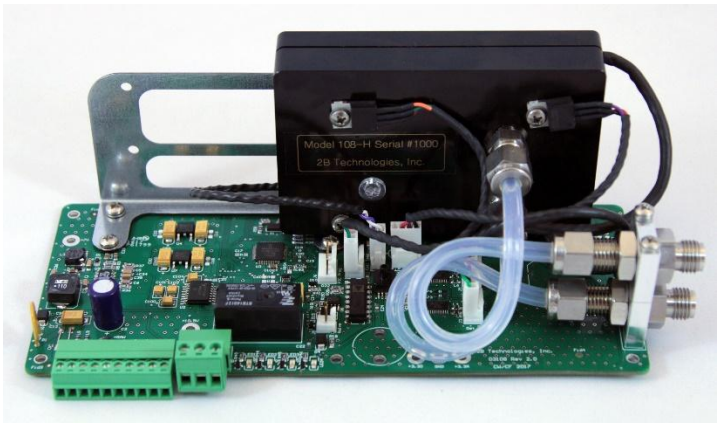
Ozone Monitor



OPERATION MANUAL

Model 108-H

Technical Support:
https://2btech.io/support/
techsupport@2btech.io
+1(303)273-0559

Contents

IDENTIFICATION RECORDS

Record the following information for future reference:

Unit serial number: _____

Warranty start date: _____
(date of receipt)

PRINTING HISTORY

This manual covers the Model 108-H Ozone Monitor used for measurement of High (0-20 wt %) ozone concentrations. New editions of this manual are complete revisions that reflect updates to the instrument itself, as well as clarifications, additions, and other modifications of the text.

Revision A-1 (serial no. 1000 and above)..... May 2017
Revision A-2 (serial no. 1010 and above).....July 2023
Revised serial commands to add L, T.
Revision A-3 (serial no. 1010 and above)..... December 2023
Updated hyperlinks.
Revision A-3 (instruments factory-calibrated after 1/1/2025) ..... March 2025
Updated ozone cross section values in Section 1.1.

TRADEMARKS & PATENTS

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CONFIDENTIALITY

The information contained in this manual may be confidential and proprietary, and is the property of 2B Technologies. Information disclosed herein shall not be used to manufacture, construct, or otherwise reproduce the goods disclosed herein. The information disclosed herein shall not be disclosed to others or made public in any manner without the expressed written consent of 2B Technologies.

WARRANTY STATEMENT

2B Technologies warrants its products against defects in materials and workmanship. 2B Technologies will, at its option, repair or replace products that prove to be defective. The warranty set forth is exclusive and no other warranty, whether written or oral, is expressed or implied. 2B Technologies specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

Warranty Period

The warranty period is one (1) year from date of receipt by the purchaser, but in no event more than thirteen (13) months from original invoice date from 2B Technologies.

Warranty Service

Warranty Service is provided to customers via web ticket, email and phone support, Monday - Friday, from 9:00 a.m. to 5:00 p.m., Mountain Time USA. The preferred method of contacting us is through our web ticketing software at:

https://2btech.io/support/

This way all technical staff at 2B Tech will be alerted of your problem and be able to respond. When you receive an email reply, please click on the Ticket link provided to continue to communicate with us directly over the internet. The web ticket approach to customer service allows us to better track your problem and be certain that you get a timely response. We at 2B Tech pride ourselves on the excellent customer service we provide.

You may also contact us by email at techsupport@2btech.io or by phone at +1(303)273-0559. In either case, a web ticket will be created, and future communications with you will be through that ticket.

Initial support involves trouble-shooting and determination of parts to be shipped from 2B Technologies to the customer in order to return the product to operation within stated specifications. If such support is not efficient and effective, the product may be returned to 2B Technologies for repair or replacement. Prior to returning the product, a Repair Authorization Number (RA) must be obtained from the 2B Technologies Service Department. We will provide you with a simple Repair Authorization Form to fill out to return with the instrument.

Shipping

2B Technologies will pay freight charges for replacement or repaired products shipped to the customer site. Customers shall pay freight charges for all products returning to 2B Technologies.

Conditions

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance, adjustment, calibration or operation by the customer. Maintenance, adjustment, calibration or operation must be performed in accordance with instructions stated in this manual. Usage of maintenance materials purchased from suppliers other than 2B Technologies will void this warranty.

Limitation of Remedies and Liability

The remedies provided herein are the Customer's sole and exclusive remedies. In no event shall 2B Technologies be liable for direct, indirect, special, incidental or consequential damages (including loss of profits) whether based on contract, tort or any other legal theory. The Ozone Monitor manual is believed to be accurate at the time of publication and no responsibility is taken for any errors that may be present. In no event shall 2B Technologies be liable for incidental or consequential damages in connection with or arising from the use of the Ozone Monitor manual and its accompanying related materials. Warranty is valid only for the country designated on the 2B Technologies quote or invoice.

WARNINGS

ENGLISH

***WARNING*:**
Any operation requiring access to the inside of the equipment, could result in injury. To avoid potentially dangerous shock, disconnect from power supply before opening the equipment.

WARNING:
This symbol,  on the instrument indicates that the user should refer to the manual for operating instructions.

WARNING:
If this instrument is used in a manner not specified by 2B Technologies, Inc. USA, the protection provided by the instrument may be impaired.

ESPAÑOL

ATENCION:
Cualquier operación que requiera acceso al interior del equipo, puede causar una lesión. Para evitar peligros potenciales, desconectarlo de la alimentación a red antes de abrir el equipo.

***ATENCION*:**
Este símbolo,  en el instrumento indica que el usuario debería referirse al manual para instrucciones de funcionamiento.

ATENCION:
Si este instrumento se usa de una forma no especificada por 2B Technologies, Inc., USA, puede desactivarse la protección suministrada por el instrumento.

FRANÇAIS

ATTENTION:
Chaque opération à l'intérieur de l'appareil, peut causer du préjudice. Afin d'éviter un shock qui pourrait être dangereux, disconnectez l'appareil du réseau avant de l'ouvrir.

ATTENTION:
Le symbol,  indique que l'utilisateur doit consulter le manuel d'instructions.

ATTENTION:
Si l'instrument n'est pas utilisé suivant les instructions de 2B Technologies, Inc., USA, les dispositions de sécurité de l'appareil ne sont plus valables.

DEUTSCH

WARNHINWEIS:
Vor dem Öffnen des Gerätes Netzstecker ziehen!

WARNHINWEIS:
Dieses, auf dem Gerät weist darauf hin, dab der Anwender zuerst das entsprechende Kapitel in der Bedienungsanleitung lesen sollte.

WARNHINWEIS:
Wenn das Gerät nicht wie durch die Firma 2B Technologies, Inc., USA, vorgeschrieben und im Handbuch beschrieben betrieben wird, können die im Gerät eingebauten Schutzvorrichtungen beeinträchtigt werden.

ITALIANO

ATTENZIONE:
Qualsiasi intervento debba essere effettuato sullo strumento può essere potenzialmente pericoloso a causa della corrente elettrica.
Il cavo di alimentazione deve essere staccato dallo strumento prima della sua apertura.

ATTENZIONE:
Il simbolo,  sullo strumento avverte l'utilizzatore di consultare il Manuale di Istruzioni alla sezione specifica.

ATTENZIONE:
Se questo strumento viene utilizzato in maniera non conforme alle specifiche di 2B Technologies, Inc. USA, le protezioni di cui esso è dotato potrebbero essere alterate.

DUTCH

OPGELET:

Iedere handeling binnenin het toestel kan beschadiging veroorzaken. Om iedere mogelijk gevaarlijke shock te vermijden moet de aansluiting met het net verbroken worden, vóór het openen van het toestel.

OPGELET:
Het symbool,  geeft aan dat de gebruiker de instructies in de handleiding moet raadplegen.

OPGELET:
Indien het toestel niet gebruikt wordt volgens de richtlijnen van 2B Technologies, Inc., USA gelden de veiligheidsvoorzieningen niet meer.

CHINESE

警告：
任何需要接触设备内部的操作均可能造成人身伤害。为避免可能的触电危险，请在打开设备前切断电源。

警告：
这个符号  在仪器上表示用户应参考说明书上的操作指南。

警告：
如果仪器没有按照美国 2B 科技公司指定方式操作，仪器的保护性能会减弱。

JAPANESE

警告：
機器の内部で操作する時、怪我できます。**危険な衝撃を回避するために、機器を開ける前に、電源を切断してください。**

警告：
機器でこの記号  を見れば、マニュアルを読んでください。

警告：
この機器は 2B テクノロジー会社、USA の指定でしなければ、機器の保護が損なえます。

1. OZONE MONITOR INTRODUCTION

The 2B Technologies Model 108-H Ozone Monitor is designed to enable accurate measurements of ozone in air over a wide dynamic range extending from 0 to 20 wt % based on the well-established technique of absorption of ultraviolet light at 254 nm. The Model 108-H is designed for integration in the user's ozone system, and makes use of the ozone system's pump to supply the air sample. The Model 108-H Ozone Monitor is lightweight (1.75 lb, 0.8 kg), has a low power consumption (~4 watt) relative to conventional instruments, and requires minimal maintenance, making it well suited for monitoring and control of ozone in industrial settings. For example, the Model 108-H is designed for measuring the output of high-concentration ozone generators.

1.1. Theory of Operation

Absorption of UV light has long been used for measurements of atmospheric ozone with high precision and accuracy. The ozone molecule has an absorption maximum at 254 nm, coincident with the principal emission wavelength of a low-pressure mercury lamp. Fortunately, few molecules found in ozone process streams absorb at this wavelength.

Figure 1.1 is a schematic diagram of the Ozone Monitor. Ozone is measured based on the attenuation of light passing through a 0.1-cm absorption cell fitted with sapphire windows. A low-pressure mercury lamp is located on one side of the absorption cell, and a sample photodiode is located on the opposite side of the absorption cell. The photodiode has a built-in interference filter centered on 254 nm, the principal wavelength of light emitted by the mercury lamp. An external air pump (user-supplied) draws sample air into the instrument at a nominal flow rate of up to 20 L/min. A beamsplitter and reference photodiode are used to monitor the lamp intensity without the sample in the beam path. The intensity of light is measured from the reference photodiode (I_o) and from the sample photodiode (I). Ozone concentration is calculated from the measurements of I_o and I according to the Beer-Lambert Law:

$$C_{O_3} = \frac{1}{\sigma l} \ln\left(\frac{I_o}{I}\right) \tag{1}$$

where l is the path length (0.1 cm) and σ is the absorption cross section for ozone at 254 nm (1.13×10^{-17} cm^2 molecule^{-1} or 304 atm^{-1} cm^{-1}), which is known with an accuracy of approximately 0.3%. The 2B Technologies instrument uses the same absorption cross section (extinction coefficient) as used in other commercial instruments.

When there is no ozone in the cell, a difference in light intensity at the reference and sample photodiodes can be expected, and it will cause a zero offset in the readings. This light intensity difference is inherent in the instrument due to the different properties of the two photodiodes, drift in the angle of the beamsplitter, contamination in the cell, and thermal drift in any of the optical components. The zero drift has been determined to be less than or equal to 2% of full scale per month, non-cumulative and can easily be

corrected for by using the zero function described below. The zero drift does not affect the slope calibration factor in any way, and the instrument does not need to be recalibrated after performing the zeroing function.

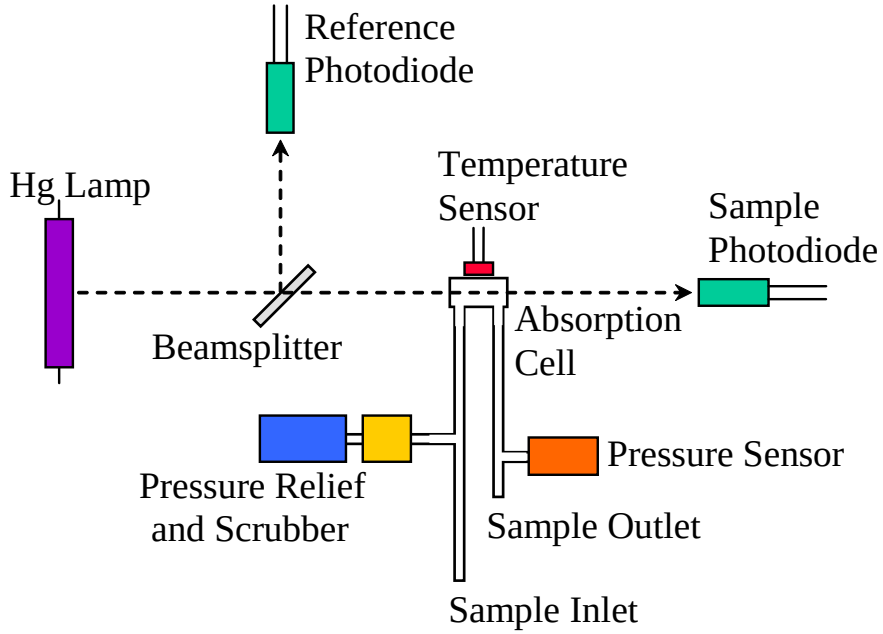


Figure 1.1. Schematic Diagram of the Ozone Monitor. *The air pump is a user-supplied external pump required for instrument operation.*

The pressure and temperature within the absorption cell are measured so that the ozone concentration can be expressed as a mixing ratio in percent by volume (vol%). The fraction of the sample that is ozone can then be calculated and used to determine the ozone concentration in percent by weight in either air (Wt.% air) or oxygen (Wt.% O_2). The instrument displays and records the cell temperature and pressure in addition to the ozone concentration. The cell pressure is displayed and logged in user-selected units of mbar, torr, or psi, and cell temperature in units of °C, °F, or K.

In principle, the measurement of ozone by UV absorption requires only a zero calibration to account for the different light intensities at the reference and sample photodiodes. However, non-linearity of the photodiode response and electronics can result in a small measurement error. Therefore, each instrument is compared with a reference ozone monitor calibrated to the International Ozone Association (IOA) buffered KI method. These results are used to calibrate the Ozone Monitor with respect to a slope (gain). The correction for slope is recorded in the instrument Birth Certificate. The slope parameter is entered into the microprocessor prior to shipment. The user may change the slope parameter from the serial menu if desired. It is recommended that the instrument be recalibrated at least once every year and preferably more frequently. The zero may drift due to temperature change or chemical contamination of the absorption cell. As discussed below, an accurate zero correction can be measured from time to time using zero gas.

1.2. Specifications: Model 108-H Ozone Monitor

Measurement Principle	UV Absorption at 254 nm, single beam
Linear Dynamic Range	0-20 wt%
Resolution	0.01 wt%
Measurement Frequency	2 s, 0.5 Hz
Data Averaging Options	10 s, 1 min, 5 min, 1 hr
Response Time, 100% of Step Change	For 2-s output: 4 s, 2 data points For 10-s output: 20 s, 2 data points
Precision (1σ) for 10-s output (rms noise)	Greater of 0.01 wt% or 2% of measurement
Limit of Detection (2σ)	0.02 wt% for 10-s averaging
Accuracy	Greater of 0.01 wt% or 2% of measurement
Calibration	Iodometric titration
Flow Rate Limits	Minimum required: 0.5 Liter/min (volumetric); Nominal: Up to 20 L/min; Maximum: 55 L/min
Operating Pressure Limits	Minimum: 0 psig; Maximum: 25 psig
Ozone Units	g m^{-3}, Ng m^{-3}, vol%, wt% air, wt% O_2
Pressure Units	torr (user must input their system pressure)
Temperature Units	°C, °F, K
Temperature and Pressure Corrected	Yes
Data Outputs	RS232, 0-2.5 V, 4-20 mA
Output Ranges	User-defined scaling factor in serial menu
Data Transfer Baud Rate	2400
Relay with Two Set Points	Relay responds based on ozone set points (user-defined in serial menu)
Power Requirements	11-28 VDC, nominally 330 mA at 12 V; 4 watt
Size	8.7 × 4.0 × 3.0 in (22 × 10 × 7.6 cm) (l × w × h)
Weight	1.75 lb (0.8 kg)

2. OPERATION

Please read all the following information before attempting to install the Ozone Monitor. For assistance, please call 2B Technologies at (303) 273-0559.

NOTE:
Save the shipping carton and packing materials that came with the Ozone Monitor. If the Ozone Monitor must be returned to the factory, pack it in the original carton. Any repairs as a result of damage incurred during shipping will be charged.

2.1. Shipping Box Contents

Open the shipping box and verify that it contains all of the items on the shipping list. If anything is missing or obviously damaged, contact 2B Technologies immediately.

2.2. Operation of the Ozone Monitor

2.2.1. Overview

To operate the Ozone Monitor, connect it to an external 12V DC power source using pins #1 and #2 of the 10-pin connector (see Figure 5.1 in Section 5 of this manual). The source can be in the range 11-28 V DC without any detrimental effects on the measurement. A circuit breaker and diode are installed on the circuit board in case of an electrical short or incorrect battery attachment. If activated, the breaker will reset itself after a few minutes.

Once the instrument has been powered on, the first dozen readings (requiring about two minutes) will be spurious, with large positive and negative swings due to the rapid warmup of the lamp and electronics. Also, ozone readings may be inaccurate during the 10-20 minutes required for the lamp, photodiodes, and internal temperature of the absorption cell to stabilize.

The air sample is supplied to the Ozone Monitor by an external pump, located in the user's ozone system. Inlet tubing may be attached to the ¼ inch stainless steel Swagelok fitting on the instrument. The inlet tubing should be made of PTFE (Teflon®), PFA, FEP, PVDF or some other inert material that does not destroy ozone and that does not desorb plasticizers and other organics that can contaminate the flow path. The length of tubing should be kept as short as possible (preferably not more than a few feet) to minimize ozone destruction within the inlet tubing. Tygon® and polypropylene (which may look like Teflon) tubing should not be used.

The Model 108-H Ozone Monitor should be operated within flow limits (0.5 to 55 L/min) and pressure limits (0 to 25 psig) of the instrument.

2.2.2. Input the System Pressure before Data Gathering

Important: The user must enter the operating system pressure (in torr) via the serial menu before beginning to gather data.

The Model 108-H Ozone Monitor does not have a pressure sensor. The user must enter the operating system pressure, via the serial menu command "p," before acquiring data. The Ozone Monitor makes use of this user-supplied pressure in its calculation of ozone concentration.

2.2.3. Operating Recommendations

The following table gives a summary of the operating recommendations mentioned in this manual.

Operating Recommendation	**Frequency**	**Section Reference**
Allow ~20 minutes for instrument warmup before taking data	Each startup	2.2.1
Input system pressure in torr	Each startup	2.2.2
Inlet tubing should be made of inert materials, such as PTFE, PFA, FED, PVDF (do not use Tygon® or polypropylene tubing)	Each use	2.2.1
Maintain flow rate within operating limits (0.5 to 55 L/min)	Each use	2.2.1
Maintain pressure within operating limits (0 to 25 psig)	Each use	2.2.1
Check the zero offset	Occasionally	4.5
Perform multipoint calibration	• Annually • Any time major disassembly of components is performed • Any time the zero or span checks give results outside of the acceptable limits	4

2.3. Collecting Data over the Serial Port in Real Time

To transmit data to a computer over the serial port in real time, connect the Ozone Monitor to the serial port of the computer.

For the serial port connection, use pins 3, 4, and 5 from the 10-pin connector (Figure 5.3, Section 5 of this manual). The RS232 protocol is 2400 baud; 8 bits; no parity; 1 stop bit. The digital pinout for the RS232 is standard and as follows: Pin 3 = transmit, Pin 4 = receive, Pin 5 = ground.

2.3.1. Data Acquisition Software

Start your data acquisition software, terminal emulation software such as HyperTerminal (a program provided with earlier versions of Windows) or Tera Term.

2.3.2. Determine the Connection Port and Set the Baud Rate

When setting up your software or terminal emulator, choose the correct COM port listed in the Device Manager. If using Windows, go to the control panel and select System and Security > System > Device Manager. Select "Ports" to see the assigned serial COM port number.

For the serial port, the baud rate setting in the data acquisition software must match the baud rate setting of the Model 108-H (2400 baud). Adjust the baud rate setting in the software's setup menu to 2400.

2.3.3. Data Output

As noted in Section 2.2.2 above, the calculation of ozone concentration makes use of the user-supplied value for system pressure. Be sure this value has been entered prior to starting your data acquisition.

The ozone concentration, internal cell temperature, cell pressure (as input by user), sample photodiode voltage, and reference photodiode voltage are sent as comma-delimited ASCII text to the serial port every 2 seconds, 10 seconds, 1 minute, 5 minutes, or 1 hour, depending on the averaging time selected from the serial menu.

For ozone units in wt% O_2 and temperature units in °C, a typical data line would read:

3.27,25.5,759,1.21798,1.15316

where:

Ozone = 3.27 wt% O_2
Cell temperature = 25.5°C
Cell pressure = 759 torr [outputs the user-supplied value]
Sample Photodiode Voltage = 1.21798 volts
Reference Photodiode Voltage = 1.15316 volts

See Section 2.4 below for how to access the serial menu.

2.4. Accessing the Serial Menu

Measurements and logging tasks can be accessed via the serial port using a terminal emulator such as Tera Term or HyperTerminal running on an attached computer. Commands can be sent using the terminal emulator set with the properties listed in the

section of this manual entitled “Collecting Data over the Serial Port in Real Time” (Section 2.3). Listed below are the letters that are commands for performing certain operations while the instrument continues to measure:

h Output serial data line header
m Serial menu
V Performs a zero while sampling

If the letter **m** is sent as a command, **menu>** will be displayed in the terminal emulator window. When the serial menu is accessed, the instrument is no longer making measurements; it is waiting for the next command to be entered. The following is the list of serial menu items accessible from this point:

Serial Menu Commands

V Perform zero function (also available during measurements). Also toggles user’s optional zeroing valve at J5 on circuit board.

a Averaging time: displays current setting and waits for new setting followed by carriage return (0 = 2 second (no averaging), 1 = 10 second, 2 = 1 minute, 3 = 5 minute, 4 = 1 hour)

z Zero (offset) calibration setting: displays current setting and waits for a new setting (-9.99 to +9.99) followed by a carriage return

s Slope calibration setting: displays current setting and waits for a new setting (-0.500 to +1.500) followed by a carriage return

p Set the pressure: Gives current user-supplied pressure setting (torr) and asks for new value (0 to 1600) followed by carriage return.

u Set the ozone units: displays current setting and waits for a new setting (0 = vol%, 1 = wt% O_2, 2 = wt% air, 3 = g/m^3, 4 = g/Nm^3) followed by carriage return.

c Set the temperature units: displays current setting and waits for new setting followed by carriage return (0 = K, 1 = °C, 2 = °F).

f Set the analog output full scale (voltage and current).

g Set the relay OFF ozone level (when ozone is greater than this, relay turns off).

j Set the relay ON ozone level (when ozone is less than this, relay turns on).

h Output serial data line header (also available during measurements).

Y Set all configuration to default[1].

n Output instrument serial number.

t Perform lamp test.

L Set to flat temperature sensor *(do not adjust; this is a factory setting)*

T Set to round temperature sensor *(do not adjust; this is a factory setting)*

? Output this help menu.

x Exit the serial menu and return to measuring.

[1] Default settings: Avg=10 s, offset=0, slope=1, T in °C, P=760 torr, O_3 in vol%.

2.5. Collecting Data from the Analog Output

The data may be logged in real time using a data logger attached to the 10-pin connector on the side of the printed circuit board using either a voltage or current recorder or data logger. The 0-2.5 V voltage output is measured across pins #6 (+) and #5 or #8 (ground). The 4-20 mA current output is measured across pins #7 (+) and #5 or #8 (ground). See Section 5 of this manual for the labeled instrument photos.

To change the analog output voltage scaling factor, send the character 'f' in the serial menu and enter a number between 0.00 and 99.99.

For example, if you entered the number 1.00 wt% O_2, then 2.5 volt (full scale) = 1.00 wt% O_2; i.e., 1 volt = 0.40 wt% O_2. Also, the current output will be scaled such that the full scale of 20 mA corresponds to 1.00 wt% O_2. A reading of zero ozone concentration will be output as 0 V and as 4 mA. Thus, the instrument is not limited to a fixed number of "ranges" common to most ozone monitors. Instead, any range can be defined.

2.6. Using and Setting the Relay Limits

The Ozone Monitor may be used to control other devices, such as an ozone generator, using the 12-amp relay located on the side of the printed circuit board. The relay connector is the smaller green 3-pin connector (see labeled photos in Section 5 of this manual).

To set the On and Off limits of a relay, enter the serial menu and press 'g' and "j" to access the high and low limits for the relay settings. Enter a number between 0.00 and 99.99 for each of the desired settings. For example, with units set to wt% O_2, "ON" ozone level = 4.90, and "OFF" ozone level = 5.10, the relay will close (pass current) until the ozone concentration exceeds 5.10 wt% O_2. Above this concentration, the switch relay will open. The relay will not close again until the ozone concentration drops below 4.90 wt% O_2. In this way, for example, the ozone concentration from an ozone generator could be controlled in the range 4.90 to 5.10 wt% O_2.

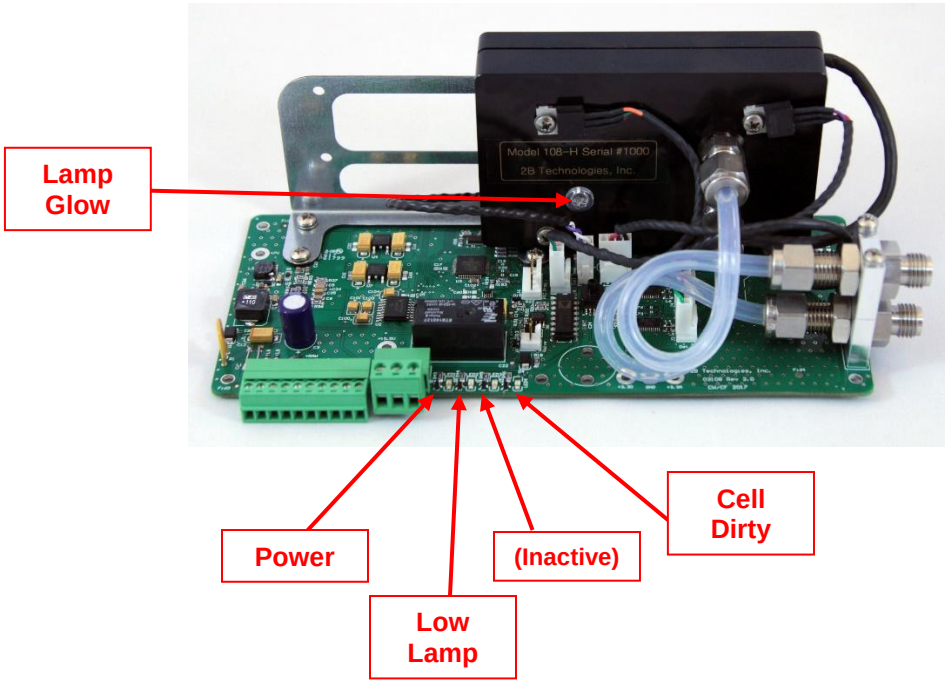
Physical connection to the relay is made by means of a supplied screw connector for attaching wires to your device. The center terminal is common. When viewing the connector from the side of the instrument (see photos in Section 5 of this manual), the terminal on the right is in normally open (i.e., it closes when the ozone concentration is below the first set point). This is the connection you would ordinarily use. The screw connector on the left is normally closed; i.e., it behaves in the opposite manner as the right screw terminal.

2.7. LED Indicator Lights and Lamp Glow Indicator

The Model 108-H has four LED lights on the side of the instrument to indicate any system issues that may require troubleshooting:

- **Power On:** The far-left LED is a Power On indicator. It indicates that there is power to the instrument and that the main circuit board is working properly. The normal state is ON.

- **Low Lamp:** Second from left is the Low Lamp indicator. This indicator comes on if the lamp voltage drops below 0.6 volts, indicating that a lamp test should be conducted (Section 2.8) and that the lamp may need replacement and/or the flow path may need cleaning. The normal state is OFF.
- **Low Flow:** LED 3 is the Low Flow indicator. This LED should remain off at all times. The Model 108-H does not have a flow meter and this LED currently has no function.
- **Cell Dirty:** LED 4, on the far right, indicates that the ratio of the sample photodiode voltage to the reference photodiode voltage is less than 0.5. This indicator light can only be activated during the zeroing function when the cell is purged with zero gas. The normal state is OFF.



The instrument also has a **Lamp Glow** indicator on the inside of the optical bench (see above). It should be illuminated when the instrument is on and functioning properly. If it is off, the lamp may have become disconnected, or the lamp is broken.

2.8. Performing a Lamp Test

If the instrument always reads near zero in the presence of ozone or if the Low Lamp indicator light is turned on (Section 2.7), it is useful to perform the lamp test to make sure that the lamp is turning on. Before performing the lamp test, allow the instrument to warm up for at least twenty minutes.

A lamp test is performed from the serial menu, using command “t.” After a few moments, the serial output will give the results of the test. The photodiode voltages will then be displayed, for example:

1.24578,1.50364

giving the sample and reference photodiode voltages, respectively. The photodiode voltages (PDV) are a measure of the lamp intensity and should be in the range 0.6-2.2 volts. Since absorbance is a ratio measurement, the absolute value of the voltages is not particularly important. However, above 2.5 volts, which could occur if the instrument is allowed to become too hot, the photodiode is saturated and the calculated ozone concentration will be zero. Photodiode voltages less than 0.6 volts without any ozone in the cell are indicative of either a weak lamp or a dirty detection cell and may result in a noisy measurement. Photodiode voltages will typically increase as the instrument warms up. Lamp drift is continuously monitored and corrected for in the firmware and thus has very little effect on the measured ozone concentration. If your lamp fails the lamp test during the first year of operation, contact us for a new lamp under the instrument warranty.

2.9 Option for Connection to User-Supplied Zeroing Valve

The Model 108-H is equipped with a 10.5V header (J5 on the circuit board) that is capable of supplying up to 500 mA of current. See Figure 5.1 of Section 5 of this manual.

Pin 1 of the header (above the ‘V’ in the Valve label) is connected to 10.5 Volts. Pin 2 of the header (above the ‘e’ in the Valve label) is connected to a MOSFET that will connect to ground when activated.

When the user sends a ‘V’ command from the serial menu (see Section 2.4) to perform an autozero, the MOSFET is activated to supply power to switch a valve and then quickly toggles back to no power after the autozero function ends.

This functionality allows the use of a valve between the ozone source and the 108-H to switch between a zero-air supply and the source. If the valve requires more voltage and or more current to activate, a relay can be used between J5 and the valve.

3. MAINTENANCE/TROUBLESHOOTING

3.1. Overview

The Model 108-H Ozone Monitor is designed to be nearly maintenance free. The only component with a limited lifetime is the lamp, which has a lifetime of ~20,000 hours). It is recommended that the instrument be returned to 2B Technologies if any of these components fail. Alternatively, the user may install these components at their own risk. In that case, please contact 2B Technologies for instructions.

The following are indications of various instrument malfunctions.

Lamp Failure: The ozone measurements will be erratic and the Lamp Test will show 0.0 volts for the photodiode voltage. The Lamp Indicator light will go on when the lamp voltage drops below 0.6 volts. The Lamp Glow indicator will also be unlit. See Section 2.7.

Contaminated Flow Path: The instrument will typically have a large positive or negative offset and the ozone readings will be low once corrected for the measured offset.

See Section 2.7 for information about the LED indicator lights on the Model 108-H Ozone Monitor and see Section 3.3 below for Troubleshooting tips.

3.2. Maintenance Recommendations

The following is a summary of recommended maintenance procedures mentioned in this manual.

Maintenance Recommendation	Frequency	Reference
Recalibrate instrument and clean flow path	At least once per year	2.2, 4.1-4.6
Clean flow path (methanol)	As needed if instrument has large offset and ozone readings are low, or if readings are noisy	3.1; send instrument to 2B Tech, or call 2B Tech for cleaning procedures

3.3. Troubleshooting

Help with troubleshooting is provided in the following table.

Table 3.1. ***Troubleshooting the Model 108-H Ozone Monitor for performance problems.*** *(Refer to Figures 5.1-5.4 in Section 5.)*

Problem/Symptom	Likely Cause	Corrective Action
Instrument does not turn on (Power On indicator light is OFF).	Power not connected properly or circuit breaker open.	Check external power connection for reverse polarity or a short and wait a few minutes for the thermal circuit breaker to reset.
Lamp Low LED is ON.	The lamp intensity is low.	If the reference photodiode voltage is near 0.6 volts, the instrument may still function properly, but the lamp should be replaced when possible.
Cell Dirty LED is ON.	Absorption cell is dirty. Poor instrument zero.	Clean the cell. Send instrument to 2B Tech or call for cleaning procedure. Zero the instrument
Cell temperature reads low by several 10's of degrees.	Absent or loose connection of temperature probe cable to circuit board.	Reattach connector to circuit board.
Analog output is constant or does not track front display.	Cable not properly connected between analog output and recording device. Wrong scaling factor entered in serial menu.	Check continuity of your analog cable to your recording device and make sure correct connector pins are being used. Check and reset analog output scaling factor in the serial menu.
Readings are noisy with standard deviations greater than 2.5 ppb.	Lamp output is weak, below 0.6 V on Lamp Test. Flow path contaminated.	Check lamp connection to circuit board. Run Lamp Test from serial menu. If photodiode voltage is less than 0.6 V, replace lamp. Clean flow path with methanol (send instrument to 2B Tech, or call for cleaning procedure).
Analog output is constant or does not track serial readings.	Cable not properly connected between analog output and recording device.	Check continuity of your analog cable to your recording device and make sure correct connector pins are being used.

	Wrong scaling factor selected in menu.	Check and reset analog output scaling factor in the serial menu.
Serial port does not work.	Wrong baud rate or COM port specified in data acquisition program. Wrong serial cable used.	Set baud rate to 2400 in data acquisition program. Determine correct COM port (Section 2.3.2). A “straight through” serial cable is provided. Some data collection devices require a ”cross over” cable in which pins 1 and 3 are exchanged between the two ends of the cable. Use a “cross over cable or additional connector that switches pins 1 and 3.
Required calibration parameters are large (>±15% slope) when calibrated using a standard ozone source or reliable ozone instrument.	Flow path is contaminated.	Clean flow path with methanol: Send instrument to 2B Tech, or call 2B Tech for cleaning procedure.

2B Technologies offers reasonably priced customer service for instrument repairs. The calibration service includes cleaning of the entire flow path with methanol, testing of all components for proper function, and calibration. The best way to contact us for service is to log a customer service ticket at https://2btech.io/support/. Normally, you will hear back from us by email within a few hours. Or, call us at +1(303)273-0559.

There is a great deal of technical information about our instruments posted as technical notes. Manuals, brochures, software, cleaning procedures and scientific papers may be downloaded at https://2btech.io/downloads/. See Section 6 of this manual for a list of replacement parts, which may be purchased either by emailing us at sales@2btech.io by calling us at +1(303)273-0559.

4. CALIBRATION AND SPAN CHECKS

4.1. Calibration Overview

A multipoint calibration should be performed within the calibration frequency, any time major disassembly of components is performed, or any time the span checks give results outside of the acceptable limits.

Every analytical instrument is subject to some drift and variation in response, making it necessary to periodically check the calibration. Since the reliability of the data collected from any analytical instrument depends on the accuracy of the calibration, it is necessary to calibrate the instrument against a recognized standard such as the International Ozone Association (IOA) KI method. This method is detailed in the Iodometric Method for the Determination of Ozone in a Process Gas, Revised Standardized Procedure 001/96 (KI Method) established by members of the Quality Assurance committees of the International Ozone Association (IOA), including the Pan American Group (PAG), European African Group (EAG) and Nippon Islands (NIG). This procedure is an expanded version of the IOA method described in: Rakness, K., et al., Guideline for Measurement of Ozone Concentration in the Process Gas from an Ozone Generator, *Ozone Science and Engineering* **18**, 209-229 (1996). It should be noted that there is no method directly traceable to NIST for ozone concentrations above 1 ppm.

Dynamic calibration is a multipoint check where gas samples of known concentrations are sampled by the instrument in order to determine a calibration relationship. Calibration is the process of adjusting the gain (slope) and offset of the Ozone Monitor against some recognized standard. The reliability of the data collected from any analytical instrument depends on the accuracy of the calibration, which is largely dependent upon its analytical traceability to a reference material or reference instrument calibration.

Because of the instability of ozone, the certification of ozone concentrations in a compressed gas cylinder is impossible due to loss of ozone over time. When ozone concentration standards are required, the ozone must be generated and certified on site.

4.2. Equipment Required for Calibration

For routine calibration, an instrument can be calibrated against a working ozone standard, which is an ozone monitor that has been calibrated against the IOA KI method. The equipment that is needed to carry out the calibration is commercially available, or it can be assembled by the user. Calibration using a working ozone standard involves the generation of ozone concentrations that are simultaneously measured by the working standard and the instrument undergoing calibration. For calibration of the Model 108-H Ozone Monitor, this procedure requires the following equipment:

1. Zero air source
2. Ozone generator
3. Sampling manifold (inert material such as PTFE or FEP only)

4. Sampling lines (inert material such as PTFE or FEP only)
5. Sampling pump
6. Ozone monitor calibrated against the IOA KI Method

Zero air can be generated either from compressed cylinders or from scrubbed ambient air. If ambient air is used, contaminants such as ozone and nitric oxide must be removed. The 2B Technologies Model 306 Ozone Calibration Source can be used to provide zero air. Detailed procedures for generating zero air are in the EPA's Technical Assistance Document for the Calibration of Ambient Ozone Monitors.

4.3. Instrument Preparation

Prior to calibration, follow the steps below:

1. Connect your pump to the outlet of the Model 108-H Ozone Monitor (see Section 5 photos).
2. Turn on the Model 108-H Ozone Monitor and allow it to stabilize for a minimum of one hour.
3. Turn on the working standard and allow it to warm up according to the instrument user manual.
4. Connect the instrument to the manifold of your ozone calibration setup. If a particle filter will be used in normal operation, the calibration must be performed through the filter. The manifold must be vented to atmosphere so that pressure does not build up in the calibration setup.
5. Verify that the flow rate into the manifold is greater than the total flow required by the ozone monitor (0.5 L/min for the Model 108-H) and any other flow demand drawing from the manifold.
6. Enter the serial menu and set the zero (Z) value to 0 .00 and the slope (S) value to 1.000.

4.4. Calibration Procedure

As noted earlier (Section 4.1), a multipoint calibration should be performed within the calibration frequency, any time major disassembly of components is performed, or any time the span checks give results outside of the acceptable limits.

With the setup as described in Sections 4.2 and 4.3 above, carry out a calibration using the following steps.

4.4.1. Measurement of Zero Gas

1. Verify that the zero-gas supply is on and the ozone generator is off.
2. Allow the Model 108-H to sample zero gas until the response is stable.
3. Perform the zero function in the serial menu (command V) to establish the zero level of the Model 108-H.
4. Optional: The user may elect to connect a separate zero-air source and a zeroing valve to the instrument, using connection J5 on the circuit board (see

Section 2.9 and Figure 5.1). In this case, the “V” command will change the valve so that zero air flows to the instrument.

4.4.2. Measurement of Ozone Standards

1. Generate an ozone concentration slightly less than the concentration range of interest and allow the ozone generator to warm up for at least 5 minutes.
2. Allow the Model 108-H Ozone Monitor to sample the ozone concentration standard until a stable response is measured.
3. Record the average response of the ozone monitor as well as the average response of the working standard.
4. Generate several other ozone concentration standards. At least 5 ozone concentration standards are recommended over the range of interest.
5. For each ozone concentration standard, record the response of the ozone monitor as well as the working standard.

4.4.3. Calibration Curve

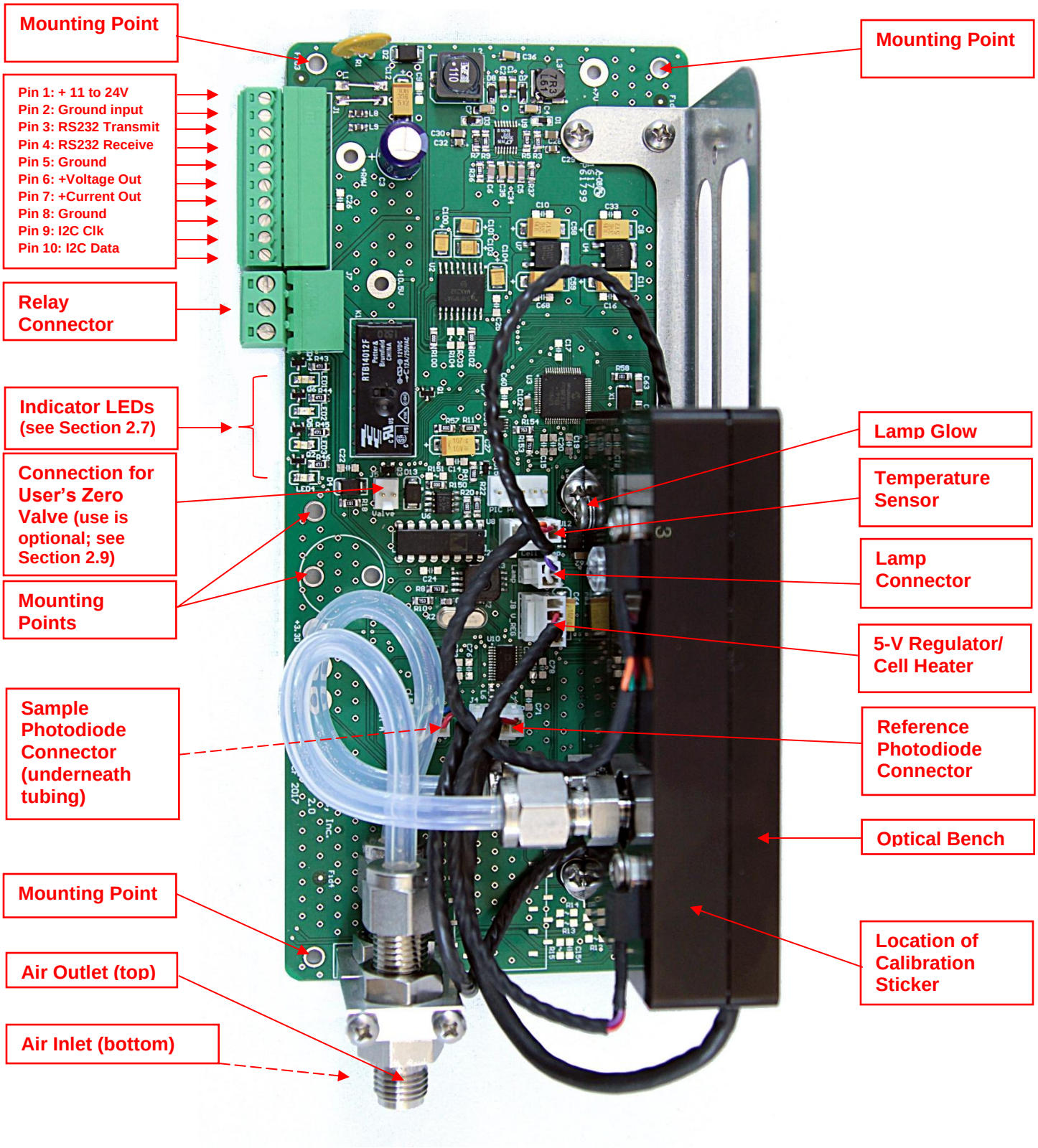
1. Plot the Model 108-H Monitor responses (x-axis) versus the corresponding standard ozone concentrations (y-axis).
2. Fit the data to a straight line ($y = mx + b$) using the linear regression technique to determine the calibration relationships.
3. Determine if any points deviate significantly from the line, which is an indication of an error in determining the calibration curve. The error may be due to the calibration setup or the ozone monitor being calibrated.
4. The slope (m) of the line is the gain factor (S) that needs to be applied to the ozone monitor response to calibrate it to the working standard. If the slope is outside of the range from 0.850 to 1.150, this is an indication of a problem in the calibration setup or the ozone monitor being calibrated.
5. Enter the serial menu and set the S calibration parameter.

4.5. Periodic Zero and Span Checks

To ensure the quality of the ozone monitor data, periodic zero and span checks can be performed by following the steps below:

1. A zero check is performed by sampling zero air with the Model 108-H as described in Section 4.4.1 above, “Measurement of Zero Gas.”
2. A span check is performed by sampling an ozone concentration at the high end of the concentration range of interest as described in Section 4.4.2 above, “Measurement of Ozone Standards.”
3. Average measurements from the zero check or span check should be within the instrument specifications. If the measurements are not within specifications, this is an indication of problem in the calibration setup or the ozone monitor being checked. The most likely problems in the ozone monitor are leaks or contamination in the optical setup. See the “Troubleshooting” section of this manual.

5. LABELED INSTRUMENT PHOTOS



5.1. Top View of the Model 108-H.

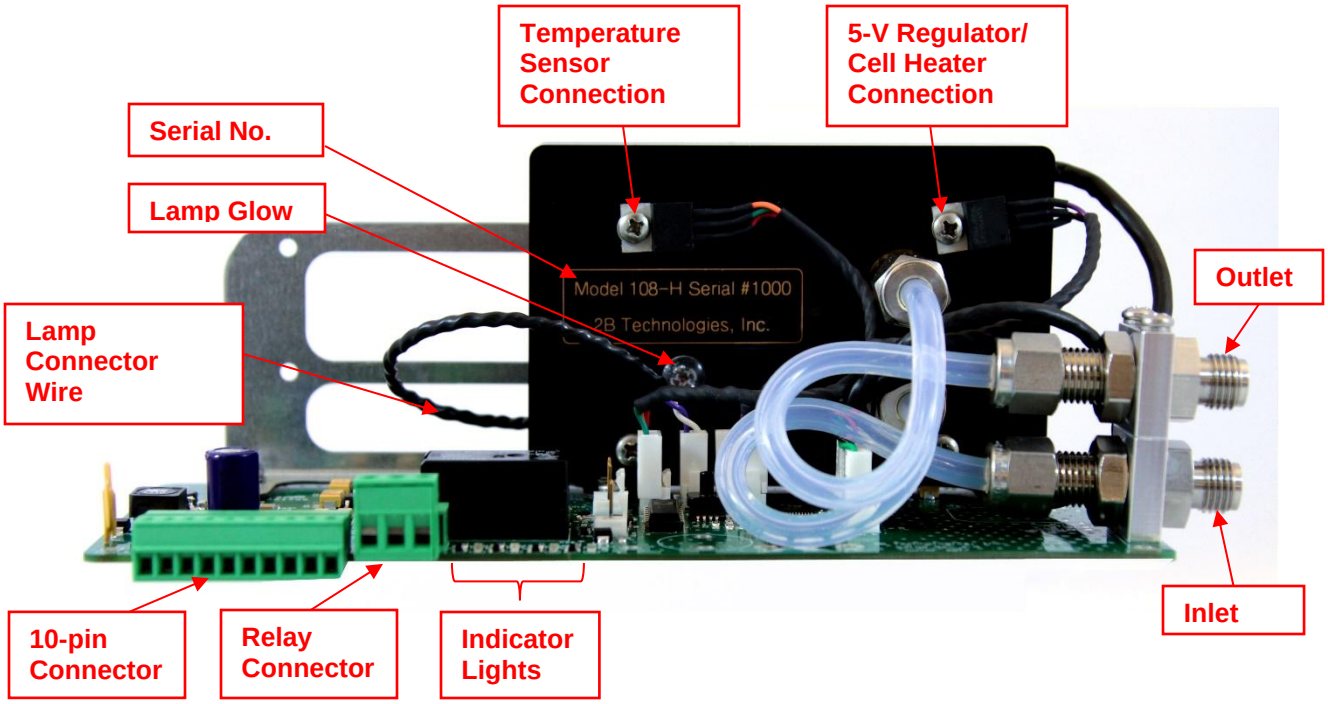


Figure 5.2. Side View of the Model 108-H.

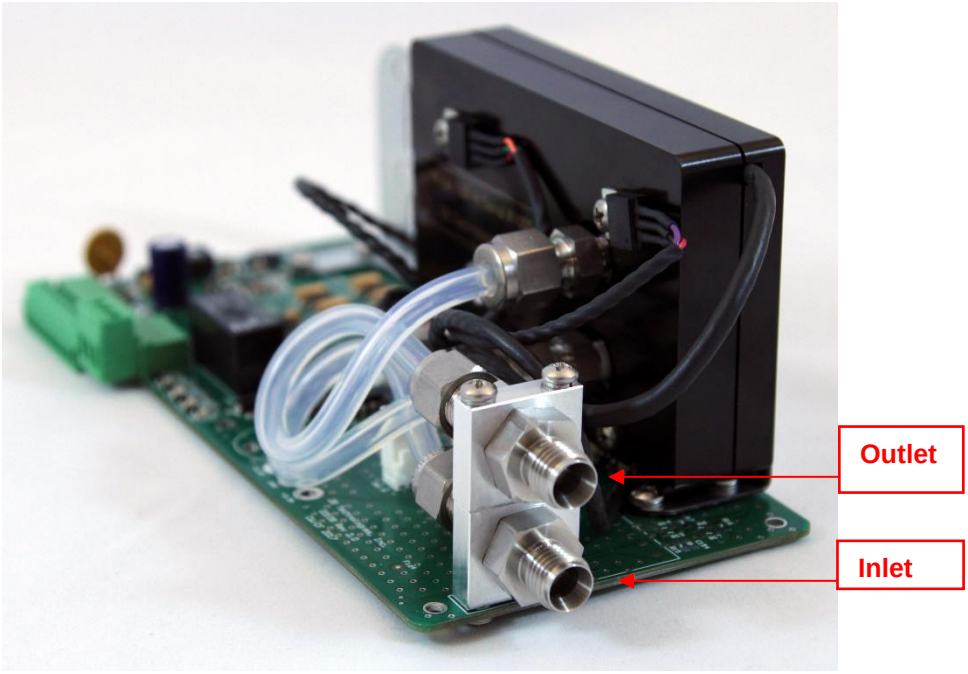


Figure 5.3. Back View of the Model 108-H.

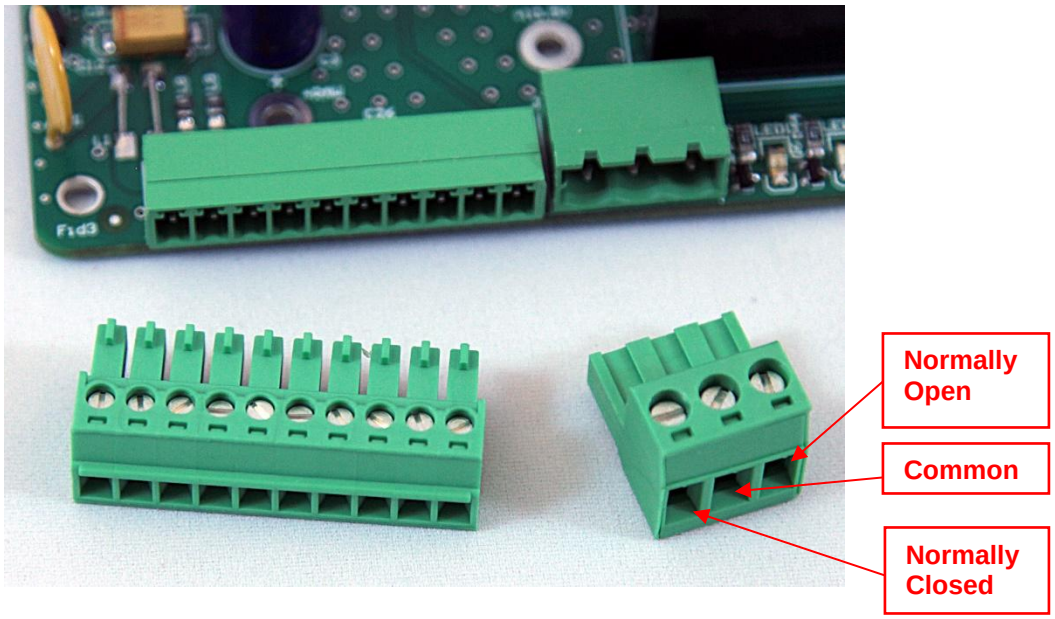


Figure 5.4. Detail of the 10-Pin and Relay Connectors of the Model 108-H.

6. REPLACEMENT PARTS

The following list includes those parts that are user serviceable.

Part Number	**Description**
OZLAMPAS108H	Lamp assembly
PDASSEMBLY108H	Photodiode assembly and cable
OZCELLAS108H	Absorption cell
RELCON108	Relay connector, single
108BRKOUT	10-pin breakout connector
SERCABL	Serial port cable (to computer)
PWRWIREHARNESS108	Power wire harness
SERWIREHARNESS108	Serial wire harness

7. SERVICE LOG

Date/ Hours	Calibrated	Cleaned	New Lamp	Other

Date/ Hours	Calibrated	Cleaned	New Lamp	Other