



User Manual

Models T703 and T703U

Photometric O₃ Calibrators

with NumaView™ Software

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TRADEMARKS

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IMPORTANT SAFETY INFORMATION

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 and inside the instrument. The symbols with messages are defined as follows:



WARNING: Electrical Shock Hazard



HAZARD: Strong oxidizer



GENERAL WARNING/CAUTION: Read the accompanying message for specific information.



CAUTION: Hot Surface Warning



Do Not Touch. Touching some parts of the instrument without protection or proper tools could result in damage to the part(s) and/or the instrument.



Technician Symbol: All operations marked with this symbol are to be performed by qualified maintenance personnel only.



Electrical Ground: This symbol inside the instrument marks the central safety grounding point for the instrument.

CAUTION

This product should only be installed, commissioned, and used strictly for the purpose and in the manner described in this manual. If you improperly install, commission, or use this instrument in any manner other than as instructed in this manual or by our Technical Support team, unpredictable behavior could ensue with possible hazardous consequences.

Such risks, whether during installation and commission or caused by improper installation/commissioning/use, and their possible hazardous outcomes include but are not limited to:



RISK	HAZARD
Liquid or dust/debris ingress	Electrical shock hazard
Improper or worn power cable	Electrical shock or fire hazard
Excessive pressure from improper gas bottle connections	Explosion and projectile hazard
Sampling combustible gas(es)	Explosion and fire hazard
Improper lift & carry techniques	Personal injury

Note that the safety of a system that may incorporate this product is the end user's responsibility.

CONSIGNES DE SÉCURITÉ

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



AVERTISSEMENT : Risque de choc électrique



DANGER : Oxydant puissant



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



MISE EN GARDE : Surface chaude



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



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



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

MISE EN GARDE

Ce produit ne doit être installé, mis en service et utilisé qu'aux fins et de la manière décrites dans le présent manuel. Si vous installez, mettez en service ou utilisez cet instrument de manière incorrecte autre que celle indiquée dans ce manuel ou sous la direction de notre équipe de soutien technique, un comportement imprévisible pourrait entraîner des conséquences potentiellement dangereuses.

Ce qui suit est une liste, non exhaustive, des risques et résultats dangereux possibles associés avec une mauvaise utilisation, une mise en service incorrecte, ou causés mauvaise commission.



RISQUE	DANGER
Pénétration de liquide ou de poussière/débris	Risque de choc électrique
Câble d'alimentation incorrect, endommagés ou usé	Choc électrique ou risque d'incendie
Pression excessive due à des connexions de bouteilles de gaz incorrectes	Risque d'explosion et d'émission de projectile
Échantillonnage de gaz combustibles	Risque d'explosion et d'incendie
Techniques de manutention, soulevage et de transport inappropriées	Blessure corporelle

Notez que la sécurité d'un système qui peut incorporer ce produit est la responsabilité de l'utilisateur final.

WARRANTY STATEMENT

WARRANTY POLICY (02024J)

Teledyne Advanced Pollution Instrumentation (Teledyne API), a business unit of Teledyne Instruments, Inc., provides that:

Prior to shipment, Teledyne API equipment is thoroughly inspected and tested. Should equipment failure occur, Teledyne API assures its customers that prompt service and support will be available. (For the instrument-specific warranty period, please refer to the “Limited Warranty” Section in the Terms and Conditions of Sale on our website at www.teledyne-api.com).

COVERAGE

After the warranty period and throughout the equipment lifetime, Teledyne API 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-TELEDYNE API MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by Teledyne API is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturer’s warranty.

PRODUCT RETURN

All units or components returned to Teledyne API should be properly packed for handling and returned freight prepaid to the nearest designated Service Center. After the repair, the equipment will be returned, freight prepaid.

The complete Terms and Conditions of Sale can be reviewed on our website.

CAUTION – AVOID WARRANTY INVALIDATION



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

CONVENTIONS USED IN THIS MANUAL

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

Special Notices appear as follows:

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

This special notice provides information to avoid damage to your instrument and possibly invalidate the warranty.

Important

IMPACT ON READINGS OR DATA

Provides information about that which could either affect accuracy of instrument readings or cause loss of data.

Note

Provides information pertinent to the proper care, operation or maintenance of the instrument or its parts.

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LIST OF APPENDICES

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APPENDIX B – Interconnect Diagram

1. INTRODUCTION, SPECIFICATIONS AND APPROVALS

This manual provides information and operation instructions for the Model T703 and the Model T703U calibrators. For simplicity the information and instructions in this manual refer to both models except where the Model T703U diverges in technical or operational aspects, in which case the T703U is clearly defined.

1.1 CALIBRATOR OVERVIEW

The Model T703 and the T703U are microprocessor controlled ozone calibrators for calibration of precision ambient ozone instruments, such as the TAPI T400. They feature an internal ozone photometer that provides very accurate closed loop feedback control of the ozone concentration. However, the T703U is capable of generating ozone in a low range (fractional mode), for ultra-low ozone production.

An almost unlimited number of independent calibration sequences may be programmed into the T703/T703U, covering time periods of up to one year. The setup of sequences is simple and intuitive and may be actuated manually, automatically, or by a remote signal. The sequences may be uploaded remotely, including remote editing. All programs are maintained in non-volatile memory.

The T703/T703U design emphasizes fast response, repeatability, overall accuracy and ease of operation. It may be combined with the Model 701 Zero Air Generator to provide the ultimate in easy to use, precise calibration for your ozone instrument's features.

Some of the exceptional features of your T703/T703U Photometric O₃ Calibrator are:

- Advanced T-Series electronics
- LCD Graphical User Interface with capacitive touch screen
- Bi directional RS-232 and 10/100Base-T Ethernet, optional USB and RS-485, ports for remote operation
- Front panel USB ports for peripheral devices
- 12 independent timers for sequences
- Nested sequences (up to 5 levels)
- Internal ozone generator and photometer allows use as primary or transfer standard
- UV Lamp Feedback modes: current control; photometer control
- Lightweight for transportability
- T703U: ultra-low ozone production down to 3ppb

1.2 SPECIFICATIONS

All specifications are based on constant conditions.

Table 1-1. T703/T703U System Specifications

PARAMETER	SPECIFICATION	
Linearity	± 1.0% of full scale	
Precision	1.0 ppb	
Response Time	T703	T703U
	<180 seconds to 95%	240 seconds to 95%
Stability (7-days)	<1% photometer feedback; <3% without photometer feedback (CNST or REF)	
Operating Temperature Range	5-40°C	
Humidity Range	0 - 95% RH, non-condensing	
Environmental Conditions	Installation Category (Over Voltage Category) II Pollution Degree 2 Intended for Indoor Use Only at Altitudes ≤ 2000m	
Dimensions (H x W x D)	7" (178 mm) x 17" (432 mm) x 24" (609 mm)	
Weight	35.5 lbs (16.1 kg) including internal zero air pump	
AC Power	Rating	Typical Power Consumption
	100V – 120V, 60Hz, 3.0 A 220V – 240V, 50/60Hz, 3.0 A	75 W (with Zero Air Pump 150 W) 95 W (with Zero Air Pump 170 W)
Analog Output Ranges	0.1 V, 1 V, 5 V or 10 V (selectable) Range with 5% under/over-range	
Standard I/O	1 Ethernet: 10/100Base-T 2 RS-232 (300 – 115,200 baud) 2 USB device ports 12 opto-isolated digital control outputs 12 opto-isolated digital control inputs 8 opto-isolated digital status outputs	
Optional I/O	1 USB com port 1 RS485 Multidrop RS232	

Table 1-2. T703/T703U Specifications for Ozone Generator

	T703	T703U
Flow Rate	1 to 5 LPM adjustable	w/internal zero air source: 1 to 5 LPM adjustable w/external zero air source: 1 to 15 LPM adjustable
Concentration	Min: 50 ppb at 2 LPM Max: 5 ppm at 1 LPM	Min: 3 ppb at 5 LPM Max: 5 ppm at 1 LPM
Output	Min: 100 ppb LPM Max: 5 ppm LPM	Min: 15 ppb LPM Max: 5 ppm LPM
Response Time:	<180 sec. to 98%	<240 sec. to 98%
Optical Feedback	Standard	

Table 1-3. T703/T703U Specifications for O₃ Photometer

PARAMETER	SPECIFICATION
Ranges	0-100 ppb to 0-10 ppm, user selectable
Zero Noise	0.3ppb (RMS)
Span Noise	<0.5%
Lower Detectable Limits	0.6 ppb (RMS)
Precision	1.0 ppb
Linearity	1.0% of Full Scale
Lag Time	<10 seconds
Rise/Fall Time	<20 sec (photometer response)
Zero Drift	<1.0 ppb / 7 days
Span Drift	<1% / 24 hours; <2% / 7 days
Flow Rate	800 cc/min +/- 10%

1.3 COMPLIANCE AND CERTIFICATIONS

This product is CE compliant and adheres to the Low Voltage and ElectroMagnetic Compatibility directives.

For any other certifications, please refer to this product's specifications sheet on our website.

2. GETTING STARTED

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

2.1 UNPACKING



CAUTION – RISK OF PERSONAL INJURY

The calibrator weighs about 18 kg (40 pounds) without options installed. To avoid personal injury, always use two persons and proper lift and carry techniques to move/relocate the calibrator.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Printed Circuit Assemblies (PCAs) are sensitive to electrostatic discharges too small to be felt by the human nervous system. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty. Refer to the manual, Fundamentals of ESD, PN 04786, which can be downloaded from our website at <http://www.teledyne-api.com>.



CAUTION – AVOID DAMAGE TO THE INSTRUMENT

BEFORE operating instrument, remove dust plugs from pneumatic ports.



WARNING!

Never disconnect or reconnect electronic circuit boards, wiring harnesses or electronic subassemblies while the unit is under power.

Note

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

1. Inspect the received packages for external shipping damage. If damaged, please advise the shipper first, then Teledyne API.
2. Included with your calibrator is a printed record of the final performance characterization performed on your instrument at the factory. This record, titled *Final Test and Validation Data Sheet*, is an important quality assurance and calibration record and should be placed in the quality records file for this instrument.
3. Carefully remove the top cover of the calibrator and check for internal shipping damage.
 - a. Inspect the interior of the instrument to ensure all circuit boards and other components are intact and securely seated.
 - b. Check the connectors of the various internal wiring harnesses and pneumatic hoses to ensure they are firmly and securely seated.
 - c. Verify that all of the optional hardware ordered with the unit has been installed. (These are checked on the paperwork accompanying the instrument).

2.1.1 VENTILATION CLEARANCE

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

Table 2-1. Instrument Ventilation Clearance Requirements

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

Various rack mount kits are available for this instrument. Call Sales for more information.

2.2 INSTRUMENT LAYOUT

The front panel (Figure 2-1) has two USB ports for peripheral device connections: mouse and keyboard as alternatives to the touchscreen interface, or flash drive for uploads/downloads (devices not included).

2.2.1 FRONT PANEL

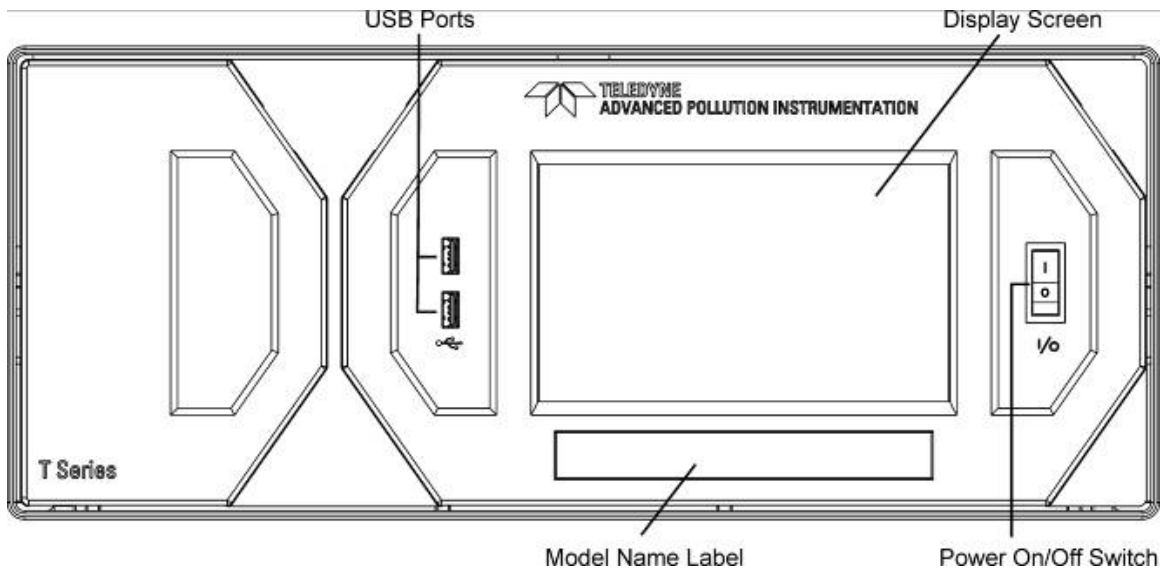


Figure 2-1. Calibrator Front Panel Layout



CAUTION – AVOID DAMAGING TOUCHSCREEN

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

2.2.2 REAR PANEL

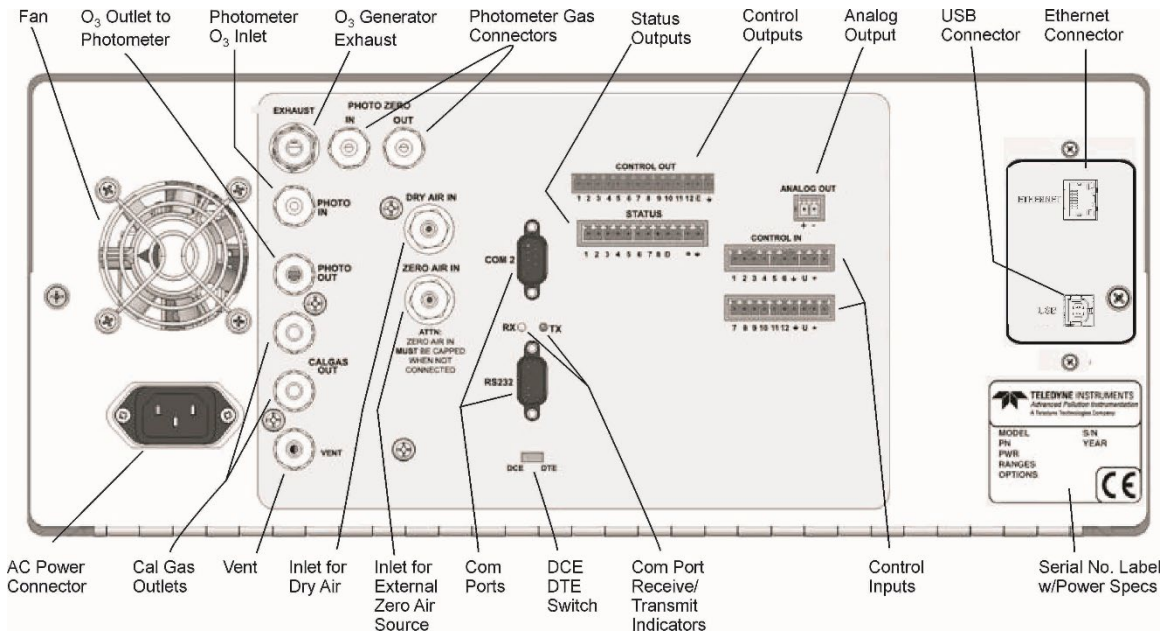




Figure 2-2. Calibrator Rear Panel Layout

Table 2-2 provides a description of the rear panel components.

Table 2-2. Rear Panel Description

COMPONENT		FUNCTION
	Fan	For cooling: pulls ambient air through chassis from side vents; exhausts through rear.
	AC Power Connector	Connector for three-prong cord to apply AC power to the instrument CAUTION! The cord's power specifications (specs) MUST comply with the power specs on the calibrator's rear panel Model number label.
	EXHAUST	Exhaust gas from ozone generator and photometer (option) CAUTION! Exhaust gas must be vented outside.
	PHOTO ZERO IN	Inlet for photometer Zero Gas (option)
	PHOTO ZERO OUT	Outlet for photometer Zero Gas (option)
	PHOTO IN	Measurement gas input for O ₃ photometer (option)
	PHOTO OUT	Calibration gas outlet to O ₃ photometer (option)
	CAL GAS OUT	Two outlets for calibration gas.
	VENT	Vent port for output manifold
	DRY AIR IN	Inlet for dry air.
	ZERO AIR IN	Inlet for external zero air source – MUST BE CAPPED WHEN NOT CONNECTED.
	COM 2	Serial communications port for RS-232 or RS-485 (option).
	RX TX	LEDs indicate receive (RX) and transmit (TX) activity on the when blinking.
	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.
	CONTROL OUT	For outputs to devices such as Programmable Logic Controllers (PLCs).
	STATUS	For outputs to devices such as Programmable Logic Controllers (PLCs).
	ANALOG OUT	For voltage or current loop outputs to a strip chart recorder and/or a data logger.
	CONTROL IN	For remotely activating the zero and span calibration modes.
	ETHERNET	Connector for network or Internet remote communication, using Ethernet cable.
	USB	Connector for direct connection (option) to a personal computer, using USB cable.
	Label w/power specs	Identifies the instrument model number and lists voltage and frequency specifications

2.2.3 INTERNAL LAYOUT

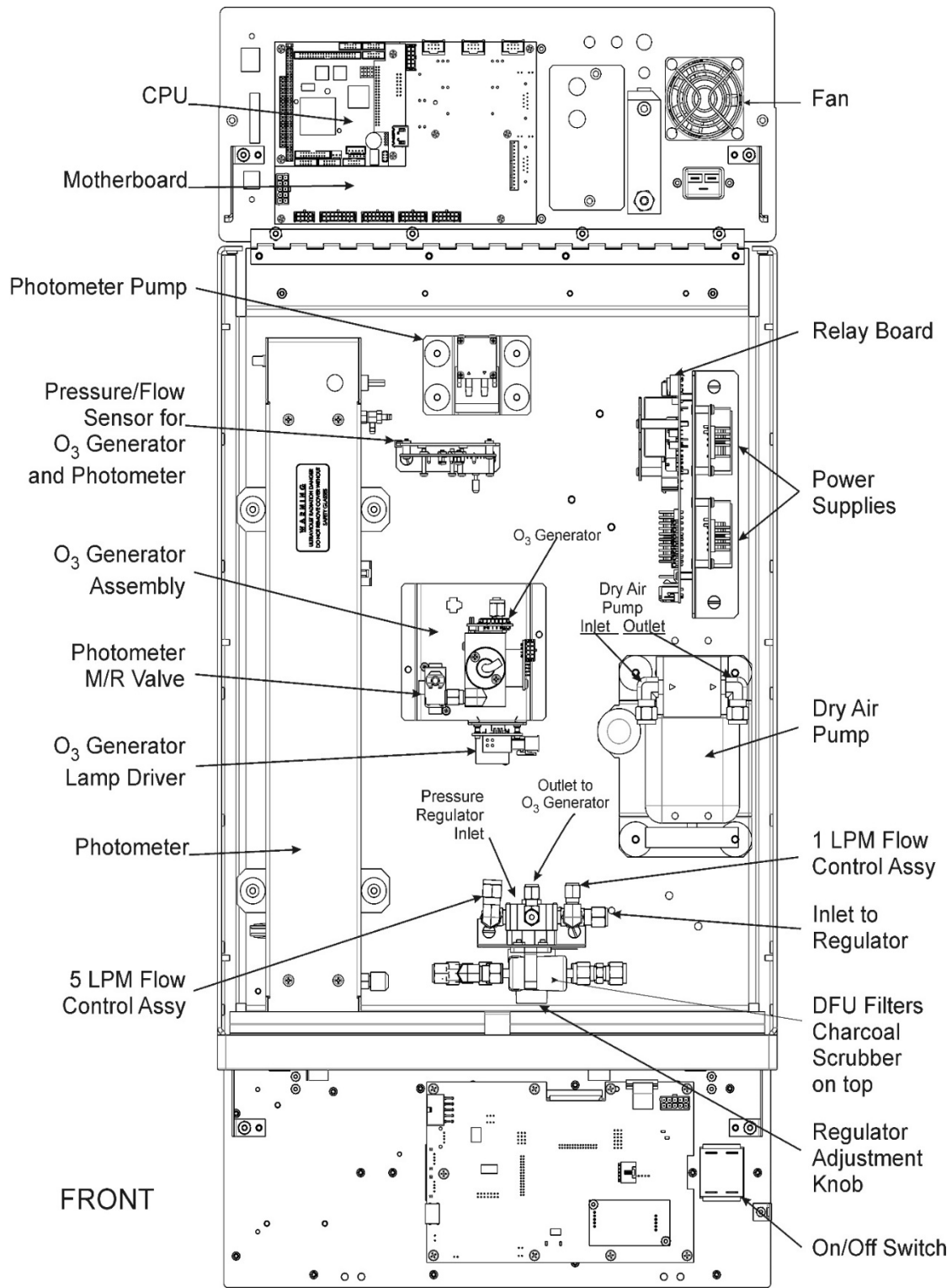


Figure 2-3. T703 Internal Layout

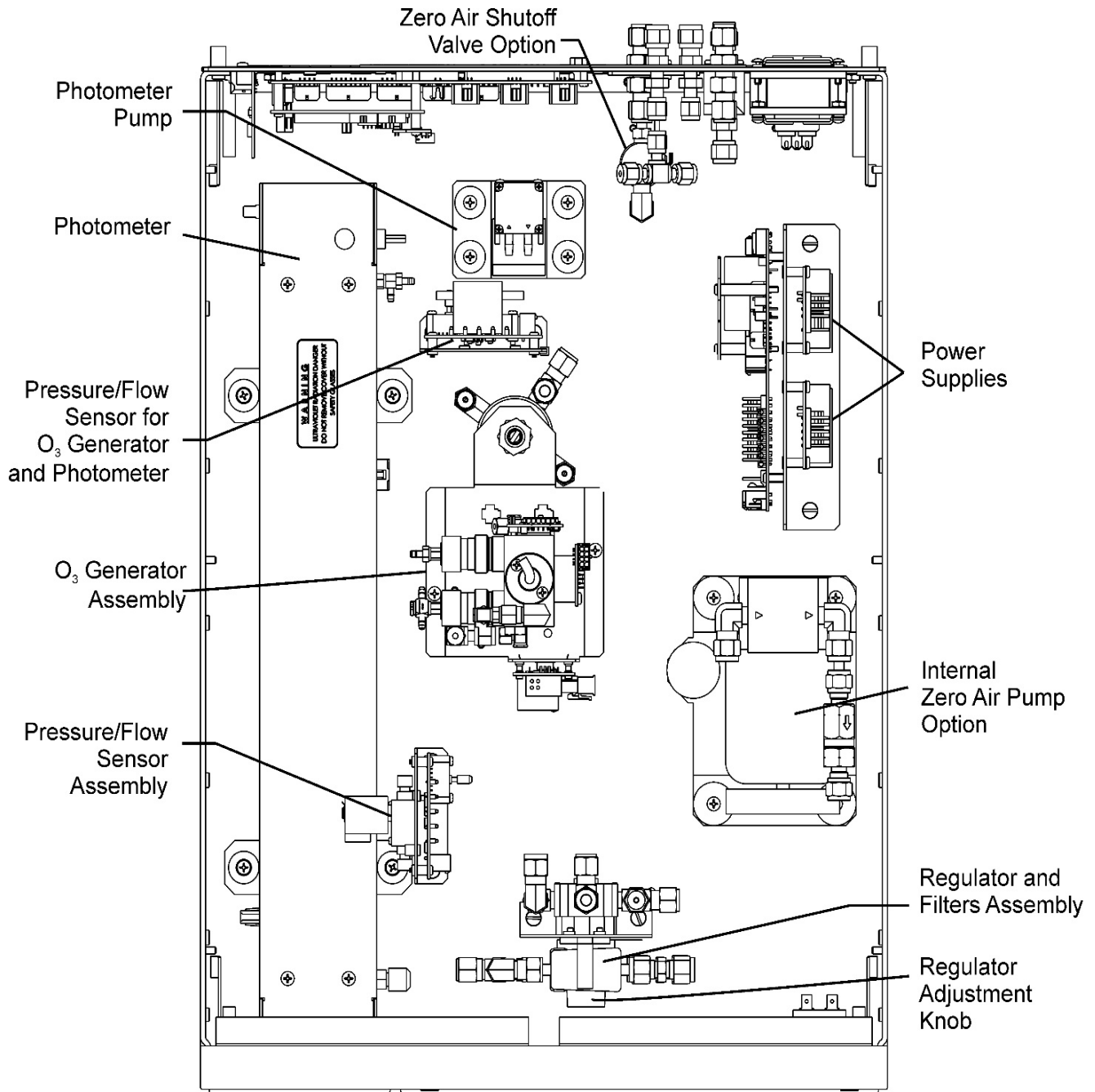


Figure 2-4. T703U Internal Layout

2.3 CONNECTIONS

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

2.3.1 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.



WARNING – ELECTRICAL SHOCK HAZARD

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



CAUTION – AVOID DAMAGE TO THE INSTRUMENT

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

2.3.1.1 CONNECTING POWER

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



CAUTION – AVOID PERSONAL INJURY

DO NOT look at the photometer UV lamp; UV light can cause eye damage.
Always wear glasses made from Safety UV filtering glass (plastic glasses are inadequate).

2.3.1.2 CONNECTING ANALOG OUTPUTS

The calibrator is equipped with an analog output channel for one of several diagnostic functions and is accessible through the ANALOG OUT connector (Figure 2-5) on the rear panel. Its standard available output is 0-5 VDC.

Attach a strip chart recorder or data-logger to the analog output connector. Configuration information is presented in the Setup Section (Setup>Analog Outputs>, Section 2.6.9).

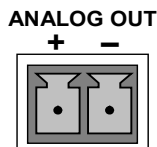


Figure 2-5. Calibrator Analog Output Connector

2.3.1.3 CONNECTING THE STATUS OUTPUTS (DIGITAL OUTPUTS)

The 12-pin STATUS connector allows the digital status outputs to report up to eight , user-selected calibrator conditions (configured through the Setup>Digital Outputs menu, Section 2.6.6) 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 emitters of these transistors are tied together and available at pin D (Figure 2-6).

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

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

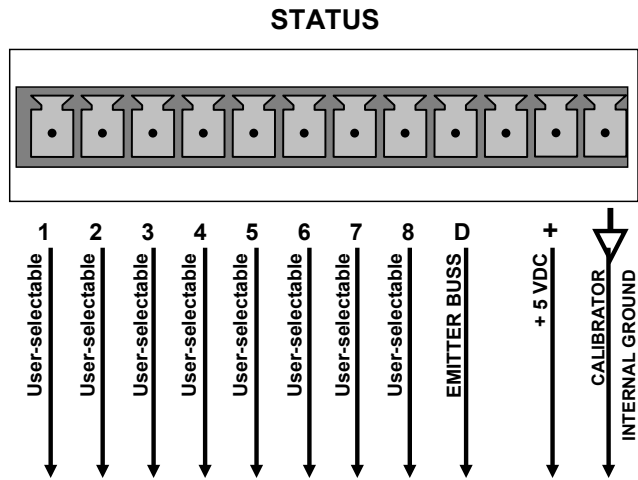



Figure 2-6. Status Output Connector

The pin assignments for the Status Outputs are:

Table 2-3. Status Output Pin Assignments

OUTPUT #	STATUS DEFINITION	CONDITION
1-8	User-Selectable	On or off
D	Emitter BUS	The emitters of the transistors on pins 1 to 8 are bussed together.
(blank)	(blank)	Not Used
+	DC POWER	+ 5 VDC
	Digital Ground	The ground level from the calibrator's internal DC power supplies.

2.3.1.4 CONNECTING THE CONTROL INPUTS (DIGITAL INPUTS)

The calibrator is equipped with 12 digital control inputs (two separate 10-pin connectors on rear panel, labeled CONTROL IN), which can be used to initiate various user-programmable calibration sequences (see Section 2.6.7.1 for instructions on assigning the control inputs to specific calibration sequences).

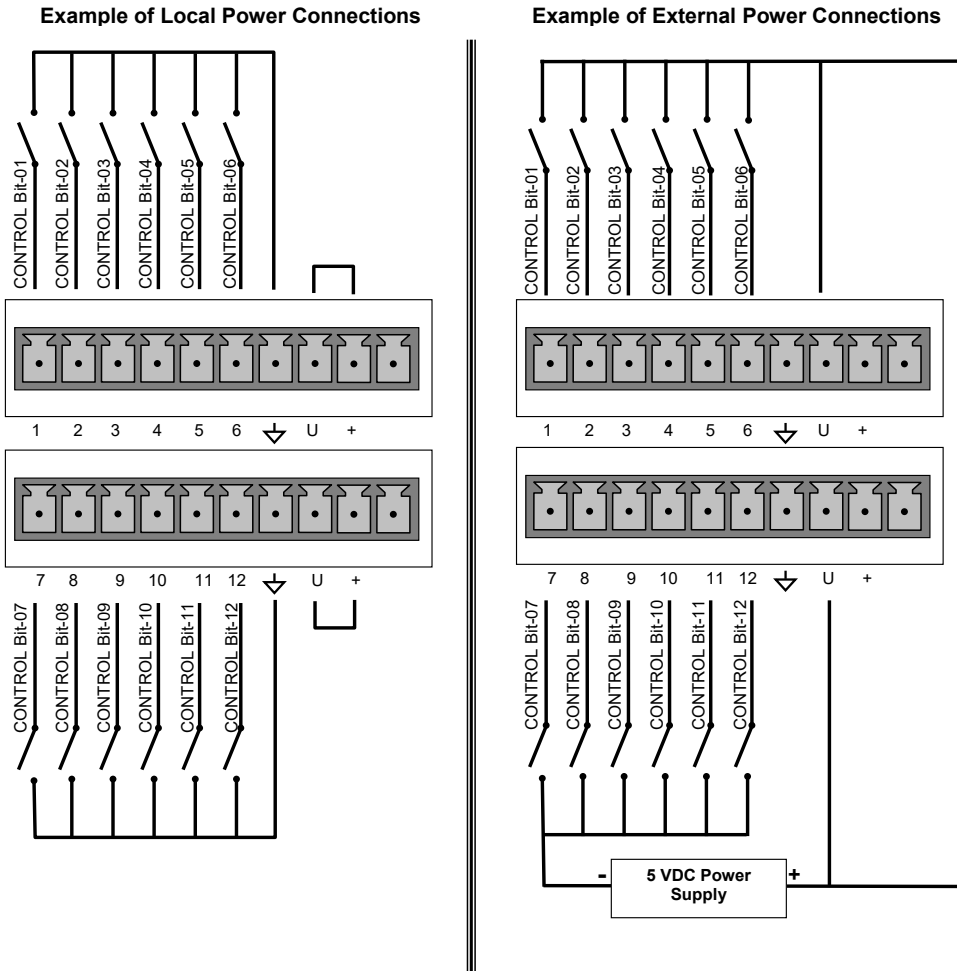


Figure 2-7. Calibrator Digital Control Input Connectors

There are two methods for energizing the control inputs. The internal +5V available from the pin labeled “+” is the most convenient method. However, if full isolation is required, an external 5 VDC power supply should be used.

Table 2-4. Calibrator Control Input Pin Assignments

CONNECTOR	INPUT	DESCRIPTION
Top	1 to 6	Can be used as either 6 separate on/off switches, or as bits 1 through 6 of a 12-bit wide binary activation code.
Bottom	7 to 12	Can be used as either 6 separate on/off switches, or as bits 7 through 12 of a 12-bit wide binary activation code.
BOTH	⏚	Chassis ground.

CONNECTOR	INPUT	DESCRIPTION
Top	U	Input pin for +5 VDC required to activate pins 1 – 6. This can be from an external source or from the “+” pin of the connector.
Bottom	U	Input pin for +5 VDC required to activate pins 7 – 12. This can be from an external source or from the “+” pin of the connector.
BOTH	+	Internal source of +5V used to actuate control inputs when connected to the U pin.

2.3.1.5 CONNECTING THE DIGITAL CONTROL OUTPUTS

The calibrator is equipped with 12 opto-isolated, digital control outputs on a 14-pin connector (Figure 2-8); see Figure 2-2 for rear panel location. These outputs may be used to interface with devices that accept logic-level digital inputs, such as Programmable Logic Controllers (plcs), data loggers, or digital relays/valve drivers, and are activated by the calibrator’s user-programmable calibration sequences. Create the sequences in Setup>Sequences menu; then map the digital control outputs to the sequences through the Setup>Digital Outputs menu (see Section 2.6.7 for instructions on assigning the control outputs to specific calibration sequences).

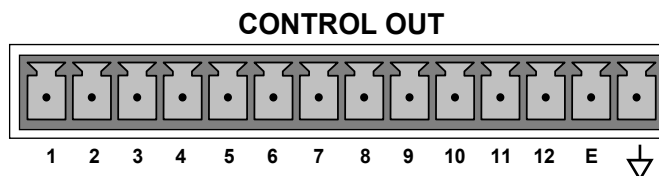


Figure 2-8. Calibrator Digital Control Output Connector

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Most PLCs have internal provisions for limiting the current the input will draw. When connecting to a unit that does not have this feature, external resistors must be used to limit the current through the individual transistor outputs to ≤50mA (120 Ω for 5V supply).

The pin assignments for the control outputs are:

Table 2-5. Calibrator Control Output Pin Assignments

PIN #	STATUS DEFINITION	CONDITION
1 - 12	Outputs 1 through 12 respectively	Closed if the sequence or sequence step activating output is operating.
E	Emitter BUS	The emitters of the transistors on pins 1 to 12 are bussed together.
⏚	Digital Ground	The ground level from the calibrator’s internal DC power supplies.

2.3.1.6 CONNECTING THE EXTERNAL VALVE DRIVER OPTION

Two 12V external valve driver assemblies (options listed in Table 2-6), are available that can drive up to eight, 8-watt valves based on the condition of the status block bits described below. The option consists of a custom Printed Circuit Assembly (PCA) that mounts to the back of the calibrator with or without a universal AC-to-DC power supply module (PSM).

The Valve Driver Outputs are mapped one-for-one to the Control Outputs 1 through 8 and can be manually actuated for troubleshooting using the Signal I/O diagnostic function in the calibrator software (see Section 7.3.9.5). However, the drive outputs are mapped in reverse to the status control bits such that Bit-0 (LSB) is valve drive 8 and Bit-7 is valve drive 1.



Figure 2-9. Calibrator Rear Panel Valve Driver Installed (with PSM connected to JP1)



Figure 2-10. Calibrator Rear Panel Valve Driver Installed (without PSM)

Table 2-6. External Valve Driver Options

OPTION	DESCRIPTION	PART NUMBER
48C	12V External Valve Driver - without PSM	072210100
48E	12V External Valve Driver - with PSM	072210300

Depending upon the capacity of the external supply either four (standard) or eight valves can be simultaneously energized.

The PCA is constructed such that it plugs through the rear panel into the Control Output connector, J1008, on the calibrator's motherboard.

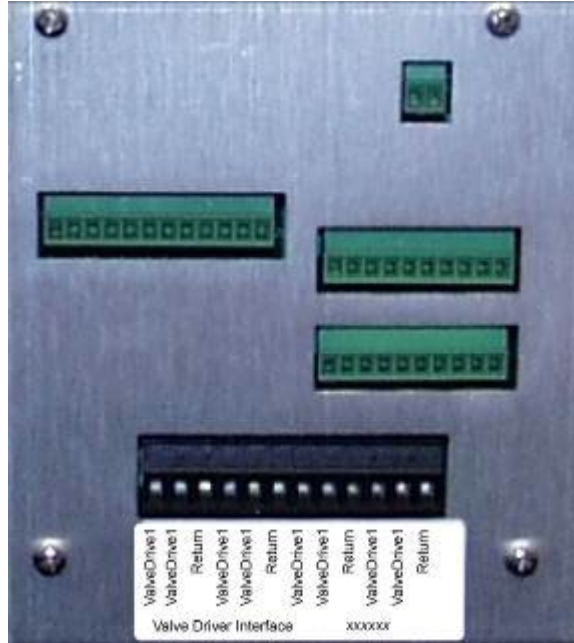



Figure 2-11. Valve-Driver Interface

OPTION 48C CONNECTIONS



CAUTION – AVOID DAMAGE TO VALVE DRIVER BOARD
Do NOT connect power supply to JP1 for Options 48C or 48D.

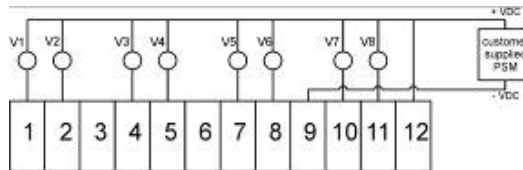


Figure 2-12. Option 48C Connections, Customer-supplied PSM to Pin 12 (+) & Pin 9 (-)

OPTION 48E CONNECTIONS

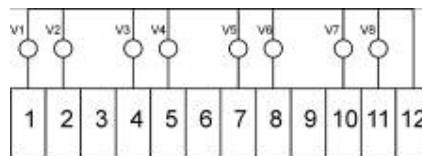


Figure 2-13. Option 48E Connections

2.3.1.7 CONNECTING THE COMMUNICATIONS INTERFACES

The T-Series analyzers are equipped with connectors for remote communications interfaces: **Ethernet**, **USB (Option)**, **RS-232**, **RS-232 Multidrop** and **RS-485** (each described below). (Configuration details for Setup>Comm are presented in Section 2.6.11).

ETHERNET CONNECTION

For network or Internet communication with the analyzer, connect an Ethernet cable from the analyzer's rear panel Ethernet interface connector to an Ethernet port. Although the analyzer is shipped with DHCP enabled by default, it should be manually assigned a static IP address (Setup>Comm>Network Settings, Section 2.6.11.4).

USB (OPTION) CONNECTION

The rear panel 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 (ensure baud rates match). A USB driver is required for complete configuration.

Note

If this option is installed, the rear panel RS232 (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 DCE-DTE switch (Figure 2-2) to select DTE or DCE as appropriate (Section 0).

Important**IMPACT ON READINGS OR DATA**

Cables that appear to be compatible because of matching connectors may incorporate internal wiring that makes the link inoperable. Check cables acquired from sources other than Teledyne API for pin assignments (Figure 2-14) before using.

RS-232 COM PORT CONNECTOR PIN-OUTS

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

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

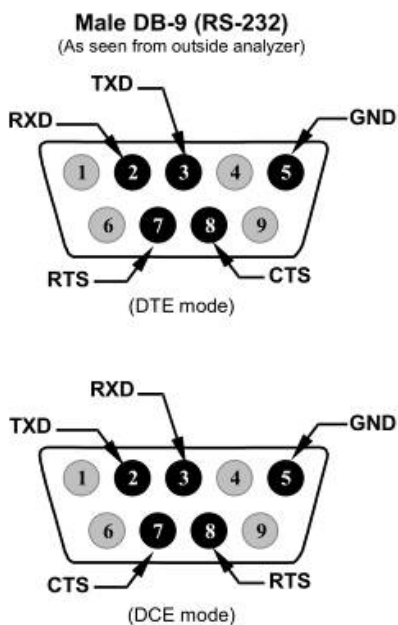


Figure 2-14. Rear Panel Connector Pin-Outs for RS-232 Mode

The signals from these two connectors are routed from the motherboard via a wiring harness to two 10-pin connectors on the CPU card, J11 and J12 (Figure 2-15).

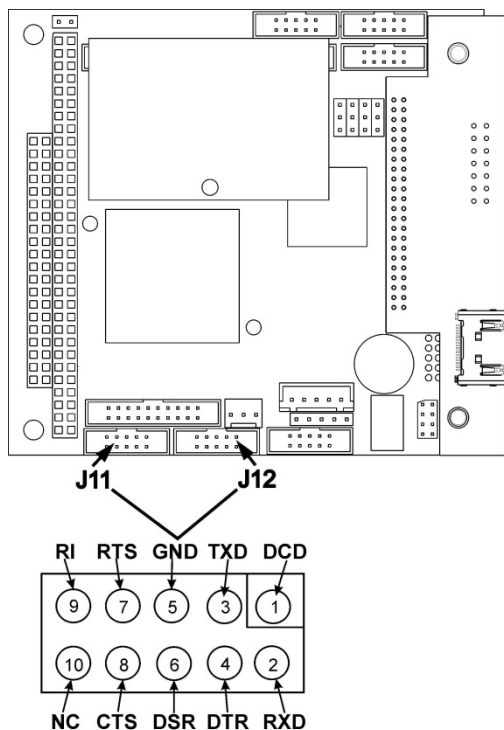


Figure 2-15. Default Pin Assignments for CPU COMM Port Connector (RS-232).

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

P/N WR000077, a DB-9 female to DB-9 female cable, 6 feet long. Allows connection of the serial ports of most personal computers.

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

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

Note

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

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

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

RS-232 COM PORT DEFAULT SETTINGS

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

- **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 MULTI-DROP (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 electrostatic discharges too small to be felt by the human nervous system. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty. For more information on preventing ESD damage, see *A Primer on Electro-Static Discharge*; the manual can be downloaded from our website at <http://www.teledyne-api.com> under Help Center > Product Manuals in the Special Manuals section.

In each instrument with the Multidrop option there is a shunt jumpering two pins on the serial Multidrop and LVDS printed circuit assembly (PCA), as shown in Figure 2-16. This shunt must be removed from all instruments except that designated as last in the multidrop chain, which must remain terminated. This requires powering off and opening each instrument and making the following adjustments:

1. With NO power to the instrument, remove its top cover and lay the rear panel open for access to the Multidrop/LVDS PCA, which is seated on the CPU.
2. On the Multidrop/LVDS PCA's JP2 connector, remove the shunt that jumpers Pins 21 ↔ 22 as indicated in Figure 2-16. (Do this for all but the last instrument in the chain where the shunt should remain at Pins 21 ↔ 22).
3. Check that the following cable connections are made in all instruments (again refer to Figure 2-16):
 - J3 on the Multidrop/LVDS PCA to the CPU's COM1 connector
(Be aware that the CPU's COM2 connector is not used in Multidrop)
 - J4 on the Multidrop/LVDS PCA to J12 on the motherboard
 - J1 on the Multidrop/LVDS PCS to the front panel LCD

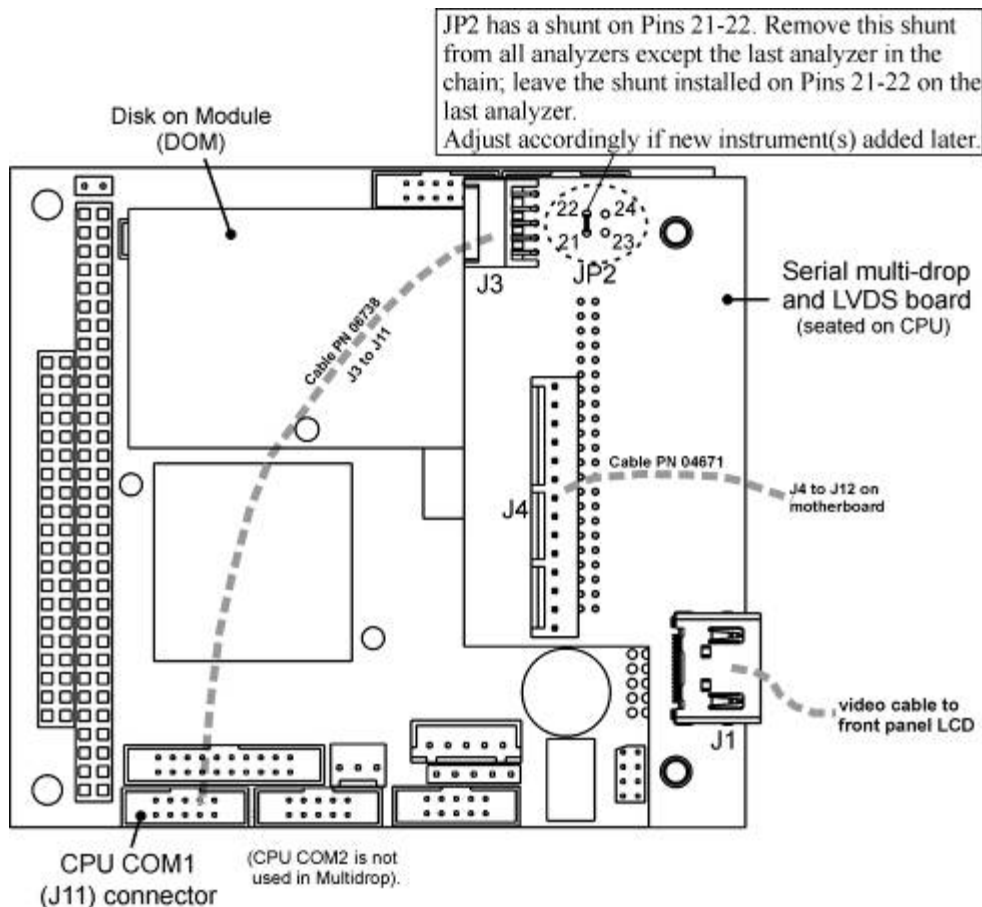


Figure 2-16. Jumper and Cables for Multidrop Mode

Note

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

4. Close the instrument.
5. Referring to Figure 2-17, use straight-through DB9 male > DB9 female cables to interconnect the host RS232 port to the first analyzer's RS232 port. Do the same from the first analyzer's COM2 port to the second analyzer's RS232 port, and from the second analyzer's COM2 port to the third analyzer's RS232 port, etc. Connect 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 (see Figure 2-2 and Section 0) 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 2.3.1.7, Connecting the Communications Interfaces, "RS-232 Connection").

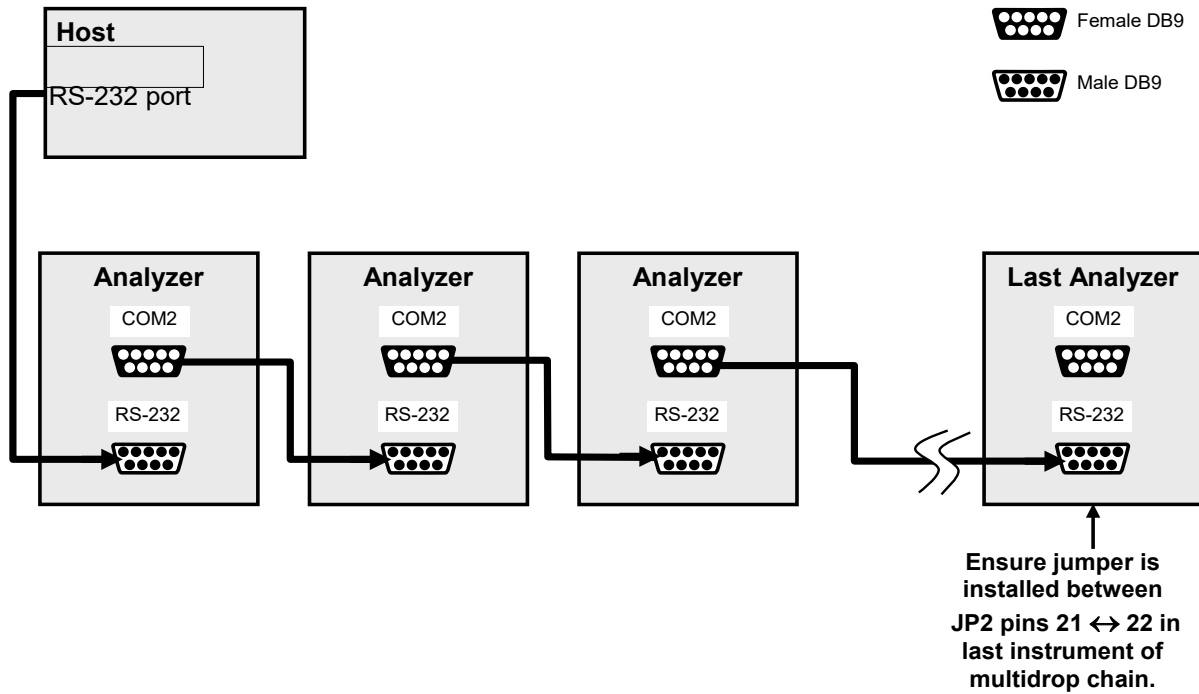


Figure 2-17. RS-232-Multidrop PCA Host/Analyzer Interconnect Diagram

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

Note

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

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

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

2.3.2 PNEUMATIC CONNECTIONS

This section shows the connections for basic pneumatic setup and for use as an ozone photometer, and provides guidance for pneumatic port configurations.

Important

IMPACT ON READINGS OR DATA

Each time the pneumatic configuration is changed for any purpose, a back pressure compensation calibration must be performed (Section 5.1).

2.3.2.1 CONNECTIONS FOR BASIC OPERATION

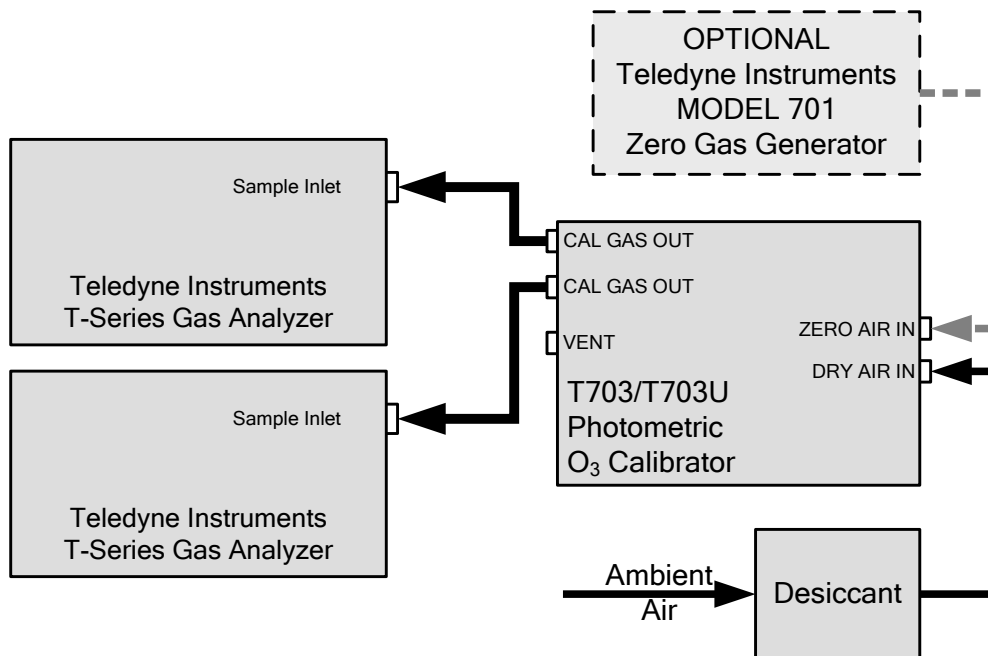


Figure 2-18. Basic Pneumatic Setup

2.3.2.2 DRY AIR IN

When using the internal zero air pump, a source of dry air should be connected to the port labeled 'Dry Air In' on the rear panel. This air should be supplied at atmospheric pressure. The supplied air should have a dew point of $-20\text{ }^{\circ}\text{C}$ or less.

Teledyne API can supply an optional desiccant cartridge that can be used to supply dry air to the T703/T703U.

2.3.2.3 ZERO AIR IN

An external pressurized source of zero air can be supplied at the ‘Zero Air’ port on the rear panel. This is the standard configuration when the zero air pump is not installed. This zero air should be scrubbed of ozone and have a dew point of -20 °C or less. The pressure of the zero air should be regulated to 20-35 psig.

Note

When connecting an external source of zero air to a T703 with an internal zero air pump installed, the zero air pump should be disabled (Setup>Vars>ZA Pump Enable, Edit and set to OFF).

2.3.2.4 OUTPUT MANIFOLD

A three-port output manifold is supplied on the rear panel of the T703/T703U enabling simultaneous testing of up to two external instruments. Sample lines for ozone instruments to be calibrated can be connected directly to this manifold.

To prevent ozone exposure, the bottom port of this manifold is used as a vent and should be connected to a proper unpressurized vent manifold. It is important that the backpressure at this vent fitting be kept to a minimum. If a vent line longer than 2 meters (~6 feet) is required, then 3/8” OD tubing should be used.

Any unused ports on this manifold must be capped.

2.3.2.5 EXHAUST

The port labeled ‘EXHAUST’ contains the exhaust gas from the internal photometer and may contain ozone. This port should be connected to a proper unpressurized vent manifold to prevent ozone exposure.

2.3.2.6 SETUP FOR OPERATION AS AN O₃ PHOTOMETER

The T703/T703U can be converted from an O₃ calibrator to an O₃ photometer to measure an external source of ozone.

Note

Gas from any external source must be supplied at atmospheric pressure.

Refer to Figure 2-19 to set up the T703/T703U as follows:

1. Remove the two loop-back tubing assemblies on the rear panel connected to the ‘PHOTO IN’ and ‘PHOTO ZERO IN’ fittings.
2. Connect the ozone source to be measured to the ‘PHOTO IN’ fitting.
 - This gas must be supplied at atmospheric pressure.
3. Connect a reference gas (Zero Air) for the photometer to the ‘PHOTO ZERO IN.’
 - This gas must be supplied at atmospheric pressure. To avoid interference effects, the reference gas should be from the same source that is being used to feed the ozone generator that is being tested.

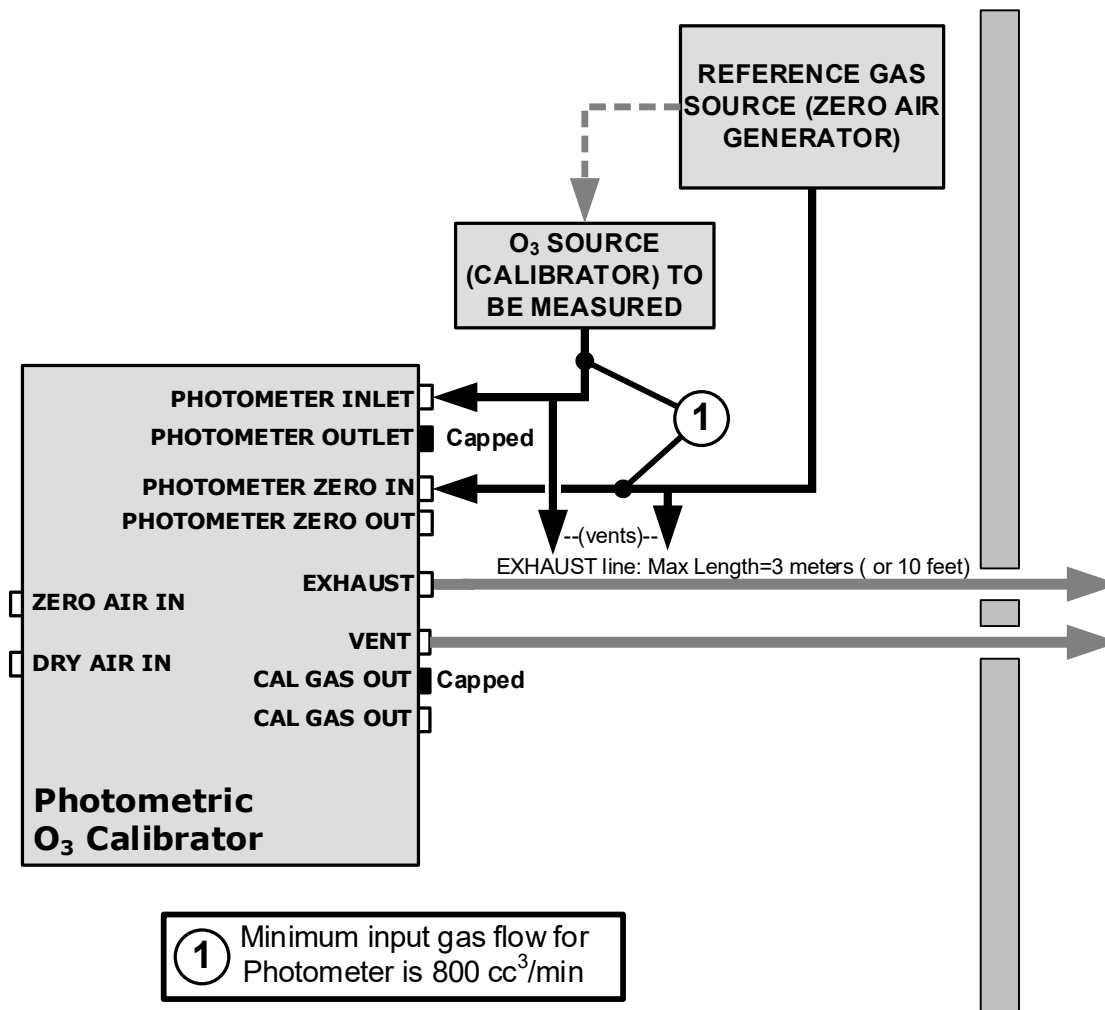


Figure 2-19. Set up to Measure an External O₃ Source

The T703/T703U is now set up to operate as an O₃ photometer. Operation instructions are provided in Section 3.3.

2.3.3 PNEUMATIC FLOW DIAGRAMS

This section shows pneumatic flow for the T703 and for the T703U.

2.3.3.1 T703 PNEUMATIC FLOW

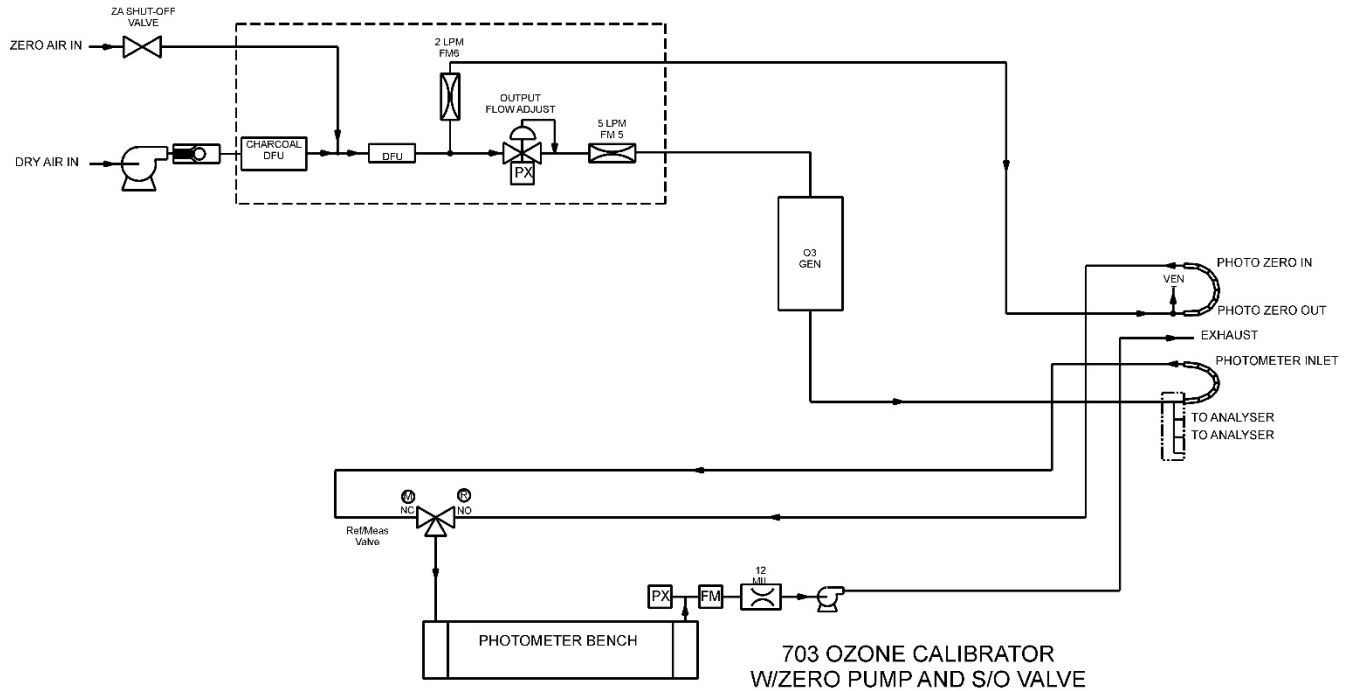


Figure 2-20. T703 Pneumatic Flow Diagram

2.3.3.2 T703U PNEUMATIC FLOW

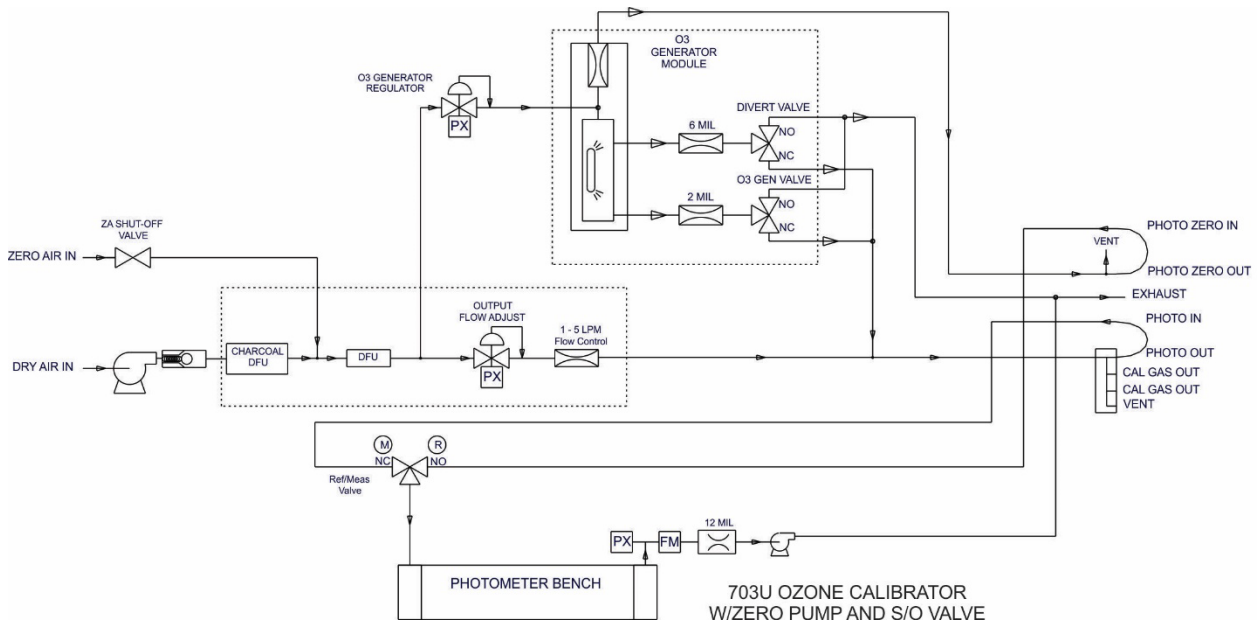


Figure 2-21. T703U Pneumatic Flow Diagram

2.4 STARTUP AND FUNCTIONAL CHECKS

If you are unfamiliar with the calibrator principles of operation, we recommend that you read Section 8.

2.4.1 INITIAL STARTUP

After making the electrical and pneumatic connections, turn on the instrument. The exhaust fan (and pump if photometer option installed) should start immediately. A sequence of status screens (Figure 2-22) appear prior to the Home page. The calibrator will be in STANDBY mode and requires a minimum of 30 minutes for all of its internal components to reach a stable operating temperature.

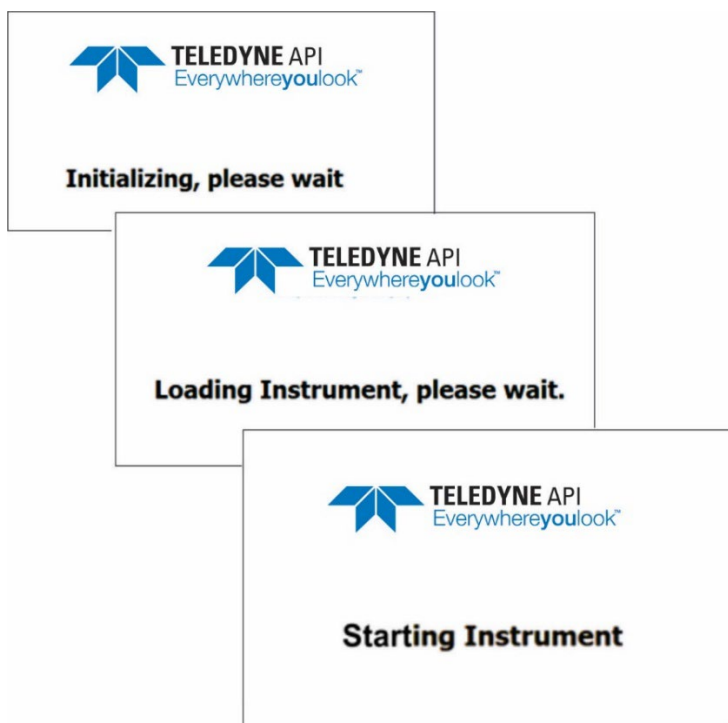


Figure 2-22. Status Screens at Startup

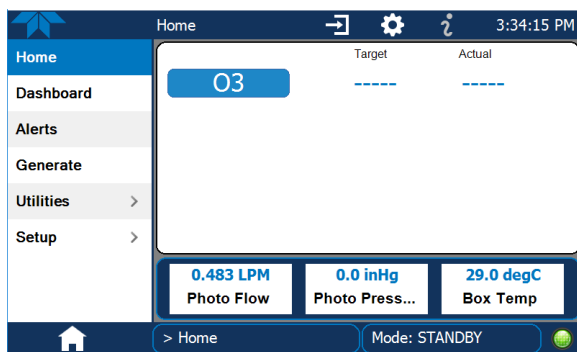


Figure 2-23. Typical Home Page Prior to Configuration

2.4.2 ALERTS: WARNINGS AND OTHER MESSAGES

Because internal temperatures and other conditions may be outside the specified limits during the warm-up period, the software will suppress most Alerts for 30 minutes after power up. The Alerts page (Figure 2-24) shows the status of any active warning conditions or user-configured Events. (For more detailed information about Alerts, see Section 2.5.3 provides, and for Events, see Section 2.6.2).

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

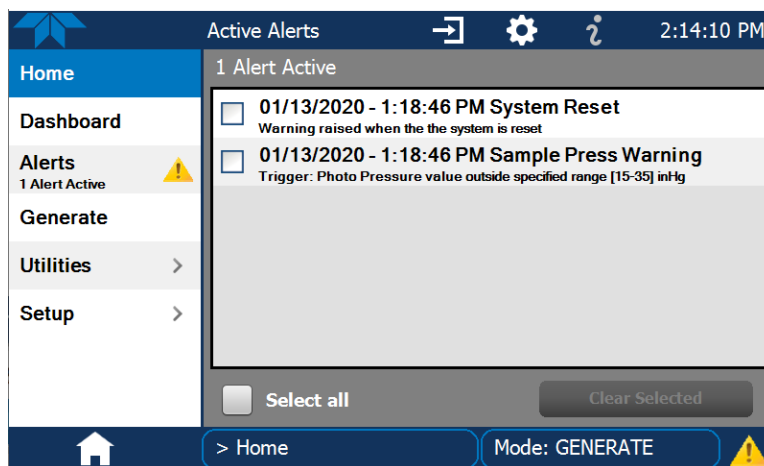


Figure 2-24. Viewing Active Alerts Page

2.4.3 FUNCTIONAL CHECKS AND VERIFICATION

During warm-up, verify that the software properly supports any hardware options that are installed by navigating to the Setup>Instrument>Product Info page.

After warm-up, verify that the instrument is functioning within allowable operating parameters by checking their values in the Dashboard:

- Check values for the operating parameters in the Dashboard page against the instrument’s Final Test and Validation Data sheet, which lists these values as they appeared before the instrument left the factory. (If any functional parameters are not displayed, configure the Dashboard through the Setup>Dashboard menu to add them, Section 2.6.3).
- Generate ozone by using the Generate>Auto menu (Section) and verify its value in the Dashboard. (Place in Standby mode after verifying and whenever ozone generation is not needed).

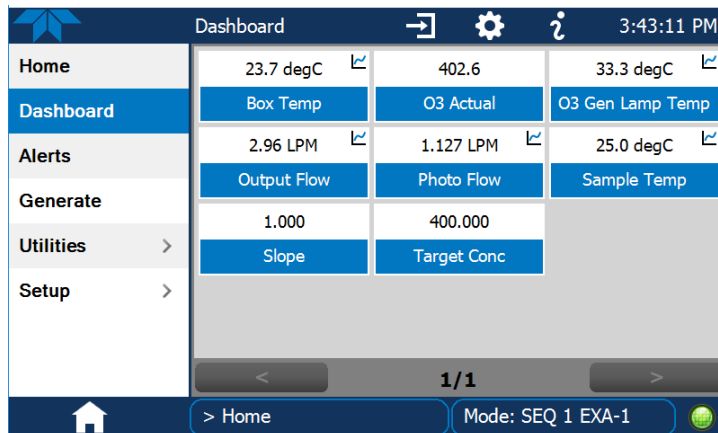


Figure 2-25. Sample Dashboard Page

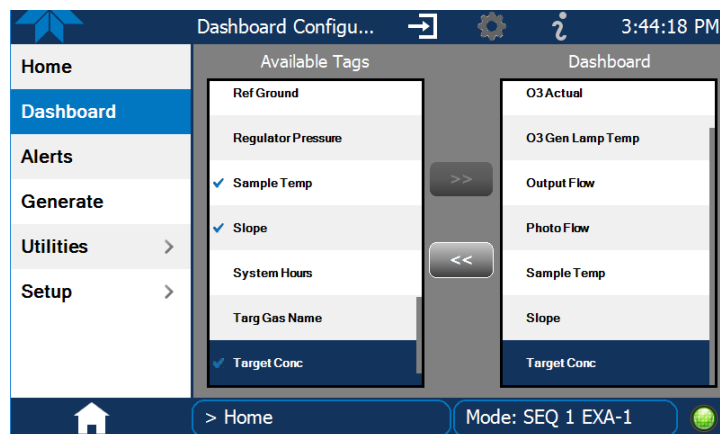


Figure 2-26. Dashboard Configurator

2.4.4 SELECTING A MODE FOR THE O₃ GENERATOR

The calibrator can generate O₃ in either of two different modes: Constant or Bench, which can be set after first ensuring that the calibrator is in Standby Mode (set via the Home page Generate menu); then in the Setup>Vars menu edit O₃ Gen Mode.

Note

The T703/T703U calibrator should always be placed in Standby mode when not needed to produce ozone (Home>Generate>Standby).

2.4.4.1 CNST (CONSTANT) MODE

In this mode, the O₃ output of the generator is based on a single, constant, drive voltage, and there is no Feedback loop control by the calibrator’s CPU.

2.4.4.2 BNCH (BENCH) MODE

The O₃ concentration control loop will use the photometer’s O₃ measurement as input. This is the default mode and is used whenever the calibrator is using the Generate>Auto menu or the Generate command in a Sequence step.

2.4.5 SETTING THE CALIBRATOR'S OUTPUT FLOW RATE

The output flow rate must consider both the total gas flow requirements of all analyzers connected to the output manifold and the minimum output flow of the O₃ generator. Figure 2-27 shows a close-up of the regulator assembly.

2.4.5.1 CALCULATING OUTPUT FLOW RATE

First, add the sum of the flow requirements of all of the instruments to which the T703/T703U will be supplying calibration gas plus 1 LPM excess flow. For example, if the T703 is expected to supply calibration gas mixtures simultaneously to two analyzers, each requiring 0.8 LPM, the minimum Total Flow output would be:

$$(0.8 + 0.8) + 1.0 = 2.6 \text{ LPM}$$

Second, calculate the flow rate requirements of the O₃ generator output, which must remain above the minimum specification of 20 PPB*LPM. Use the following equation to determine the minimum flow rate (FT) for the O₃ generator output:

$$F_T \geq \frac{20 \text{ ppb} \cdot \text{LPM}}{O_3 \text{ Conc}}$$

Compare the values calculated from the of the above formulae; the greater of the two is the minimum Total Flow that must be set.

2.4.5.2 OUTPUT FLOW RATE SETUP

To set the output flow:

1. Open the front panel of the calibrator by releasing the two snap-in fasteners at the top of the front panel.
2. Pull out the regulator knob and adjust the regulator until the desired flow is achieved.
 - The front panel of the calibrator displays the approximate output flow based on the measured regulator pressure, but this flow should be verified with an independent calibrated flow meter attached to one of the CAL GAS outlets on the back of the instrument.
3. Push the pressure regulator knob (Figure 2-27) back in to lock.
4. Close the front panel.

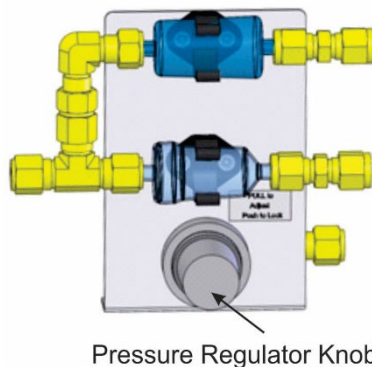


Figure 2-27. Output Pressure Regulator Assembly

2.5 MENU OVERVIEW

Table 2-7 describes the main menus and provides cross-references to the respective sections with configuration details.

Table 2-7. Menu Overview

MENU	DESCRIPTION	REFERENCE
Home	View and plot concentration readings and other user-selected parameters set up through the configuration shortcut or the Setup>Homescreen menu.	Sections 2.5.1 and 2.6.5
Dashboard	View user-selected parameters (Setup>Dashboard) and their values, some of which can be displayed in a live-plot graph (Figure 2-28).	Sections 2.5.2 and 2.6.3
Alerts	View and clear active Alerts that were triggered by either factory-defined or user-configured Events (see Setup>Events). Active and past Alerts are recorded in the Utilities>Alerts Log).	Section 2.5.3
Generate	Generate ozone. Execute sequences configured in the Setup>Sequences menu. Execute Levels configured in the Setup>Levels menu. Place the calibrator in Standby mode.	Section 2.5.4
Utilities	View logs, download data and firmware updates, copy configurations between instruments, and run diagnostics.	Section 2.5.5
Datalog View	Displays the data logs that were configured via the Setup>Data Logging menu. From this list a log can be selected and filters applied to view the desired data, which is downloadable through the Utilities>USB Utilities page.	Section 2.5.5.1
Alerts Log	Displays a history of Alert messages triggered by factory-defined and user-defined Events, such as warnings and alarms (See Section 2.6.2 for Events configuration).	Section 2.5.5.2
USB Utilities	Serves multiple purposes using a flash drive connected to the instrument's front panel USB port: <ul style="list-style-type: none"> • download data from instrument's Data Acquisition System (DAS), the Data Logger, to a flash drive (Section 2.5.5.3) • update firmware (Section 6.3) • transfer instrument configuration from/to other instruments of the same model (Section 2.5.5.3) • download a basic operation functionality report (Section 6.2) 	Section 2.5.5.3

MENU	DESCRIPTION	REFERENCE
Diagnostics	Provides access to various pages that facilitate troubleshooting.	(various)
Analog Inputs	This page shows voltage signals of several analog input parameters, including those from other instrumentation when the External Analog Inputs Option is installed.	Section 7.1.3
Analog Outputs	Shows voltage signals for one parameter (configured through Setup>Analog Outputs, Section 2.6.9).	Section 7.1.4
Digital Inputs	Shows whether specific available Signal In features are active (ON) or inactive (OFF).	Section 7.1.3
Digital Outputs	Activate (ON)/deactivate (OFF) user-specified Signal Out features (configured in the Setup>Digital Outputs menu, Section 2.6.6).	Section 7.1.3
Photo Flow Cal	Calibrate the photometer flow.	Section 5.3.1
Output Flow Cal	Configure flow range, slope, offset, and sensor offset.	Section 5.3.2
O3 Gen Cal	Calibrates the Ozone Generator using a table of drive voltages for initial settings.	Section 5.5
Back Pressure Compensation	Required any time there is a change made in the pneumatic configuration or after a gas pressure calibration.	Section 5.1
Bench Cal	Calibrate the ozone photometer (bench)	Section 5.4.3
Pressure Cal	Calibrate pressure sensors.	Section 5.1
Setup	Configure a variety of features and functions for customized operation.	Section 2.6
Datalogging	Track and record concentration and calibration data and selectable diagnostic parameters, the reports for which can be viewed in the Utilities>Datalog View menu and downloaded to a flash drive via the Utilities>USB Utilities menu (Section 2.6.1.3).	Section 2.6
Events	Select parameters and define the conditions by which they are to be flagged and recorded in the Alerts log (Utilities>Alerts Log) when they are triggered.	Section 2.6.2
Dashboard	Select parameters monitoring instrument functionality (Figure 2-25, Figure 2-26).	Section 2.6.3
Vars	Manually adjust several software variables that define specific operational parameters.	Section 2.6.4
Homescreen	Configure the three meters located along the bottom of the display to show desired functions (Figure 2-47, Figure 2-28).	Section 2.6.5
Digital Outputs	Map the rear-panel digital status outputs to a variety of signals present in the instrument to monitor operating conditions or custom Events (Setup>Events).	Section 2.6.6
Sequences	Create automated sequential calibration steps.	Section 2.6.7
Levels	Create individual flow and concentration outputs for LEADS	Section 2.6.8
Analog Outputs	Send user-selected parameter readings in the form of user-defined voltage or current loop signals as outputs to a strip chart recorder and/or the data logger.	Section 2.6.9
Instrument	View product and system information, including list of options, if any; view network settings; view/adjust Date and Time settings; and check for firmware updates when connected to a network that is connected to the Internet.	Section 2.6.10
COMM	View and configure network and serial communications.	Section 2.6.11

2.5.1 HOME

Figure 2-28 shows the features of the main interface from the Home page. The meters at the bottom of the display are user-selectable (see Section 2.6.5).

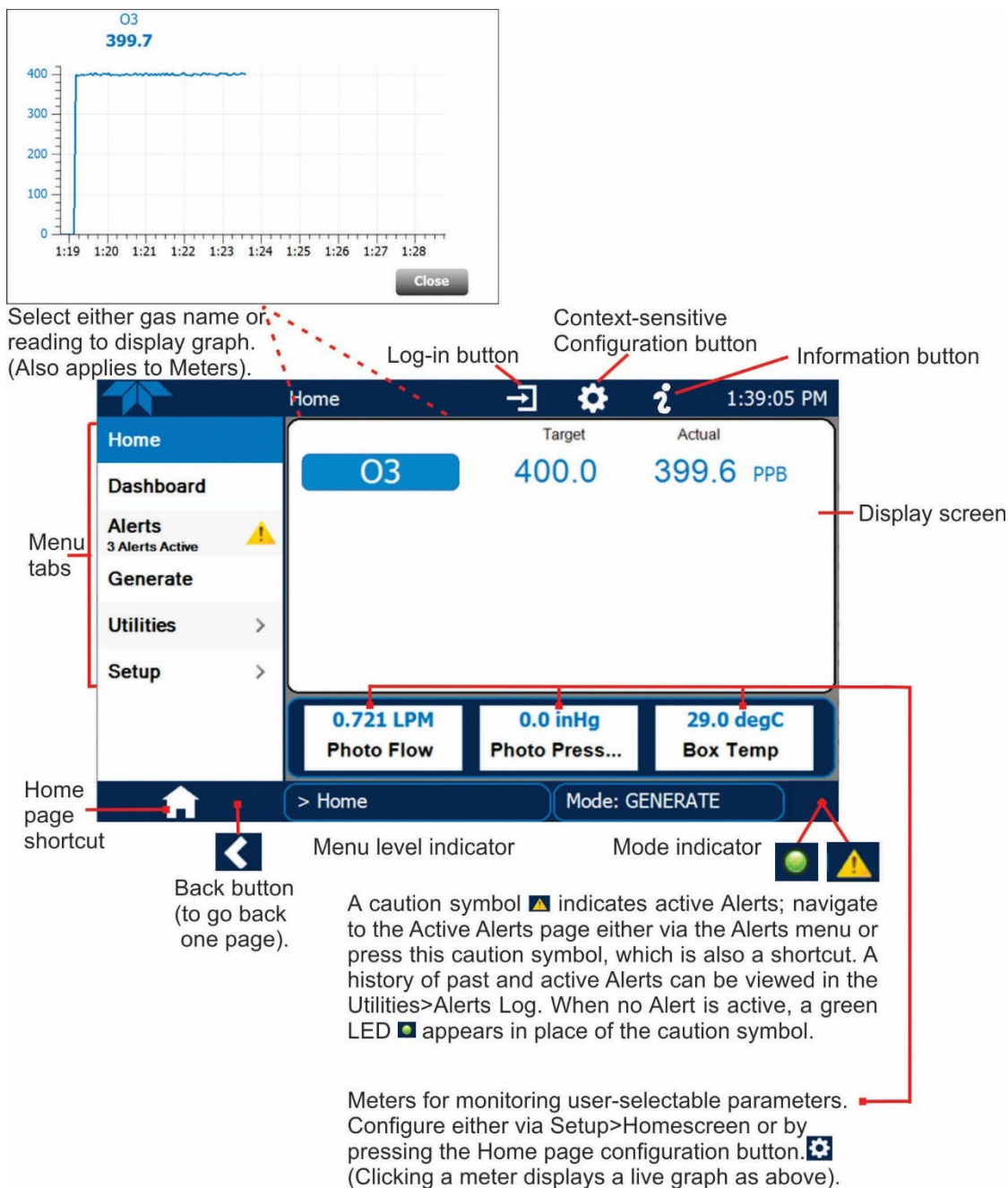


Figure 2-28. User Interface Orientation

Note

The last page on display prior to drilling into a menu remains on display until a choice in the menu is selected.

2.5.2 DASHBOARD

The dashboard displays an array of user-selected parameters and their values (Figure 2-29). If there is a graphing icon in the upper right corner of a parameter, pressing that parameter displays a live plot of its readings, as in Figure 2-30. Depending on the number of available parameters selected, the Dashboard can have more than one page. See Section 2.6.3 for configuration details.

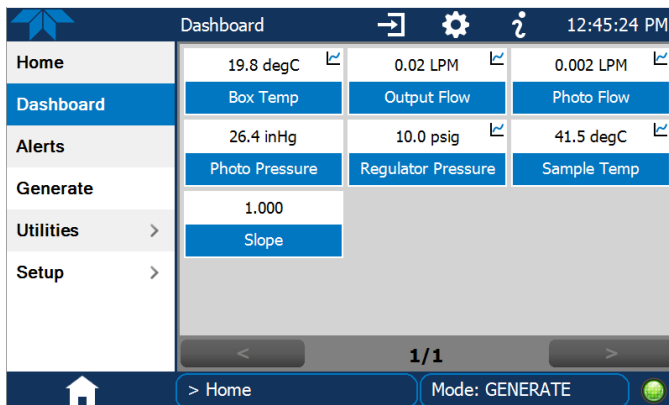


Figure 2-29. Dashboard Page

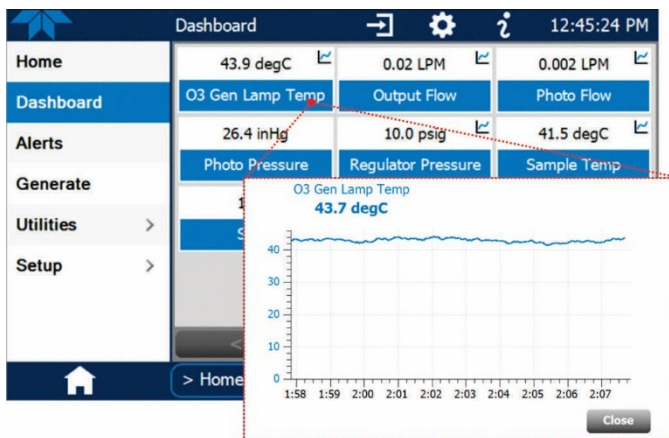


Figure 2-30. Viewing a Live Plot from Dashboard Page

Three of the dashboard parameters can be set up for continuous display as meters located below the concentration display of the Home page through the Setup>Homescreen menu (Section 2.6.5).

2.5.3 ALERTS

Alerts are notifications triggered by specific criteria having been met by either factory-defined conditions (standard and not editable) or user-defined Events (Section 2.6.2). The Active Alerts page shows the status of any active warning conditions or Events that have been triggered.

When Alerts are triggered, a caution symbol appears in both the Alerts menu tab and in the bottom right corner of the software interface, which serves as a shortcut to the Alerts page from any other page. View a list of currently active Alerts by pressing either the Alerts menu on the Home screen or by pressing the Alerts shortcut (Figure 2-31).

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

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

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

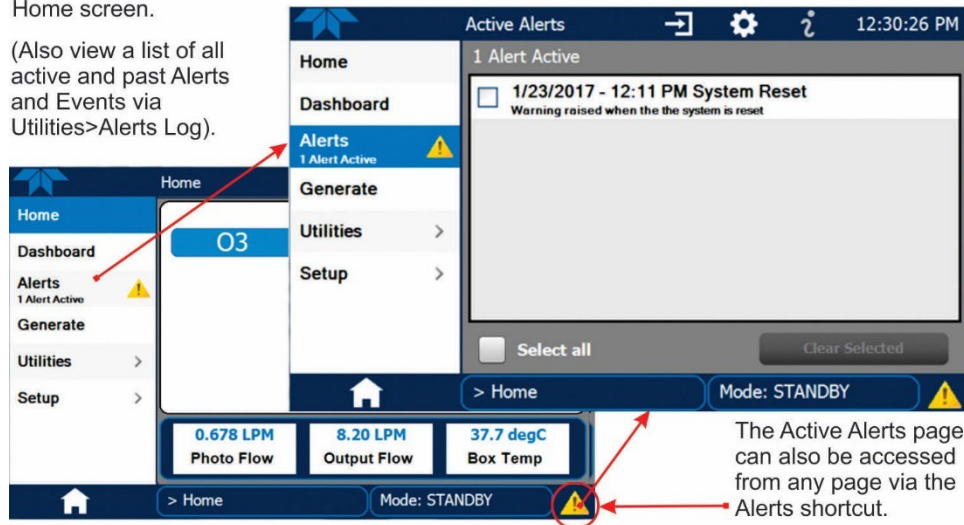


Figure 2-31. Navigating to the Active Alerts Page

Alerts appear as either latching or non-latching:

- Latching. displayed in Active Alerts screen when an Event is triggered and must be cleared by the user.
- Non-latching: Active Alerts screen continuously updates based on the Event criteria, clearing on its own.

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

When all Alerts are cleared, the Alerts menu tab no longer shows the caution symbol, and a green LED replaces the caution symbol in the bottom right corner of the interface (Figure 2-32). However, Alerts can reappear if the conditions causing them are not resolved. For troubleshooting guidance, refer to the instrument’s user manual.

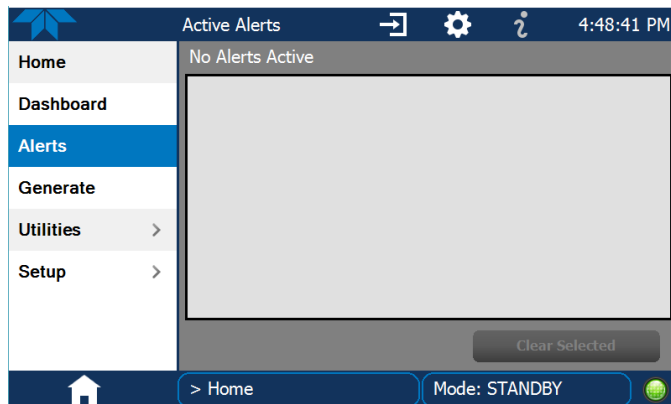


Figure 2-32. Active Alerts Cleared

2.5.4 GENERATE

The Generate menu provides the ability to:

- Generate either ozone or zero air
- Execute a Sequence (configured in the Setup menu)
- Execute a Level (configured in the Setup menu)
- Place the instrument into Standby mode (suspend generating gas)

The Generate menu is presented in Section 3.1. To configure Sequences, see Section 2.6.7 or to configure Levels, see Section 2.6.8

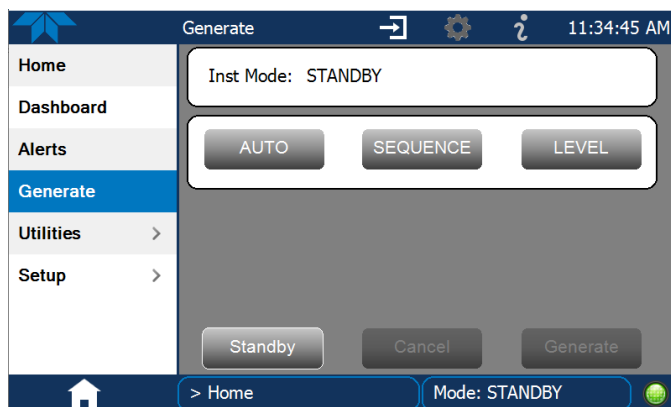


Figure 2-33. Generate Page

2.5.5 UTILITIES

The Utilities menu opens to the Datalog View, the Alerts Log, the USB Utilities, and the Diagnostics submenus.

2.5.5.1 DATALOG VIEW

The Datalog View tab displays a list of data logs that were configured in the Setup>Data Logging menu (Section 2.6.1). From this list a log can be selected and filters applied to view the desired data.

2.5.5.2 ALERTS LOG

The Alerts Log holds a history of alerts that were triggered by factory-defined and user-defined Events, such as warnings and alarms.

2.5.5.3 USB UTILITIES (DOWNLOADS AND UPDATES)

The USB Utility page serves multiple purposes using a flash drive connected to the instrument's front panel USB port:

- downloading Data Acquisition System (DAS) data from the instrument to a flash drive (presented below).
- updating firmware (presented below and in Section 6.3).
- copying a configuration from one instrument to other same-model instruments (presented below).
- downloading a basic operation functionality report (presented below and in Section 6.2)

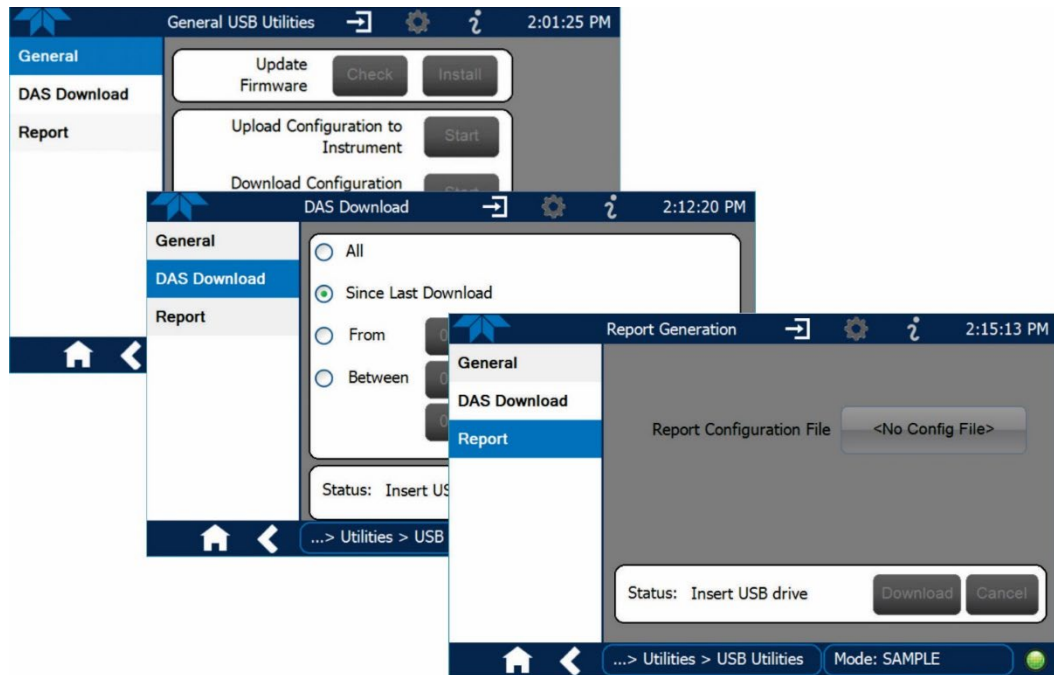


Figure 2-34. USB Utilities Pages

The Status field shows when an inserted flash drive has been detected, at which time firmware updates, configuration copying and DAS downloading can be carried out.

DOWNLOADING DAS (DATA ACQUISITION SYSTEM) DATA

DAS data (collected by the Datalogger, Section 2.6.1) can be downloaded from the instrument to a flash drive through the Utilities>USB Utilities>DAS Download menu, as follows:

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



Figure 2-35. DAS Download Page

2. To copy the data to the flash drive, press the Start button next to “Download DAS Data from Instrument.” (The Cancel button will be enabled).
3. When complete, as indicated in the Status field, the Cancel button becomes the Done button: press Done and then remove the flash drive.

UPDATING FIRMWARE

It is possible to check for firmware updates, reload current firmware, and to update firmware remotely. Because this is a maintenance item and there is more than one way to implement an update, instructions are provided in Section 6.3.

TRANSFERRING CONFIGURATION TO OTHER INSTRUMENTS

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

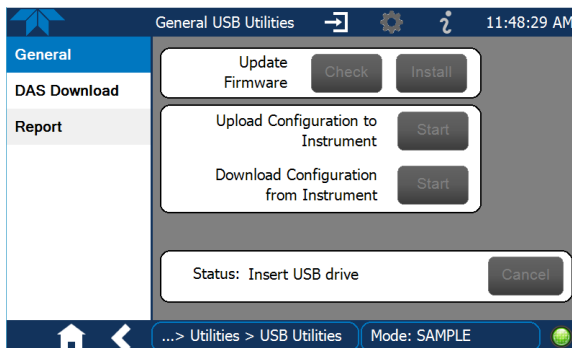


Figure 2-36. Configuration Transfer

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

When the Status field indicates that the upload is complete, remove the flash drive.

GENERATING A REPORT

The Report page is used typically for monitoring the functionality of the instrument. A new report is generated every 24 hours and can be downloaded, and it can be uploaded to a Cloud service for TAPI Technical Support. Because it is used in maintenance and troubleshooting, the Report feature is presented in Section 6.2.

2.5.5.4 DIAGNOSTICS

The Diagnostics menu provides access to several features, such as signals for inputs and outputs which can be helpful in troubleshooting (Section 7). The outputs are configurable through the Setup menu, and also some important calibration functions are located here. When an item in the menu is selected, the display shows its description. Table 2-7 on page 50 also provides descriptions.

Note

Some Diagnostics items do not appear in the menu until the instrument is placed in Standby mode (Home>Generate menu).

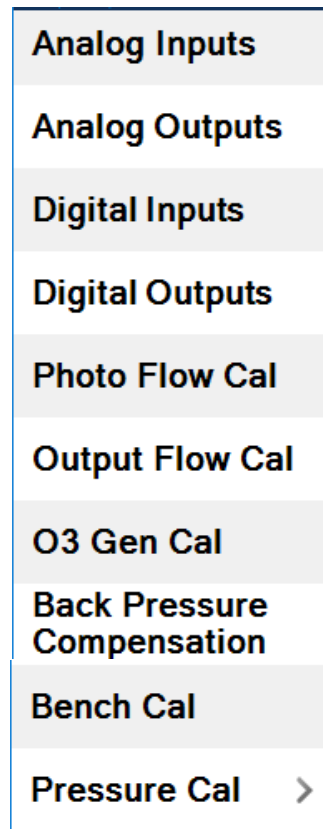


Figure 2-37. Sample Diagnostics Menu (may differ by calibrator configuration)

2.5.6 SETUP

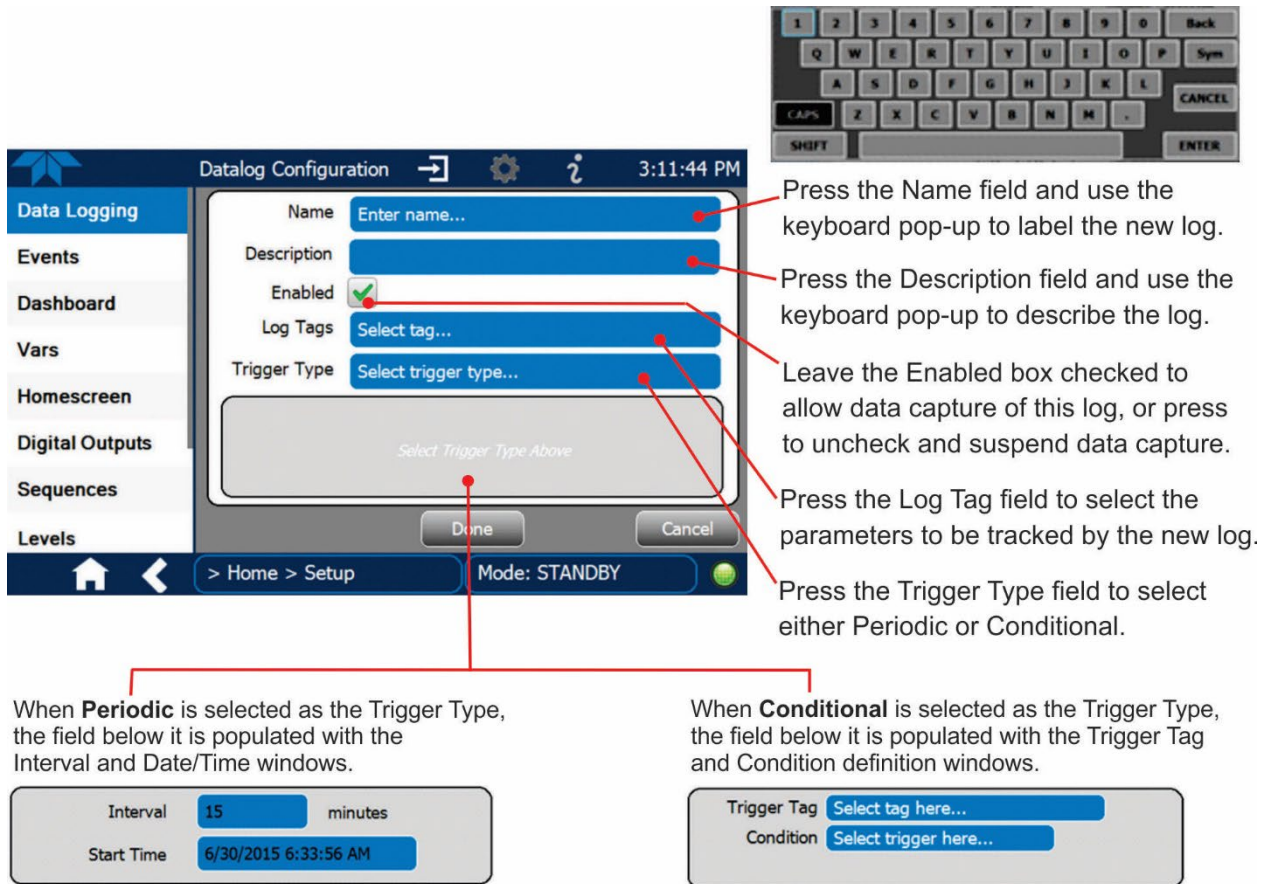
The Setup menu is used to configure the instrument's software features, gather information on the instrument's performance, and configure and access data from the Datalogger, the instrument's internal data acquisition system (DAS). Section 2.6 provides details for the menus under Setup.

2.6 SETUP MENU: FEATURES/FUNCTIONS CONFIGURATION

Use the Setup menu to configure the instrument's software features, to gather information on the instrument's performance, and to configure and access data from the Datalogger, the instrument's internal data acquisition system (DAS). Once the setups are complete, the saved configurations can be downloaded to a USB drive through the Utilities>USB Utilities menu and uploaded to other instruments of the same model (Section 2.7).

2.6.1 SETUP>DATA LOGGING (DATA ACQUISITION SYSTEM, DAS)

The Data Logger captures and stores user-defined data. In the Setup>Data Logging menu press the ADD button to create a new log, or select an existing log from the Data Logging list and press the EDIT or DELETE button to make the desired changes. Follow instruction shown in Figure 2-38.



The figure shows a screenshot of the instrument's 'Datalog Configuration' menu. The menu is titled 'Datalog Configuration' and shows a time of 3:11:44 PM. On the left is a navigation menu with options: Data Logging, Events, Dashboard, Vars, Homescreen, Digital Outputs, Sequences, and Levels. The main area contains fields for: Name (Enter name...), Description, Enabled (checked), Log Tags (Select tag...), and Trigger Type (Select trigger type...). Below these fields is a large grey box with the text 'Select Trigger Type Above'. At the bottom are 'Done' and 'Cancel' buttons. A keyboard pop-up is shown in the top right corner.

Callouts from the keyboard and the main screen provide instructions:

- Press the Name field and use the keyboard pop-up to label the new log.
- Press the Description field and use the keyboard pop-up to describe the log.
- Leave the Enabled box checked to allow data capture of this log, or press to uncheck and suspend data capture.
- Press the Log Tag field to select the parameters to be tracked by the new log.
- Press the Trigger Type field to select either Periodic or Conditional.

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

Interval	15	minutes
Start Time	6/30/2015 6:33:56 AM	

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

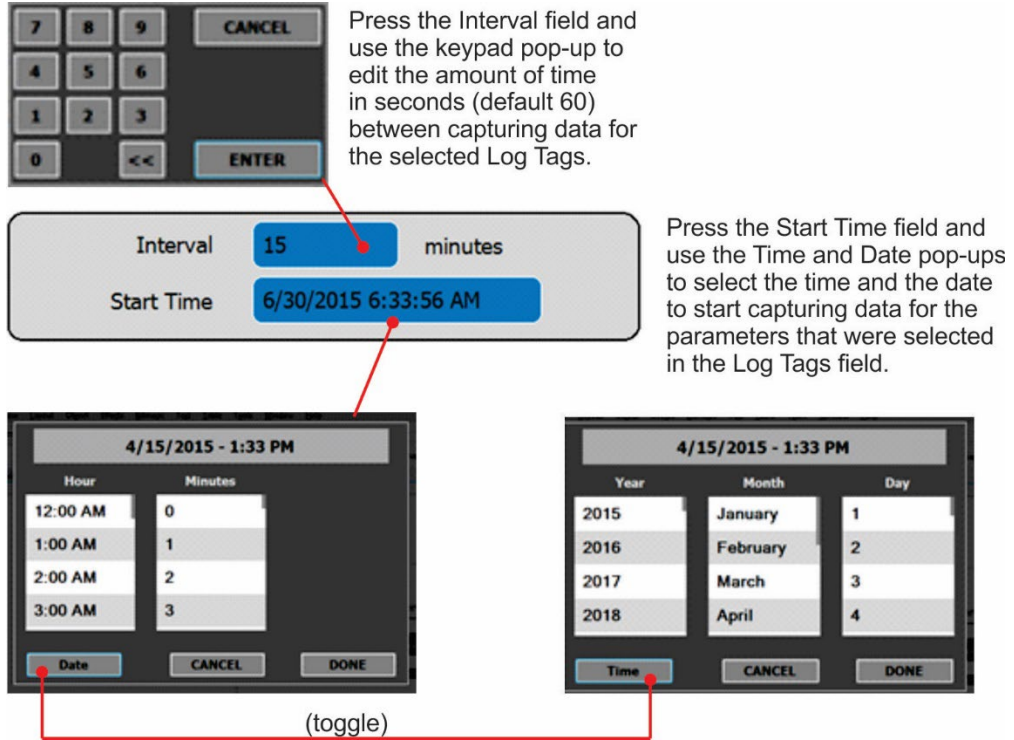
Trigger Tag	Select tag here...
Condition	Select trigger here...

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

Figure 2-38. Data Log Configuration

2.6.1.1 CONFIGURING TRIGGER TYPES: PERIODIC

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



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

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

(toggle)

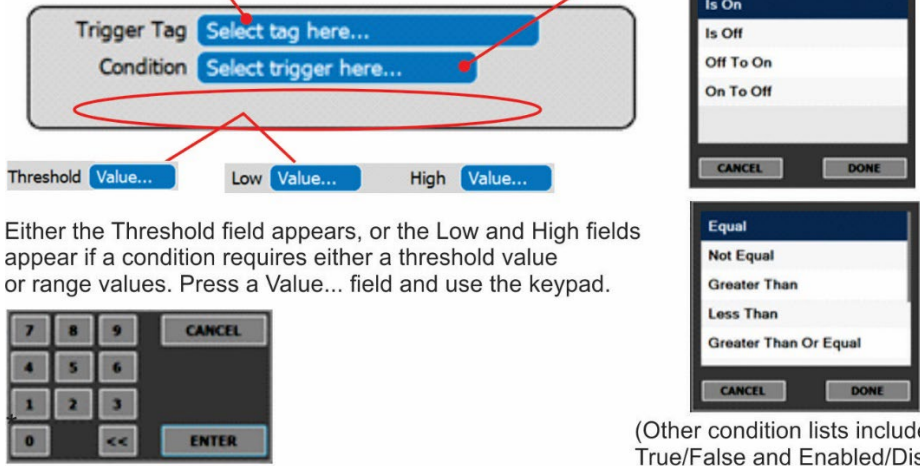
Figure 2-39. Datalog Periodic Trigger Configuration

2.6.1.2 CONFIGURING TRIGGER TYPES: CONDITIONAL

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

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

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



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

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

Figure 2-40. Datalog - Conditional Trigger Configuration

2.6.1.3 DOWNLOADING DAS (DATA ACQUISITION SYSTEM) DATA

In the Utilities>USB Utilities menu, instrument data can be downloaded to a flash drive, as presented here.

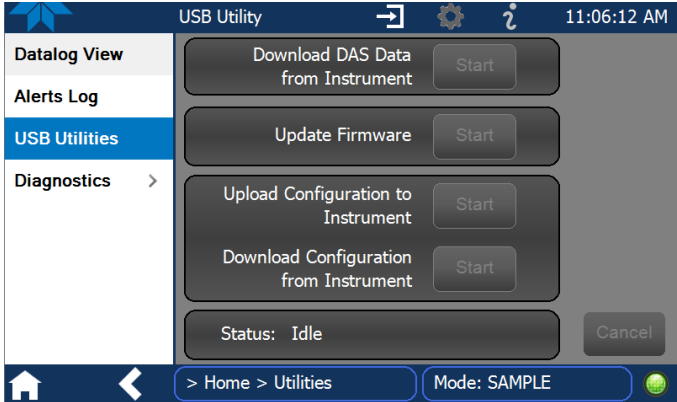


Figure 2-41. USB Utility Page

8. Press USB Utilities menu to open the utility page (Figure 2-41).
9. Insert a flash drive into a front panel USB port and wait for the Status field to indicate that the drive has been detected and available buttons are enabled (Figure 2-42).

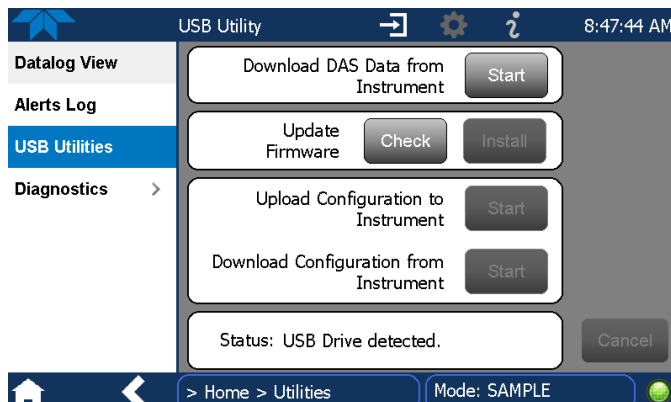


Figure 2-42. DAS Data Download

10. To copy the data to the flash drive, press the Start button next to “Download DAS Data from Instrument.” (The Cancel button will be enabled).
11. Wait for the Status field to indicate that the transfer is complete and that the Cancel button becomes the Done button.
12. Press the Done button; then remove the flash drive.

(The Update Firmware field is for checking for and installing firmware updates when the instrument is connected to the Internet and is presented in Section 6.2. The Upload/Download Configuration field is for transferring instrument configuration from/to other instruments and is presented in Section 2.7).

2.6.2 SETUP>EVENTS

Events are occurrences that relate to any operating function and will trigger Alerts (Section 2.5.3). Events can provide diagnostic information about the instrument, typically referred to as “Warnings”, or they can provide additional instrument functionality, such as concentration alarms. The instrument comes from the factory with a number of pre-defined warning Events, while the Setup>Events Configuration page provides the capability to create additional, user-defined Events. Events are listed in the Events page (Figure 2-43) under the Setup menu.

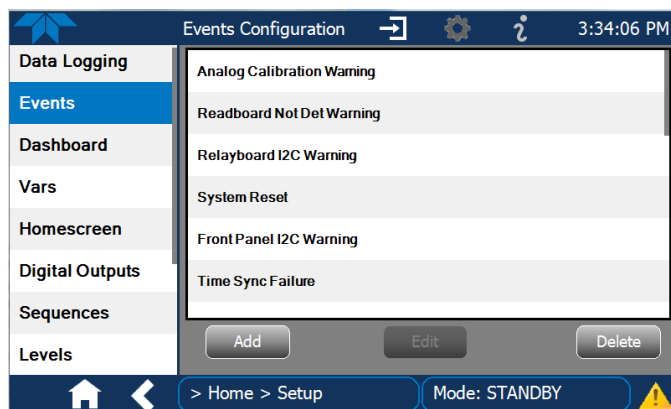
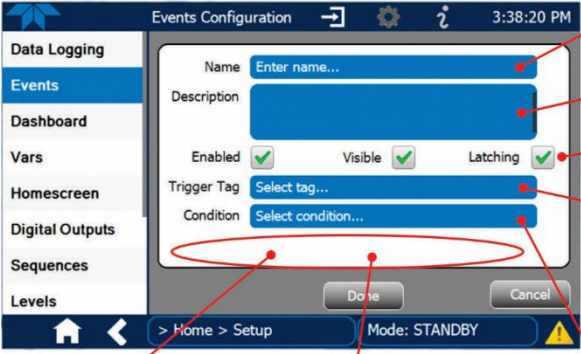


Figure 2-43. Events List

Access the Events Configuration page either from the Active Alerts page (Alerts Menu) by pressing the configuration button, or through the Home>Setup>Events menu (Figure 2-43). Press ADD to create a new Event (refer to Figure 2-44 for details), or select an existing Event to either Edit or Delete it.



Press the Name field and use the keyboard pop-up to name the new event.

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

Choose whether to make the event enabled, visible, and/or latching.

Press the Trigger Tag field to select a tag from the list of parameters for the trigger event.

Press the Condition field to select from a list of conditions to be applied to the trigger.

Either the Threshold field appears, or the Low and High fields appear in this area, only when a condition requires either a threshold value or range values; then a keypad pops up for entering the value(s).

(Gray scroll bar indicates additional choices available; drag list to scroll).

Figure 2-44. Event Configuration

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

2.6.3 SETUP>DASHBOARD

Configure the Dashboard to show the functions and conditions desired for viewing. Select an available tag in the left column and press the right arrow to populate the Dashboard.

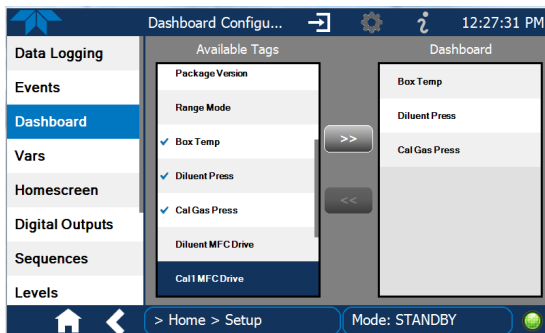


Figure 2-45. Dashboard Configuration

2.6.4 SETUP>VARS: INTERNAL VARIABLES

The calibrator has several user-adjustable software variables, which define certain operational parameters. Usually, these variables are automatically set by the instrument's firmware, but can be manually redefined using the Setup>Vars menu. Select a Var to see its description to the right in the VARS Configurator. Press the Edit button to change the attributes of the selected Var.

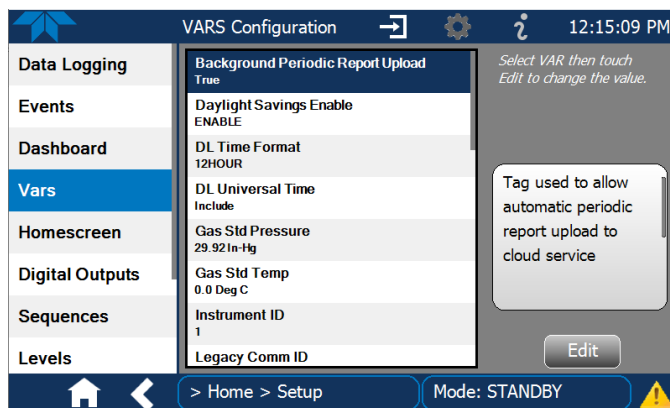


Figure 2-46. Vars Configuration

2.6.5 SETUP>HOMESCREEN

Configure the Homescreen to display three of the available tags and their values in the meters located along the bottom of Home page. Refer to Figure 2-28 for an orientation to Home page and Figure 2-47 for Homescreen configuration page.

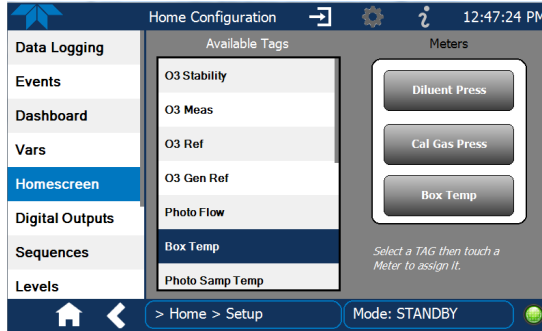


Figure 2-47. Homescreen Configuration

2.6.6 SETUP>DIGITAL (STATUS) OUTPUTS

Specify the function of each digital output (connected through the rear panel STATUS connector) by mapping the output to a selection of “Signals” present in the instrument. Create custom “Signals” in the Setup>Events menu (Section 2.6.2). (If the Motherboard Relay Option was installed, the four additional relays can also be mapped).

To map Digital Outputs to Signals:

1. In the Outputs list select a pin to be configured.
2. In the Signals list select a parameter to assign to the selected pin.
3. Press the Map button.
4. If/as needed, toggle the polarity by pressing the Polarity button.
5. To save, press the Apply button, or to discard, press the Home or the back icon (a pop-up provides a warning that the changes will be lost, and will prompt for confirmation to apply changes or not). Another option is to reassign the pin to the “Not Mapped” parameter.

These status outputs are visible in the Utilities>Diagnostics>Digital Outputs menu, and are labeled “Digital Output [#]” followed by the signal name. They can be selected and their state changed between ON and OFF. (Note that the Digital Outputs list in the Utilities>Diagnostics menu also includes the Control Outputs and other functions).

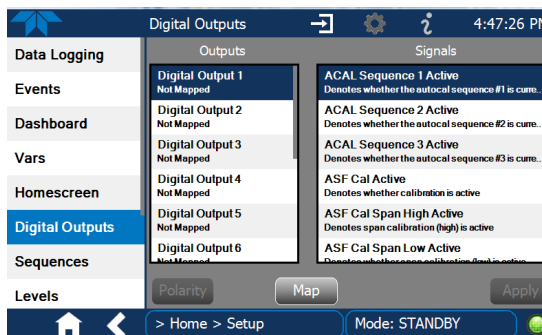


Figure 2-48. Digital Outputs Setup

2.6.7 SETUP>SEQUENCES: AUTOMATIC CALIBRATION OPERATIONS

This menu appears only when the Mode is set to STANDBY (from the Generate menu)). The calibrator can be set up to perform automatic calibration sequences of multiple steps. These sequences can perform all of the calibration mixture operations available for manual operation and can be initiated by one of the following methods:

- front panel touch screen buttons
- internal timer
- external digital control inputs
- RS-232 interface
- Ethernet interface
- sub-processes in another sequence

Multiple sequences can be programmed and enabled or disabled. Configurable sequence attributes are listed and described in Table 2-8. Figure 2-49 illustrates sequence setup.

Note

Last in = first out: the last step input into the program during configuration under “Edit Steps” is the first step executed, which means that multiple steps must be input in their reverse order; advanced planning is recommended.

Table 2-8. Calibration Sequences Configuration Attributes

ATTRIBUTE NAME	DESCRIPTION
Name	Allows the user to input a unique label identifying the sequence.
Timer	Controls the date and time to start the sequence (Timer Start) and the amount of time to wait before repeating the sequence (Timer Delta) if the Repeat Count attribute is set.
Repeat Count	Number of times to execute the same sequence.
Input CC	Specifies which of the calibrator’s Digital Control Inputs will initiate the sequence.
Output CC	Specifies which of the calibrator’s Digital Control Outputs will be set when the sequence is active.
<input checked="" type="checkbox"/> Enable	Checked Enable box enables the attribute to initiate the sequence as configured. Unchecked Enable box disables the attribute’s initiation of the sequence.

ATTRIBUTE NAME	DESCRIPTION	
Step Types	Selections for programming the activities and instructions that make up the calibration sequence.	
	GENERATE	Puts the instrument into GENERATE mode. Similar in operation and effect to the Generate>Generate>AUTO function used at the front panel.
	STANDBY	Puts the calibrator in Standby mode for the duration
	EXECSEQ	Calls another sequence to be executed at this time. The calling sequence will resume running when the called sequence is completed. Up to 5 levels of nested sequences can be programmed.
	SET CC OUTPUT	Causes the sequence to activate the calibrator's digital control outputs. Similar to the CC OUTPUT attribute, but can be set and reset by individual steps. It is very useful in situations where the control outputs are being used to trigger other devices that need to be turned off and on in sync with the operation of the calibrator as it progresses through the sequence.
	LEVEL	Allows the sequence to execute a LEADS function created in the Setup>Levels menu.
	SET STATUS BLOCK	Allows activation of Status Block 1 for rear panel physical Control Outputs and/or Status Block 2 for communicating status.

Note

The last instruction in a sequence should always be to place the calibrator in **STANDBY** mode.

Figure 2-49 shows the main screens in Sequence configuration.

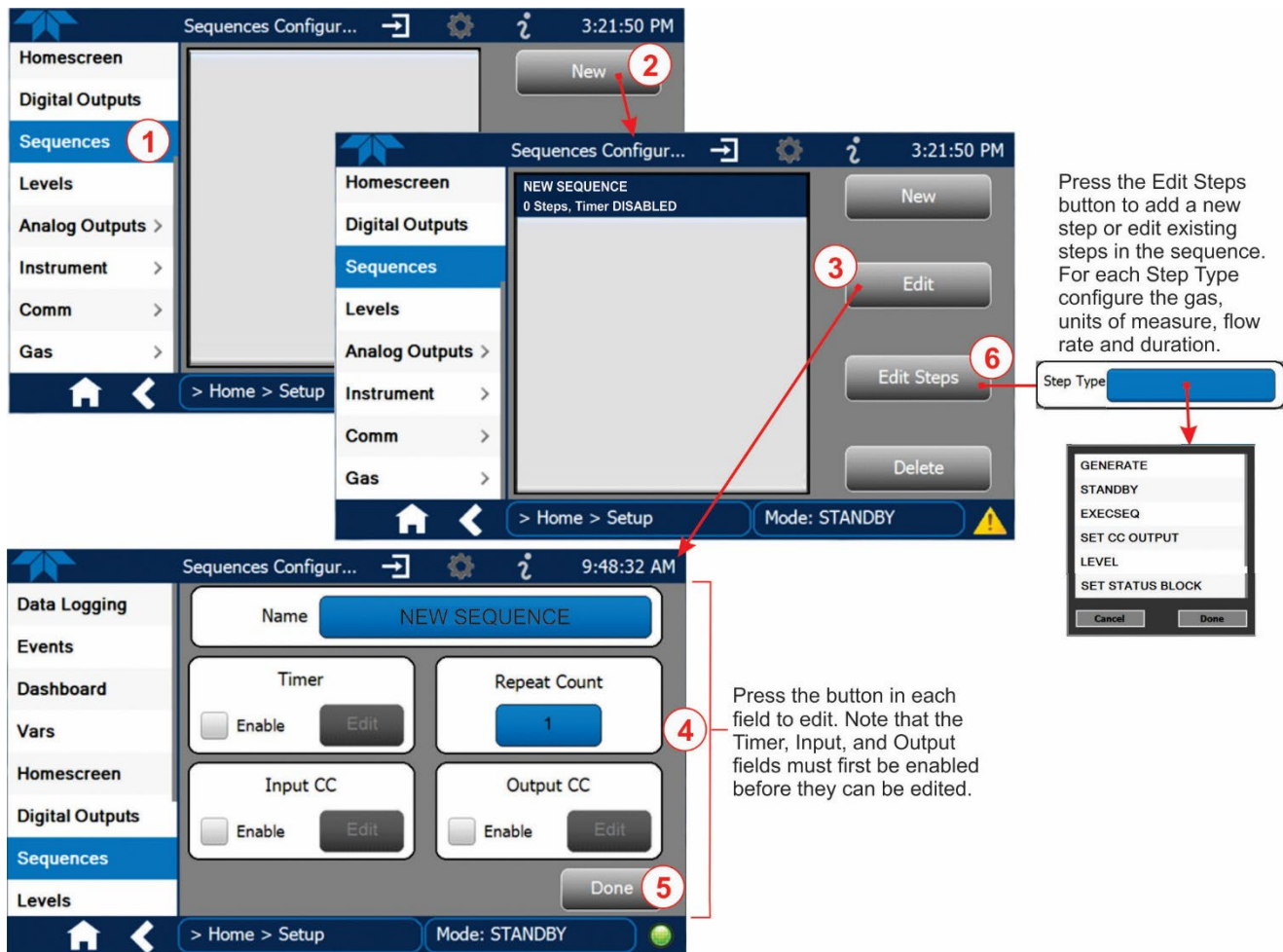


Figure 2-49. Sequence Configuration

Note

When the start time is set for a date/time that has passed, the sequence will properly calculate the next run time based on that past date/time.

2.6.7.1 SETTING UP CONTROL INPUTS FOR A SEQUENCE

The calibrator’s control inputs allow the entire sequence to be triggered from an external source. This feature allows the calibrator to operate in a slave mode so that external control sources, such as a data logger can initiate the calibration sequences.

The calibrator’s control inputs connector is located on the rear panel (Figure 2-2).

- 12 separate ON/OFF switches assigned to separate calibration sequences or;
- A 12-bit wide bus allowing the user to define activation codes for up to 4095 separate calibration sequences.

To assign a **CC INPUT** pattern/code to a particular sequence in the Setup>Sequences menu:

1. Select the desired Sequence (or create a new Sequence).
2. In the Input CC field check the Enable box.
3. Press the Edit button.
4. Check the desired control input pin(s).
5. Press Done.

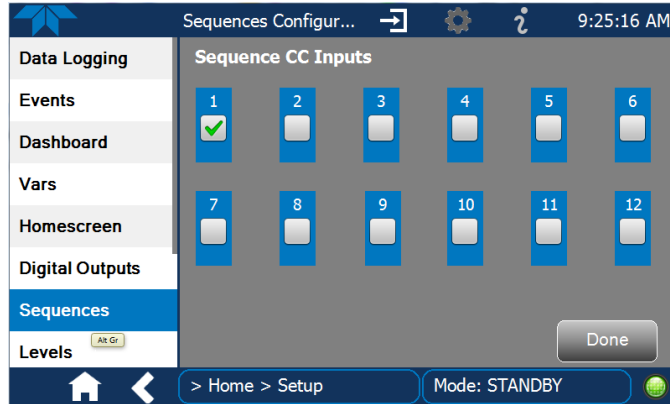


Figure 2-50. Sequence CC Inputs Setup Page

2.6.7.2 SETTING UP CONTROL OUTPUTS FOR A SEQUENCE

The calibrator’s control outputs allow the calibrator to control devices that accept logic-level digital inputs, such as programmable logic controllers (PLCs), data loggers, or digital relays/valve drivers.

They can be used as:

- 12 separate ON/OFF switches assigned to separate calibration sequences, or
- a 12-bit wide bus allowing the user to define activation codes for up to 4095 separate calibration sequences.

They can be set so that they are:

- active whenever a particular calibration sequence is operating, or
- activated or deactivated as individual steps within a calibration sequence (see Section 2.6.7.4).

To assign a **CC OUTPUT** pattern/code to a particular sequence in the Setup>Sequences menu:

1. Select the desired Sequence (or create a new Sequence).
2. In the Output CC field check the Enable box.
3. Press the Edit button to open the Sequence CC Outputs page.
4. Check the desired control output pin(s).
5. Press Done.

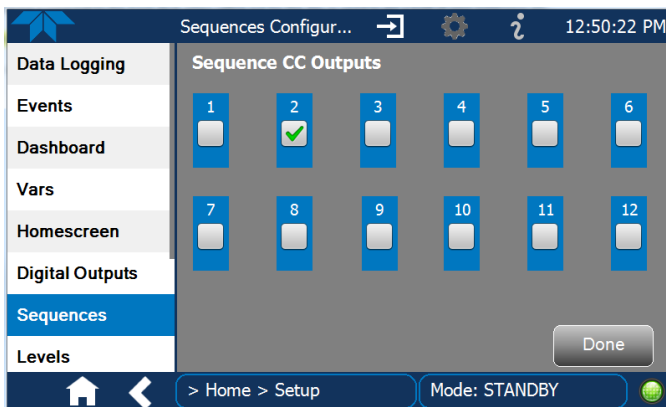


Figure 2-51. Sequence CC Outputs Setup Page

2.6.7.3 PARAMETERS FOR THE STEP TYPES

Several parameters are configurable within a Step Type (Table 2-8 contains step type descriptions), such as gas, concentration, units of measure, and/or flow. Each Step Type has its own parameters, and all allow setting a Duration in minutes, except EXECSEQ, which is for nesting previously configured sequences. Duration causes the calibrator to continue performing the Step Type for the number of minutes input.

2.6.7.4 DELETING OR EDITING SEQUENCES OR INDIVIDUAL STEPS IN A SEQUENCE

In the Setup>Sequences menu, select the Sequence to be changed, and press the button for the intended action:

Edit. Edit the Sequence name, timer, repeat count, input and output CCs.

Edit Steps. Add a new step within the sequence (New).

Select a specific step within the sequence to change (Edit or Delete).

Delete. Delete the entire sequence with all of its steps.

2.6.8 SETUP > LEVELS: SETTING UP AND USING LEADS (DASIBI) OPERATING LEVELS

(This menu appears only when the Mode is set to STANDBY (from the Generate menu)).

2.6.8.1 GENERAL INFORMATION ABOUT LEADS LEVELS

The calibrator can be equipped with a version of firmware that includes support for LEADS, a data collection and analysis system LEADS specifically designed for handling meteorological and environmental data particularly when there is a need to integrate data

and control instrumentation from several different manufacturers. When a calibrator is equipped with the optional LEADS software used in conjunction with data loggers located in the central data analysis facility, it is possible to collect and buffer data between the various calibrators, analyzers and metrological equipment remotely located at an air monitoring station.

Because LEADS was originally developed for use with TNRCC using Dasibi 5008 calibrators, the LEADS version of the calibrator includes support for Dasibi “Dot” serial data commands and operational “Levels”.

It also includes a method for driving external devices via contact closure control outputs in conjunction with an optional bolt-on valve driver assembly (see Section 2.3.1.6).

Note

For more information on the LEADS system, please visit <http://www.meteostar.com/>.

2.6.8.2 DOT COMMANDS

The Dasibi “Dot” commands form a text-based (ASCII) data protocol that is transmitted between a control computer (XENO data logger in this case) and a calibrator or ambient gas analyzer over an RS-232 connection. The details of the protocol are beyond the scope of this document, but in its simplest form the protocol is based on a two or three digit integer preceded by a control-A and a period (.) and then followed by a “!” and a two digit checksum.

EXAMPLE: **^A.xxx!nn**

For further information on Dot commands, please contact Teledyne API’S Technical Support team.

A calibrator equipped with LEADS software can be simultaneously operated over the same COMM port using standard Teledyne API’s serial data commands and is compatible with APICOM versions 5 and later which include an added feature that allows a user to edit, upload and download Level tables.

2.6.8.3 PROGRAMMING, EDITING, AND ACTIVATING LEVELS

Up to twenty Levels can be programmed and used with the calibrator, using a range of ID numbers from 0-98. Level 99 is reserved for standby. The Levels are not time based and do not include characteristics such as start time or duration; therefore, a single LEVEL cannot switch between different concentration levels and flow rates. Separate flow and concentration outputs must be programmed into separate LEVELs which are then individually started and stopped either by an operator at the calibrator’s front panel or through a serial data operation over the RS-232 or Ethernet ports.

2.6.8.4 PROGRAMMING LEVELS

To program a new Level, refer to Figure 2-52 for the following steps:

1. Navigate to the Setup>Levels menu.
2. Use the New button to start a new Level (Default first new Level ID is 0; default Action is Generate)

3. Use the Edit button to start programming the new Level.
4. Use the Level field to assign a different ID (numeric keypad pops up)
5. In the Action field, press the GENERATE button to select the Gas, either ZERO or O3.
6. For generating O3, configure the concentration and units in the pop-up window.
7. Configure one or both of two Status output blocks:
 - Status Block1: This block corresponds to the physical CONTROL OUTPUT connections located on the back panel of the calibrator (see Figure 2-2 and Section 2.3.1.5).
 - Status Block2: The second status block does not correspond to any physical output but is used to communicate status over the serial data port.
8. Press the Done button to complete the programming for the individual Level.



Figure 2-52. Levels Programming and Editing

2.6.8.5 EDITING/DELETING LEVELS

To edit an existing Level, navigate to the Setup>Levels menu, select a Level and start with Step 3 above.

To delete an existing Level, navigate to the Setup>Levels menu, select a Level and use the Delete button.

2.6.8.6 ACTIVATING LEVELS

To activate an existing Level, from Home page navigate to the Generate menu, press the LEVEL button, then select the Level by its ID, and press the Generate button.

2.6.9 SETUP > ANALOG OUTPUT

The calibrator comes equipped with one configurable analog output. It can be set by the user to carry the current signal level of any one of several functions in the calibrator. The Analog Out connector will output an analog VDC signal that rises and falls in relationship with the value of the selected function.

1. In the Setup>Analog Outputs>Analog Output Cfg menu press the button in the Signal Out field and select a function for output from the pop-up list. (Selecting “Not Mapped” disables all other fields in the Analog Output Configurator).
2. In the Min Max fields input the minimum and maximum values for the selected function’s range.
3. In the Calibration Type field, select either AUTO or MANUAL.
 - AUTO sets the software to automatically calibrate the user-selected Signal Out function.
 - MANUAL allows fine and coarse adjustments when calibrating the user-selected Signal Out function.
4. In the Range field* select either voltage or current loop and the desired full-scale value of the signal output (see Section 2.6.9.1).
5. In the Recorder Offset field* input a bipolar voltage offset if needed to compensate for noise (see Section 2.6.9.2). This field is not available when Range is set to Current loop.
6. For the Allow Overrange box, either check to allow $\pm 5\%$ over range, or leave blank if your recording device is sensitive to excess voltage or current.
7. Press the Apply button.
8. Go to the Analog Output Cal menu to calibrate the new settings (see Section 2.6.9.3).

* Changes to Range or Recorder Offset require that this output be recalibrated.



Figure 2-53. Analog Output Configuration

2.6.9.1 ANALOG OUTPUT VOLTAGE RANGE CONFIGURATION

In its standard configuration, the analog outputs is set to output a 0 – 5 VDC signals. Several other output ranges are available (see Table 2-9). Each range is usable from -5% to + 5% of the rated span.

Table 2-9. Analog Output Voltage Range Min/Max

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

The default offset for all ranges is 0 VDC.

2.6.9.2 ADDING A RECORDER OFFSET

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

2.6.9.3 ANALOG OUTPUT CHANNEL CALIBRATION

Analog Output calibration needs to be carried out on first startup of the calibrator (performed in the factory as part of the configuration process) or whenever recalibration is required. The analog outputs can be calibrated automatically or adjusted manually.

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

Note

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

MANUAL CALIBRATION OF THE ANALOG OUTPUTS CONFIGURED FOR VOLTAGE RANGES

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

Calibration is performed with a voltmeter connected across the output terminals and by changing the actual output signal level in 100, 10 or 1-count increments in the Analog Output Cal page with the Calibration Type set to Manual.

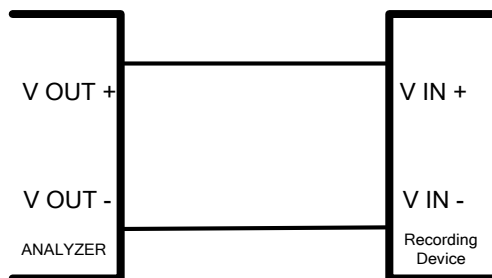


Figure 2-54. Setup for Calibrating the Analog Output Signals

Table 2-10. Voltage Tolerances for the Analog Output 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

Adjust the signal levels of the analog output in the Setup>Analog Outputs>Analog Output Cal menu.

2.6.10 SETUP > INSTRUMENT

This submenu displays product, system, and software information for the instrument (useful for identifying the software and hardware when contacting Technical Support), and allows time zone and language selection. It is also an alternate place to check for and install software updates.

Special instrument or software features or installed options may also be listed here.

2.6.11 SETUP > COMM: COMMUNICATIONS PORTS

This menu is for specifying the various communications configurations.

2.6.11.1 COM1/COM2

Configure the instrument's COM1 or COM2 ports to operate in modes listed in Table 2-11.

Table 2-11. COM1/COM2 Configuration

MODE	DESCRIPTION
Baud Rate	Set the baud rate for the COM1 or COM2 port being configured.
Command Prompt Display	Enable/disable a command prompt to be displayed when in terminal mode.
Data Bits	Set the data bits to 7 or 8 (typically set in conjunction with Parity and Stop bits).
Echo and Line Editing	Enable/disable character echoing and line editing.
Handshaking Mode	Choose SOFTWARE handshaking for data flow control (do NOT use SOFTWARE handshaking mode when using MODBUS RTU for Protocol mode; select only HARDWARE or OFF for MODBUS RTU), or HARDWARE for CTS/RTS style hardwired transmission handshaking. (This style of data transmission handshaking is commonly used with modems or terminal emulation protocols). Or choose to turn OFF handshaking.
Hardware Error Checking	Enable/disable hardware error checking.
Hardware FIFO	Enable/disable the hardware First In – First Out (FIFO) for improving data transfer rate for that COM port.
Modem Connection	Select either a modem connection or a direct cable connection.
Modem Init String	Input an initialization string to enable the modem to communicate.
Multidrop	Enable/disable multidrop mode for multi-instrument configuration on a single communications channel. Multidrop requires a unique ID for each instrument in the chain (Setup>Vars>Instrument ID).
Parity	Select odd, or even, or no parity (typically set in conjunction with Data Bits and Stop Bits).
Protocol	Select among the communications protocols: TAPI, MODBUS RTU, or MODBUS ASCII (MODBUS: Section 4.4
Quiet Mode	Enable/disable Quiet mode, which suppresses any feedback from the analyzer (such as warning messages) to the remote device and is typically used when the port is communicating with a computer program where such intermittent messages might cause communication problems. Such feedback is still available but a command must be issued to receive them.
RS-485	Enable/disable the rear panel COM2 Port for RS-485 communication. RS-485 mode has precedence over Multidrop mode if both are enabled. Also, RS-485 configuration disables the rear panel USB port.
Security	Enable/disable the requirement for a password for this serial port to respond. The only command that is active is the request-for-help command (? CR).
Stop bits	Select either 0 or 1 stop bit (typically set in conjunction with Parity and Data bits).

2.6.11.2 TCP PORT1

TCP Port1 allows choosing whether or not to display the command prompt, editing the Port 1 number for defining the terminal control port by which terminal emulation software addresses the instrument, such as Internet or NumaView™ Remote software, and enabling or disabling security on this port.

2.6.11.3 TCP PORT2

TCP Port2 is configured with the port number for MODBUS.

2.6.11.4 NETWORK SETTINGS

The Setup>Comm>Network Settings menu is for Ethernet configuration. The address settings default to automatic configuration by Dynamic Host Configuration Protocol (DHCP). Most users will want to configure the instrument with a static IP address: click the Static radio button to manually assign a static IP address (consult your network administrator, and see Table 2-12 for information).

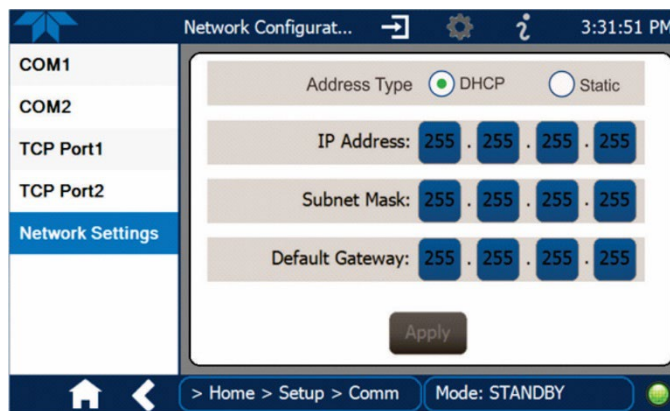


Figure 2-55. Communications Configuration, Network Settings

Table 2-12. LAN/Ethernet Configuration Properties

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

2.7 TRANSFERRING CONFIGURATION TO OTHER INSTRUMENTS

Once an instrument is configured, the same configuration can be copied to other instruments of the same Model.

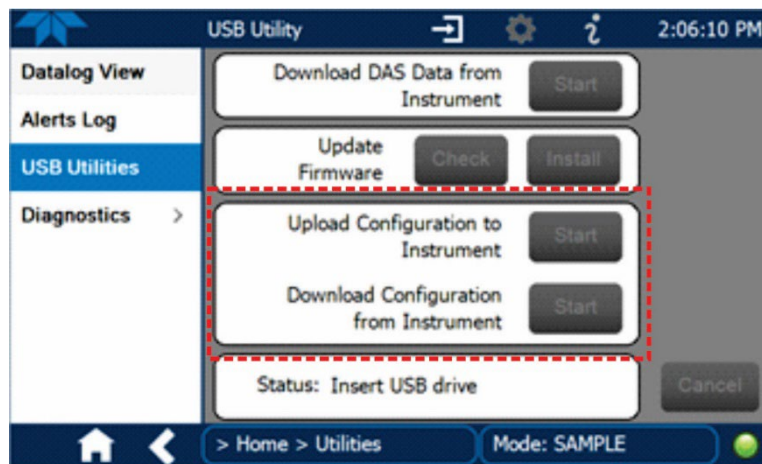


Figure 2-56. Configuration Transfer

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

3. OPERATING MODES, BASIC OPERATION, AND CONFIGURATIONS

This Section starts with a description of the basic modes of operation in order to begin operation right away, and then provides configuration instructions for other functions.

Standby is the most common of the calibrator’s software operating modes; place the calibrator in Standby while configuring the calibrator and performing other procedures. Generate is another common mode; use this mode to generate ozone or zero air, or to execute sequences or levels that were configured under the Setup menu.

Note that the ozone generator in the T703U can operate in a high range or a low range. High range is similar to the standard T703. Low range is more like a fractional mode in that it is used for producing ultra-low levels of ozone (viewable in the Dashboard with the O3GenFraction tag). The T703U low range operation is automatically invoked based on the O₃ concentration and total flow specified, i.e., when O₃ output is < 500 PPB*LPM.

Table 3-1 presents descriptions of the modes. Sections 3.1 through 3.2.3 provide details.

Table 3-1. Calibrator Operating Modes

MODE	DESCRIPTION	
STANDBY	The calibrator and all of its subsystems are inactive. Always ensure that the calibrator is in this mode when performing configurations (Section). The Standby button is in the Generate page.	
GENERATE	In this mode, the instrument is engaged in producing ozone or zero air.	
	AUTO	The calibrator generates ozone or zero air as selected (Section 3.2.1).
	SEQUENCE	The calibrator executes Sequences (Section 3.2.2) that were configured in the Setup>Sequences menu (Section 2.6.7).
	LEVEL	The calibrator executes Levels (Section 3.2.3), which are operational functions for LEADS (Section 2.6.8.1) that were configured in the Setup>Levels menu (Section 2.6.8).

3.1 STANDBY MODE

When the calibrator is in Standby mode (Generate>Standby), it is inactive, although Dashboard functions and Alerts continuously update as displayed in the front panel. Airflow is maintained during Standby mode so that the generator can continue to operate at its most efficient temperature.

3.2 GENERATE MODE

In Generate Mode the calibrator generates either zero air or the O₃ concentration set by the user in the Auto function or in the selected Sequence or Level preprogrammed by the user.

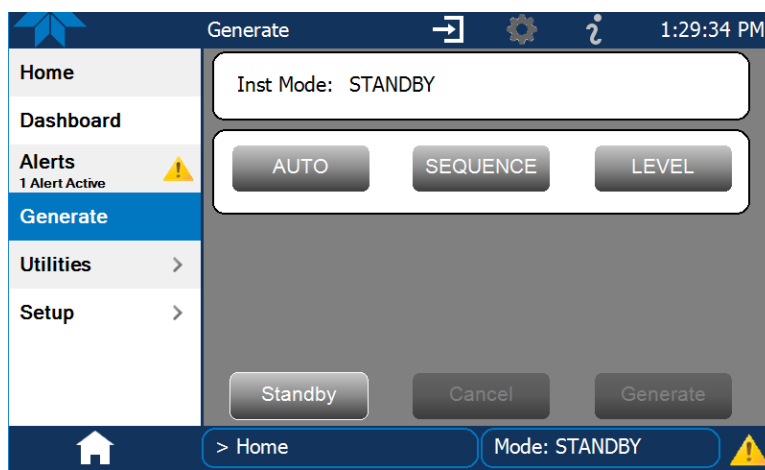


Figure 3-1. Generate Menu

3.2.1 GENERATE>AUTO

Pressing the AUTO button brings up the Gas field to select either ozone and the desired concentration and units, or to select ZERO. After making the selection(s), press the Generate button.

To stop generating either ozone or zero air, press the Standby button.

3.2.2 GENERATE > SEQUENCE

Sequences, a set of calibration steps for serial execution, are configured in the Setup>Sequences menu (Section 2.6.7). To execute a Sequence, navigate to the Generate menu (Figure 3-1), press the SEQUENCE button, and select the desired Sequence, then press the Generate button.

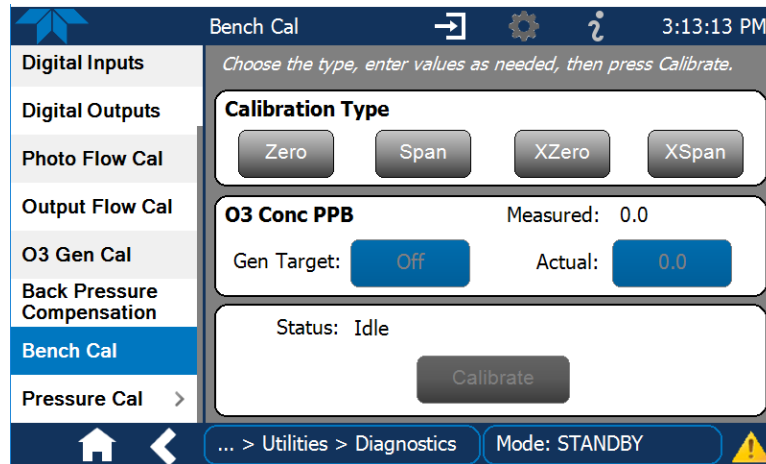
3.2.3 GENERATE > LEVEL

Levels, operational functions for LEADS (Section 2.6.8.1), are configured in the Setup>Levels menu (Section 2.6.8). To execute a Level, navigate to the Generate menu (Figure 3-1), press the LEVEL button and select the Level to execute, then press the Generate button.

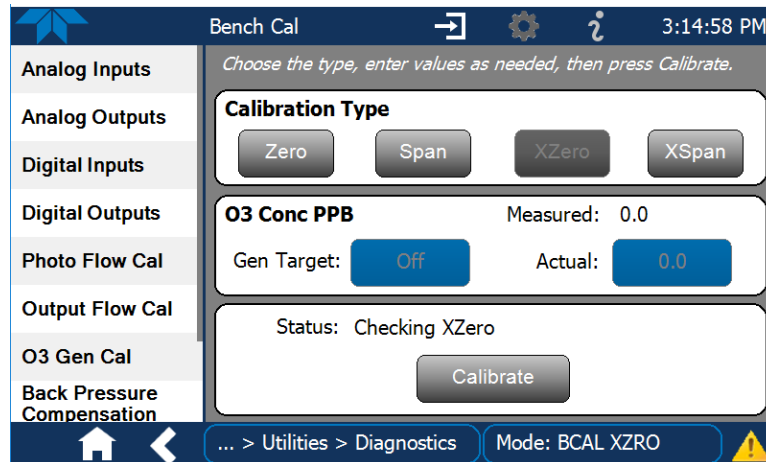
3.3 OPERATION AS AN O₃ PHOTOMETER

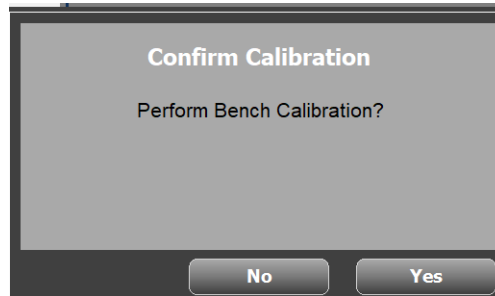
To operate the T703/T703U as a photometer for measuring an external source of ozone:

1. Make the pneumatic connections for this function as presented in Section 2.3.2.6, ensuring that the external gas sources are supplied at atmospheric pressure.
2. Navigate to the Setup>Vars> menu and set the “ZA Pump Enable” Var to OFF (this turns off the internal zero air pump while the external zero air source is in use for this particular application).
3. Navigate to the Utilities>Diagnostics>Bench Cal menu.



4. Press the XZero button, wait 30 minutes to allow for stability, then press the Calibrate button and confirm calibration request by pressing the Yes button; wait for the Status field to display “Success.”





5. Press the XSpan button, wait 30 minutes to allow for stability, then press the Calibrate button and confirm calibration request by pressing the Yes button; wait for the Status field to display "Success."

The Measured reading will appear in the field above the Status field.

4. COMMUNICATIONS AND REMOTE OPERATION

The instrument rear panel connections include an Ethernet port, a USB port (option) and two serial communications ports (labeled RS232, which is the COM1 port, and COM2) located on the rear panel (refer to Figure 2-2). These ports allow the ability to communicate with, issue commands to, and receive data from the analyzer through an external computer system or terminal.

This section provides pertinent information regarding communication equipment, the communications ports, and communications protocol. Data acquisition is set up through the Datalogger (Section 2.6). **DATA TERMINAL/COMMUNICATION EQUIPMENT (DTE DCE)**

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

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

To allow the analyzer to be used with terminals (DTE), modems (DCE) and computers (which can be either), a switch mounted below the serial ports on the rear panel, labeled **DCE DTE**, 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.

4.2 MODES, BAUD RATE AND SERIAL COMMUNICATION

Referring to Table 2-11, use the SETUP>COMM menu to configure COM1 (labeled **RS232** on instrument rear panel) and/or COM2 (labeled **COM2** on instrument rear panel) for communication modes, baud rate and serial communications. If using a USB option communication connection, setup requires the instrument's baud rate to match your personal computer baud rate.

4.2.1 SERIAL COMMUNICATION: RS-232

The RS232 and COM2 communications (COMM) ports operate on the RS-232 protocol (default configuration). Configurations for these two COM ports (Section 2.6.11.1) are:

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

Note

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

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

4.2.2 SERIAL COMMUNICATION: RS-485 (OPTION)

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

4.3 ETHERNET

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

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

Table 4-1. Ethernet Status Indicators

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

4.4 MODBUS COMMUNICATIONS PROTOCOL

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

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.

4.4.1 MODBUS Com PORT CONFIGURATION

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

Ethernet. MODBUS is available on TCP port 502. By default, port 502 is assigned to the instrument’s TCP Port 2. In the Setup>Comm> TCP Port menu, check to see that it is set to “502” (Figure 4-1).

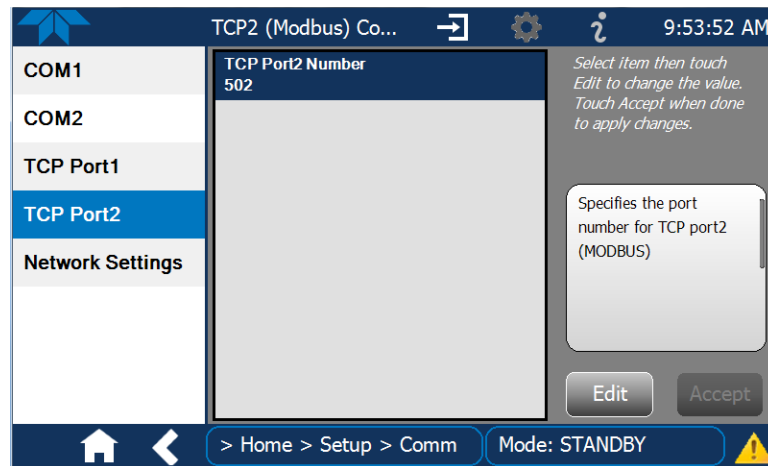


Figure 4-1. MODBUS via Ethernet

Serial COM. Both COM1 (labeled “RS232” on the instrument’s rear panel) and COM2 are configurable for RS-232 or RS-485 communication with either MODBUS RTU or MODBUS ASCII transmission modes. In the Setup>Comm COM1[COM2] menu, edit the Protocol parameter to select a MODBUS transmission mode; edit Baud Rate, Parity, Data Bits, etc., if necessary (see descriptions in Table 2-11).

Important

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

Press the Accept button to apply the settings. (Figure 4-2 shows an example for MODBUS RTU).

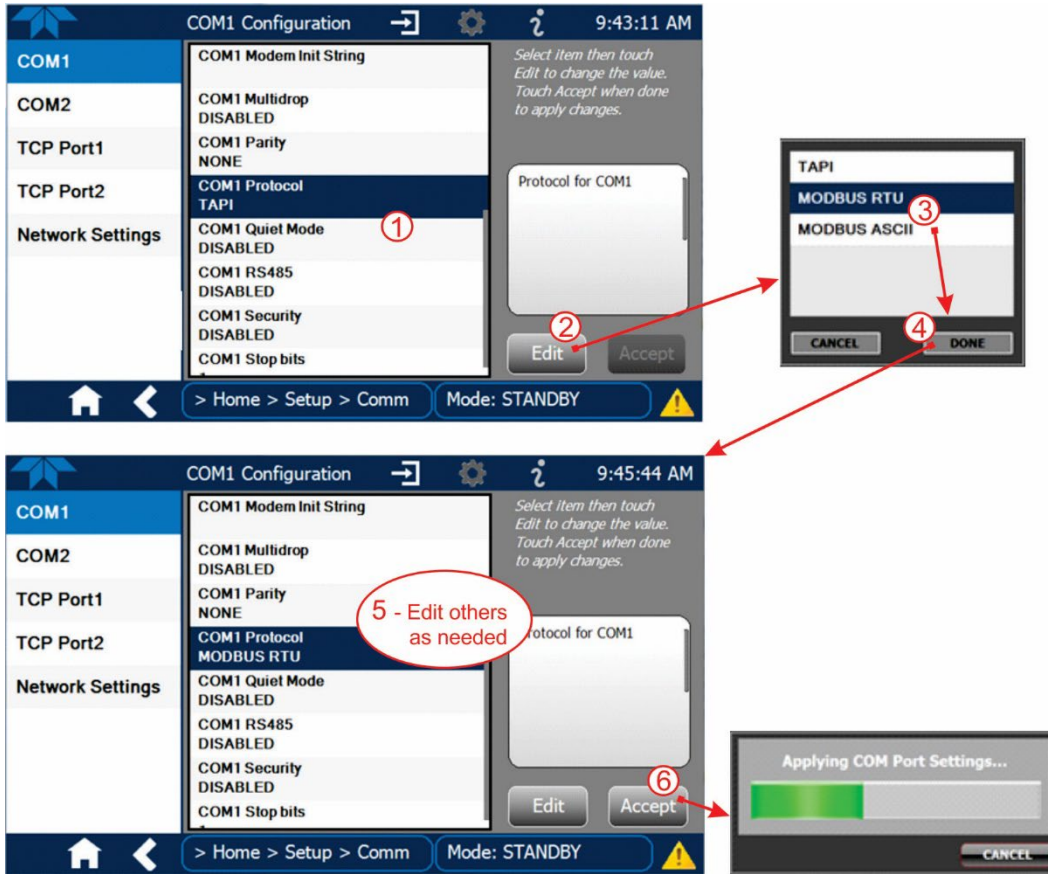


Figure 4-2. MODBUS via Serial Communication (example)

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

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

5. CALIBRATION AND VERIFICATION

Basic electronic calibration of the instrument is performed at the factory. Normally there is no need to perform this factory calibration in the field; however, the performance of the instrument's two key subsystems should be verified periodically and adjusted if necessary:

- O₃ Photometer: performance should be periodically verified against an external transfer standard.
- O₃ Generator: should be periodically calibrated.

Note Calibration of subsystems will be rendered inaccurate if there are issues with pressure or flow. Follow the order of procedures as recommended herein.

Prior to verifying and calibrating these subsystems, it is important to verify and calibrate the gas pressure sensors first, then run a back pressure compensation, followed by gas flow calibration, and finally a leak check, all in that order. These procedures will help to eliminate any issues that would interfere with accurate verification and calibration of the bench and should be performed in the order presented in the next several subsections.

5.1 VERIFYING AND CALIBRATING THE GAS PRESSURE SENSORS

Note The procedures described in this Section require a separate pressure meter/monitor.

The T703 Calibrator has two sensors that monitor the pressure of the gases flowing through the instrument: a Regulator pressure sensor and a Photometer Sample Gas pressure sensor. The T703U also has those two sensors plus one more: an O₃ Generator Regulator pressure sensor. The data collected by these sensors are used to compensate the final concentration calculations for changes in atmospheric pressure and are stored in the CPU's memory as test functions:

Table 5-1. T703/T703U Pressure Sensors

SENSOR	ASSOCIATED TEST FUNCTION	UNITS	PRESSURE MONITOR MEASUREMENT POINT
Regulator Pressure Sensor	REG PRESSURE	PSIG	Capped fitting on backside of regulator assembly. See Figure 5-3.
Photometer Sample Gas Pressure Sensor	PHOTO SPRESS	IN-HG-A	Use monitor to measure ambient atmospheric pressure at the calibrator's location.
(T703U only) O ₃ Generator Regulator Pressure Sensor	O3 PRES	PSIG	Capped fitting on O ₃ Generator Regulator assembly. See Figure 5-4.

5.1.1 PRESSURE SENSOR CALIBRATION SET UP

Attach the independent, calibrated pressure meter/monitor at the location shown in Figure 5-1 for T703, or at the locations shown in Figure 5-2 for T703U.

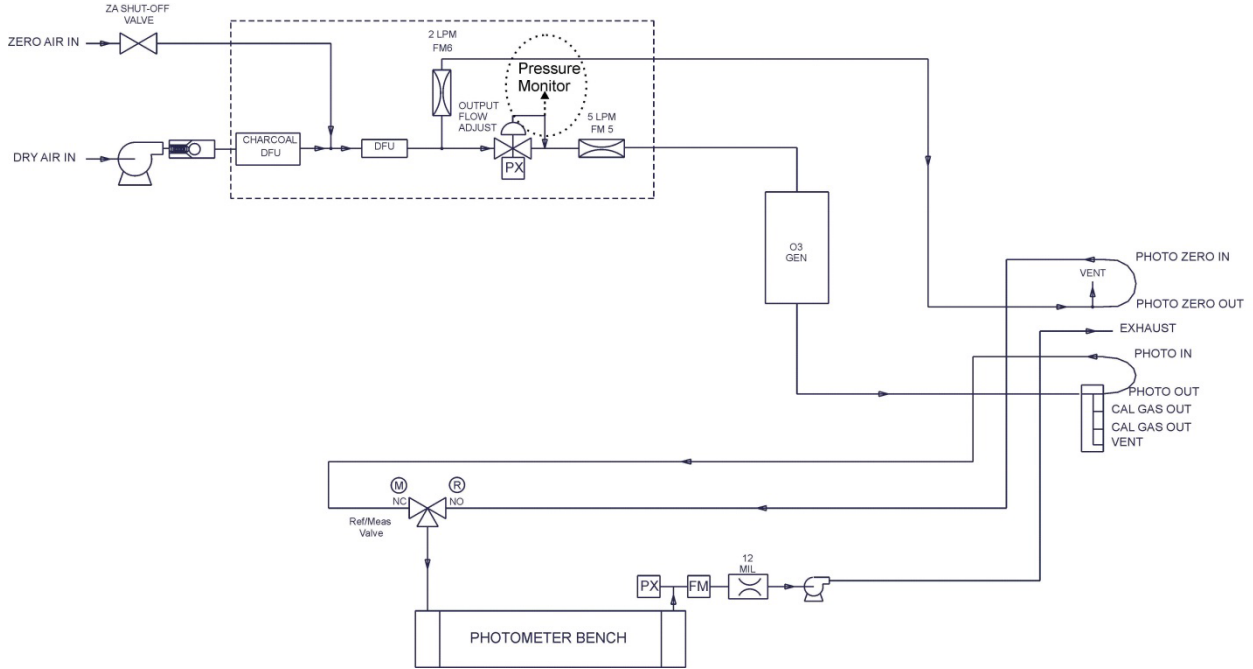


Figure 5-1. T703 Pressure Monitor Points

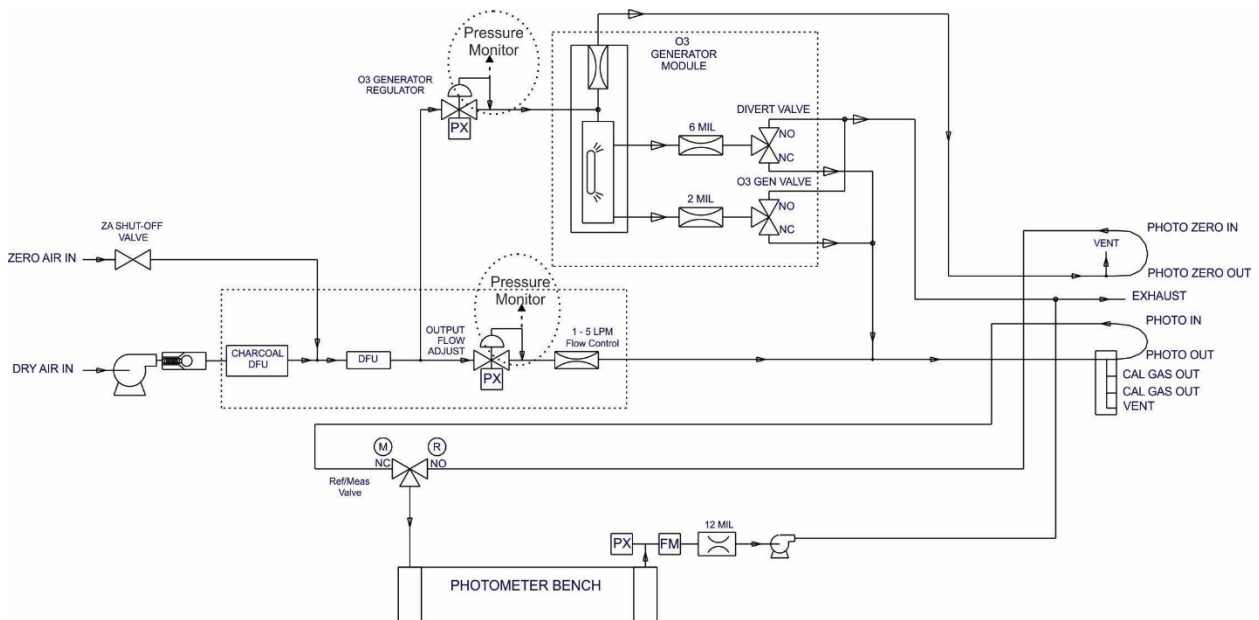


Figure 5-2. T703U Pressure Monitor Points

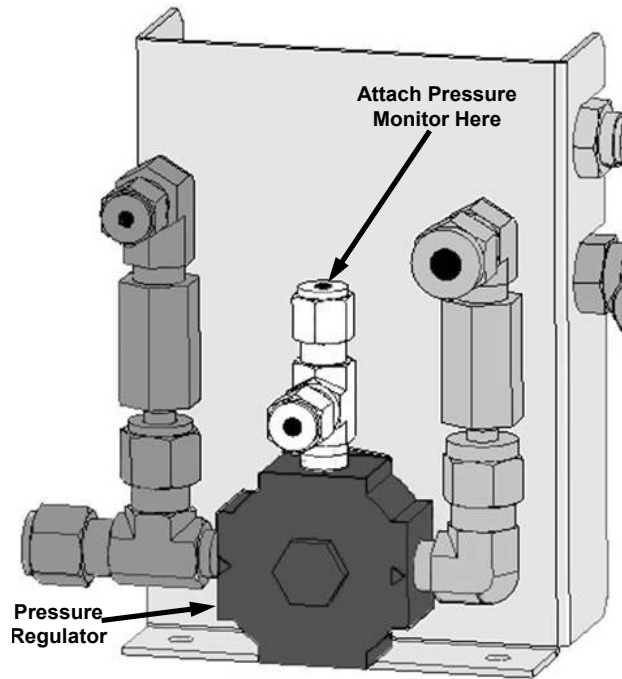


Figure 5-3. Pressure Regulator Monitor Connection (T703 and T703U)

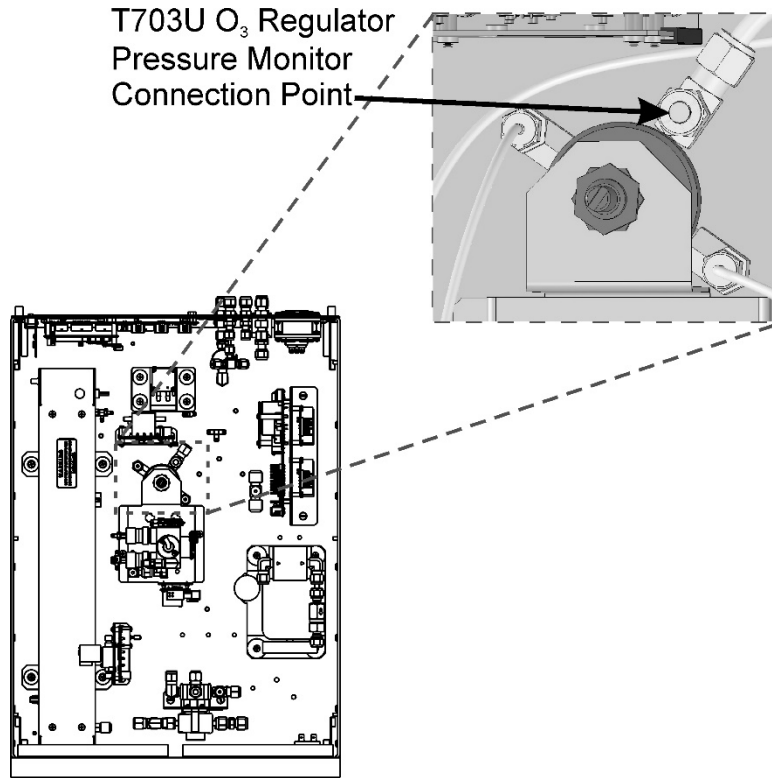


Figure 5-4. O₃ Regulator Pressure Monitor Point (T703U only)

5.1.2 PRESSURE SENSOR CALIBRATION

The following procedure requires a pump. There is an internal pump in the T703 and in the T703U.

1. Turn off the calibrator and open the top cover.
2. Connect a pressure meter to the Regulator Pressure measurement fitting (see Figure 5-3). This fitting is located on the backside of the regulator assembly.
3. If the unit is a T703U, also connect a pressure meter to the O₃ Regulator (Figure 5-4)
4. Turn on the calibrator and navigate to the Utilities>Diagnostics>Pressure Cal menu.
5. Select the pressure sensor to be calibrated, and in the “Actual Pressure” field (press button to bring up keypad) input value obtained from pressure meter and press Enter. (Enable the valve if interface shows an Enable button).
6. Press the Calibrate button, and then confirm that the calibration is to be carried out.
7. Follow with a Back Pressure Compensation, described next.

The Status field should read “Success” when complete.

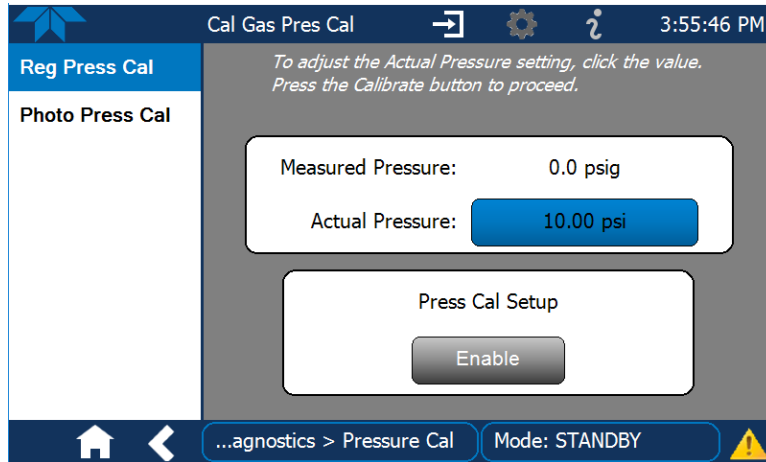


Figure 5-5. T703 Pressure Calibration Menu

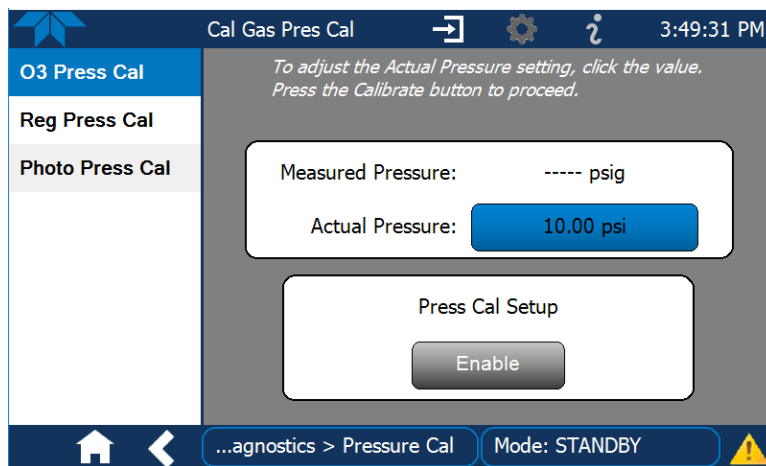


Figure 5-6. T703U Pressure Calibration Menu

5.2 BACK PRESSURE COMPENSATION

After calibrating a gas pressure sensor (and after making any pneumatic configuration change, whether to the instrument locally or to the system), there is risk of impacting the internal measure/reference pressure. To compensate for this, a back pressure compensation calibration should be performed. To do this, ensure that the calibrator is in Standby Mode (under Generate menu), then navigate to the Utilities>Diagnostics>Back Pressure Compensation menu, and press the Calibrate button; the operation will take a few minutes.

Another occasion to run a Back Pressure Compensation is if there is a fluctuating difference of more than .2 in Hg in the Photo Pressure parameter while ozone is being generated. This would be where the Meas/Ref valve is cycling (about six seconds per full cycle), and the Photo Pressure reading changes by more than .2 as the valve switches approximately every three seconds.

5.3 GAS FLOW CALIBRATION

The T703/T703U has two gas flow characteristics that affect its performance: the flow of gas through the sample chamber of the instrument's photometer (Photo Flow) and the total gas flow being output (Output Flow). While both are stored in the calibrator's memory and used to compensate the final concentration calculations for changes in atmospheric pressure, they are calculated quite differently: the Photo Flow rate is calculated by applying the slope factor from the previous Photo Flow calibration to the reading measured by a flow sensor located on the pressure/flow sensor PCA, whereas the Output Flow rate is calculated by applying a separate slope factor to an interpolated value.

Both can be viewed in the Dashboard (if not shown, use the Setup>Dashboard menu).

Run the Photo Flow Cal (Section 5.3.1) and then the Output Flow Cal (Section 5.3.2).

5.3.1 CALIBRATING THE PHOTOMETER'S SAMPLE GAS FLOW (PHOTO FLOW CAL)

Note

The procedures described in this Section requires that an independent, calibrated gas flow meter/monitor be connected to the T703/T703U's rear panel EXHAUST fitting.

1. Connect an independent, calibrated external flow meter/monitor per the preceding Note.
2. Navigate to the Utilities>Diagnostics>Photo Flow Cal menu (Figure 5-8).
3. Press the Enable button to start the flow.
4. Adjust the Actual Flow as measured by the external flow meter and press the ENTER button.
5. Press the Calibrate button.
6. A confirmation window will pop up: pressing the No button aborts the calibration, or pressing the Yes button starts the calibration.
7. The Status field will display "Success" when complete.

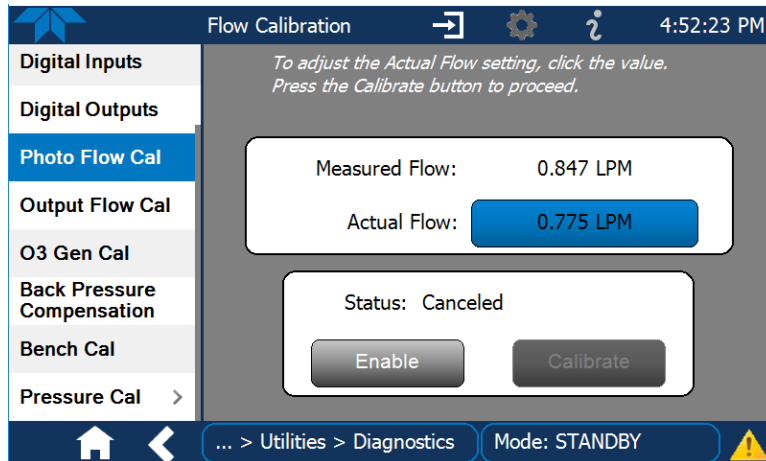


Figure 5-7. Photo Flow Calibration Menu

5.3.2 CALIBRATING THE OUTPUT GAS FLOW (OUTPUT FLOW CAL)

Note

The procedures described in this Section requires that an independent, calibrated external gas flow meter/monitor be connected to one CAL GAS OUT port, with the other CAL GAS OUT PORT and the VENT port capped.

1. Connect an independent, calibrated external flow meter/monitor per the preceding Note. Figure 5-9 and Figure 5-10 show the flow paths for T703 and T703U, respectively.
2. Navigate to the Utilities>Diagnostics>Output Flow Cal menu (Figure 5-8).

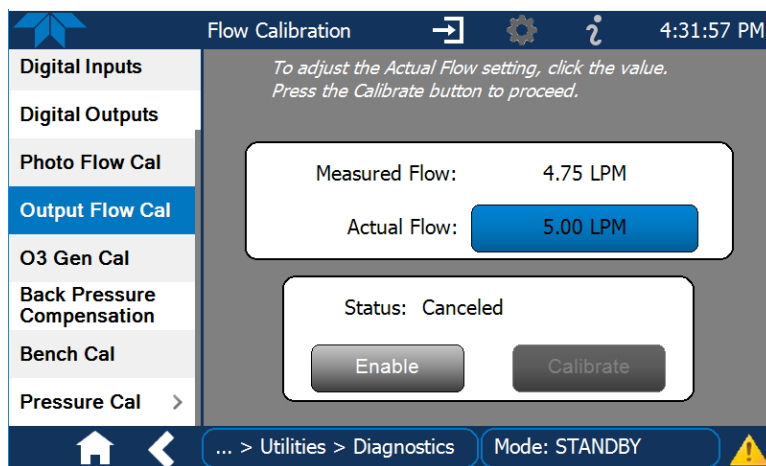


Figure 5-8. Output Flow Calibration Menu

3. Press the Enable button to start the flow.
4. Adjust the Actual Flow as measured by the external flow meter and press the ENTER button.
5. Press the Calibrate button.
6. A confirmation window will pop up: pressing the No button aborts the calibration; pressing the Yes button starts the calibration.
7. The Status field will display "Success" when complete.

- Now run a leak check Run a leak check (Section 6.5.1) prior to moving on to verifying and calibrating the bench.

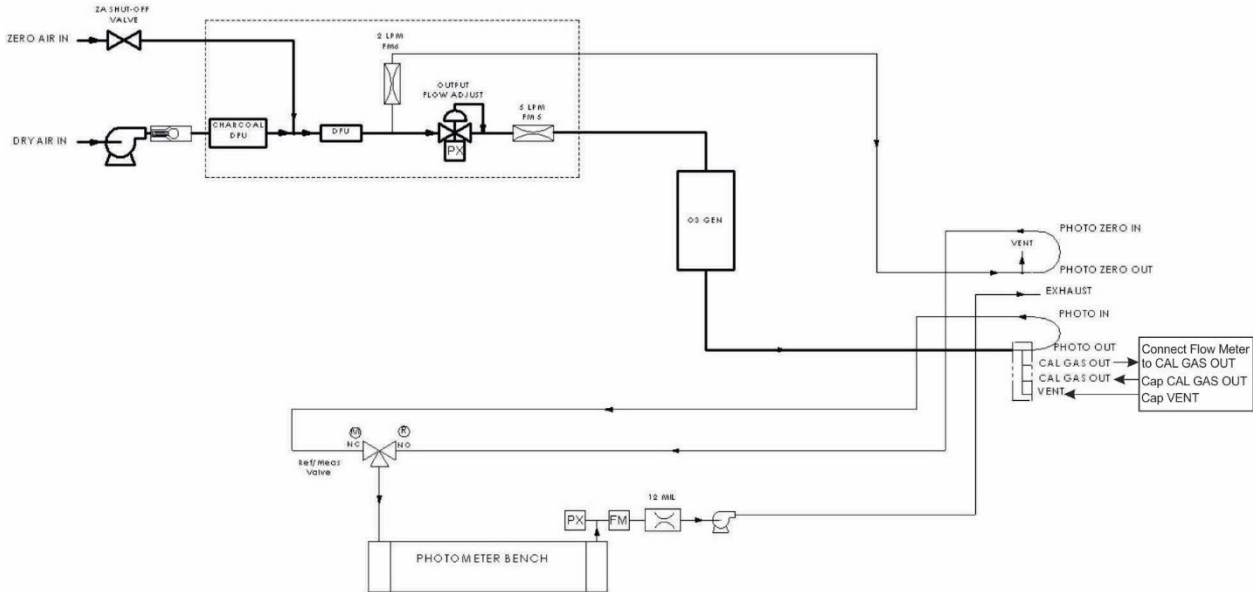


Figure 5-9. T703 Output Flow Calibration Flow

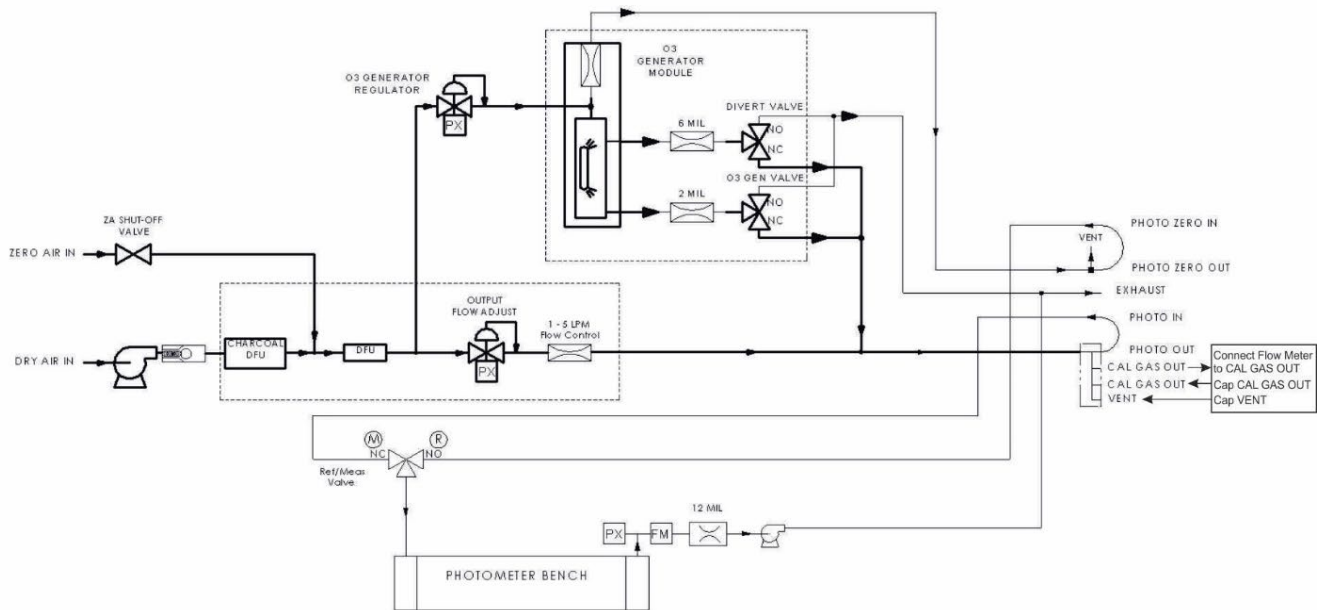


Figure 5-10. T703U Output Flow Calibration Flow

5.4 VERIFYING AND CALIBRATING THE O₃ PHOTOMETER (BENCH)

The accuracy of O₃ produced by the calibrator depends entirely on the accuracy of the photometer; therefore, it is very important to verify its accuracy and calibrate if necessary. The verification procedure can be performed by using either the instrument's internal O₃ generator or an external source of O₃. For zero air, either the internal ZA pump can be used or an external source, such as a Teledyne API's Model 701 Zero Air Generator can be used.

- Setup illustrations: Section 5.4.1
- Performance verification instructions: Section 5.4.2
- Calibration instructions (if required): Section 5.4.3

5.4.1 SETUP FOR VERIFYING AND CALIBRATING THE O₃ PHOTOMETER

Note This operation requires an external reference photometer.

Place the calibrator in Standby mode (from the Generate menu), and set up the calibrator and reference photometer as illustrated in either Figure 5-11 (when using the internal ozone generator) or Figure 5-12 (when using an external ozone source). When using the internal ozone generator, the zero air can be configured in either of two ways:

- External Zero Air: cap the DRY AIR IN port, and disable the internal zero air pump via the Setup>Vars>ZA Pump Enable menu (press the Edit button to change to OFF).

or

- Internal Zero Air: connect a dry air filter to the DRY AIR IN port, cap the ZERO AIR IN port, and enable the zero air pump via the Setup>Vars>ZA Pump Enable menu (press the Edit button to change to ON).

The manifold's excess gas should be vented to a suitable vent outside of the room. This vent should be of large enough internal diameter to avoid any appreciable pressure drop, and it must be located sufficiently downstream of the output ports to assure that no ambient air enters the manifold due to eddy currents or back diffusion.

Note It is recommended that the calibration manifold's exhaust vent have a minimum internal diameter of 3/8 inch and a maximum length of 3 meters (or 10 feet).

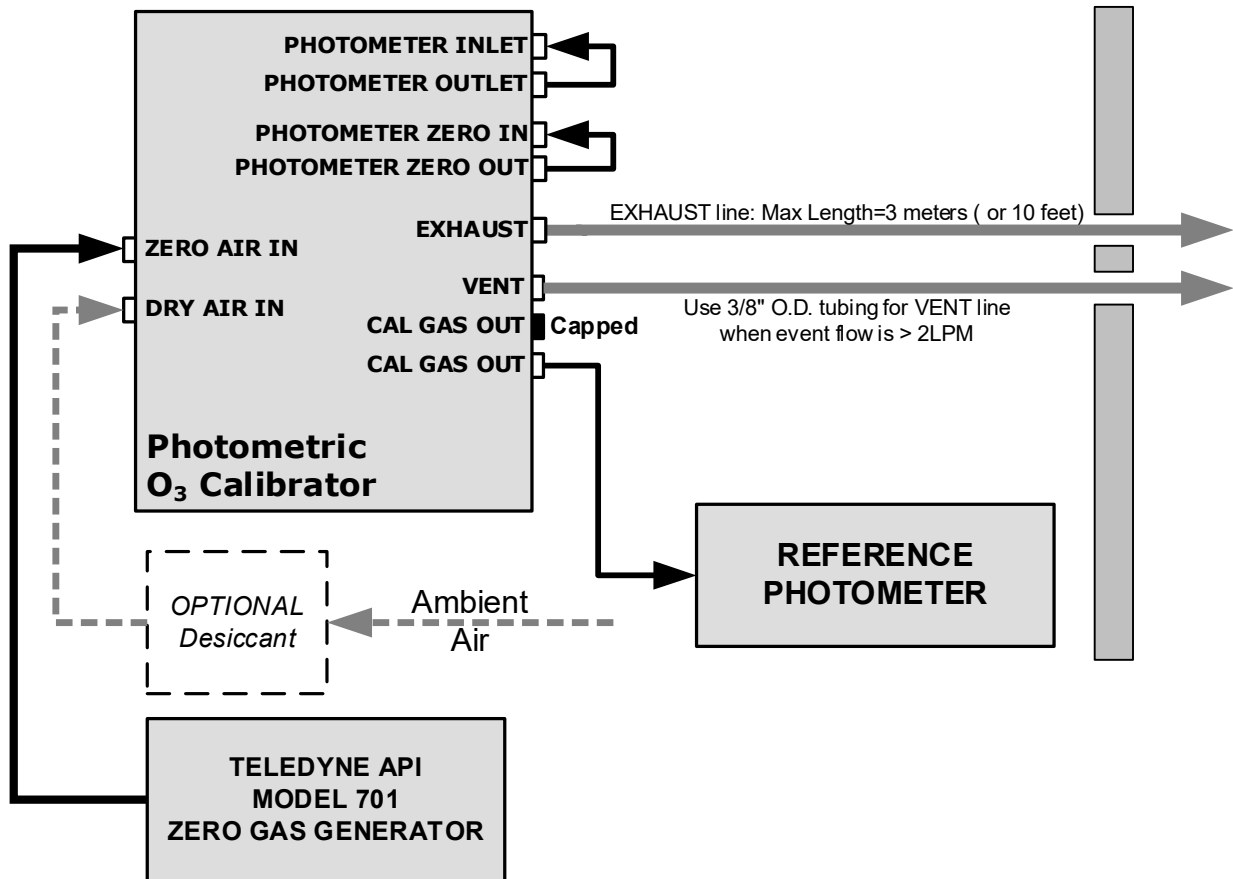


Figure 5-11. Set up for Verifying O₃ Photometer Using Internal O₃ Generator

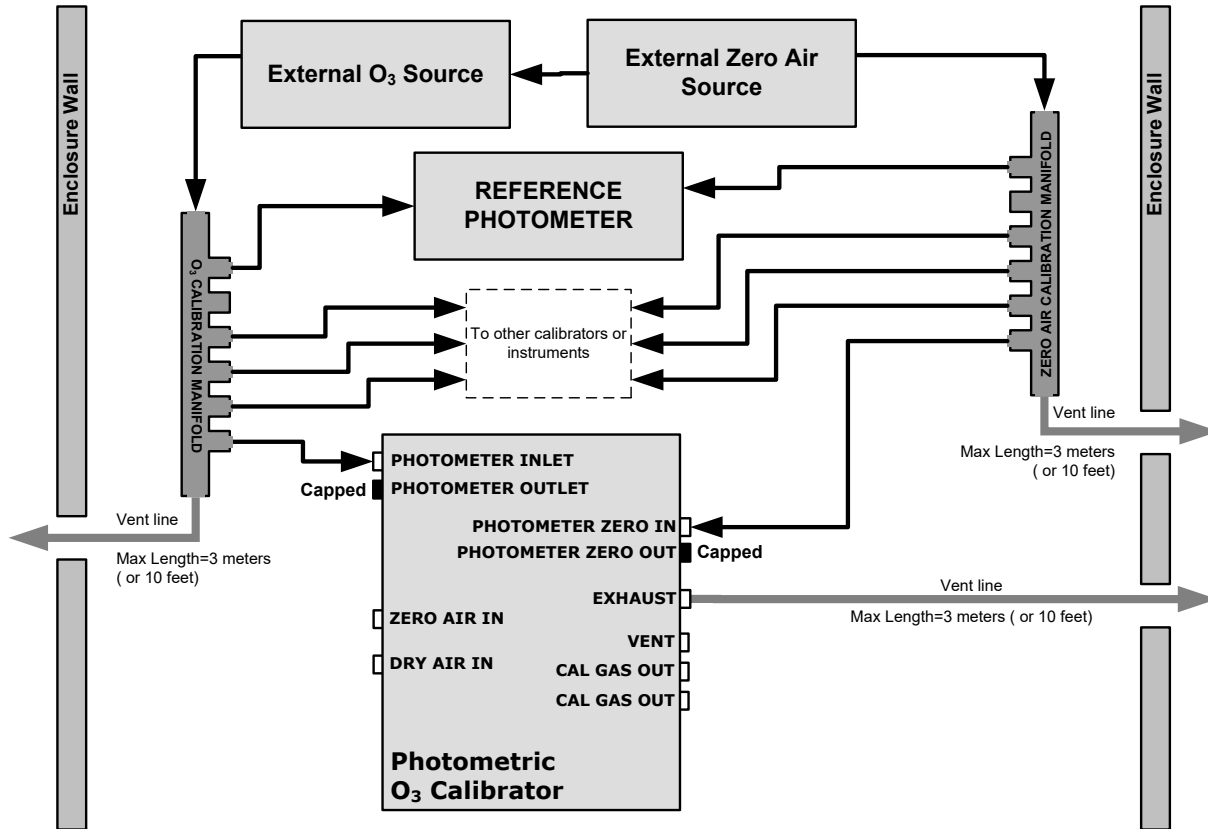


Figure 5-12. Set up for Verifying O₃ Photometer Using an External O₃ Generator

5.4.2 VERIFYING O₃ PHOTOMETER PERFORMANCE

To verify the performance of photometer after setting up the connections (Section 5.4.1), place the calibrator in Standby mode (in Generate menu), and perform the following steps:

1. In the Generate menu press the AUTO button.
2. Ensure the Gas is set to O₃, and set the target concentration and units of measure, as desired.
3. Press the Generate button and see the settings in the upper portion of the display.
4. Go to Home page and wait about 10 minutes or more until the reading under “Actual” stabilizes before comparing that value to the reading of the reference photometer to ensure they are within 1% of each other (If not, calibrate per Section 5.4.3).
5. If the performance check is acceptable, go on with operations. If the check results are not acceptable, then move on to Calibrating the O₃ Photometer.

5.4.3 CALIBRATING THE O₃ PHOTOMETER (BENCH)

First zero the photometer (Section 5.4.3.1), then span the photometer (Section 5.4.3.2)

5.4.3.1 PHOTOMETER ZERO CALIBRATION

This procedure sets the values held in the calibrator’s memory for zero point Offset and Slope.

1. Ensure the calibrator is in Standby mode and navigate to the Utilities>Diagnostics>Bench Cal menu.
2. Select the Calibration Type: The Zero button is for internal zero calibration, and the XZero button is for external zero calibration.
3. Allow Zero air to enter the PHOTO ZERO IN port of the calibrator’s rear panel.
4. Press the Calibrate button. (Pressing “Yes” in the Confirm Calibration window changes the Offset and Flow values for the O₃ measurement, where “No” aborts the calibration).

5.4.3.2 PHOTOMETER SPAN CALIBRATION

This procedure sets the response Slope for the photometer.

1. Ensure the calibrator is in Standby mode and navigate to the Utilities>Diagnostics>Bench Cal menu.
2. Select the Calibration Type: The Span button is for internal span calibration, and the XSpan button is for external span calibration.
3. For an internal span, set the Gen Target value and the Actual value, then press the Calibrate button, or for an external span, set the Actual value, then press the Calibrate button.

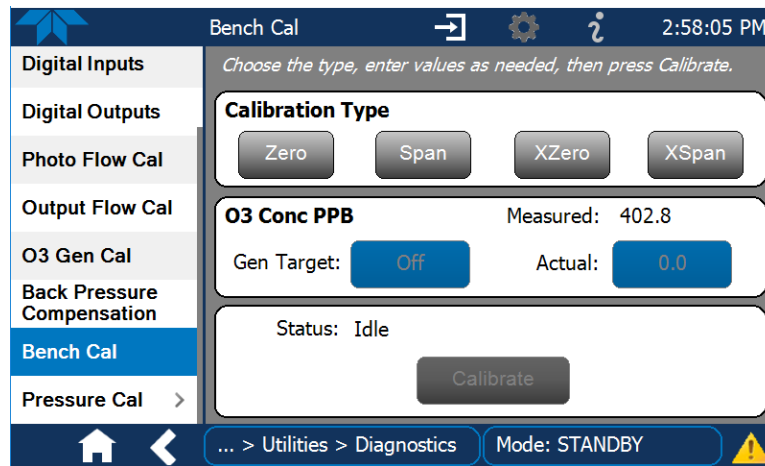


Figure 5-13. Bench Calibration Screen

5.5 CALIBRATING THE O₃ GENERATOR

The T703/T703U calibrator’s software includes a routine for automatically calibrating the O₃ generator. A calibration table of drive voltages stored in the calibrator’s memory is the basis for this calibration. This table is used by the T703/T703U to set initial O₃ generator drive settings.

The calibrator's software includes a routine for automatically calibrating the O₃ generator. It should be used only under the following circumstances:

- When your facility's Standard Operating Procedure (SOP) requires it, or
- When there has been a change to a component of the ozone generator tower

And only after first:

- Performing a pressure leak check (Section 6.5.1), followed by
- Running a Back Pressure Compensation (Section 5.1)

To run the automatic O₃ generator calibration program:

1. Connect a Cal Gas Out port to an ozone reference analyzer or to a manifold and cap the other Cal Gas Out port.
2. Set up the vent either by using the vent on the manifold and capping the calibrator's rear Vent port, or vent the calibrator's rear Vent port with at least a 10-inch tube.
3. Navigate to Utilities>Diagnostics and press O3 Gen Cal.

6. MAINTENANCE

Predictive diagnostic functions including failure warnings and alarms built into the calibrator's firmware allow the user to determine when repairs are necessary without performing painstaking preventative maintenance procedures.

Follow the maintenance schedule provided in this section.

6.1 MAINTENANCE SCHEDULE

Table 6-1 shows a typical maintenance schedule for the calibrator. The actual frequency of performing these procedures can vary depending on the operating environment. Additionally, in some cases, there are local regulations or standards that also need to be considered. Please note that in certain environments (i.e. dusty, very high ambient pollutant levels) some maintenance procedures may need to be performed more often than shown.

Note

If the instrument has the optional O₃ photometer installed, a Span and Zero Calibration Check must be performed on the photometer following some of the maintenance procedure listed below. See Section 5.1 for instructions on performing checks.



WARNING – RISK OF ELECTRICAL SHOCK

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



CAUTION

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

Table 6-1. Maintenance Schedule

ITEM	ACTION	FREQ	CAL CHECK REQ'D. ¹	DATE PERFORMED										
Verify Basic Functions	Record and analyze (Dashboard)	Weekly or after any Maintenance or Repair	No											
Photometer Pump Diaphragm	No Replacement Required. Under Normal Circumstances the Pumps Will Last the Lifetime of the Instrument.													
Dry Air Pump Diaphragm	Replace (Section 6.5.3)	Annually or as needed (per frequency/length of use)	Yes											
Absorption Tube	Inspect --- Clean or Replace (Section 6.5.2)	As Needed	Yes after cleaning	Cleaning of the Photometer Absorption Tube should not be required as long as ONLY CLEAN, DRY, PARTICULATE FREE Zero Air (Diluent Gas) is used with the calibrator										
Perform Leak Check	Verify Leak Tight (Section 6.5.1)	Annually or after any Maintenance or Repair	Yes											
Pneumatic lines	Examine and clean	As needed	Yes if cleaned											

6.2 OPERATIONAL HEALTH CHECKS

Navigate to the Utilities>USB Utilities>Report menu (Figure 6-1) to download a report on the basic operations of the instrument. To download the report for your own viewing on a computer or to send to others, insert a flash drive into a front panel USB port and press the Download button, which is enabled when the instrument detects the flash drive.

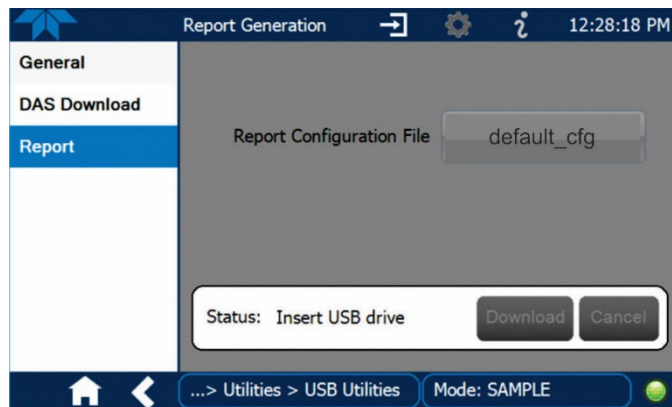


Figure 6-1. Report Generation Page

The report can also be set to generate periodically and sent to a Web services “cloud” where it is available for viewing by Teledyne API technical support personnel. Set this function with two Vars:

Setup>Vars>Upload Report to Cloud: set to True.

Setup>Vars>Report Upload>Interval: edit the number of hours between report uploads.

6.3 SOFTWARE/FIRMWARE UPDATES

There are two ways to check for and acquire updates: either remotely or manually.

6.3.1 REMOTE UPDATES

The instrument must be connected to a network that is connected to the Internet. In the Setup>Instrument menu, select the Remote Update menu and the Check for Updates button. If an update is available, it can be downloaded through this page.

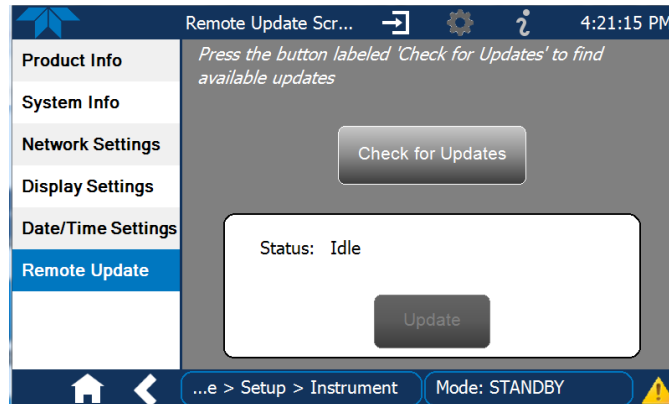


Figure 6-2. Remote Update Page

6.3.2 MANUAL RELOAD/UPDATE PROCEDURES

To reload or update firmware, first contact Technical Support to obtain the applicable file(s): api-techsupport@teledyne.com / 800-324-5190.

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

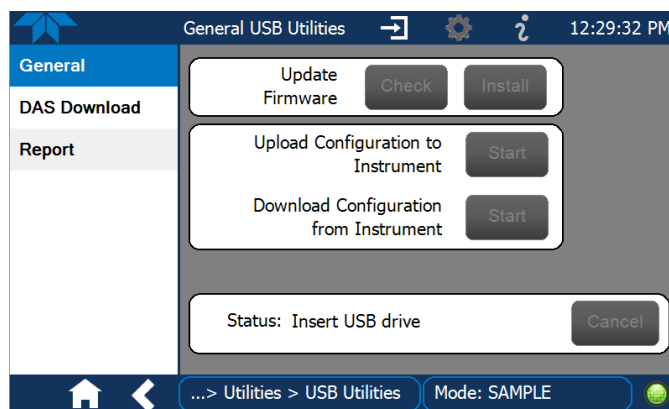


Figure 6-3. General Utilities Page

3. Insert a flash drive into a front panel USB port and wait for the Status field to indicate that the drive has been detected.
4. In the Update Firmware field, press the Check button for the instrument to determine whether the firmware on the flash drive is more recent than what is

currently installed. Once it's been determined that the firmware is new, the Install button will be enabled; if the firmware version on the flash drive is the same as or older than the current firmware of the instrument, the Install button will not be enabled.

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

6.3.3 INSTRUMENT DISPLAY CALIBRATION (FOR EARLIER INSTRUMENTS)

This Section applies to instruments shipped before January 2017. Although unlikely, if ever the touchscreen appears unresponsive or responds incorrectly, the screen can be calibrated via the Setup>Instrument>Display Settings menu.

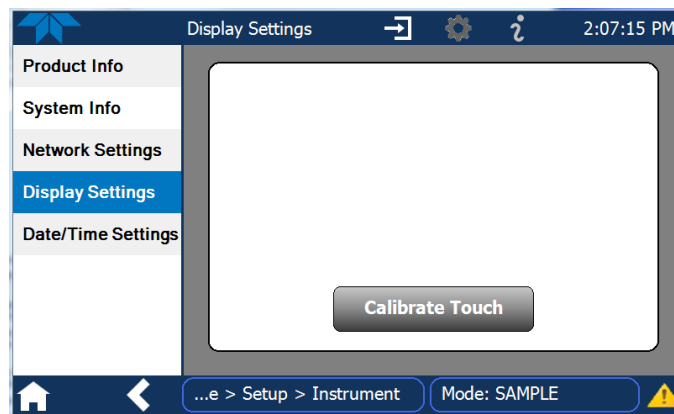


Figure 6-4. Touchscreen Calibration Page

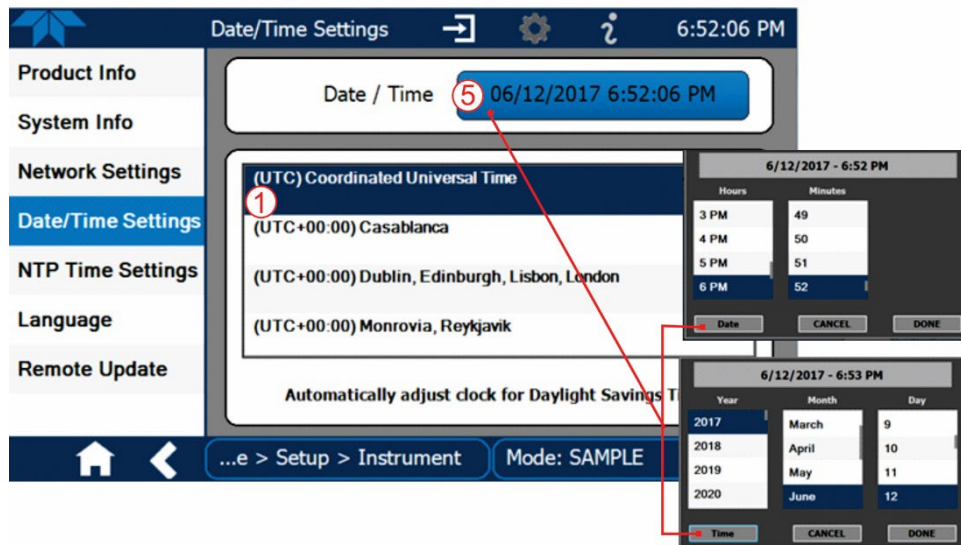
1. Connect a mouse to either of the front panel USB ports.
2. Navigate with the pointer to Setup>Instrument>Display Settings.
3. Click on “Calibrate Touch” and a crosshair appears in the center of the display screen.
4. Note that a timer function is enabled, allowing only 15 seconds to start the calibration process. If the timer expires, the instrument will exit the calibration screen and return to normal operation.
5. Click the very center of the crosshair.
6. When a new crosshair appears in the upper left corner of the screen, carefully and accurately click and hold the very center of that crosshair until it finishes shrinking, then release.
7. Repeat Step 6 for each of the corners.
8. Once the process is completed, a CANCEL and an ACCEPT button appear in the lower left corner: Test the accuracy of the calibration by touching parts of the screen and see that the mouse pointer follows your touches.
9. If you press the CANCEL button, the calibration won't be altered. Otherwise, press the ACCEPT button.

6.4 TIME ZONE CHANGES

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

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

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



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

Figure 6-5. Time Zone Change Requirements

6.5 MAINTENANCE PROCEDURES

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

6.5.1 PRESSURE LEAK CHECK

The following pressure leak check instructions can be used with either a leak checker or a tank of pressurized gas, with the two-stage regulator adjusted to ≤ 15 psi, a shutoff valve and pressure gauge may be used.



CAUTION

Once the fittings have been wetted with soap solution, do not apply a vacuum as this will cause soap solution to be drawn into the instrument, contaminating it.

DO NOT EXCEED 15 PSI PRESSURE.

1. Turn OFF power to the calibrator.
2. Remove the instrument cover
3. Install a leak checker or tank of gas as described above on the “DRY AIR IN” port at the rear panel.
4. Install caps on the Internal Vent and on the following rear panel fittings:
 - Exhaust
 - Vent
 - Zero Air In
 - Both CALGAS OUT fittings

Due to normal internal leakage that occurs with pumps, they will need to be bypassed for the leak check:

5. Locate the dry air pump.
6. Disconnect the two fittings on the dry air pump and install a union fitting in place of the pump.
7. Locate the photometer pump.
8. Disconnect the two fittings on the photometer pump and install a union fitting in place of the pump.
9. Pressurize the calibrator with the leak checker or with the tank – *without exceeding 15 psi pressure*, allowing enough time to pressurize the instrument fully.
10. Check each fitting with soap bubble solution and look for bubbles (*do not reapply vacuum as doing so will draw soap solution into the instrument and contaminate it*).
11. Once the leak has been located and repaired, remove any residual soap solution from the instrument interior with a clean, absorbent cloth.

The leak-down rate should be < 1 in-Hg (0.4 psi) in 5 minutes after the pressure is shut off.

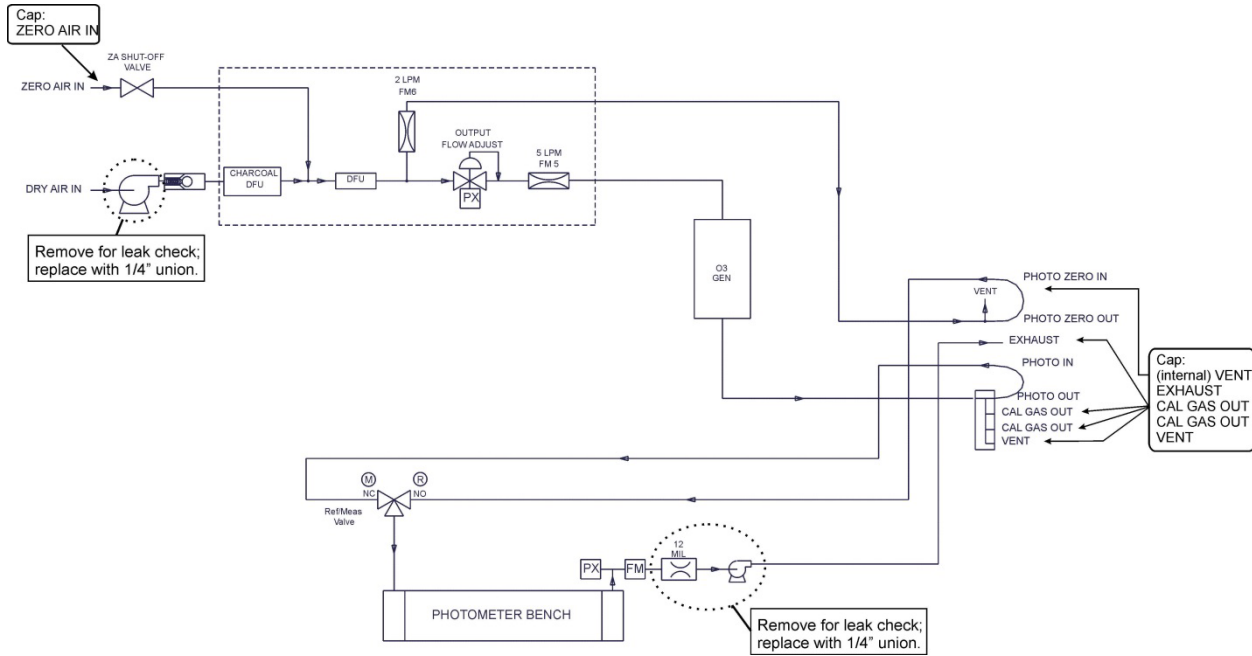


Figure 6-6. T703 Pneumatic Setup for Performing Pressure Leak Checks

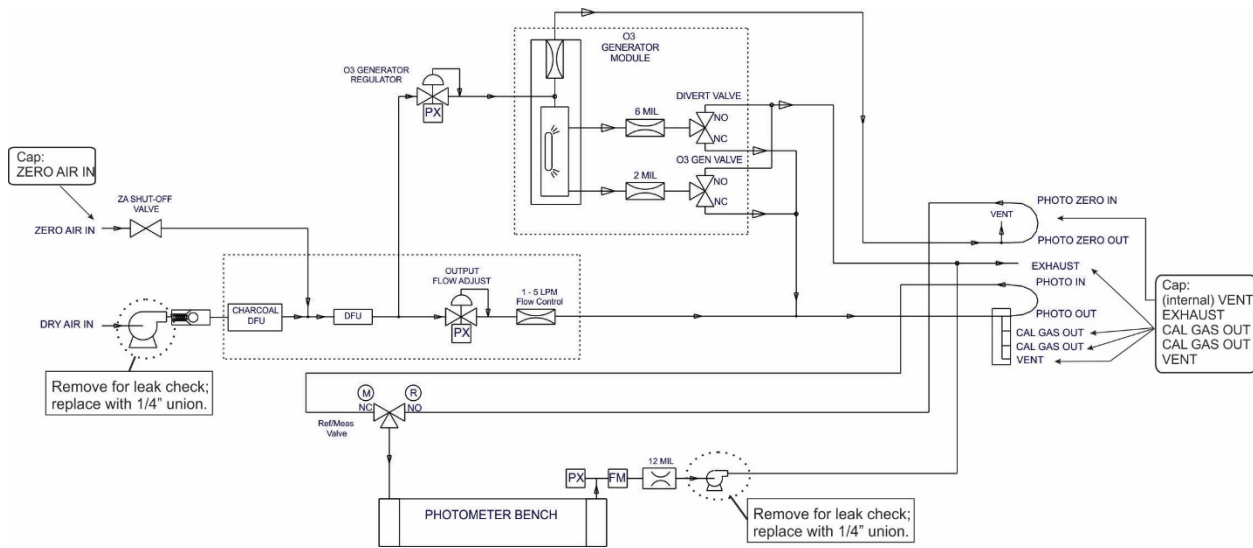


Figure 6-7. T703U Pneumatic Setup for Performing Pressure Leak Checks

6.5.2 ABSORPTION TUBE CLEANING OR REPLACEMENT

Note

Although this procedure should never be needed as long as the user is careful to supply the photometer with clean, dry and particulate free zero air only, it is included here for those rare occasions when cleaning or replacing the absorption tube may be required.

1. Remove the center cover from the optical bench.
2. Unclip the sample thermistor from the tube.
3. Loosen the two screws on the round tube retainers at either end of the tube.
4. Using both hands, carefully rotate the tube to free it.
5. Slide the tube towards the lamp housing.
 - The front of the tube can now be slid past the detector block and out of the instrument.



CAUTION

Do not cause the tube to bind against the metal housings. The tube may break and cause serious injury.

6. Clean the tube by rinsing with de-ionized water.
7. Air dry the tube.
8. Check the cleaning job by looking down the bore of the tube.
 - It should be free from dirt and lint.
9. Inspect the o-rings that seal the ends of the optical tube (these o-rings may stay seated in the manifolds when the tube is removed).
10. If there is any noticeable damage to these o-rings, they should be replaced.
11. Re-assemble the tube into the lamp housing and perform an Auto Leak Check on the instrument.

Note

It is important for proper optical alignment that the tube be pushed all the way towards the front of the optical bench when it is reassembled prior to gently retightening the tube retainer screws. This will ensure that the tube is assembled with the forward end against the stop inside the detector manifold.

6.5.3 DRY AIR PUMP DIAPHRAGM REPLACEMENT

The diaphragm in the internal dry air pump will periodically wear out and require replacement, the frequency dependent on usage. Contact Technical Support for the rebuild kit. Instructions and diagrams are included with the kit.

Always perform a Flow and Leak Check after rebuilding the pump.

6.5.4 UV SOURCE LAMP ADJUSTMENT

This procedure provides in detail the steps for adjustment of the UV source lamp in the optical bench assembly. This procedure should be done whenever the Photo Reference function (in the Vars menu) value drops below 3000 mV.

1. Ensure that the calibrator is warmed-up and has been running for at least 30 minutes before proceeding.
2. Remove the cover from the calibrator.
3. Locate the Photometer option (see Figure 2-4).
4. Locate the UV detector gain adjust pot on the photometer assembly (see Figure 6-8).
5. Navigate to the Utilities>Diagnostics>Analog Inputs menu and scroll to the Photo Detector input.
6. Using an insulated pot adjustment tool, Turn the UV Detector Gain Adjustment Pot until the value of Photo Detector is as close as possible to **4600.0 MV**.
 - Additional adjustment can be made by physically rotating the lamp in its housing. To do this:
 - a. Slightly loosen the UV lamp setscrew.
 - b. Next, slowly rotate the lamp up to ¼ turn in either direction while watching the Photo Detector signal until the optimum lamp position is determined, then re-tighten the lamp setscrew.
7. If a minimum reading of **3500.0 mV** cannot be reached, the lamp must be replaced.
8. Replace the cover on the calibrator.

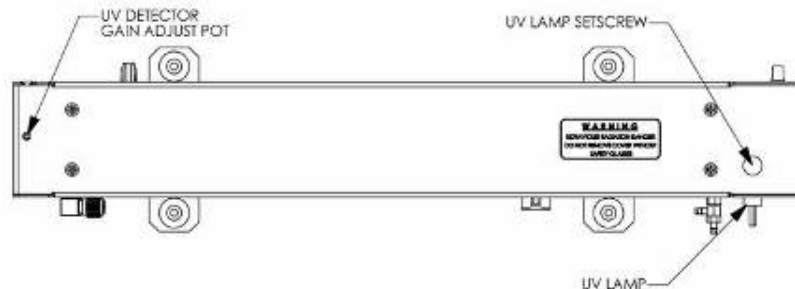


Figure 6-8. Photometer Assembly – Lamp Adjustment / Installation

6.5.5 UV SOURCE LAMP REPLACEMENT

This procedure details the steps for replacement of the UV source lamp in the optical bench assembly. This procedure should be done whenever the lamp can no longer be adjusted as described in Section 6.5.3.

1. Turn the calibrator off.
2. Remove the cover from the calibrator.
3. Locate the Optical Bench Assembly (see Figure 2-4).
4. Locate the UV lamp at the front of the optical bench assembly (see Figure 6-8).
5. Unplug the lamp cable from the power supply connector on the side of the optical bench.
6. Slightly loosen (do not remove) the UV lamp setscrew and pull the lamp from its housing.

7. Install the new lamp in the housing, pushing it all the way in. Leave the UV lamp setscrew loose for now.
8. Turn the calibrator back on and allow it to warm up for at least 30 minutes.
9. Turn the UV detector gain adjustment pot (See Figure 6-8) clockwise to its minimum value. The pot may click softly when the limit is reached.
10. Perform the UV Lamp Adjustment procedure described in Section 6.5.3, with the following exceptions:

Slowly rotate the lamp in its housing (up to ¼ turn in either direction) until a **MINIMUM** value is observed.

- Ensure the lamp is pushed all the way into the housing while performing this rotation.
- If the Photo Detector value (Utilities>Diagnostics>Analog Inputs>Photo Detector) will not drop below 5000 mV while performing this rotation, contact Teledyne API'S Technical Support for assistance.

Once a lamp position is found that corresponds to a minimum observed value for Photo Detector, tighten the lamp setscrew at the approximate minimum value observed.

Adjust Photo Detector within the range of 4400 – 4600 mV.

11. Replace the cover on the calibrator.



CAUTION

The UV lamp contains mercury (Hg), which is considered hazardous waste. The lamp should be disposed of in accordance with local regulations regarding waste containing mercury.

6.5.6 OZONE GENERATOR UV LAMP ADJUSTMENT OR REPLACEMENT

This procedure details the steps for replacement and initial adjustment of the ozone generator lamp. If you are adjusting an existing lamp, skip to Step 8.

1. Turn off the calibrator.
2. Remove the cover from the calibrator.
3. Locate the O₃ generator (see Figure 2-4).

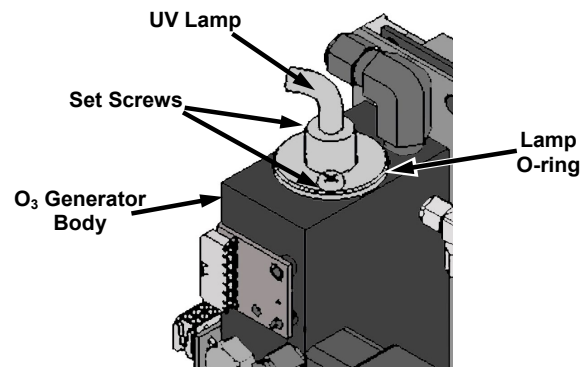


Figure 6-9. O₃ Generator UV Lamp Location

4. Remove the two setscrews on the top of the O₃ generator and gently pull out the old lamp.



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5. Inspect the o-ring beneath the nut and replace if damaged.
6. Install the new lamp in O₃ generator housing, ensuring that it is fully seated.
7. Tighten the two setscrew
8. Turn on calibrator and allow it to stabilize for at least 30 minutes.
9. Replace the calibrator's cover.
10. Perform an auto-leak check (See Section 6.5.1).
11. Perform an Ozone Generator calibration (see Section 5.5).

7. TROUBLESHOOTING AND SERVICE

This Section contains a variety of methods for identifying and solving performance problems with the calibrator.



ATTENTION

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

7.1 GENERAL TROUBLESHOOTING

The Dynamic Dilution Calibrator 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 operating parameters without disturbing monitoring operations.

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

1. Note any warning messages and take corrective action as necessary.
2. View and compare Dashboard functions' values to factory values. Note any major deviations from the factory values and take corrective action.
3. Use the internal electronic status LEDs to determine whether the electronic communication channels are operating properly.
 - Verify that the DC power supplies are operating properly by checking the voltage test points on the relay PCA.
 - Note that the calibrator's DC power wiring is color-coded and these colors match the color of the corresponding test points on the relay PCA.
 - Follow the procedures defined in Section 2.4.2 to confirm that the calibrator's vital functions are working (power supplies, CPU, relay PCA, etc.).

7.1.1 FAULT DIAGNOSIS WITH ALERTS

The most common and/or serious instrument failures will result in a warning message being displayed as an Alert. Table 7-1 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 indication of the specific failures referenced by the warnings. In this case, it is recommended that proper operation of power supplies (See Section 7.3.3), the relay PCA (See Section 7.3.7), and the motherboard (See Section 7.3.9) be confirmed before addressing the specific warning messages.

Table 7-1. Warning Messages in Alerts Page

ALERT	FAULT CONDITION	POSSIBLE CAUSES
Configuration Reset to Default	Configuration and Calibration data reset to original Factory state.	<ul style="list-style-type: none"> - Failed Disk-on-Module - User has erased configuration data
Box Temp Warning	Temperature inside chassis out of range.	<ul style="list-style-type: none"> - Failed fan. - Insufficient clearance at vents.
Lamp Driver Warning	The CPU is unable to communicate with either the O ₃ generator or photometer lamp I ² C driver chip.	<ul style="list-style-type: none"> - I²C has failed
Pressure Warning	Internal gas pressure is <15 PSIG or > 36 PSIG	<ul style="list-style-type: none"> - Zero or source air supply is incorrectly set up or improperly vented. - Leak or blockage exists in the calibrator's internal pneumatics - Failed CAL GAS or DUILUENT pressure sensor
O ₃ Gen Temp Warning	IZS Ozone Generator Temp is outside of control range of 48°C ± 3°C.	<ul style="list-style-type: none"> - No IZS option installed, instrument improperly configured - O₃ generator heater - O₃ generator temperature sensor - Relay controlling the O₃ generator heater - Entire Relay PCA - I²C Bus
O ₃ Pump Warning	The photometer pump failed to turn on within the specified timeout period (default = 30 sec.).	<ul style="list-style-type: none"> - Failed Pump - Problem with Relay PCA - 12 VDC power supply problem
Photo Lamp Temp Warning	The photometer lamp temp is < 51°C or >61°C.	Possible failure of: <ul style="list-style-type: none"> - Bench lamp heater - Bench lamp temperature sensor - Relay controlling the bench heater - Entire Relay PCA - I²C Bus - Hot Lamp
Photo Lamp Stability Warning	Value output during the Photometer's reference cycle changes from measurements to measurement more than 25% of the time.	<ul style="list-style-type: none"> - Faulty UV source lamp - Noisy UV detector - Faulty UV lamp power supply - Faulty ± 15 VDC power supply

ALERT	FAULT CONDITION	POSSIBLE CAUSES
Photo Ref Warning	Occurs when Ref is <2500 mVDC or >4950 mVDC.	Possible failure of: <ul style="list-style-type: none"> - UV Lamp - UV Photo-Detector Preamp
Rearboard Not Det Warning	Motherboard on rear panel not detected on power up.	<ul style="list-style-type: none"> - This warning only appears on Serial I/O COMM Port(s) Front Panel Display will be frozen, blank or will not respond. - Failure of motherboard
Regulator Pressure Warning	Regulator pressure is < 15 PSIG or > 25 PSIG.	<ul style="list-style-type: none"> - Zero or source air supply is incorrectly set up or improperly vented. - Incorrectly adjusted O₃ zero air pressure regulator - Leak or blockage exists in the calibrator's internal pneumatics - Failed O₃ Generator Input pressure sensor
Relayboard I2C Warning	The CPU cannot communicate with the Relay PCA.	<ul style="list-style-type: none"> - I²C Bus failure - Failed relay PCA - Loose connectors/wiring
System Reset	The computer has rebooted.	<ul style="list-style-type: none"> - 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

7.1.2 FAULT DIAGNOSIS WITH DASHBOARD FUNCTIONS

Besides being useful as predictive diagnostic tools, the Dashboard functions can be used to isolate and identify many operational problems when combined with a thorough understanding of the calibrator's Theory of Operation (see Section 8).

The acceptable ranges for these functions are listed in the "Nominal Range" column of the calibrator Final Test and Validation Data Sheet shipped with the instrument. Values outside these acceptable ranges indicate a failure of one or more of the calibrator'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.

Table 7-2 contains some of the more common causes for these values to be out of range.

Table 7-2. Functions – Indicated Failures

FUNCTION	DIAGNOSTIC RELEVANCE
O3 Flow	Gas flow problems directly affect the concentration accuracy of the calibrator's calibration gas mixtures.
O3 Gen Drive	Check the O ₃ generator heater and temperature sensors.
O3 Gen Lamp Temp	Incorrect Lamp temperature can affect the efficiency and durability of the O ₃ generator's UV lamp.
Reg Press	Same as Regulator Pressure Warning in Table 7-1.

FUNCTION	DIAGNOSTIC RELEVANCE
Box Temp	Box Temperature typically runs ~7°C warmer than ambient temperature. See Box Temp Warning in Table 7-1.
Photo Meas & Photo Ref	<p>If the value displayed is too high the UV Source has become brighter. Adjust the variable gain potentiometer on the UV Preamp Board in the optical bench.</p> <p>If the value displayed is too low:</p> <ul style="list-style-type: none"> - < 200mV – Bad UV lamp or UV lamp power supply; replace. - < 2500mV – Lamp output has dropped, adjust UV Preamp Board or replace lamp. <p>If the value displayed is constantly changing:</p> <ul style="list-style-type: none"> - Bad UV lamp. - Defective UV lamp power supply. - Failed I²C Bus. <p>If the Photo Ref value changes by more than 10mV between zero and span gas:</p> <ul style="list-style-type: none"> - Defective/leaking switching valve.
Photo Flow	<p>Gas flow problems directly affect the accuracy of the photometer measurements.</p> <ul style="list-style-type: none"> - Check for Gas Flow problems. See Section Table 7-1.
Photo Lamp Temp	<p>Poor photometer temp control can cause instrument noise, stability and drift. Temperatures outside of the specified range or oscillating temperatures are cause for concern. Possible causes of faults are the same as Photo Lamp Temp Warning from Table 7-1.</p>
Photo Pressure	<p>The pressure of the gas in the photometer's sample chamber is used to calculate the concentration of O₃ in the gas stream. Incorrect sample pressure can cause inaccurate readings.</p> <ul style="list-style-type: none"> - Check for Gas Flow problems. See Section Table 7-1.
Sample Temp	<p>The temperature of the gas in the photometer's sample chamber is used to calculate the concentration of O₃ in the gas stream. Incorrect sample temperature can cause inaccurate readings.</p> <p>Possible causes of faults are:</p> <ul style="list-style-type: none"> - Bad bench lamp heater - Failed sample temperature sensor - Failed relay controlling the bench heater - Failed Relay PCA - I²C Bus malfunction - Hot lamp
Slope	<p>Values outside range indicate:</p> <ul style="list-style-type: none"> - Contamination of the Zero Air or Span Gas supply. - Instrument is miss-calibrated. - Blocked Gas Flow. - Faulty Sample Pressure Sensor or circuitry. - Bad/incorrect Span Gas concentration.
Offset	<p>Values outside range indicate: Contamination of the Zero Air supply.</p>

7.1.3 USING THE DIAGNOSTIC SIGNAL I/O FUNCTIONS

The signals found in the Dashboard and in the Utilities>Diagnostics submenus, combined with a thorough understanding of the instrument's Principles of Operation (Section 8), are useful for troubleshooting in three ways:

- The technician can view the raw, unprocessed signal level of the calibrator'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 calibrator.

7.1.4 USING THE ANALOG OUTPUTS MENU

The signals available (only one at a time can be used) for output over the calibrator's only analog output channel can also be used as diagnostic tools. That signal was set up through the Setup>Analog Outputs>Analog Output Cfg menu (Section 2.6.9).

Compare the Utilities>Diagnostics>Analog Outputs>Analog Output 4's voltage value to the reading for the same parameter in Home>Dashboard. The scaled voltage signal should be relative to the Dashboard reading. For example, if Analog Output 4 were mapped to Box Temp (in the Setup>Analog Outputs>Analog Output Cfg menu), and its Min Max values were set to 0 and 100, respectively, then a Dashboard Box Temp reading of ~30°C (6-7° above room temperature) should correspond to a voltage signal around ~1450 mV. (See Section 7.3.13.1 for this example).

Table 7-3. Analog Inputs Readings as Diagnostic Tools

PARAMETER	DESCRIPTION	ZERO	FULL SCALE	CAUSES OF EXTREMELY HIGH / LOW READINGS
O3 Meas	The raw output of the photometer during its measure cycle	0 mV	5000 mV*	<p>If the value displayed is:</p> <ul style="list-style-type: none"> - >5000 mV: The UV source has become brighter; adjust the UV Detector Gain potentiometer. - < 100mV – Bad UV lamp or UV lamp power supply. - < 2500mV – Lamp output has dropped, adjust UV Preamp Board or replace lamp. <p>If the value displayed is constantly changing:</p> <ul style="list-style-type: none"> - Bad UV lamp. - Defective UV lamp power supply. - Failed I²C Bus.
O3 Ref	The raw output of the photometer during its reference cycle	0 mV	5000 mV	<p>If the PHOTO REFERENCE value changes by more than 10mV between zero and span gas:</p> <ul style="list-style-type: none"> - Defective/leaking M/R switching valve.
Sample Pressure	The pressure of gas in the photometer absorption tube	0 "Hg	40 "Hg-In-A	Check for Gas Flow problems.
Photo Flow	The gas flow rate through the photometer	0 cm ³ /min	1000 cm ³ /m	Check for Gas Flow problems.
Sample Temp	The temperature of gas in the photometer absorption tube	0 C°	70 C°	Possible causes of faults are the same as Sample Temp in Table 7-2.
Photo Lamp Temp	The temperature of the photometer UV lamp	0 C°	70 C°	<p>Possible failure of:</p> <ul style="list-style-type: none"> - Bench lamp heater - Bench lamp temperature sensor - Relay controlling the bench heater - Entire Relay PCA - I²C Bus - Hot Lamp
O3 Gen Lamp	The temperature of the O ₃ generator's UV lamp	0 mV	5000 mV	Same as PHOTO LAMP TEMP WARNING from Table 7-1.
Box Temp	The temperature inside the calibrator's chassis	0 C°	70 C°	Possible causes of faults are the same as Box Temp from Table 7-1.
O3 Photo Conc	The current concentration of O ₃ being measured by the photometer.	---	---	<ul style="list-style-type: none"> - I²C Bus malfunction - Gas flow problem through the photometer. - Electronic failure of the photometer subsystems. - Failure or pressure / temperature sensors associated with the photometer. - Bad/incorrect Span Gas concentration. - Contamination of the Zero Air supply. - Malfunction of the O₃ generator. - Internal A/D converter problem.

7.2 USING THE INTERNAL ELECTRONIC STATUS LEDs

Several LEDs are located inside the instrument to assist in determining if the calibrators CPU, I²C bus and Relay PCA are functioning properly.

7.2.1 CPU STATUS INDICATOR

DS5, a red LED, that is located on upper portion of the motherboard, just to the right of the CPU board, flashes when the CPU is running the main program loop. After power-up, approximately 30 – 60 seconds, DS5 should flash on and off. If DS5 does not flash then the program files may have become corrupted; contact Technical Support because it may be possible to recover operation of the calibrator. If after 30 – 60 seconds, DS5 is flashing, then the CPU is bad and must be replaced.

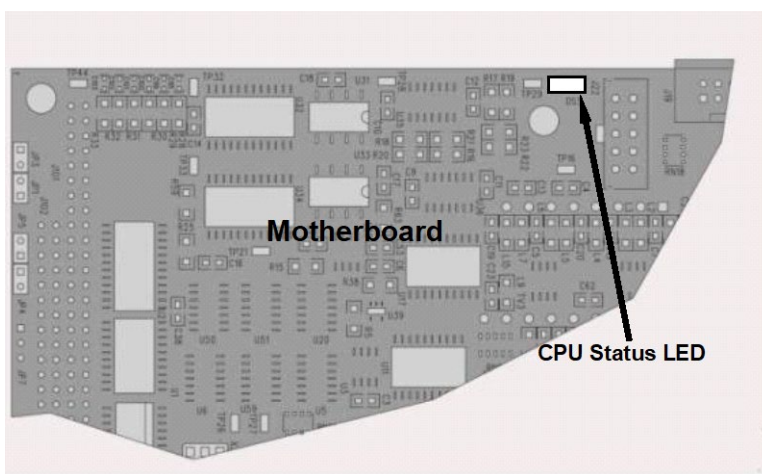


Figure 7-1. CPU Status Indicator

7.2.2 RELAY PCA STATUS LEDs

There are several LEDs located on the Relay PCA, indicating functional status. Some are not used on this model.

7.2.2.1 RELAY BOARD I²C BUS WATCHDOG STATUS LED

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

Table 7-4. 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, valve driver board or relay PCA Faulty connectors/wiring between motherboard, valve driver board or relay PCA Failed/Faulty +5 VDC power supply (PS1)

If D1 is blinking, then the other LEDs can be used in conjunction with the signals under the Utilities>Diagnostics to identify hardware failures of the relays and switches on the Relay.

7.2.2.2 RELAY BOARD OTHER STATUS LEDS

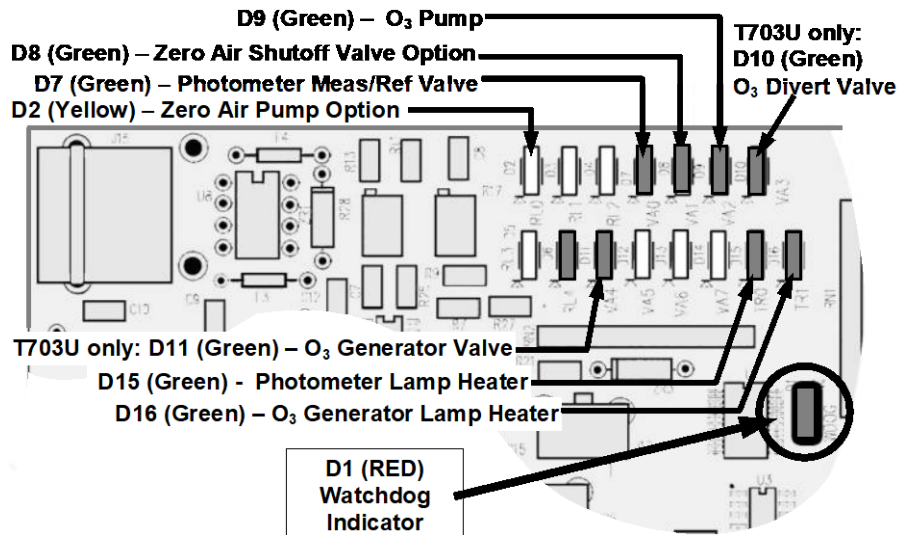


Figure 7-2. Relay PCA Status LEDS Used for Troubleshooting

Table 7-5. Relay PCA Status LED Failure Indications

LED	INDICATES	ACTIVATED BY	DIAGNOSTIC TECHNIQUE
D2 Yellow	AC- powered Zero Air Pump (option) status	ZERO_AIR_PUMP	Pump should start /stop. If not: <ul style="list-style-type: none"> • Failed pump • Failed AC Relay on Relay PCA • Failed Relay PCA • Faulty AC Power Supply (PS2) • Faulty Connectors/Wiring
D7 Green	Photometer Meas/Ref Valve status	PHOTO_REF_VALVE	Valve should audibly change states. If not: <ul style="list-style-type: none"> • Failed Valve • Failed Relay Drive IC on Relay PCA • Failed Relay PCA • Faulty +12 VDC Supply (PS2) • Faulty Connectors/Wiring
D8 Green	Zero Air Shutoff Valve (option) status	ZA_SHUTOFF_VALVE	
D9 Green	DC-powered O ₃ Pump status	O3_PUMP_ON	Pump should start /stop. If not: <ul style="list-style-type: none"> • Failed pump • Failed Drive IC on Relay PCA • Failed Relay PCA • Faulty +12 VDC Supply (PS2) • Faulty Connectors/Wiring
D10 Green	T703U Divert Valve status	O3_DIVERT_VALVE	Valve should audibly change states. If not: <ul style="list-style-type: none"> • Failed Valve • Failed Relay Drive IC on Relay PCA • Failed Relay PCA • Faulty +12 VDC Supply (PS2) • Faulty Connectors/Wiring
D11 Green	T703U O ₃ Generator Valve status	O3_GEN_VALVE	
D15 Green	Photometer Heater status	PHOTO_LAMP_HEATER	Voltage displayed should change. If not: <ul style="list-style-type: none"> • Failed Heater • Faulty Temperature Sensor • Failed AC Relay • Faulty Connectors/Wiring
D16 Green	Status of O ₃ Generator Heater status	O3_GEN_HEATER	

7.3 SUBSYSTEM CHECKOUT

The preceding sections of this manual discussed a variety of methods for identifying possible sources of failures or performance problems within the calibrator. This section describes how to check individual components or subsystems to determine if any and which is actually the cause of the problem being investigated.

7.3.1 VERIFY SUBSYSTEM CALIBRATION

A good first step when troubleshooting the operation of the calibrator is to verify that its major subsystems are properly calibrated. These are:

- Gas pressure calibration (see Section 5.1).
- Photometer calibration (see Section 5.1).
- O₃ generator calibration (see Section 5.5).

7.3.2 AC MAIN POWER

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

- Internally, the status LEDs located on the Relay PCA, motherboard and CPU should turn on as soon as the power is supplied.
- If they do not, check the circuit breaker built into the ON/OFF switch on the instrument's front panel.



WARNING

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

7.3.3 DC POWER SUPPLY

If you have determined that the calibrator’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: 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 indicated in Table 7-6 (refer to Figure 7-3 for test point locations).

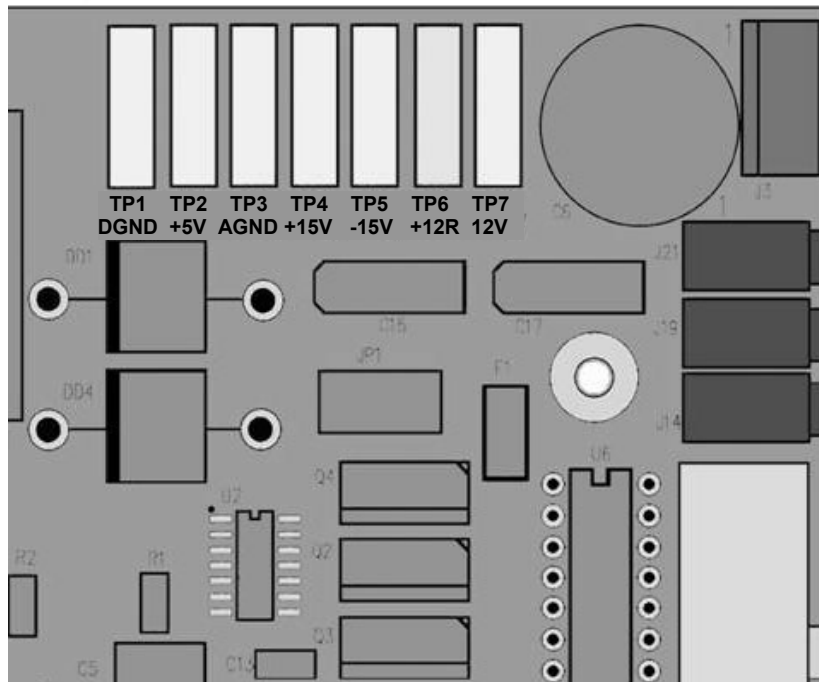


Figure 7-3. Location of DC Power Test Points on Relay PCA

Table 7-6. DC Power Test Point and Wiring Color Codes

NAME	TEST POINT	WIRE COLOR
Dgnd	TP1	Black
+5V	TP2	Red
Agnd	TP3	Green
+15V	TP4	Blue
-15V	TP5	Yellow
+12R	TP6	Purple
+12V	TP7	Orange

A voltmeter should be used to verify that the DC voltages are correct per the values in Table 7-7, and an oscilloscope, in AC mode, with band limiting turned on, can be used to evaluate whether the supplies are producing excessive noise (> 100 mV p-p).

Table 7-7. DC Power Supply Acceptable Levels

POWER SUPPLY ASSY	VOLTAGE	CHECK RELAY PCA TEST POINTS				MIN V	MAX V
		FROM TEST POINT		TO TEST POINT			
		NAME	#	NAME	#		
PS1	+5	Dgnd	1	+5	2	4.8	5.25
PS1	+15	Agnd	3	+15	4	13.5	16V
PS1	-15	Agnd	3	-15V	5	-14V	-16V
PS1	Agnd	Agnd	3	Dgnd	1	-0.05	0.05
PS1	Chassis	Dgnd	1	Chassis	N/A	-0.05	0.05
PS2	+12	+12V Ret	6	+12V	7	11.75	12.5
PS2	+12V Ret	+12V Ret	6	Dgnd	1	-0.05	0.05

7.3.4 I²C Bus

Operation of the I²C bus can be verified by observing the behavior of D1 on the relay PCA. Assuming that the DC power supplies are operating properly, the I²C bus is operating properly if D1 is flashing and is not operating properly if D1 is not blinking (either solid off or solid lit).

7.3.5 TOUCHSCREEN INTERFACE

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

- The touch-screen controller may be malfunctioning.
- The internal USB bus may be malfunctioning.

You can verify this failure by logging on to the instrument using `or` a terminal program. If the analyzer responds to remote commands and the display changes accordingly, the touch-screen interface may be faulty.

7.3.6 LCD DISPLAY MODULE

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

7.3.7 RELAY PCA

The Relay PCA can be most easily checked by observing the condition of the status LEDs on the Relay PCA (see Section 7.2.2) and using the Utilities>Diagnostics>Digital Outputs menu to toggle each LED **ON** or **OFF**.

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

associated control device on the Relay PCA is bad. Several of the control devices are in sockets and can be easily replaced. Table 7-8 lists the control device associated with a particular function.

Table 7-8. Relay PCA Control Devices

FUNCTION	CONTROL DEVICE	IN SOCKET
UV Lamp Heater	Q2	No
O ₃ Gen Heater	Q3	No
All Valves	U5	Yes
AC Dry air Pump	K1	No
DC Photometer Pump	U1	No

7.3.8 PHOTOMETER O₃ GENERATOR PRESSURE/FLOW SENSOR ASSEMBLY

This assembly is only present in calibrators with O₃ generator and/or photometer installed. The pressure/flow sensor PCA, located at the rear of the instrument between the O₃ generator and the photometer pump (see Figure 2-3 for T703; see Figure 2-4 for T703U) can be checked with a voltmeter. The following procedure assumes that the wiring is intact and that the motherboard as well as the power supplies are operating properly:

7.3.8.1 BASIC PCA OPERATION

- Measure the voltage across C1 it should be 10 VDC ± 0.25 VDC. If not, then the board is bad.
- Measure the voltage between TP2 and TP1 C1. It should be 10 VDC ± 0.25 VDC. If not, then the board is bad.
- Measure the voltage across C2 it should be 5 VDC ± 0.25 VDC. If not, then the board is bad.

7.3.8.2 PHOTOMETER PRESSURE SENSOR

1. Measure the pressure on the inlet side of S1 with an external pressure meter.
2. Measure the voltage across TP4 and TP1.
 - The expected value for this signal should be:

$$\text{Expected mVDC} = \left(\frac{\text{Pressure}}{30.0_{\text{In-Hg-A}}} \times 4660_{\text{mVDC}} \right) + 250_{\text{mVDC}} \quad \pm 10\%_{\text{rdg}}$$

EXAMPLE. If the measured pressure is 20 In-Hg-A, the expected voltage level between TP4 and TP1 would be between 2870 mVDC and 3510 mVDC.

EXAMPLE. If the measured pressure is 25 In-Hg-A, the expected voltage level between TP4 and TP1 would be between 3533 mVDC and 4318 mVDC.

- If this voltage is out of range, then it could be that pressure transducer S1 is bad, that the board is bad, or that there is a pneumatic failure preventing the pressure transducer from sensing the absorption cell pressure properly.

7.3.8.3 O₃ GENERATOR PRESSURE SENSOR (GAUGE PRESSURE)

1. Measure the pressure on the inlet side of S2 with an external pressure meter.
2. Measure the voltage across TP5 and TP1.
 - The expected value for this signal should be:

$$\text{Expected mVDC} = \left(\frac{\text{Pressure}}{100_{\text{psig}}} \times 4250_{\text{mVDC}} \right) + 250_{\text{mVDC}} \pm 10\%_{\text{rdg}}$$

EXAMPLE: If the measured pressure is 25 psig, the expected voltage level between TP4 and TP1 would be between 1182 mVDC and 1444 mVDC.

EXAMPLE: If the measured pressure is 30 psig, the expected voltage level between TP4 and TP1 would be between 1373 mVDC and 1677 mVDC.

- If this voltage is out of range, then it could be that pressure transducer S1 is bad, that the board is bad, or that there is a pneumatic failure preventing the pressure transducer from sensing the absorption cell pressure properly.

7.3.8.4 PHOTOMETER FLOW SENSOR

1. Measure the voltage across TP3 and TP1.
 - With proper flow (800 cc/min through the photometer), this should be approximately 4.5V (this voltage will vary with altitude).
 - With flow stopped (photometer inlet disconnected or pump turned OFF) the voltage should be approximately 1V.
 - If the voltage is incorrect, it could be that the flow sensor S3 is bad, that the board is bad, or that there is a leak upstream of the sensor.

7.3.9 MOTHERBOARD

7.3.9.1 A/D FUNCTIONS

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

1. View the value of Ref 4096mV and of Ref Ground. If both are within 3 mV of nominal (4096 and 0), and are stable ± 0.5 mV, then the basic A/D is functioning properly. If not, then the motherboard is bad.
2. Alternatively, choose a parameter in the Utilities>Diagnostics>Analog Inputs menu.
 - Compare the voltage measured at its origin (see the interconnect drawing in Appendix B) with the voltage displayed on the front panel.
 - If the wiring is intact but there is a large difference between the measured and displayed voltage (± 10 mV) then the motherboard is bad.

7.3.9.2 ANALOG OUTPUTS VOLTAGE TEST

To verify that Analog Output 4, if configured, is working properly, connect a voltmeter to the rear panel ANALOG OUT connector and perform an output step test as follows:

1. Navigate to the Utilities>Diagnostics>Analog Outputs page.

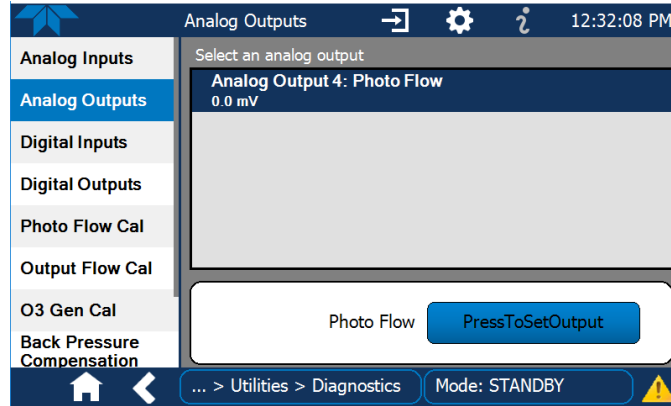


Figure 7-4. Analog Outputs Page Example

2. Press the “PresstoSetOutput” button.
3. Set the desired percent of the signal output in the numeric keypad that pops up, and press Enter.
4. Compare the value displayed in the Analog Output field to the voltmeter.

For each percentage set, the output should be within 1% of the nominal value. Use Table 7-9 as an example. Ensure to take into account any offset that may have been programmed into the analog output channel.

Table 7-9. Analog Output Test Function - Nominal Values Voltage Outputs

SIGNAL %	FULL SCALE OUTPUT OF VOLTAGE RANGE			
	100MV	1V	5V	10V
	NOMINAL OUTPUT VOLTAGE			
0	0	0	0	0
20	20 mV	0.2	1	2
40	40 mV	0.4	2	4
60	60 mV	0.6	3	6
80	80 mV	0.8	4	8
100	100 mV	1.0	5	10

If one or more of the readings fails to be within range, it is likely that there has been a failure of the either or both of the DACs and their associated circuitry on the motherboard.

7.3.9.3 DIGITAL (STATUS) OUTPUTS

To test the status output electronics:

1. Connect a jumper between the “D” pin and the “▽” pin on the rear panel STATUS output connector.
2. Connect a 1000 ohm resistor between the “+” pin and the pin corresponding to the status output that is being tested.
3. Connect a voltmeter between the “▽” pin and the pin of the output being tested (as mapped in the Setup>Digital Outputs menu).
4. Under the Utilities>Diagnostics menu, scroll through the inputs and outputs until you get to the output in question and observe whether it toggles ON or OFF.
5. Alternatively, highlight the Output in the Utilities>Diagnostics menu and toggle it ON or OFF while observing the voltage on the voltmeter. It should vary between 0 volts for ON and 5 volts for OFF.

7.3.9.4 DIGITAL CONTROL INPUTS

The rear panel CONTROL IN connectors correspond to the Digital Inputs panel in the Utilities>Diagnostics menu.

Table 7-10. Calibrator Control Input Pin Assignments and Digital Inputs Panel

CONNECTOR	INPUT	CORRESPONDING
Top	1	Control Input 01
Top	2	Control Input 02
Top	3	Control Input 03
Top	4	Control Input 04
Top	5	Control Input 05
Top	6	Control Input 06
Bottom	7	Control Input 07
Bottom	8	Control Input 08
Bottom	9	Control Input 09
Bottom	10	Control Input 10
Bottom	11	Control Input 11
Bottom	12	Control Input 12

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

EXAMPLE: to test the rear panel CONTROL IN pin “1”:

1. In the Utilities>Diagnostics>Digital Inputs menu view the output named Control Input 01.
2. Connect a jumper from the “+” pin on the appropriate connector to the “U” on the same connector.
3. Connect a second jumper from the “▽” pin on the connector to the “1” pin.
4. The status of Control Input 01 should change to read “ON”.

7.3.9.5 CONTROL OUTPUTS

To test the Control Output electronics:

1. Connect a jumper between the “E” pin and the “▽” pin on the status output connector.
2. Connect a 1000 ohm resistor between the “+” pin and the pin for the status output that is being tested.
3. Connect a voltmeter between the “▽” pin and the pin of the output being tested (see Table 7-11).
4. Scroll the Utilities>Diagnostics>Digital Outputs menu 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 7-11. Control Outputs Pin Assignments and Functions Check

PIN (LEFT TO RIGHT)	CORRESPONDING DIGITAL OUTPUTS
1	Control Output 01
2	Control Output 02
3	Control Output 03
4	Control Output 04
5	Control Output 05
6	Control Output 06
7	Control Output 07
8	Control Output 08
9	Control Output 09
10	Control Output 10
11	Control Output 11
12	Control Output 12

7.3.10 CPU

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

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

In some rare circumstances, this failure may be caused by a bad IC on the motherboard, specifically U57, the large, 44 pin device on the lower right hand side of the board. If this is true, removing U57 from its socket will allow the instrument to start up but the measurements will be invalid.

If the analyzer stops during initialization (the front panel display shows a fault or warning message), it is likely that the DOM, the firmware or the configuration and data files have been corrupted.

7.3.11 THE CALIBRATOR DOESN'T APPEAR ON THE LAN OR INTERNET

Most problems related to Internet communications via the Ethernet card will be due to problems external to the calibrator (e.g. bad network wiring or connections, failed routers, malfunctioning servers, etc.) However, there are several symptoms that indicate the problem may be with the Ethernet card itself.

If neither of the Ethernet cable's two status LED's (located on the back of the cable connector) is lit while the instrument is connected to a network:

- Verify that the instrument is being connected to an active network jack.
- Check the internal cable connection between the Ethernet card and the CPU board.

7.3.12 RS-232 COMMUNICATIONS

7.3.12.1 GENERAL RS-232 TROUBLESHOOTING

Teledyne API calibrators 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 2.3.1.7 for connector and pin-out information.
- The BAUD rate and protocol are incorrectly configured. See Section 2.6.11.1.
- If a modem is being used, additional configuration and wiring rules must be observed. See Section 2.6.11.1.
- Incorrect setting of the DTE-DCE Switch is set correctly. See Section 0.
- Verify that the cable (P/N 03596) that connects the serial COMM ports of the CPU to J12 of the motherboard is properly seated.

7.3.13 TEMPERATURE PROBLEMS

Individual control loops are used to maintain the set point of the Photometer UV Lamp (optional), and the Ozone Generator Lamp (optional). If any of these temperatures are out of range or are poorly controlled, the calibrator will perform poorly.

7.3.13.1 BOX / CHASSIS TEMPERATURE

The box temperature sensor can't be directly accessed with a voltmeter to check its resistance. Instead, the **Box Temp** voltage signal must be configured in the Setup>Analog Outputs>Analog Output Cfg menu first: Map the Signal Out field to Box Temp and scale it 0.0 degC (Min) to 100.0 degC (Max); set the Calibration type to AUTO. Start calibration in the Analog Output Cal menu. Compare the Home>Dashboard>Box Temp value to the Utilities>Diagnostics>Analog Outputs>Analog Output 4: Box Temp voltage. That voltage signal on a scale of 0 to 5,000 mV should be relative to the scaled temperature value. For example, at ~30°C (6-7° above room temperature) the signal should be ~1450 mV.

7.3.13.2 PHOTOMETER SAMPLE CHAMBER TEMPERATURE

In the Dashboard, the temperature of the gas in the photometer sample chamber (Photo Samp Temp) should read approximately 5.0°C higher than the Box Temp reading.

7.3.13.3 UV LAMP TEMPERATURE

There are three possible causes for the UV Lamp temperature to have failed.

- The UV Lamp heater has failed. Check the resistance between pins 5 and 6 on the six-pin connector adjacent to the UV Lamp on the Optical Bench.
 - It should be approximately 30 Ohms.
- Assuming that the I²C bus is working and that there is no other failure with the Relay board, the FET Driver on the Relay Board may have failed.
 - Using the PHOTO_LAMP HEATER parameter under the Signal I/O function of the Diag menu, as described above, turn on and off the UV Lamp Heater (D15 on the relay board should illuminate as the heater is turned on).
 - Check the DC voltage present between pin 1 and 2 on J13 of the Relay Board.
 - If the FET Driver has failed, there will be no change in the voltage across pins 1 and 2.
- If the FET Driver Q2 checks out OK, the thermistor temperature sensor in the lamp assembly may have failed.
 - Unplug the connector to the UV Lamp Heater/Thermistor PCB and measure the resistance of the thermistor between pins 5 and 6 of the 6-pin connector.
 - The resistance near the 58 °C set point is ~8.1k ohms.

7.3.13.4 OZONE GENERATOR TEMPERATURE

There are three possible causes for the Ozone Generator temperature to have failed.

- The O3 Gen heater has failed. Check the resistance between pins 5 and 6 on the six-pin connector adjacent to the UV Lamp on the O3 Generator. It should be approximately 5 Ohms.
- Assuming that the I²C bus is working and that there is no other failure with the Relay board, the FET Driver on the Relay Board may have failed. Using the O3 Gen Lamp Heater Control parameter in the Utilities>Diagnostics>Digital Outputs menu as described above, turn the UV Lamp Heater on and off. Check the DC voltage present between pin 1 and 2 on J14 of the Relay Board.

If the FET Driver has failed, there should be no change in the voltage across pins 1 and 2.

- If the FET Driver checks out OK, the thermistor temperature sensor in the lamp assembly may have failed. Unplug the connector to the Ozone Generator Heater/Thermistor PCB and measure the resistance of the thermistor between pins 5 and 6 of the 6-pin connector.

7.4 TROUBLESHOOTING THE O₃ PHOTOMETER

Issues with the O₃ photometer could be related to either dynamic functions or to Measure/Reference valve functions.

7.4.1 DYNAMIC PROBLEMS WITH THE O₃ PHOTOMETER

Dynamic problems are problems that only manifest themselves when the photometer is measuring O₃ concentration gas mixtures. These can be the most difficult and time consuming to isolate and resolve.

Since many photometer behaviors that appear to be a dynamic in nature are often a symptom of a seemingly unrelated static problems, it is recommended that dynamic problems not be addressed until all static problems, warning conditions and subsystems have been checked and any problems found are resolved.

Once this has been accomplished, the following most common dynamic problems should be checked.

7.4.1.1 NOISY OR UNSTABLE O₃ READINGS AT ZERO

- Check for leaks in the pneumatic system as described in Section 6.5.1.
- Confirm that the Zero gas is free of Ozone.
- Confirm that the Source Lamp is fully inserted and that the lamp hold-down thumb-screw is tight.
- Check for a dirty Absorption Cell and/or pneumatic lines. Clean as necessary as described in Section 6.5.2.
- Disconnect the exhaust line from the optical bench (the pneumatic line at the lamp end of the bench) and plug the port in the bench. If readings remain noisy, the problem is in one of the electronic sections of the instrument. If readings become quiet, the problem is in the instrument's pneumatics.

7.4.1.2 NOISY, UNSTABLE, OR NON-LINEAR SPAN O₃ READINGS

- Check for leaks in the pneumatic systems as described in Section 6.5.1.
- Check for proper operation of the meas/ref switching valve as described in Section 7.4.2.
- Check for dirty absorption cell and clean or replace as necessary as described in Section 6.5.2.
- Check for operation of the A/D circuitry on the motherboard. See Section 7.3.9.1.
- Confirm the Sample Temperature, Sample Pressure and Sample Flow readings are correct. Check and adjust as required.

7.4.1.3 SLOW RESPONSE TO CHANGES IN CONCENTRATION

- Check for dirty absorption cell and clean or replace as necessary as described in Section 6.5.2.
- Check for pneumatic leaks as described in Section 6.5.1.
- The photometer needs 800 cm³/min of gas flow. Ensure that this is accounted for when calculating total required output flow for the calibrator (see Section 2.4.5).

7.4.1.4 THE ANALOG OUTPUT SIGNAL LEVEL DOES NOT AGREE WITH FRONT PANEL READINGS

- Confirm that the recorder offset (see Section 2.6.9.2) is set to zero.
- Perform an Analog Output calibration (see Section 2.6.9.3).

7.4.1.5 CANNOT ZERO

- Check for leaks in the pneumatic system as described in Section 6.5.1.
- Confirm that the Zero gas is free of Ozone.
- The photometer needs 800 cm³/min of gas flow. Ensure that this is accounted for when calculating total required output flow for the calibrator (see Section 2.4.5).

7.4.1.6 CANNOT SPAN

- Check for leaks in the pneumatic systems as described in Section 6.5.1.
- Check for dirty absorption cell and clean or replace as necessary as described in Section 6.5.2.
- Check for operation of the A/D circuitry on the motherboard. See Section 7.3.9.1.
- Confirm the Sample Temperature, Sample Pressure and Sample Flow readings are correct. Check and adjust as required.
- The photometer needs 800 cm³/min of gas flow. Ensure that this is accounted for when calculating total required output flow for the calibrator (see Section 2.4.5).

7.4.2 CHECKING THE MEASURE / REFERENCE VALVE

To check the function of the photometer's measure / reference valve:

1. View the Dashboard parameter, O3 Ref (configure via Setup>Dashboard if needed).
2. Feed zero gas and wait for stability.
3. Note the O3 Ref value.
4. Feed span gas and wait for stability.
5. Note the O3 Ref value.
6. If there is a difference between the two values of more than 1 mV, then call Technical Support to replace the valve.

7.5 TROUBLESHOOTING THE O₃ GENERATOR

Troubleshooting the O₃ generator differs between the T703 (Section 7.5.1) and the T703U (Section 7.5.2).

7.5.1 TROUBLESHOOTING THE O₃ GENERATOR IN THE T703



WARNING

Hazardous voltage present - use caution.

It is not always possible to determine with certainty whether a problem is the result of the UV Lamp or the Lamp Power Supply, however, the steps presented here will provide a reasonable confidence test of the Lamp Power Supply.

1. Ensure that the calibrator is in STANDBY mode.
2. Unplug the cable connector at P1 on the Lamp Power Supply and confirm that +15VDC is present between Pins 1 and 2 on the cable connector.
3. If this voltage is incorrect, check the DC test points on the Relay PCA as described in Section 7.3.3.
4. Begin generating O₃.
5. Navigate to the Dashboard and note the reading for the O₃ Gen Drive (if needed, configure the Dashboard to display it).
6. Remove the cover of the photometer and check for the presence of the following voltages on the UV lamp power supply PCA:
 - The reading between TP1 and TP4 (grnd) should match the Dashboard's reading for O₃ Gen Drive, ± 10 mVDC.
 - If this voltage is incorrect, either the UV lamp Power Supply PCA is faulty or the I²C bus is not communicating with the UV lamp power supply PCA.
 - A reading between TP3 and TP4 (grnd) should be +5VDC
 - If this voltages is less than 4.8 or greater than 5.25 either the 5 VDC power supply or the UV lamp power supply PCA are faulty.

If the above voltages check out, it is more likely that a problem is due to the UV lamp than due to the Lamp Power Supply. Replace the UV lamp and if the problem persists, replace the Lamp Power Supply.

7.5.2 TROUBLESHOOTING THE O₃ GENERATOR IN THE T703U

There is some difference in troubleshooting the O₃ generator for the T703U:

1. Make sure the calibrator is idling in Standby mode.
2. Unplug the cable connector at P1 on the Lamp Power Supply and confirm that +15VDC is present between Pins 1 and 2 on the cable connector.
3. If this voltage is incorrect, check Relay PCA DC test points (Section 7.3.3).
4. Remove the cover of the photometer (see Figure 8-21) and check for the presence of the following voltages on the UV lamp power supply PCA:
 - +800 mVDC \pm 10 mVDC between TP1 and TP4 (grnd)
If this voltage is incorrect, either the UV lamp power supply PCA is faulty or the I²C bus is not communicating with the UV lamp power supply PCA.
 - +5VDC between TP3 and TP4 (grnd)
If this voltages is less than 4.8 or greater than 5.25, either the 5 VDC power supply or the UV lamp power supply PCA are faulty.

If the above voltages check out, it is more likely that a problem is due to the UV Lamp than due to the Lamp Power Supply. Replace the UV Lamp and if the problem persists, replace the Lamp Power Supply.

7.6 SERVICE PROCEDURES

7.6.1 SERVICING THE SAMPLE FLOW CONTROL ASSEMBLY

The critical flow orifice is housed in the flow control assembly located on the top of the optical bench. A sintered filter protects the jewel orifice so it is unusual for the orifice to need replacing, but if it does, or the filter needs replacement please use the following procedure (contact Technical Support for parts and kits):

1. Turn off power to the calibrator.
2. Locate the assembly to be repaired, see Figure 7-5 (T703) or Figure 7-6 (T703U).
3. Disconnect the pneumatic connection from the flow assembly.
4. Remove the fitting and the components as shown in the exploded view in Figure 7-7.
5. Replace the o-rings (p/n OR000001) and the sintered filter (p/n FL000001).
6. If replacing the critical flow orifice itself (P/N 000941000), make sure that the side with the colored window (usually red) is facing downstream to the gas flow.
7. Apply new Teflon[®] tape to the male connector threads.
8. Reassemble in reverse order.

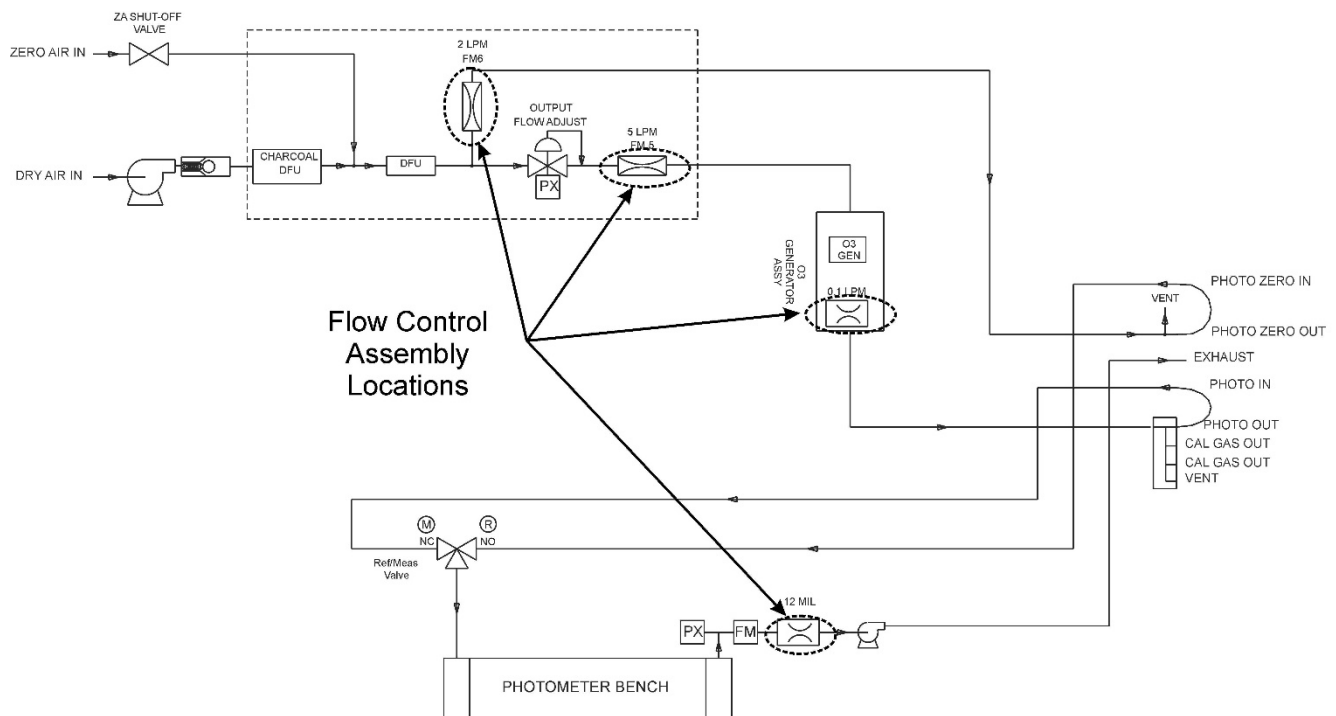


Figure 7-5. Location of Gas Flow Control Assemblies - T703

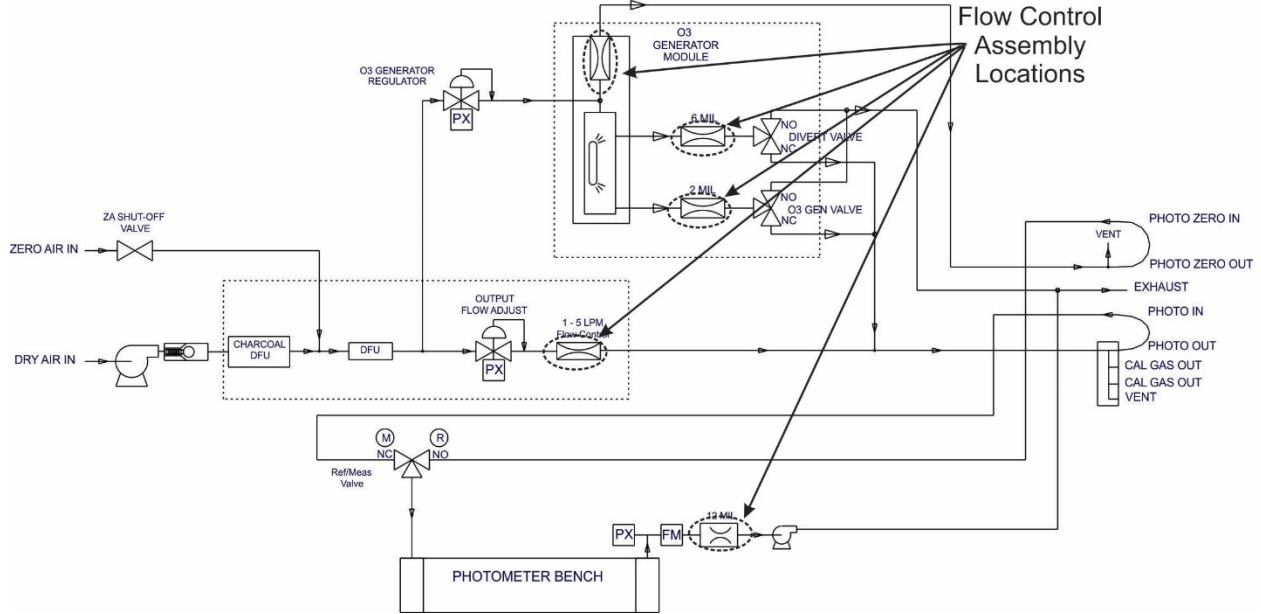


Figure 7-6. Location of Gas Flow Control Assemblies - T703U

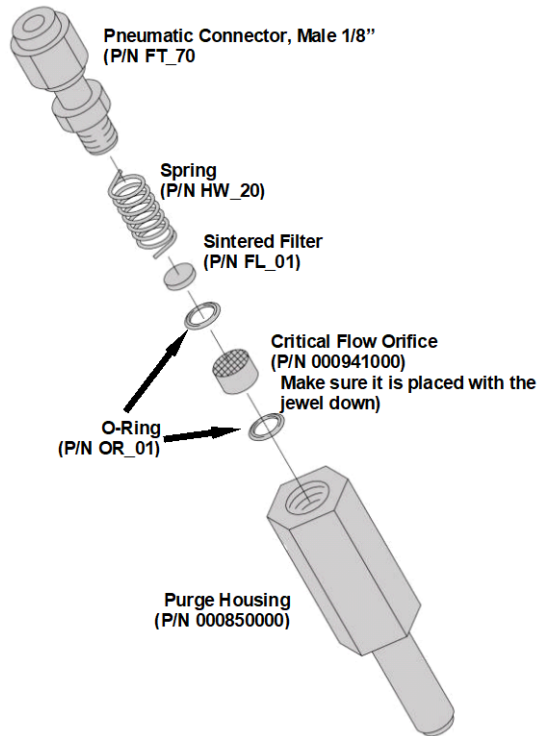


Figure 7-7. Critical Flow Restrictor Assembly Disassembly

7.6.2 REPLACING THE DISK-ON-MODULE

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

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

7.7 TECHNICAL ASSISTANCE

If this manual and its Service Section do not solve your problems, technical assistance may be obtained from Teledyne API, Technical Support:

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

7.8 FREQUENTLY ASKED QUESTIONS (FAQS)

The following list of FAQs is from the Teledyne API's Technical Support Department's most commonly asked questions relating to the Dynamic Dilution Calibrator.

QUESTION	ANSWER
My ozone reading is not what I should expect - why?	Look at the Photo Ref/Meas. These are most likely too low and need to be adjusted up to 4500mV. Another possible cause would be no gas flow to the photometer causing the O ₃ reading to be out of range - low
When I generate ozone, it takes a long time to settle out, or it fluctuates around the value until finally stabilizing.	Perform an O ₃ Gen Adjust (Section 6.5.6), and then an O ₃ Gen Calibration (Section 5.5). Re-run points.
Why do some buttons appear grayed out or disappear?	They are deactivated until applicable.
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 (Section 2.3.1.7 under RS-232 COM Port Connector Pin-outs). The DCE/DTE switch on the back of the analyzer is not set properly; ensure that both green and red lights are on (Section 0). The baud rate of the analyzer's COM port does not match that of the serial port of your computer/data logger.
When should I change the sintered filter(s) in the calibrator's critical flow orifice(s) and how do I change them?	The sintered filters do not require regular replacement. Should one require replacement as part of a troubleshooting or repair exercise, contact Technical Support.
How often should I rebuild the photometer pump on my calibrator?	It does not require rebuilding; the entire pump should be replaced every two years.
How long do the UV lamps of the optional O ₃ generator and photometer last?	The typical lifetime is about 2-3 years.

8. PRINCIPLES OF OPERATION

This section describes the instrument's pneumatic operation (Section 8.1), the electronic operation (Section 8.2), and then principles behind the O₃ generator operation (Section 8.5) and the Photometer operation (Section 8.6).

8.1. PNEUMATIC OPERATION

8.1.1. GAS FLOW

Gas flow rates are set by various flow control assemblies in the gas stream(s); each of the assemblies includes a critical flow orifice to regulate the flow.

8.1.2. PHOTOMETER CRITICAL FLOW ORIFICE

Critical flow orifices operate without moving parts by taking advantage of the laws of fluid dynamics. By restricting the flow of gas through the orifice, a pressure differential is created. This pressure differential combined with the action of the calibrator's pump draws the gas through the orifice.

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

The actual flow rate of gas through the orifice (volume of gas per unit of time), depends on the size and shape of the aperture in the orifice. The larger the hole, the more gas molecules, moving at the speed of sound, pass through the orifice.

8.1.3. INTERNAL GAS PRESSURE SENSORS

There are two pressure sensors in the T703/T703U: one for the regulator and one for the photometer. A 100 psig pressure sensor monitors the downstream regulator pressure, and a 0-15 psia (absolute pressure) range sensor measures the pressure of gas in the photometer's absorption tube. The data are used by the CPU when calculating the O₃ concentration inside the absorption tube.

8.2. ELECTRONIC OPERATION

8.2.1. OVERVIEW

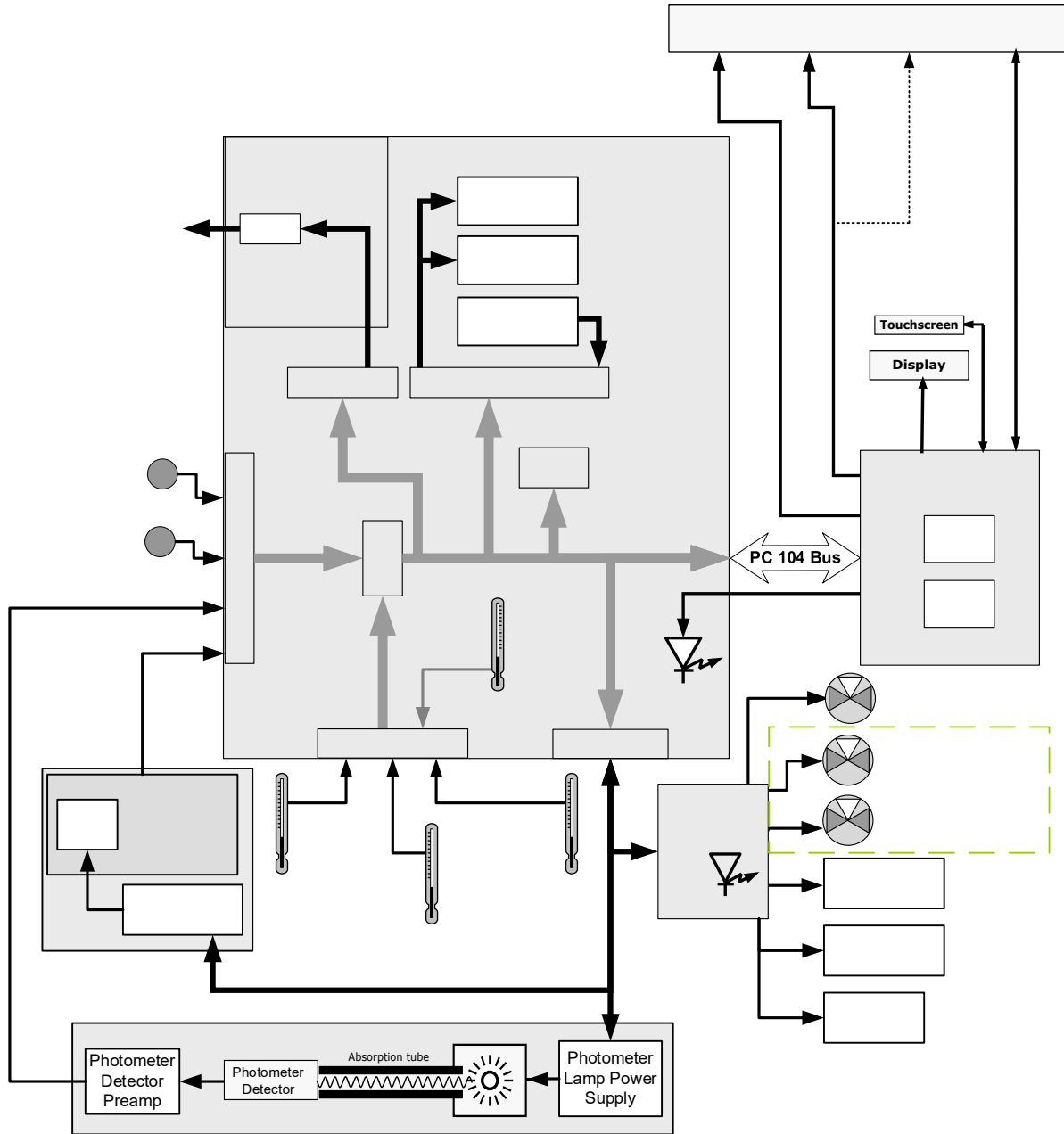


Figure 8-1. Electronic Block Diagram

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

The motherboard is directly mounted to the inside rear panel and collects data, performs signal conditioning duties and routes incoming and outgoing signals between the CPU and the calibrator's other major components.

Data are generated by the various sub components of the T703; analog signals are converted into digital data by a unipolar, analog-to-digital converter, located on the motherboard.

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

8.2.2. CENTRAL PROCESSING UNIT (CPU)

The unit's CPU card (Figure 8-2) is installed on the motherboard located inside the rear panel. It is a low power (5 VDC, 720mA max), high performance, Vortex 86SX-based microcomputer running Windows CE. Its operation and assembly conform to the PC-104 specification.

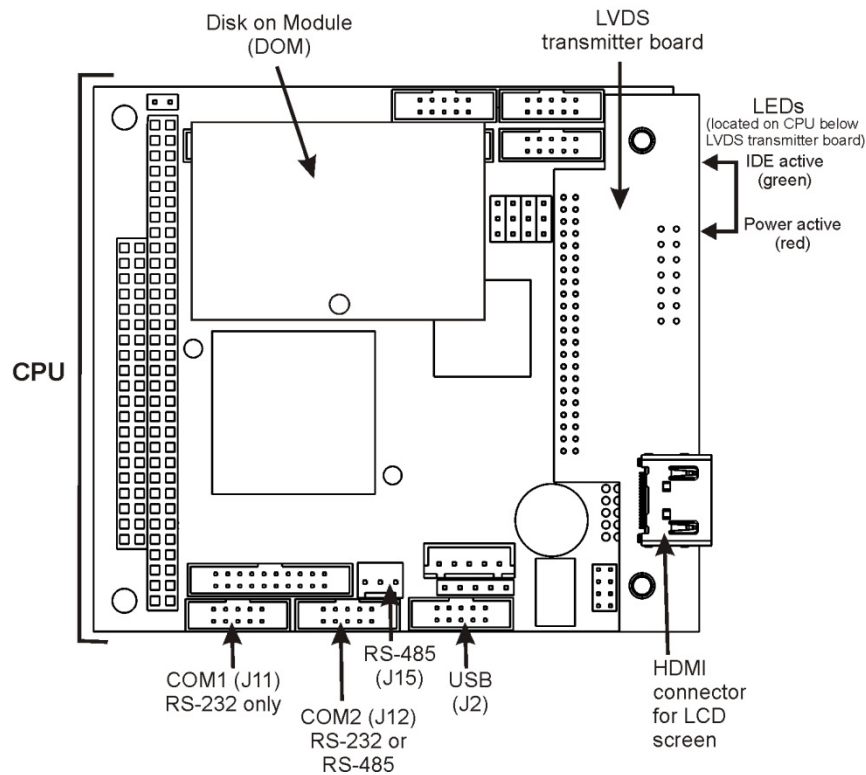


Figure 8-2. CPU Board Annotated

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



8.2.2.1. DISK ON MODULE (DOM)

The DOM is a 44-pin IDE flash chip with a storage capacity up to 256 MB. It is used to store the computer's operating system, the Teledyne API firmware, and most of the operational data.

8.2.2.2. FLASH CHIP

This non-volatile, embedded flash chip includes 2MB of storage for calibration data as well as a backup of the calibrator's configuration. Storing these key data onto a less frequently accessed chip significantly decreases the chance of data corruption.

In the unlikely event that the flash chip should fail, the calibrator will continue to operate with just the DOM. However, all configuration information will be lost, requiring the unit to be recalibrated.

8.2.3. RELAY PCA

The relay board is one of the central switching and power distribution units of the calibrator. It contains power relays, valve drivers and status LEDs for all heated zones and valves, as well as thermocouple amplifiers, power distribution connectors and the two switching power supplies of the calibrator. The relay board communicates with the motherboard over the I²C bus. Its status indicators and components can be used for troubleshooting power problems and valve or heater functionality.

Generally, the relay PCA is located in the right-rear quadrant of the calibrator and is mounted vertically on the backside of the same bracket as the instrument's DC power supplies, however the exact location of the relay PCA may differ from model to model.

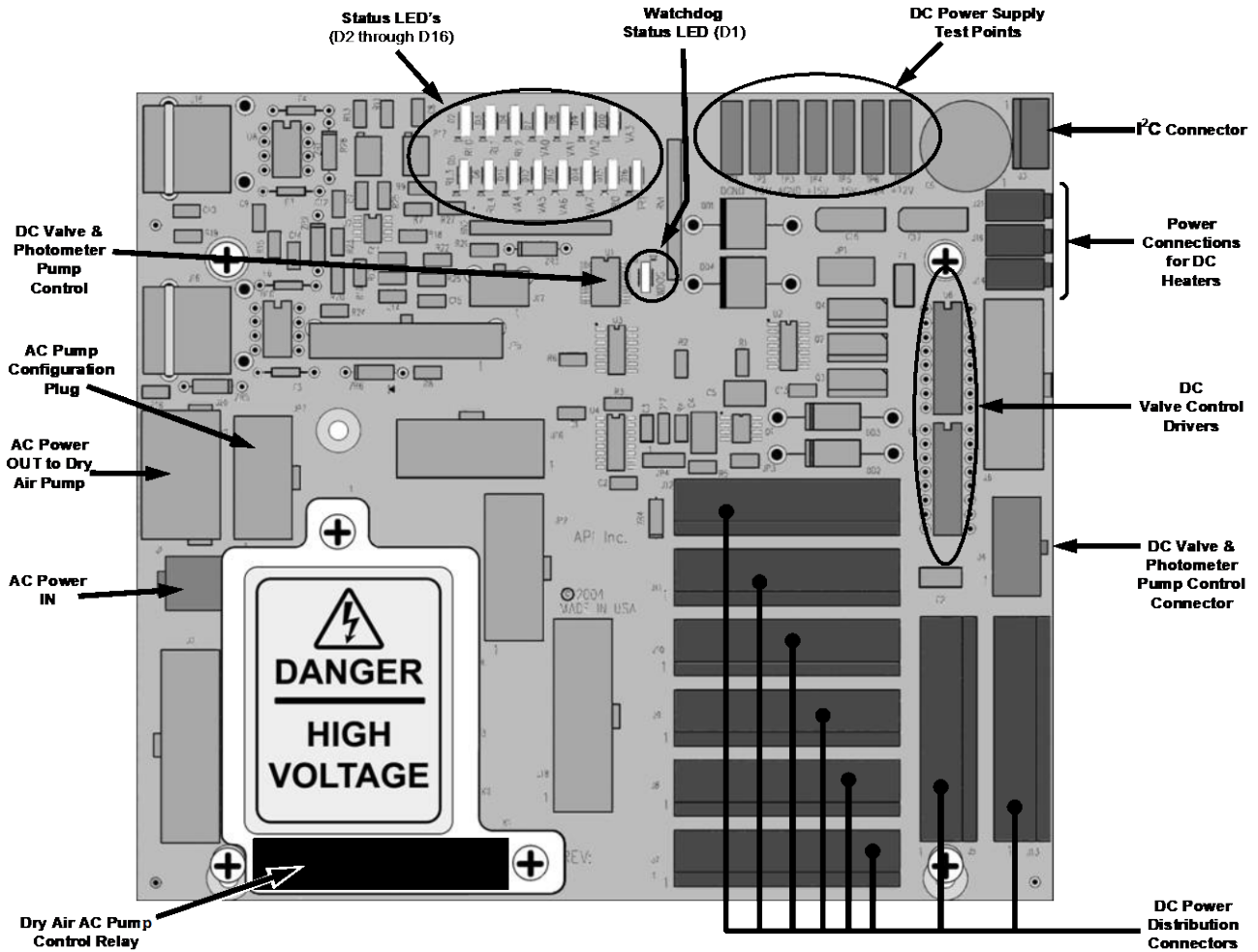


Figure 8-3. Relay Board PCA with AC Relay Retainer Removed

This version of the Relay PCA includes one AC relay that controls the AC-powered Dry Air (zero air) pump. A plastic insulating safety shield covers the remaining empty AC Relay sockets.



WARNING – RISK OF ELECTRICAL SHOCK

Never remove this safety shield while the instrument is plugged in.
The contacts of the AC relay sockets beneath the shield carry high AC voltages even when no relays are present.

8.2.3.1. VALVE CONTROL

The relay board also hosts two valve driver IC's, each of which can drive up four valves. In the T703, the relay PCA controls only those valves associated with the O₃ generator and photometer.

In the T703U, the relay PCA controls two additional valves: the Divert valve and the O₃ Gen valve.

8.2.3.2. HEATER CONTROL

The relay PCA controls the DC heaters for the O₃ generator and photometer lamp housing.

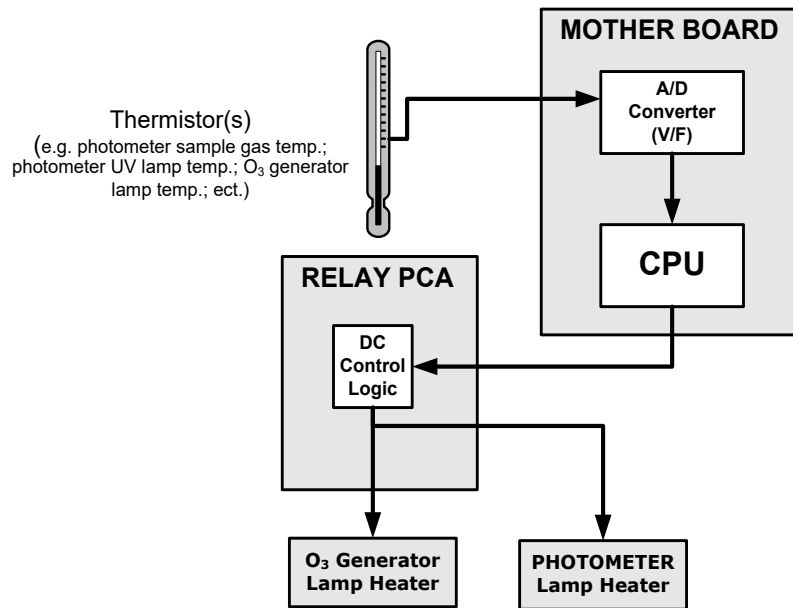


Figure 8-4. Heater Control Loop Block Diagram.

8.2.3.3. RELAY PCA STATUS LEDs AND WATCH DOG CIRCUITRY

Sixteen LEDs are located on the calibrator's relay board (Figure 8-5) to indicate the status of the calibrator's heating zones and some of its valves; included is a general operating watchdog indicator. Table 8-1 shows the states of these LEDs and their respective functionality. Not all LEDs are used.

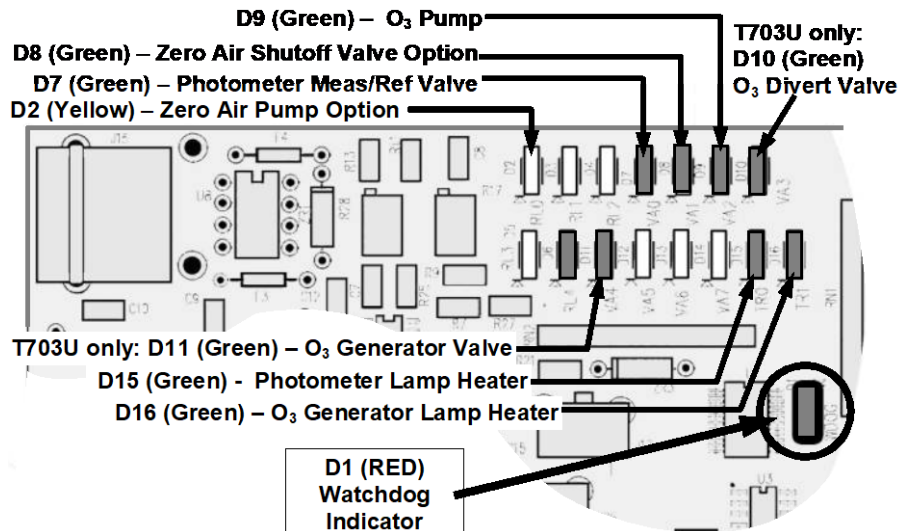


Figure 8-5. Status LED Locations - Relay PCA

TABLE 8-1. RELAY BOARD STATUS LEDS

LED	COLOR	DESCRIPTION	FUNCTION/INDICATION
D1	Red	Watchdog Circuit; I ² C bus operation.	Blinks when I ² C bus is operating properly
D2	Yellow	Zero Air Pump (option) Status	When lit the zero air AC pump is running.
D3-6	SPARE		
D7	Green	Photometer Meas/Ref Valve Status	When lit the valve open to the Measure gas path; when not lit while instrument is running, the valve is open to the Reference gas path.
D8	Green	Zero Air Shutoff Valve (option) Status	When lit, ZA shutoff valve open.
D9	Green	O ₃ Pump Status	When lit, O ₃ pump running
D10	Green	T703U Divert Valve Status	when lit, divert valve open.
D11	Green	T703U O ₃ Generator Valve Status	When lit, O ₃ generator valve open.
D12 - 14	SPARE		
D15	Green	Photometer Lamp Heater Status	When lit the photometer UV lamp heater is on
D16	Green	O ₃ Generator Lamp Heater	When lit the O ₃ generator UV lamp heater is on

8.2.3.4. RELAY PCA WATCHDOG INDICATOR (D1)

The most important of the status LEDs on the relay board is the red I²C Bus watchdog LED. It is controlled directly by the calibrator's CPU over the I²C bus. Special circuitry on the relay PCA watches the status of D1. Should this LED ever stay ON or OFF for 30 seconds (indicating that the CPU or I²C bus has stopped functioning) this Watchdog Circuit automatically shuts all valves and turns off all heaters and lamps.

8.2.4. MOTHERBOARD

This is the largest electronic assembly in the calibrator and is mounted to the rear panel as the base for the CPU board and all I/O connectors. This printed circuit assembly provides a multitude of functions including A/D conversion, digital input/output, PC-104 to I²C translation, temperature sensor signal processing and is a pass through for the RS-232 and RS-485 signals.

8.2.4.1. A TO D CONVERSION

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

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

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

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

8.2.4.2. SENSOR INPUTS

The key analog sensor signals are coupled to the A/D converter through the master multiplexer from two connectors on the motherboard. Terminating resistors (100 k Ω) on each of the inputs prevent cross talk between the sensor signals.

8.2.4.3. THERMISTOR INTERFACE

This circuit provides excitation, termination and signal selection for several negative-coefficient, thermistors (temperature sensors) located inside the calibrator.

8.2.4.4. ANALOG OUTPUTS

The calibrator comes equipped with one analog output. It can be set by the user to carry the current signal level of any one of the parameters (see Table 7-4) and will output an analog VDC signal that rises and falls in relationship with the value of the parameter.

8.2.4.5. EXTERNAL DIGITAL I/O

The external digital I/O performs two functions.

The **STATUS** outputs carry logic-level (5V) signals through an optically isolated 8-pin connector on the rear panel of the calibrator. These outputs convey on/off information about certain calibrator conditions such as **CONC VALID**. They can be used to interface with certain types of programmable devices.

The **CONTROL** outputs can be used to initiate actions by external peripheral devices in conjunction with individual steps of a calibration sequence.

The **CONTROL** inputs can be initiated by applying 5V DC power from an external source such as a PLC or data logger. Zero and span calibrations can be initiated by contact closures on the rear panel.

8.2.4.6. I²C DATA BUS

I²C is a two-way, clocked, bi-directional, digital serial I/O bus that is used widely in commercial and consumer electronic systems. A transceiver on the motherboard converts data and control signals from the PC-104 bus to I²C. The data is then fed to the relay board, optional analog input board and valve driver board circuitry.

8.2.4.7. POWER-UP CIRCUIT

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

8.2.5. POWER SUPPLY AND CIRCUIT BREAKER

The calibrator operates in two main AC power ranges: 100-120 VAC and 220-240 VAC (both $\pm 10\%$) between 47 and 63 Hz. A 5 ampere circuit breaker is built into the ON/OFF switch. In case of a wiring fault or incorrect supply power, the circuit breaker will automatically turn off the calibrator.

Note

The calibrator is equipped with a universal power supply that allows it to accept any AC power configuration, within the limits specified in Table 2-2.



CAUTION

Should the power circuit breaker trip, correct the condition causing this situation before turning the calibrator back on.

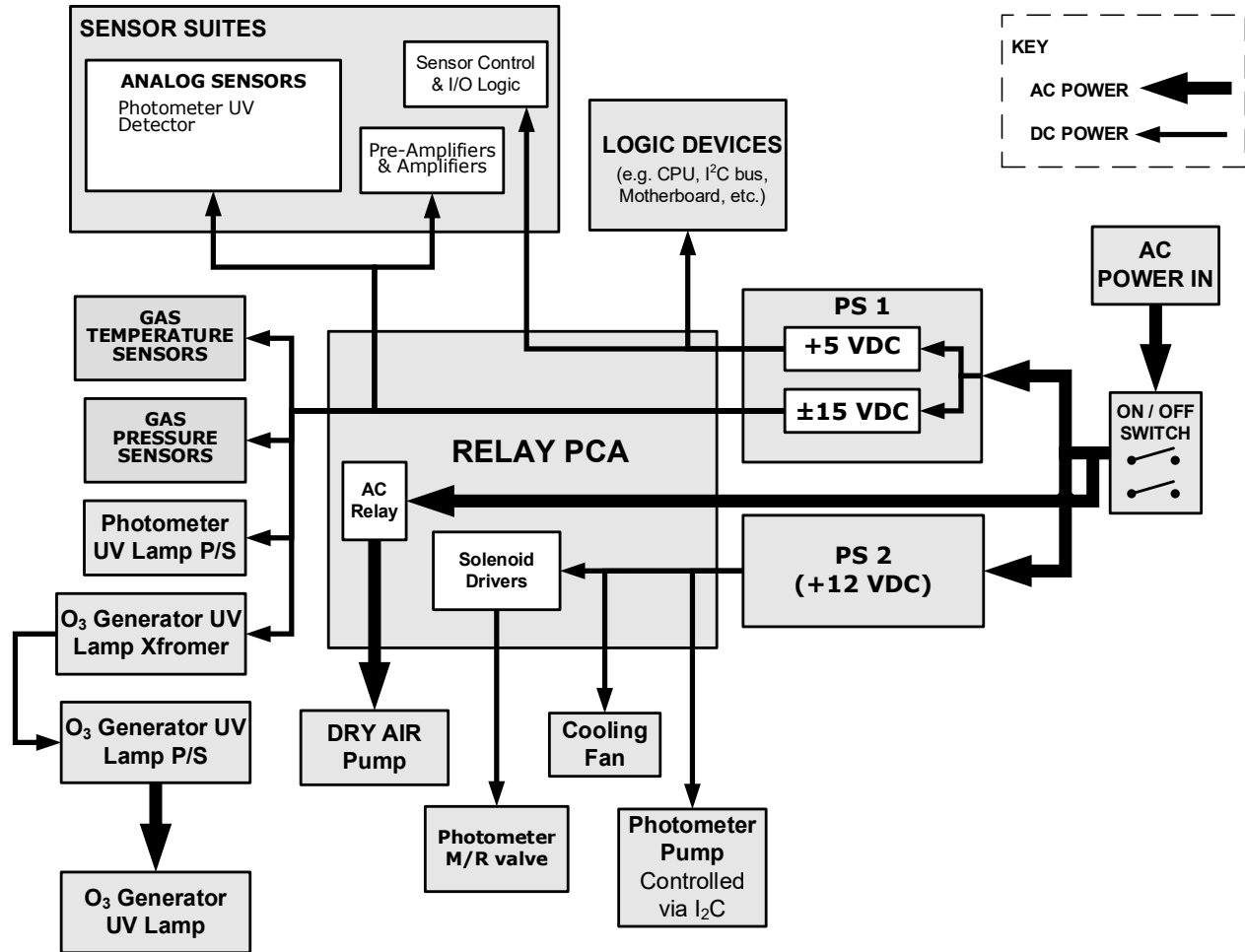


Figure 8-6. Power Distribution Block diagram

8.2.6. AC POWER CONFIGURATION

The digital electronic systems will operate with any of the specified power regimes. As long as instrument 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.

On the other hand, in some of the calibrators the internal dry air pump must be properly configured (Section 8.2.6.1) for the type of power being supplied to the instrument.

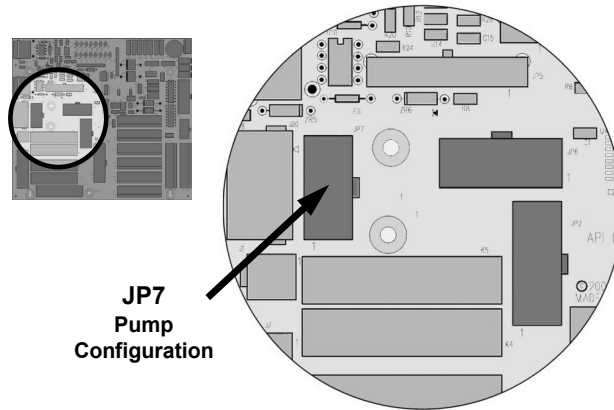


Figure 8-7. Location of the AC Configuration Jumper for the Dry Air Pump

8.2.6.1. AC CONFIGURATION – INTERNAL PUMP (JP7)

AC power configuration for the internal dry air pump is set using Jumper set JP7.

Table 8-2. AC Power Configuration for Internal Pumps (JP7)

LINE POWER	LINE FREQUENCY	JUMPER COLOR	FUNCTION	JUMPER BETWEEN PINS
110VAC 115 VAC	60 HZ	WHITE	Connects pump pin 3 to 110 / 115 VAC power line	2 to 7
			Connects pump pin 3 to 110 / 115 VAC power line	3 to 8
			Connects pump pins 2 & 4 to Neutral	4 to 9
	50 HZ ¹	BLACK	Connects pump pin 3 to 110 / 115 VAC power line	2 to 7
			Connects pump pin 3 to 110 / 115 VAC power line	3 to 8
			Connects pump pins 2 & 4 to Neutral	4 to 9
220VAC 240 VAC	60 HZ	BROWN	Connects pump pins 3 and 4 together	1 to 6
			Connects pump pin 1 to 220 / 240VAC power line	3 to 8
	50 HZ ¹	BLUE	Connects pump pins 3 and 4 together	1 to 6
			Connects pump pin 1 to 220 / 240VAC power line	3 to 8

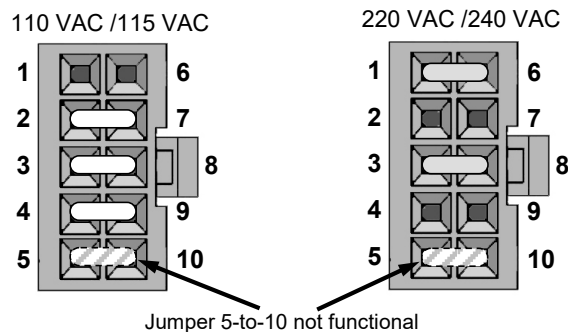


Figure 8-8. Pump AC Power Jumpers (JP7)

8.3. FRONT PANEL TOUCHSCREEN/DISPLAY INTERFACE

The most commonly used method for communicating with the T703/T703U Dynamic Dilution Calibrator is via the instrument's front panel LCD touchscreen display. The LCD display is controlled directly by the CPU board. The touchscreen is interfaced to the CPU by means of a touchscreen controller that connects to the CPU via the internal USB bus and emulates a computer mouse.

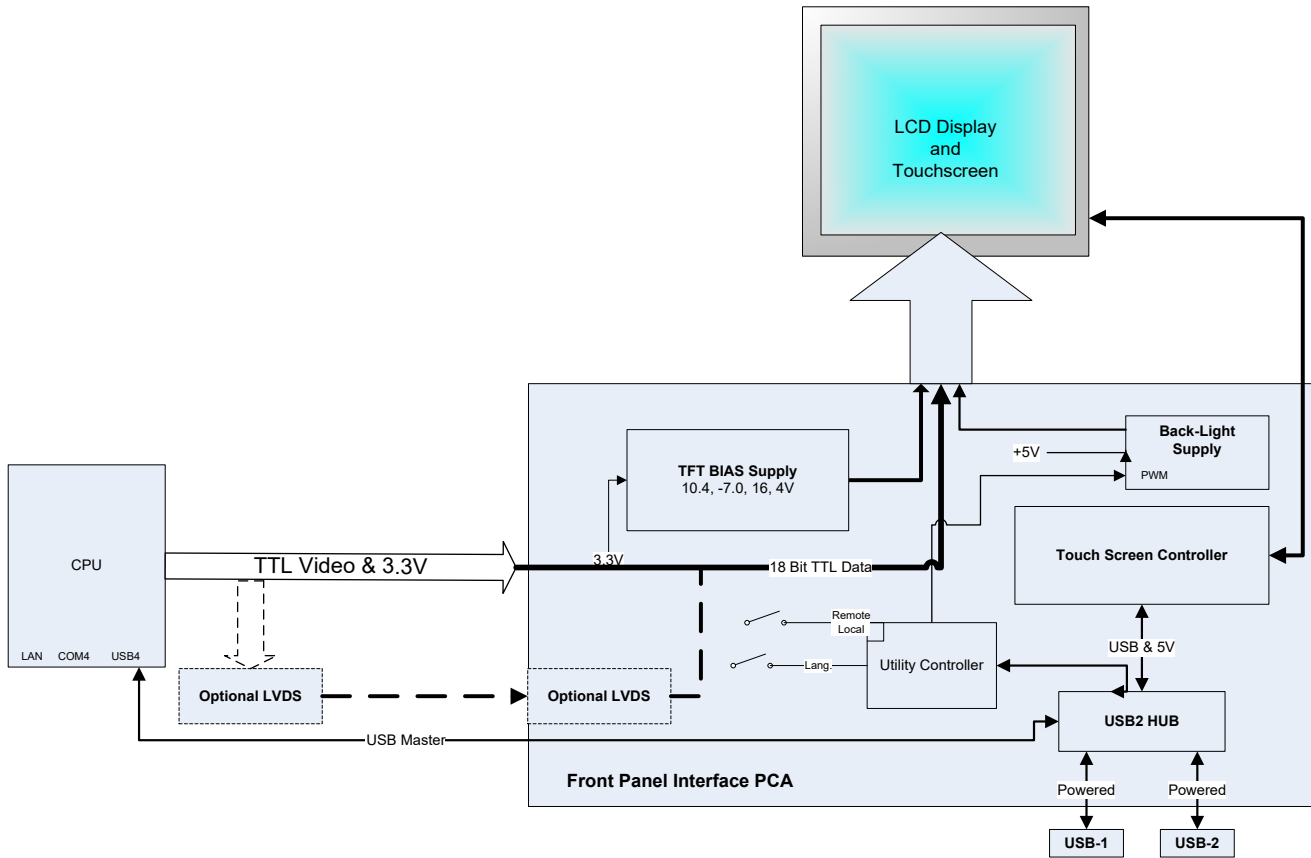


Figure 8-9. Front Panel Layout

The LCD display is controlled directly by the CPU board. The touchscreen is interfaced to the CPU by means of a touchscreen controller that connects to the CPU via the internal USB bus and emulates a computer mouse.

8.3.1 FRONT PANEL INTERFACE PCA

The front panel interface PCA controls the various functions of the display and touchscreen. For driving the display, this board provides connectivity between the CPU video controller and the LCD display module. In addition, it contains:

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

8.4. SOFTWARE OPERATION

The calibrator’s core module is a high performance, Vortex 86SX-based microcomputer running Windows CE. Inside Windows CE, special software developed by Teledyne API interprets user commands from the various interfaces, performs procedures and tasks, stores data in the CPU’s various memory devices, and calculates the concentration of the gas being sampled.

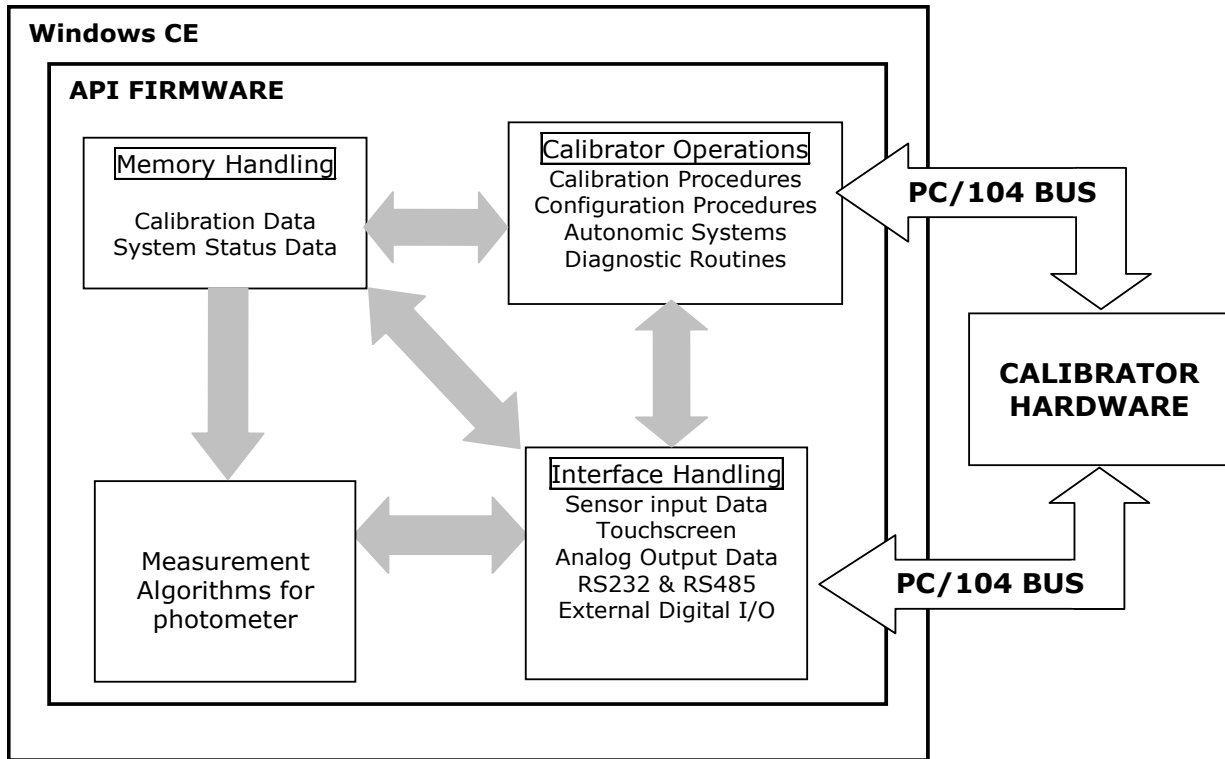


Figure 8-10. Schematic of Basic Software Operation

8.5. O₃ GENERATOR OPERATION

8.5.1. PRINCIPLE OF PHOTOLYTIC O₃ GENERATION

The two main principles of ozone generation are UV-light and corona discharge. The T703/T703U calibrator employs the UV-light method to produce low, accurate concentrations of the desired ozone. An ultra-violet lamp inside the generator emits a precise wavelength of UV Light (185 nm). Ambient air is passed over the lamp, splitting some of the air's molecular oxygen (O₂) into individual oxygen atoms (O) that attach to other remaining oxygen molecules (O₂), forming ozone (O₃).

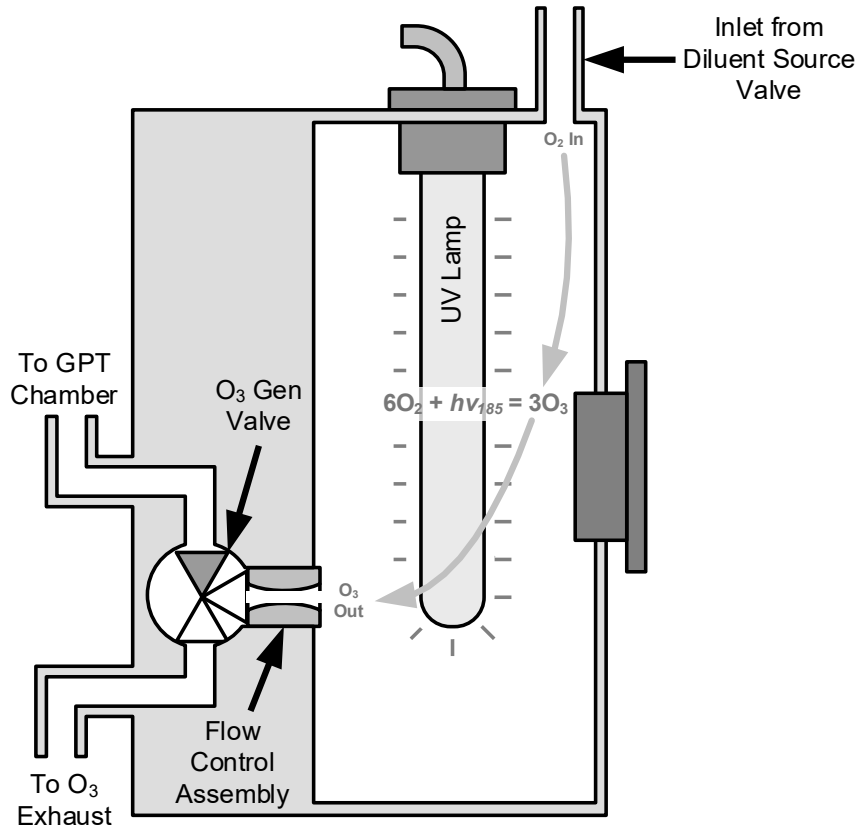


Figure 8-11. O₃ Generator Internal Pneumatics

8.5.2. O₃ GENERATOR PNEUMATIC OPERATION

The rate of flow through the O₃ generator is controlled by a flow control assembly located on the Regulator Sub-Assembly in the front of the calibrator.

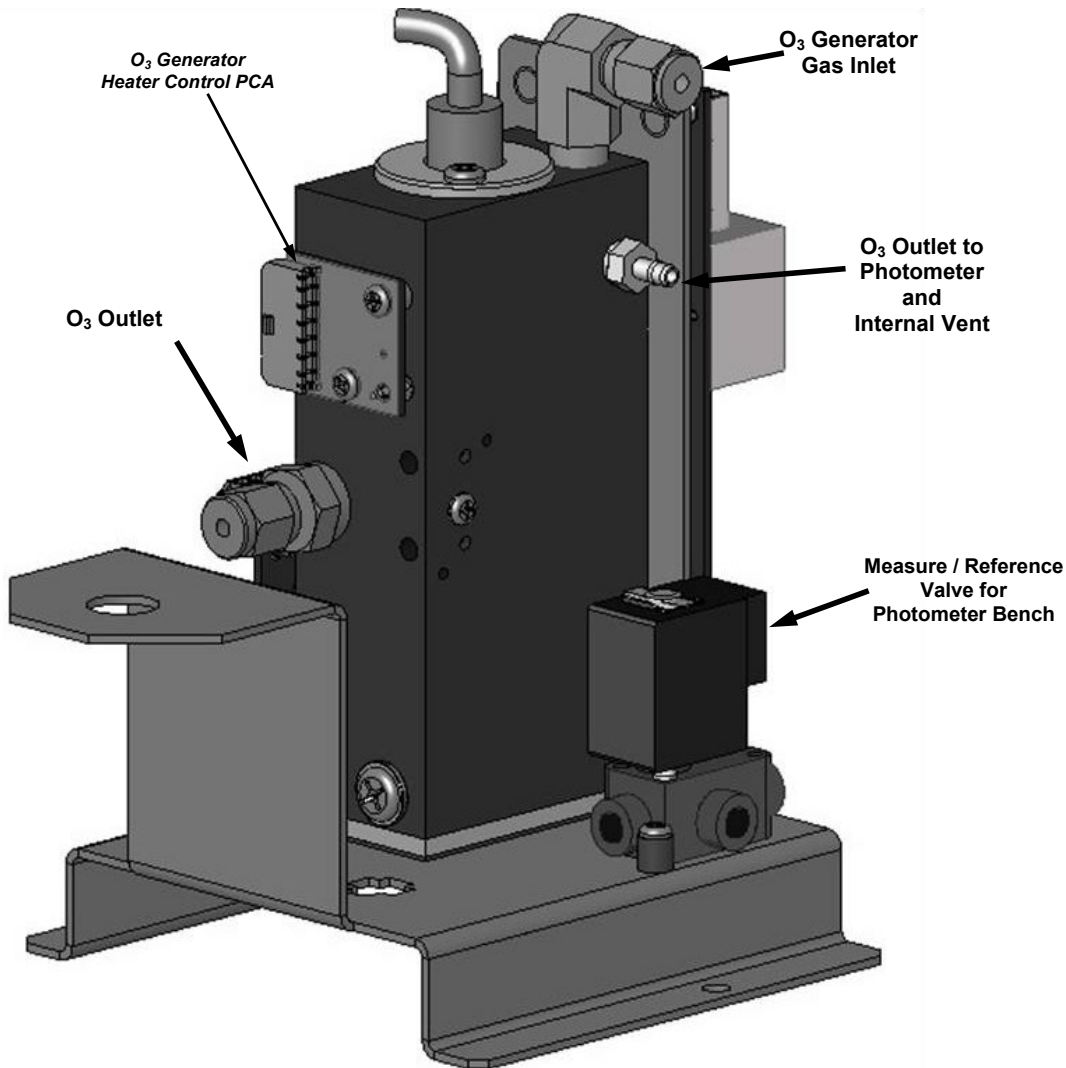


Figure 8-12. O₃ Generator Valve and Gas Fixture Locations

8.5.3. O₃ GENERATOR ELECTRONIC OPERATION

Electronically the O₃ generator and its subcomponents act as peripheral devices operated by the CPU via the motherboard. Sensor signals, such as the UV lamp thermistor are routed to the motherboard, where they are digitized. Digital data is sent by the motherboard to the calibrator's CPU and where required stored in either flash memory or on the CPU's disk-on-chip. Commands from the CPU are sent to the motherboard and forwarded to the various devices via the calibrator's I²C bus.

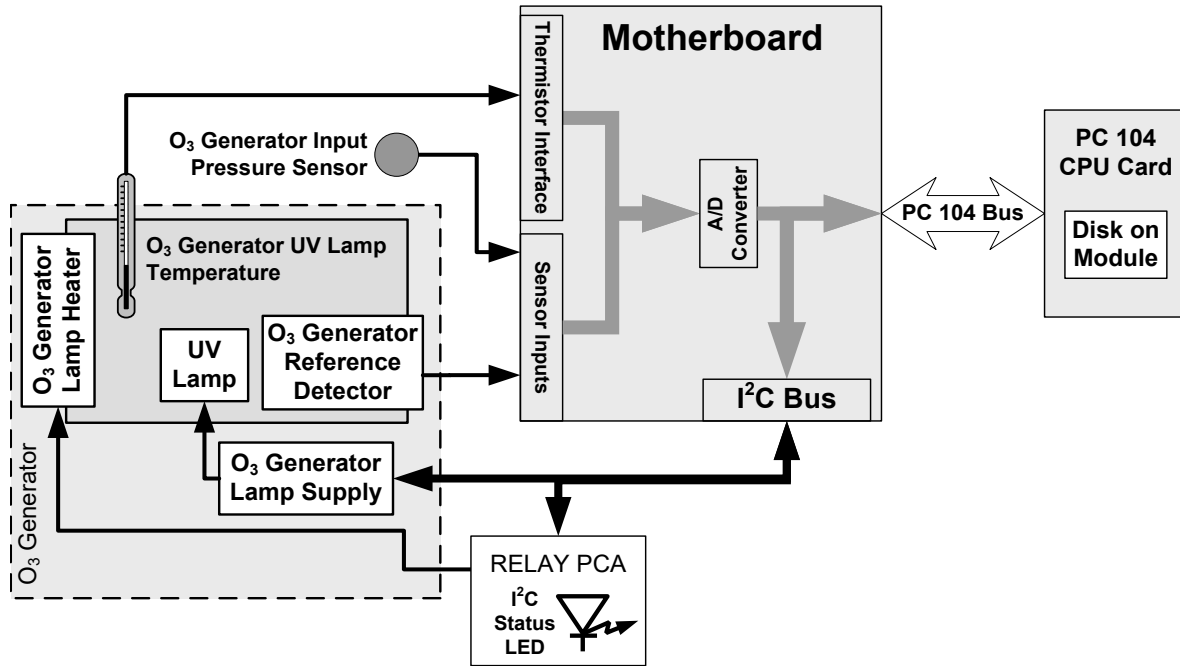


Figure 8-13. O₃ Generator Electronic Block Diagram

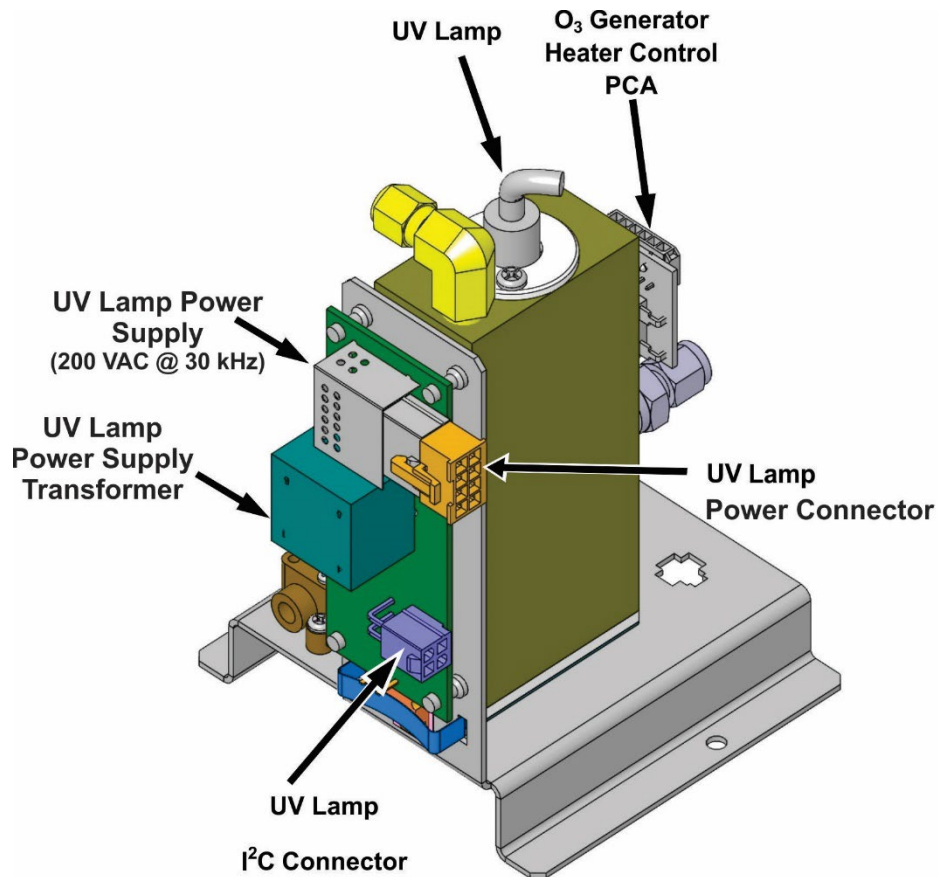


Figure 8-14. O₃ Generator Electronic Components Location

8.5.4. O₃ GENERATOR TEMPERATURE CONTROL

In order to operate at peak efficiency the UV lamp of the O₃ generator is maintained at a constant 48°C. If the lamp temperature falls below 43°C or rises above 53°C a warning is issued by the CPU.

This temperature is controlled as described in the section on the relay PCA (see Section 8.2.3.2). The location of the thermistor and heater associated with the O₃ generator is shown below:

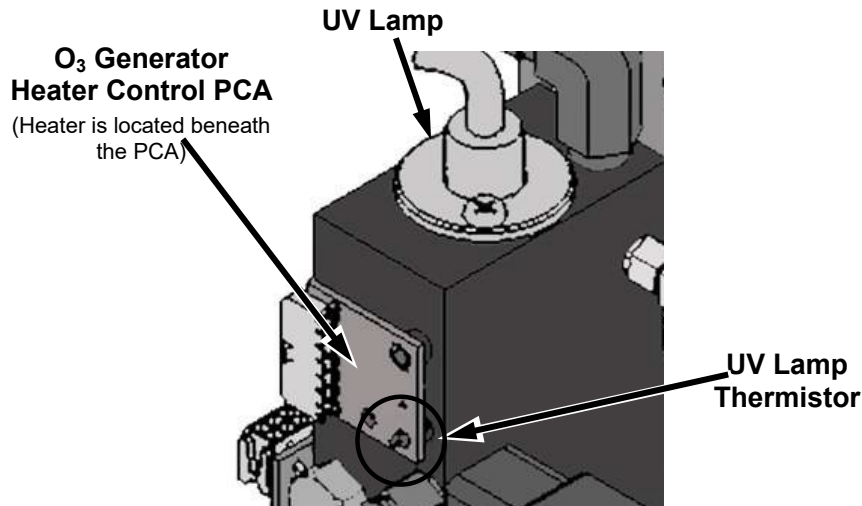


Figure 8-15. O₃ Generator Temperature Thermistor and DC Heater Locations

8.6. PHOTOMETER OPERATION

The calibrator's photometer determines the concentration of Ozone (O₃) in a sample gas drawn through it. Sample and calibration gasses must be supplied at ambient atmospheric pressure in order to establish a stable gas flow through the absorption tube where the gas' ability to absorb ultraviolet (UV) radiation of a certain wavelength (in this case 254 nm) is measured.

Gas bearing O₃ and zero air are alternately routed through the photometer's absorption tube. Measurements of the UV light passing through the sample gas with and without O₃ present are made and recorded.

Calibration of the photometer is performed in software and does not require physical adjustments. Two internal variables, a slope and offset are used to adjust the calibration of the photometer.

The CPU uses these calibration values, the UV absorption measurements made on the sample gas in the absorption tube along with data regarding the current temperature and pressure of the gas to calculate a final O₃ concentration.

8.6.1. MEASUREMENT METHOD

8.6.1.1. CALCULATING O₃ CONCENTRATION

The basic principle by which photometer works is called Beer's Law (also referred to as the Beer-Lambert equation). It defines the how light of a specific wavelength is absorbed by a particular gas molecule over a certain distance at a given temperature and pressure. The mathematical relationship between these three parameters for gasses at Standard Temperature and Pressure (STP) is:

Equation 9-5

$$I = I_o e^{-\alpha LC} \quad \text{at STP}$$

Where:

***I*_o** is the intensity of the light if there was no absorption.

I is the intensity with absorption.

L is the absorption path, or the distance the light travels as it is being absorbed.

C is the concentration of the absorbing gas. In the case of the Model T703, Ozone (O₃).

α is the absorption coefficient that tells how well O₃ absorbs light at the specific wavelength of interest.

To solve this equation for ***C***, the concentration of the absorbing Gas (in this case O₃), the application of a little algebra is required to rearrange the equation as follows:

Equation 9-6

$$C = \ln\left(\frac{I_o}{I}\right) \times \left(\frac{1}{\alpha L}\right) \quad \text{at STP}$$

Unfortunately, both ambient temperature and pressure influence the density of the sample gas and therefore the number of ozone molecules present in the absorption tube thus changing the amount of light absorbed.

In order to account for this effect the following addition is made to the equation:

Equation 9-7

$$C = \ln\left(\frac{I_o}{I}\right) \times \left(\frac{1}{\alpha L}\right) \times \left(\frac{T}{273 \text{ K}} \times \frac{29.92 \text{ inHg}}{P}\right)$$

Where:

T = sample ambient temperature in degrees Kelvin

P = ambient pressure in inches of mercury

Finally, to convert the result into Parts per Billion (PPB), the following change is made:

Equation 9-8

$$C = \ln\left(\frac{I_o}{I}\right) \times \left(\frac{10^9}{\alpha L}\right) \times \left(\frac{T}{273 \text{ K}} \times \frac{29.92 \text{ inHg}}{P}\right)$$

In a nutshell the photometer:

- Measures each of the above variables: ambient temperature; ambient gas pressure; the intensity of the UV light beam with and without O₃ present;
- Inserts know values for the length of the absorption path and the absorption coefficient, and:
- Calculates the concentration of O₃ present in the sample gas.

8.6.1.2. THE MEASUREMENT / REFERENCE CYCLE

In order to solve the Beer-Lambert equation it is necessary to know the intensity of the light passing through the absorption path both when O₃ is present and when it is not. A valve called the measure/reference (M/R) valve, physically located on front-left corner of the O₃ generator assembly (see Figures 3-4 and 9-14) alternates the gas stream flowing to the photometer between zero air (diluent gas) and the O₃ output from the O₃ generator. This cycle takes about 6 seconds.

Table 8-3. Photometer Measurement / Reference Cycle

TIME INDEX	STATUS
0 sec.	Measure/Reference Valve Opens to the Measure Path.
0 – 2 sec.	Wait Period. Ensures that the Absorption tube has been adequately flushed of any previously present gasses.
2 – 3 sec.	Analyzer measures the average UV light intensity of O ₃ bearing Sample Gas (I) during this period.
3 sec.	Measure/Reference Valve Opens to the Reference Path.
3 – 5 sec.	Wait Period. Ensures that the Absorption tube has been adequately flushed of O ₃ bearing gas.
5 – 6 sec.	Analyzer measures the average UV light intensity of Non-O ₃ bearing Sample Gas (I_o) during this period.
CYCLE REPEAT EVERY 6 SECONDS	

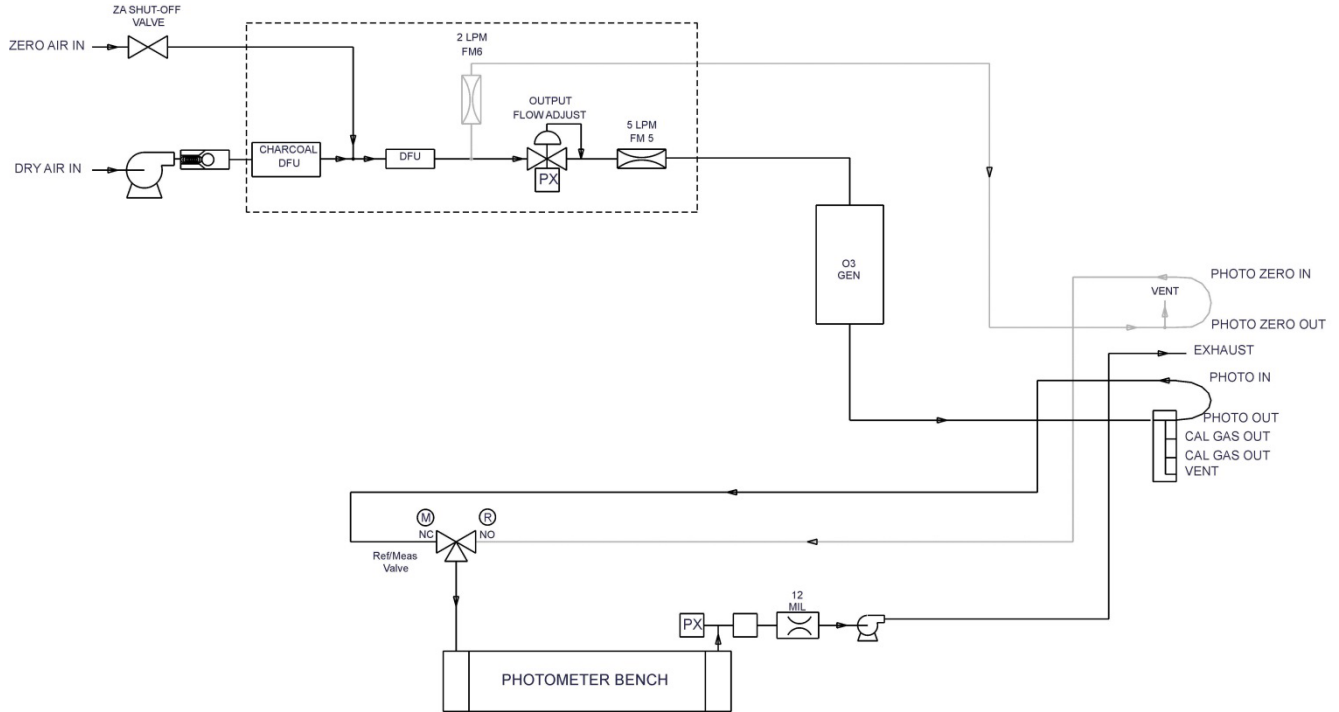


Figure 8-16. T703 O₃ Photometer Gas Flow – Measure Cycle

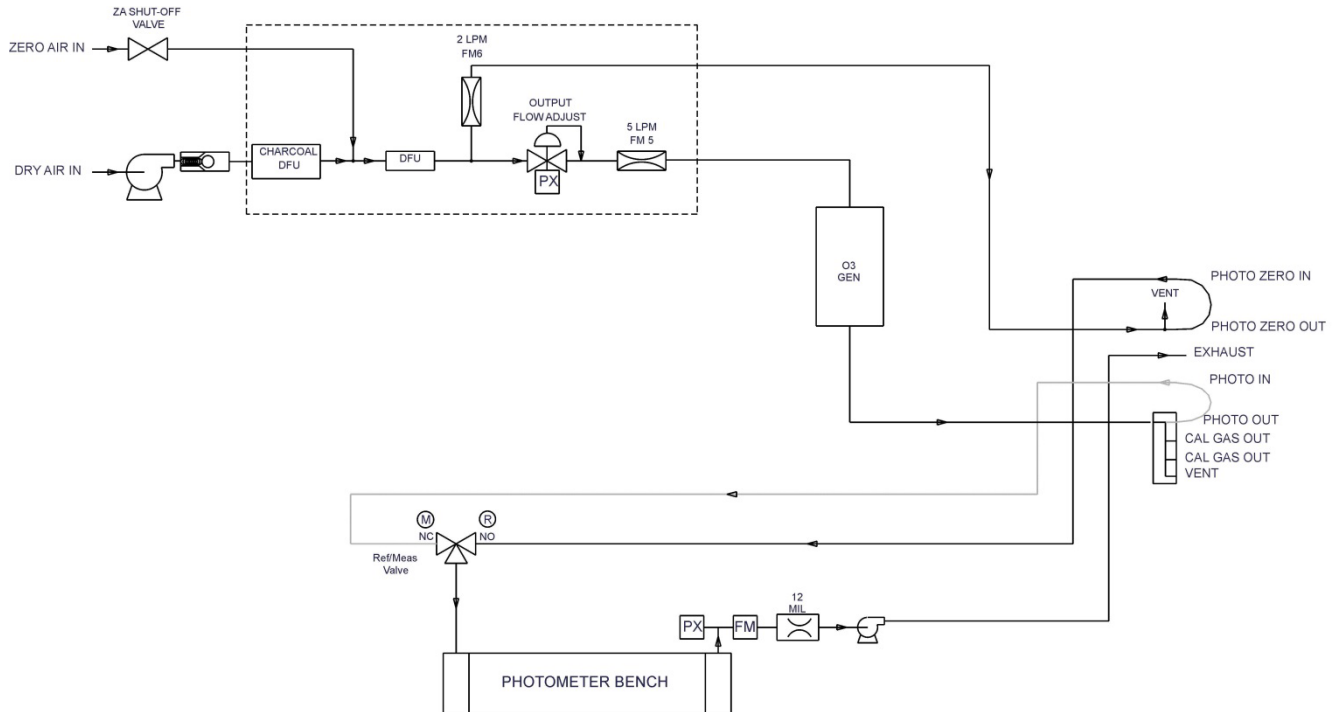


Figure 8-17. T703 O₃ Photometer Gas Flow – Reference Cycle

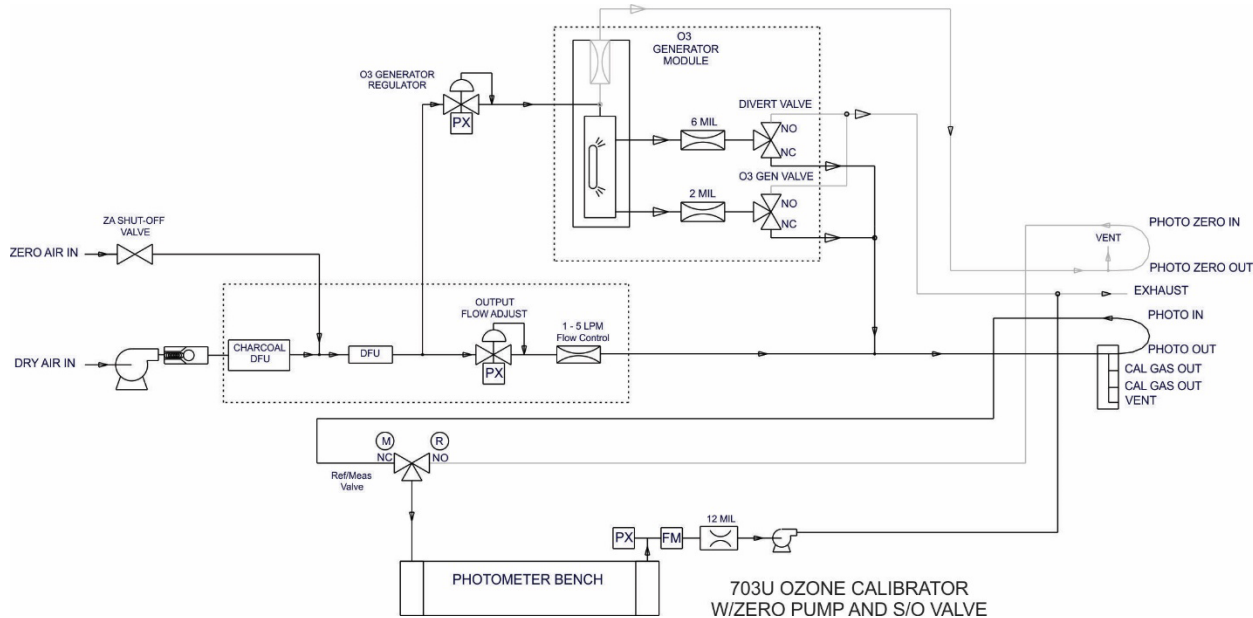


Figure 8-18. T703U O₃ Photometer Gas Flow – Measure Cycle

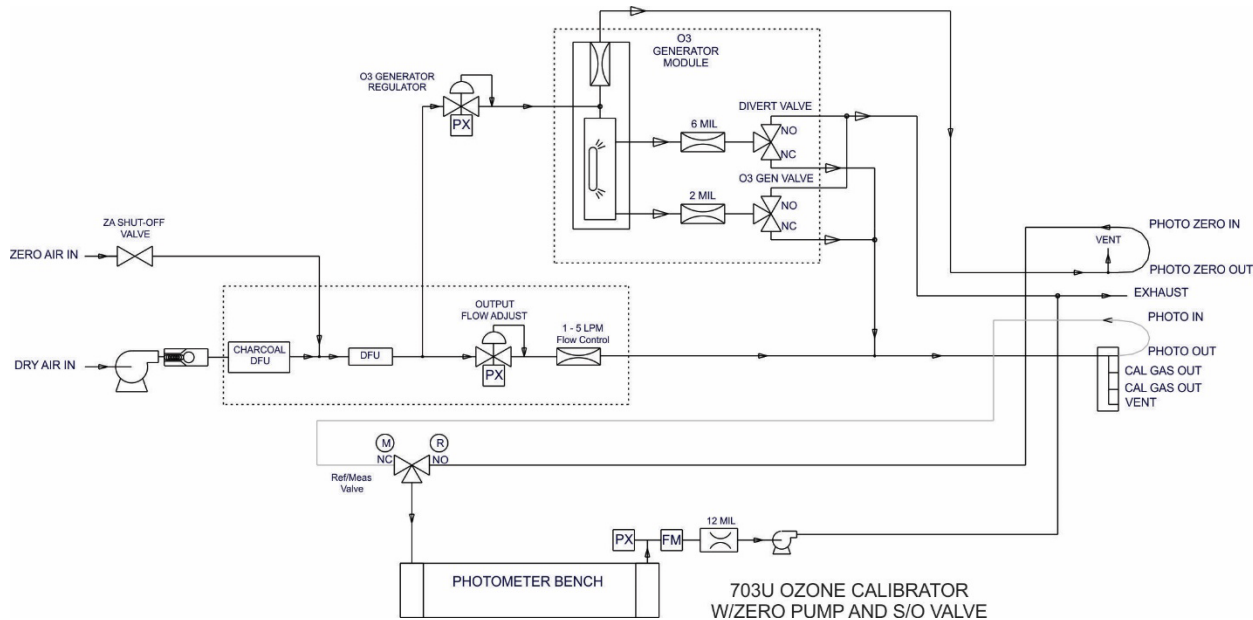


Figure 8-19. T703U O₃ Photometer Gas Flow – Reference Cycle

8.6.1.3. THE ABSORPTION PATH

In the most basic terms, the photometer uses a high energy, mercury vapor lamp to generate a beam of UV light. This beam passes through a window of material specifically chosen to be both non-reactive to O₃ and transparent to UV radiation at 254nm and into an absorption tube filled with sample gas.

Because ozone is a very efficient absorber of UV radiation the absorption path length required to create a measurable decrease in UV intensity is short enough (approximately 42 cm) that the light beam is only required to make one pass through the Absorption Tube.

Therefore, no complex mirror system is needed to lengthen the effective path by bouncing the beam back and forth.

Finally, the UV passes through a similar window at the other end of the absorption tube and is detected by a specially designed vacuum diode that only detects radiation at or very near a wavelength of 254nm. The specificity of the detector is high enough that no extra optical filtering of the UV light is needed.

The detector reacts to the UV light and outputs a current signal that varies in direct relationship with the intensity of the light shining on it. This current signal is amplified and converted to a 0 to 5 VDC voltage analog signal voltage sent to the instrument's motherboard where it is digitized. The CPU to be uses this digital data in computing the concentration of O₃ in the absorption tube.

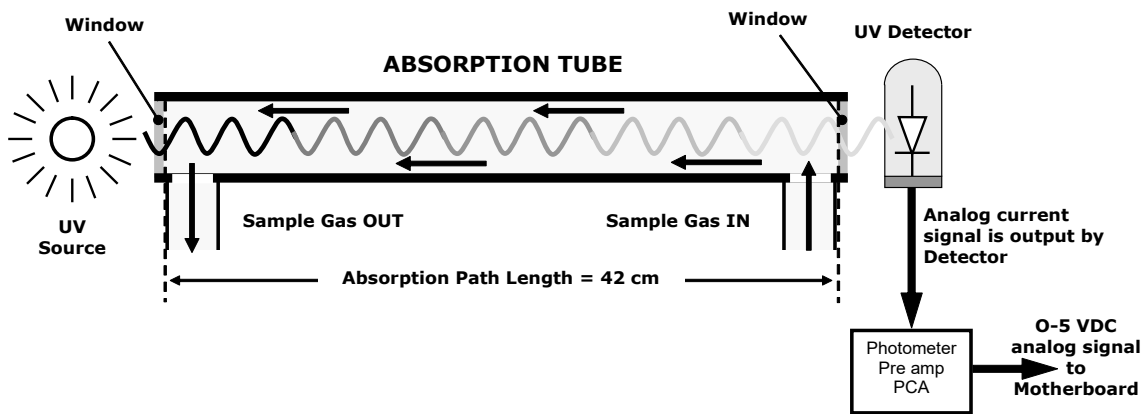


Figure 8-20. O₃ Photometer Absorption Path

8.6.1.4. INTERFERENT REJECTION

It should be noted that the UV absorption method for detecting ozone is subject to interference from a number of sources. The photometer has been successfully tested for its ability to reject interference from sulfur dioxide, nitrogen dioxide, nitric oxide, water, and meta-xylene.

While the photometer rejects interference from the aromatic hydrocarbon meta-xylene, it should be noted that there are a very large number of other volatile aromatic hydrocarbons that could potentially interfere with ozone detection. If the calibrator is installed in an environment where high aromatic hydrocarbon concentrations are suspected, specific tests should be conducted to reveal the amount of interference these compounds may be causing.

8.6.2. PHOTOMETER LAYOUT

The Photometer is where the absorption of UV light by ozone is measured and converted into a voltage. It consists of several sub-assemblies:

- A mercury-vapor UV lamp. This lamp is coated in a material that optically screens the UV radiation output to remove the O₃ producing 185nm radiation. Only light at 254nm is emitted.
- An AC power supply that supplies the current for starting and maintaining the plasma arc of the mercury vapor lamp.

- A thermistor and DC heater attached to the UV Lamp to maintain the Lamp at an optimum operating temperature.
- 42 cm long quartz absorption tube.
- A thermistor attached to the quartz tube for measuring sample gas temperature.
- Gas inlet and outlet mounting blocks that rout sample gas into and out of the photometer.
- The vacuum diode, UV detector that converts UV light to a DC current.
- A preamplifier assembly, which convert the Detector's current output into a DC Voltage then amplifies it to a level readable by the A to D converter circuitry of the instrument's motherboard

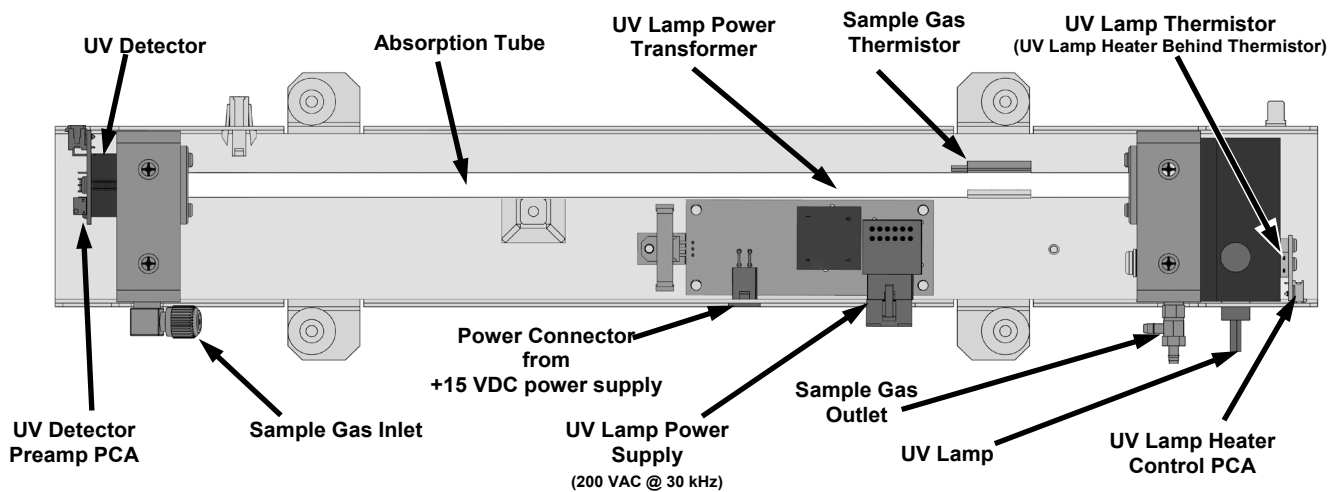


Figure 8-21. O₃ Photometer Layout – Top Cover Removed

8.6.3. PHOTOMETER PNEUMATIC OPERATION

The flow of gas through the photometer is created by a small internal pump that pulls air through the instrument. There are several advantages to this “pull through” configuration. Placing the pump downstream of the absorption tube avoids problems caused by the pumping process heating and compressing the sample.

In order to measure accurately the presences of low concentrations of O₃ in the sample air it is necessary to establish and maintain a relatively constant and stable volumetric flow of sample gas through the photometer. The simplest way to accomplish this is by placing a flow control assembly containing a critical flow orifice directly upstream of the pump but downstream of the absorption tube.

The critical flow orifice installed in the pump supply line is tuned to create a gas flow of 800 cm³/min. A pressure sensor and a flow sensor, located on the O₃ generator / photometer pressure flow sensor PCA, monitor the pressure and flow rate of the gas passing through the photometers absorption tube.

8.6.4. PHOTOMETER ELECTRONIC OPERATION

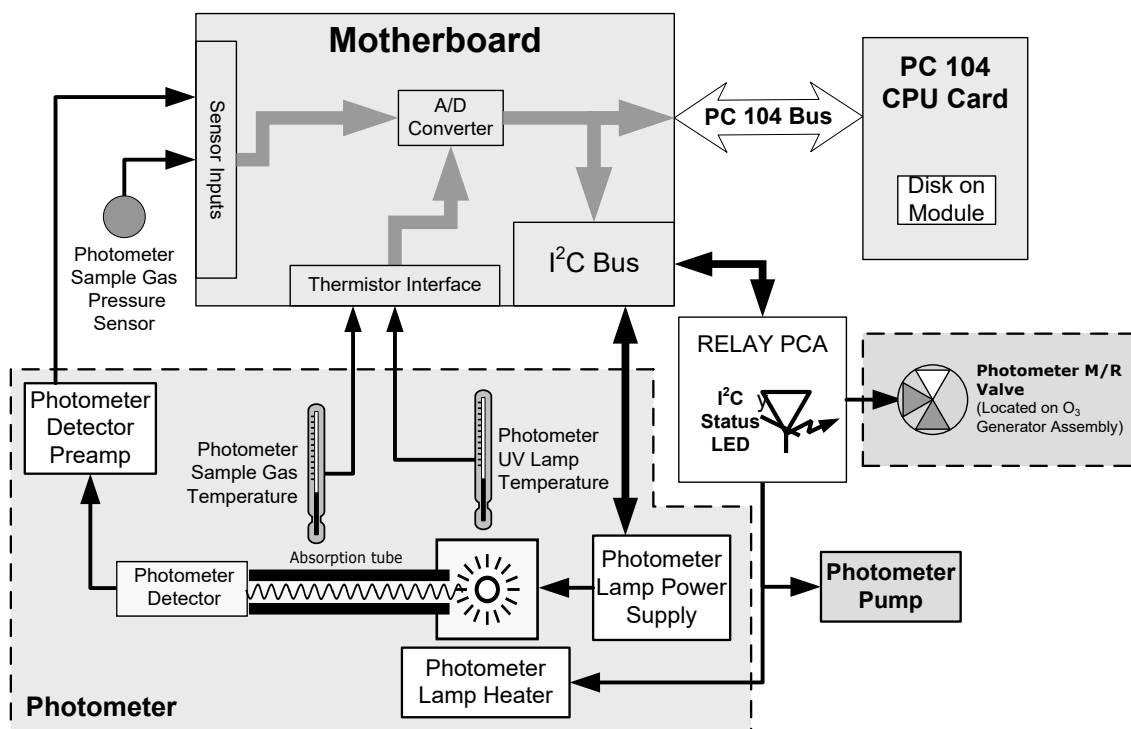


Figure 8-22. O₃ Photometer Electronic Block Diagram

Like the O₃ generator, the O₃ photometer and its subcomponents act as peripheral devices operated by the CPU via the motherboard. Communications to and from the CPU are handled by the motherboard.

Outgoing commands for the various devices such as the photometer pump, the UV lamp power supply the UV Lamp heater are issued via the I²C bus to circuitry on the relay PCA which turns them ON/OFF. The CPU also issues commands over the I²C bus that cause the relay PCA to cycle the measure/reference valve back and forth.

Incoming data the UV light detector is amplified locally then converted to digital information by the motherboard. Output from the photometer's temperature sensors is also amplified and converted to digital data by the motherboard. The O₃ concentration of the sample gas is computed by the CPU using this data (along with gas pressure and flow data received from the pressure sensors).

8.6.5. O₃ PHOTOMETER TEMPERATURE CONTROL

In order to operate at peak efficiency, the UV lamp of the O₃ photometer is maintained at a constant 58°C. This is intentionally set at a temperature higher than the ambient temperature of the operating environment to make sure that local changes in temperature do not affect the UV Lamp. If the lamp temperature falls below 56°C or rises above 61°C a warning is issued by the calibrator's CPU.

This temperature is controlled as described in the section on the relay PCA (Section 8.2.3.2).



8.6.6. PNEUMATIC SENSORS FOR THE O₃ PHOTOMETER

The several sensors located on the pneumatic sensor just to the left rear of the O₃ generator assembly measure the absolute pressure and the flow rate of gas inside the photometer's absorption tube. This information is used by the CPU to calculate the O₃ concentration of the sample gas. Both of these measurements are made downstream of the absorption tube but upstream of the pump. A critical flow orifice located between the flow sensor and the pump maintains the gas flow through the photometer at 800 cm³/min.

GLOSSARY

Note: Some terms in this glossary may not occur elsewhere in this manual.

TERM	DESCRIPTION/DEFINITION
10BaseT	an Ethernet standard that uses twisted (“T”) pairs of copper wires to transmit at 10 megabits per second (Mbps)
100BaseT	same as 10BaseT except ten times faster (100 Mbps)
APICOM	name of a remote control program offered by Teledyne-API to its customers
ASSY	Assembly
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 light energy that is actually converted into electricity
CEM	<i>Continuous Emission Monitoring</i>
Chemical formulas that may be included in this document:	
CO ₂	carbon dioxide
C ₃ H ₈	propane
CH ₄	methane
H ₂ O	water vapor
HC	general abbreviation for hydrocarbon
HNO ₃	nitric acid
H ₂ S	hydrogen sulfide
NO	nitric oxide
NO ₂	nitrogen dioxide
NO _x	nitrogen oxides, here defined as the sum of NO and NO ₂
NO _y	nitrogen oxides, often called odd nitrogen: the sum of NO _x plus other compounds such as HNO ₃ (definitions vary widely and may include nitrate (NO ₃), PAN, N ₂ O and other compounds as well)
NH ₃	ammonia
O ₂	molecular oxygen
O ₃	ozone
SO ₂	sulfur dioxide
cm ³	metric abbreviation for <i>cubic centimeter</i> (replaces the obsolete abbreviation “cc”)
CPU	<i>Central Processing Unit</i>
DAC	<i>Digital-to-Analog Converter</i>
DAS	Data Acquisition System
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 256MB 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	Electrically Erasable Programmable Read-Only Memory also referred to as a FLASH chip or drive
ESD	Electro-Static Discharge
ETEST	Electrical Test
Ethernet	a standardized (IEEE 802.3) computer networking technology for local area networks (LANs), facilitating communication and sharing resources
FEP	<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	Gas Filter Correlation
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	Liquid Crystal Display
LED	<i>Light Emitting Diode</i>
LPM	Liters Per Minute
MFC	<i>Mass Flow Controller</i>
M/R	Measure/Reference

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



T703, T703U

TERM	DESCRIPTION/DEFINITION
TEC	<i>Thermal Electric Cooler</i>
TPC	<i>Temperature/Pressure Compensation</i>
USB	<i>Universal Serial Bus: a standard connection method to establish communication between peripheral devices and a host controller, such as a mouse and/or keyboard and a personal computer or laptop</i>
VARS	<i>Variables, the variable settings of the instrument</i>
V-F	<i>Voltage-to-Frequency</i>
Z/S	<i>Zero / Span</i>

APPENDIX A – MODBUS REGISTERS

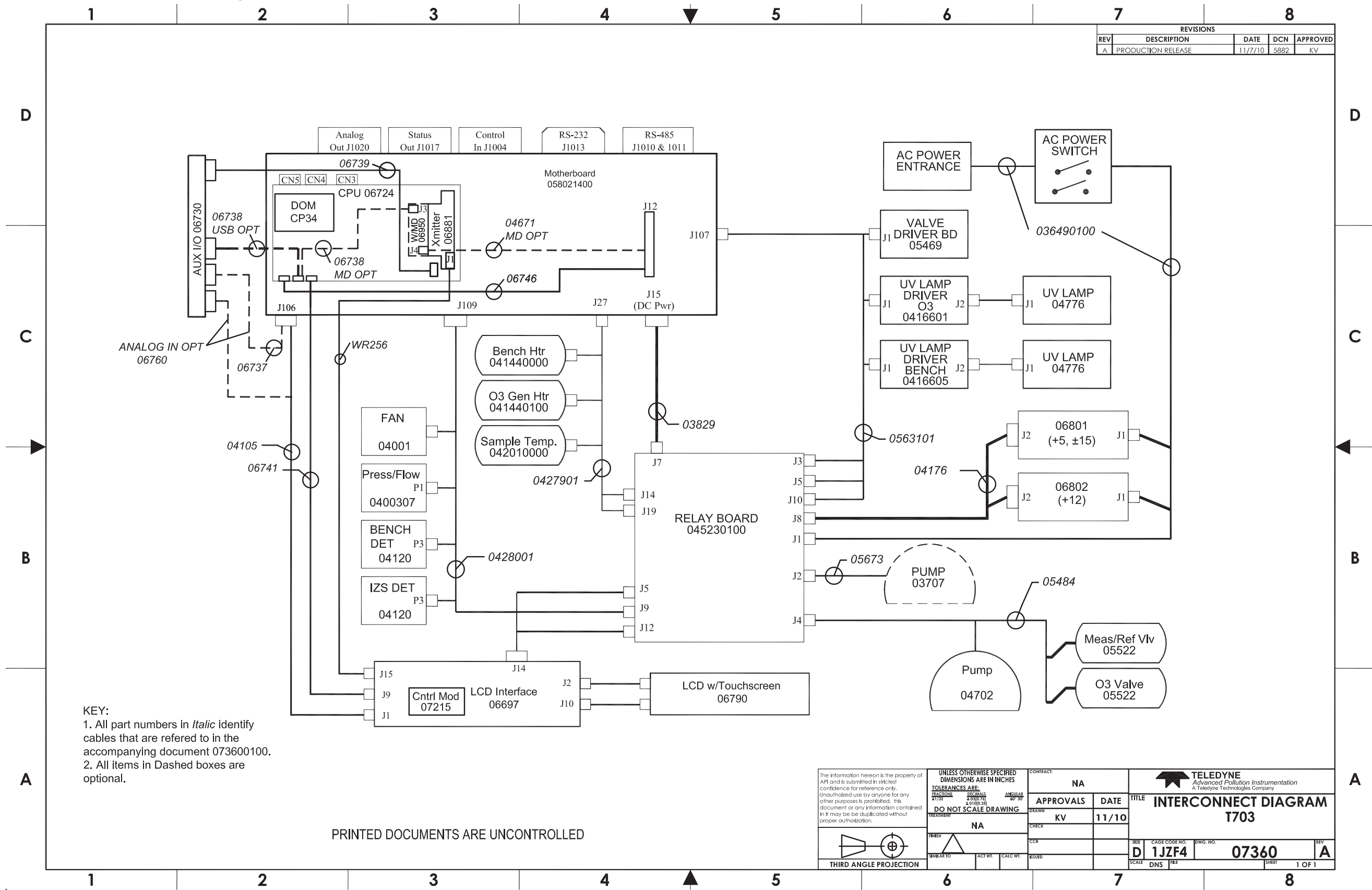
MODBUS REGISTER ADDRESS (DEC., 0-BASED)	DESCRIPTION	UNITS
MODBUS FLOATING POINT INPUT REGISTERS (32-BIT IEEE 754 FORMAT; READ IN HIGH-WORD, LOW-WORD ORDER; READ-ONLY)		
0	Output flow rate	LPM
2	Photometer measured ozone concentration	PPB
4	N/A	-
6	Ozone generator lamp drive	mV
8	Ozone generator lamp temperature	°C
10	Regulator pressure	PSIG
12	Internal box temperature	°C
14	Photometer detector measure reading	mV
16	Photometer detector reference reading	mV
18	Photometer sample flow rate	LPM
20	Photometer lamp temperature	°C
22	Photometer sample pressure	Inches Hg
24	Photometer sample temperature	°C
26	Photometer slope computed during zero/span bench calibration	—
28	Photometer offset computed during zero/span bench calibration	PPB
30	Ground reference	mV
32	Precision 4.096 mV reference	mV
MODBUS DISCRETE INPUT REGISTERS (SINGLE-BIT; READ-ONLY)		
0	System reset warning	
1	Box temperature warning	
2	Photometer lamp temperature warning	
3	O ₃ generator lamp temperature warning	
4	Photometer reference warning	
5	N/A	
6	O ₃ generator reference detector warning	
7	Rear board communication warning	
8	Relay board communication warning	
9	O ₃ generator or photometer lamp I ² C driver chip communication warning	
10	Front panel communication warning	
11	Analog calibration warning	
12	System is OK (same meaning as <i>SYSTEM_OK</i> I/O signal)	
13	O ₃ generator not yet stabilized	
14	Calibration is active	
15	Sequence is active	
16	Regulator pressure warning ¹	



T703, T703U

MODBUS REGISTER ADDRESS (DEC., 0-BASED)	DESCRIPTION	UNITS
MODBUS COIL REGISTERS (SINGLE-BIT; READ/WRITE)		
00-99	Trigger execution of sequence whose name begins with “00” - “99”. Turning a coil on executes a sequence. Turning a coil off does nothing. When reading coils, the value indicates which sequence is executing. If a coil is on, the sequence is executing; if off the sequence is not executing. Supports nested sequences, so multiple sequence coils may be on simultaneously.	
100	Turning coil on turns on purge. Turning coil off does nothing. When reading coil, the value indicates whether purge is active. If on, purge is active; if off, purge is not active. Purge may be invoked within a sequence, so purge coil may be on at the same time as a sequence coil.	
101	Turning coil on puts instrument in standby. Turning coil off does nothing. When reading coil, the value indicates whether instrument is in standby mode. If on, instrument is in standby; if off, instrument is not in standby.	
200-211	Connected to the control outputs (CONTROL_OUT_1– CONTROL_OUT_12). These coils may be turned both on and off. Reading the coils indicates the current state.	
¹ Regulator pressure monitoring option.		

Appendix B - Interconnect Diagram



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	<small>THIRD ANGLE PROJECTION</small>	<small>SCALE</small> DNS FILE	<small>SIZE</small> D 1JZF4 <small>CAGE CODE NO.</small> 07360 <small>DWG. NO.</small> 07360 <small>REV</small> A