Ozone Monitor

2B Technologies, Inc.

OPERATION MANUAL

Model 202

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IDENTIFICATION RECORDS

Record the following information for future reference:

Unit serial number: _____

Warranty start date: _____
(date of receipt)

PRINTING HISTORY

New editions are complete revisions of the manual and incorporate all previous update pages and write-in instructions. This manual will be revised as necessary. Revisions can be in the form of new editions, update pages, or write-in instructions.

Revision B ..... October 2001

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, Inc. 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, Inc.

WARRANTY STATEMENT

2B Technologies, Inc. warrants its products against defects in materials and workmanship. 2B Technologies will, at its option, repair or replace products which 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 Periods

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, Inc.

Warranty Service

Warranty Service is provided to customers through phone support, Monday - Friday, from 9:00 a.m. to 5:00 p.m., Mountain Time USA. Phone support is for 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 phone 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.

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 customer. Maintenance, adjustment, calibration or operation must be performed in accordance with instructions stated in the Ozone Monitor 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.

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.

1. *OZONE MONITOR INTRODUCTION*

The 2B Technologies Ozone Monitor is designed to enable accurate measurements of atmospheric ozone in the mixing ratio over a wide dynamic range extending from a limit of detection of 1.5 parts-per-billion by volume (ppbv) to an upper limit of 100 parts-per-million (ppmv) based on the well established technique of absorption of ultraviolet light at 254 nm. The Ozone Monitor is light weight (4.7 lb., 2.1 kg.) and has a low power consumption (≈3.5 watt) relative to conventional instruments and is therefore well suited for applications such as:

- vertical profiling using balloons, kites, remotely piloted aircraft, and other aircraft where space and weight are highly limited
- long-term monitoring at remote locations where power is highly limited
- urban arrays of ground-based detectors
- personal exposure monitoring for studies of health effects of air pollutants

Compared to electrochemical ozone sondes, the Ozone Monitor is simpler to operate, does not require chemical reagents, and has a faster response time.

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 at significant concentrations in the atmosphere absorb at this wavelength. However, interferences, such as organic compounds containing aromatic rings, can occur in highly polluted air.

Figure 1 is a schematic diagram of the ozone monitor. Ozone is measured based on the attenuation of light passing through a 15-cm long absorption cell fitted with quartz windows. A low-pressure mercury lamp is located on one side of the absorption cell, and a 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 air pump draws sample air into the instrument at a flow rate of approximately 1 L/min. A solenoid valve switches so as to alternately send this air directly into the absorption cell or through an ozone scrubber and then into the absorption cell. The intensity of light at the photodiode is measured in air that has passed

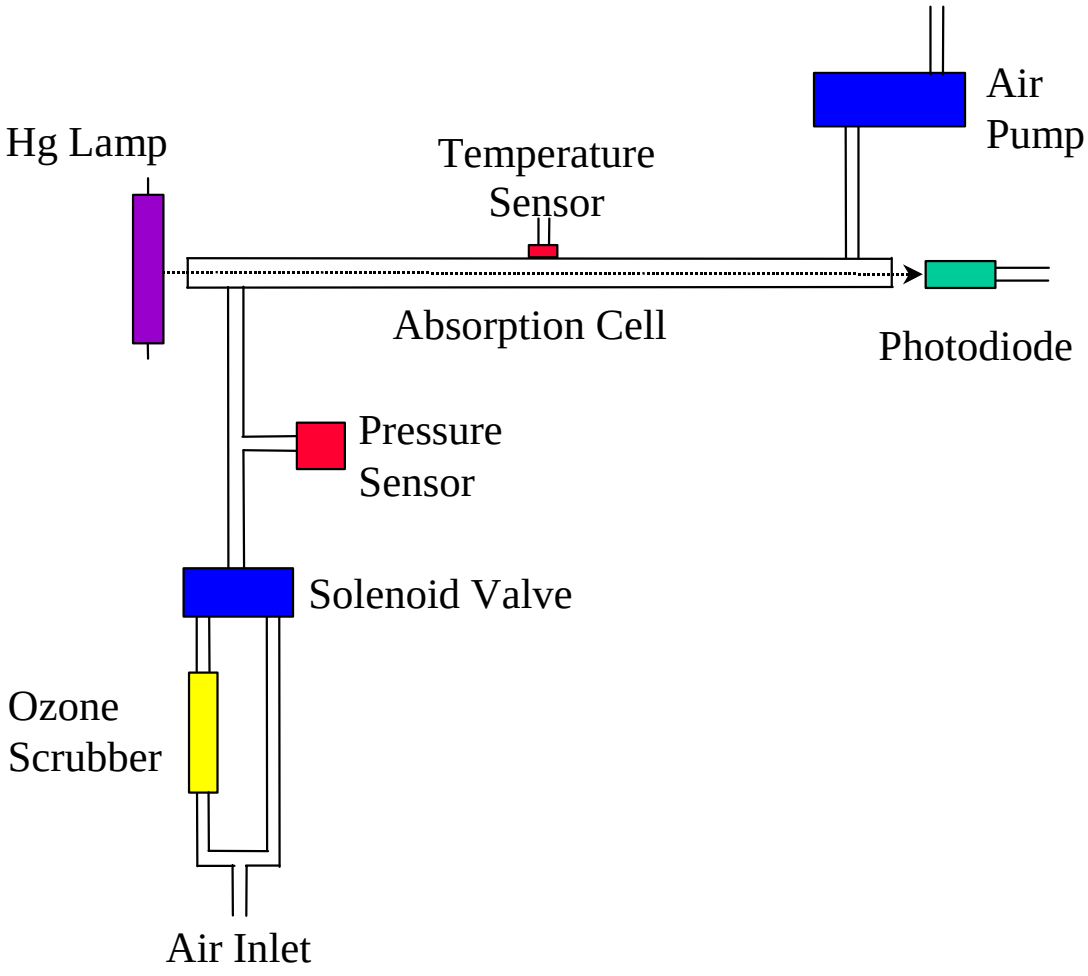


Figure 1. Schematic diagram of the ozone instrument.

through the ozone scrubber (I_o) and air that has not passed through the scrubber (I). Ozone concentration is calculated from the measurements of I_o and I according to the Beer-Lambert Law:

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

where l is the path length (15 cm) and σ is the absorption cross section for ozone at 254 nm (1.15×10^{-17} cm^2 molecule^{-1} or 308 atm^{-1} cm^{-1}), which is known with an accuracy of approximately 2%. The 2B Technologies instrument uses the same absorption cross section (extinction coefficient) as used in other commercial instruments.

The logarithm of equation 1 is approximated in the microprocessor of the instrument with sufficient accuracy to provide five orders of dynamic range; ozone mixing ratios are measured up to 100 ppmv, as compared to 1 ppmv for most commercial ozone instruments.

The pressure and temperature within the absorption cell are measured so that the ozone concentration can be expressed as a mixing ratio in parts-per-billion by volume (ppbv). The instrument displays and records the cell temperature and pressure in addition to the ozone mixing ratio. The cell pressure is displayed and logged in units of either Torr or mbar and the cell temperature in units of either ^{o}C or K.

In principle, the measurement of ozone by UV absorption requires no external calibration; it is an absolute method. However, non-linearity of the photodiode response and electronics can result in a small measurement error. Therefore, each instrument is compared with a conventional ozone spectrophotometer in the laboratory over a wide range of ozone mixing ratios. These results are used to calibrate the Ozone Monitor with respect to an offset and slope (gain or sensitivity). The corrections for offset and slope are recorded in the instrument Birth Certificate and on a calibration sticker that can be viewed by removing the top cover of the instrument. These calibration parameters are entered into the microprocessor prior to shipment. The user may change the calibration parameters from the front panel if desired. It is recommended that the instrument be recalibrated at least once every year and preferably more frequently. The offset may drift due to temperature change or chemical contamination of the absorption cell. As discussed below, an accurate offset correction can be measured from time to time using the ozone scrubber supplied with the instrument.

OZONE MONITOR SPECIFICATIONS

Power Requirements ..... 11-14 V DC, nominally 300 mA at 12 V, 3.6 watt

Dimensions.....3.5” x 8.3” x 11.6”

Weight .....4.7 lbs (2.1 kg)

Weight with case removed.....1.6 lb (0.7 kg)

Precision.....higher of 1.5 ppbv or 2%

Accuracy.....higher of 1.5 ppbv or *2*%

2. OPERATION

Please read all the following information before attempting to install the Ozone Monitor. For assistance, please call 2B Technologies at (303)216-1489.

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.

Shipping Box Contents

Open the shipping box and verify that it contains the following:

1. Ozone monitor
2. 110 V AC power adapter
3. Cigarette lighter adapter
4. Bare-wire 12 V DC battery adapter
5. Serial port cable
6. Zeroing cartridge
7. Ozone Monitor manual
8. Ozone Monitor birth certificate (inside manual)
9. Quality control data sheet and graph (inside manual)
10. Three external jacks for analog inputs

If anything is missing or obviously damaged, contact 2B Technologies immediately.

Operation of the Ozone Monitor

To operate the Ozone Monitor, connect it to an external power source and turn the instrument on by flipping the front panel switch. The instrument requires a 12 V DC source which can be supplied by: 1) the 110-220 V AC power adapter,

2) a cigarette lighter adapter plugged into a 12 V DC source such as found in an automobile or many light aircraft, or 3) a 12 V battery. The source can be in the range 11-14 V DC without any detrimental effects on the measurement. When using a battery, be certain to attach the positive (red) and negative (black) wires correctly. 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. (Some early instruments have an additional circuit breaker installed on the rear of the instrument. This breaker has a manual reset switch.)

Lead-acid batteries are available from numerous manufacturers in a wide range of sizes and amp-hour ratings. The larger of these, such as those for automobiles or boats, will supply power for weeks or months. Batteries packs in the correct voltage range may be constructed from nickel-cadmium (rechargeable) or lithium (light weight but not rechargeable) batteries for operation for a few hours.

Once turned on, the instrument will display “2B Tech Ver x.xx”, where x.xx is the version number of the software installed on the microprocessor. After a few seconds, the instrument will start displaying readings for ozone and the temperature and pressure of the absorption cell. 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 15-20 minutes required for the lamp, photodiode, and internal temperature of the absorption cell to stabilize.

Inlet tubing may be attached to the ¼ inch nylon Swagelok fitting on the back of the instrument. The tubing should be made of PTFE, PFA or some other inert material that does not destroy ozone. The length of tubing should be kept as short as possible (not more than a few feet) to minimize ozone destruction. Tygon, polypropylene (which may look like teflon) and metal tubing should not be used. A Teflon inlet filter is highly recommended to prevent internal contamination of the tubing and absorption cell by particulate matter. The filter should be tested for ozone loss by measuring ambient ozone with and without the filter attached.

If the instrument is being flown, the inlet should not point directly into the wind, because the resulting pressure fluctuations will result in a noisy signal. Although the instrument compensates for temperature drift, if strong

temperature fluctuations are expected, as in vertical profiling applications using balloons, the instrument should be placed in a thermally insulated box.

Measurement of the Zero Offset

The electronic zero of the instrument may be measured by attaching an ozone destruction cartridge to the air inlet for a period of 5-10 minutes. For an accurate measurement, the instrument must have been turned on long enough for the internal temperature to stabilize. The observed offset, which can amount to a few ppbv, can be corrected by the changing this calibration parameter from the front panel, as described below.

Collecting Data from the Analog Output

The data may be logged in real time using a data logger attached to the BNC analog output. The range of the analog output is 0-2.5 V. The output is scaled according to one of four sensitivities, chosen from the microprocessor menu, as described below. These are: 1 V = 200 ppbv (range of 0-500 ppbv); 1 V = 0.4 ppmv (range of 0-1 ppmv); 1 V = 4 ppmv (range of 0-10 ppmv); and 1 V = 40 ppmv (range of 0-100 ppmv). There is a small positive offset, typically 2 mV in the analog output, but this offset varies from instrument to instrument. The offset can be measured by simultaneously observing the panel display and measuring the analog output with a voltmeter.

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 using the 9-pin cable provided. Activate your data acquisition software; e.g., Hyperterminal (available on most Windows®-based computers) or Tera Term Pro (free download from www.download.com). The later software is preferred since Hyperterminal has a 500-line buffer limit, but the user may set the maximum buffer size for Tera Term Pro. Using these terminal emulation programs, data may be saved to a text file and then opened in Microsoft Excel (or other spread sheet program) where it may be converted to formatted data in columns by defining delimiters (such as commas and carriage returns) for data manipulation and graphing.

The ozone mixing ratio (ppbv), internal cell temperature (K or ^{o}C), cell pressure (Torr or mbar), values of three external analog inputs in volts (if activated from the menu), date, and time are sent as comma-delimited ASCII text to the serial port (2400 baud, 8 bits, no parity, 1 stop bit) every ten seconds, 1 minute, 5 minutes, or 1 hour, depending on the averaging time selected from the microprocessor menu. Time is provided in 24-hour (military) format, and the date is given in European style (day/month/year).

A typical data line would read:

67,35.3,980.6,1.3876,2.3143,0.1875,15/10/01,18:31:27

where:

Ozone = 67 ppbv
Cell temperature = 35.3 ^{o}C (may be expressed in K if chosen from menu)
Cell pressure = 980.6 mbar (may be expressed in Torr if chosen from menu)
Analog input A = 1.3876 volts
Analog input B = 2.3143 volts
Analog input C = 0.1875 volts
Date = October 15, 2001
Time = 6:31:27 pm

The three external inputs are omitted from the data line if they are turned off using the menu, as described below. The analog inputs allow measurements made by other instruments to be transmitted to a computer simultaneously with those of ozone and the time and date stamp; these inputs may also be logged in the instrument's internal memory, as described below. Examples of external measurements that are commonly made along with ozone are external temperature, pressure, and relative humidity, but the outputs of any instrument may be input to the Ozone Monitor. The analog inputs may range from 0 to +2.5000 volts and are measured with an accuracy of approximately ±0.0001 volt. An input voltage greater than +5.0 volts or less than –0.3 volts may permanently damage the instrument.

If the Ozone Monitor has been set to the log data mode, the output serial data line will be preceded by the log number; e.g.,

2893,67,35.3,980.6,1.3876,2.3143,0.1875,15/10/01,18:31:27

where 2893 is the log number.

In addition to data lines, messages are written to the serial port when logging is begun or ended, when transmission of data from the logger is begun and ended, when data collection is interrupted (e.g., due to a power failure) and when the averaging time is changed.

Data Averaging and Data Logging Using the Menu

When first turned on, the instrument will start making measurements at a rate of once every 10 s. Data, along with up to three external voltages, may be logged in the internal data logger. Up to 20,480 data lines containing log number, ozone mixing ratio, internal temperature, internal pressure, date and time may be stored in internal memory, corresponding to an operational time of 2.4 days. Averaging times of 1 min, 5 min and 1 hr also may be selected from the menu, thereby allowing the instrument to operate for 2.0 weeks, 2.4 months and 2.4 years, respectively, before filling the memory. The maximum number of data lines is halved if the three analog inputs are logged along with the other data. Thus, when logging the three analog inputs, the memory will allow operation for slightly more than 1 day, 1 week, 1 month or 1 year for averaging times for 10 s, 1 min, 5 min and 1 hr, respectively.

Selecting the Menu

The menu is accessed using the Select button on the front panel of the instrument. To reach the menu, hold down the Select button until the display shows:

Main Menu

Then, release the button. The panel will now display:

Main Menu
Dat Avg Cfg

where **Dat**, **Avg**, and **Cfg** are submenus that may be selected. A blinking cursor will show across the **D** of the **Dat** submenu. Clicks Clicks (button pushes within ¾ s) of the Select button are used to move within the menu and select operating parameters as follows:

- Single clicks move the cursor from one menu item to another.
- Double clicks select a menu item.
- Triple clicks move the cursor up one level in the menu.

Once in the menu, the cursor may be moved between the four submenus **Dat**, **Avg**, and **Cfg** by single clicks of the Select button.

To Log Data

Double click on the **Dat** submenu. The display will now show:

Data Menu
Xmt End Log

To start logging data, use single clicks to move the cursor to **Log**, and then double click to select the logging mode. This will return you to the **Main Menu**. To start data acquisition, triple click anywhere in the **Main Menu**. The display will immediately show the time (hours:minutes) and date (day/month/year) as in the following example:

Menu
09:43 17/10/01

After a few seconds, the instrument will display:

Menu
Log = 0:0

The Ozone Monitor will then alternately display every five seconds: 1) the ozone mixing ratio and log number and 2) the ozone concentration, internal temperature and internal pressure. For example, the display might read:

O3= 56 ppbv
T=305.6 P=730.4

where the ozone value is most current measurement of ozone, and T and P are the cell temperature and pressure (in units of K and Torr, in this case). After 5 seconds (midway between the next 10-s measurement cycle), as an example, the display will be replaced by:

O3= 56 ppbv
Log= 193:0

where **O3** is the ozone value most recently written to the logger, and the log number is 193.

If averaging has been selected, then the above display will be replaced by:

Avg O3=56 ppbv
Log= 193:4

Again 193 refers to the most recent log number. The "4" in 193:4 refers to the number of 10-s data points that have been measured so far for inclusion in the next average to be displayed and logged. If 10-s averaging is used (i.e., no averaging), this number will always be 0. If 1-min averaging is used, this number will increment from 0 to 5; for 5-min averaging, the number will increment from 0 to 29; and for 1-hr averaging, it will increment from 0 to 359. This number is displayed so that the user will know how many more 10-s measurements need to be made before a new average is displayed and logged.

If there is a power failure while the instrument is in the logging mode, logging will resume after power is restored. A note of

Data Interrupt - Time Error < 60s

will be written to the logger prior to writing the first new data line. In the case of a power failure, as many as 10 data lines may be lost because the microprocessor writes to the logger memory in groups of 10 lines. All data residing only in the volatile memory of the microprocessor are lost when power is interrupted. Also, the start time for logging of additional data following a

power interruption will be accurate only to the nearest minute (or nearest hour when Avg = 1 hr).

The instrument can accommodate multiple data interruptions due to power failures. For example, one can purposely switch the instrument off, move to another location and restart logging simply by turning the instrument back on. Data sets will be separated by the data interrupt message. However, as mentioned above, start times will be accurate only to the nearest minute or hour. If more accurate measurements of time are required, it is recommended that an external clock be used to assign an accurate time to the log number of the first data line following a purposeful power interruption. The incremental times between data lines are exact (i.e., 10 s, 1 min, 5 min and 1 hr).

Note: Once logging has started, you should not enter the menu, except to end logging. Entering the menu stops data acquisition, which is treated in the same way as a power failure; i.e., when logging is resumed, the start time for the new data will be accurate only to the nearest minute (nearest hour if 1-hr averaging is being used). In particular, you should not change the averaging time or turn the external inputs on or off while in the logging mode, as the earlier data stored in the logger memory will not be retrieved

To Stop Logging Data

Hold the Select button down to obtain the **Main Menu**. Go to the **Dat** submenu by double clicking on **Dat**. Use single clicks to move to the **End** function. Double click on **End**. This will end data logging and move the cursor to **Xmt**. You may now transmit the data to a computer by double clicking on **Xmt** (see below). Alternatively, you may return to the **Main Menu** by using a triple click and then use another triple click to completely exit the menu and start making measurements (but not logging them). The stored data will reside in memory (even when new measurements are being made) and can be transmitted using the **Xmt** function as often as you like. However, all stored data are lost once logging is started again using the **Log** function. Thus, you should always transmit your data to a computer before restarting logging.

If you fail to **End** logging prior to transmitting the data using the **Xmt** function, the instrument will automatically execute the **End** function for you prior to

transmitting the data. *(Note: This is a significant change from earlier versions of the instrument and software. You can no longer transmit data and then continue logging data into the same data log.)*

To Transmit Logged Data to a Computer Using the Serial Port

Connect the serial port of the instrument to the serial port of your computer using the cable provided. Enable a data acquisition program on the computer such as Microsoft Hyperterminal (available on most Windows® platforms) or preferably Terra Term Pro (available for download on the www.download.com web site. As mentioned earlier, the disadvantage of Hyperterminal is that it has a 500 line buffer limitation.

Hold down the Select button to obtain the **Main Menu**. Go to the **Dat** submenu by double clicking on **Dat**. Double click on **Xmt**. The message "Logged Data" will be written to the serial port, followed by a carriage return and all of the lines of logged data. After all data are transmitted, the message "End Logged Data" and a carriage return are written. After transmission is complete, you can return to any position in the menu or resume ozone measurements. The logged data continues to be available for transmission until a new data log is started.

To Average Data

Hold down the Select button to obtain the **Menu**. Select **Avg** using single clicks and double click on **Avg** to obtain the **Avg** menu:

Avg Menu
10s 1m 5m 1h

Use single clicks to move the cursor to **10s**, **1m**, **5m** or **1h** for averaging times of 10 s (no averaging), 1 min, 5 min or 1 hr averaging, respectively. Then double click on the averaging time you want to use. This will return you to the **Main Menu**. To start acquiring data, triple click anywhere in the **Main Menu**. Unlike earlier models of the instrument (software versions lower than 4.0), these averaging times are exact (based on a real-time clock). A 1-min average is the mean of six 10-s measurements, a 5-min average is the mean of 60 10-s measurements, and a 1-hr average is the mean of 360 10-s measurements.

While in averaging mode, the current 10-s measurement is displayed alternately with the average value, as discussed above.

Averaged data may be logged, thereby greatly extending the length of time that the data logger can be used.

To Set the Calibration Parameters

The instrument is calibrated at the factory where slope and offset parameters are entered into the instrument's memory. These preset calibration parameters are given in the instrument's Birth Certificate and recorded on the calibration sticker viewable with the top cover removed. However, the calibration parameters may be changed by the user. For example, it may be desirable to provide a positive offset by a known amount (e.g., 10 ppbv) if the analog output is being used for external data logging since the analog output does not go negative below zero ppbv. Some measured values will be below zero at very low ozone mixing ratios or while zeroing the instrument with an external scrubber. Also, the instrument zero may drift by a few ppbv over time. For this reason, frequent zeroing of the instrument using an external ozone scrubber to determine the offset is recommended. Any change in the slope (gain) of the instrument is likely due to a serious problem such as contamination, an air leak, obstruction of air flow, or loss of catalytic activity by the internal ozone scrubber, but it also can be adjusted. Once the zero of the instrument is corrected, the slope may be adjusted so that the instrument readout agrees with a standard ozone source or with the readout from another instrument whose calibration is considered to be accurate.

To change the calibration parameters, select **Cfg** from the **Main Menu** by double clicking to give the configuration menu:

Cfg Menu
D/T Cal I/O Unt

Now double click on **Cal**. The following submenu with the values of the current calibration parameters when then appear:

Cal Menu

Z=-2 S=1.01

Here Z is the offset applied (in this case -2 ppbv) and S is the slope applied (in this case 1.01). The value of Z is added to the measured ozone value and value of S is then multiplied by the measured ozone value. For example, if the instrument reads an average of 3 ppbv with the external scrubber in place, the value of z should be set to –3. If after correction for the zero, the instrument consistently reads 2% low, the value of S should be set to 1.02.

When the **Cal Menu** first appears, the cursor will be beneath the **Z**. Single clicks will change the value of **Z** in the range –9 to 9. A double click will move the cursor to lie beneath **S**. Single clicks will change the value of **S** in the range 0.91 to 1.09. Additional double clicks will move the cursor between **Z** and **S**. Once the values of **Z** and **S** are set, a triple click from any location will return the display to the **Cfg** menu, and an additional triple click will return to the **Main Menu**. The calibration parameters reside in non-volatile memory and are not affected by power failures.

To Set the Time and Date

From the **Main Menu**, select the **Cfg** submenu with a double click. Next, select the **D/T** submenu with a double click. The display will read, for example:

D/T: 10:32:21
17/10/2001

meaning that it is 21 seconds after 10:32 a.m. on October 17, 2001. The blinking cursor will lie under the first digit of the time (10:30:20). Single clicks will advance this digit (cycling through 0, 1 and 2). A double click will advance the cursor to the second digit of the time (0 in this case), which in turn can be changed by single clicks. Double clicks will advance the cursor to the next time digit (3 in this example), etc. Once the time and date is correct, a triple click will return to the **Main Menu**. As in setting a digital watch, the seconds should be set in advance of the real time since the clock starts to run again only when the set time is entered; in this case by a triple click. Note that the year can be set to as high as 2999, an indication of the confidence we have in our instrument.

To Turn On/Off the External Inputs

From the **Cfg** submenu, select **I/O** with a double click to give the input/output menu, for example:

I/O Menu
Ext=Off 1V=0.2

In this case, the three external analog inputs are turned off and won't be transmitted over the serial port or logged. To activate the external inputs, double click on **Off** to change the state to **On**. A triple click will return the display to the **Cfg** menu.

To Change the Scale for the Analog Output

An analog output is provided via a BNC connector at the back of the instrument for those who want to record their data with a chart recorder or external logger. The full scale of the analog output is 2.5 V. The scaling of this output can be changed using the input/output menu. The most sensitive output of 1V = 0.2 ppmv = 200 ppbv is normally used for measurements in the ambient atmosphere. This corresponds to a range of 0-500 ppbv. The ozone measurement is linear to 100 ppmv, however, and a variable scaling of the output therefore is provided for measurements of high ozone levels. This scaling may be changed by accessing the input/output menu. Select the input/output menu as described above for turning on/off the external inputs. The display will read, for example:

I/O Menu
Ext=Off 1V=0.2

Using a single click move the cursor to the first numeric digit (0 in this case) of **1V=0.2**. Double clicks will cycle the display between **1V=0.2**, **1V=0.4**, **1V=4**, and **1V =40**, corresponding to scalings of 1 volt equal to 0.2, 0.4, 4 and 40 ppmv (200, 400, 4000 and 40000 ppbv) and full scale outputs of 0.5, 1, 10 and 100 ppmv (500, 1000, 10000 and 100000 pbv) When the correct choice is displayed, a triple click will return the display to the **Cfg** menu.

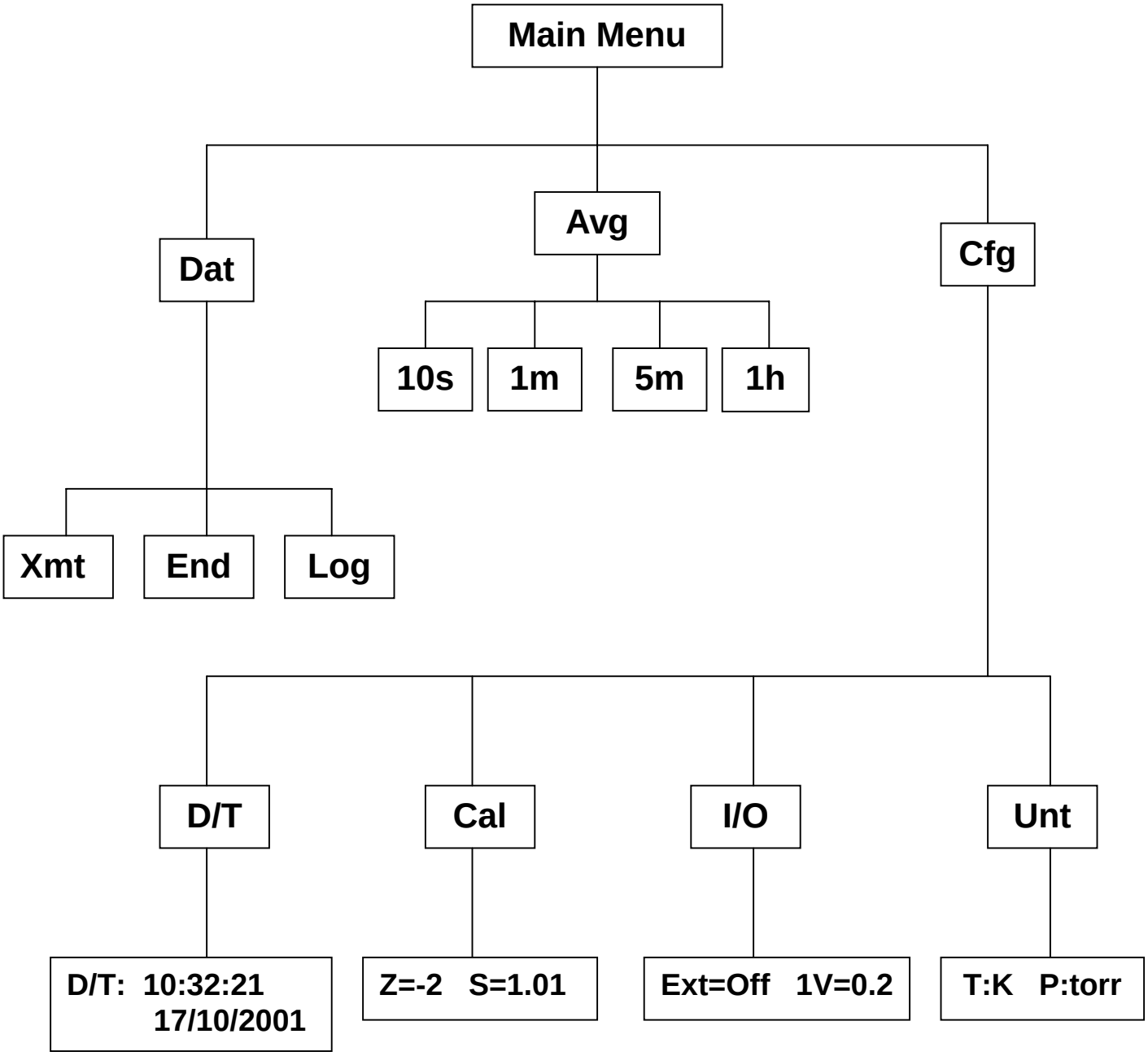
To Change the Units for Internal Temperature and Pressure

From the **Cfg** menu, select **Unt** with a double click to give the following menu, for example:

Units Menu
T:K P:torr

Single clicks will cycle the cursor between temperature (**T**) and pressure (**P**). Temperature units may be selected as either Kelvin (**K**) or Celsius (**C**) using double clicks. Pressure units may be selected as either **torr** or **mbar**. A triple click returns the display to the **Cfg** menu.

The following diagram on the following page summarizes the complete menu:


Main Menu
Dat
Avg
Cfg
10s
1m
5m
1h
Xmt
End
Log
D/T
Cal
I/O
Unt
D/T: 10:32:21
17/10/2001
Z=-2 S=1.01
Ext=Off 1V=0.2
T:K P:torr

3. MAINTENANCE/TROUBLESHOOTING

The Ozone Monitor is designed to be nearly maintenance-free. The only component that requires routine maintenance is the ozone scrubber, which should be changed at least once every six months of operation. Other user serviceable components include the lamp, air pump, and solenoid valve, all of which are easily replaced should they fail. Also, the inlet filter (user supplied) should be changed as recommended by the filter manufacturer.

If the instrument fails to operate correctly, common problems can be identified and corrected using Table I. If the problem cannot be corrected, the instrument may be shipped to 2B Technologies for service. Please phone or email in advance for shipping instructions.

The figures following Table I provide a "guided tour" of the instrument so that critical components and connectors may be easily identified. A list of serviceable parts is provided in Section 4 at the end of this manual.

Table I. *Troubleshooting the Ozone Monitor for performance problems.*

Problem/symptom	Likely cause	Corrective action
Instrument does not turn on.	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.
	Power cable not connected to circuit board.	Remove top cover and disconnect and reconnect power cable to circuit board.
Display is blank or nonsense.	Bad connection of display to circuit board.	Remove top cover and reconnect display to circuit board. Check solder connections to display.

Cell temperature reads low by several 10's of degrees.	Absent or loose connection of temperature probe cable to circuit board.	Remove top cover and reattach connector to circuit board.
Readings are noisy with standard deviations greater than 2.0 ppbv.	Lamp is not on.	Remove top cover and check lamp connection to circuit board. Remove bottom cover, turn instrument on, and visually check to see that lamp turns on at the same time the air pump turns on. ***CAUTION: Do not look at the lamp without appropriate eye protection. Severe injury may occur due to exposure to UV light.*** Replace lamp.
	Lamp output is weak.	Measure photodiode voltage on circuit board. If voltage is less than 1.0 V DC, replace lamp.
	Excessive vibration.	Provide additional vibration insulation for the instrument such as a foam pad.
Analog output is constant or does not track front display.	Cable not properly connected between analog output BNC and circuit board.	Remove top cover and reconnect cable between analog output and circuit board.
Select switch does not work.	Cable not properly connected between select switch and circuit board.	Remove top cover and reconnect select switch cable to circuit board.
Serial port does not work.	Cable not properly connected between serial port 9-pin connector and circuit	Remove top cover and reconnect serial port cable to circuit board.

	board. Wrong serial cable used.	 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 outside the adjustable range (±9 ppbv offset and/or ±9% slope) when calibrated using a standard ozone source or reliable ozone instrument.	Ozone scrubber is contaminated. Connecting tubing and absorption cell are contaminated. Solenoid valve is contaminated and not opening and closing properly. Absorption cell is contaminated.	Replace ozone scrubber. Be sure to use an inlet filter to remove particulate matter. Remove cell by first removing the aluminum block containing the photodiode. Rinse cell with methanol, dry with zero air and replace cell. Replace all inlet tubing with Teflon-lined Tygon® tubing. Remove solenoid valve, rinse with methanol, dry with zero air, and replace. Remove inlet and outlet tubing, flush cell with methanol and dry with clean compressed air, nitrogen or helium.

Instrument always reads close to zero for ozone concentration.	Solenoid valve cable is not properly connected to circuit board.	Reattach solenoid valve cable to circuit board.

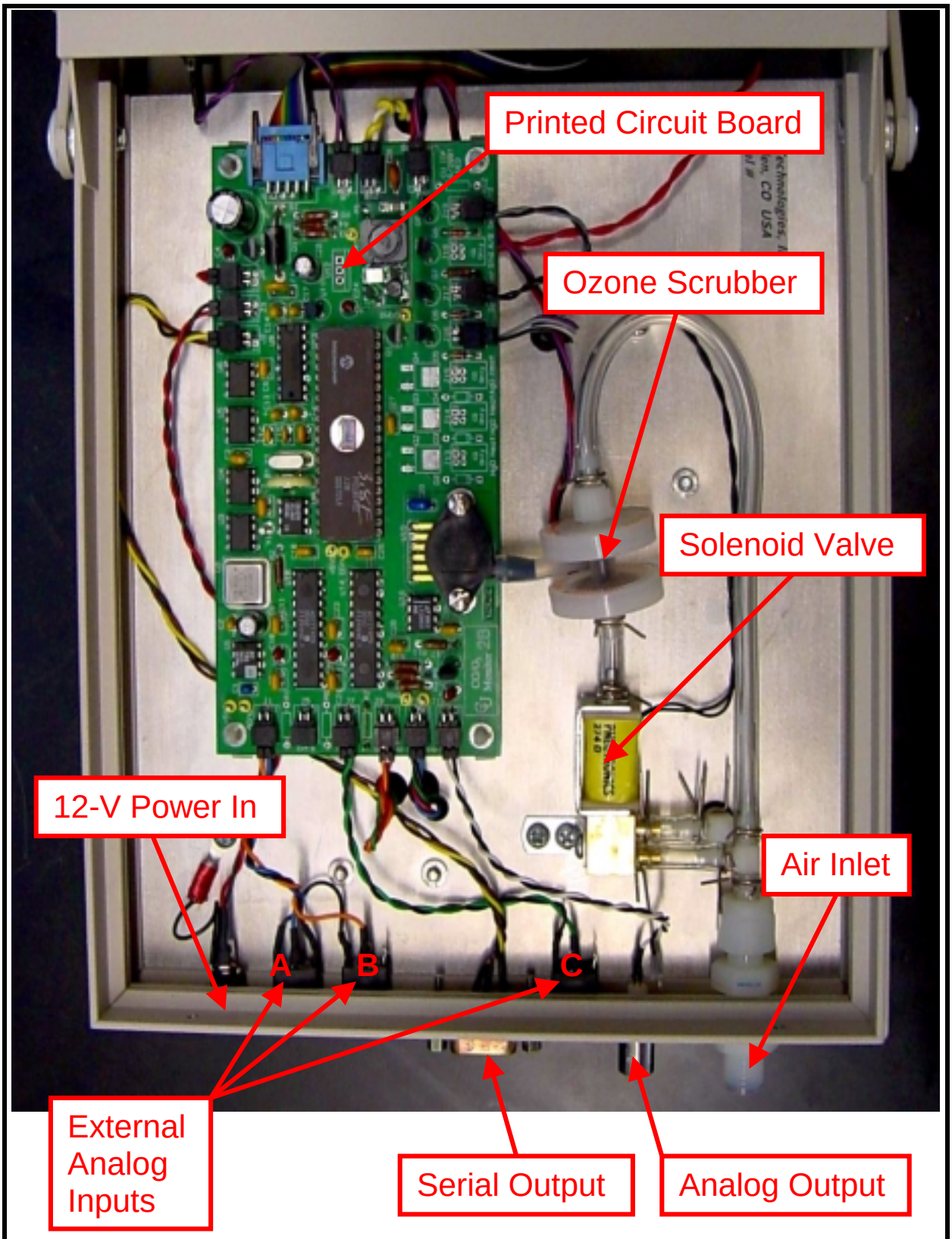


FIGURE 3-1: ***Top view of Ozone Monitor with cover removed.***

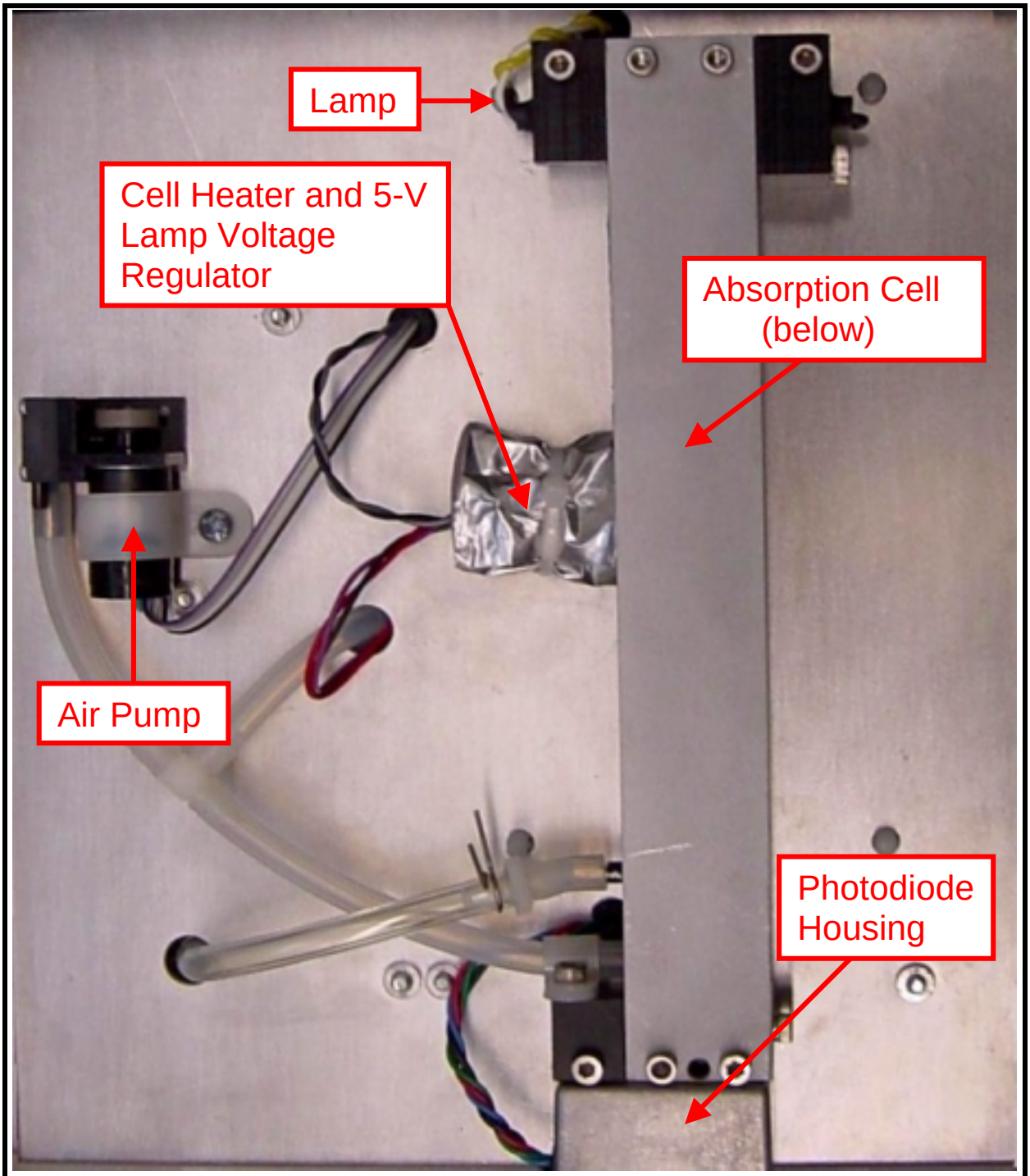


FIGURE 3-2: ***Bottom view of Ozone Monitor with cover removed.***

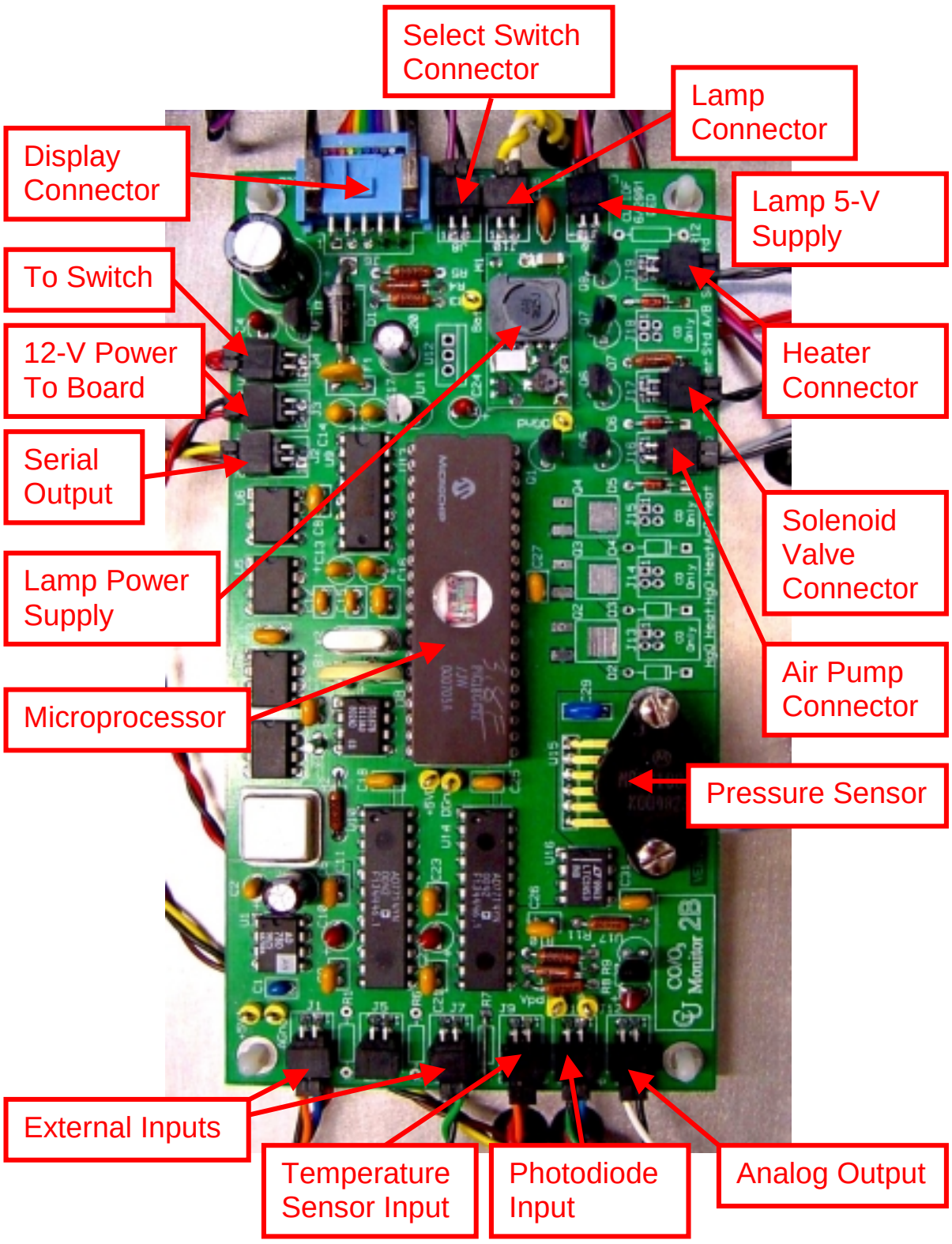


FIGURE 3-3: ***Printed Circuit Board.***

4. PARTS LIST

The following list includes those parts that are user serviceable.

Part Number	Description
SCRBINT	Ozone scrubber (internal)
SCRBEXT	Ozone scrubber (external)
OZLAMP	Lamp and cable
OZVLV	Solenoid valve
OZBRD	Circuit board without microprocessor
OZMCP	Microprocessor
OZDSP	LCD display and cable
OZPUMP	Air pump
PDASSY	Photodiode assembly and cable
OZCELL	Absorption cell
PWRASSY	Power connector/circuit breaker assembly
SERCABL	Serial port cable (to computer)
SERCON	Serial port connector and cable
BNCCON	Analog output BNC connector and cable
ANACON	Analog input connector
110ADP	110 V AC adapter
PWRWIR	Bare wire power cable
12VADP	12 V DC cigarette lighter adapter
TEFTYG	Teflon-lined Tygon® tubing
SILTUB	Silicone tubing