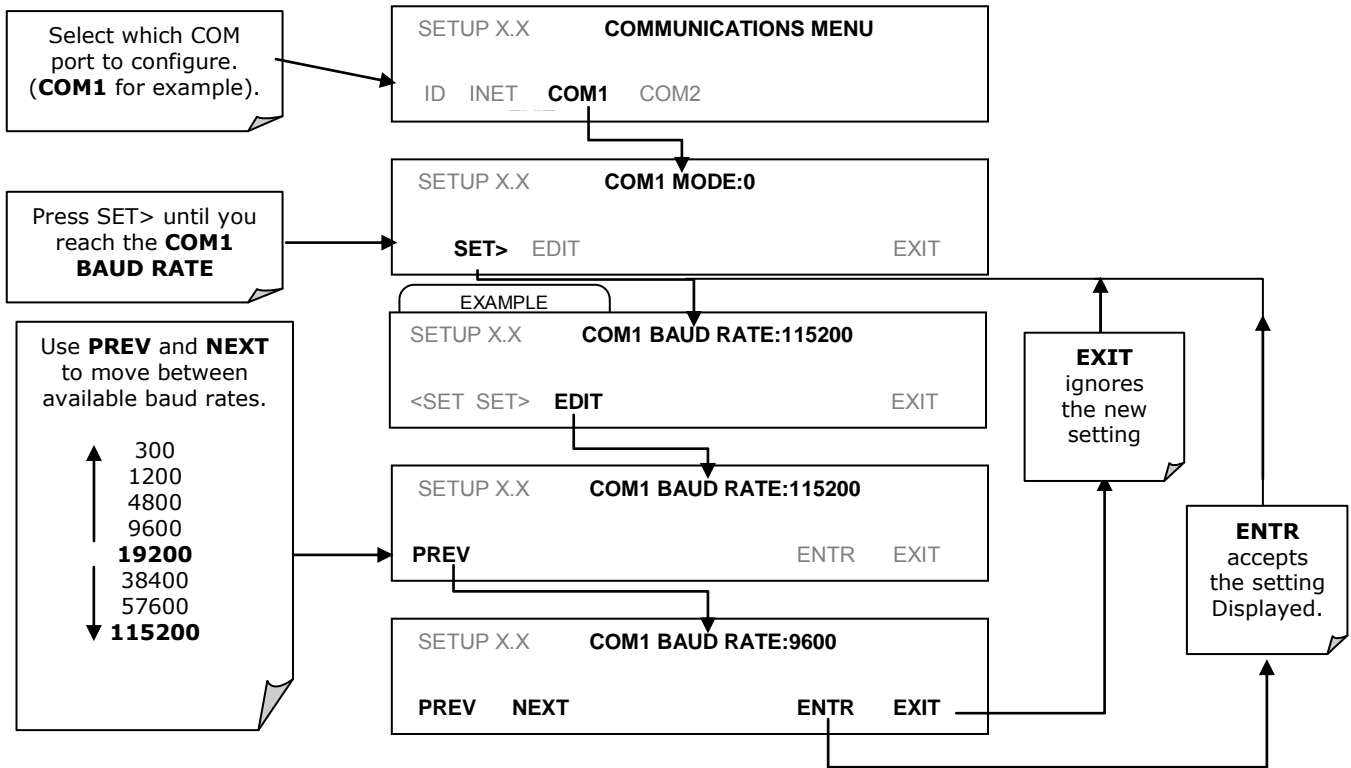
MODE ¹	ID	DESCRIPTION
QUIET	1	Quiet mode suppresses any feedback from the analyzer (such as warning messages) to the remote device and is typically used when the port is communicating with a computer program where such intermittent messages might cause communication problems. Such feedback is still available 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.
(RESERVED)	16	
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. Also, configuring for RS-485 disables the rear panel USB port.
SECURITY	4	When enabled, the serial port requires a password before it will respond (see Section 6.4). 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 ²	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 → COMM → COM[1 OR 2] → MODE menu ² The default setting for this feature is ON . Do not disable unless so instructed by Teledyne API's Technical Support personnel.		

Communication Modes for each COM port being used must be configured independently. To turn on or off the communication modes for either COM1 or COM2, access the **SETUP>MORE>[COM1 OR COM2]** menu, and at the COM1 [2] Mode menu press **EDIT**.



7.2.2. COM PORT BAUD RATE

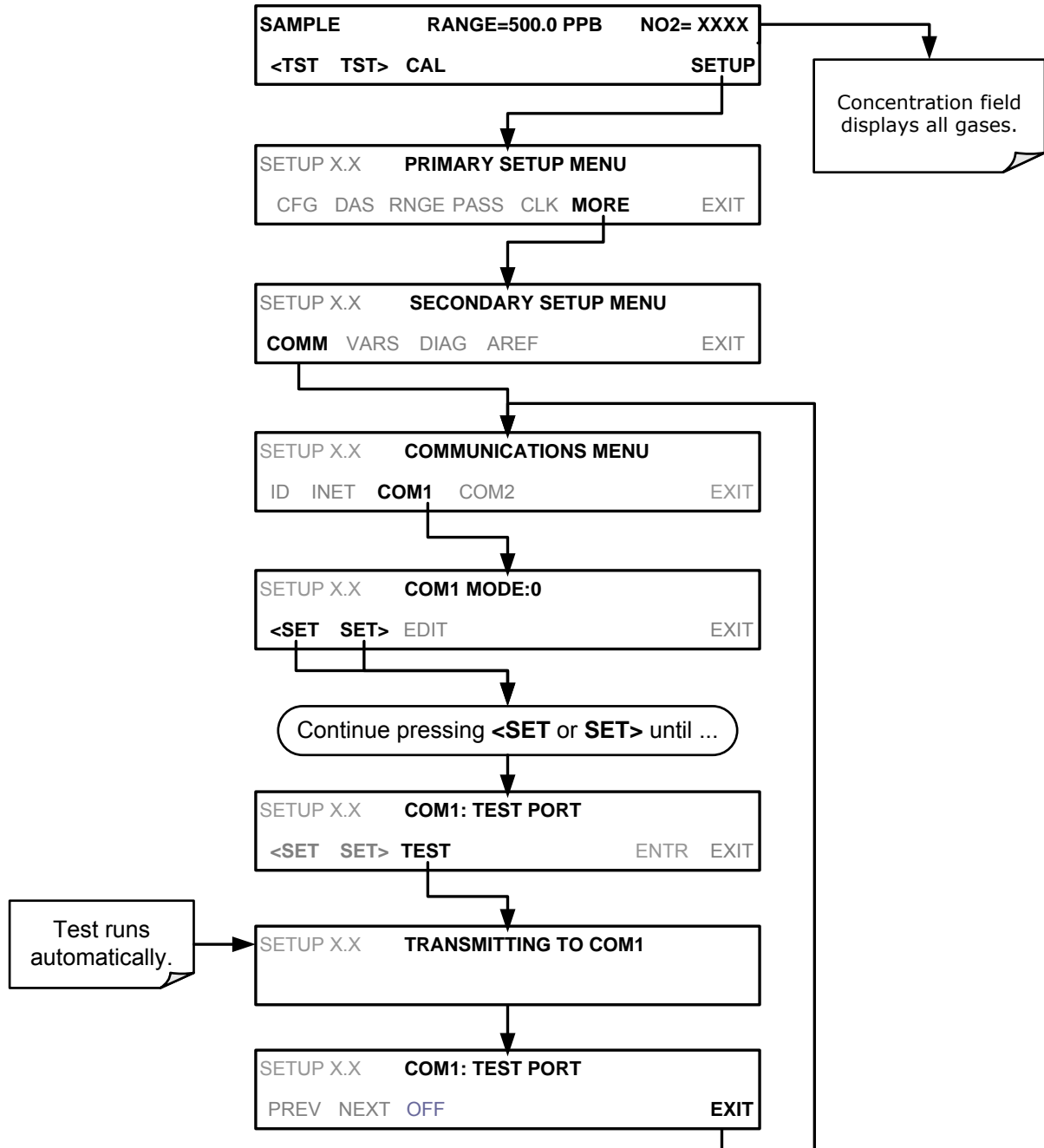
To select the baud rate of either COM port, go to **SETUP>MORE>COMM** and select either **COM1** or **COM2** as follows (use **COM2** to view/match your personal computer baud rate when using the USB port, Section 7.6):



7.2.3. COM PORT TESTING

The serial ports can be tested for correct connection and output in the COMM 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 button sequence:



7.3. RS-232

The RS232 and COM2 communications (COMM) ports operate on the RS-232 protocol (default configuration). Possible configurations for these two COM ports are summarized as follows:

- **RS232** port can also be configured to operate in single or RS-232 Multidrop mode (Option 62); refer to Section 3.3.1.8.
- **COM2** port can be left in its default configuration for standard RS-232 operation including multidrop, or it can be reconfigured for half-duplex RS-485 operation (please contact the factory for this configuration).

Note that the **COM2** port and the USB port cannot be used simultaneously except when COM2 is used for multidrop communication.

A code-activated switch (CAS) can also be used on either RS232 or COM2 port to connect typically between 2 and 16 send/receive instruments (host computer(s) printers, data loggers, analyzers, monitors, calibrators, etc.) into one communications hub. Contact Teledyne API Sales for more information on CAS systems.

To configure the analyzer's communication ports, use the **SETUP>MORE>COMM** menu (Section 6.6), and configure per Section 7.2 information.

7.4. RS-485 (OPTION)

The COM2 port of the instrument's rear panel is set up for RS-232 communication but can be reconfigured for RS-485 communication. Contact Technical Support. If this option was elected at the time of purchase, the rear panel was preconfigured at the factory. USB communications is not available when RS-485 is configured.

7.5. ETHERNET

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

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

Table 7-2: 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 (Section 7.5.2). 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 7.5.1 below details static IP address configuration.

7.5.1. CONFIGURING ETHERNET COMMUNICATION MANUALLY (STATIC IP ADDRESS)

To configure Ethernet communication manually:

1. Connect a cable from the analyzer's Ethernet port to a Local Area Network (LAN) or Internet port.
2. From the analyzer's front panel touchscreen, access the Communications Menu (SETUP>MORE>COMM, see Figure 6-2).
3. Enter the INET menu shown in Figure 7-1, turning DHCP mode to OFF and editing the Instrument and Gateway IP addresses and Subnet Mask to the desired settings (default settings shown in Table 7-3).

Alternatively, from the computer, enter the same information through an application such as HyperTerminal.

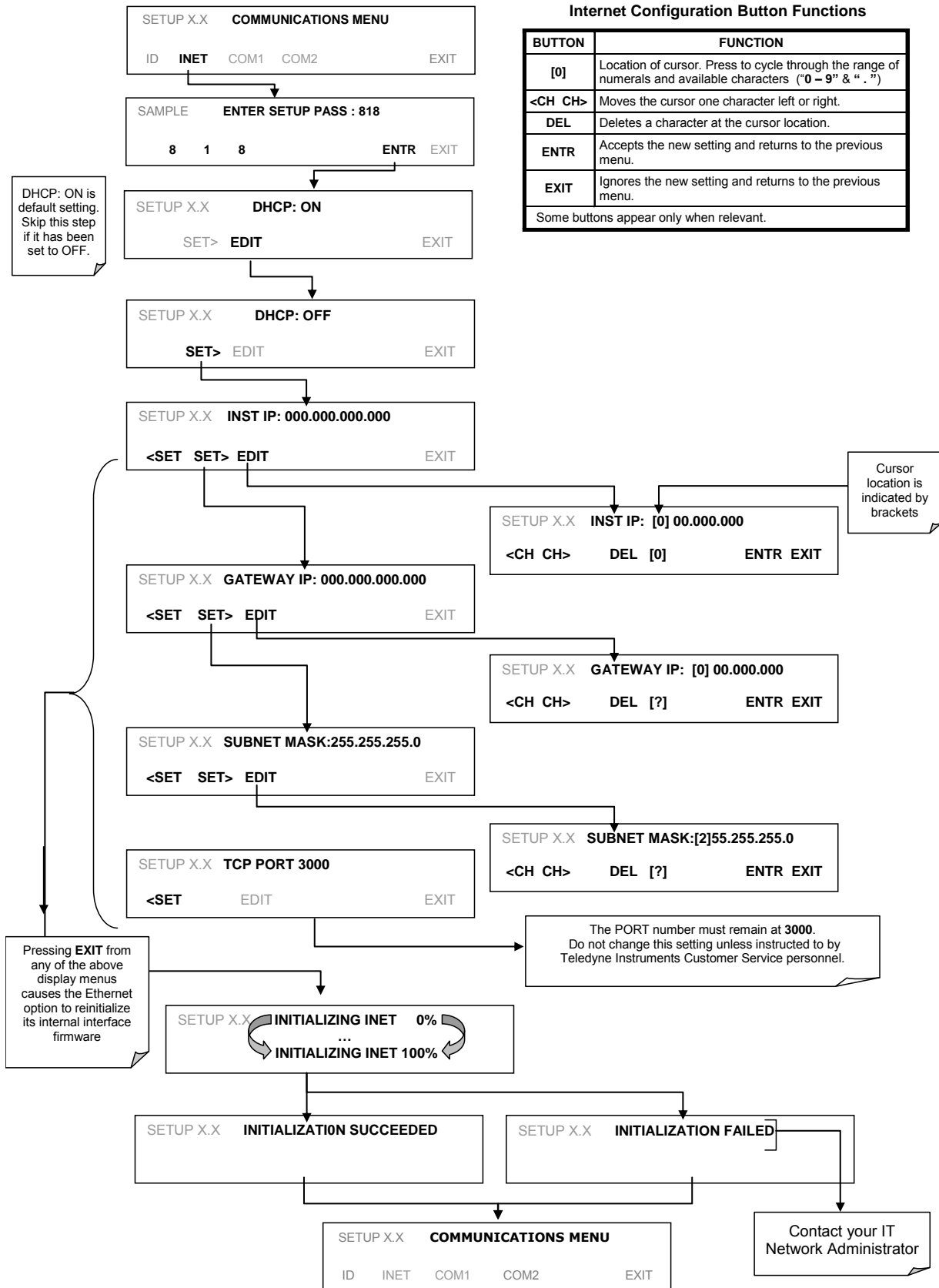


Figure 7-1: COMM - LAN /Internet Manual Configuration

Table 7-3: LAN/Ethernet Default 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	[initially blank]	The name by which your analyzer will appear when addressed from other computers on the LAN or via the Internet. To assign or change, see Section 7.5.2.1.
¹ Do not change the setting for this property unless instructed to by Teledyne API's Technical Support personnel.		

7.5.2. CONFIGURING ETHERNET COMMUNICATION USING DYNAMIC HOST CONFIGURATION PROTOCOL (DHCP)

The default Ethernet setting is DHCP.

1. Consult with your network administrator to affirm that your network server is running DHCP.
2. Access the Communications Menu (SETUP>MORE>COMM, see Figure 6-2).
3. Enter the INET menu and follow the setup sequence as follows:

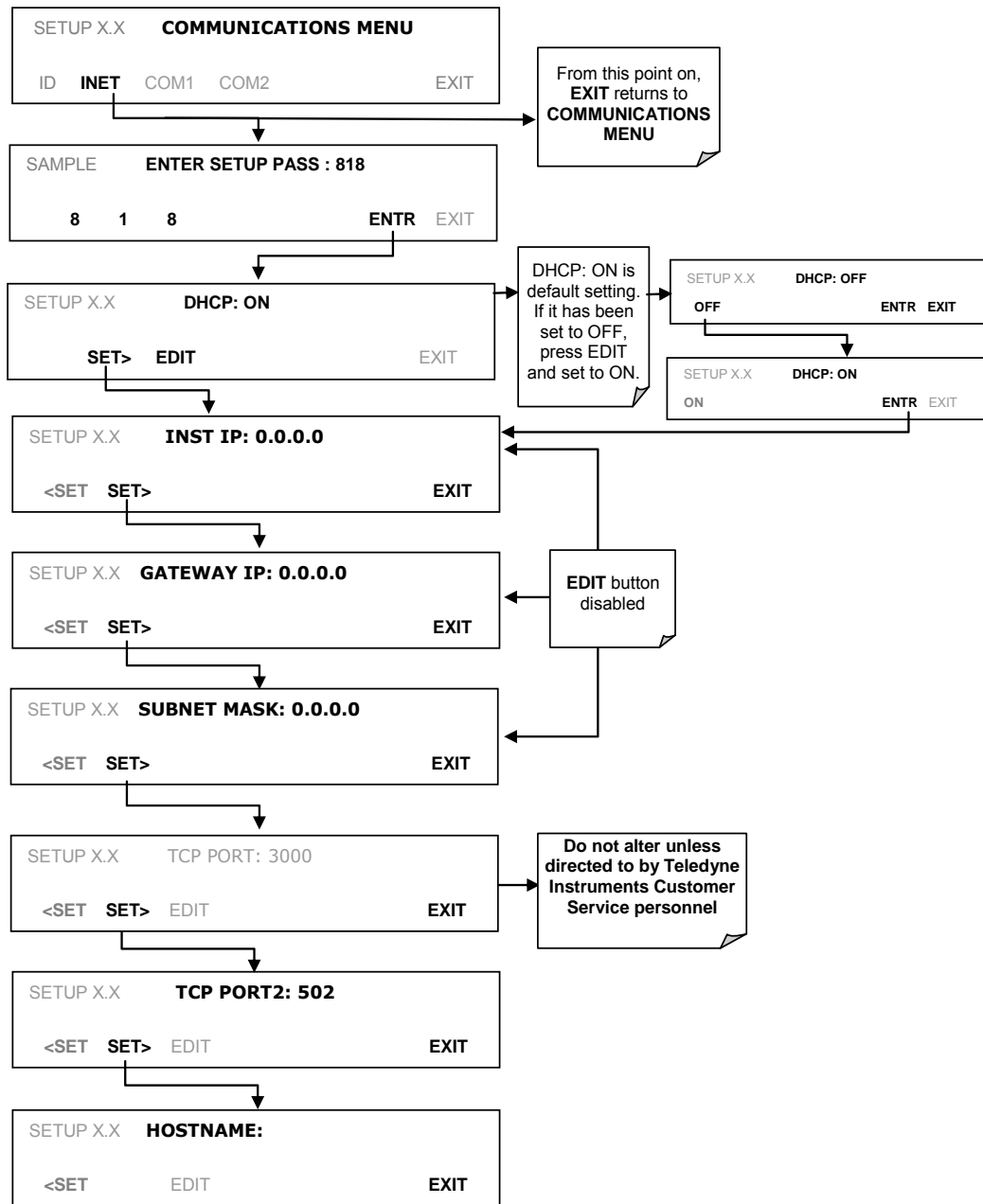


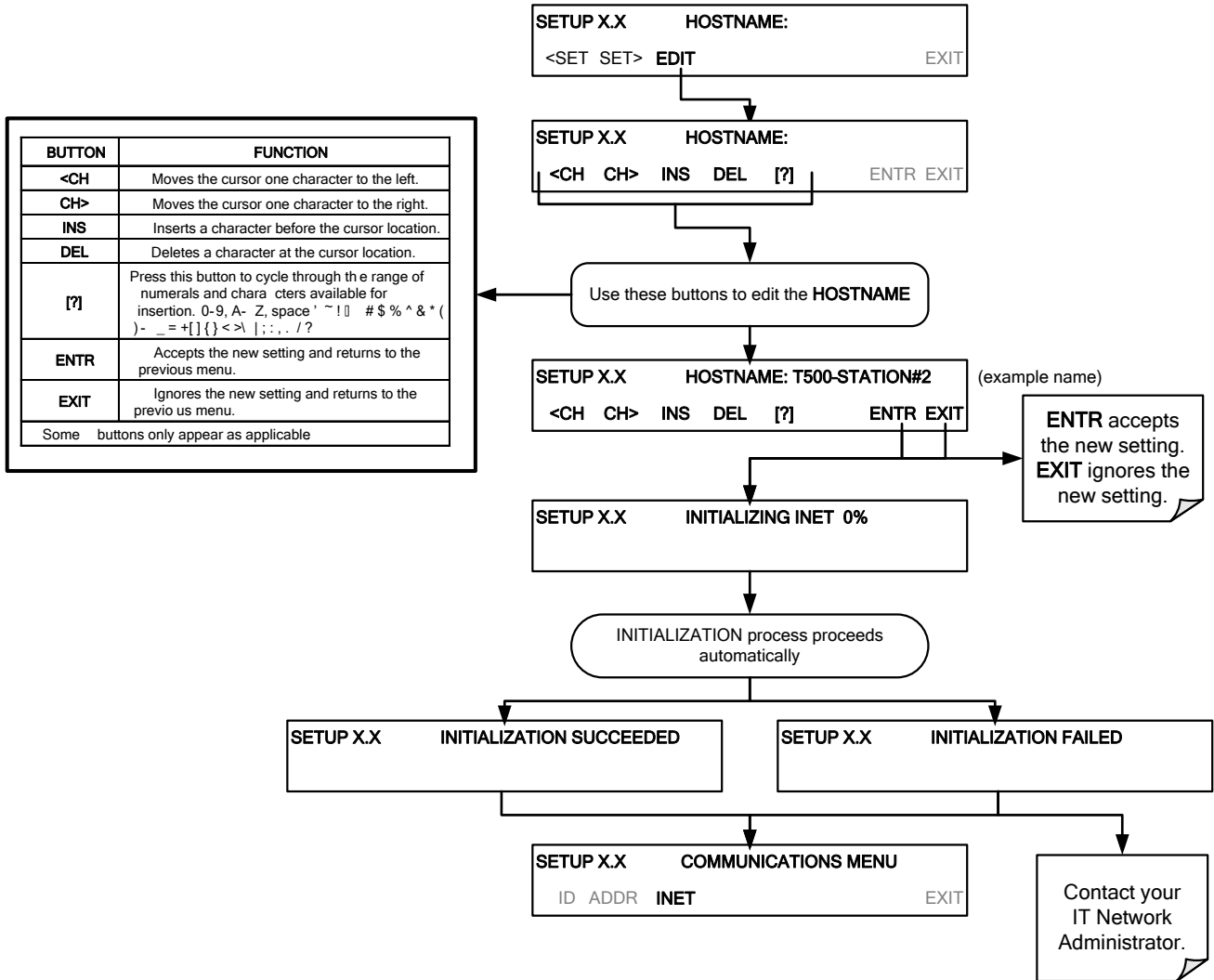
Figure 7-2: COMM – LAN / Internet Automatic Configuration (DHCP)

Note

If the gateway IP, instrument IP and the subnet mask are all zeroes (i.e., "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.

7.5.2.1. CHANGING THE ANALYZER'S HOSTNAME

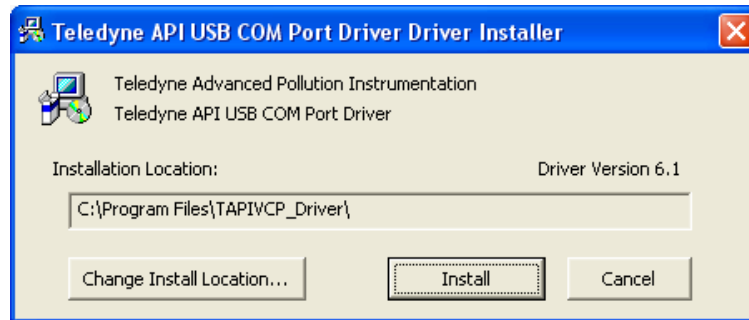
The **HOSTNAME** is the name by which the analyzer appears on your network. The initial default Hostname is blank. To assign or change this name (particularly if you have more than one T500U analyzer on your network, where each must have a different Hostname), enter the **SETUP>COMM>INET** menu and scroll to the **HOSTNAME** menu as in Figure 7-2; make the changes as follows:



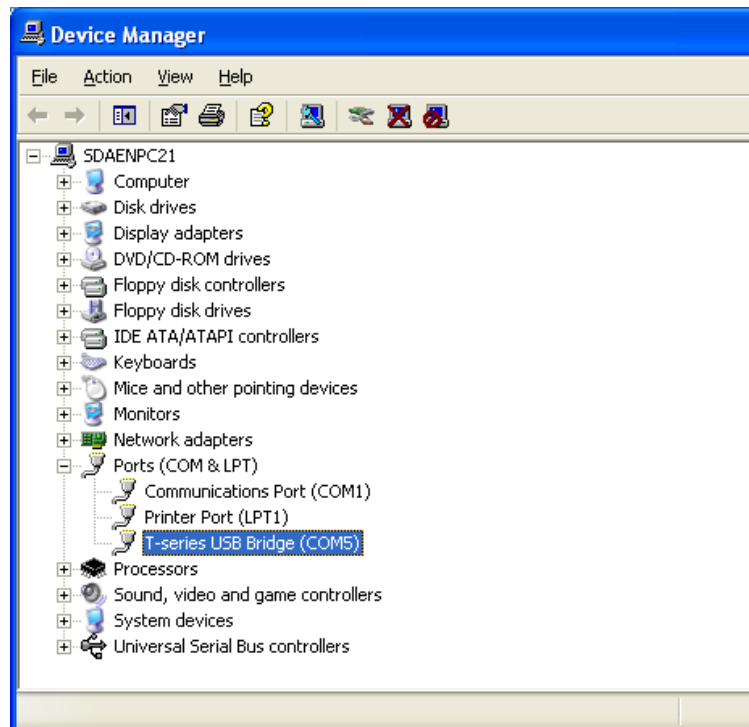
7.6. USB PORT FOR REMOTE ACCESS

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.

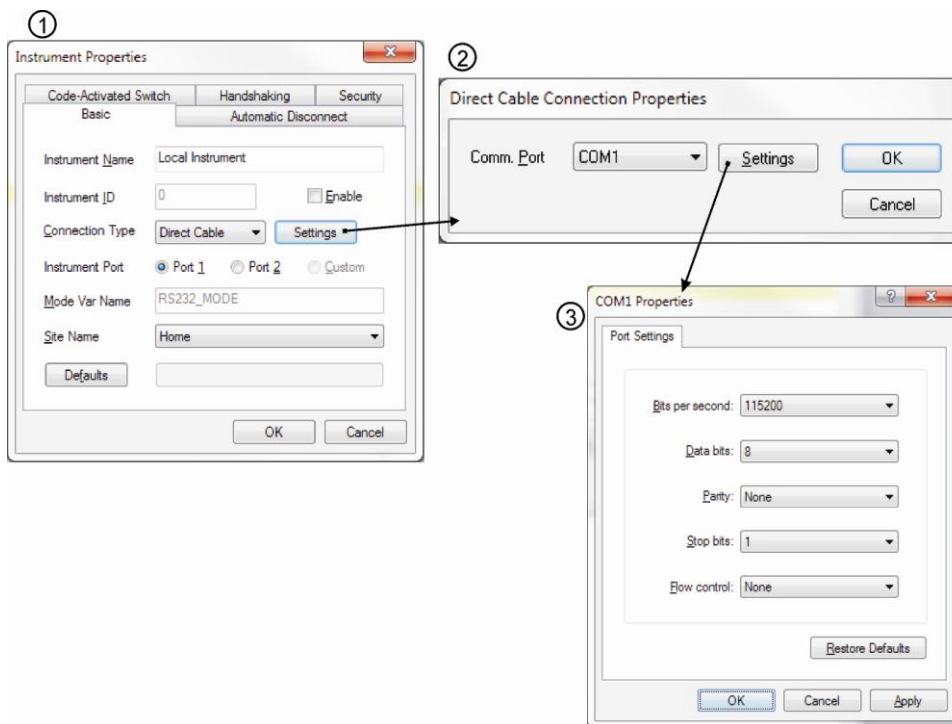
5. In the instrument's SETUP>MORE>COMM>COM2 menu, make the following settings:

Baud Rate: 115200

COM2 Mode Settings:

Quiet Mode	ON
Computer Mode	ON
MODBUS RTU	OFF
MODBUS ASCII	OFF
E,8,1 MODE	OFF
E,7,1 MODE	OFF
RS-485 MODE	OFF
SECURITY MODE	OFF
MULTIDROP MODE	OFF
ENABLE MODEM	OFF
ERROR CHECKING	ON
XON/XOFF HANDSHAKE	OFF
HARDWARE HANDSHAKE	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

Using the USB port disallows use of the rear panel COM2 port except for multidrop communication.

7.7. COMMUNICATIONS PROTOCOLS

Communication protocols include Hessen and MODBUS.

7.7.1. 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. Teledyne API's implementation supports both of these principal features.

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

7.7.1.1. HESSEN COM PORT CONFIGURATION

Hessen protocol requires the communication parameters of the T500U's COM ports to be set differently than the standard configuration as shown in the table below.

Table 7-4: RS-232 Communication Parameters for Hessen Protocol

PARAMETER	STANDARD	HESSEN
Baud Rate	300 – 19200	1200
Data Bits	8	7
Stop Bits	1	2
Parity	None	Even
Duplex	Full	Half

To change the baud rate of the T500U's COM ports, See Section 7.2.2.

To change the remaining COM port parameters listed in the table above, see Section 7.2.1, Table 7-1.

Note

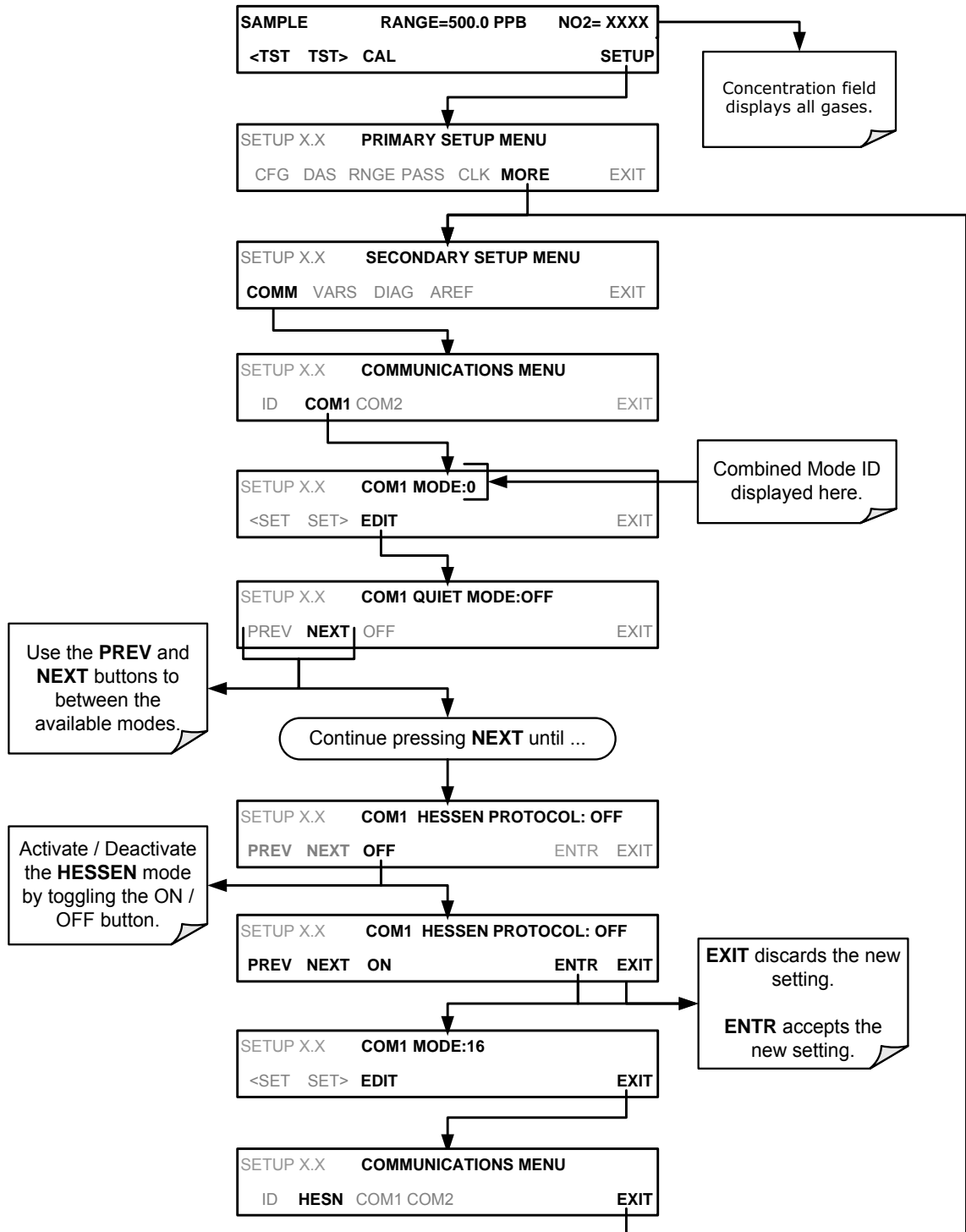
Ensure that the communication parameters of the host computer are also properly set.

Also, the instrument software has a 200 ms latency period before it responds to commands issued by the host computer. This latency should present no problems, but you should be aware of it and only issue commands to the instrument at an appropriate pace.

7.7.1.2. ACTIVATING HESSEN PROTOCOL

Once the COM port has been properly configured, the next step is to activate the Hessen mode for COM ports and configure the communication parameters for the port(s) appropriately.

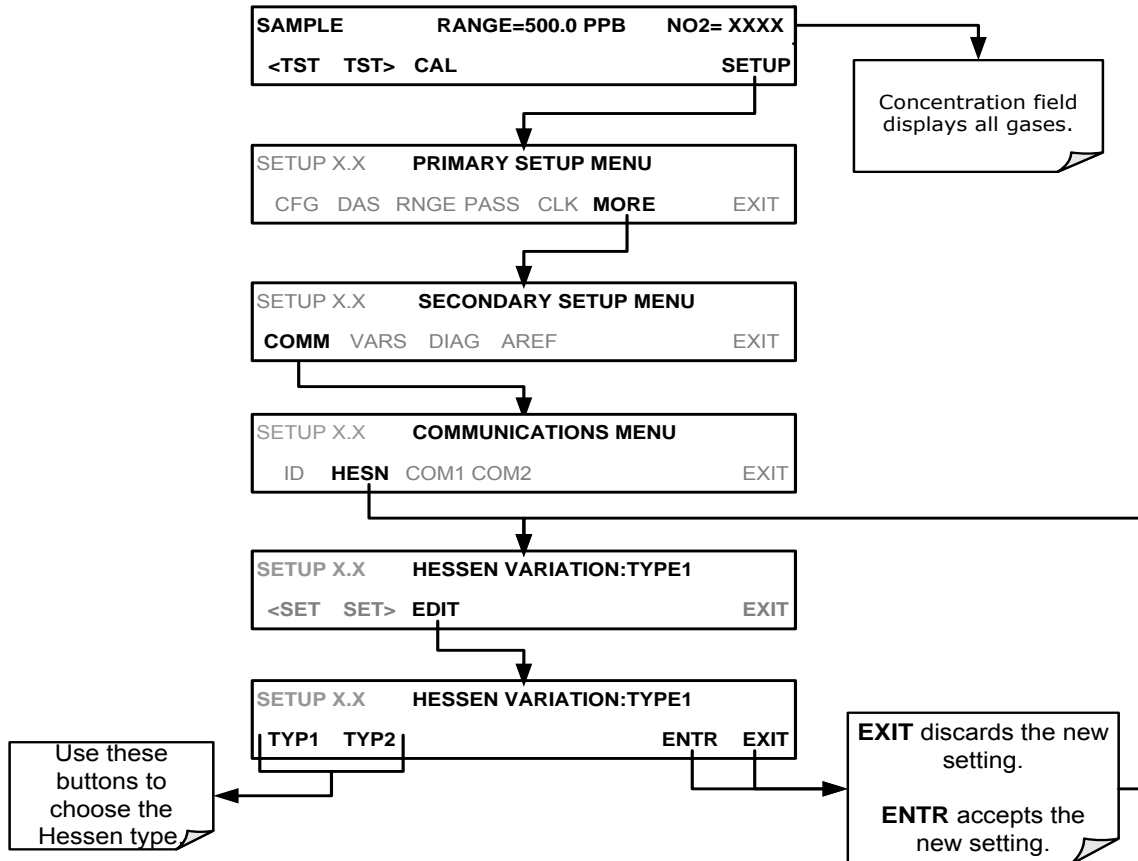
To activate the Hessen Protocol, press:



7.7.1.3. 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's web site: <http://www.teledyne-api.com/manuals/>.

To select a Hessen Protocol Type press:



NOTE

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

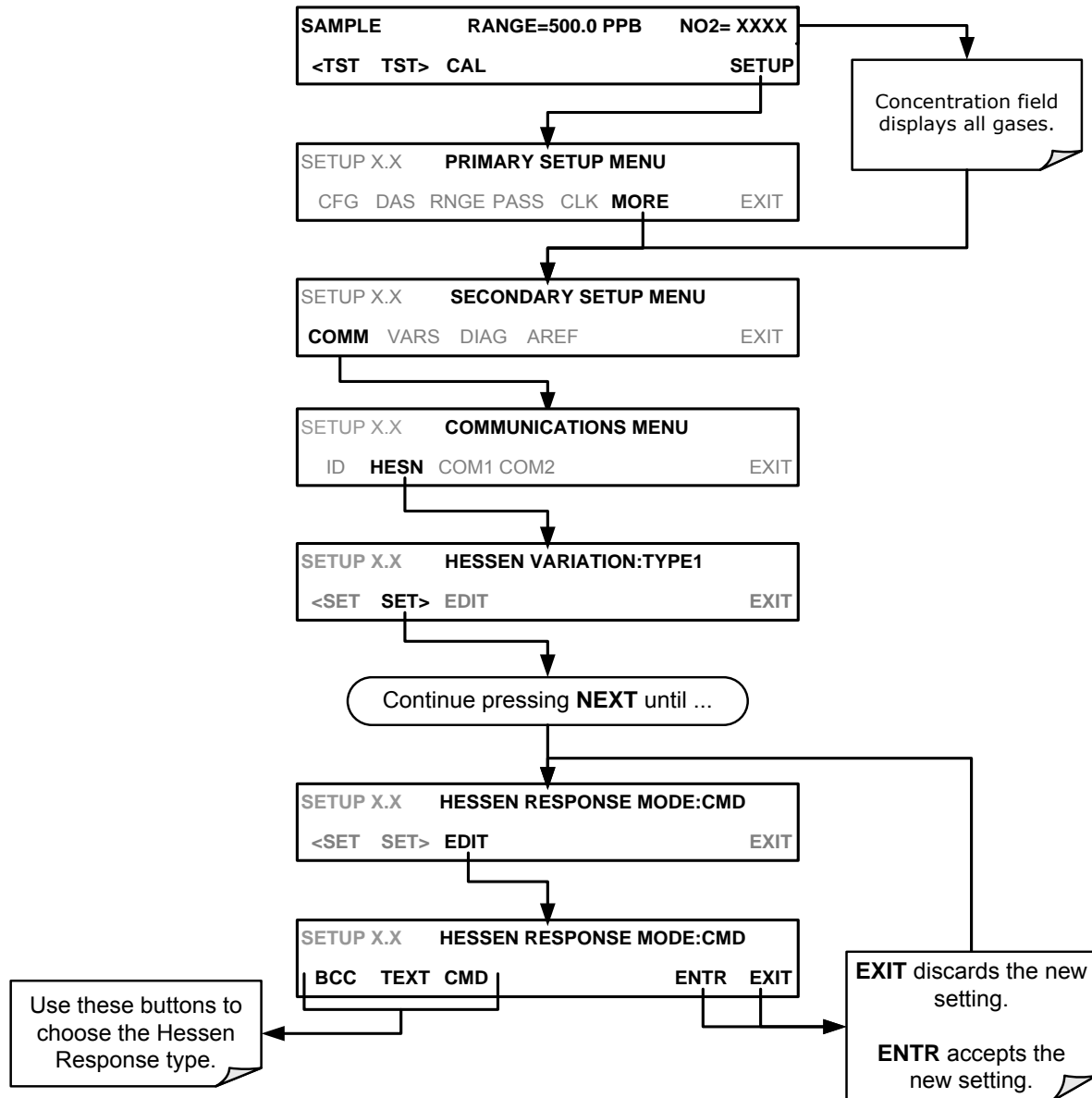
7.7.1.4. SETTING THE HESSEN PROTOCOL RESPONSE MODE

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

Table 7-5: Teledyne API's Hessen Protocol Response Modes

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

To Select a Hessen response mode, press:



7.7.1.5. HESSEN PROTOCOL GAS LIST ENTRY FORMAT AND DEFINITIONS

The T500U 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 to be reported (the T500U has only one gas type: NO₂).

RANGE The concentration range for this gas. This feature permits the user to select which concentration range will be used. The T500U analyzer has two ranges: **RANGE1** or LOW & **RANGE2** or HIGH (see Section 6.3).

1. 0 - The HESSEN protocol to use whatever range is currently active.
2. 1 - The HESSEN protocol will always use RANGE1 for this gas.
3. 2 - The HESSEN protocol will always use RANGE2 for this gas.
4. 3 - Not applicable to the T500U analyzer.

GAS ID An identification number assigned to a specific gas. The T500U analyzer measures only NO₂, which has the following ID number:

NO₂ 213

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. It's default gas list consists of only reads:

NO2, 0, 213, REPORTED

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

7.7.1.6. SETTING HESSEN PROTOCOL STATUS FLAGS

Teledyne API's' implementation of Hessen protocols includes a set of 16 status bits that the instrument includes in responses to inform the host computer of its condition. This status flag includes an 8-bit set for Operational status follows by another 8-bit set for Failure status. Each 8-bit status message is formatted as a 2-digit hexadecimal number. Each bit can be assigned to one operational or warning message flag. The default settings for these bit/flags are:

Table 7-6: Default Hessen Status Flag Assignments

STATUS FLAG NAME	DEFAULT BIT ASSIGNMENT	
	HEX	BITS
OPERATIONAL FLAGS (8 BITS)		
In MANUAL Calibration Mode	x02	0000 0010
In ZERO Calibration Mode	x04	0000 0100
In SPAN Calibration Mode	x08	0000 1000
INVALID CONC	x80	1000 0000
SPARE/UNUSED	x01	0000 0001
UNITS OF MEASURE FLAGS (ONLY BITS 5 AND 6 OF THE OPERATIONAL FLAG)		
UGM		00
MGM		01
PPB		10
PPM		11
WARNING FLAGS (8 BITS)		
ANY PRESS WARN	x04	0000 0100
SAMPLE TEMP WARNING	x08	0000 1000
INTERNAL PUMP OVERRIDE SET TO OFF	x10	0001 0000
IZS TEMP WARNING ¹	x20	0010 0000
BENCH LED DISABLED	x40	0100 0000
OVEN TEMP WARNING	x80	1000 0000
UNASSIGNED FLAGS		
MANIFOLD TEMPERATURE ²	FRONT PANEL COMMUNICATION WARNING	
BOX TEMP WARNING	ANALOG CALIBRATION WARNING	
SYSTEM RESET	DYNAMIC ZERO WARNING	
RELAY BOARD WARNING	DYNAMIC SPAN WARNING	
REAR BOARD NOT DETECTED	IN MULTI-POINT CALIBRATION MODE	
AUTOREF WARNING		
¹ Only applicable if the optional internal span gas generator is installed. ² Only applicable if the T500U is equipped with the optional manifold. It is possible to assign more than one flag to the same Hessen status bit. This allows the grouping of similar flags, such as all temperature warnings, under the same status bit. Be careful not to assign conflicting flags to the same bit as each status bit will be triggered if any of the assigned flags is active.		

7.7.2. MODBUS

This section provides MODBUS communications protocol setup instructions; see Appendix A for MODBUS registers. This 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, downloadable from our website at <http://www.teledyne-api.com/software/apicom/>. Also refer to www.modbus.org for MODBUS communication protocols.

Minimum Requirements

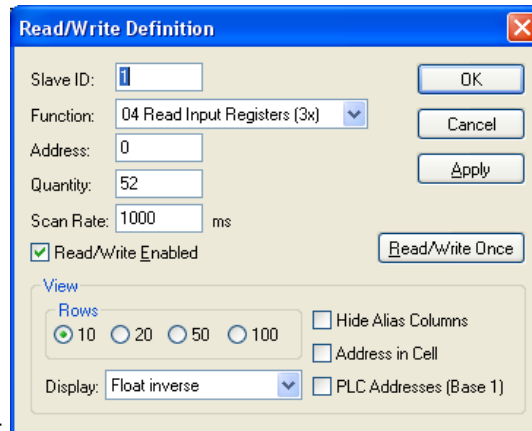
- Instrument firmware with MODBUS capabilities installed.
- MODBUS-compatible software (TAPI uses MODBUS Poll for testing; see www.modbustools.com)
- Personal computer
- Communications cable (Ethernet or USB or RS232)
- Possibly a null modem adapter or cable

Table 7-7. MODBUS Setup Instructions

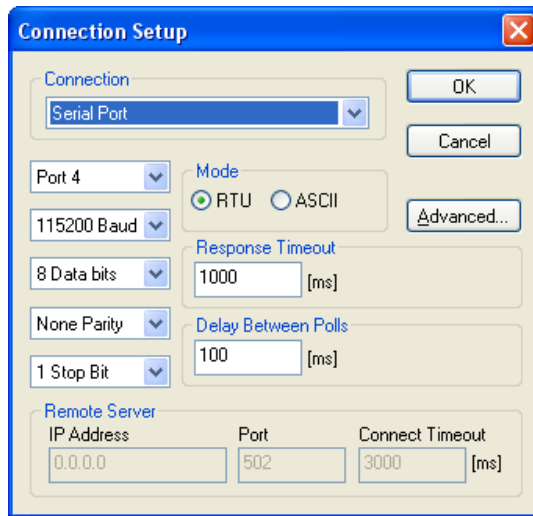
Actions	
Set Com Mode parameters	<p>Comm</p> <p>Ethernet: Using the front panel menu, go to SETUP – MORE – COMM – INET; scroll through the INET submenu until you reach TCP PORT 2 (the standard setting is 502), then continue to TCP PORT 2 MODBUS TCP/IP; press EDIT and toggle the menu button to change the setting to ON, then press ENTR. (Change Machine ID if needed: see “Slave ID”).</p> <p>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).</p> <p>Slave ID</p> <p>If your analyzer is connected to a network with at least one other analyzer of the same model, a unique Slave ID must be assigned to each. Using the front panel menu, go to SETUP – MORE – COMM – ID. The MACHINE ID default is the same as the model number. Toggle the menu buttons to change the ID.</p>
Reboot analyzer	For the settings to take effect, power down the analyzer, wait 5 seconds, and power up again.
Make appropriate cable connections	<p>Connect your analyzer via either:</p> <ul style="list-style-type: none"> • 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 • 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"> 1. Click Setup / [Read / Write Definition] /. <ol style="list-style-type: none"> a. In the Read/Write Definition window (see example that follows) select a Function (what you wish to read from the analyzer). b. Input Quantity (based on your firmware’s register map). c. In the View section of the Read/Write Definition window select a Display (typically Float Inverse). d. Click OK. 2. Next, click Connection/Connect. <ol style="list-style-type: none"> a. In the Connection Setup window (see example that follows), select the options based on your computer. b. Press OK.
Read the Modbus Poll	Use the Register Map to find the test parameter names for the values displayed (see

Actions

Register example that follows If desired, assign an alias for each.

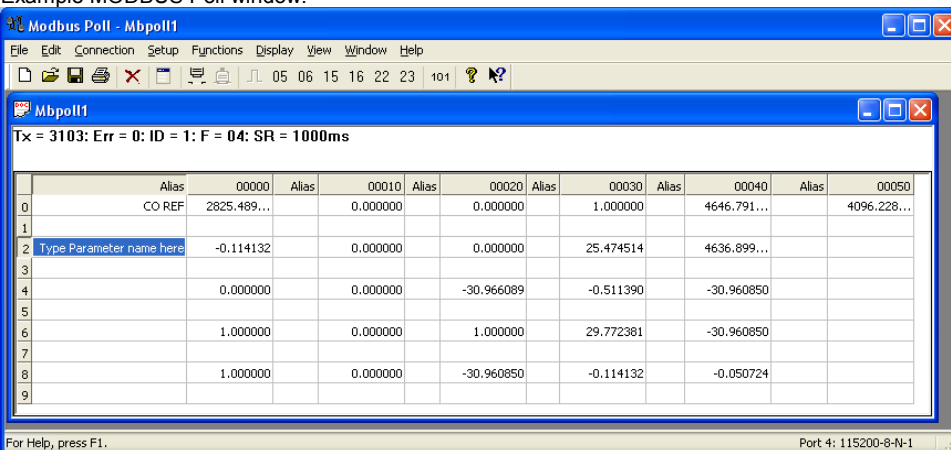


Example Read/Write Definition window:



Example Connection Setup window:

Example MODBUS Poll window:



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8. DATA ACQUISITION SYSTEM (DAS) AND APICOM

The internal data acquisition system (DAS) enables the analyzer to store concentration and calibration data as well as a host of diagnostic parameters. This feature can store a large number of data points covering days, weeks or months of valuable measurements, depending on individual configurations. The data records 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 electronic spreadsheets).

The DAS permits users to access stored data through the instrument's front panel or remotely through its communication ports. 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 (APICOM DAS Manual, PN 07463, which can be downloaded from our website at <http://www.teledyne-api.com> under Help Center > Product Manuals in the Special Manuals section).

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 (Section 8.2.1).

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.

Note

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

The principal 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.

The green **SAMPLE LED** on the instrument front panel not only indicates the analyzer status, but also indicates certain aspects of the DAS status:

- **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.

8.1. DAS STRUCTURE

The DAS is designed around the feature of a “record”, a single data point. The types of data captured in a record are defined by two properties:

- **PARAMETER** type that defines the kind of data to be stored (e.g. the average of NO₂ concentrations measured with three digits of precision). See Section 8.1.3.3.
- A **TRIGGER** event that defines when the record is made (e.g. timer; every time a calibration is performed, etc.). See Section 8.1.3.2.

The specific **PARAMETERS** and **TRIGGER** events that describe an individual record are defined in a construct called a **DATA CHANNEL** (see Section 8.1.3).

8.1.1. DAS CHANNELS

Users may create up to 20 data channels and each channel can contain a triggering event and one or more parameters. For each channel, the following are selected:

- one triggering event
- up to 50 data parameters, which can be the 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 8-1: 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, DAS Trigger Events).
NUMBER AND LIST OF PARAMETERS	A user-configurable list of data types to be recorded in any given channel.	1	Any available parameter (see Appendix A, DAS Parameters).
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	Limited by available storage space, which depends on DAS configuration.
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 ² .	OFF	OFF or ON

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

² When enabled records are not recorded until the DAS_HOLD OFF period is passed after calibration mode. DAS_HOLD OFF SET in the VARS menu (see Section 6.7).

8.1.1.1. DEFAULT DAS CHANNELS

A set of default Data Channels has been included in the analyzer's software for logging NO₂ concentrations as well as certain predictive diagnostic data. Table 8-2 describes these channels for the software revision shipped with the T500U at the time of this writing. Figure 8-1 shows the APICOM interface with the default configuration.

Table 8-2: T500U Default DAS Channels

Channel	Description
CONC	Samples NO ₂ 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, the flow control (sample flow) and the sample filter (clogging indicated by a drop in sample pressure) over time to predict when maintenance will be required. By default, the last 360 daily averages (about 1 year) are stored.
CALDAT	Logs new slope and offset of NO ₂ measurements every time a zero or span calibration is performed and the result changes the value of the slope (triggering event: SLPCHG). The NO ₂ stability (to evaluate if the calibration value was stable) is also stored. This data channel will store data from the last 200 calibrations and can be used to document analyzer calibration and is useful for detect trends in slope and offset (instrument response) when performing predictive diagnostics as part of a regular maintenance schedule (Section 11.1). 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.
CALCHECK	This channel logs concentrations and the stability each time a zero or span check (not calibration) is finished (triggered by exiting any calibration menu). The data of this channel enable the user to track the quality of zero and span responses over time and assist in evaluating the quality of zero and span gases and the analyzer's noise specifications. The STABIL parameter documents if the analyzer response was stable at the point of the calibration check reading. The last 200 data points are retained.
DIAG	Daily averages of temperature zones, flow and pressure data as well as some other diagnostic parameters. This data is useful for predictive diagnostics and maintenance of the T500U.
HIRES	Records one-minute, instantaneous data of all active parameters in the T500U. Short-term trends as well as signal noise levels can be detected and documented. The last 1500 data points are stored. Readings during calibration and the calibration hold off period are included in the averages.

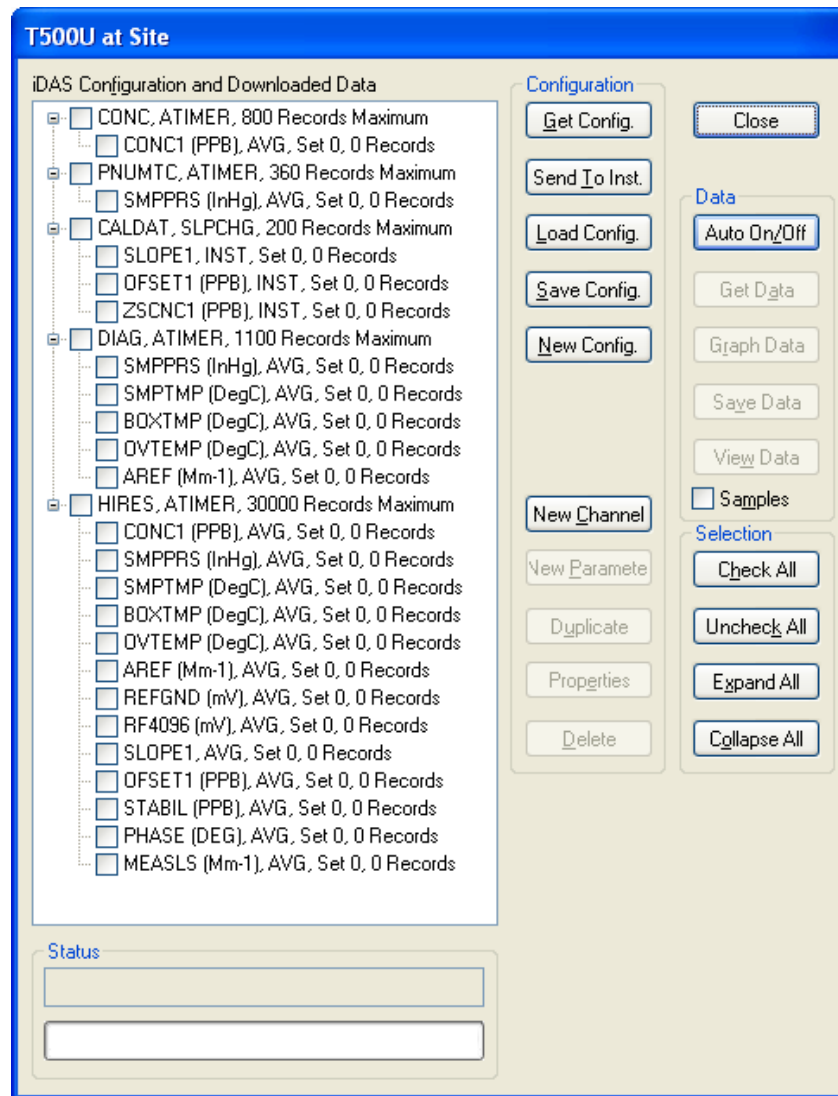


Figure 8-1: Example Default DAS Configuration in APICOM Interface

These default data channels can be used as they are, or they can be customized (Section 8.1.3) from the front panel to fit a specific application. They can also be deleted to make room for custom user-programmed Data Channels.

IMPORTANT

IMPACT ON READINGS OR DATA

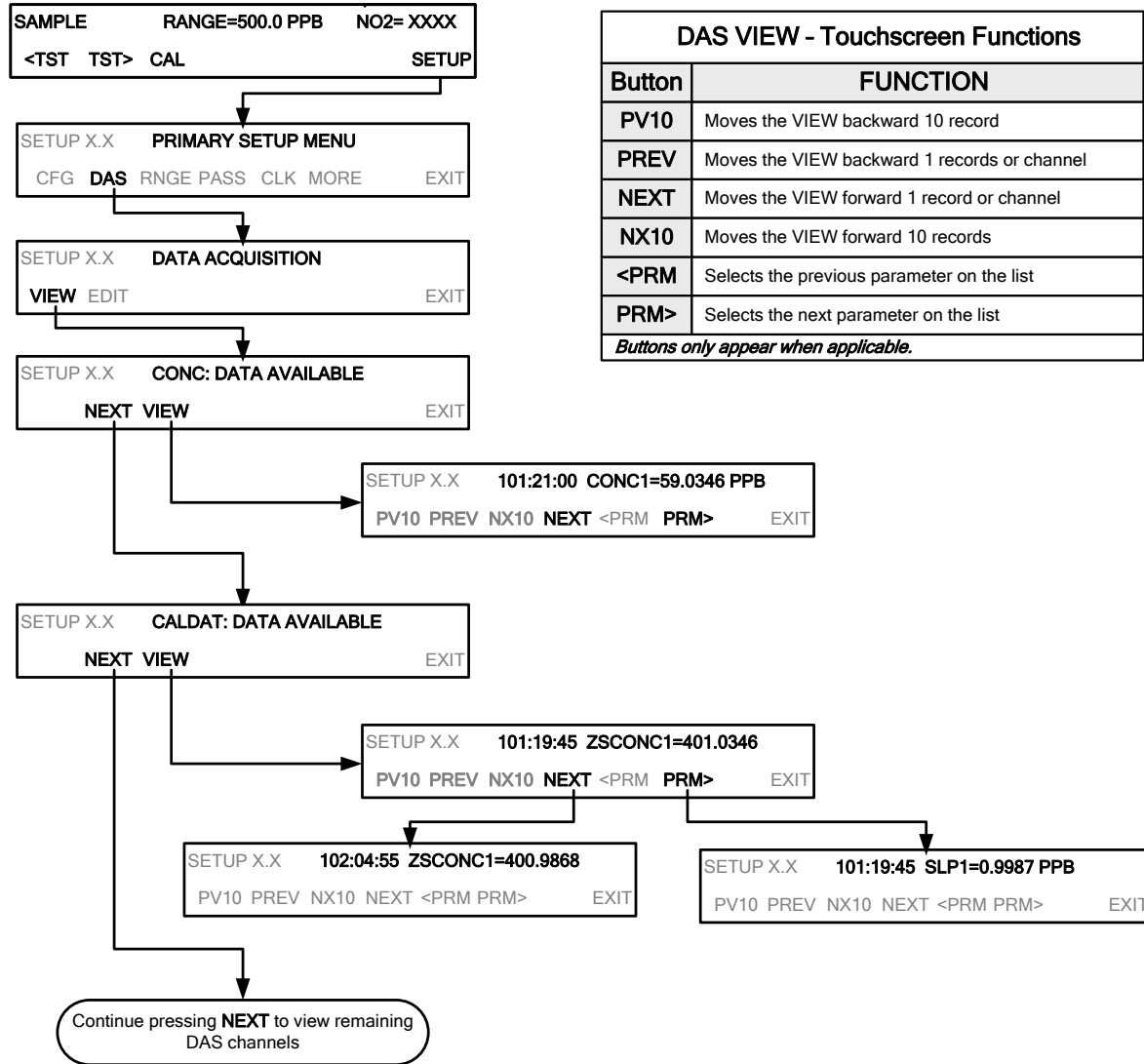
Sending a DAS configuration to the analyzer through its COM ports will replace the existing configuration and will delete all stored data. Back up any existing data and the DAS configuration before uploading new settings.

8.1.1.2. DAS CONFIGURATION LIMITS

The number of DAS objects is limited by the instrument’s finite storage capacity. 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 APICOM DAS manual.

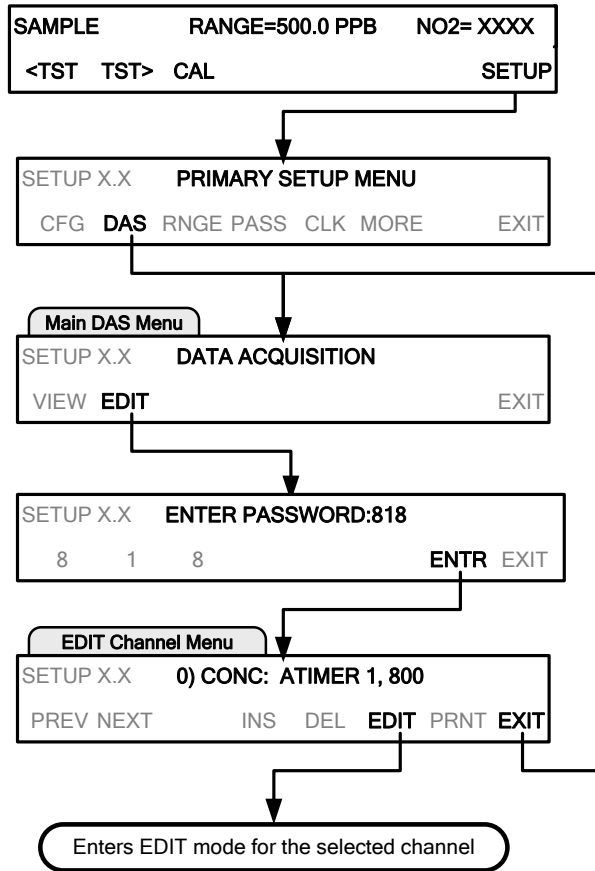
8.1.2. VIEWING DAS DATA AND SETTINGS

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



8.1.3. EDITING DAS DATA CHANNELS

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



DAS EDIT - Touchscreen Button 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:

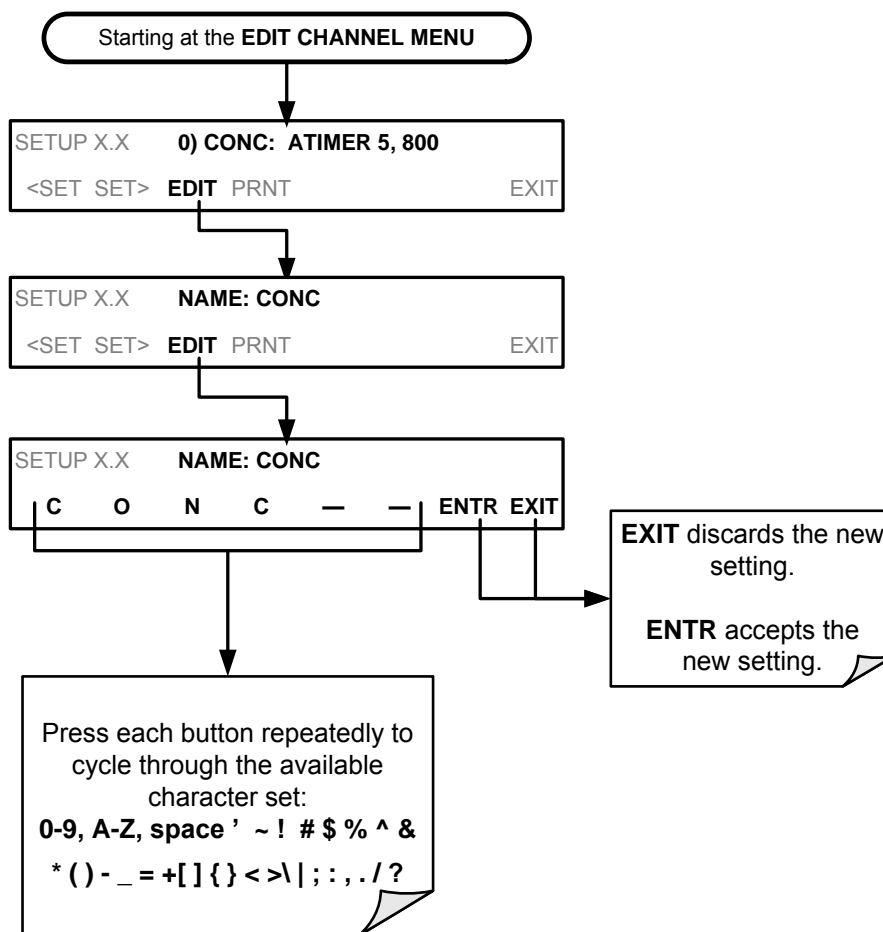
0) CONC: ATIMER, 1, 800

Translates to the following configuration:

Channel No.: 0
NAME: CONC
TRIGGER EVENT: ATIMER
PARAMETERS: Five parameters are included in this channel
EVENT: This channel is set up to store 800 records.

8.1.3.1. EDITING DAS DATA CHANNEL NAMES

To edit the name of a DAS data channel, follow the instruction shown in Section 8.1.3 then press:



8.1.3.2. EDITING DAS TRIGGERING EVENTS

Triggering events define when and how the DAS records a measurement of any given data channel. Triggering events are firmware-specific; they are listed Appendix A of this manual. 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 SLPCHG** (exit zero, exit span, 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 useful for monitoring response drift and documenting when the instrument was calibrated.
- **WARNINGS**: Some data may be useful when stored if one of several warning messages appears such as **WSAMPPRESS** (sample pressure warning). This is helpful for troubleshooting by monitoring when a particular warning occurred.

Note

A list of DAS Trigger Events can be found in Appendix A of this manual.

8.1.3.3. EDITING DAS PARAMETERS

Data parameters are types of data that may be measured and stored by the DAS. For each Teledyne API's 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 T500U. DAS parameters include data such as NO₂ concentration measurements, temperatures of the various heaters placed around the analyzer, and pressure 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, Mm-1, 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. To change the units of measure for concentration readings, see Section 6.3.3.4.

Note

DAS does not keep track of the units (i.e., PPM or PPB) of each concentration value. Therefore, DAS data files may contain concentration data recorded in more than one type of unit if the units of measure were changed during data acquisition

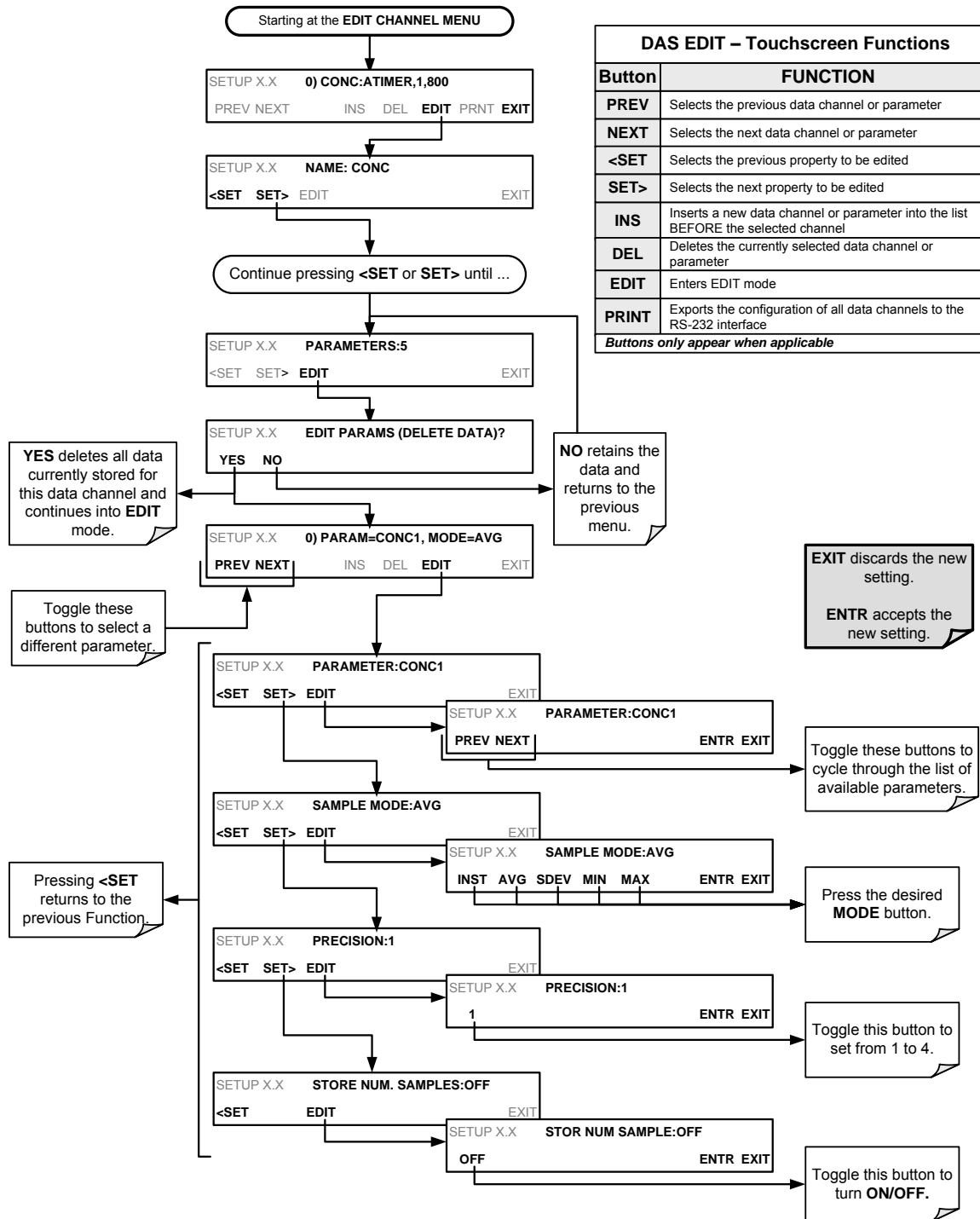
Each data parameter has user-configurable functions that define how the data are recorded which are listed in Table 8-3:

Table 8-3: 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 PPB" Setting 0 ; "400 PPB"
STORE NUM. SAMPLES	OFF: Stores only the average (default). ON: Stores the average and the number of samples in 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.

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 8.1.3 then press:



Note

When the **STOR 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.

8.1.3.4. EDITING SAMPLE PERIOD AND REPORT PERIOD

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

- **SAMPLE PERIOD:** Determines how often DAS temporarily records a sample reading of the parameter in volatile memory (default is one minute), and generally cannot be accessed from the standard DAS front panel menu, but is available via the instruments communication ports by using APICOM or the analyzer's standard serial data protocol. **SAMPLE PERIOD** is only used when the DAS parameter's sample mode is set for AVG, SDEV, MIN or MAX
- **REPORT PERIOD:** Sets how often the sample readings stored in volatile memory are processed, (e.g., average, minimum or maximum are calculated) and the results stored permanently in the instrument's Disk-on-Module (DOM) 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.

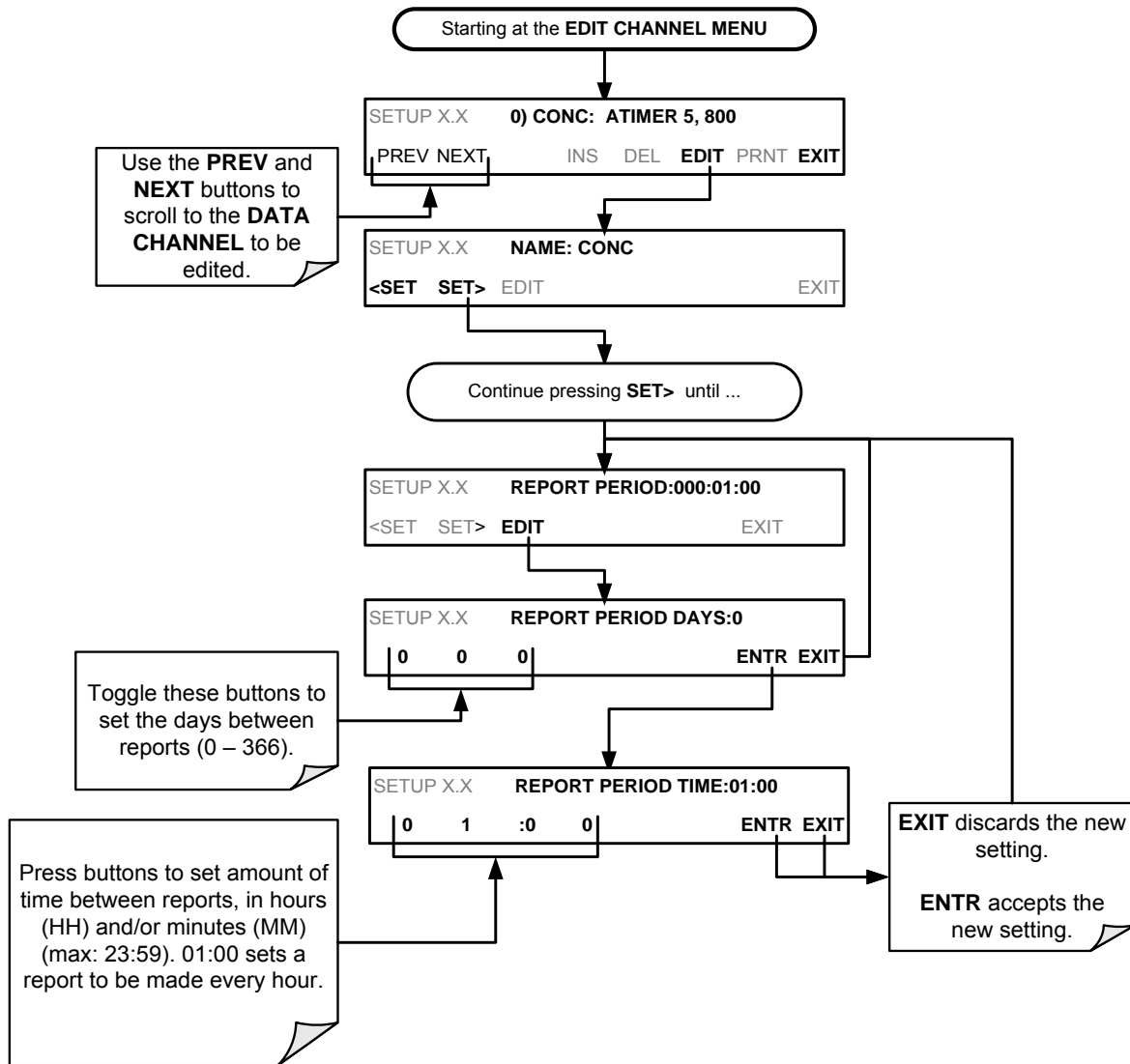
Note

In AVG, SDEV, MIN or MAX sample modes (see Section 8.1.3.3), 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 COM 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 8.1.3 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** is 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** is 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 parameters are 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.

8.1.3.5. 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 during that period are lost. Once the instrument is turned back on, the DAS restarts taking samples and temporarily stores them in volatile memory as part of the **REPORT PERIOD** currently active at the time of restart. 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.

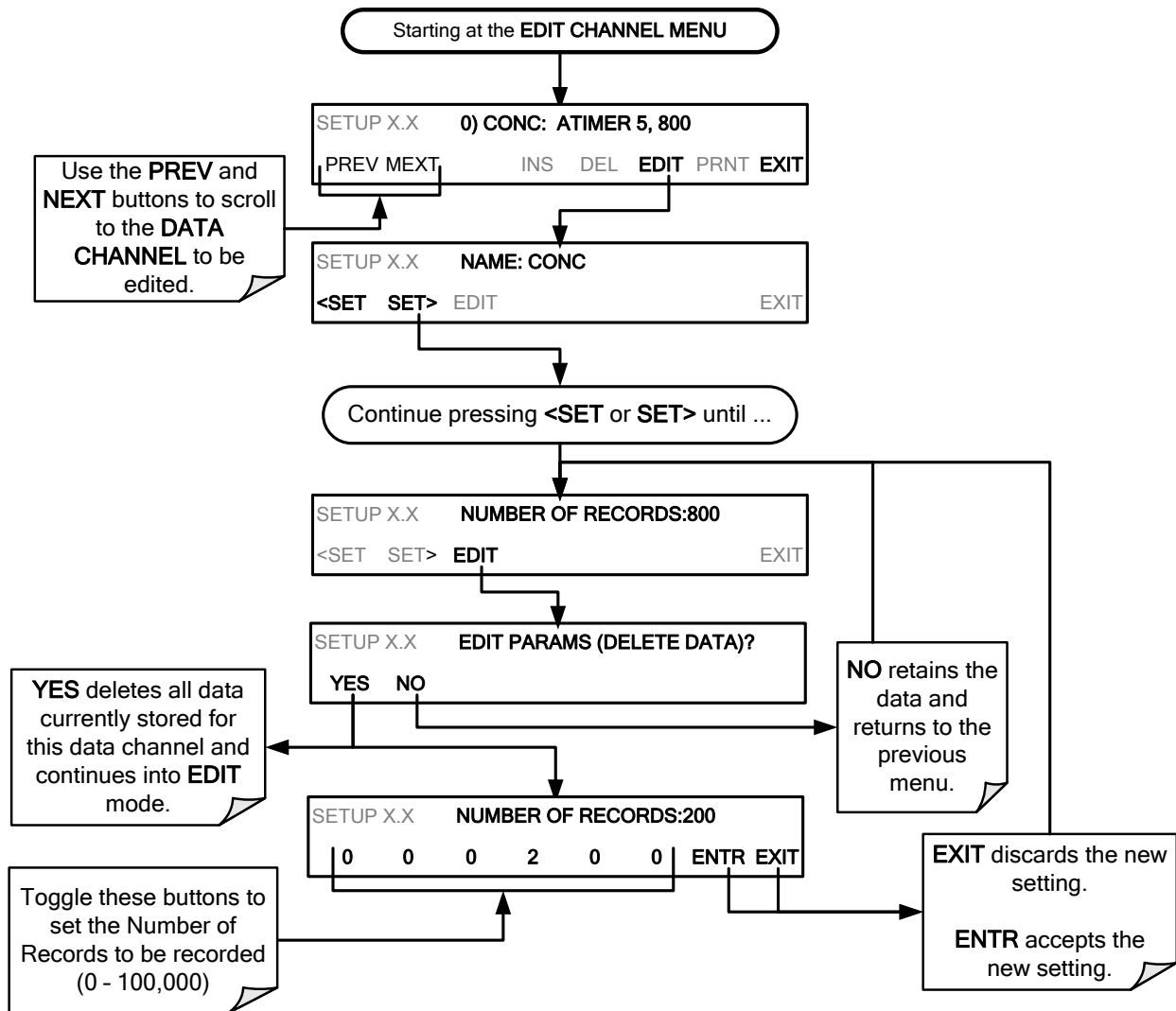
The **STORE NUM SAMPLES** feature will also report the number of sample readings taken since the instrument was restarted.

8.1.3.6. EDITING THE NUMBER OF RECORDS

The number of data records in the DAS is limited by its configuration. Every additional data channel, parameter, number of samples setting etc. will reduce the maximum amount of data points. In general, however, the maximum data capacity is divided among 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. (The **ENTR** button will disappear when trying to specify more records than space allows). 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.

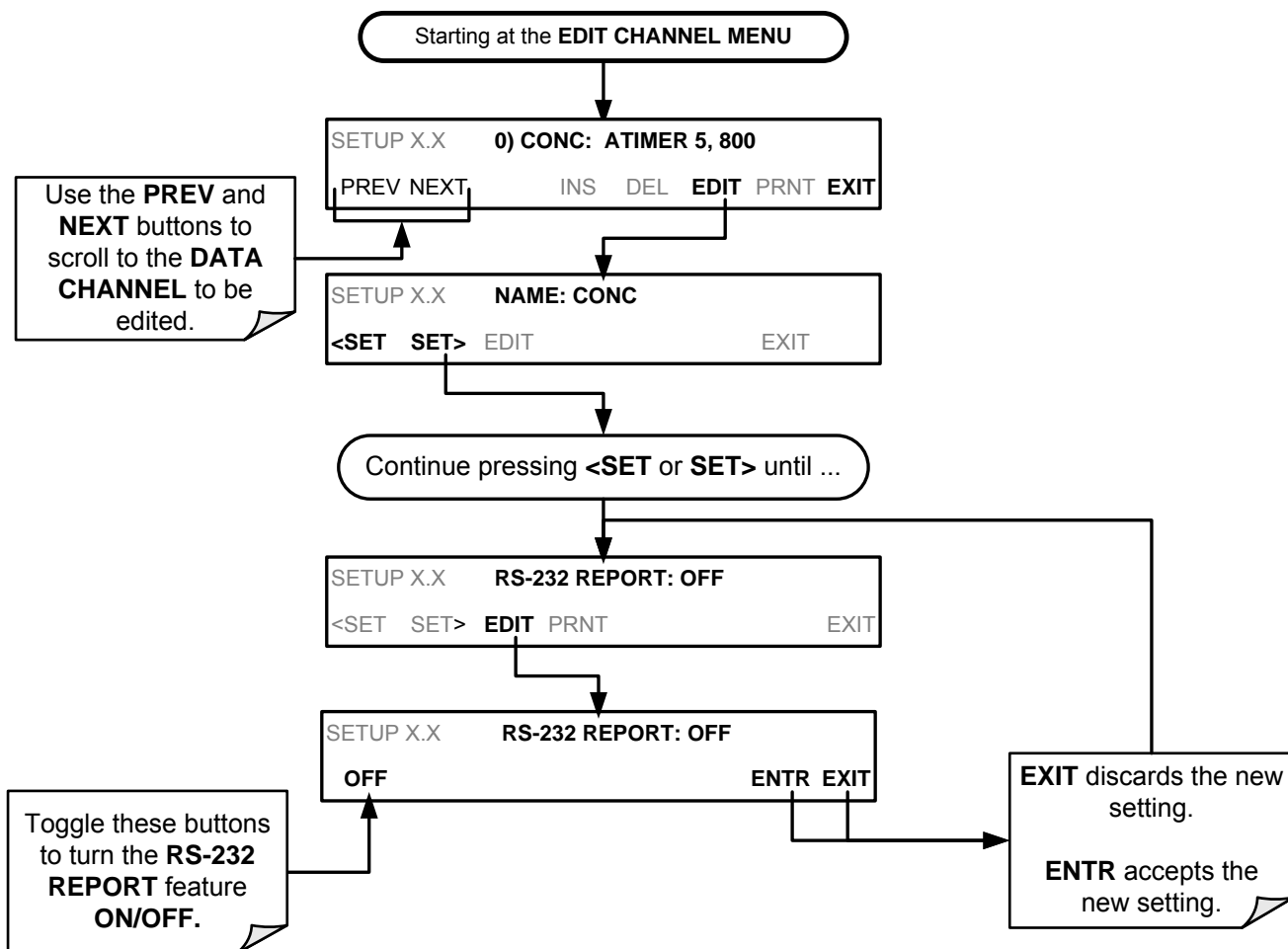
To set the **NUMBER OF RECORDS**, follow the instruction shown in Section 8.1.3 then press:



8.1.3.7. 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.

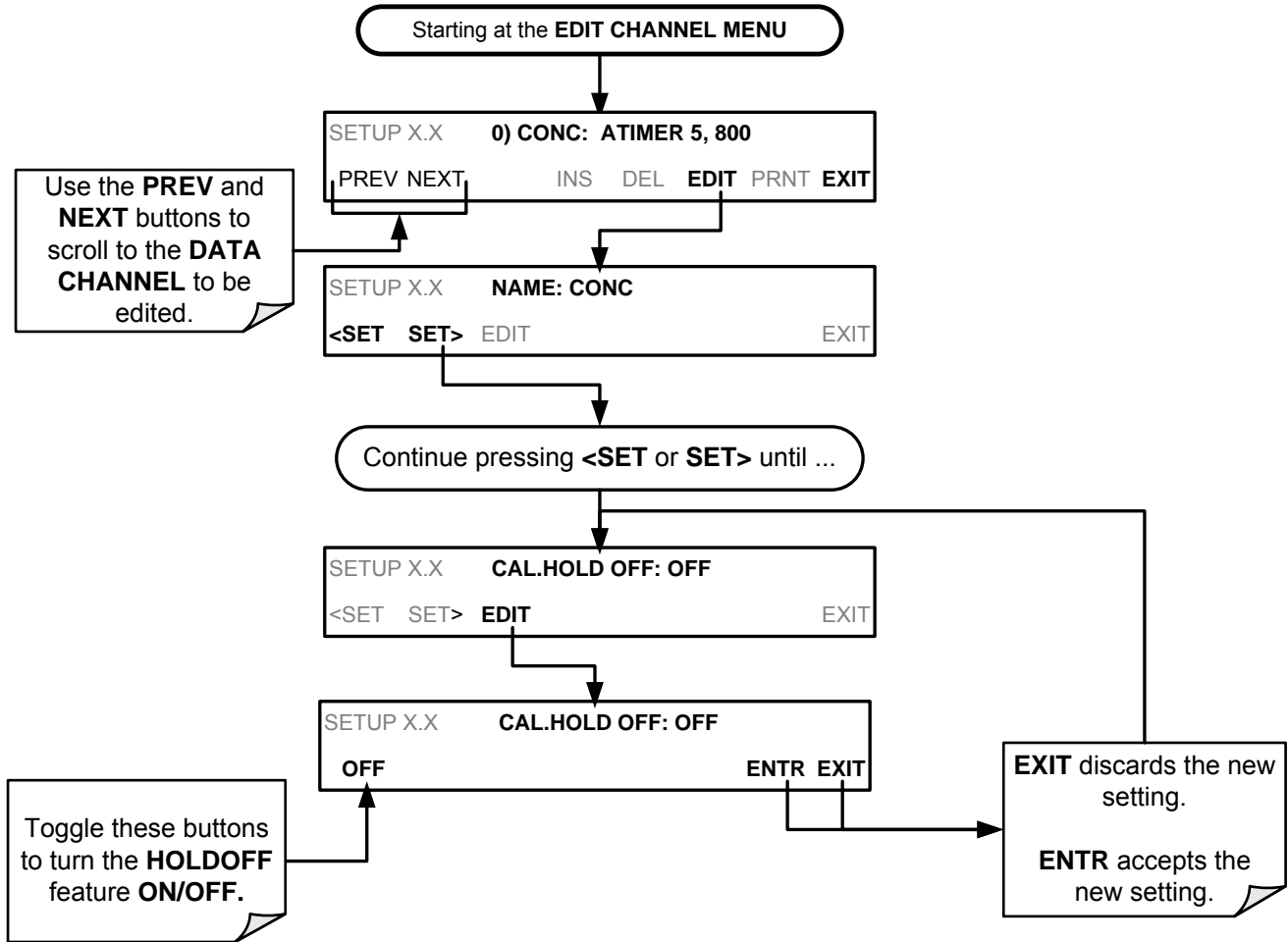
To enable automatic **COM port** reporting, follow the instruction shown in Section 8.1.3 then press:



8.1.3.8. HOLDOFF FEATURE

The DAS **HOLDOFF** feature prevents data collection during calibration operations.

To enable or disable the **HOLDOFF**, follow the instruction shown in Section 8.1.3 then press:



HOLDOFF also prevents DAS measurements from being made at certain times when the quality of the analyzer's NO₂ measurements may be suspect (e.g. while the instrument is warming up). In this case, the length of time that the **HOLDOFF** feature is active is determined by the value of the internal variable (**VAR**), **DAS_HOLDOFF**.

To set the length of the **DAS_HOLDOFF** period, go to the **SETUP>MORE>VAR**s menu and at the **DAS_HOLDOFF** parameter (see Table 6-2), press the Edit button.

8.1.3.9. 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.

8.1.3.10. THE STARTING DATE FEATURE

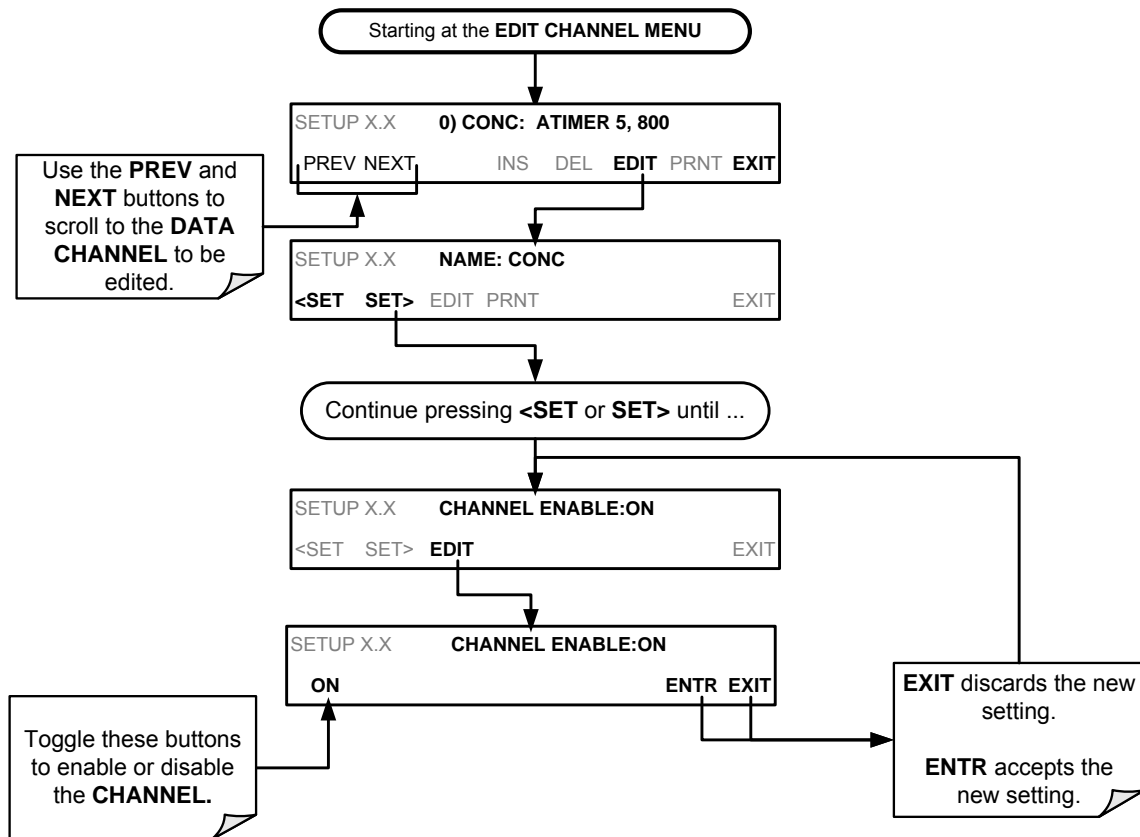
This option allows the user to specify a starting date for any given channel when the user wants to start data acquisition only after a certain time and date. If the **STARTING DATE** is in the past (the default condition), the DAS ignores this setting and begins recording data as defined by the **REPORT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

8.1.3.11. DISABLING/ENABLING DATA CHANNELS

Data channels can be temporarily disabled, which can reduce the read/write wear on the Disk-on-Module (DOM).

To disable a data channel, go to the DAS>EDIT menu as shown in Section 8.1.3 then continue as follows:



8.2. REMOTE DAS CONFIGURATION

The DAS can be configured and operated remotely via either the APICOM interface or a terminal emulation program. Once a DAS configuration is edited (which can be done offline and without interrupting DAS data collection), it is conveniently uploaded to the instrument and can be stored on a computer for later review, alteration or documentation and archival.

8.2.1. DAS CONFIGURATION VIA APICOM

Refer to the APICOM DAS user manual (Teledyne API's P/N 07463) for configuring DAS through the APICOM interface. (Download the APICOM software from our website at <http://www.teledyne-api.com/software/apicom/>).

8.2.2. 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 8-2 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.


```

Instrument: HyperTerminal
File Edit View Call Transfer Help
[Icons]
SETUP PROPERTIES FOR ENGDAT:
NAME: ENGDAT
EVENT: ATTIMER
REPORT PERIOD: 000:00:02
NUMBER OF RECORDS: 2000
RS-232 REPORT: ON
CHANNEL ENABLED: ON
CAL_HOLD OFF: OFF
PARAMETERS: 14
PARAMETER=RCTEMP, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=CNVTMP, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=PMTTMP, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=BOXTMP, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=O3FLOW, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=SNPFLW, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=SNPPRS, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=RCPRES, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=AZERO, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=HVPS, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=PMTDET, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=RF4096, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
PARAMETER=REFGND, MODE=AVG, PRECISION=4, STORE_SAMPLES=OFF
Connected 00:01:32 Auto detect TCP/IP SCROLL CAPS NUM Capture Print echo

```

Figure 8-2: DAS Configuration through a Terminal Emulation Program

See Section 9.2.1 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

Back up data and the original DAS configuration before editing the DAS. Although it is possible to edit DAS parameters of one channel through the front-panel without affecting other channels, uploading a DAS configuration script to the analyzer through its communication ports will erase all data, parameters and channels and replace them with the new DAS configuration.

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9. 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 3.3.1.8.

The T500U 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).

9.1. COMPUTER MODE

Computer Mode is used when the analyzer is connected to a computer with a dedicated interface program such as APICOM, downloadable from our website at <http://www.teledyne-api.com/software/apicom/>.

9.2. INTERACTIVE MODE

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

9.2.1. 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 9-1 and in Appendix A.

9.2.1.1. HELP COMMANDS IN INTERACTIVE MODE

Table 9-1: 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 button.
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-C	Pauses the listing of commands.
Control-P	Restarts the listing of commands.

9.2.1.2. COMMAND SYNTAX

Commands are not case-sensitive and all arguments within one command (i.e. ID numbers, key words, 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) that defines the type of command. Allowed designators are listed in Table 9-2 and Appendix A, Terminal Command Designators.

[ID] is the machine identification number (Section 6.6.1). Example: the Command “? 200” 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 500.

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 button on a computer).

Table 9-2: Teledyne API's Serial I/O Command Types

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

9.2.1.3. DATA TYPES

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

Integer data are 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 are 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 numbers are 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 are used to specify the value of variables or I/O signals that may assume only two values. They are denoted by the key words ON and OFF.

Text strings are 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.

9.2.1.4. 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 7.2.1, Table 7-1).

Status reports include warning messages, calibration and diagnostic status messages. Refer to Appendix A-3, Warnings and Test Measurements, for a list of the possible messages, and this for information on controlling the instrument through the RS-232 interface.

9.2.1.5. 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 9-2.
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 troubleshooting and reference purposes. Terminal emulation programs such as HyperTerminal can capture these messages to text files for later review.

9.3. REMOTE ACCESS BY MODEM

The T500U 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 P/N WR0000024).

Once the cable has been connected, check to ensure that:

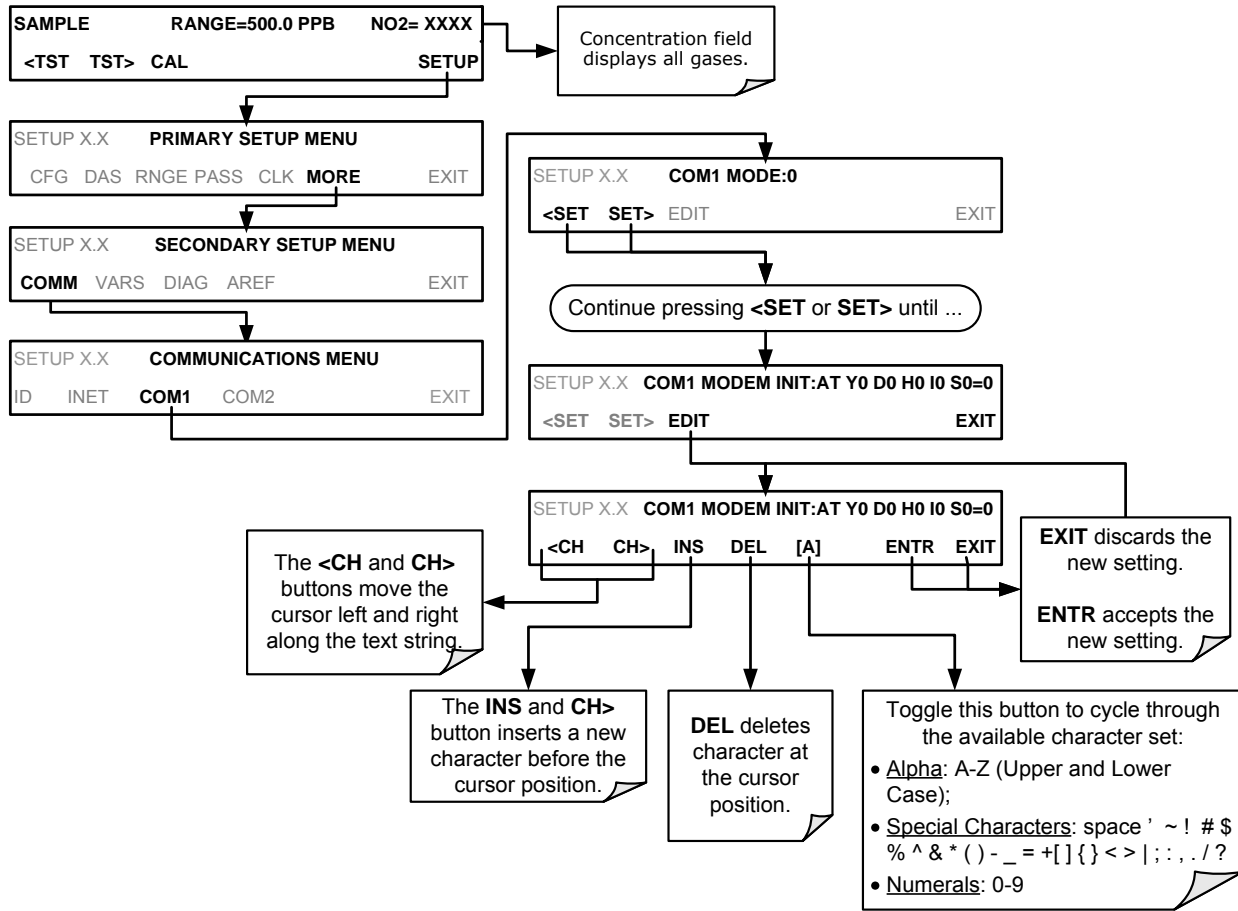
- The DTE-DCE is in the DCE position.
- The T500U COM port is set for a baud rate that is compatible with the modem,
- The Modem is designed to operate with an 8-bit word length with one stop bit.
- The **MODEM ENABLE** communication mode is turned **ON** (Mode 64, see Section 7.2.1).

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:

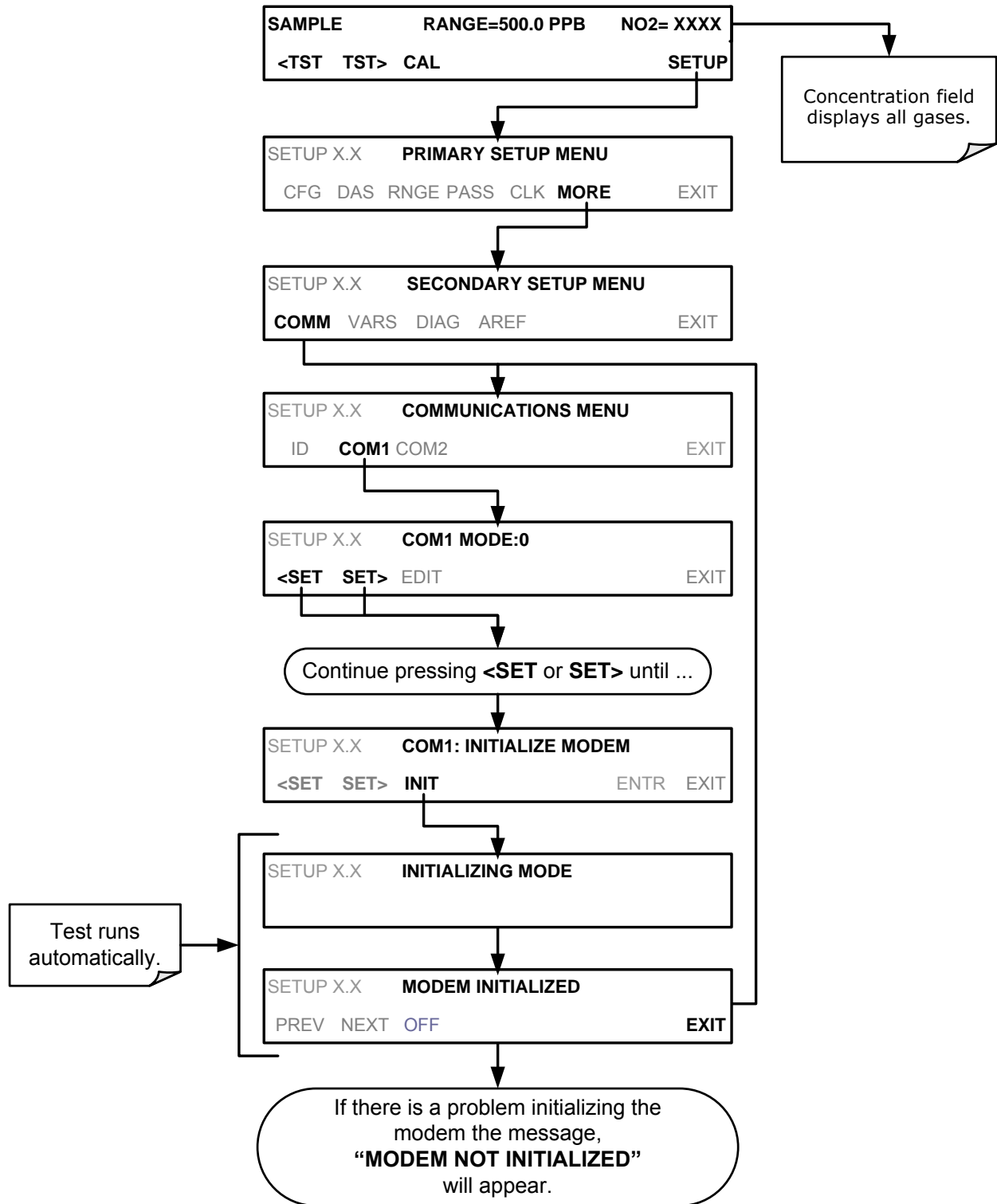
AT Y0 D0 H0 I0 S0=0

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

To edit this setting press:



To initialize the modem press:



9.4. PASSWORD SECURITY FOR SERIAL REMOTE COMMUNICATIONS

In order to provide security for remote access of the T500U, 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** (refer to Section 6.4). 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 T100 analyzer with **SECURITY MODE** feature enabled, type:

```
LOGON 940331
```

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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10. CALIBRATION

Calibration of the T500U Analyzer requires:

- Zero-air source
- Span gas source
- Teflon-type for all gas line materials
- A recording device such as a strip-chart recorder and/or data logger (optional)
- Exiting the calibration mode to sample mode, following a successful CALZ or CALS. The Auto Reference feature (Section 6.9) is disabled while in calibration mode.

For electronic documentation, the internal data acquisition system (DAS) can be used (Section 8).

This section discusses calibration gases, provides the basic method for manually checking the calibration, and for manually performing actual calibration of the T500U analyzer.

10.1. CALIBRATION GASES

Zero air or zero calibration gas is defined as a gas that is similar in chemical composition to the measured medium but without the gas to be measured by the analyzer. A zero air generator such as the Teledyne API's Model 701 can be used. Please visit the company website for more information.

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

Alternatively, if a calibrator is available that is a trusted source of stable ozone, e.g., Teledyne API Model T700U with certified photometer, it is possible to use that O₃ output directly to obtain the NO₂ concentration.

10.1.1. SPAN GAS FOR MULTIPOINT CALIBRATION

Some applications, such as EPA monitoring, require a multipoint calibration where span gases of different concentrations are needed. We recommend using an NO₂ gas of higher concentration combined with a gas dilution calibrator such as a Teledyne API's Model T700. For more information see Section 3.3.2.1 and Section 12.

10.1.2. NO₂ PERMEATION TUBES

Teledyne API offers an optional internal span gas generator that utilizes an NO₂ permeation tube as a span gas source. The accuracy of these devices is only about $\pm 5\%$.

Whereas this may be sufficient for quick, daily calibration checks, we recommend using certified NO₂ gases for accurate calibration.

CAUTION!

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

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

(See Figure 3-4 for location and Section 11.3.2 for instructions on how to remove the perm tube when the unit is not in operation).

10.2. 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 T500U.

- 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 T500U provides an internal data acquisition system (DAS), which is described in detail in Section 8.

APICOM, a remote control program, is also provided as a convenient and powerful tool for data handling, download, storage, quick check and plotting (see Sections 8.2.1, and the APICOM software manual downloadable from:

<http://www.teledyne-api.com/manuals>).

10.3. MANUAL CALIBRATION CHECKS AND CALIBRATION OF THE T500U IN ITS BASE CONFIGURATION

IMPORTANT

IMPACT ON READINGS OR DATA

ZERO/SPAN CALIBRATION CHECKS VS. ZERO/SPAN CALIBRATION

NEVER press the ENTR button if you are only *checking* 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 T500U.

10.3.1. SETUP FOR BASIC CALIBRATION CHECKS AND CALIBRATION

Connect the sources of zero air and span gas as shown below in one of the following ways:

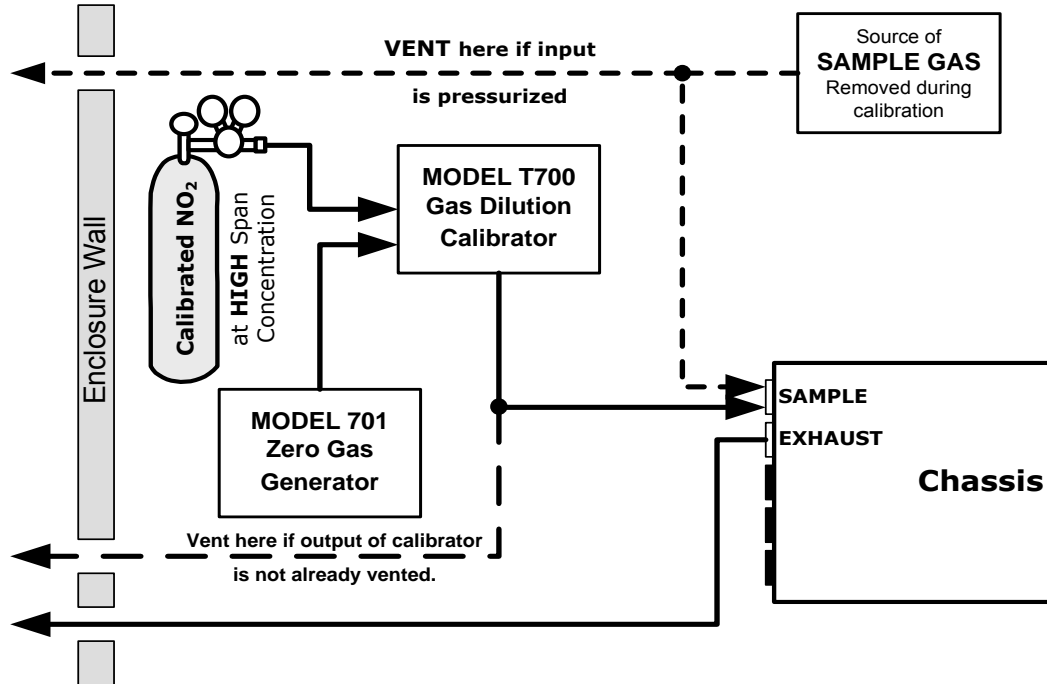
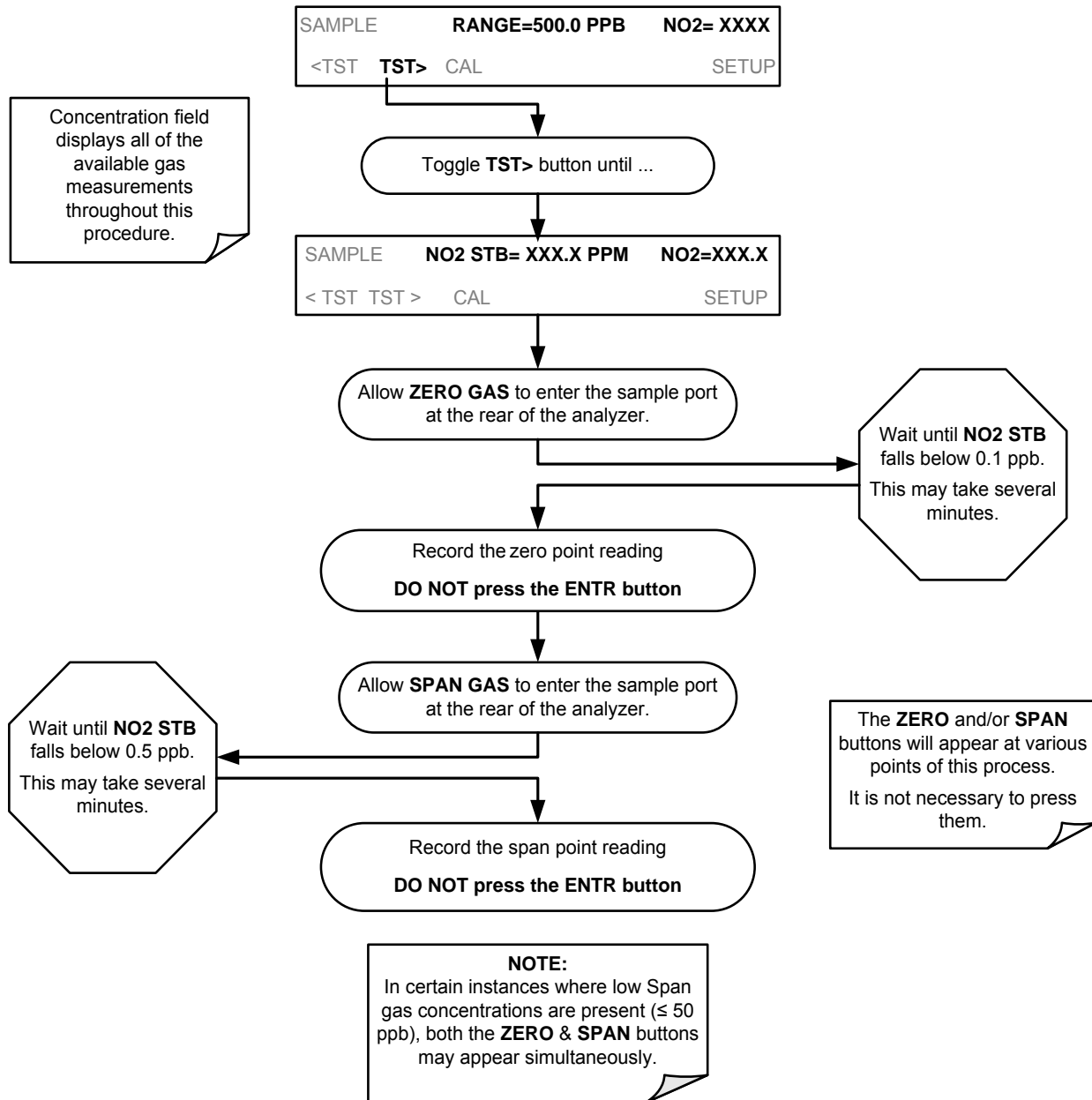


Figure 10-1: Set up for Manual Calibrations/Checks in Base Configuration w/Gas Dilution Calibrator

10.3.2. PERFORMING A BASIC MANUAL CALIBRATION CHECK



Note

If the ZERO or SPAN buttons are not displayed, the measurement made is outside the allowable range for a reliable calibration.

10.3.3. PERFORMING A BASIC MANUAL CALIBRATION

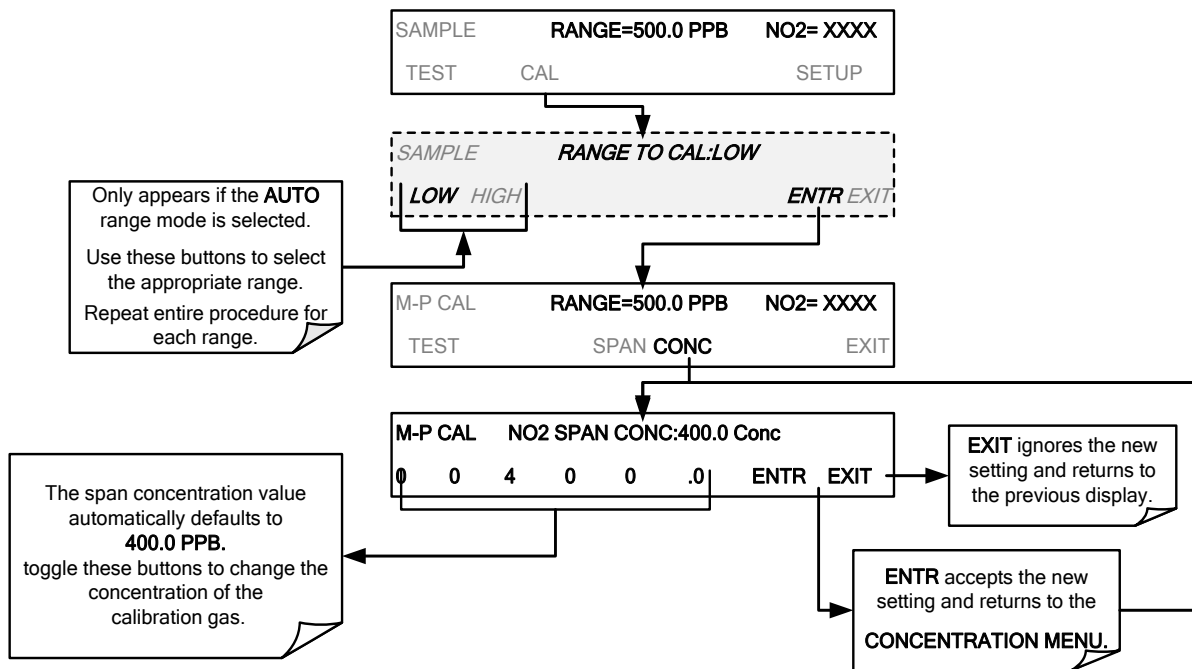
The following section describes the basic method for manually calibrating the T500U analyzer.

If the analyzer's reporting range is set for the **AUTO** range mode, a step will appear for selecting which range is to be calibrated (**Range 1** or **Range 2**, user-defined in the **SETUP>RNGE>MODE>DUAL** menu, Section 6.3.3.2). Each of these two ranges **MUST** be calibrated separately.

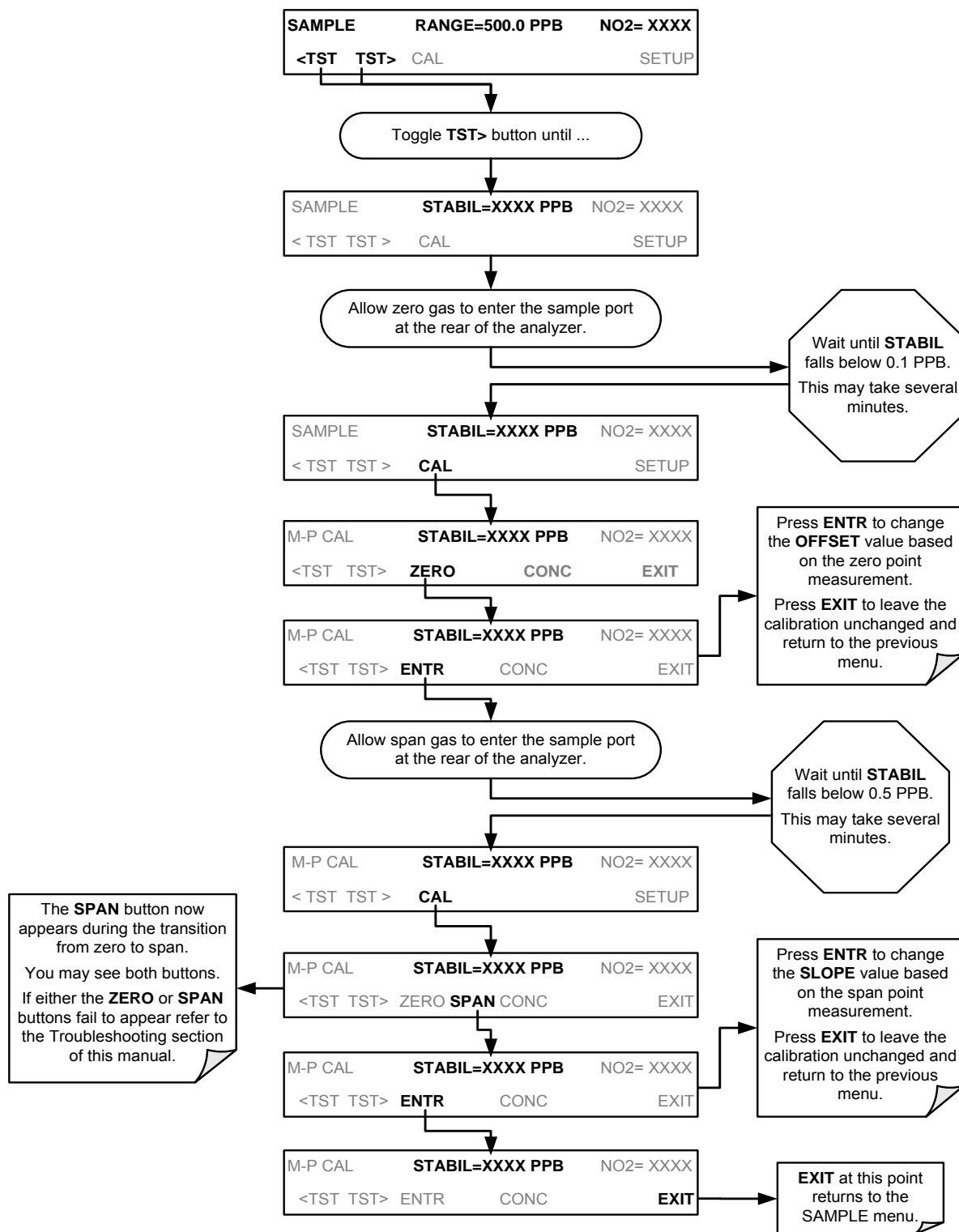
10.3.3.1. SETTING THE EXPECTED SPAN GAS CONCENTRATION

The span gas concentration should be 80% of range of concentration values likely to be encountered in your application. The default factory reporting range setting is 500 ppb and the default span gas concentration is 400.0 ppb.

To set the span gas concentration, press:



10.3.3.2. ZERO/SPAN POINT CALIBRATION PROCEDURE



Note

If the ZERO or SPAN buttons are not displayed, the measurement is out of the allowable range allowed for a reliable calibration.

10.4. MANUAL CALIBRATION WITH THE INTERNAL SPAN GAS GENERATOR

IMPORTANT

IMPACT ON READINGS OR DATA

The internal span gas generator's NO₂ permeation tube has a limited accuracy of about $\pm 5\%$. It can be used to calibrate the analyzer. However, TAPI recommends using the permeation device for informal calibration *checks* (Section 10.4.3)

10.4.1. PERFORMING "PRECISION" MANUAL CALIBRATION FOR INTERNAL SPAN GAS (IZS) GENERATOR OPTION

It is necessary to perform a precision calibration using more accurate zero and span gas standards prior to IZS span calibration or cal check.

To perform a precision calibration of the T500U, connect external sources of zero air and calibrated span gas (Section 10.1) and temporarily disconnect the sample gas source as shown below; then follow the procedures described in Section 10.3.3.

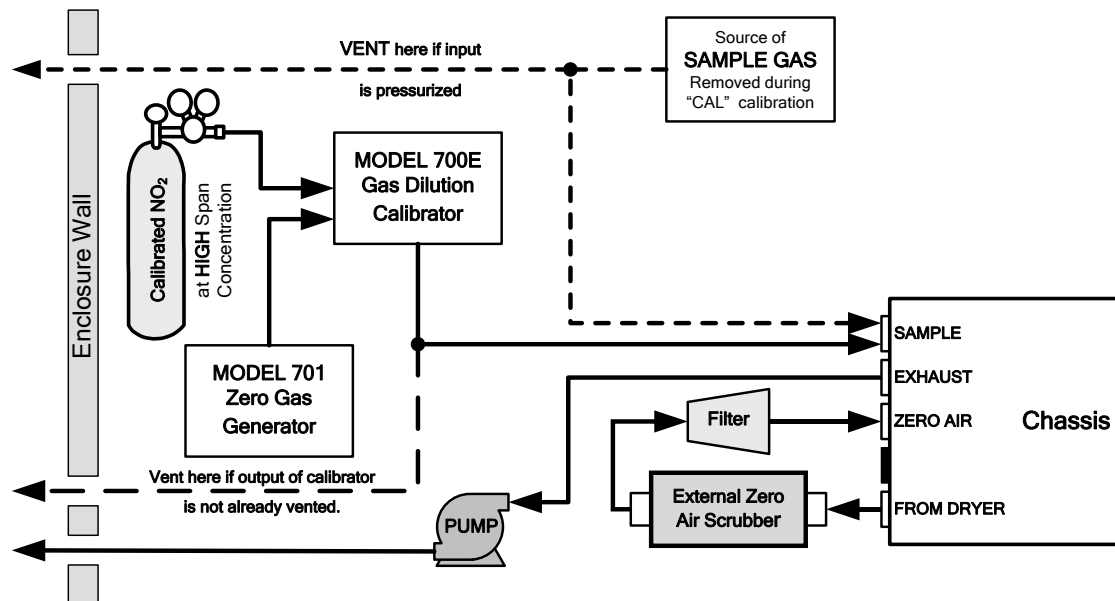


Figure 10-2: Pneumatic Connections for T500U Precision Calibration when IZS Generator Present

IMPORTANT

IMPACT ON READINGS OR DATA

DO NOT USE THE CALZ or CALS buttons even though they will be visible, as this will cause the instrument to use the internal zero air and span gas.

Instead, press the CAL button. This will cause the analyzer to use the external calibration gas sources.

10.4.2. SETUP FOR CALIBRATION WITH THE INTERNAL SPAN GAS GENERATOR

Connect the sources of zero air and span gas as shown in Figure 10-3.

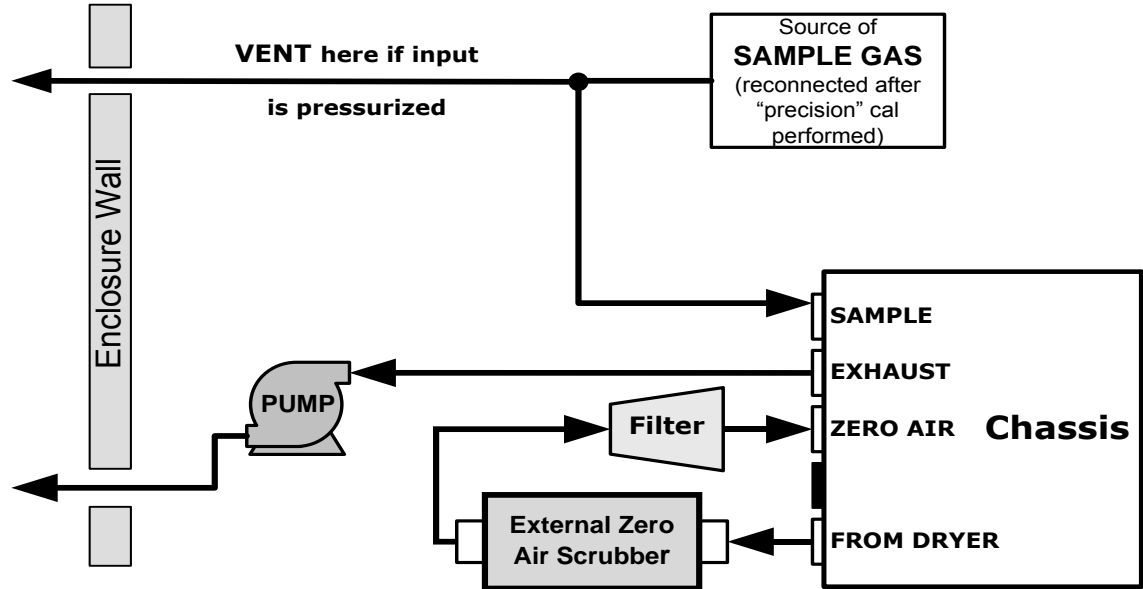
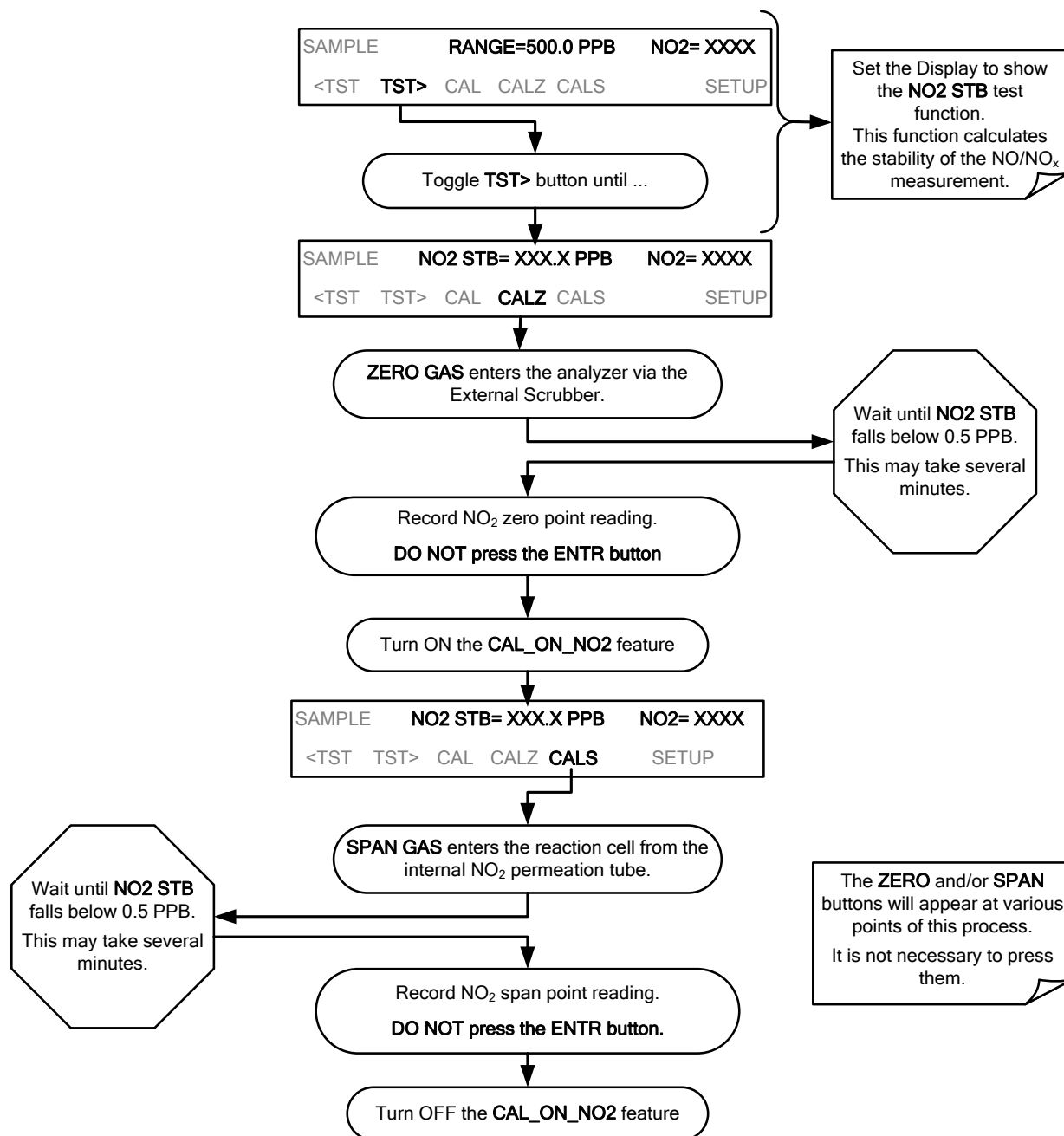


Figure 10-3: Pneumatic Connections for Manual Calibration/Checks with the Internal Span Gas Generator

10.4.3. PERFORMING A MANUAL CALIBRATION CHECK WITH THE INTERNAL SPAN GAS GENERATOR



Note

If the **ZERO** or **SPAN** buttons are not displayed, the measurement made is out of the allowable range for a reliable calibration. See Section 13.4.4 for troubleshooting tips.

10.4.4. PERFORMING A MANUAL CALIBRATION WITH THE INTERNAL SPAN GAS GENERATOR

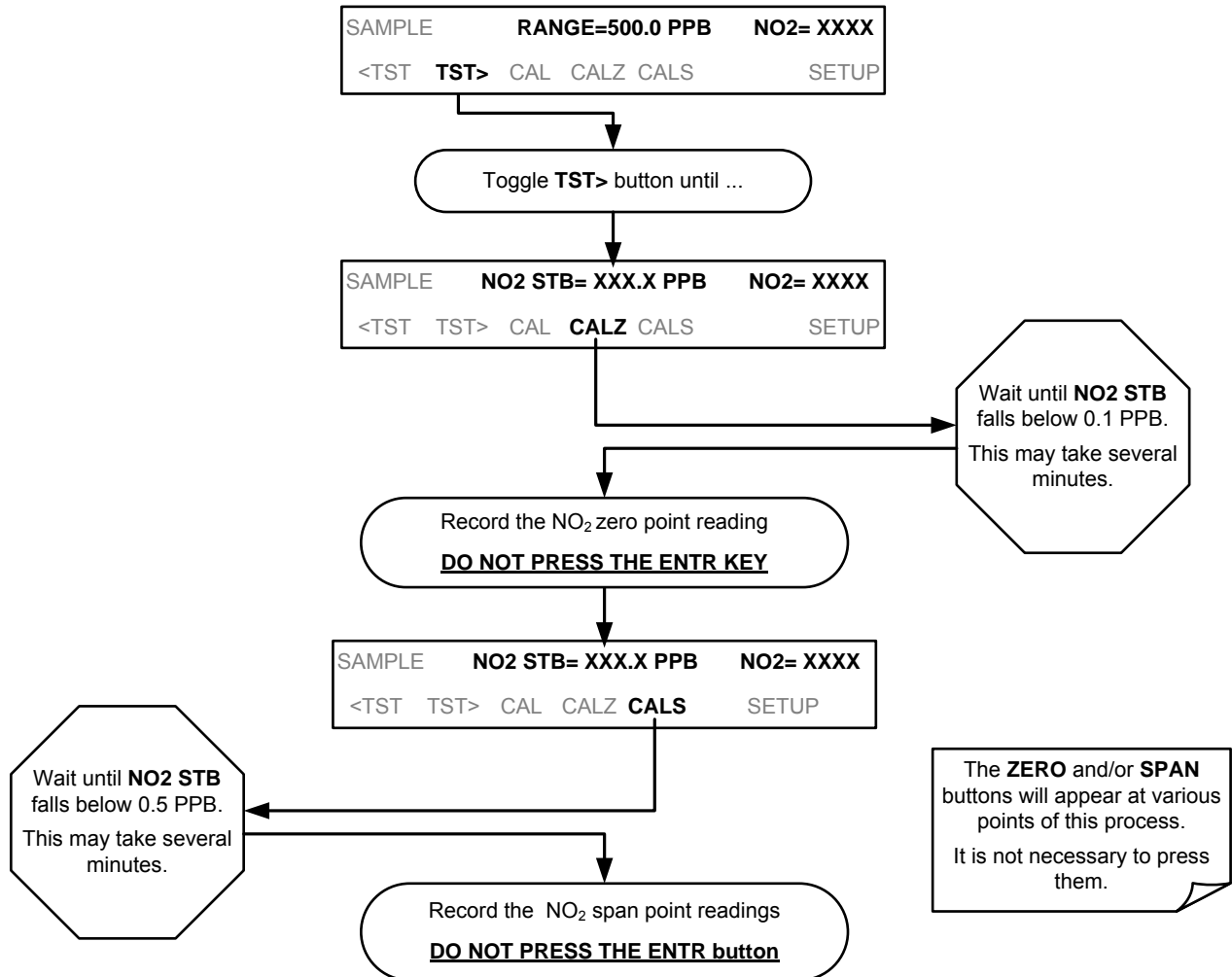
If the analyzer's reporting range is set for the **AUTO** range mode, a step will appear for selecting which range is to be calibrated (**LOW** or **HIGH**, user-selected in the **SETUP>RNGE>MODE>DUAL** menu, Section 6.3.3.2). Each of these two ranges *MUST be calibrated separately*.

10.4.4.1. SETTING THE EXPECTED SPAN GAS CONCENTRATION

When calibrating the instrument using the internal permeation tube as a span gas source, it is necessary to know, as close as possible, the concentration value of the gas being outputted by the tube. To determine this value:

1. Perform a precision calibration of the instrument as described in Section 10.4.1.
2. Perform a calibration check as described in Section 10.4.3.
 - Record the value displayed for NO₂ during the span check portion of the procedure.
 - This will be the concentration value used in subsequent calibrations using the internal span gas source.
 - It is a good idea to measure the permeation tube output once every 4 to 6 months.
3. Ensure that the reporting range span point is set for a value at least 10% higher than the measured value of the permeation tube output.

10.4.5. MANUAL CALIBRATION CHECKS WITH VALVE OPTIONS INSTALLED



10.4.6. MANUAL CALIBRATION USING VALVE OPTIONS

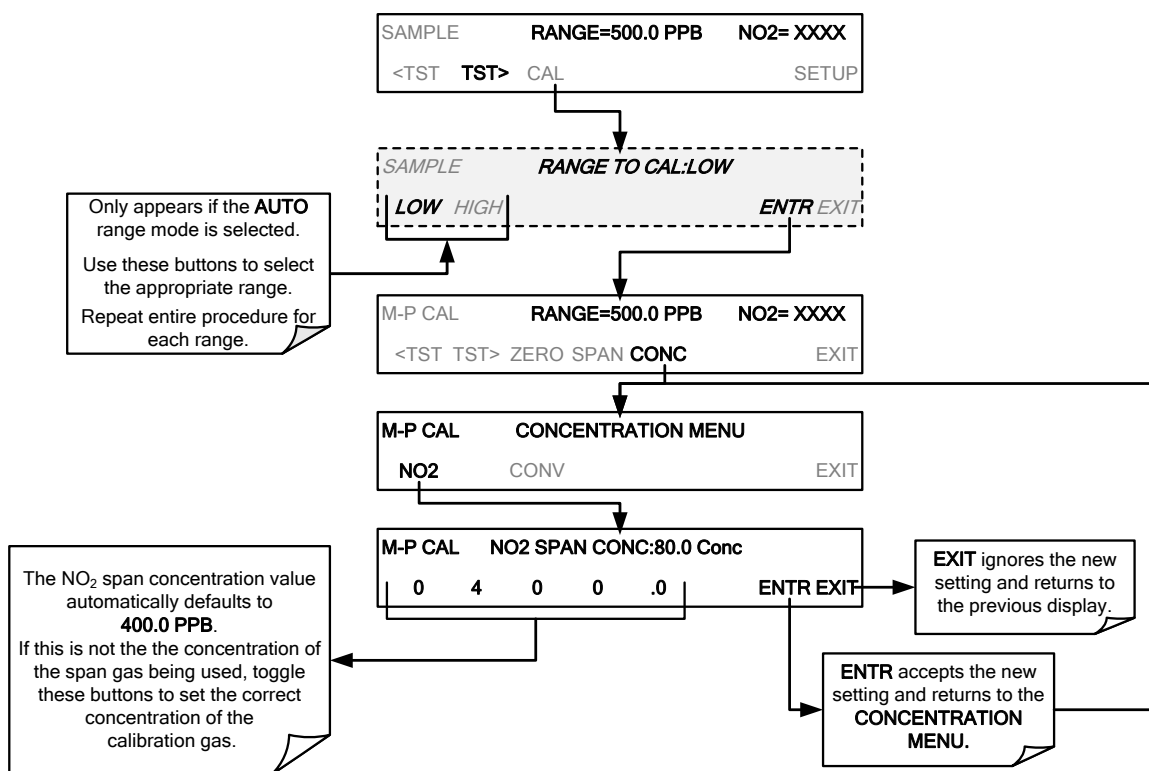
The following section describes the basic method for manually calibrating the T500U analyzer.

If the analyzer's reporting range is set for the **AUTO** range mode, a step will appear for selecting which range is to be calibrated (**LOW** or **HIGH**). Each of these two ranges *MUST be calibrated separately*.

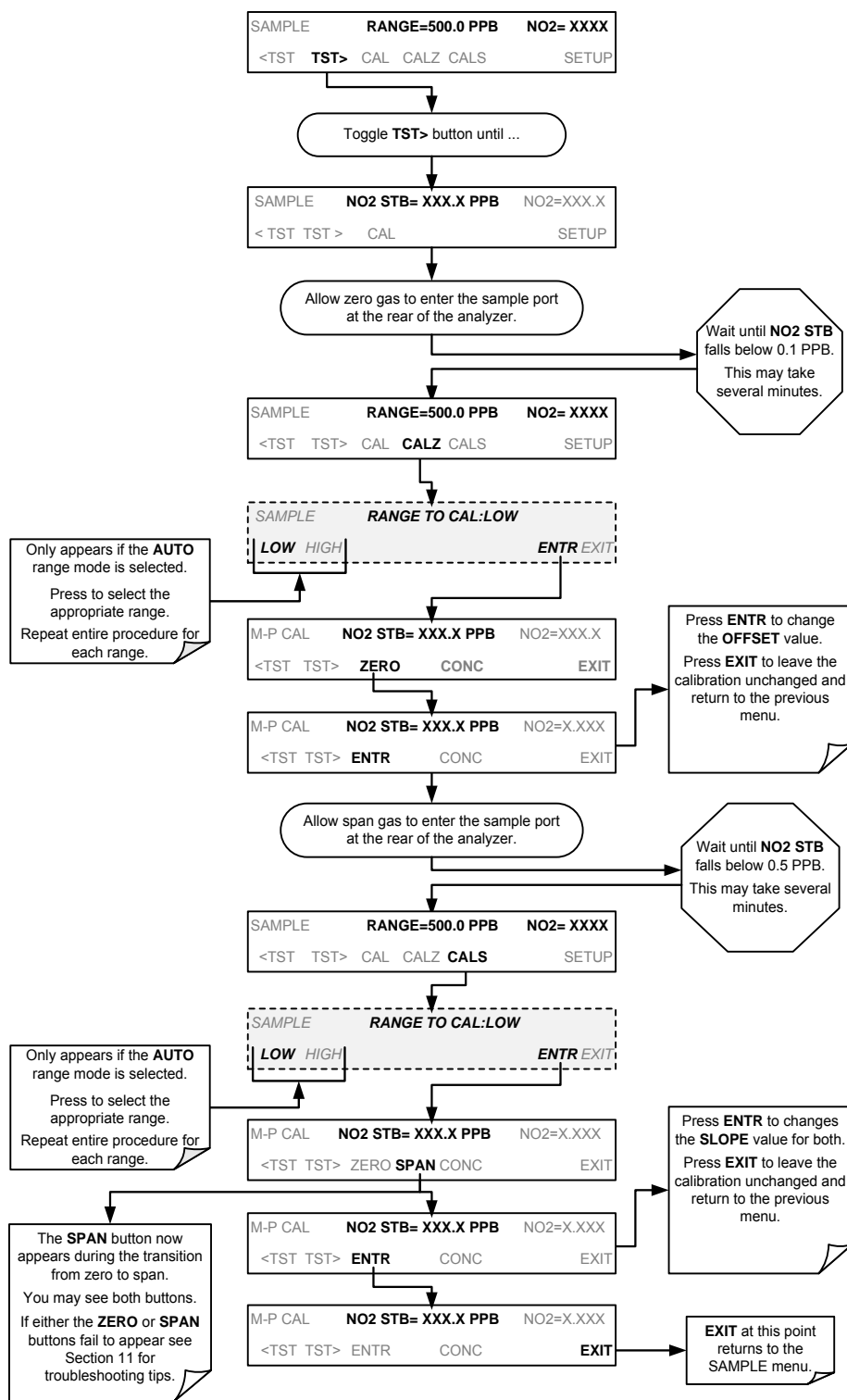
10.4.6.1. SETTING THE EXPECTED SPAN GAS CONCENTRATION

The NO₂ span gas concentration should be 80% of range of the concentration value likely to be encountered in your application. The default factory reporting range setting is 500 ppb and the default span gas concentration is 400.0 ppb.

To set the span gas concentration, press:



10.4.6.2. ZERO/SPAN POINT CALIBRATION PROCEDURE FOR VALVE OPTIONS



Note

If the ZERO or SPAN buttons are not displayed, the measurement made during is out of the range allowed for a reliable calibration.

10.4.6.3. USE OF ZERO/SPAN VALVE WITH REMOTE CONTACT CLOSURE

Contact closures for controlling calibration and calibration checks are located on the rear panel **CONTROL IN** connector. Instructions for setup and use of these contacts are in Section 3.3.1.6.

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

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

Contact Closures and AutoCal's "CALIBRATE" Enabled

If contact closures are being used in conjunction with the analyzer's AutoCal feature (Section 10.5) and the AutoCal attribute "CALIBRATE" is enabled, the T500U will not re-calibrate the analyzer UNTIL the contact is opened. At this point, the new calibration values will be recorded before the instrument returns to **SAMPLE** mode.

Contact Closures and AutoCal's "CALIBRATE" Disabled

If the AutoCal attribute "CALIBRATE" is *disabled*, the instrument will return to **SAMPLE** mode, leaving the instrument's internal calibration variables unchanged.

10.5. AUTOMATIC ZERO/SPAN CAL/CHECK (AUTOCAL)

The AutoCal system allows unattended periodic operation of the **ZERO/SPAN** valve options by using the T500U's internal time of day clock. AutoCal operates by executing **SEQUENCES** programmed by the user to initiate the various calibration modes of the analyzer and open and close valves appropriately. It is possible to program and run up to three separate sequences (**SEQ1**, **SEQ2** and **SEQ3**). Each sequence can operate in one of three modes, or be disabled.

Table 10-1: AUTOCAL Modes

MODE NAME	ACTION
DISABLED	Disables the Sequence.
ZERO	Causes the Sequence to perform a Zero calibration/check.
ZERO-SPAN	Causes the Sequence to perform a Zero point calibration/check followed by a Span point calibration/check.
SPAN	Causes the Sequence to perform a Span concentration calibration/check only.

For each mode, there are seven parameters that control operational details of the **SEQUENCE** as presented next in Table 10-2.

Table 10-2: AutoCal Attribute Setup Parameters

ATTRIBUTE	ACTION
TIMER ENABLED	Turns on the Sequence timer.
STARTING DATE	Sequence will operate after Starting Date.
STARTING TIME	Time of day sequence will run.
DELTA DAYS	Number of days to skip between each Sequence execution. <ul style="list-style-type: none"> • If set to 7, for example, the AutoCal feature will be enabled once every week on the same day.
DELTA TIME	Number of hours later each “Delta Days” Sequence is to be run. <ul style="list-style-type: none"> • If set to 0, the sequence will start at the same time each day. Delta Time is added to Delta Days for the total time between cycles. • This parameter prevents the analyzer from being calibrated at the same daytime of each calibration day and prevents a lack of data for one particular daytime on the days of calibration
DURATION	Number of minutes the sequence operates. <ul style="list-style-type: none"> • This parameter needs to be set such that there is enough time for the concentration signal to stabilize. • The STB parameter shows if the analyzer response is stable at the end of the calibration. • This parameter is logged with calibration values in the DAS.
CALIBRATE	Enable to do a calibration – Disable to do a cal check only.
RANGE TO CAL	LOW calibrates the low range, HIGH calibrates the high range.

The following example sets sequence #2 to do a zero-span calibration every other day starting at 2:15PM on July 31, 2013, lasting 15 minutes, without calibration. This will start ½ hour later each iteration.

Table 10-3: Example AutoCal Sequence

MODE AND ATTRIBUTE	VALUE	COMMENT
SEQUENCE	2	Define Sequence #2
MODE	ZERO-SPAN	Select Zero and Span Mode
TIMER ENABLE	ON	Enable the timer
STARTING DATE	31 JUL 2013	Start after July 31, 2013
STARTING TIME	14:15	First Span starts at 2:15PM
DELTA DAYS	2	Do Sequence #2 every other day
DELTA TIME	00:30	Do Sequence #2 ½ -hr later each day
DURATION	15.0	Operate Span valve for 15 min
CALIBRATE	OFF	Calibrate at end of Sequence

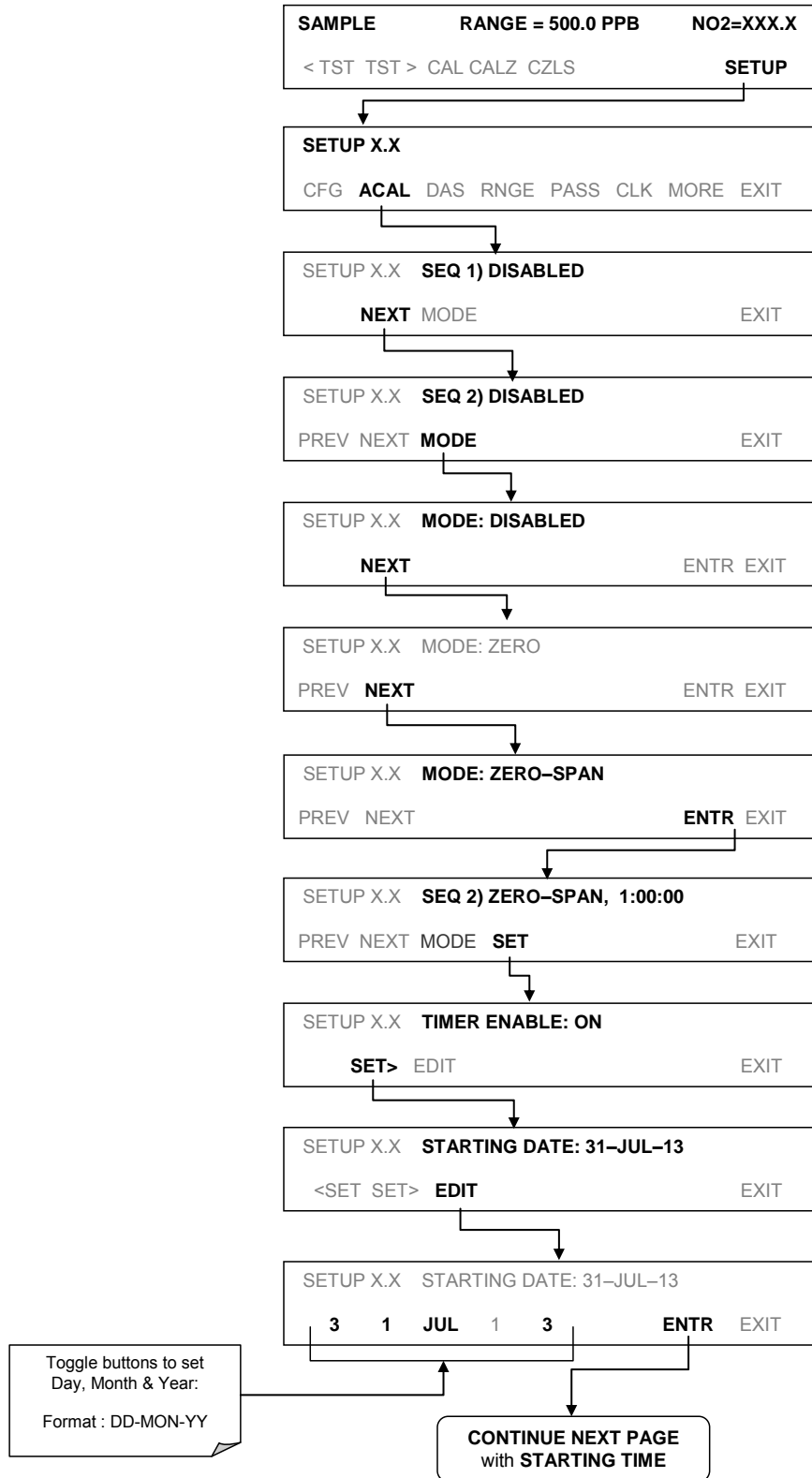
IMPORTANT

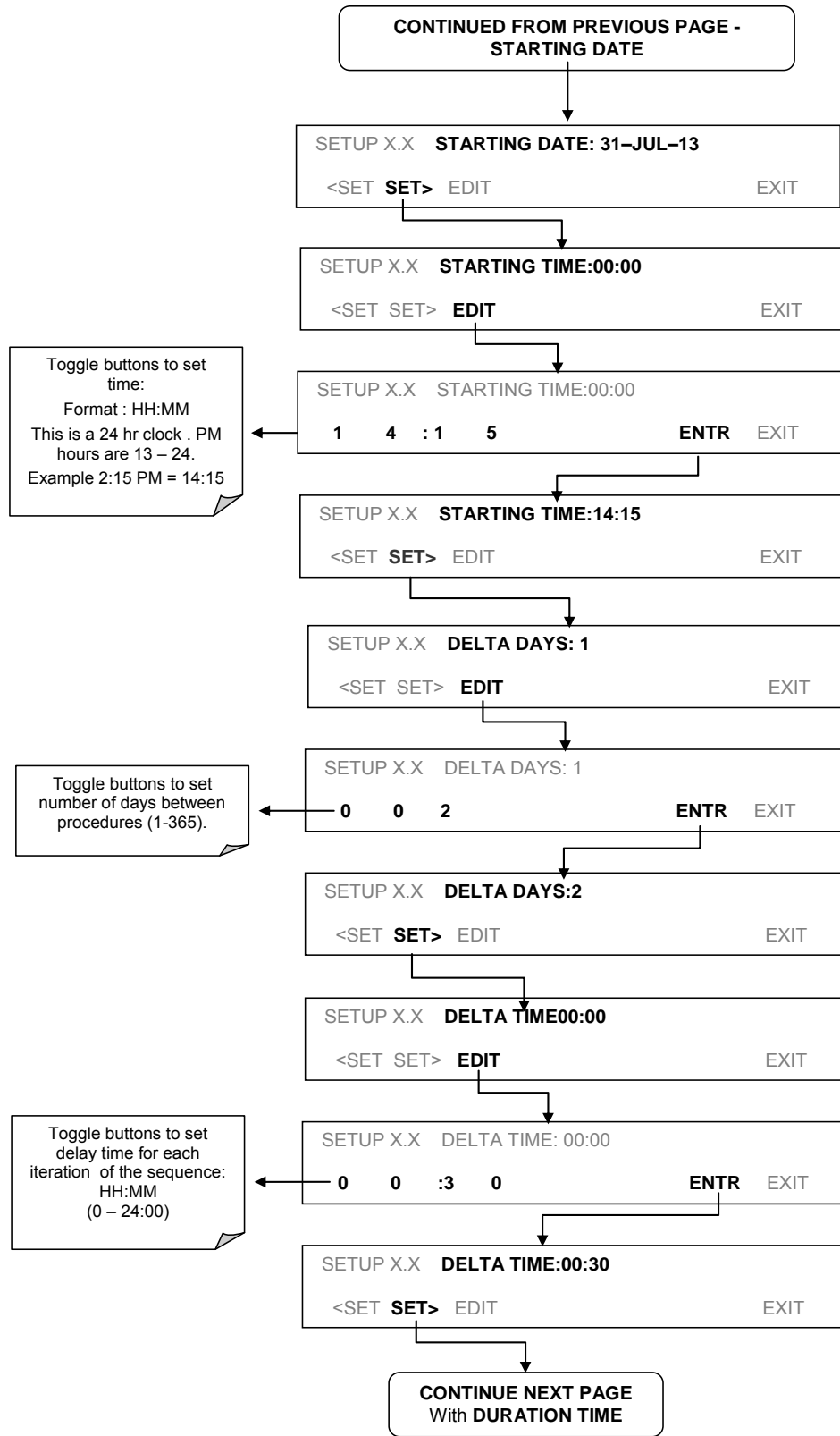
IMPACT ON READINGS OR DATA

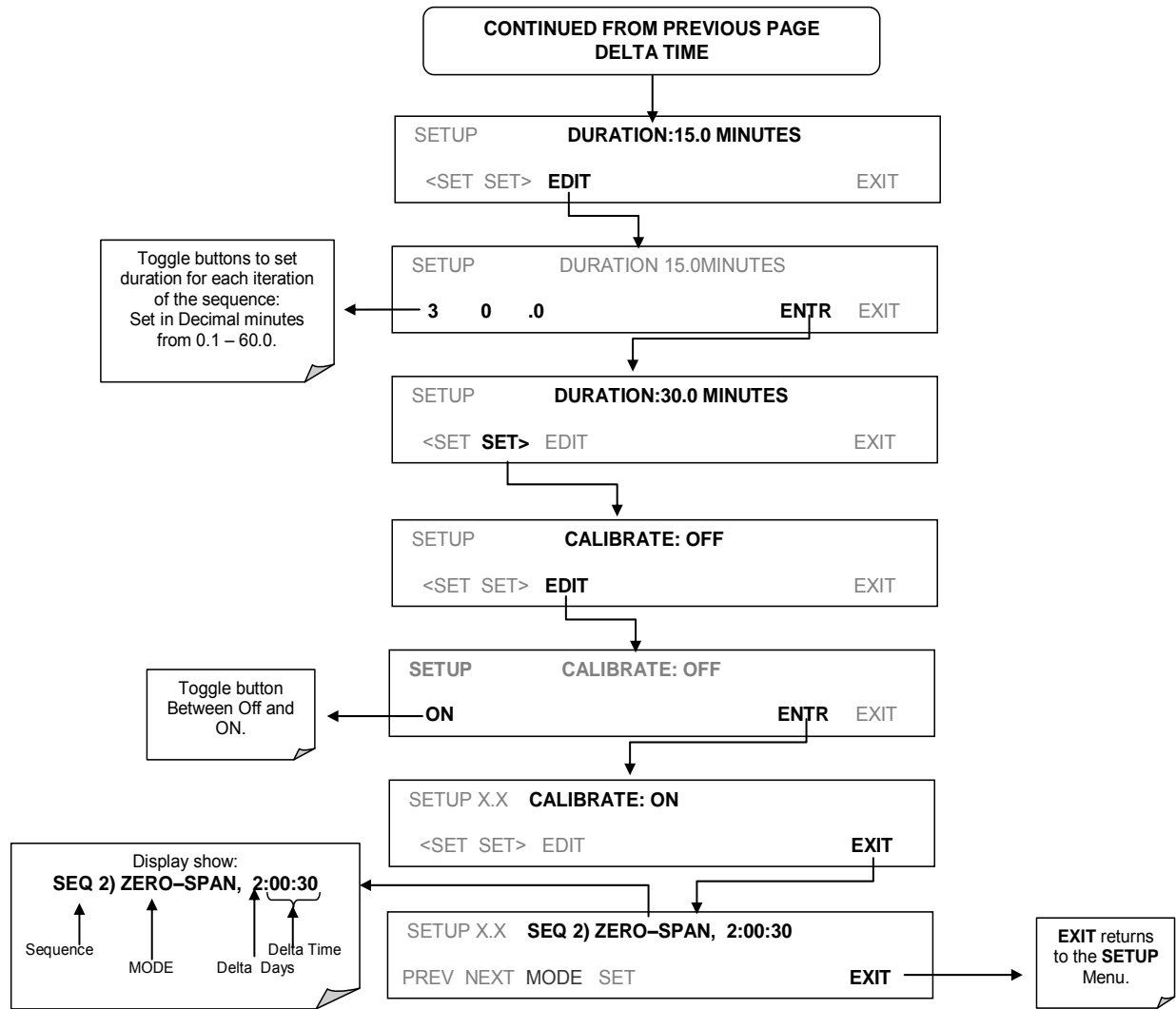
- The programmed STARTING_TIME must be a minimum of 5 minutes later than the real time clock for setting real time clock (see Section 6.5).
- Avoid setting two or more sequences at the same time of the day.
- Any new sequence that is initiated whether from a timer, the COM ports or the contact closure inputs will override any sequence that is in progress.
- The CALIBRATE attribute must always be set to OFF on analyzers with IZS Options installed and functioning.
- Calibrations should ONLY be performed using sources of Zero Air and Span Gas whose accuracy is traceable to EPA or NIST standards.

10.5.1. SETUP → ACAL: PROGRAMMING AND AUTO CAL SEQUENCE

To program the example sequence shown in Table 10-3, press:







Note

If at any time an unallowable entry is selected (Example: Delta Days > 367) the ENTR button will disappear from the display.

10.6. CALIBRATION QUALITY ANALYSIS

Following calibration, evaluate the analyzer's calibration **SLOPE** and **OFFSET** parameters. Their values describe the linear response curve of the analyzer, indicating the quality of the calibration.

First, record the values of the SLOPE and OFFSET test functions (in **SAMPLE** Mode press the <TST TST> buttons, see Section 5.2), all of which are automatically stored in the DAS channel **CALDAT** for data analysis, documentation and archival.

Ensure that these values are within the limits listed in Table 10-4 and frequently compare them to those values on the *Final Test and Validation Data Sheet (P/N 07853)* that came attached to your manual, which should not be significantly different. If they are, refer to Section 13.1.2 in Troubleshooting and Service.

Table 10-4: Calibration Data Quality Evaluation

Function	Minimum Value	Optimum Value	Maximum Value
SLOPE	-0.800	1.000	1.200
OFFSET	-10 ppb	0.0 ppb	10.0 ppb

11. MAINTENANCE

Although the T500U analyzer requires little service, a few simple procedures should be performed regularly to ensure that the T500U continues to operate accurately and reliably over its lifetime. In general, the exterior can be wiped down with a lightly damp cloth; avoid spraying anything directly onto any part of the analyzer.

Service and troubleshooting are covered in Section 13.

11.1. MAINTENANCE SCHEDULE

Table 11-1 shows a typical maintenance schedule for the T500U. 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.



WARNING – ELECTRICAL SHOCK HAZARD

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



CAUTION – QUALIFIED PERSONNEL

These maintenance procedures must be performed by qualified technicians only.

IMPORTANT

IMPACT ON READINGS OR DATA

A span and zero calibration check (see **CAL CHECK REQ'D** Column of Table 11-1, T500U Maintenance Schedule) must be performed following some of the maintenance procedures.

To perform a **CHECK** of the instrument's Zero or Span Calibration, follow the calibration check steps in Section 10.4.

DO NOT press the **ENTR** button at the end of each operation. Pressing the **ENTR** button resets the stored values for **OFFSET** and **SLOPE** and alters the instrument's Calibration.

Alternately, use the **Auto Cal** feature described in Section 10.5 with the **CALIBRATE** attribute set to **OFF**.

Table 11-1: T500U Maintenance Schedule

ITEM	ACTION	FREQ	CAL CHECK REQ'D	DATE PERFORMED										
TEST functions	Review and evaluate	Weekly	No											
Particulate filter	Change particle filter	Yearly	No											
Zero/span check	Evaluate offset and slope	Weekly	No											
Zero/span calibration	Zero and span calibration	Every 3 months	Yes											
Spectrometer mirrors	Contact Technical Support	As necessary due to excessive Measured Loss	Yes											
Pneumatic sub-system	Check for leaks in gas flow paths	Annually or after repairs involving pneumatics	Yes if a leak is repaired											
Internal Pump	Replace	Measured Flow less than 800 cm ³ /min	Yes											

11.2. PREDICTIVE DIAGNOSTICS

Predictive diagnostic functions including failure warnings and alarms built into the analyzer's firmware allow the user to determine when repairs are necessary.

The Test Functions can also 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 Test and Validation Data Sheet*, P/N 07853.

The following table 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.

Table 11-2: Predictive Uses for Test Functions

FUNCTION	EXPECTED	ACTUAL	INTERPRETATION & ACTION
SAMP (pressure)	Constant within atmospheric changes (Typically 2 InHg below ambient)	Fluctuating	Developing leak in pneumatic system. Check for leaks.
		Slowly increasing	Developing leak in pneumatic system prior to the sample restrictor. Check for leaks. Sample pump requires replacement. Check flow rate.
		Slowly decreasing	Flow path is clogging up. Replace sample filter.
AREF	Constant within $\pm 100\text{Mm}^{-1}$ of check-out value	Significantly increasing	Developing AREF valve failure. Replace valve.
			Developing leak in pneumatic system. Check for leaks.
			Debris on mirrors. Replace charcoal scrubber.
NO₂ (Concentration)	Constant for constant concentrations	Slowly decreasing signal for same concentration	Developing leak in pneumatic system. Check for leaks.

Note

It is recommended that the above test functions be checked weekly.

11.3. MAINTENANCE PROCEDURES

The following procedures are to be performed periodically as part of the standard maintenance of the T500U.

11.3.1. REPLACING THE SAMPLE PARTICULATE FILTER

The particulate filter should be inspected often for signs of plugging or contamination.

To change the filter:

Turn OFF the analyzer to prevent drawing debris into the instrument.

Open the T500U's hinged front panel and disconnect the pneumatic fittings, using the appropriate wrenches, and remove the disposable sample filter.

Note

Flow enters filter at bottom and exits at top.

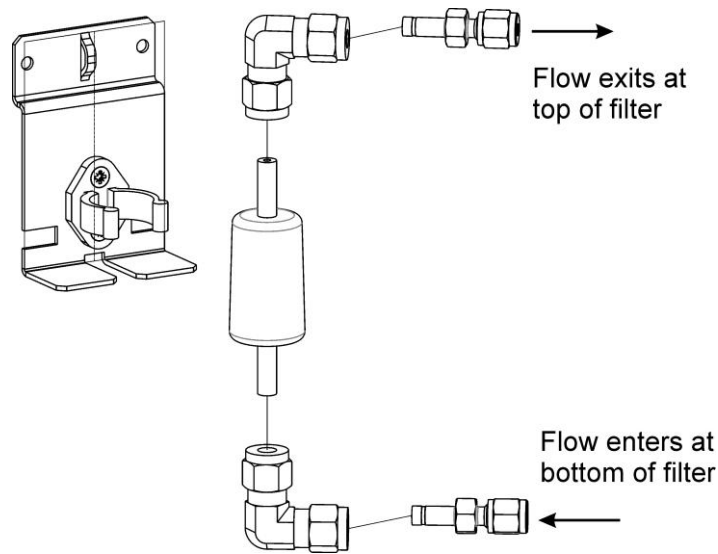


Figure 11-1: Replacing the Sample Filter

11.3.2. CHANGING THE INTERNAL SPAN GAS GENERATOR PERMEATION TUBE

1. Turn off the analyzer, unplug the power cord and remove the cover.
2. Locate the permeation tube oven next to the sample cell.
3. Remove the top layer of insulation if necessary.
4. Unscrew the black aluminum cover of the oven (3 screws) using a medium Phillips-head screw driver. (Leave the fittings and tubing connected to the cover).
5. Remove the old permeation tube and replace it with the new tube. (Ensure that the tube is placed into the larger of two holes and that the open permeation end of the tube (plastic) is facing up).
6. Re-attach the cover with three screws (Ensure that the three screws are tightened evenly).
7. Replace the analyzer cover, plug the power cord back in and turn on the analyzer.
8. Carry out a span check to see if the new permeation device works properly (see Section 10.3.2).
9. The permeation rate may need several days to stabilize.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Do not leave instrument turned off for more than 8 hours without removing the permeation tube. Do not ship the instrument without removing the permeation tube. The tube continues to emit NO₂, even at room temperature and will contaminate the entire instrument.

11.3.3. CHECKING FOR PNEUMATIC LEAKS



CAUTION - TECHNICAL INFORMATION

Do not exceed 10 psi when pressurizing the system during either Sample Flow checks or Detailed Leak checks.

11.3.3.1. DETAILED PRESSURE LEAK CHECK

Obtain a leak checker similar to Teledyne API's P/N 01960, which contains a small pump, shut-off valve, and pressure gauge to create an over-pressure condition. Alternatively, a tank of pressurized gas, with the two-stage regulator adjusted to ≤ 10 psi, a shutoff valve and a pressure gauge may be used.

ATTENTION

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

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

11.3.3.2. PERFORMING A SAMPLE FLOW CHECK

IMPORTANT**IMPACT ON READINGS OR DATA**

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

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

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

12. EPA PROTOCOL CALIBRATION

To ensure high quality, accurate measurements at all times, the T500U analyzer must be calibrated prior to use. A quality assurance program centered on this aspect and including attention to the built-in warning features of the analyzer, periodic inspection, regular zero/span checks, regular evaluation of test parameters for predictive diagnostics and data analysis and routine maintenance of the instrument are paramount to achieving this goal.

The US EPA strongly recommends that you obtain a copy of the publication Quality Assurance Handbook for Air Pollution Measurement Systems (abbreviated, Q.A. Handbook Volume II); USEPA Order Number: EPA454R98004; or NIST Order Number: PB99-129876.

This manual can be purchased from:

- EPA Technology Transfer Network (<http://www.epa.gov/ttn/amtic>)
- National Technical Information Service (NTIS, <http://www.ntis.gov/>)

Specific regulations regarding the use and operation of ambient NO_x analyzers can be found in Section 12.1 Reference 1.

If the T500U is used for EPA compliance monitoring, it must be calibrated in accordance with EPA guidelines. The instrument(s) supplying the zero air and Span calibration gasses used must themselves be calibrated and that calibration must be traceable to an EPA/NIST primary standard.

12.1. REFERENCES RELATING TO NO₂ MONITORING

1. Environmental Protection Agency, Title 40, Code of Federal Regulations, Part 50, Appendix E, Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence), Federal Register, 41 (232), 52688-52692, December 1976 (as amended at 48 FR 2529, Jan 20, 1983).
2. Ellis, Elizabeth C. Technical Assistance Document for the Chemiluminescence Measurement of Nitrogen Dioxide, U.S. Environmental Protection Agency, Research Triangle Park, NC. 83 pages, December 1975. Available online at <http://www.epa.gov/ttn/amtic/files/ambient/criteria/reldocs/4-75-003.pdf>.
3. Environmental Protection Agency, Title 40, Code of Federal Regulations, Part 58, Appendix A, Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence), Federal Register, 41 (232), 52688-52692, December 1976 (as amended at 48 FR 2529, Jan 20, 1983).

4. Mavrodineanu, R., and Gills, T. E., Standard Reference Materials: Summary of Gas Cylinder and Permeation Tube Standard Reference Materials Issued by the National Bureau of Standards, Document SP260-108, May 1987. And: Taylor, J. K., Standard Reference Materials: Handbook for SRM Users, Document number SP260-100, February 1993. Available online at: http://patapsco.nist.gov/srmcatalog/sp_publications/publications.htm
5. Quality Assurance Handbook for Air Pollution Measurement Systems - Volume I, "A Field Guide to Environmental Quality Assurance," EPA-600/R-94/038a, April 1994. Available online at: <http://www.epa.gov/ttn/amtic/qabook.html>.
6. Quality Assurance Handbook for Air Pollution Measurement Systems - Volume II, Ambient Air Specific Methods. EPA-600/4-77/027a, December 1986. US EPA Order Number: 454R98004, available at the National Technical Information Service (NTIS), 5285 Port Royal Rd Springfield, VA 22151. Portions are also available at: <http://www.epa.gov/ttn/amtic/qabook.html>.
7. Environmental Protection Agency, Title 40, Code of Federal Regulations, Part 58, Appendix B, Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence), Federal Register, 41 (232), 52688-52692, December 1976 (as amended at 48 FR 2529, Jan 20, 1983).
8. Quality Assurance Guidance Document. Reference Method for the Determination of Nitrogen Dioxide in the Atmosphere (Chemiluminescence). Draft document, 58 pages, February 2002. Office of Air Quality Planning and Standards, Research Triangle Park NC 27711, draft document available at <http://www.epa.gov/ttn/amtic/qabook.html>. Guidelines about the measurement of NO₂ in this document replace those in the old QA Handbook and should be consulted as the latest reference.

13. TROUBLESHOOTING AND SERVICE

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

Note:

To support your understanding of the technical details of maintenance, Section 14, Principles of Operation, provides information about how the instrument works.



CAUTION

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



WARNING RISK OF ELECTRICAL SHOCK

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

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

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

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

Use common sense when operating inside a running analyzer.

Note

The front panel of the analyzer is hinged at the bottom and may be opened to gain access to various components mounted on the panel itself or located near the front of the instrument (such as the particulate filter).

Remove the locking screw located at the right-hand side of the front panel.

13.1. GENERAL TROUBLESHOOTING

The T500U 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:

- Note any **WARNING MESSAGES** and take corrective action as necessary.
- 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.
- 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.
- 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 (refer to Section 11.3.3).
- Check for gas flow problems such as clogged or blocked internal/external gas lines, damaged seals, punctured gas lines, a damaged / malfunctioning pumps, etc.

13.1.1. 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 13-1 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 sub-system (power supply, relay PCA motherboard) has failed rather than an indication of the specific failures referenced by the warnings.

The analyzer will alert the user that a Warning Message is active by flashing the FAULT LED and 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/touch screen examples provide an illustration of each (top: Fault message with CLR button; bottom: MSG button to read and clear fault).



Figure 13-1. CLR and MSG Menu Buttons

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

To view or clear the various warning messages press:

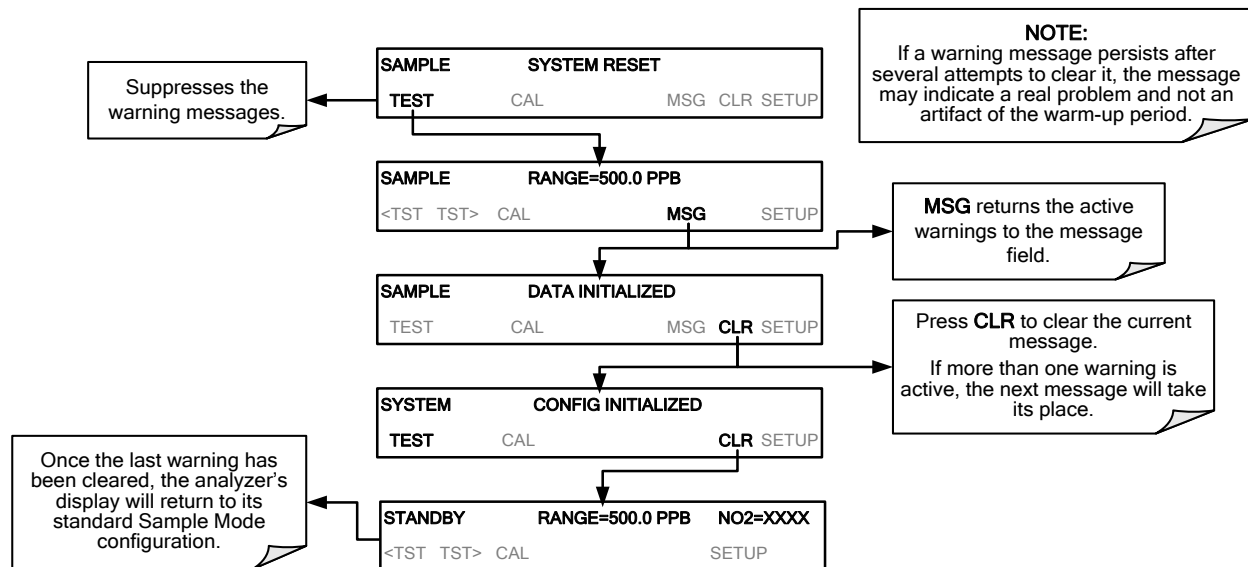


Table 13-1: Front Panel Warning Messages

WARNING	FAULT CONDITION	POSSIBLE CAUSES
AUTO REF WARNING	AREF value outside allowable limit.	Drift in baseline loss due to large leak. Sample filter bypassed. Mirrors require cleaning.
BOX TEMP WARNING	Chassis temperature outside allowable limits.	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.	This WARNING only appears on Serial I/O COM port(s) Front Panel Display will be frozen, blank or will not respond. Failure of Motherboard
RELAY BOARD WARN	The CPU cannot communicate with the Relay Board.	I ² C Bus failure Failed Relay Board Loose connectors/wiring
SAMPLE PRESS WARN	Sample pressure outside allowable limits.	Leak Malfunctioning valve Malfunctioning pump Clogged flow restrictor Note that the internal pump will stop running if the sample pressure reaches 15 InHg, and will restart when the sample pressure reaches acceptable levels.
SYSTEM RESET	The analyzer (CPU) has rebooted.	This message occurs at power on. If it is confirmed that power has not been interrupted: Failed +5 VDC power Fatal Error caused software to restart Loose connector/wiring

Note

A failure of the analyzer's CPU, motherboard or power supplies can result in any or ALL of the above messages.

13.1.2. FAULT DIAGNOSIS WITH TEST FUNCTIONS

In addition to being useful as predictive diagnostic tools, the test functions viewable from the analyzers front panel can be used to isolate and identify many operational problems when combined with a thorough understanding of the analyzer's principles of operation (see Section 14).

The acceptable ranges for these test functions are listed in the "Nominal Range" column of the analyzer *Final Test and Validation Data Sheet* (P/N 07853) shipped with the instrument. Values outside these acceptable ranges indicate a failure of one or more of the analyzer's subsystems. Functions whose values are still within acceptable ranges but have significantly changed from the measurement recorded on the factory data sheet may also indicate a failure.

Note

A value of "XXXX" displayed for any of these TEST functions indicates an OUT OF RANGE reading.

Note

Sample Pressure measurements are represented in terms of ABSOLUTE pressure because this is the least ambiguous method reporting gas pressure.

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

Table 13-2: Test Functions - Indicated Failures

TEST FUNCTION	INDICATED FAILURE(S)
SMP PRS (pressure)	Leak; malfunctioning valve; malfunctioning pump; clogged flow restrictor; sample inlet overpressure. (Note that the pump will stop running if the sample pressure reaches 15 InHg, and will restart after the sample pressure reaches an acceptable level)
SMP Temp	Sample temperature out of range; broken thermistor.
OVEN TEMP	Oven temperature out of range; broken thermistor.
BOX TEMP	Environment out of temperature operating range; broken thermistor.
MANIFOLD TEMP	Manifold temperature out of range; broken thermistor.
IZS TEMP	IZS temperature out of range; broken thermistor.

13.1.3. 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 touchscreen. These signals are useful for troubleshooting in three ways:

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

This allows the technician to observe systematically the effect of directly controlling these signals on the operation of the analyzer. Following is 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.

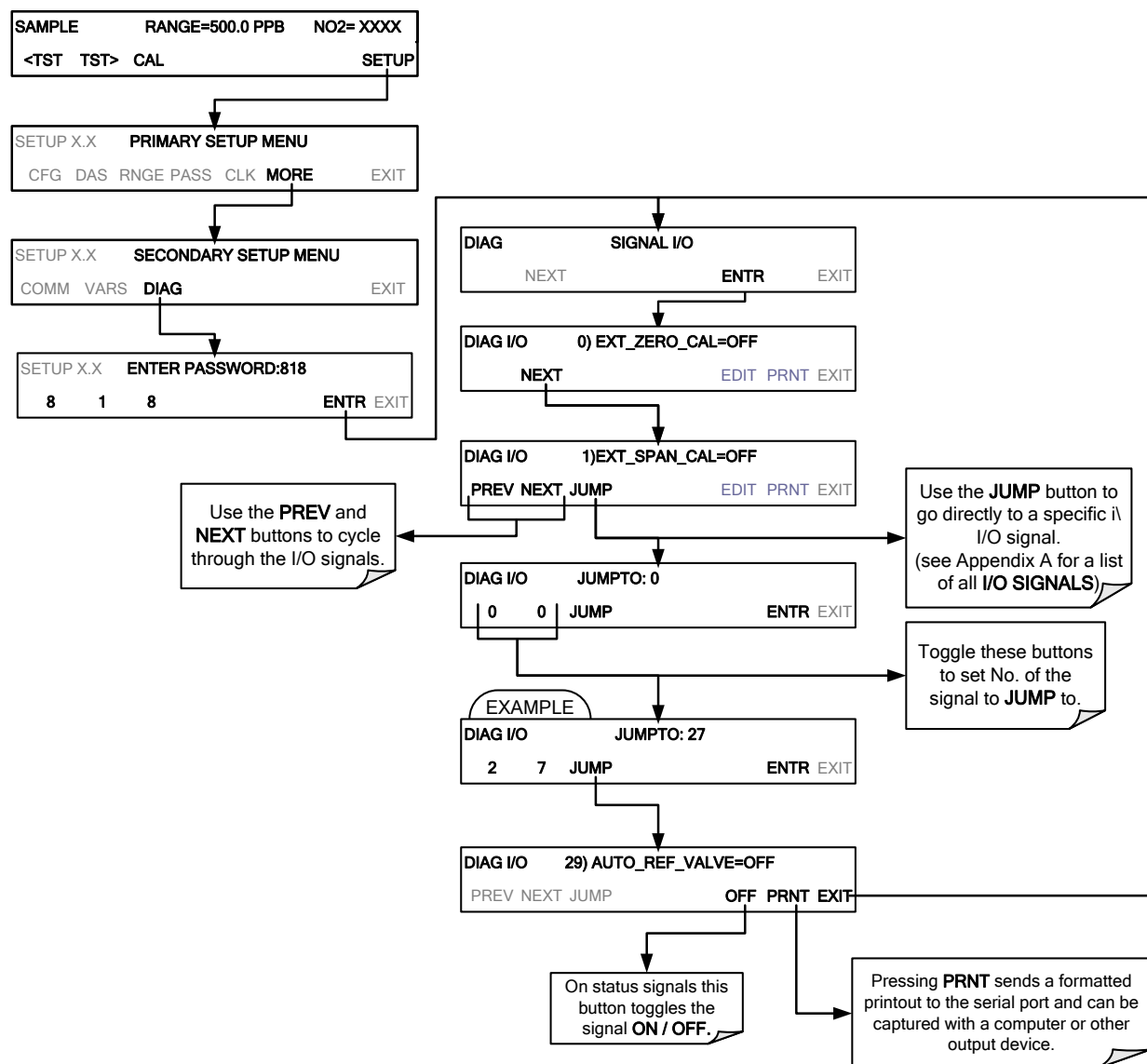


Figure 13-2: Example of Signal I/O Function

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.

See Appendix A for a complete list of the parameters available for review under this menu.

13.2. USING THE ANALOG OUTPUT TEST CHANNEL

The signals available for output over the T500U's analog output channel can also be used as diagnostic tools. See Section 6.8.2 for instruction on activating the analog output and selecting a function. See Table 13-1 for possible causes of extremely high or low readings.

13.3. 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 PCA are functioning properly.

13.3.1. 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 – 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, contact Teledyne API's Technical Support Department (see Section 13.9) because it may be possible to recover operation of the analyzer. If after 30 – 60 seconds, neither DS5 is flashing nor have any characters been written to the front panel display then the CPU is bad and must be replaced.

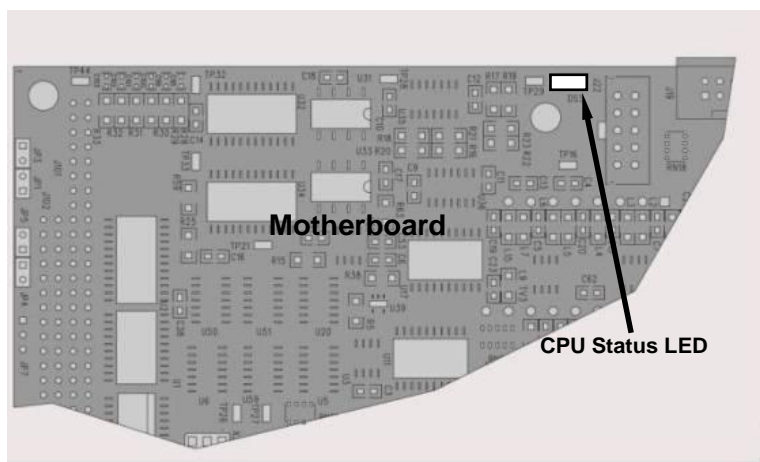


Figure 13-3: CPU Status Indicator

13.3.2. RELAY PCA STATUS LEDS

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

13.3.2.1. I²C BUS WATCHDOG STATUS LEDS

The most important is D1 (see Figure 13-4), which indicates the health of the I²C bus.

Table 13-3: 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, Touchscreen or Relay PCA Faulty Connectors/Wiring between Motherboard, Touchscreen 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.

13.3.2.2. RELAY PCA STATUS LEDES

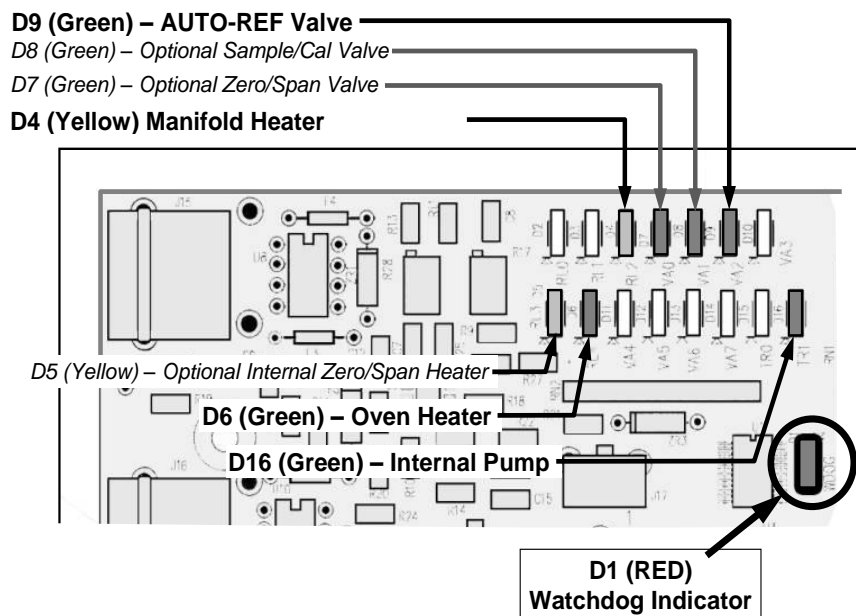


Figure 13-4: Relay PCA Status LEDs Used for Troubleshooting

Table 13-4: Relay PCA Status LED Failure Indications

LED	COLOR	COMPONENT	FAULT STATUS	INDICATED FAILURE(S)
LED ROW 1				
D2-D3	spares			
D4	Yellow	Manifold heater	Continuously ON or OFF	Heater broken, thermistor broken
D7	Green	Internal Zero/Span (option) valve	Continuously ON or OFF	Valve broken or stuck, valve driver chip broken
D8	Green	Sample/Cal valve (option)	Continuously ON or OFF	Valve broken or stuck, valve driver chip broken
D9	Green	Auto Reference valve	Continuously ON or OFF	Valve broken or stuck, valve driver chip broken
D10	spare			
LED ROW 2				
D5	Yellow	Internal Zero/Span (option) heater	Continuously ON or OFF	Heater broken, thermocouple broken
D6	Green	Oven heater	Continuously ON or OFF	Heater broken, thermistor broken
D11-15	spares			
D16	Green	Internal pump	Continuously ON or OFF	Not receiving power; relay board bad

13.4. CALIBRATION PROBLEMS

This section describes possible causes of calibration problems.

13.4.1. NEGATIVE CONCENTRATIONS

A negative concentration value can be caused by calibration error: If the zero air were contaminated, and the analyzer was calibrated at “zero”, the analyzer may report a negative value when measuring air that contains little or no NO₂.

13.4.2. NO RESPONSE

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

1. Confirm the lack of response by supplying or NO₂ span gas of about 80% of the range value to the analyzer.
2. Check the sample flow rate for proper value.
3. Check for disconnected cables to the sensor module.

13.4.3. UNSTABLE ZERO AND SPAN

Leaks in the T500U or in the external gas supply and vacuum systems are the most common source of unstable and non-repeatable concentration readings.

1. Check for leaks in the pneumatic systems as described in Section 11.3.3.
2. Consider pneumatic components in the gas delivery system outside the T500U such as a change in zero air source (ambient air leaking into zero air line or a worn-out zero air scrubber) or a change in the span gas concentration due to zero air or ambient air leaking into the span gas line.
3. Once the instrument passes a leak check, do a flow check (this chapter) to ensure that the instrument is supplied with adequate sample air.
4. Confirm the sample pressure, sample temperature, and sample flow readings are correct and steady.
5. Verify that the sample filter element is clean and does not need to be replaced.

13.4.4. INABILITY TO SPAN - NO SPAN BUTTON (CAL5)

In general, the T500U will not display certain buttons whenever the actual value of a parameter is outside of the expected range for that parameter. If the calibration menu does not show a **SPAN** button when carrying out a span calibration, the actual concentration must be outside of the range of the expected span gas concentration, which can have several reasons.

1. Verify that the expected concentration is set properly to the actual span gas concentration in the CONC sub-menu.
2. Confirm that the span gas source is accurate.
 - This can be done by comparing the source with another calibrated analyzer, or by having the span gas source verified by an independent traceable photometer.
3. Check for leaks in the pneumatic systems as described in Section 11.3.3.
 - Leaks can dilute the span gas and, hence, the concentration that the analyzer measures may fall short of the expected concentration defined in the CONC sub-menu.
4. If the low-level, hardware calibration has drifted or was accidentally altered by the user, a low-level calibration may be necessary to get the analyzer back into its proper range of expected values.
 - One possible indicator of this scenario is a slope or offset value that is outside of its allowed range (0.8-1.2 for slope, -10 to 10 for offsets).

13.4.5. INABILITY TO ZERO - NO ZERO BUTTON (CALZ)

In general, the T500U will not display certain buttons whenever the actual value of a parameter is outside of the expected range for that parameter. If the calibration menu does not show a **ZERO** button when carrying out a zero calibration, the actual gas concentration must be significantly different from the actual zero point (as per last calibration), which may be for any of several reasons.

- Confirm that there is a good source of zero air.
- Check to ensure that there is no ambient air leaking into the zero air line.
- Check for leaks in the pneumatic systems as described in Section 11.3.3.

13.4.6. NON-LINEAR RESPONSE

The T500U was factory calibrated to a high level of NO₂ and should be linear to within 1% of full scale. Common causes for non-linearity are:

- Leaks in the pneumatic system:
 - Leaks can add an offset signal to the ambient sample, zero air or span gas, whose concentration can fluctuate while a linearity test is being performed.
 - Check for leaks as described in Section 11.3.3.
- The calibration device is in error:
 - Check flow rates and concentrations, particularly when using low concentrations.
 - If a mass flow calibrator is used and the flow is less than 10% of the full scale flow on either flow controller, you may need to purchase lower concentration standards.
- The standard gases may be mislabeled as to type or concentration.
 - Labeled concentrations may be outside the certified tolerance.
- The sample delivery system may be contaminated.
 - Check for dirt in the sample lines.
- Dilution air contains sample or span gas.
- Incoming concentrations may not be linear.
 - Check input bottles.
- Span gas overflow is not properly vented and creates a back-pressure on the sample inlet port.
 - Also, if the span gas is not vented at all and does not supply enough sample gas, the analyzer may be evacuating the sample line.
 - Ensure to create and properly vent excess span gas.

13.4.7. DISCREPANCY BETWEEN ANALOG OUTPUT AND DISPLAY

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

- This becomes more likely when using a low concentration or low analog output range.
- Analog outputs running at 0.1 V full scale should always be calibrated manually.
- See Section 6.8.3.2 for a detailed description of this procedure.

13.5. OTHER PERFORMANCE PROBLEMS

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

13.5.1. EXCESSIVE NOISE

Excessive noise levels under normal operation usually indicate leaks in the sample supply or the analyzer itself. Ensure that the sample or span gas supply is leak-free and carry out a detailed leak check as described earlier in this chapter.

Other sources of measurement noise may be related to cabling issues. Gain access to the instrument, when powered down, and reset the cable connectors.

13.5.2. SLOW RESPONSE

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

- Dirty or plugged sample filter or sample lines.
- Sample inlet line is too long.
- Dirty or plugged flow restrictor. Check flows, pressures and, if necessary, change restrictor.
- Wrong materials in contact with sample - use glass, stainless steel or Teflon materials only.
- Insufficient time allowed for purging of lines upstream of the analyzer. Wait until stability is reached.
- Insufficient time allowed for NO₂ calibration gas source to become stable. Wait until stability is reached.

13.5.3. AREF WARNINGS

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

Note

There will not be an AREF warning if the AREF feature was disabled due to prolonged time in CAL mode. Ensure the instrument is returned to SAMPLE mode as soon as a calibration has been completed.

Note

The AREF warning displays the value of the Auto Reference reading when the warning occurs.

If this value is higher than 1100 Mm-1, check that the Auto Reference valve is operating properly:

- In the **DIAG** menu go to **SIGNAL I/O>AUTO_REF_VALVE** to toggle the valve on and off.
- Listen to hear whether the valve is switching, and see if the respective LED on the relay board lights accordingly.
- Check the power supply to the valve (12 V to the valve should turn on and off when measured with a voltmeter).

Note

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

If the Auto Reference valve is working properly, then the problem could be due to dirty mirrors. Please contact Technical Support to confirm this, prior to removing the optical bench, in order to rule out other possibilities (Section 13.9).

13.6. SUBSYSTEM CHECKOUT

The preceding sections of this manual discussed a variety of methods for identifying possible sources of failures or performance problems within the analyzer. In most cases this included a list of possible causes and, in some cases, quick solutions or at least a pointer to the appropriate sections describing them. This section describes how to determine if a certain component or subsystem is actually the cause of the problem being investigated.

13.6.1. AC MAIN POWER

The T500U analyzer's electronic systems will operate with any of the specified power regimes. As long as the system is connected to 100-120 VAC or 220-240 VAC at either 50 or 60 Hz it will turn on and after about 30 seconds show a front panel display.

- Internally, the status LEDs located on the Relay PCA, Motherboard and CPU should turn on as soon as the power is supplied.
- If they do not, check the circuit breaker built into the ON/OFF switch on the instruments front panel.
- If the instrument is equipped with an internal pump, it will begin to run. If it does not:
 - Verify that the pump connection is mated correctly.
 - Verify that there are no kinks in the tubing that would restrict pump operation.
 - Note that the pump will stop running if the sample pressure reaches 15 InHg, and will restart after the sample pressure reaches an acceptable level



WARNING – ELECTRICAL SHOCK HAZARD

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

13.6.2. 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 PCA follow a standard color-coding scheme as defined in the following table.

Table 13-5: DC Power Test Point and Wiring Color Codes

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

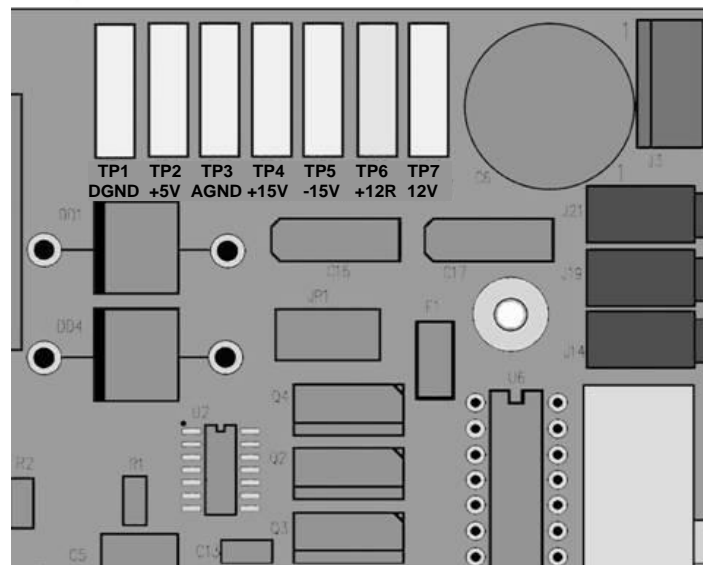


Figure 13-5: Location of DC Power Test Points on Relay PCA

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 13-6: DC Power Supply Acceptable Levels

POWER SUPPLY	VOLTAGE	CHECK RELAY BOARD TEST POINTS				MIN V	MAX V
		FROM Test Point		TO Test Point			
	NAME	#	NAME	#			
PS1	+5	DGND	1	+5	2	+4.85	+5.25
PS1	+15	AGND	3	+15	4	+13.5	+16.0
PS1	-15	AGND	3	-15V	5	-13.5	-16.0
PS1	AGND	AGND	3	DGND	1	-0.05	+0.05
PS1	Chassis	DGND	1	Chassis	N/A	-0.05	+0.05
PS2	+12	+12V Ret	6	+12V	7	+11.8	+12.5
PS2	DGND	+12V Ret	6	DGND	1	-0.05	+0.05

13.6.3. I²C BUS

Operation of the I²C bus can be verified by observing the behavior of D1 on the relay PCA & D2 on the Valve Driver PCA. Assuming that the DC power supplies are operating properly, the I²C bus is operating properly if D1 on the relay PCA and D2 of the Valve Driver PCA are flashing

There is a problem with the I²C bus if both D1 on the relay PCA and D2 of the Valve Driver PCA are ON/OFF constantly.

13.6.4. LCD/DISPLAY MODULE

Touchscreen Interface

Assuming that there are no wiring problems and that the DC power supplies are operating properly, the display screen should light and show the splash screen and other indications of its state as the CPU goes through its initialization process.

13.6.5. RELAY PCA

The Relay PCA can be most easily checked by observing the condition of the status LEDs on the Relay PCA (see Section 13.3.2), and using the **SIGNAL I/O** submenu under the **DIAG** menu (see Section 13.1.3) to toggle each LED **ON** or **OFF**.

If D1 on the Relay PCA is flashing and the status indicator for the output in question (Heater power, Valve Drive, etc.) toggles properly using the Signal I/O function, then the associated device (valve, heater, etc.) may be bad.

13.6.6. MOTHERBOARD

13.6.6.1. TEST CHANNEL / ANALOG OUTPUTS VOLTAGE

The **ANALOG OUTPUT** submenu, located under the **SETUP → MORE → DIAG** menu is used to verify that the T500U analyzer's three analog outputs are working properly. The test generates a signal on all three outputs simultaneously as shown in the following table:

Table 13-7: Analog Output Test Function - Nominal Values Voltage Outputs

		FULL SCALE OUTPUT OF VOLTAGE RANGE (see Section 6.8.3.1)			
		100MV	1V	5V	10V*
STEP	%	NOMINAL OUTPUT VOLTAGE			
1	0	0	0	0	0
2	20	20 mV	0.2	1	2
3	40	40 mV	0.4	2	4
4	60	60 mV	0.6	3	6
5	80	80 mV	0.8	4	8
6	100	100 mV	1.0	5	10

* For 10V output, increase the Analog Output Calibration Limits (AOUT CAL LIM in the DIAG>Analog I/O Config menu) to 4% (offset limit) and 20% (slope limit).

For each of the steps the output should be within 1% of the nominal value listed except for the 0% step, which should be within 0mV \pm 2 to 3 mV. Ensure you take into account any offset that may have been programmed into channel (See Section 6.8.3.9).

If one or more of the steps fails to be within these ranges, it is likely that there has been a failure of the either or both of the Digital-to-Analog Converters (DACs) and their associated circuitry on the motherboard. To perform the test connect a voltmeter to the output in question and perform an analog output step test as follows:

13.6.6.2. 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.

Use the Signal I/O function (see Section 13.1.3 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, \pm 0.2 mV, then the basic A/D is functioning properly. If not, then the motherboard is bad.

Choose a parameter in the Signal I/O function list (see Section 13.1.3) such as **EXT_ZERO_CAL**

- Compare this voltage at its origin (see the interconnect drawing and interconnect list 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.

13.6.6.3. STATUS OUTPUTS

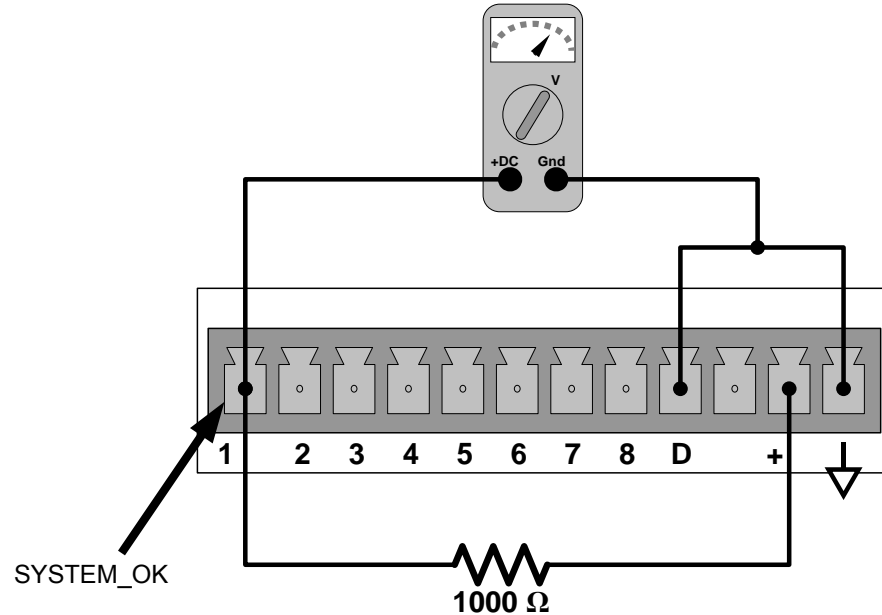


Figure 13-6: Typical Set Up of Status Output Test

To test the status output electronics:

1. Connect a jumper between the "D" pin and the "▽" pin on the status output connector.
2. Connect a 1000 ohm resistor between the "+" pin and the pin for the status output that is being tested.
3. Connect a voltmeter between the "▽" pin and the pin of the output being tested.
4. Under the DIAG → Signal I/O menu (see Section 13.1.3), scroll through the inputs and outputs until you get to the output in question.
5. Alternately, turn on and off the output noting the voltage on the voltmeter.
 - It should vary between 0 volts for ON and 5 volts for OFF.

Table 13-8: Status Outputs Check

PIN (LEFT TO RIGHT)	STATUS
1	ST_SYSTEM_OK
2	ST_CONC_VALID
3	ST_HIGH_RANGE
4	ST_ZERO_CAL
5	ST_SPAN_CAL
6	ST_DIAG_MODE
7	<i>Not Used on T500U</i>
8	ST_O2_CAL

13.6.6.4. CONTROL INPUTS

The control input bits can be tested by applying a trigger voltage to an input and watching changes in the status of the associated function under the **SIGNAL I/O** submenu:

EXAMPLE: to test the “A” control input:

Under the **DIAG** → Signal I/O menu (see Section 13.1.3), scroll through the inputs and outputs until you get to the output named **EXT_ZERO_CAL**.

Connect a jumper from the “+” pin on the appropriate connector to the “U” on the same connector.

Connect a second jumper from the “▽” pin on the connector to the “A” pin.

The status of EXT_ZERO_CAL should change to read “ON”.

Connect a second jumper from the “▽” pin on the connector to the “B” pin.

The status of EXT_ZERO_CAL should change to read “ON”.

Table 13-9: T500U Control Input Pin Assignments and Corresponding Signal I/O Functions

INPUT	CORRESPONDING I/O SIGNAL
A	EXT_ZERO_CAL
B	EXT_SPAN_CAL1
C, D, E & F	NOT USED

13.6.7. CPU

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

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

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

13.6.8. RS-232 COMMUNICATIONS

13.6.8.1. GENERAL RS-232 TROUBLESHOOTING

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

- Incorrect cabling and connectors. See Section 3.3.1.8, *RS-232 Connection*, and Figure 3-11 for connector and pin-out information.
- The BAUD rate and protocol are incorrectly configured. See Sections 3.3.1.8 and 7.2.2.
- If a modem is being used, additional configuration and wiring rules must be observed. See Section 9.3
- Incorrect setting of the DTE – DCE Switch. See Section 7.1 to set correctly.
- Verify that cable (P/N 03596) that connects the serial COM ports of the CPU to J12 of the motherboard is properly seated.

13.6.8.2. TROUBLESHOOTING ANALYZER/MODEM OR TERMINAL OPERATION

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

1. Check cables for proper connection to the modem, terminal or computer.
2. Check to ensure that the DTE-DCE is in the correct position as described in Section 7.1.
3. Check to ensure that the set up command is correct (see Section 9.3).
4. Verify that the Ready to Send (RTS) signal is at logic high. The T500U sets pin 7 (RTS) to greater than 3 volts to enable modem transmission.
5. Ensure that the BAUD rate, word length, and stop bit settings between modem and analyzer match. See Section 7.2.2.
6. Use the RS-232 test function to send "w" characters to the modem, terminal or computer. See Section 7.2.3.
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. Ensure that the communications software or terminal emulation software is functioning properly.

Note

Further help with serial communications is available in a separate manual "RS-232 Programming Notes" Teledyne API's P/N 01350.

13.6.9. INTERNAL SPAN GAS GENERATOR AND VALVE OPTIONS

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

- Check for the physical presence of the valves or the IZS option.
- Check front panel for correct software configuration. When the instrument is in SAMPLE mode, the front panel display should show CALS and CALZ buttons in the second line of the display. The presence of the buttons indicates that the option has been enabled in software. In addition, the IZS option is enabled if the TEST functions show a parameter named IZS TEMP.

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

The permeation tube of the internal span gas generator option is heated with a proportional heater circuit and the temperature is maintained at $50^{\circ}\text{C} \pm 1^{\circ}\text{C}$. Check the front panel display or the **IZS_TEMP** signal voltage using the **SIGNAL I/O** function under the **DIAG** Menu (Section 6.8.1). At 50°C , the temperature signal from the IZS thermistor should be around 2500 mV.

13.6.10. TEMPERATURE SENSOR

13.6.10.1. BOX TEMPERATURE SENSOR

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

- Box temperature will vary with, but will usually read about 5° C higher than, ambient (room) temperature because of the internal heating zones.
- To check the box temperature functionality, we recommend checking the **BOX_TEMP** signal voltage using the **SIGNAL I/O** function under the **DIAG** Menu (Section 13.1.3).
- At about 30° C, the signal should be around 1500 mV.
- To check the accuracy of the sensor, use a calibrated external thermometer / temperature sensor to verify the accuracy of the box temperature as follows:
 - Place it inside the chassis, next to the thermistor labeled **XT1** (above connector J108) on the motherboard.
 - Compare its reading to the value of the test function **BOX TEMP**.

13.7. SERVICE PROCEDURES

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

Note

.....
Maintenance procedures (e.g., replacement of regularly changed expendables) are discussed in Section 11 and are not listed here).

Also, there may be more detailed service notes for some of the below procedures. Contact Teledyne API's Technical Support Department.
.....



WARNING – ELECTRICAL SHOCK HAZARD

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



CAUTION – QUALIFIED TECHNICIAN

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

13.7.1. DISK-ON-MODULE REPLACEMENT PROCEDURE

Note

Servicing 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. Please learn more about preventing ESD damage in our manual, *Fundamentals of ESD*, PN 04786, available on our website at <http://www.teledyne-api.com> in Help Center>Product Manuals, under Special Manuals.

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

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

If the replacement DOM carries a firmware revision, re-enter all of the setup information.

13.7.2. REMOVING / REPLACING THE RELAY PCA FROM THE INSTRUMENT

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

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

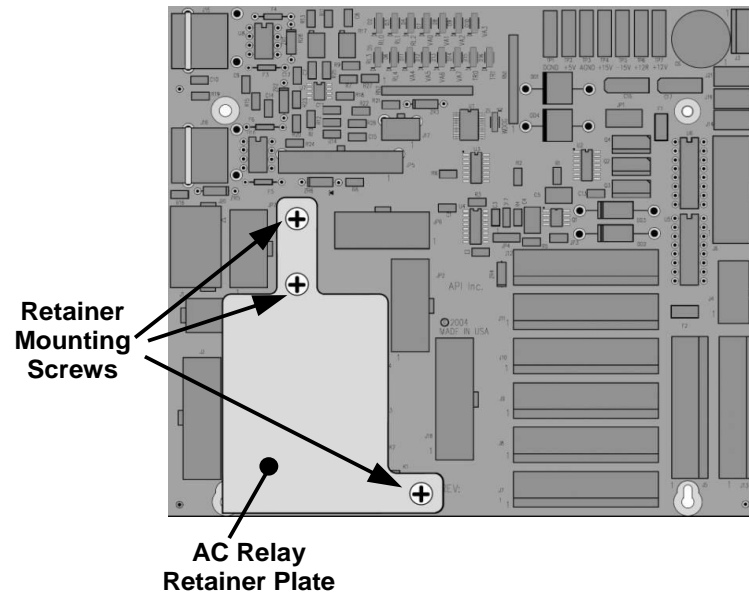


Figure 13-7: Relay PCA with AC Relay Retainer In Place

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

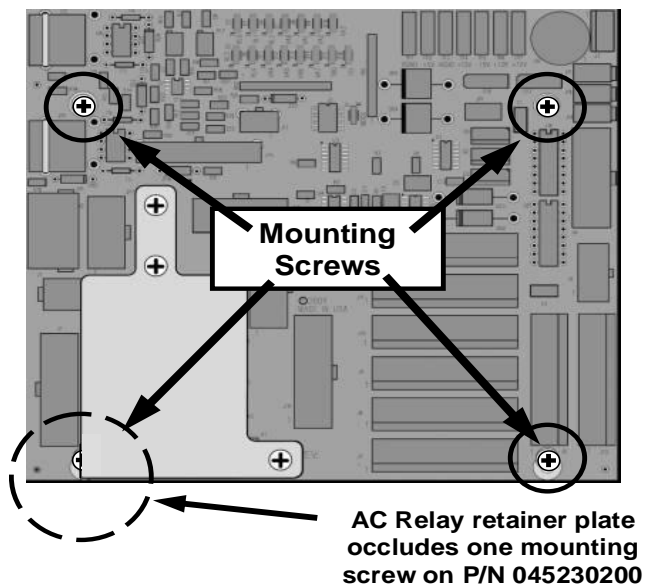


Figure 13-8: Relay PCA Mounting Screw Locations

13.8. FREQUENTLY ASKED QUESTIONS

The following list was compiled from the Teledyne API's Technical Support Department's most commonly asked questions relating to the T500U Analyzer.

QUESTION	ANSWER
Why does the ENTR button sometimes disappear on the front panel display?	Sometimes the ENTR button will disappear if you select a setting that is invalid or out of the allowable range for that parameter, such as trying to set the 24-hour clock to 25:00:00 or a range to less than 1 or more than 20000 ppb. Once you adjust the setting to an allowable value, the ENTR button will re-appear.
Why is the ZERO or SPAN button not displayed during calibration?	The T500U disables certain these buttons expected span or zero value entered by the users is too different from the gas concentration actually measured value at the time. This is to prevent the accidental recalibration of the analyzer to an out-of-range response curve. EXAMPLE: The span set point is 400 ppb but gas concentration being measured is only 50 ppb.
How do I enter or change the value of my Span Gas?	Press the CONC button found under the CAL or CALS buttons of the main SAMPLE display menus to enter the expected NO ₂ span concentration. See Section 10.3.3.1 or for more information.
Can I automate the calibration of my analyzer?	Any analyzer with zero/span valve can be automatically calibrated using the instrument's AutoCal feature.
How do I measure the sample flow?	Sample flow is measured by attaching a calibrated flow meter to the sample inlet port when the instrument is operating. The sample flow should be 900 cm ³ /min ±10%. Section 13.3.12.3 includes detailed instructions on performing a check of the sample gas flow.
Can I use the DAS system in place of a strip chart recorder or data logger?	Yes. Section 8 describes the setup and operation of the DAS system in detail.
How often do I need to change the particulate filter?	Once per week or as needed. Section 11.1 contains a maintenance schedule listing the most important, regular maintenance tasks. Highly polluted sample air may require more frequent changes.

QUESTION	ANSWER
How long does the sample pump last?	<p>The sample pump should last one to two years and should be replaced when necessary. Use the RCEL pressure indicator on the front panel to see if the pump needs replacement.</p> <p>If this value goes above 10 in-Hg-A, on average, the pump needs to be replaced.</p>
Why does my RS-232 serial connection not work?	<p>There are several possible reasons:</p> <ul style="list-style-type: none"> • The wrong cable: please use the provided or a generic “straight-through” cable (do not use a “null-modem” type cable) and ensure the pin assignments are correct (Sections 3.3.1.8 and 7.3). • The DCE/DTE switch on the back of the analyzer is not set properly; ensure that both green and red lights are on (Section 7.1). • The baud rate of the analyzer’s COM port does not match that of the serial port of your computer/data logger (Section 7.2.2).
How do I make the instrument’s display and my data logger agree?	<p>This most commonly occurs when an independent metering device is used besides the data logger/recorder to determine gas concentration levels while calibrating the analyzer. These disagreements result from the analyzer, the metering device and the data logger having slightly different ground levels.</p> <p>Use the data logger itself as the metering device during calibration procedures.</p>
How do I set up and use the Contact Closures (Control Inputs) on the Rear Panel of the analyzer?	See Section 3.3.1.6.

13.9. TECHNICAL ASSISTANCE

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

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

Toll-free Phone: 800-324-5190

Phone: 858-657-9800

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/manuals/>.

14. PRINCIPLES OF OPERATION

The Cavity Attenuated Phase Shift (CAPS) NO₂ monitor operates as an optical absorption spectrometer that yields both reliable and accurate measurements of ambient nitrogen dioxide down to sub ppb concentrations, with lower noise levels than chemiluminescence-based monitors. The CAPS method uses light from a blue Ultraviolet (UV) light emitting diode (LED) centered at 450 nm, a measurement cell with high reflectivity mirrors located at either end to provide an extensive optical path length, and a vacuum photodiode detector. These components are assembled into the optical cell which resides in a temperature-controlled oven. The oven raises the ambient temperature of the sample gas to 45 degrees Celsius. This mitigates the formation of moisture on the surfaces of the mirrors while also minimizing changes in the absorption coefficient due to temperature fluctuations.

As stated, the T500U analyzer measures NO₂ directly, using optical absorption. This phenomenon is well-defined and is described by Beer's Law, where the Absorbance (lost light) is directly proportional to both the path-length and concentration of the absorbing gas.

$$A = \epsilon l c$$

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

The CAPS method employed in the T500U is unique in that it applies this fundamental optical absorption law in the frequency domain, rather than using relative changes in light intensity as the primary signal. Ultraviolet light (UV) from the modulating high intensity LED enters a near confocal optical cell (Figure 14-1) through the rear of mirror A. The intensity of the light, as observed by the detector, which is also modulating at a slightly different frequency, located behind Mirror B, builds exponentially in the cell while the LED is ON. The opposite is true when the LED is OFF. Because both mirrors are highly reflective at 450 nm, a prominent absorption band for NO₂, the light takes a considerable amount of time to plateau in the absence of the absorbing gas. However, when NO₂ is present, the mean path length traveled by the light is significantly reduced. This has two effects on the observed intensity as measured by the detector:

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

Thus, an observed phase shift from the modulating LED is detected (Figure 14-2). The phase shift is largest when measuring zero air and decreases when NO₂ is present.

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

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

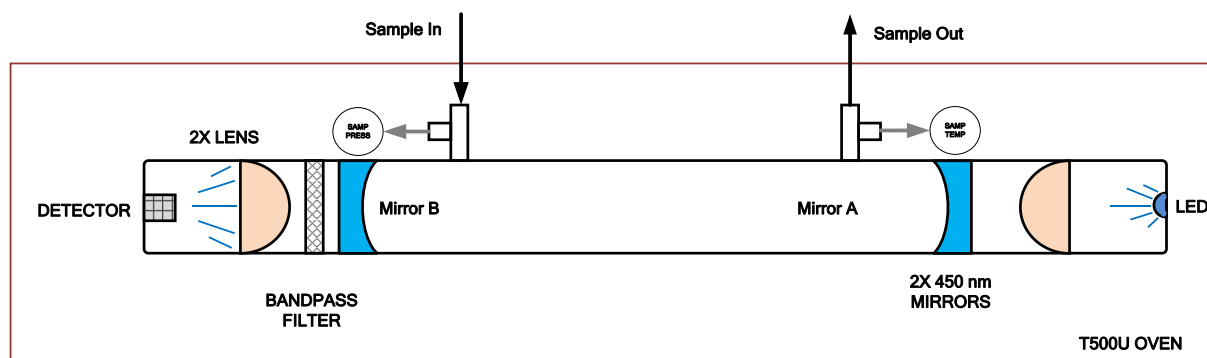


Figure 14-1: T500U Optical Absorption Cell

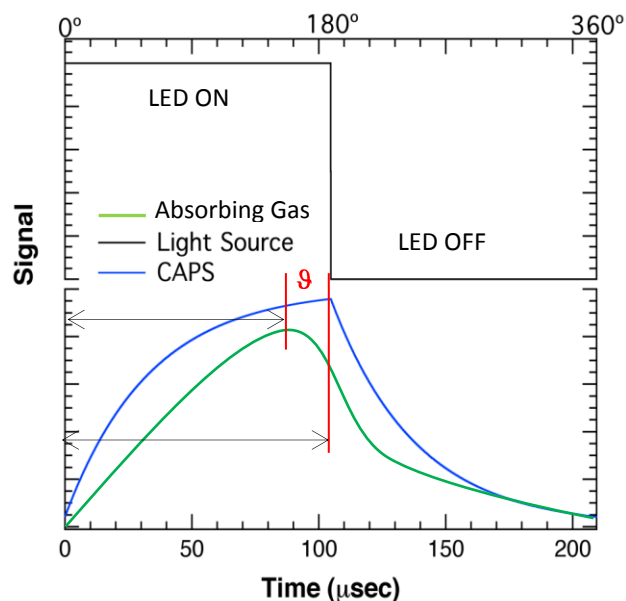


Figure 14-2: Phase Shift Representation of Increased Concentration of NO₂

(Black = LED State, Blue = Light build up in the absence of NO₂, Green = phase shifted\attenuated light)

GLOSSARY

Note that not all terms defined in this glossary are included 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>
CD	<i>Corona Discharge</i> , a frequently luminous discharge, at the surface of a conductor or between two conductors of the same transmission line, accompanied by ionization of the surrounding atmosphere and often by a power loss
CE	<i>Converter Efficiency</i> , the percentage of the total amount that is actually converted (e.g., light energy into electricity; NO ₂ into NO, etc.)
CEM	<i>Continuous Emission Monitoring</i>
Chemical formulas that may be included in this document:	
CO ₂	carbon dioxide
C ₃ H ₈	propane
CH ₄	methane
H ₂ O	water vapor
HC	general abbreviation for hydrocarbon
HNO ₃	nitric acid
H ₂ S	hydrogen sulfide
NO	nitric oxide
NO ₂	nitrogen dioxide
NO _x	nitrogen oxides, here defined as the sum of NO and NO ₂
NO _y	nitrogen oxides, often called odd nitrogen: the sum of NO _x plus other compounds such as HNO ₃ (definitions vary widely and may include nitrate (NO ₃), PAN, N ₂ O and other compounds as well)
NH ₃	ammonia
O ₂	molecular oxygen
O ₃	ozone
SO ₂	sulfur dioxide
cm ³	metric abbreviation for <i>cubic centimeter</i> (replaces the obsolete abbreviation "cc")
CPU	<i>Central Processing Unit</i>
DAC	<i>Digital-to-Analog Converter</i>
DAS	<i>Data Acquisition System</i>
DCE	<i>Data Communication Equipment</i>
DFU	<i>Dry Filter Unit</i>

Term	Description/Definition
DHCP	<i>Dynamic Host Configuration Protocol.</i> A protocol used by LAN or Internet servers to automatically set up the interface protocols between themselves and any other addressable device connected to the network
DIAG	<i>Diagnostics</i> , the diagnostic settings of the analyzer.
DOM	<i>Disk On Module</i> , a 44-pin IDE flash drive with up to 128MB storage capacity for instrument's firmware, configuration settings and data
DOS	<i>Disk Operating System</i>
DRAM	<i>Dynamic Random Access Memory</i>
DR-DOS	<i>Digital Research DOS</i>
DTE	<i>Data Terminal Equipment</i>
EEPROM	<i>Electrically Erasable Programmable Read-Only Memory</i> also referred to as a FLASH chip or drive
ESD	<i>Electro-Static Discharge</i>
ETEST	<i>Electrical Test</i>
Ethernet	a standardized (IEEE 802.3) computer networking technology for local area networks (LANs), facilitating communication and sharing resources
FEP	<i>Fluorinated Ethylene Propylene</i> polymer, one of the polymers that Du Pont markets as <i>Teflon</i> [®]
Flash	non-volatile, solid-state memory
FPI	<i>Fabry-Perot Interface</i> : a special light filter typically made of a transparent plate with two reflecting surfaces or two parallel, highly reflective mirrors
GFC	<i>Gas Filter Correlation</i>
I ² C bus	a clocked, bi-directional, serial bus for communication between individual analyzer components
IC	<i>Integrated Circuit</i> , a modern, semi-conductor circuit that can contain many basic components such as resistors, transistors, capacitors etc in a miniaturized package used in electronic assemblies
IP	<i>Internet Protocol</i>
IZS	<i>Internal Zero Span</i>
LAN	<i>Local Area Network</i>
LCD	<i>Liquid Crystal Display</i>
LED	<i>Light Emitting Diode</i>
LPM	<i>Liters Per Minute</i>
MFC	<i>Mass Flow Controller</i>
Mm-1	Units of measurement used to express light absorption, expressed in MEGA (10 ⁶) per meter.
M/R	<i>Measure/Reference</i>
NDIR	<i>Non-Dispersive Infrared</i>

Term	Description/Definition
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, the PCB with electronic components, ready to use</i>
PC/AT	<i>Personal Computer / Advanced Technology</i>
PCB	<i>Printed Circuit Board, the bare board without electronic component</i>
PFA	<i>Per-Fluoro-Alkoxy, an inert polymer; one of the polymers that Du Pont markets as Teflon[®]</i>
PLC	<i>Programmable Logic Controller, a device that is used to control instruments based on a logic level signal coming from the analyzer</i>
PLD	<i>Programmable Logic Device</i>
PLL	<i>Phase Lock Loop</i>
PMT	<i>Photo Multiplier Tube, a vacuum tube of electrodes that multiply electrons collected and charged to create a detectable current signal</i>
P/N (or PN)	<i>Part Number</i>
PPB	<i>Parts per billion</i>
PPM	<i>Parts per million</i>
PPT	<i>Parts per trillion</i>
PSD	<i>Prevention of Significant Deterioration</i>
PTFE	<i>Poly-Tetra-Fluoro-Ethylene, a very inert polymer material used to handle gases that may react on other surfaces; one of the polymers that Du Pont markets as Teflon[®]</i>
PVC	<i>Poly Vinyl Chloride, a polymer used for downstream tubing</i>
Rdg	Reading
RS-232	specification and standard describing a serial communication method between DTE (Data Terminal Equipment) and DCE (Data Circuit-terminating Equipment) devices, using a maximum cable-length of 50 feet
RS-485	specification and standard describing a binary serial communication method among multiple devices at a data rate faster than RS-232 with a much longer distance between the host and the furthest device
SAROAD	<i>Storage and Retrieval of Aerometric Data</i>
SLAMS	<i>State and Local Air Monitoring Network Plan</i>
SLPM	<i>Standard Liters Per Minute of a gas at standard temperature and pressure</i>
STP	<i>Standard Temperature and Pressure</i>

Term	Description/Definition
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: Software Documentation, Library Revision 7.0.3

APPENDIX A-1: SOFTWARE MENU TREES AND INDEX.....	A-3
APPENDIX A-2: SETUP VARIABLES FOR SERIAL I/O.....	A-9
APPENDIX A-3: WARNINGS AND TEST MEASUREMENTS	A-10
APPENDIX A-4: SIGNAL I/O DEFINITIONS.....	A-13
APPENDIX A-5: TRIGGER EVENTS AND DAS FUNCTIONS	A-17
APPENDIX A-6: TERMINAL COMMAND DESIGNATORS AND COMMAND LINE OPTIONS ...	A-19
APPENDIX A-7: MODBUS REGISTER MAP.....	A-22

APPENDIX A-1: Software Menu Trees and Index

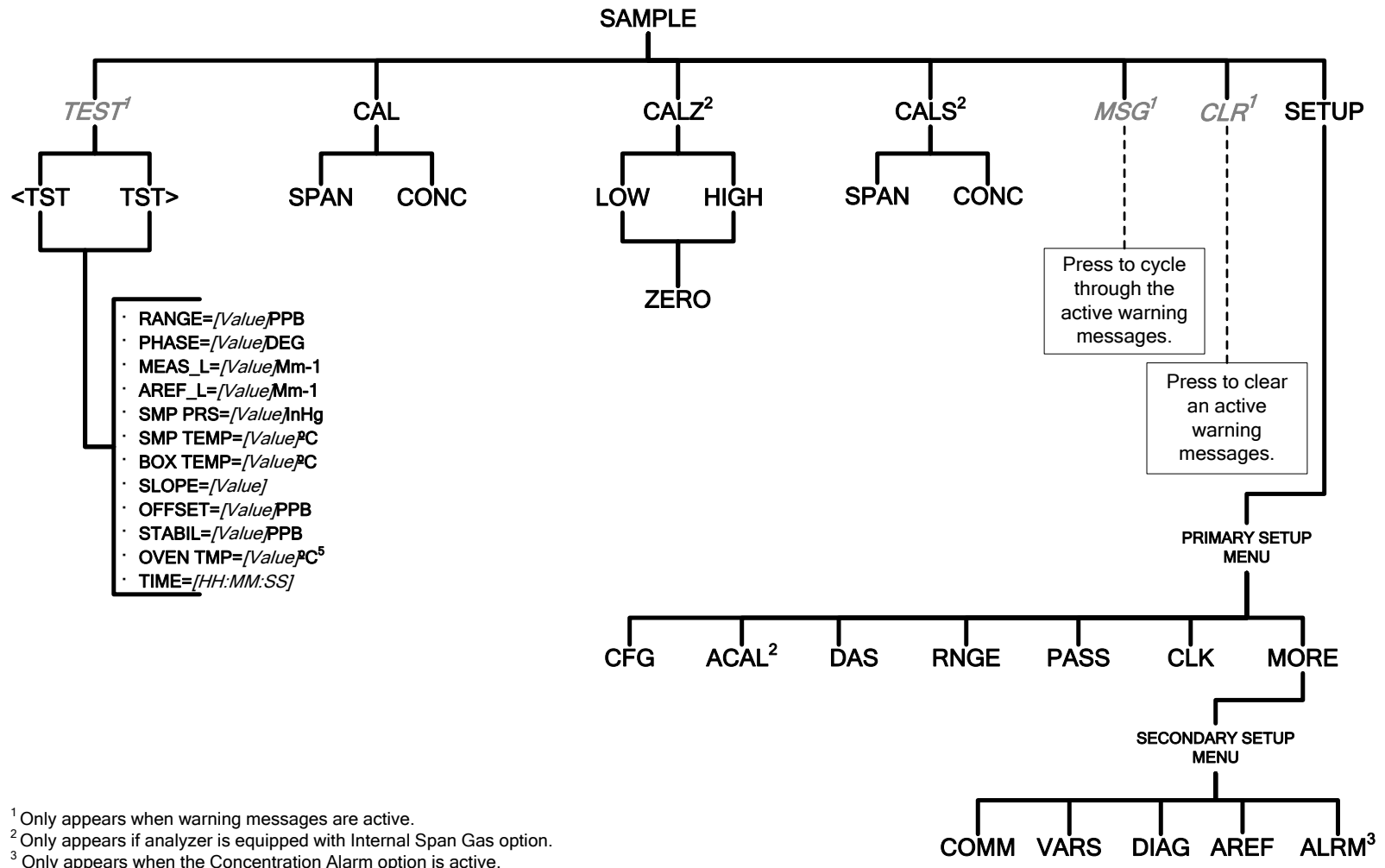
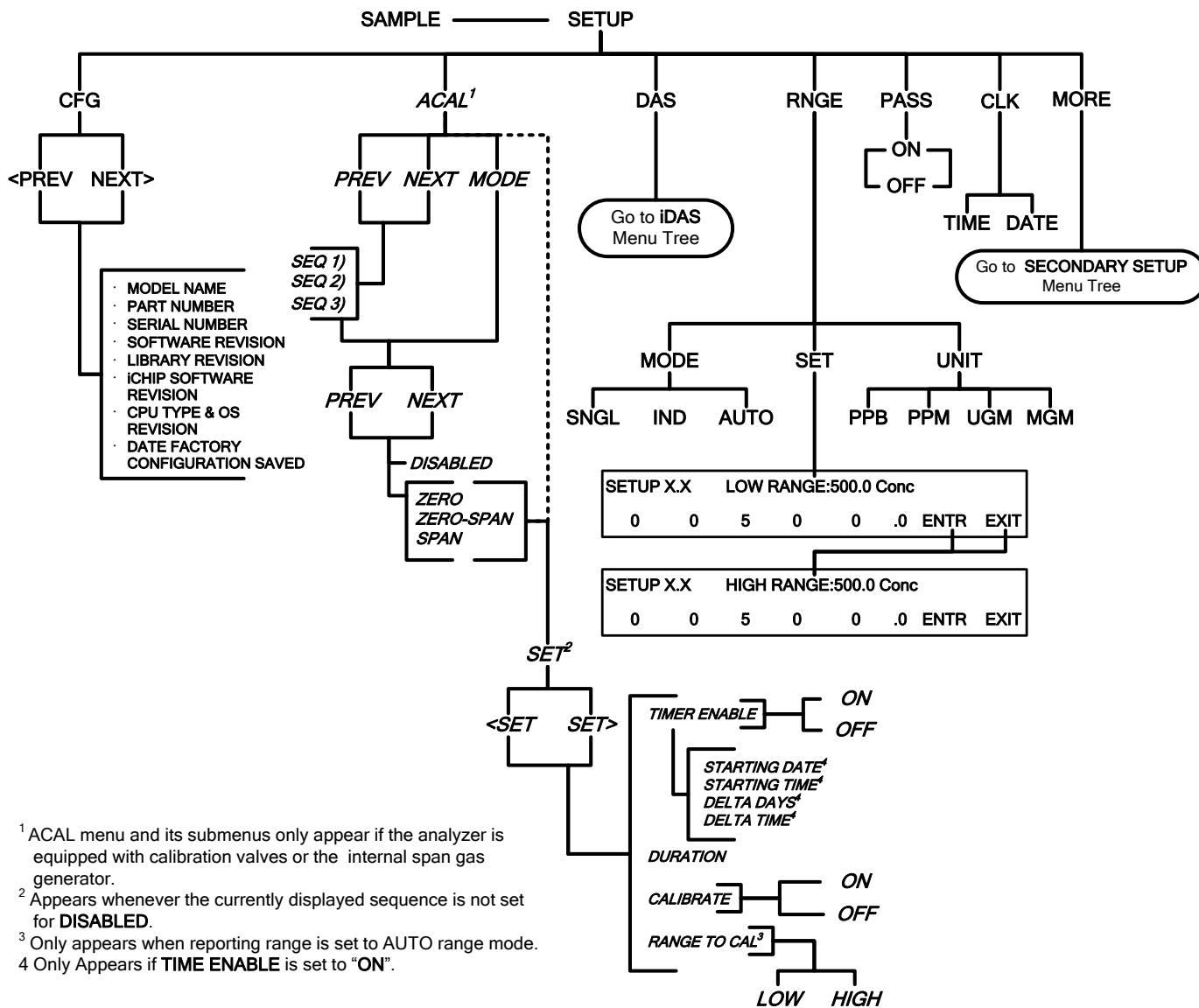


Figure A-1: Basic Sample Display Menu



¹ ACAL menu and its submenus only appear if the analyzer is equipped with calibration valves or the internal span gas generator.
² Appears whenever the currently displayed sequence is not set for **DISABLED**.
³ Only appears when reporting range is set to AUTO range mode.
⁴ Only Appears if **TIME ENABLE** is set to "ON".

Figure A-2: Primary Setup Menu (Except DAS)

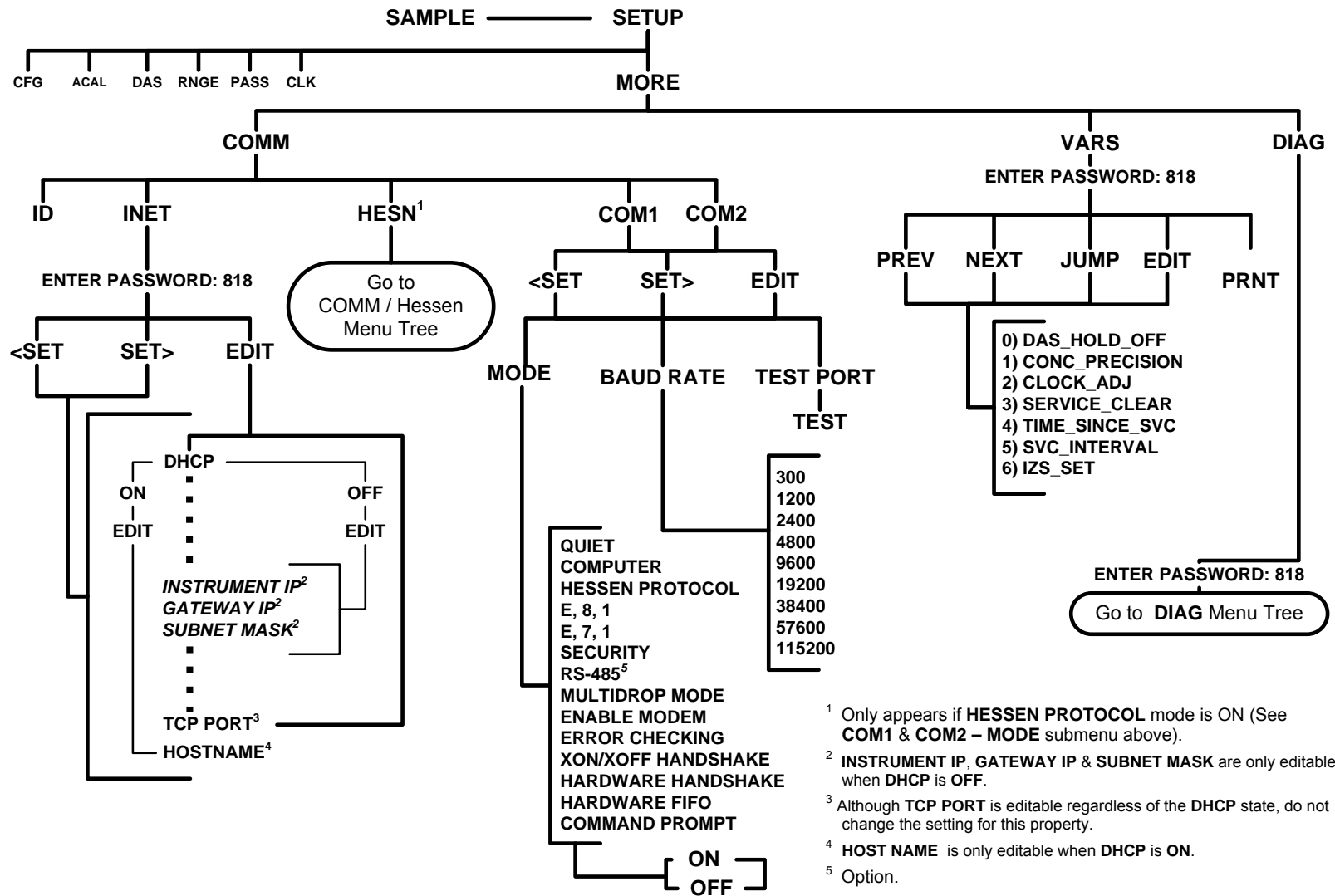
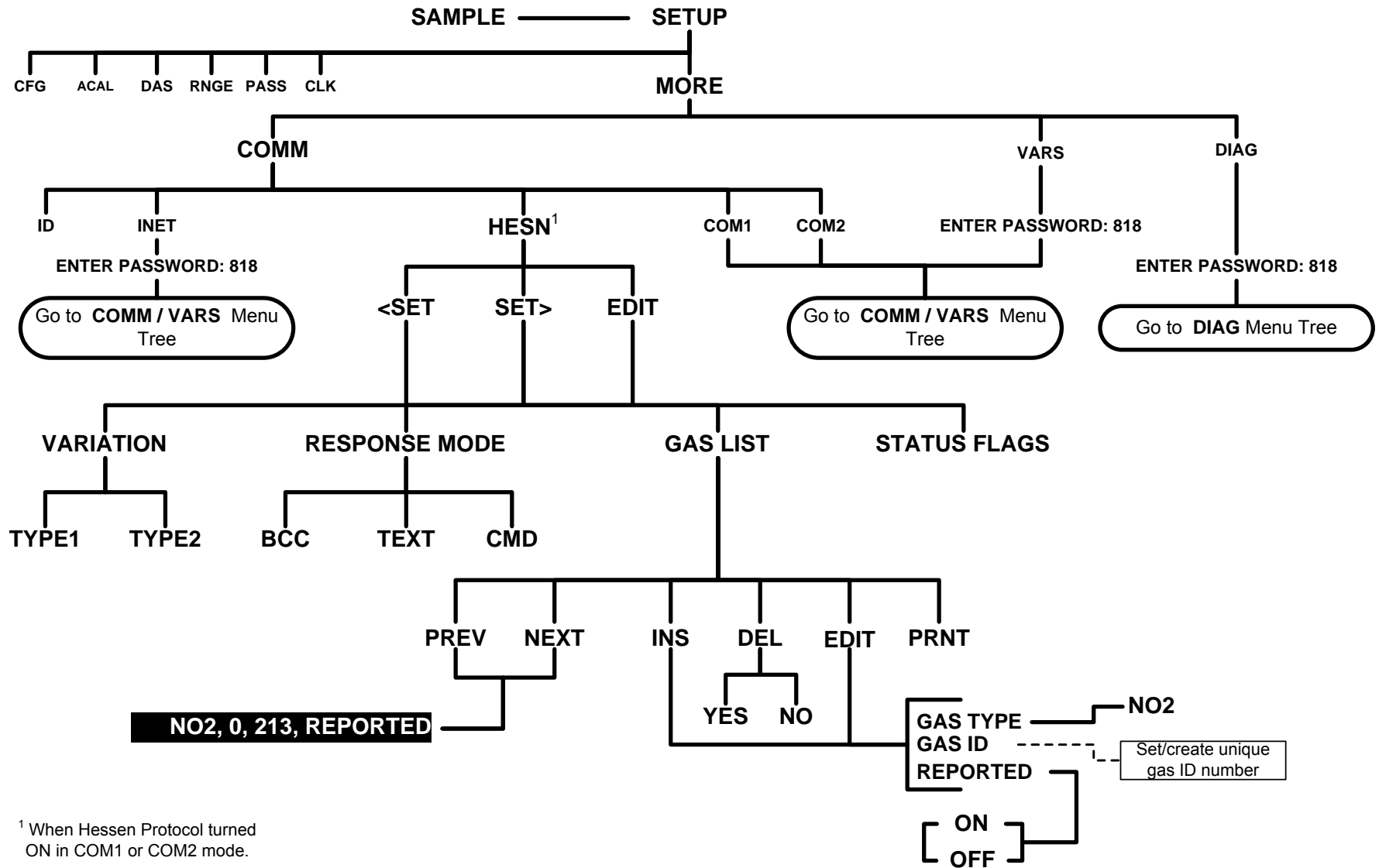


Figure A-3: Secondary Setup Menu (COMM & VARS)



¹ When Hessen Protocol turned ON in COM1 or COM2 mode.

Figure A-4: Secondary Setup Menu (HESSEN)

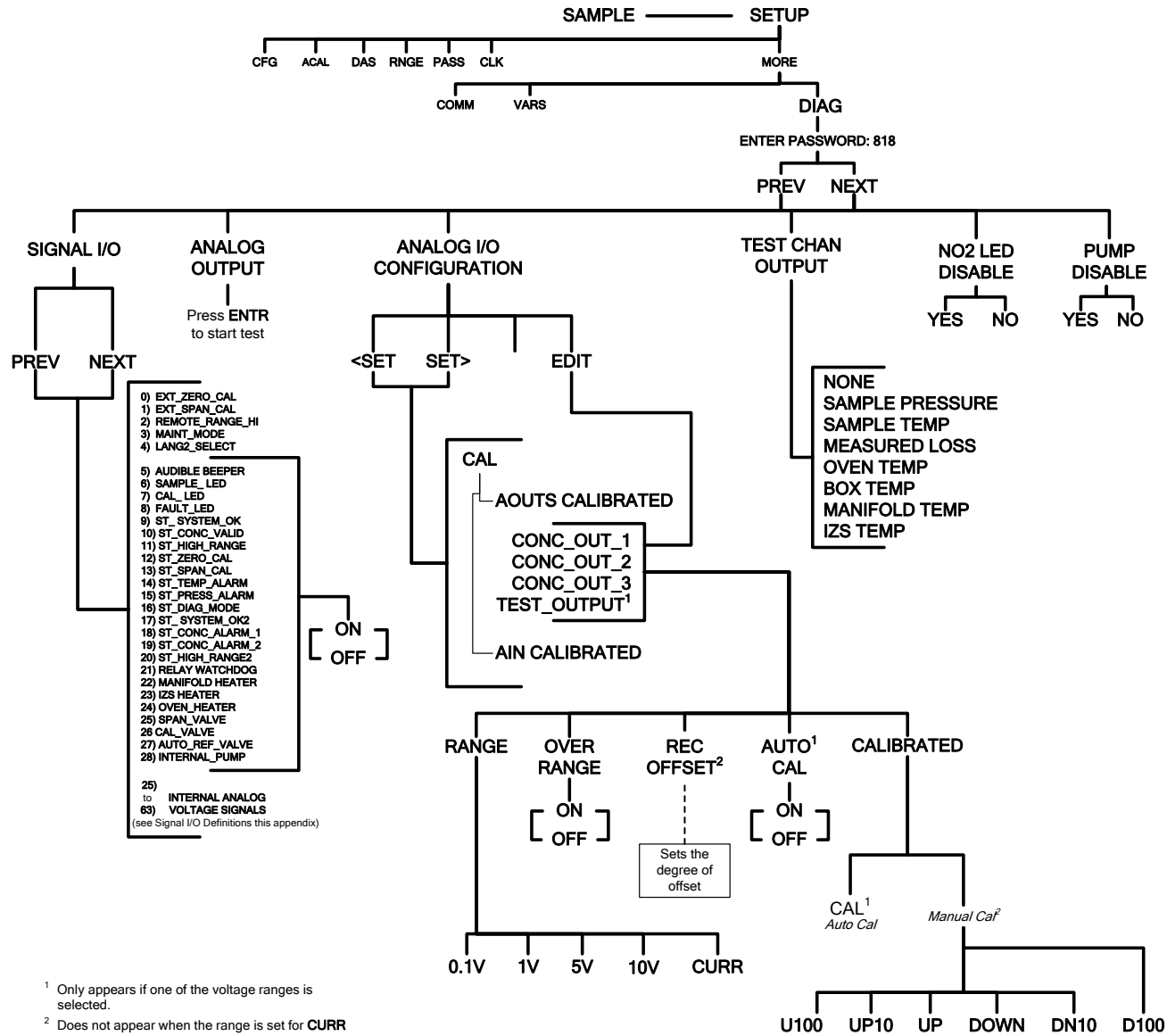


Figure A-5: Secondary Setup Menu (DIAG)

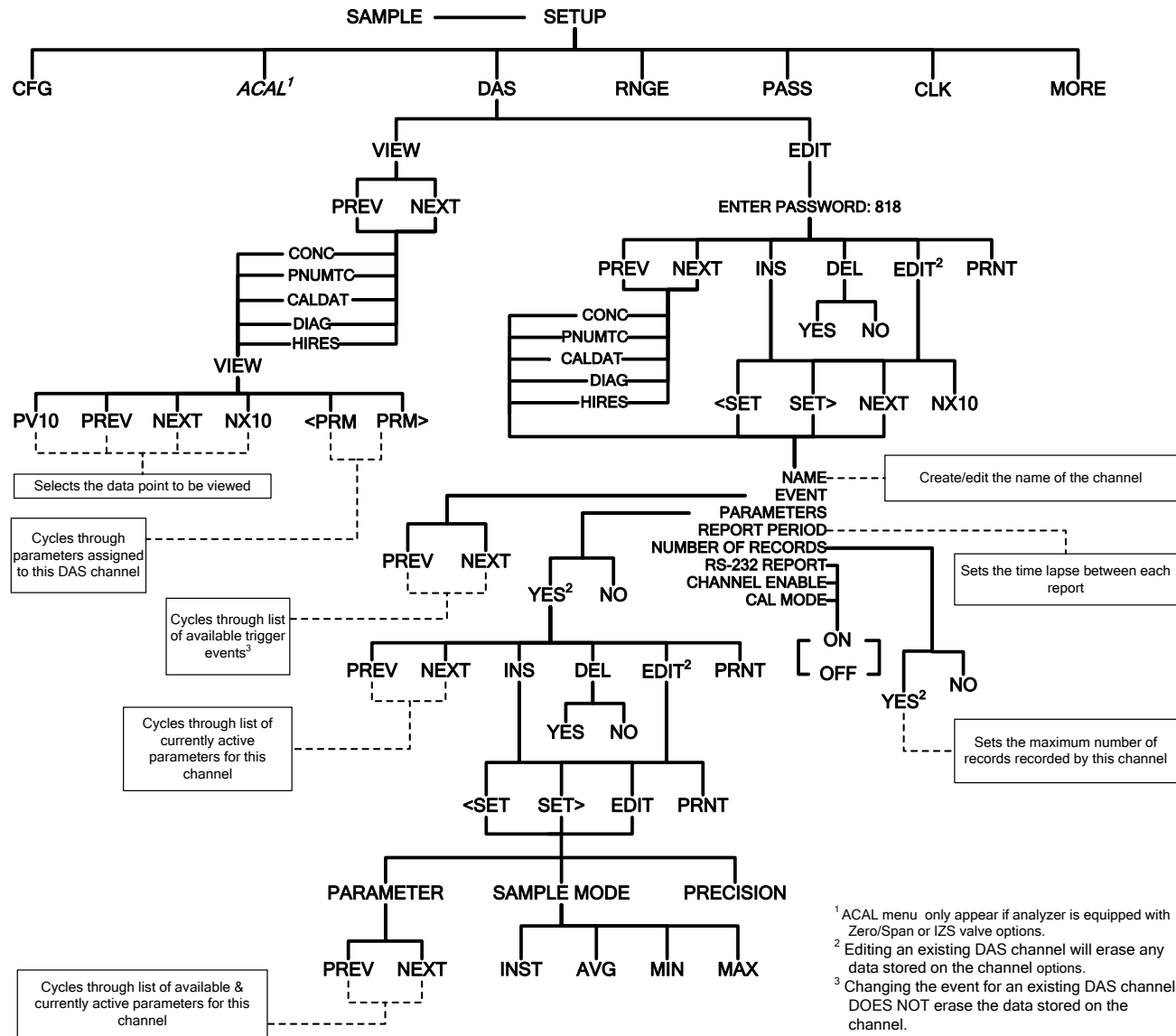


Figure A-6: Internal Data Acquisition (DAS) Menu

APPENDIX A-2: Setup Variables for Serial I/O**Table A- 1: T500U Setup Variables**

Setup Variable	Numeric Units	Default Value	Value Range	Description
DAS_HOLD_OFF	Minutes	15	0.5-20	Duration of DAS hold-off period.
CONC_PRECISION	—	3	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	—	OFF	OFF ON	ON resets the service interval timer.
TIME_SINCE_SVC	Hours	0	0-500000	Time since last service.
SVC_INTERVAL	Hours	0	0-100000	Sets the interval between service reminders.
IZS_SET	°C	51 Warnings: 50-52	30-70	IZS temperature set point and warning limits.

APPENDIX A-3: Warnings and Test Measurements**Table A-2: Warning Messages**

Name	Message Text	Description	Real-Time
WSYSSERVICE	SYSTEM SERVICE	System service interval has elapsed.	Yes
WSYSRES	SYSTEM RESET	Instrument was power-cycled or the CPU was reset.	Yes ¹
WDATAINIT	DATA INITIALIZED	Data storage was erased.	No
WCONFIGINIT	CONFIG INITIALIZED	Configuration storage was reset to factory configuration or erased.	No
WNO2ALARM1 ⁴	NO2 ALARM1 WARN	NO ₂ concentration alarm limit #1 exceeded	Yes
WNO2ALARM2 ⁴	NO2 ALARM2 WARN	NO ₂ concentration alarm limit #2 exceeded	Yes
WMANIFOLD	MANIFOLD TEMP WARN	Manifold temperature outside of warning limits.	Yes
WIZSTEMP	IZS TEMP WARNING	IZS temperature outside of warning limits specified by <i>IZS_SET</i> variable.	Yes
WOVENTEMP	OVEN TEMP WARNING	Oven temperature outside of warning limits.	Yes
WSAMPPRESS	SAMPLE PRESS WARN	Sample pressure outside of warning limits.	Yes
WSAMPTEMP	SAMPLE TEMP WARN	Sample temperature outside of warning limits.	Yes
WBOXTEMP	BOX TEMP WARNING	Chassis temperature outside of warning limits.	Yes
WAUTOREF	AUTO REF WARNING	Auto-ref value outside of warning limit.	Yes ⁵
WBASELINE	BASELINE LOSS WARN	Bench baseline loss value outside of limits.	Yes ⁶
WDYNZERO	CANNOT DYN ZERO	Contact closure zero calibration failed while <i>DYN_ZERO</i> was set to <i>ON</i> .	Yes ²
WDYNSPAN	CANNOT DYN SPAN	Contact closure span calibration failed while <i>DYN_SPAN</i> was set to <i>ON</i> .	Yes ³
WREARBOARD	REAR BOARD NOT DET	Rear board was not detected during power up.	Yes
WRELAYBOARD	RELAY BOARD WARN	Firmware is unable to communicate with the relay board.	Yes
WLAMPDRIVER	LAMP DRIVER WARN	Firmware is unable to communicate with either the O ₃ generator or photometer lamp I ² C driver chip.	Yes
WFRONTPANEL	FRONT PANEL WARN	Firmware is unable to communicate with the front panel.	Yes
WPUMP	INTERNAL PUMP OFF	Internal pump is not running.	Yes
WANALOGCAL	ANALOG CAL WARNING	The A/D or at least one D/A channel has not been calibrated.	Yes

Name	Message Text	Description	Real-Time
¹	Cleared 45 minutes after power up.		
²	Cleared the next time successful zero calibration is performed.		
³	Cleared the next time successful span calibration is performed.		
⁴	Concentration alarm option.		
⁵	Applies when AREF is enabled.		
⁶	Applies when AREF is disabled.		

Table A- 3: Test Measurements

Name ¹	Message Text	Description
RANGE	RANGE=500.0 PPB ³	D/A range in single or auto-range modes.
RANGE1	RANGE1=500.0 PPB ³	D/A #1 range in dual range mode.
RANGE2	RANGE2=500.0 PPB ³	D/A #2 range in dual range mode.
PHASE	PHASE=15.32 DEG	Box phase value.
MEASLOSS	MEAS_L=300.1 Mm ⁻¹	Measurement loss value.
AUTOREF	AREF_L=400.3 Mm ⁻¹	Autoref value.
SAMPPRESS	SMP PRS=29.92 InHg	Sample pressure.
SAMPTEMP	SMP TEMP=31.2 C	Sample temperature.
BOXTEMP	BOX TEMP=31.3 C	Box internal temperature.
SLOPE	SLOPE=1.000	Slope for current range, computed during zero/span calibration.
OFFSET	OFFSET=0.0 PPB ³	Offset for current range, computed during zero/span calibration.
STABILITY	STABIL=0.0 PPB ³	Concentration stability (standard deviation based on setting of <i>STABIL_FREQ</i> and <i>STABIL_SAMPLES</i>).
RESPONSE ²	RSP=3.11(0.00) SEC	Instrument response. How frequently concentration is updated. Time in parenthesis is standard deviation.
MANIFOLDTEMP	MF TEMP= 50.1 C	Manifold temperature.
MANIFOLDDTY ²	MF HTR=45.1%	Manifold heater duty cycle.
IZSTEMP	IZS TEMP= 50.1 C	IZS temperature.
IZSDTY ²	IZS HTR=45.1%	IZS heater duty cycle.
OVENTEMP	OVEN TMP= 50.1 C	Oven temperature.
OVENPTY ²	OVEN HTR=45.1%	Oven heater duty cycle.
SIGTHRUPUT	SIG=2414.7 MV	Bench signal throughput value.
SIN_1	SIN 1=-15413	Bench SIN_1/2 value.
COS_1	COS 1=25173	Bench COS_1/2 value.
SIN_2	SIN 2=-15413	Bench SIN_2/2 value.
COS_2	COS 2=25173	Bench COS_2/2 value.

Name ¹	Message Text	Description
SIN_OV	SIN OVP=2	Bench SIN overlap value.
COS_OV	COS OVP=3	Bench COS overlap value.
ACCUM_OV	ACCUM OV=0	Bench accum overflow value.
TESTCHAN	TEST=2753.9 MV	Value output to <i>TEST_OUTPUT</i> analog output, selected with <i>TEST_CHAN_ID</i> variable.
XIN1 ⁴	AIN1=37.15 EU	External analog input 1 value in engineering units.
XIN2 ⁴	AIN2=37.15 EU	External analog input 2 value in engineering units.
XIN3 ⁴	AIN3=37.15 EU	External analog input 3 value in engineering units.
XIN4 ⁴	AIN4=37.15 EU	External analog input 4 value in engineering units.
XIN5 ⁴	AIN5=37.15 EU	External analog input 5 value in engineering units.
XIN6 ⁴	AIN6=37.15 EU	External analog input 6 value in engineering units.
XIN7 ⁴	AIN7=37.15 EU	External analog input 7 value in engineering units.
XIN8 ⁴	AIN8=37.15 EU	External analog input 8 value in engineering units.
CLOCKTIME	TIME=14:48:01	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 Engineering software. ³ Current instrument units. ⁴ External analog input option.		

APPENDIX A-4: Signal I/O Definitions**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 I2C 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_ZERO_CAL	0	0 = go into zero calibration 1 = exit zero calibration
	1	Spare
EXT_SPAN_CAL ¹	2	0 = go into span calibration 1 = exit span calibration
REMOTE_RANGE_HI ²	3	0 = remote select high range 1 = default range
	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 ⁴ , MB_RELAY_37 ³	5	1 = conc. limit 1 exceeded 0 = conc. OK Controlled by MODBUS coil register
ST_CONC_ALARM_2 ⁴ , MB_RELAY_38 ³	6	1 = conc. limit 2 exceeded 0 = conc. OK Controlled by MODBUS coil register

Signal Name	Bit or Channel Number	Description
ST_HIGH_RANGE2 ⁵ , MB_RELAY_39 ³	7	1 = high auto-range in use (mirrors <i>ST_HIGH_RANGE</i> status output) 0 = low auto-range Controlled by MODBUS coil register
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 = hold off or other conditions
ST_HIGH_RANGE	2	0 = high auto-range in use 1 = low auto-range
ST_ZERO_CAL	3	0 = in zero calibration 1 = not in zero
ST_SPAN_CAL	4	0 = in span calibration 1 = not in span
ST_TEMP_ALARM	5	0 = any temperature alarm 1 = all temperatures OK
	6	Spare
ST_PRESS_ALARM	7	0 = any pressure alarm 1 = all pressures OK
A status outputs, alternate status outputs factory option		
ST_DIAG_MODE	5	0 = in diagnostic mode 1 = not in diagnostic mode
B status outputs, U27, J1018, pins 1-8 = bits 0-7, default I/O address 324 hex		
ST_DIAG_MODE	0	0 = in diagnostic mode 1 = not in diagnostic mode
	1-7	Spare
B status outputs, alternate status outputs factory option		
ST_TEMP_ALARM	0	0 = any temperature alarm 1 = all temperatures OK
ST_PRESS_ALARM	3	0 = any pressure alarm 1 = all pressures OK
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

Signal Name	Bit or Channel Number	Description
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
	1-2	Spare
MANIFOLD_HEATER	3	0 = Manifold heater on 1 = off
IZS_HEATER	4	0 = IZS heater on 1 = off
OVEN_HEATER	5	0 = Oven heater on 1 = off
SPAN_VALVE	6	0 = let span gas in 1 = let zero gas in
CAL_VALVE	7	0 = let cal. gas in 1 = let sample gas in
AUTO_ZERO_VALVE	8	0 = let zero air in 1 = let sample gas in
	9-14	Spare
INTERNAL_PUMP	15	0 = Internal pump on 1 = Internal pump off
Rear board primary MUX analog inputs		
	0-3	Spare
	4	Temperature MUX
	5-6	Spare
TEST_INPUT_7	7	Diagnostic test input
TEST_INPUT_8	8	Diagnostic test input
REF_4096_MV	9	4.096V reference from MAX6241
	10-13	Spare
	14	DAC loopback MUX
REF_GND	15	Ground reference
Rear board temperature MUX analog inputs		
BOX_TEMP	0	Internal box temperature
OVEN_TEMP	1	Oven temperature
IZS_TEMP	2	IZS temperature
	3-5	Spare
TEMP_INPUT_6	6	Diagnostic temperature input
MANIFOLD_TEMP	7	Manifold temperature input

Signal Name	Bit or Channel Number	Description
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	0	Concentration output #1
DATA_OUT_1 ⁶		Data output #1
CONC_OUT_2	1	Concentration output #2
DATA_OUT_2 ⁶		Data output #2
DATA_OUT_3 ⁶	2	Data output #3
TEST_OUTPUT	3	Test measurement output
DATA_OUT_4 ⁶		Data output #4
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
I²C analog output (AD5321), default I²C address 18 hex		
	0	Spare
I²C analog output (AD5321), default I²C address 1A hex		
	0	Spare
¹ Internal span option. ² Remote range control option. ³ MODBUS option. ⁴ Concentration alarm option. ⁵ High auto range relay option. ⁶ User-configurable D/A output option. ⁷ External analog input option.		

APPENDIX A-5: DAS Trigger Events and Parameters**Table A- 5: DAS Trigger Events**

Name	Description
ATIMER	Automatic timer expired
EXITZR	Exit zero calibration mode
EXITSP	Exit span calibration mode
EXITMP	Exit multi-point calibration mode
SLPCHG	Slope and offset recalculated
EXITDG	Exit diagnostic mode
CONC1W ¹	Concentration limit 1 exceeded
CONC2W ¹	Concentration limit 2 exceeded
AREFW	Auto-ref warning
BASELW	Bench baseline loss warning
BCHCOM	Bench communication failure warning
MFTMPW	Manifold temperature warning
IZSTMPW	IZS temperature warning
OVTMPW	Oven temperature warning
STEMPW	Sample temperature warning
SPRESW	Sample pressure warning
BTEMPW	Box temperature warning
¹ Concentration alarm option.	

Table A- 6: DAS Parameters

Name	Description	Units
SLOPE1	Slope for range #1	—
SLOPE2	Slope for range #2	—
OFSET1	Offset for range #1	PPB
OFSET2	Offset for range #2	PPB
ZSCNC1	Concentration for range #1 during zero/span calibration, just before computing new slope and offset	PPB
ZSCNC2	Concentration for range #2 during zero/span calibration, just before computing new slope and offset	PPB
CONC1	Concentration for range #1	PPB
CONC2	Concentration for range #2	PPB
STABIL	Concentration stability	PPB
AREF	Auto-ref offset	Mm ⁻¹
MFTEMP	Manifold temperature	°C
MFDUTY	Manifold temperature duty cycle	%

Name	Description	Units
IZTEMP	IZS temperature	°C
IZDUTY	IZS temperature duty cycle	%
OVTEMP	Oven temperature	°C
OVDUTY	Oven temperature duty cycle	%
SMPTMP	Sample temperature	°C
SMPPRS	Sample pressure	Inches Hg
PHASE	Phase	Deg
MEASLS	Measured loss	Mm ⁻¹
BOXTMP	Internal box temperature	°C
TEST7	Diagnostic test input (TEST_INPUT_7)	mV
TEST8	Diagnostic test input (TEST_INPUT_8)	mV
TEMP6	Diagnostic temperature input (TEMP_INPUT_6)	°C
REFGND	Ground reference	mV
RF4096	Precision 4.096 mV reference	mV
XIN1 ¹⁰	External analog input 1 value	Volts
XIN1SLPE ¹⁰	External analog input 1 slope	eng unit / V
XIN1OFST ¹⁰	External analog input 1 value	eng unit
XIN2 ¹⁰	External analog input 2 value	Volts
XIN2SLPE ¹⁰	External analog input 2 slope	eng unit / V
XIN2OFST ¹⁰	External analog input 2 value	eng unit
XIN3 ¹⁰	External analog input 3 value	Volts
XIN3SLPE ¹⁰	External analog input 3 slope	eng unit / V
XIN3OFST ¹⁰	External analog input 3 value	eng unit
XIN4 ¹⁰	External analog input 4 value	Volts
XIN4SLPE ¹⁰	External analog input 4 slope	eng unit / V
XIN4OFST ¹⁰	External analog input 4 value	eng unit
XIN5 ¹⁰	External analog input 5 value	Volts
XIN5SLPE ¹⁰	External analog input 5 slope	eng unit / V
XIN5OFST ¹⁰	External analog input 5 value	eng unit
XIN6 ¹⁰	External analog input 6 value	Volts
XIN6SLPE ¹⁰	External analog input 6 slope	eng unit / V
XIN6OFST ¹⁰	External analog input 6 value	eng unit
XIN7 ¹⁰	External analog input 7 value	Volts
XIN7SLPE ¹⁰	External analog input 7 slope	eng unit / V
XIN7OFST ¹⁰	External analog input 7 value	eng unit
XIN8 ¹⁰	External analog input 8 value	Volts
XIN8SLPE ¹⁰	External analog input 8 slope	eng unit / V
XIN8OFST ¹⁰	External analog input 8 value	eng unit
¹⁰ External analog input option.		

APPENDIX A-6: Terminal Command Designators and Command Line Options
Table A-7: Terminal Command Designators

Command	Additional Command Syntax	Description
? [ID]		Display help screen and this list of commands
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.

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

Table A-8 Firmware Command Line Options

Option	Description
/?, /h	Prints command line usage without executing the firmware.
/u CPU-type	<i>CPU-type</i> specifies the CPU type to use: 0 = Generic PC (default) 1 = AR-B1320, 386SX, PC/104 2 = AR-B9612A, 386SX, PC/104
/d device	<i>Device</i> specifies the display type to use: 0 = PC video display and keyboard (default) 1 = Onyx I/O, parallel display (not currently supported) 2 = DMM-32 I/O, parallel display (not currently supported) 3 = ICA90, 8574-based I ² C display 4 = API "E" series rear board, parallel display 5 = API "E" series rear board, 8574-based I ² C display
/y	Runs the firmware without prompting. This is useful for executing the firmware automatically from within a batch file. The default is to prompt for confirmation.
/w	Disables the watchdog timer. The default is enabled.
/n file	<i>File</i> specifies a different name and/or location for the configuration file. The default is "config.bin" in the same directory as the executable file. If you have configured flash memory as a disk drive, such as B:, then you can store the configuration information in the flash using the command line option <code>-o "b:\config.bin"</code> .
/r file	<i>File</i> specifies an alternate resource file containing the firmware's default configuration. The default is the executable file.
/a address	<i>Address</i> specifies the Com port for the bench interface. The default is 3. Valid values are 2-4.
/b address ^{3, 5}	<i>Address</i> specifies the I/O address of the I ² C interface data register. The default is 0x32c (hex). This is usually 0x310 for the ICA90 board.
/c address ^{3, 5}	<i>Address</i> specifies the I/O address of the I ² C interface control register. The default is 0x32f (hex). This is usually 0x311 for the ICA90 board.
/q irq ^{3, 5}	<i>IRQ</i> specifies the IRQ number of the I ² C interface. The default is IRQ5.
/k irq ^{3, 4, 5}	<i>IRQ</i> specifies the IRQ number of the keyboard (0 = use polling mode instead of interrupt mode). The default is IRQ12.

Option	Description
/i address ^{3, 5}	<i>Address</i> specifies the I ² C bus address of the host CPU. The default is 0x57 (hex).
/s address ^{3, 5}	<i>Address</i> specifies the I ² C bus address of the keyboard/display. The default is 0x4A (hex).
/l address	<i>Address</i> specifies the I ² C bus address of the relay board. The default is 0x44 (hex).
³ This option is used with display type 3. ⁴ This option is used with display type 4. ⁵ This option is used with display type 5.	
Typical command lines <ul style="list-style-type: none"> <li data-bbox="267 617 1307 646">• PC keyboard/display: T500U_B7 /y /w <li data-bbox="267 646 1307 676">• AR-B1320 CPU and 8574-based keyboard/display: T500U_B7 /y /u 1 /d 5 	

APPENDIX A-7: MODBUS Register Map

MODBUS Register Address (dec., 0-based)	Description	Units
MODBUS Floating Point Input Registers (32-bit IEEE 754 format; read in high-word, low-word order; read-only)		
6	Slope for range #1	—
8	Slope for range #2	—
10	Offset for range #1	PPB
12	Offset for range #2	PPB
14	Concentration for range #1 during zero/span calibration, just before computing new slope and offset	PPB
16	Concentration for range #2 during zero/span calibration, just before computing new slope and offset	PPB
18	Concentration for range #1	PPB
20	Concentration for range #2	PPB
22	Concentration stability	PPB
24	Auto-ref value	Mm ⁻¹
26	Oven temperature	°C
28	Oven temperature duty cycle	%
30 ⁵	Manifold temperature	°C
32 ⁵	Manifold temperature duty cycle	%
34 ⁶	IZS lamp temperature	°C
36 ⁶	IZS temperature duty cycle	%
38	Sample temperature	°C
40	Sample pressure	Inches Hg
42	Internal box temperature	°C
46	Diagnostic test input (TEST_INPUT_7)	mV
48	Diagnostic test input (TEST_INPUT_8)	mV
50	Diagnostic temperature input (TEMP_INPUT_6)	°C
54	Ground reference	mV
56	Precision 4.096 mV reference	mV
130 ¹⁰	External analog input 1 value	Volts
132 ¹⁰	External analog input 1 slope	eng unit /V
134 ¹⁰	External analog input 1 offset	eng unit
136 ¹⁰	External analog input 2 value	Volts
138 ¹⁰	External analog input 2 slope	eng unit /V
140 ¹⁰	External analog input 2 offset	eng unit
142 ¹⁰	External analog input 3 value	Volts
144 ¹⁰	External analog input 3 slope	eng unit /V
146 ¹⁰	External analog input 3 offset	eng unit
148 ¹⁰	External analog input 4 value	Volts

MODBUS Register Address (dec., 0-based)	Description	Units
150 ¹⁰	External analog input 4 slope	eng unit /V
152 ¹⁰	External analog input 4 offset	eng unit
154 ¹⁰	External analog input 5 value	Volts
156 ¹⁰	External analog input 5 slope	eng unit /V
158 ¹⁰	External analog input 5 offset	eng unit
160 ¹⁰	External analog input 6 value	Volts
162 ¹⁰	External analog input 6 slope	eng unit /V
164 ¹⁰	External analog input 6 offset	eng unit
166 ¹⁰	External analog input 7 value	Volts
168 ¹⁰	External analog input 7 slope	eng unit /V
170 ¹⁰	External analog input 7 offset	eng unit
172 ¹⁰	External analog input 8 value	Volts
174 ¹⁰	External analog input 8 slope	eng unit /V
176 ¹⁰	External analog input 8 offset	eng unit
MODBUS Floating Point Holding Registers (32-bit IEEE 754 format; read/write in high-word, low-word order; read/write)		
2	Maps to <i>NO2_SPAN1</i> variable; target span concentration for range #1	Conc. units
6	Maps to <i>NO2_SPAN2</i> variable; target span concentration for range #2	Conc. units
MODBUS Discrete Input Registers (single-bit; read-only)		
0	Auto-ref warning	
1	Oven temperature warning	
2 ⁵	Manifold temperature warning	
3 ⁶	IZS temperature warning	
4	Baseline loss warning	
5	Bench com warning	
6		
7	Box temperature warning	
8	Sample temperature warning	
9		
10	Sample pressure warning	
11	System reset warning	
12	Rear board communication warning	
13	Relay board communication warning	
14		
15	Front panel communication warning	
16	Analog calibration warning	

MODBUS Register Address (dec., 0-based)	Description	Units
17	Dynamic zero warning	
18	Dynamic span warning	
19	Invalid concentration	
20	In zero calibration mode	
21		
22	In span calibration mode	
23	In multi-point calibration mode	
24	System is OK (same meaning as <i>SYSTEM_OK</i> I/O signal)	
25 ³	NO ₂ concentration alarm limit #1 exceeded	
26 ³	NO ₂ concentration alarm limit #2 exceeded	
27 ⁴	In Manual mode	
MODBUS Coil Registers (single-bit; read/write)		
0	Maps to relay output signal 36 (<i>MB_RELAY_36</i> in signal I/O list)	
1	Maps to relay output signal 37 (<i>MB_RELAY_37</i> in signal I/O list)	
2	Maps to relay output signal 38 (<i>MB_RELAY_38</i> in signal I/O list)	
3	Maps to relay output signal 39 (<i>MB_RELAY_39</i> in signal I/O list)	
20 ¹	Triggers zero calibration of NO ₂ range #1 (on enters cal.; off exits cal.)	
22 ¹	Triggers span calibration of O ₃ range #1 (on enters cal.; off exits cal.)	
23 ¹	Triggers zero calibration of NO ₂ range #2 (on enters cal.; off exits cal.)	
25 ¹	Triggers span calibration of NO ₂ range #2 (on enters cal.; off exits cal.)	
¹ Set <i>DYN_ZERO</i> or <i>DYN_SPAN</i> variables to <i>ON</i> to enable calculating new slope or offset. Otherwise a calibration check is performed. ³ Concentration alarm option. ⁴ Hessen option. ⁵ Manifold heater option. ⁶ IZS option. ¹⁰ 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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T500U Spare Parts List
08067A DCN5543, 18 March 2014
page 1 of 1

Item number	Product name
004330000	ZERO AIR SCRUBBER (NO/NO2)
005960000	AKIT, EXP, ACT CHARCOAL, (2 BTL@64 FL-OZ EA)
005970000	AKIT, EXP, PURAFIL (2 BTL@64 FL-OZ EA)
014030000	AKIT, NOX EXPENDABLES, IZS
019340700	ASSY, SAMPLE THERMISTOR, T500U
040010000	ASSY, FAN REAR PANEL (B/F)
045230200	PCA, RELAY CARD
052820000	ASSY, IZS, HEATER/THERM, NOX
058021100	PCA, MOTHERBD, GEN 5-ICOP(PA)
058800000	ASSY, THERMISTOR, OVEN
058820100	ASSY, HEATER w/THERM, 75W 120V
058820200	ASSY, HEATER w/THERM, 75W 240V
059940200	ASSY, SAMPLE GAS CONDITIONER, T500U
066970000	PCA, INTRF. LCD TOUCH SCRNM, F/P
067240000	CPU, PC-104, VSX-6154E, ICOP *(PA)
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(PA)
068810000	PCA, LVDS TRANSMITTER BOARD
069500000	PCA, SERIAL & VIDEO INTERFACE BOARD
072150000	ASSY. TOUCHSCREEN CONTROL MODULE
076490000	ASSY, LED, T500U
076730000	PCA, CAPS DAQ
077660000	ASSY, CARTRIDGE, MIRROR, T500U
077670000	ASSY, DETECTOR / MIXER, W/O COVER, T500U
078330000	DOM, W/SOFTWARE, T500U*
078340000	MANUAL, OPERATORS, T500U
078510000	ASSY, PUMP, INTERNAL, T500U
080680000	ASSY, SAMPLE FILTER, T500U, FL-33
080680100	ASSY, SCRUBBER, AREF, T500U, FL-20
080680200	ASSY, FILTER, AREF, T500U, FL-03
080680300	ASSY, FILTER, EXH, T500U, FL-03
KIT000207	KIT, RELAY RETROFIT
KIT000219	AKIT, 4-20MA CURRENT OUTPUT
KIT000231	KIT000231 KIT, RETROFIT, M200E Z/S VALVE
KIT000253	ASSY & TEST, SPARE PS37
KIT000254	ASSY & TEST, SPARE PS38
RL0000015	RELAY, DPDT, (KB)
SW0000025	SWITCH/CIR BRK, VDE, CE *(KB)
WR0000008	POWER CORD, 10A

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Appendix C
Warranty/Repair Questionnaire
T500U
 (08062A, DCN5543)



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ADVANCED POLLUTION INSTRUMENTATION
Everywhere you look™

CUSTOMER: _____ PHONE: _____

CONTACT NAME: _____ FAX NO. _____

SITE ADDRESS: _____

MODEL SERIAL NO.: _____ FIRMWARE REVISION: _____

1. ARE THERE ANY FAILURE MESSAGES? _____

PLEASE COMPLETE THE FOLLOWING TABLE: (NOTE: *DEPENDING ON OPTIONS INSTALLED, NOT ALL TEST PARAMETERS SHOWN BELOW WILL BE AVAILABLE IN YOUR INSTRUMENT*)

*IF OPTION IS INSTALLED

PARAMETER	RECORDED VALUE	ACCEPTABLE VALUE
RANGE	PPB/PPM	5 PPB TO 1000 PPB
PHASE	DEG	30 ± 10 WITH ZERO AIR
MEAS_L WITH ZERO AIR	Mm-1	400 – 800 WITH ZERO AIR
MEAS_L WITH SPAN GAS	Mm-1 PPB	400 – 1800 Mm-1 0-1000 PPB
AREF_L	Mm-1	400 – 800 WITH ZERO AIR
SMP PRS	IN-HG-A	~ 1-5" < AMBIENT (CONSTANT)
SMP TEMP	°C	45 ± 3°C
BOX TEMP	°C	AMBIENT ± 5°C
SLOPE		1.0 ± 0.3
OFFSET	PPB	0.0 ± 5
NO ₂ STAB	PPB/PPM	≤ 1 PPB WITH ZERO AIR
OVEN TMP	°C	45 ± 1°C
IZS TEMP*	°C	50 ± 1°C
Values are in the Signal I/O		
REF_4096_MV	MV	4096mv ±2mv and Must be Stable
REF_GND	MV	0± 0.5 and Must be Stable

2. WHAT IS THE SAMPLE PRESSURE WITH THE SAMPLE INLET ON REAR OF MACHINE CAPPED?

SAMPLE PRESSURE - _____ IN-HG-A

3. WHAT IS THE SAMPLE FLOW MEASURED AT THE SAMPE INPUT?

SAMPLE FLOW - _____ CM₃

4. WHAT ARE THE FAILURE SYMPTOMS? _____

Teledyne API Technical Support
 EMAIL: sda_techsupport@teledyne.com
 PHONE: (858) 657-9800 TOLL FREE: (800) 324-5190 FAX: (858) 657-9816

Appendix C
Warranty/Repair Questionnaire
T500U
(08062A, DCN5543)



TELEDYNE
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Everywhereyoulook™

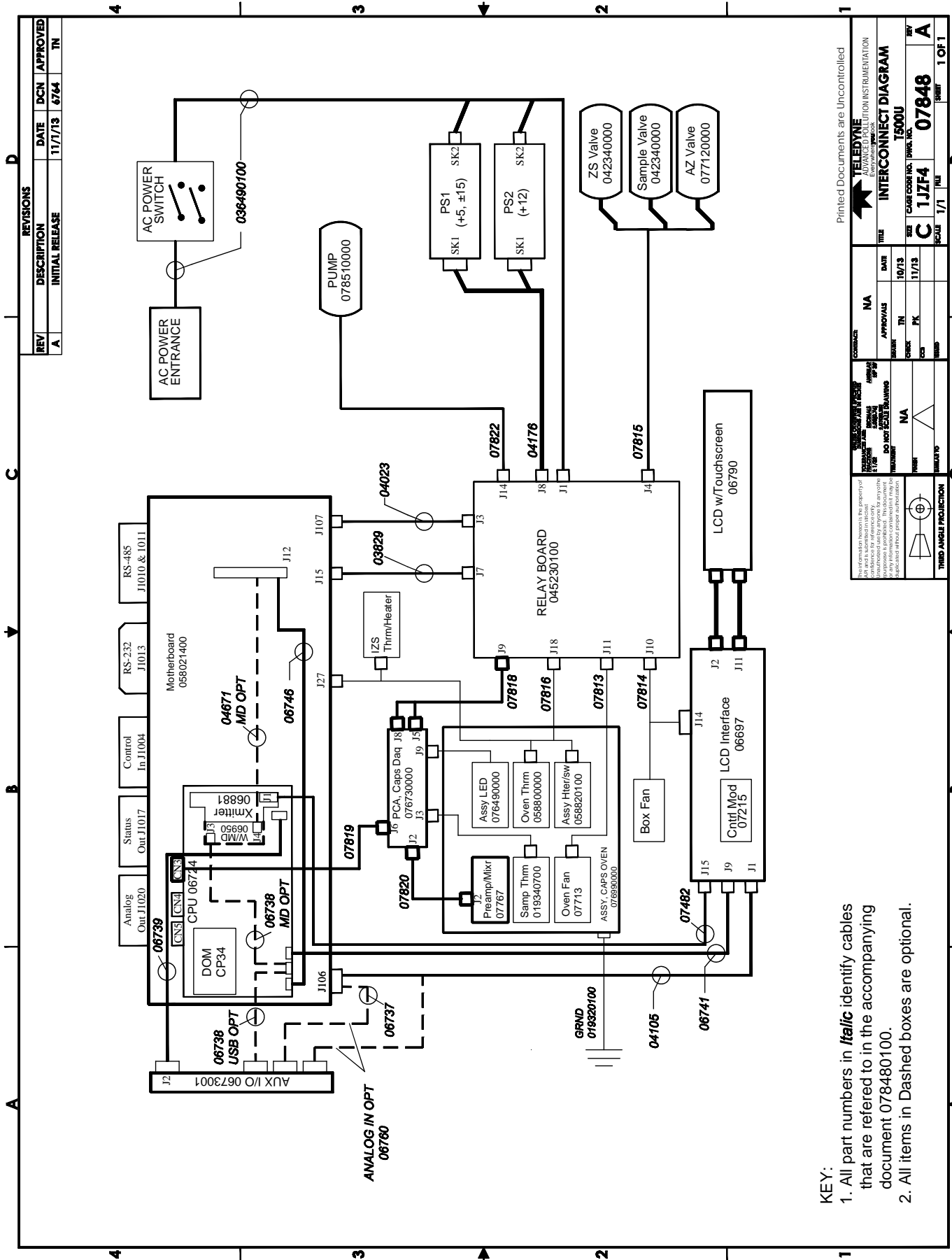
5. WHAT TEST(S) HAVE YOU DONE TRYING TO SOLVE THE PROBLEM? _____

6. IF POSSIBLE, PLEASE INCLUDE A PORTION OF A STRIP CHART PERTAINING TO THE PROBLEM AND CIRCLE THE PERTINENT DATA.

THANK YOU FOR PROVIDING THIS INFORMATION. YOUR ASSISTANCE ENABLES TELEDYNE API TO RESPOND FASTER TO THE PROBLEM THAT YOU ARE ENCOUNTERING.

APPENDIX D – Interconnect Diagram

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KEY:
 1. All part numbers in *italic* identify cables that are referred to in the accompanying document 078480100.
 2. All items in Dashed boxes are optional.

REVISIONS			
REV	DESCRIPTION	DATE	DCN APPROVED
A	INITIAL RELEASE	11/17/13	6764 TN

TELEDYNE ADVANCED POLLUTION INSTRUMENTATION ENVIRONMENTAL SYSTEMS		TITLE	
NA	DATE	10/13	11/13
APPROVALS	DATE	10/13	11/13
DESIGNED BY	DATE		
DRAWN BY	DATE		
CHECKED BY	DATE		
INSTRUMENT	DATE		
TESTED BY	DATE		
DO NOT SCALE DRAWING			
SCALE	1/1		
SHEET	1		
TOTAL	1		
REV	C	1/JF4	07848
REV	A		

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