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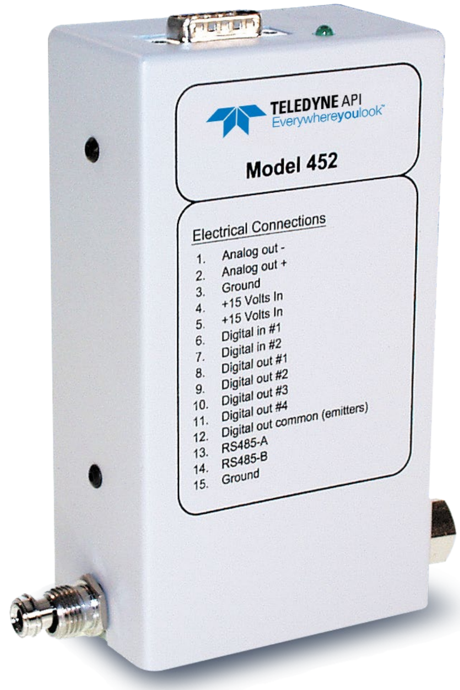

MODEL 452
PROCESS OZONE SENSOR
User Manual

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Notice of Copyright

Revisions to this Manual are intended to clarify existing descriptions and are not intended to infer any changes to customers under copy exact requirements.

Trademarks

Safety Messages

Important safety messages are provided throughout this manual for the purpose of avoiding personal injury or instrument damage. Please read these messages carefully. Each safety message is associated with a safety alert symbol and is placed throughout this manual; the safety symbols are also located inside the instrument. It is imperative that you pay close attention to these messages, the descriptions of which are as follows:

WARNING: Electrical Shock Hazard

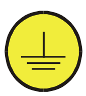
HAZARD: Strong oxidizer

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

CAUTION: Hot Surface Warning

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

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



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

CAUTION

This 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

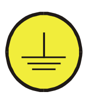
DANGER : Oxydant puissant

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

WARRANTY POLICY (02024J)

Teledyne API (TAPI), a business unit of Teledyne Instruments, Inc., provides that:

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

COVERAGE

After the warranty period and throughout the equipment lifetime, TAPI stands ready to provide on-site or in-plant service at reasonable rates similar to those of other manufacturers in the industry. All maintenance and the first level of field troubleshooting are to be performed by the customer.

NON-TAPI MANUFACTURED EQUIPMENT

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

Product Return

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

The complete Terms and Conditions of Sale can be reviewed at http://www.teledyne-api.com.

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.

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1 Product Descriptions

1.1 Model 452 Process Ozone Sensor

The Teledyne API Model 452 is a microprocessor-based sensor for measuring the concentration of gaseous ozone in processes such as semiconductor wafer fabrication, water treatment, and ozone research. The Model 452 can be used as a full flow process sensor or as a sensor to monitor a small flow of gas diverted from a process stream.

The Model 452 features a standard 0-5 volt analog signal for reporting process concentration as well as 4 digital status outputs for sensor diagnostics. A bi-directional serial interface is also provided for computer control.

The Model 452 operates from an external +15 vdc power source.

2 Specifications and Approvals

Note: All specifications contained herein are subject to change without notice. Please contact Teledyne API to obtain the current specifications.

2.1 Mechanical Specifications

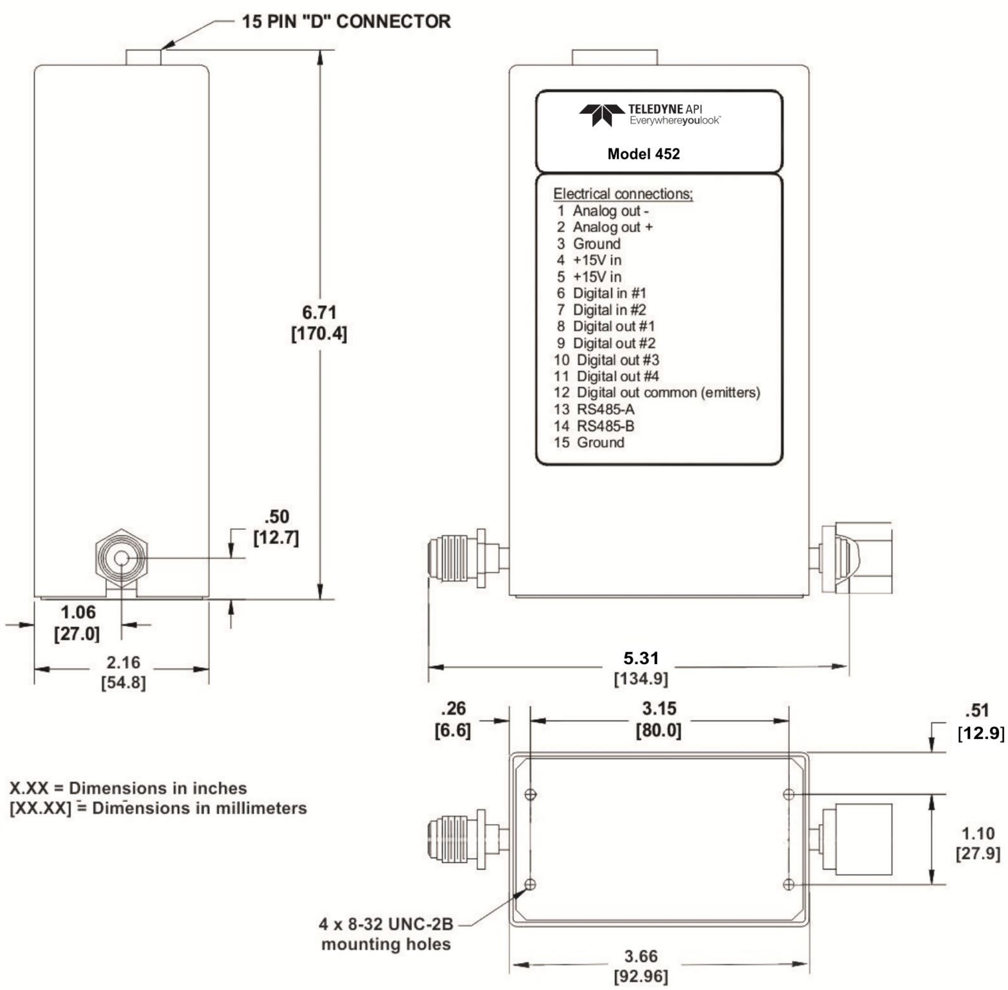


Figure 2-1: Model 452 High Purity Ozone Sensor

Weight:	2.8 lbs. (1.27 kg)
Fittings*:	¼” stainless steel compression (tube) or ¼” VCR Fittings (specified at time of order)
Wetted Materials:	316L Stainless Steel, PTFE, Sapphire

2.2 Performance Specifications

Accuracy:	±1% of Full Scale.
Repeatability:	1% of Full Scale
Response Time:	2 sec. to 95%
Zero Drift:	1% Full Scale/month (non –cumulative)

2.3 Operating Limits

Measurement Range*:	0-5, 0-10, 0-15, 0-20, 0-25% w/w 0-100, 0-200, 0-300, 0-400, 0-500 g/Nm3
Pressure Compensation:	Up to 3 Bar absolute
Operating Pressure*	7 – 30 psia or 25 – 60 psia
Proof pressure:	115 psia
Flow:	0.5-25.0 SLPM (See Figure 2-2)
Temperature range:	5 to 45 °C
Warm-Up Period:	30 minutes

2.4 Electrical Specifications

Power Input:	+15 volts ±1.0 volt (1.5 A maximum)
Analog Output:	0-5V Full Scale
Zero Cal:	Contact Closure Input
Status Indicators:	4 status LEDs
Digital Outputs:	Sensor OK, Invalid Reading, Lamp Low, Cell Dirty (Opto-isolated)
Serial Data Interface*:	RS232 or RS485, Half-Duplex, 9600 Baud

2.5 Calibration Reference

Span Calibration:	Traceable to Buffered KI laboratory calibration
Standard Temperature and Pressure (g/Nm3 only):	0°C and 760 mmHg

*These specifications are configurable by the factory at ordering

2.6 Pressure Drop

Figure 2-2 below shows the approximate pressure drop from the inlet fitting to the outlet fitting as a function of volumetric flow rate.

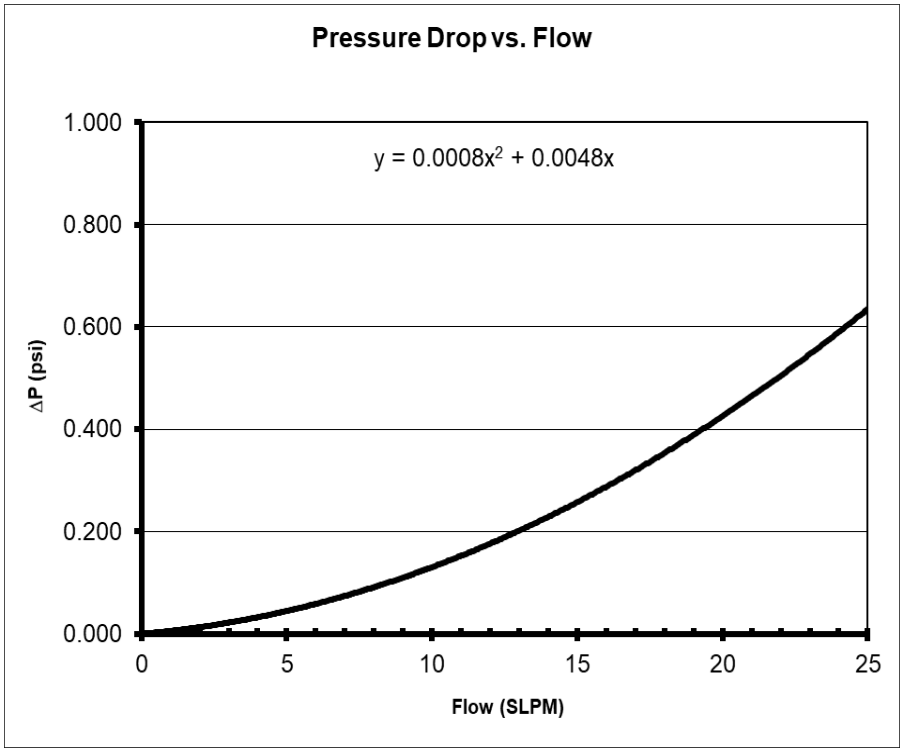


Figure 2-2: Pressure Drop vs. Flow

2.7 Approvals

This product is CE compliant and adheres to the Low Voltage and Electromagnetic Compatiblity Directives.

3 Theory of Operation

The detection of ozone molecules is based on absorption of 254 nm UV light due to an internal electronic resonance of the O_3 molecule. The Model 452 uses a mercury lamp constructed so that a large majority of the light emitted is at the 254 nm wavelength. Light from the lamp shines through an absorption cell through which the sample gas being measured is passed. The ratio of the intensity of light passing through the gas to a reference measurement, which does not pass through the gas, forms the ratio I/I_o. This ratio forms the basis for the calculation of the ozone concentration.

The Beer-Lambert equation, shown below, calculates the concentration of ozone from the ratio of light intensities.

$$C_{O_3} = -\frac{1}{\alpha \times \ell} \times \frac{\mathrm{T}}{273^o\,\mathrm{K}} \times \frac{14.695\,psi}{\mathrm{P}} \times \ln\frac{\mathrm{I}}{\mathrm{I}_o}$$

Where:

I	= Intensity of light passed through the sample
I_o	= Intensity of light through sample free of ozone
α	= Absorption coefficient
P	= Pressure
C_{O_3}	= Concentration of ozone
T	= Sample temperature in degrees Kelvin
psi	= Pressure in pounds per square inch (absolute)
ℓ	= Path length

As can be seen the concentration of ozone depends on more than the intensity ratio. Temperature and pressure influence the density of the sample. The density changes the number of ozone molecules in the absorption cell, which impacts the amount of light, removed from the light beam. These effects are addressed by directly measuring temperature and pressure and including their actual values in the calculation. The absorption coefficient is a number that reflects the inherent ability of ozone to absorb 254 nm light. Lastly, the absorption path length determines how many molecules are present in the column of gas in the absorption cell.

The intensity of light is converted into a voltage by the detector/preamp module. The voltage is converted into a number by a high resolution analog-to-digital converter. The digitized signal, along with the other variables, is used by the CPU to compute the concentration of ozone using the above formula.

4 Installation

4.1 Unpacking

Upon receiving the Model 452 please verify that no apparent shipping damage has occurred. If damage has occurred, please advise shipper first, then Teledyne API.

4.2 Mechanical Installation

Mount the Model 452 to a stable platform using four #8-32UNC screws. See Figure 2-1 for mounting-hole dimensions.

Please ensure the sensor is properly grounded during installation and prior to use. If the instrument's manifold is not fully grounded, the detectors may be influenced by electrical interference, resulting in changes to the measured concentration output.

CAUTION – PREVENT DAMAGE TO INSTRUMENT

Do not allow the mounting screws to penetrate beyond 1/8 of an inch (3.2 mm) into the bottom of the instrument.

CAUTION – PREVENT ELECTRICAL INTERFERENCE

If the mounting platform is non-conductive or not connected to earth ground, then a separate connection to earth ground should be made using one of the mounting screws. Failure to provide a proper earth ground connection may make the Model 452 susceptible to electrical interference from external sources.

4.3 Electrical Connections

Electrical connections are made to the Model 452 using the 15 pin D-Sub male connector on the top of the device. Figure 4-1 shows the pin-out of the 15-pin connector and typical connections.

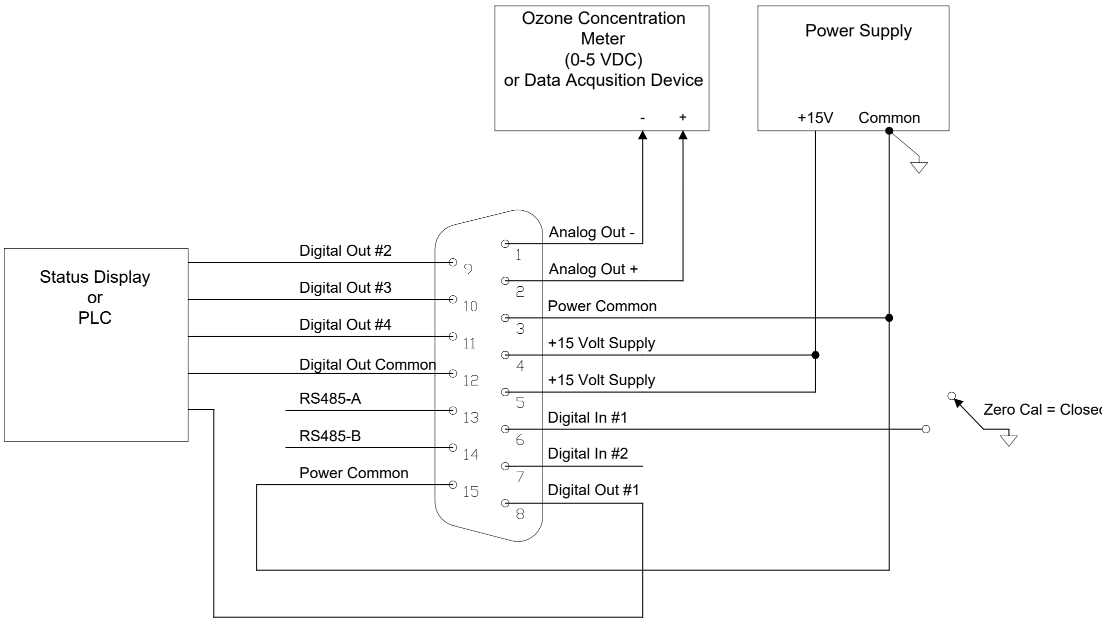


Figure 4-1: Electrical Connections

4.3.1 Power Supply

The Model 452 requires a +15 VDC power source capable of supplying 1.5 A. DC power can be connected through the male DB-15 connector or through the coaxial power jack. The coaxial power jack is configured so that the ground connection is on the outside (shield) and the +15V connection is on the center pin.

If power is to be supplied through the DB-15 connector, the positive terminal of the power supply should be connected to pins 4 and 5 on the 15-pin connector and the common terminal should be connected to pins 3 and 15.

If an AC Power Adapter is used to provide power, it should be connected to the coaxial power connector adjacent to the DB-15 connector on the top of the Model 452.

4.3.2 Analog Output

The analog output is a 0-5 volt signal representing the ozone concentration measured by the sensor. The output is scaled to the concentration range that the sensor has been set to measure. Check the serial number label on the Model 452 to determine the concentration range.

For best performance, the analog output should be connected to a voltmeter or A/D converter with a differential input and a minimum input impedance of 2KΩ.

4.3.3 Zero Calibration Input

The zero calibration input is located on Digital Input #1. To zero the Model 452, Digital Input #1 should be connected to the power common for at least 1 second. This can be accomplished using a Normally Open switch or relay.

4.3.4 Status Outputs

The Model 452 has four digital status outputs for indicating error status and when operational parameters have moved out of normal limits. These outputs are in the form of opto-isolated open-collector transistors. They can be used to drive status LED's on a display panel or interface to a digital device such as a Programmable Logic Controller (PLC).

Figure 4-2 below shows the most common way of connecting the digital outputs to an external device such as PLC. Note: Most devices, such as PLC's, have internal provision for limiting the current that the input will draw from an external device. When connecting to a unit that does not have this feature, external dropping resistors must be used to limit the current through the transistor output to 50mA or less.

See Sections 7.2 and 7.2.5 for details on using the Status Outputs for diagnosing sensor and system-level malfunctions.

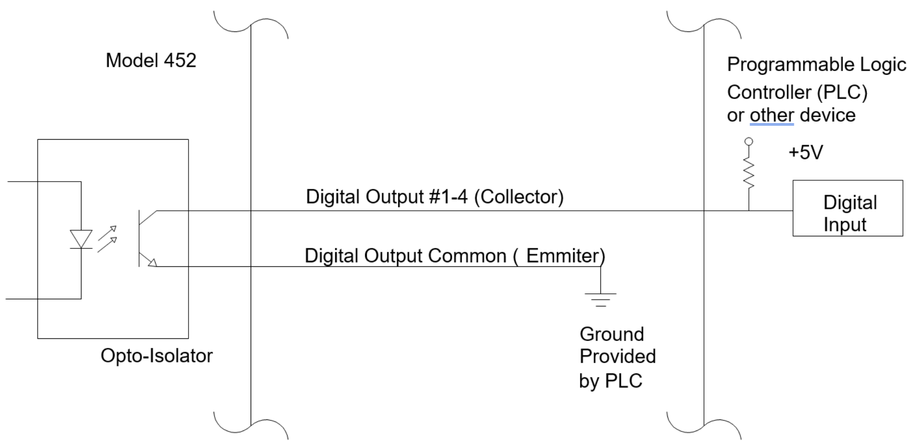


Figure 4-2: Digital Output Connections

4.3.5 RS232/485 Interface

The Model 452 features a bi-directional digital serial interface that can be used for sensor control and data acquisition. The serial port is normally configured at the factory for either RS232 or RS485 communications. Consult the serial number tag on your device for the port's configuration. Figure 4-3 and Figure 4-4 show typical connections. Section 5 provides Communications details.

Controller serial port parameters are as follows:

Baud Rate	9600
Parity	None
Data Bits	8
Stop Bits	1

M452 DB-15 Pin#	Function	Host DB-9 Pin#
13	Rx	3
14	Tx	2
15	GND	5

Figure 4-3. RS232 Connection

M452 DB-15 Pin#	Function	Host RS485
13	A	RS485-A
14	B	RS485-B
15	GND	GND

Figure 4-4. RS485 Connection

See Section 7.3 in the Sensor and System Troubleshooting section for verifying and configuring the serial communications connector.

4.4 Gas Connections

Gas connections to the Model 452 are made by using either ¼” compression tube fittings) or ¼” VCR™ face seal fittings (fitting option specified at time of purchase). The ¼” compression fittings can be used with ¼” O.D. Stainless Steel or Teflon™ tubing. The Model 452 is not sensitive to flow direction; it does not matter which of the two fittings is used as the gas inlet.

To avoid contamination of the optical cell in the Model 452, ensure that all tubing upstream of the Model 452 is properly cleaned and purged **before** the Model 452 is installed.

In order to achieve an acceptable response time and to avoid sample degradation, the system should be set up so that a minimum flow rate of 0.1 SLPM is established through the Model 452. If long tubing runs are used between the measurement point and the Model 452, then higher flow rates should be used to avoid sample degredation. Appropriate tests should be conducted to determine minimum flow requirements.

4.5 Start-Up and Calibration Procedure

1. Verify that the proper electrical connections have been made (See Section 4.3) and apply power to the Model 452, allowing it to warm up for at least 30 minutes.
2. Purge the Model 452 with zero gas (usually oxygen) at a minimum flow rate of 0.1 SLPM for a minimum of 5 minutes to purge.
3. Check that the Status Outputs are in their normal states and no errors are indicated (refer to Table 7-1).
4. Close the zero calibration input (See Section 4.3.3) for a minimum of 1 second to perform the automatic zero calibration.
5. Re-check the Status Outputs to ensure that no errors are indicated.
6. Check the voltage on the analog output (See Section 4.3.2) and verify that it reads 0.000 ± 0.010 volts.

The Model 452 is now ready for operation.

5 Communications

(If there is a need to troubleshoot, refer to Section 7.3, and to Figure 7-2 or Figure 7-3, according to which CPU PCA your device is configured with.

5.1.1 RS485/RS232 Commands

All commands are valid for either RS232 or RS485 hardware configuration.

Calibration Command:

d – Calibrate Zero

```
1 byte 1 byte   1 byte  1 byte
<ADDRESS>  <command>  <CR>  <CHKSUM>
```

ADDRESS must match address of sensor. Range is 0-9 ASCII OR'd w/0x80 (hi bit set) = 0xB0-B9. Applies to commands ONLY.

CHKSUM is the sum of all characters beginning with the address, ending with <cr>.
Always AND result with 0x7F, so high bit = 0. DO NOT send two's complement.

Response:

`OK<CR><CHKSUM>` for an acknowledge

`ERR<CR><CHKSUM>` for an error

Data Request Command:

a – **Send** Data:

```
1 byte 1 byte   1 byte  1 byte
<ADDRESS>   a      <CR>  <CHKSUM>
```

Response:

```
<address>,<Pressure>,<Cell_Temp>,<Meas_mv>,<Ref_mV>,<O3_wt%><CR><CHKSUM>
or:
```

`ERR<CR><CHKSUM>` for an error

Address range is ASCII numbers 0-9 (hi bit clear) = (0x30-39). Applies to responses ONLY.

Address Change Command:

i (x) – Set Address

```
1 byte      1 byte      1 byte       1 byte     1 byte
0xAA          i       <New Address>    <CR>     <CHKSUM>
```

Address is 0xAA(Hex.) (Note high bit already set.) This is the general call address that all sensors will receive.

<New Address> is binary value for new address (ie. 0x00 – 0x03)

Note: Control input #2 on M452 (I2C port, bit 1) must be latched (input pulled to ground) prior to initiating this command. This is required to inform the sensor that it is being addressed. This is the only command that requires this action. Note that this control input (Pin 7 on the DB15 connector) has an internal pull-up resistor and so does not require an external pull-up. Input should be released when acknowledge is received.

Response:

OK<CR><CHKSUM> for an acknowledge

ERR<CR><CHKSUM> for an error

5.1.2 Sample Serial Port Code

The following is some example code in written in Visual Basic that demonstrates how these commands could be sent to the instrument:

```
Dim check_sum, address, cmd_code As Byte
address = (&H30 + 0) Or &H80                ‘ Address 0, converts to ASCII 0 and sets high
                                            bit to 1‘ can substitute any allowable address
cmd_code = Asc("a")                         ‘ Sends ‘a’ command, can substitute ‘d’
check_sum = address + cmd_code + 13         command here
check_sum = check_sum And &H7F              ‘ Set high bit to 0 for check_sum. This prevents‘
                                            check_sum from being interpreted as an address
                                            for ‘ other sensors on the bus.
Comm1.Output = Chr(address) &
Chr(cmd_code) & _ Chr(13) & Chr(check_sum)
```

6 Maintenance: UV Lamp Replacement / Adjustment

The only user-serviceable part in the Model 452 is the lamp, which either can be adjusted or replaced and adjusted. For these procedures, refer to Figure 6-1, Figure 6-2, and Figure 6-3, and adhere to all Safety messages herein. For all other service, contact TAPI Technical Support.

WARNING

High voltages exist inside the sensor. Please use caution when sensor cover is removed.

CAUTION – AVOID WARRANTY INVALIDATION

The electronics used in TAPI analyzers are sensitive to Electrostatic Discharge (ESD). When working on any TAPI device, please ensure that you are properly grounded prior to handling or touching any electronic circuitry in the analyzers. Failure to comply with proper anti-Electro-Static Discharge (ESD) handling instructions may void your warranty. Refer to the manual, Fundamentals of ESD, PN 04786, which can be downloaded from our website at http://www.teledyne-api.com.

CAUTION – SAFETY RISK

There is risk of dangerous UV exposure when the cover is removed from the sensor. Take necessary precautions to avoid exposure and to protect eyes.

CAUTION – QUALIFIED SERVICE PERSONNEL ONLY

These procedures must be performed by qualified technicians only.

IMPORTANT **Use only distilled or de-ionized water with clean, lint-free towels and swabs when cleaning any components in TAPI equipment unless otherwise instructed.**

- To replace the lamp, follow all steps from Step 1 forward.
- To only adjust the voltage, follow Steps 1 through 5, and then skip to Step 13 and continue through the last step.

Note that some instructions will vary, depending on which Central Processing Unit (CPU) Printed Circuit Assembly (PCA) board is installed in the instrument.

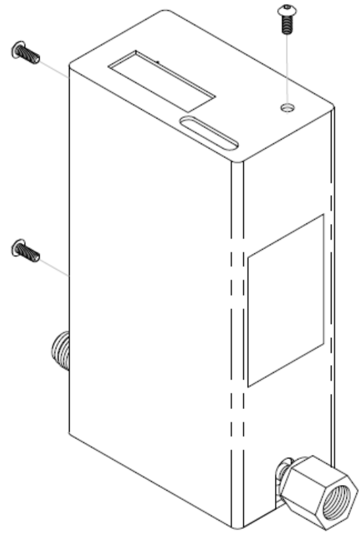


Figure 6-1: Cover Assembly Screws

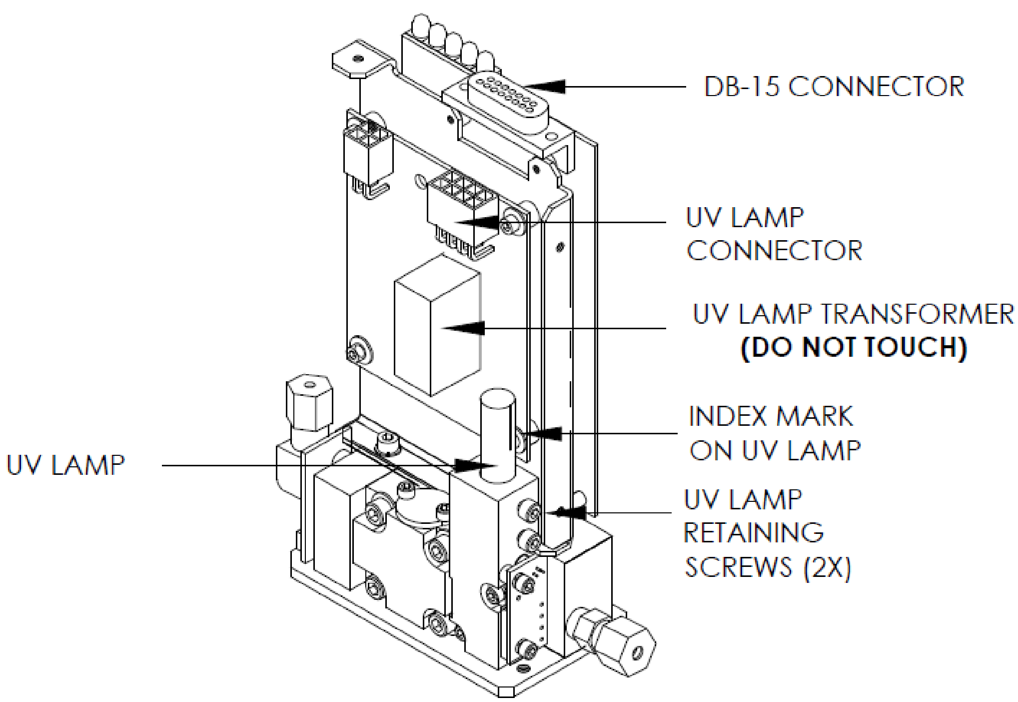


Figure 6-2: UV Lamp Orientation

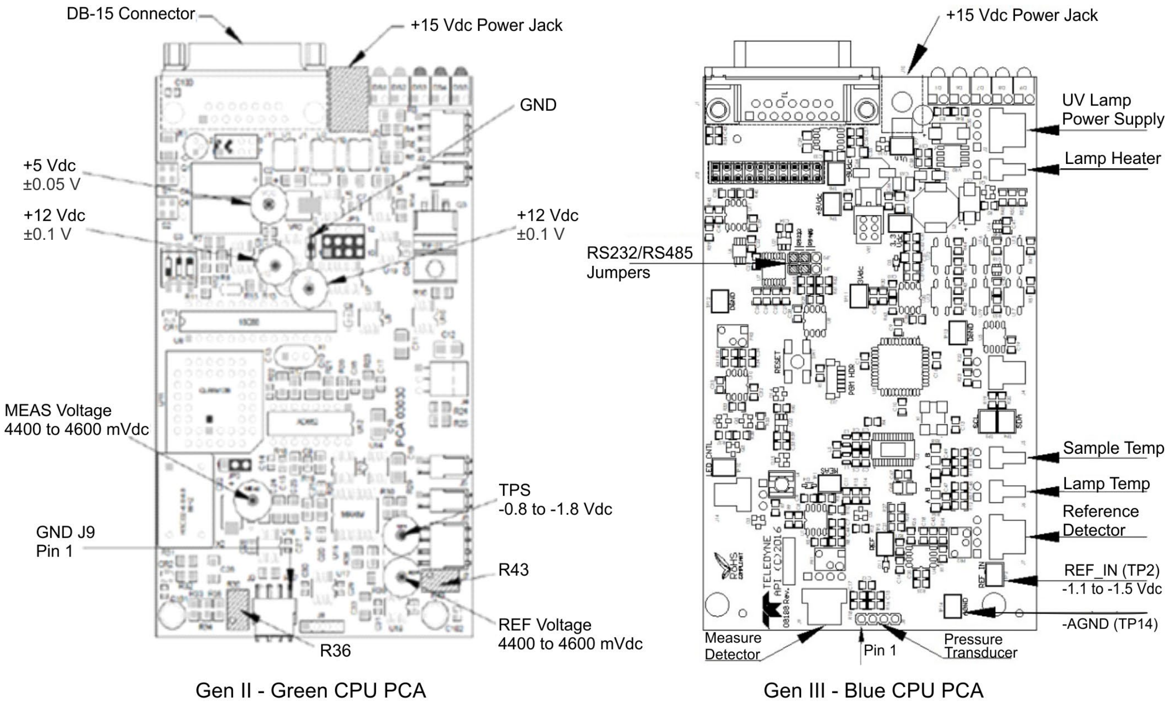


Figure 6-3: Voltage Adjustment Locations

> **CAUTION – PREVENT CONTAMINANT INFILTRATION**
>
> **Be careful to keep the lamp free from contaminants such as fingerprints. If the lamp becomes contaminated, clean the lamp's optical surface with alcohol first, then with distilled or deionized water. Do NOT allow any liquid to infiltrate the analyzer.**

1. Flush the analyzer with zero gas to exhaust any possible residual high concentration of O_3.
2. Remove the analyzer from the equipment (if necessary) to access the cover screws and the internal components of the analyzer.
3. Remove +15VDC Power to J10 (+15 VDC Power Jack) or DB-15 connector.
4. Remove the three screws shown in Figure 6-1.
5. Carefully slide cover up and off of instrument.
6. Squeeze the release tab of the UV lamp connector (Figure 6-2) and pull up the connector to disconnect lamp.
7. Loosen two UV Lamp Retaining screws (Figure 6-2) approximately one turn counter-clockwise or until the lamp moves freely.
8. Slide the UV lamp up and out of UV Lamp Block.
9. Install the new UV lamp, ensuring that the UV lamp is all the way down in the UV lamp block and the index mark or inverted "V" notch is aligned as shown in Figure 6-2.

10. Tighten one of the UV Lamp retaining screws very carefully. The torque specification for the screw(s) is 1.5 in/lbs.
11. Apply +15 VDC Power to J10 (+15 VDC Power Jack) or through DB-15 connector.
12. Allow the new lamp and analyzer to warm up for at least one hour.
13. Measure and adjust the voltage according to either the Gen II or Gen III instructions (according to the applicable CPU PCA, referring to Figure 6-3) that follow:

- **Voltage Adjustment for Gen II (CPU PCA board is green):**

  1. Measure DC Voltage from GND Ref (D1) to TP 5.

  2. Verify the DVM reads between –0.8 and –1.8 VDC

  3. If reading is outside that range, adjust the UV lamp to achieve the proper voltage by first loosening the UV lamp retaining screws just enough to adjust the UV lamp by rotating slightly.

  4. Torque both UV Lamp Retaining screws to 1.5 in-lbs.

  5. After torqueing, reconfirm that the TP5 voltage reads between –0.8 to –1.8 VDCz

- **Voltage Adjustment for Gen III (CPU PCA board is blue):**

  1. Measure DC Voltage from AGND (TP14) to REF_IN (TP2).

  2. Verify the DVM reads between –1.1 and –1.5 Vdc

  3. If reading is outside that range, adjust the UV lamp to achieve the proper voltage by first loosening the UV lamp retaining screws just enough to adjust UV lamp by rotating slightly if needed to achieve the proper voltage.

  4. Torque both UV Lamp Retaining screws to 1.5 in-lbs.

  5. After torqueing, reconfirm that the TP2 voltage reads between –1.1 to –1.5 Vdc

14. If proper voltages cannot be attained or the voltages are not stable, contact TAPI Technical Support Department for assistance or to arrange for return and repair of the sensor.

15. **For Gen III sensors, skip to Step 16; for Gen II sensors only, adjust the Reference and Measure detectors as follows:**

  1. Measure DC Voltage from GND Ref (D1) to TP REF.

  2. Adjust R43 until TP REF voltage measures 4500 +/- 100mV.

  3. Check DC Voltage from GND Ref (D1) to TP MEAS.

  4. Adjust R36 until TP REF voltage measures 4500 +/- 100mV.

  5. Power off and jump to Re-install Cover step.

16. **For Gen III sensors only, recalibrate internal scales for Warning parameters as follows:**

    1. While unit still under power, connect pin & (Digital Input #2) on the DB-15 connector to pin 15 (GND) for at least 5 seconds.

    2. Verify that the System OK LED blinks once to confirm that calibration is complete

    3. Power off and reinstall cover per next step.

17. **Re-install Cover**

CAUTION – PREVENT DAMAGE TO INSTRUMENT

Take extreme care to not catch any of the cables with the cover. Tuck the cables upward first, then slide the cover down over them. If you feel any of the cables catch on the cover, remove the cover and ensure that all the cables are seated correctly.

    1. Ensuring cables are tucked in, carefully slide cover onto Instrument as shown in Figure 6-1.

    2. Replace the three screws securing the cover and torque to 12 in-lbs.

18. **Re-install Sensor and Zero Instrument**

    1. Re-install the sensor in the O3 system and power on.

    2. Allow the sensor to warm-up for a minimum of 2 hours after power-on.

    3. Flow O2 through the sensor for a minimum of 5 minutes to purge.

    4. Perform a zero calibration and check that all status LEDs on the unit are in their normal states and no warnings are indicated.

UV Lamp replacement and adjustment or adjustment only is now complete.

7 Sensor and System Troubleshooting

This chapter provides guidelines for diagnosing system and sensor malfunctions using the four digital Status Outputs included in the Model 452. All troubleshooting should be done after the Model 452 has been turned on and allowed to warm up for at least 15 minutes.

CAUTION – QUALIFIED SERVICE PERSONNEL ONLY
These procedures must be performed by qualified technicians only.

7.1 Status LEDs

On the top of the Model 452 are five status LEDs, (Figure 7-1).

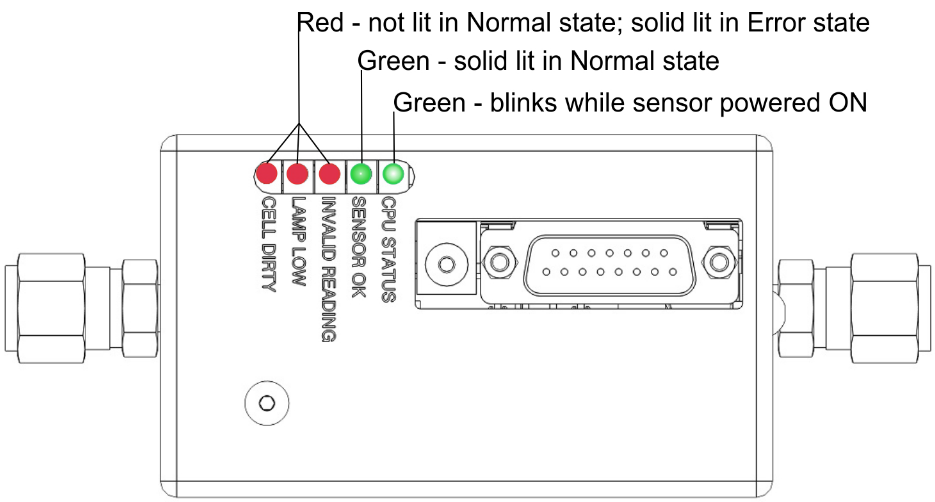


Figure 7-1. Status LEDs

The Status LED labeled ‘CPU STATUS’ is used to verify the status of the CPU inside the Model 452. This LED should blink on and off continuously while the sensor is on. If this LED stops blinking while power is applied to the sensor, a CPU failure is indicated.

The other four Status LEDs on the Model 452 exactly mirror the four Status Outputs described in the following sections.

7.2 Status Outputs

Table 7-1 below describes the function of the status outputs. More details as to the meaning of the status outputs are described in the subsections that follow.

Table 7-1: Status Outputs

Output #	Name	On State	Off state	Troubleshooting
1	Sensor OK	Normal State	Reference or Measure > 4995mV; Reference < 400mV	Section 7.2.1
2	Invalid Reading	Pressure > 45 psia, Negative Ozone Concentration	Normal State	Section 7.2.2
3	Lamp Low	Reference Detector<600mV	Normal State	Section 7.2.3
4	Cell Dirty	Measure/Reference ratio < 0.5 (zero gas)	Normal State	Section 7.2.4

7.2.1 Sensor OK

The normal state for the Sensor OK output is ON. During the warm-up period on start-up this output will stay off until the UV lamp reaches a minimum intensity. If this output remains off after the 30 minute warm-up period, or goes off during normal operation, then the Model 452 is in need of servicing.

If the Sensor OK output turns off *and* the Lamp Low output is on, this indicates that the lamp intensity has dropped below the minimum level required for proper operation. See Lamp Low, Section 7.2.3.

If the Sensor OK output turns off *and* the Lamp Low output is also off, then one of the analog voltages in the sensor has exceeded the range of the internal A/D converter.Carry out the adjustment procedures provided in Section 6.

7.2.2 Invalid Reading

The normal state for the Invalid Reading output is OFF. If this output turns on, this indicates that the Model 452 is still operational, but a system fault or calibration fault exists that may make the current ozone reading invalid.

The Invalid Reading output is turned on for any of the following conditions:

- When the measured pressure in the Model 452 exceeds 45 psia. Reduce the pressure going to the sensor.
- When the measured concentration has exceeded the full-scale concentration range of the sensor. Check the serial number tag for the full-scale concentration range. Reduce the ozone concentration.
- The sensor is indicating an excessive negative reading. Perform a zero calibration (Section 4.5).

7.2.3 Lamp Low

The normal state for the Lamp Low output is OFF. If this output turns on, this indicates that the UV lamp intensity as measured by the reference detector has dropped below 600mV.

If the Lamp Low output turns ON and the Sensor OK output is ON, this indicates that the lamp intensity is still adequate for measurement, but adjustment should be made when possible.

If the Lamp Low output turns ON and the Sensor OK output is OFF, this indicates a failure condition and accurate measurement is no longer possible. Check lamp output and adjust or replace as needed (Section 1.1.

7.2.4 Cell Dirty

The normal state for the Cell Dirty output is OFF. If this output turns on, then the ratio of the measure detector to the reference detector (at zero) is < 0.5, indicating a loss of optical transmission through the windows in the absorption cell or a calibration fault. Call Technical Support.

7.2.5 Status Output Summary Table

Table 7-2 below is a logic truth table summarizing the recommended actions based on the states of the four status outputs. A ‘1’ indicates the output is ON, a ‘0’ indicates the output is OFF, and ‘X’ indicates the output is in either state.

Table 7-2: Status Output Truth Table

Sensor OK	Invalid Reading	Lamp Low	Cell Dirty	Actions
1	0	0	0	Normal operation, no action required
0	X	X	X	Service required
1	1	X	X	Check Pressure > 45 psia Verify that concentration has not exceeded full scale range of sensor. Calibrate at Zero.
1	X	1	X	Lamp adjustment useful, though not required
1	X	X	1	Calibrate at zero Contact Technical Support

7.3 No Communication

The 452 is configured and set at the factory for serial communications for either RS-232 or RS 485 protocols. RS-232 is typically used when making a one-to-one connection between the instrument and a single computer or PLC. If the instrument will be used with an ozonator controller, or with a computer or PLC acting as acontroller, the communications protocol required is RS-485.

Check that the CPU STATUS LED on the top of the unit is flashing. Verify the comm jumper settings are correct for the application. Refer to figures below.

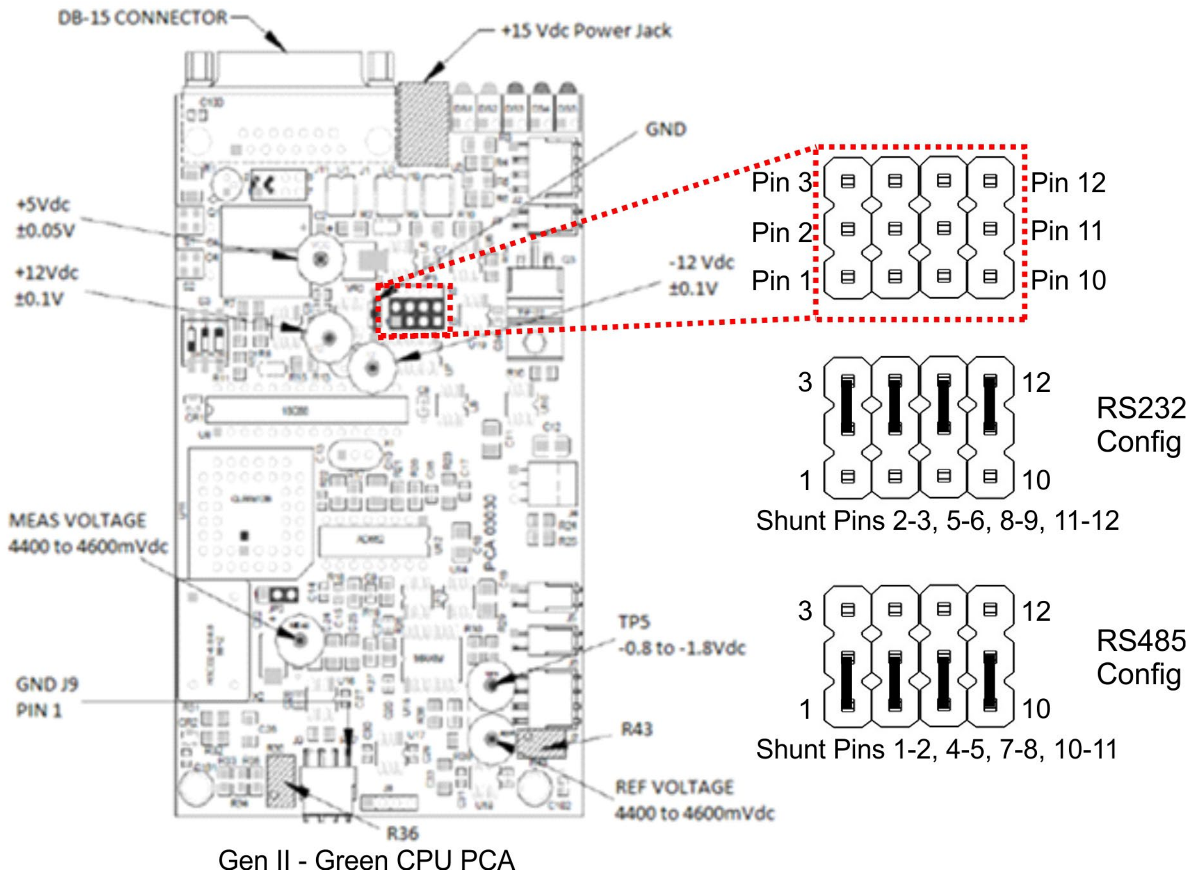
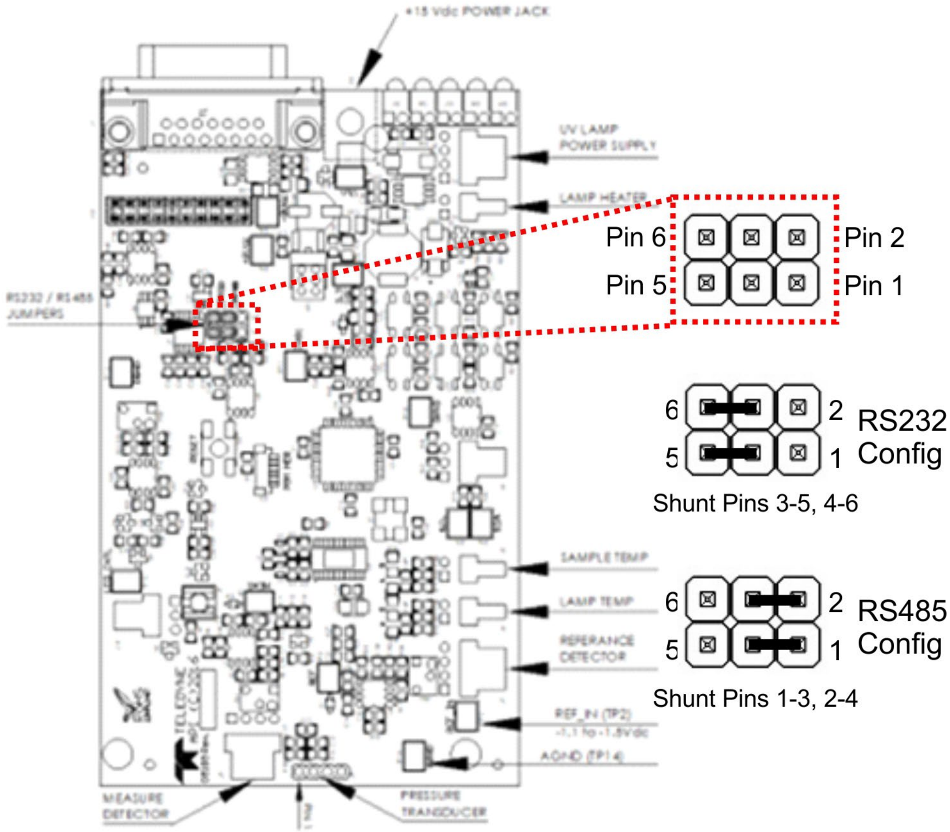


Figure 7-2. Gen II – Serial Comm Jumper Settings



Gen III - Blue CPU PCA

Figure 7-3. Gen III – Serial Comm Jumper Settings

7.4 Technical Assistance

If this manual and its trouble-shooting / repair sections do not solve your problems, technical assistance may be obtained from:

Teledyne API Technical Support

9970 Carroll Canyon Road, San Diego, CA 92131

Phone: +1 858 657 9800 or 1-800 324 5190

Fax: +1 858 657 9816

Email: api-techsupport@teledyne.com.