

Addendum Model 48i Model 48i High Level

Part Number 109263-00
31Dec2009

Internal Oxygen Sensor Option

Thermo Fisher Scientific has an exciting new option to add to its Model 48i series of Gas Filter Correlation Infrared Analyzers. The Paramagnetic Oxygen (O₂) Sensor gives the source measurement of CO extended capabilities and the ability to read and report the concentration of oxygen in the sample stream up to 100%.

Along with the ability to measure O₂ and display the concentration on the front panel, the flexibility of the iSeries platform allows reporting through analog voltage outputs, current outputs, serial RS-232/RS-485 ports or Ethernet.

Additionally, the program allows the user to correct the CO readings for the amount of oxygen in the sample. Selectable O₂ concentrations can be used as the correction factor (for example: CO corrected to 6% O₂ or any other percentage).

This addendum is organized as follows:

- “Specifications” on page 2
- “Calibration” on page 3
- “Operation” on page 5
- “Troubleshooting” on page 19
- “Servicing” on page 22
- “Optional Equipment” on page 25
- “C-Link Protocol Commands” on page 27
- “MODBUS Protocol” on page 31

Specifications

The following table lists the manufacturer's specifications for the optional internal oxygen sensor.

Table. Optional Internal Oxygen Sensor Specifications

Technology	Paramagnetic (Pm)
Range	0-100% O ₂
Accuracy (Intrinsic error)	<±0.1% O ₂
Linearity	<±0.1% O ₂
Repeatability	<±0.1% O ₂
Zero Drift	<±0.2% O ₂ per month (excludes up to 0.1% O ₂ in the first 24 hours of operation)
Response Time (T ₁₀ -T ₉₀)	<2.5 seconds
Weight	Approximately 2 lbs. (in addition to standard instrument)

Calibration

This section describes how to calibrate the optional internal O₂ sensor.



Be sure to power the analyzer for half an hour at normal operating conditions (with the cover on) before calibration. The internal O₂ sensor should be calibrated at the zero and span points, as described in the following procedure.

Note The total airflow of the calibration gases must exceed the total demand of the analyzer. The Model 48*i* and Model 48*i* High Level require approximately 1000 cc/min of sample flow, so a total airflow of at least 1100 cc/min is recommended. ▲

Use the following procedure to calibrate the oxygen sensor under normal conditions. If you are unable to calibrate the oxygen sensor effectively using the following procedure, use the Alternate Calibration Procedure.

Calibration Equipment:



Test gas: Nitrogen zero gas - span gas approximately 20% oxygen concentration.

1. Supply the nitrogen zero gas to the SAMPLE port on the rear of the analyzer and wait for the O₂ reading to stabilize.
2. From the Main Menu choose Calibration > **Calibrate O₂ Background** and press  to set the O₂ background to zero.
3. Supply the O₂ Span gas to the SAMPLE port on the rear of the analyzer and wait for the O₂ reading to stabilize.
4. From the Main Menu choose Calibration > **Calibrate O₂ Coefficient**, enter the span concentration, and press  to set the O₂ coefficient.

Note If you were unable to calibrate the oxygen sensor effectively using this procedure, recalibrate using the “Alternate Sensor Calibration” procedure that follows. ▲

Alternate Sensor Calibration

Use the following procedure if the standard calibration procedure described previously fails to calibrate properly or for high altitude (5000m/15400 ft) calibration.

1. Supply the nitrogen zero gas to the SAMPLE port on the rear of the analyzer.
2. From the Main Menu choose Calibration Factors > **O₂ Background**, set the O₂ background to zero, and press  to set the O₂ background.
3. Use the screwdriver to adjust zero potentiometer RV1 such that the O₂ value reads 0.00% O₂.
4. Use the screwdriver to adjust the span potentiometer RV2 fully clockwise.
5. Supply the O₂ span gas to the SAMPLE port on the rear of the analyzer.
6. From the Main Menu choose Calibration Factors > **O₂ Coefficient**, set the O₂ coefficient to 1.000, and press  to set the O₂ coefficient.
7. Use the screwdriver to adjust the coarse span potentiometer RV3 such that the O₂ reading is 20% greater than the calibration gas value. For example, 25% O₂ span gas should be set to produce an output of 30.00% O₂.
8. Use the screwdriver to adjust the Span potentiometer RV2 such that the O₂ reading indicates the correct percent concentration. For example, 25% oxygen span gas should be set to produce a measurement of 25.00%.
9. Replace the cover, wait 30 minutes for the instrument to stabilize, and repeat the four steps in the “Calibration” procedure.

Operation

This section describes the updates of the menu-driven software to include the following new screens added for the optional internal O₂ sensor.

- Calibration Factors
- Calibration
- Instrument Controls
- Diagnostics
- Alarms
- Service

Calibration Factors Menu

The O₂ Background menu item and the O₂ Coefficient menu item are displayed only when the internal O₂ sensor option is installed.

- In the Main Menu, choose **Calibration Factors**.


```
CALIBRATION FACTORS:
>BKG                      0.00
COEF                      1.000
O2 BKG                    0.00
O2 COEF                   1.000
RESET USER CAL DEFAULTS






RANGE  AVG  DIAGS  ALARM
```

O₂ Background

The O₂ Background screen is used to perform a manual zero calibration of the oxygen sensor. Before performing a zero calibration, allow the analyzer to sample nitrogen until stable readings are obtained. The first line of the display shows the current O₂ reading. The second line of the display shows the O₂ background correction that is stored in memory. The O₂ background correction is a value, expressed in %, that is subtracted from the O₂ reading to produce the O₂ reading that is displayed.

In the example below, the analyzer displays 0.12% of O₂ while sampling nitrogen. A background correction of 0.00% means that 0% is being subtracted from the O₂ concentration being displayed. Therefore, the background correction must be increased to 0.12% in order for the O₂ reading to be at 0%, i.e., an O₂ reading of 0.12% minus an O₂ background reading of 0.12% gives the corrected O₂ reading of 0%.

To set the O₂ reading in the example below to zero, use  to increment the O₂ background correction to 0.12%. As the O₂ background correction is increased, the O₂ concentration is decreased. Note that at this

point, pressing  and  however, has no effect on the analog outputs or the stored O₂ background correction of 0.00%. A question mark following both the O₂ reading and the O₂ background correction indicates that these are proposed changes as opposed to implemented changes. To escape this screen without saving any changes, press  to return to the Calibration Factors menu or  to return to the Run screen. Press  to actually set the O₂ reading to 0.00% and store the new background correction of 0.12%. Then the question mark prompt beside the O₂ reading disappears.



- In the Main Menu, choose Calibration Factors > **O₂ Background**.

```

O2 BACKGROUND:
      O2:      0.12 %
SET BKG TO:   0.00 % ?
      ↑↓ INC/DEC
      ← SAVE VALUE
RANGE  AVG  DIAGS  ALARM
  
```

O₂ Coefficient

The O₂ Coefficient screen allows the O₂ span coefficients to be changed manually while sampling span gas of known concentration.

The display shows the current O₂ concentration reading. The next line of the display shows the O₂ span coefficient that is stored in memory and is being used to correct the O₂ concentration. Notice that as the span coefficient value is changed, the current O₂ concentration reading on the above line also changes. However, no real changes are made to the value stored in memory until  is pressed. Only proposed changes, as indicated by a question mark prompt, are displayed until  is pressed.

Note The concentration value will show “ERROR” if the measured concentration is not a valid span value (either too high or too low). ▲

- In the Main Menu, choose Calibration Factors > **O₂ Coefficient**.

```

O2 COEFFICIENT:
      O2:      20.80
SET COEF TO:  1.00  ?
      ↑↓ INC/DEC
      ← SAVE VALUE
RANGE  AVG  DIAGS  ALARM
  
```

Calibration Menu

The Calibrate O₂ Background menu item and the Calibrate O₂ Coefficient menu item are displayed only when the internal O₂ sensor option is installed.

- In the Main Menu, choose **Calibration**.

```
CALIBRATION:
>CAL BACKGROUND
CAL COEF
ZERO SPAN CHECK
CAL O2 BACKGROUND
CAL O2 COEFFICIENT

RANGE  AVG  DIAGS  ALARM
```

Calibrate O₂ Background

The Calibrate O₂ Background screen is used to adjust the background, or perform a “zero calibration.” Be sure the analyzer samples nitrogen until the readings stabilize. The display shows the current O₂ reading.

- In the Main Menu, choose Calibration > **Calibrate O₂ Background**.

```
O2 BACKGROUND:
O2:          0.12 %
CURRENTLY:   0.00 % ?

    ← SET O2 TO ZERO

RANGE  AVG  DIAGS  ALARM
```

Calibrate O₂ Coefficient

The Calibrate O₂ Coefficient screen is used to adjust the O₂ span concentration while sampling span gas of known concentration.

The display shows the current O₂ concentration reading. The next line of the display is where the O₂ calibration gas concentration is entered.

- In the Main Menu, choose Calibration > **Calibrate O₂ Coefficient**.

```
CALIBRATE O2:
O2:          20.80 %
SPAN CONC:   20.80

    ↔ MOVE CURSOR
    ↑↓ CHANGE VALUE  ← SAVE

RANGE  AVG  DIAGS  ALARM
```

Instrument Controls Menu

The O₂ Compensation menu item is only displayed if the internal O₂ sensor option is installed.

- In the Main Menu, choose **Instrument Controls**.

```
INSTRUMENT CONTROLS:
>DATALOGGING SETTINGS
COMMUNICATION SETTINGS
I/O CONFIGURATION
TEMPERATURE COMPENSATION
PRESSURE COMPENSATION ↓
RANGE  AVG  DIAGS  ALARM

O2 COMPENSATION
SCREEN CONTRAST
SERVICE MODE
DATE/TIME
TIMEZONE
```

O₂ Compensation

The O₂ Compensation screen is used to turn oxygen compensation on or off. When O₂ compensation is enabled, the following equation is applied to the concentration value to generate a corrected value (CO COR). The corrected value may be output on the analog outputs, stored in logging memory, or output as streaming data. The corrected values are not displayed on the Run screen on the front panel, only the non-corrected values:

$$C_{comp} @ O2_{corr} = C * \left(\frac{20.9 - O2_{corr}}{20.9 - O2_{meas}} \right)$$

Abbreviations: C is the measured concentration, O_{2_{corr}} is the oxygen concentration that C is corrected to (this value is set by the user in the SERVICE > O2 CORRECTION CONC menu and defaults to 15%). O_{2_{meas}} is the measured O₂ concentration, which is clamped at 20.8% to prevent divide-by-zero errors. C_{comp} is the corrected concentration (CO COR) that may be used for analog outputs or datalogging.

The O2 CONC line shows the measured O₂ concentration if the compensation is on or the correction O₂ concentration if it is off.

- In the Main Menu, choose > Instrument Controls > **O2 Compensation**.


```

O2 COMPENSATION:
O2 CONC:      15.02 %
CURRENTLY:    ON
SET TO:      OFF ?

      ← TOGGLE VALUE

RANGE  AVG  DIAGS  ALARM

```

Datalogging Settings

This section displays a sub-menu list of the analog output signal group choices that can be logged for the current field. The corrected concentrations item is only displayed if the O₂ compensation option is enabled.

- In the Main Menu, choose > Instrument Controls > Datalogging Settings > Select Content > **Field 1–32**.

```

DATA IN LREC FIELD 1:
>CONCENTRATIONS
CORRECTED CONCENTRATIONS
OTHER MEASUREMENTS
ANALOG INPUTS

RANGE  AVG  DIAGS  ALARM

```

Corrected Concentrations

The Corrected Concentrations screen allows the user to select the output signal that is tied to the selected field item.

- In the Main Menu, choose > Instrument Controls > Datalogging Settings > Select Content > select Field > **Corrected Concentrations**.

```

CORRECTED CONCENTRATIONS:
>NONE
CO COR
LO CO COR
HI CO COR

RANGE  AVG  DIAGS  ALARM

```

Other Measurements

The Other Measurements screen allows the user to select the output signal that is tied to the selected field item. The O₂ sensor temp item is only displayed if the internal O₂ sensor option is installed.

- In the Main Menu, choose > Instrument Controls > Datalogging Settings > Select Content > select Field > **Other Measurements**.

```

OTHER MEASUREMENTS:
>NONE
S/R
INT TEMP
BENCH TEMP
BENCH PRES
↓
RANGE  AVG  DIAGS  ALARM

SAMPLE FLOW
INTENSITY
MOTOR SPEED
BIAS SUPPLY
SCRUBBER EFF
EXT ALARMS
O2 SENS TEMP

```

Communication Settings

This section displays a sub-menu list of the analog output signal group choices that allow for configuration of the 8 streaming data output items. The corrected concentrations item is only displayed if the O₂ compensation option is enabled.

- In the Main Menu, choose > Instrument Controls > Communication Settings > Streaming Data Config > **Item 1–8**.

```

CHOOSE STREAM DATA:
>CONCENTRATIONS
CORRECTED CONCENTRATIONS
OTHER MEASUREMENTS
ANALOG INPUTS

RANGE  AVG  DIAGS  ALARM

```

Corrected Concentrations

The Corrected Concentrations screen allows the user to select the output signal that is tied to the selected streaming data item.

- In the Main Menu, choose > Instrument Controls > Communication Settings > Streaming Data Config > select Item > **Corrected Concentrations**.

```

CORRECTED CONCENTRATIONS:
>NONE
CO COR
LO CO COR
HI CO COR

RANGE  AVG  DIAGS  ALARM

```

Other Measurements

The Other Measurements screen allows the user to select the output signal that is tied to the selected streaming data item. The O₂ sensor temp is only displayed if the internal O₂ sensor option is installed.

- In the Main Menu, choose > Instrument Controls > Communication Settings > Streaming Data Config > select Item > **Other Measurements**.

```
OTHER MEASUREMENTS:
>NONE
S/R
INT TEMP
BENCH TEMP
BENCH PRES
RANGE  AVG  DIAGS  ALARM
SAMPLE FLOW
INTENSITY
MOTOR SPEED
BIAS SUPPLY
SCRUBBER EFF
EXT ALARMS
O2 SENS TEMP
```

I/O Configuration

This section describes the configuration of the analyzer's I/O system.

Output Relay Settings

This section displays a sub-menu list of the alarm status that is tied to the selected relay output. The O₂ conc items are only displayed if the internal O₂ sensor option is installed.

- In the Main Menu, choose > Instrument Controls > I/O Configuration > Output Relay Settings > select Relay > Instrument State > **Alarms**.

```

ALARMS:
>NONE
GEN ALARM
CONC MAX
CONC MIN
INT TEMP
↓
RANGE  AVG  DIAGS  ALARM

BENCH TEMP
PRESSURE
SAMPLE FLOW
INTENSITY
MOTOR SPEED
BIAS VOLTAGE
MB STATUS
MIB STATUS
I/O BD STATUS
CONC ALARM
ZERO CHK/CAL
SPAN CHK/CAL
EXT ALARM 1
EXT ALARM 2
EXT ALARM 3
O2 CONC MAX
O2 CONC MIN

```

Analog Output Configuration

This section displays a sub-menu list of the minimum and maximum values that are tied to the selected analog output channel. See the following table for a list of choices. The O₂ sensor items are only displayed if the internal O₂ sensor option is installed.

- In the Main Menu, choose > Instrument Controls > I/O Configuration > Analog Output Config > select Channel > **Set Minimum Value** or **Set Maximum Value**.

```

MINIMUM OUTPUT PERCENT:
SELECTED OUTPUT:  V ALL
CURRENTLY:        N/A %
SET TO:           0000.0 % ?
↑↓ CHANGE VALUE  ← SAVE
RANGE  AVG  DIAGS  ALARM

```

Table. Analog Output Zero to Full-Scale Table

Output	Zero % Value	Full-Scale 100% Value
CO	Zero (0)	Range Setting
LO CO	Zero (0)	Range Setting
HI CO	Zero (0)	Range Setting
Range Status	Changing the setting for this output is not recommended	
Sample/Reference Ratio	0.0	1.2
LO Sample/Reference Ratio	0.0	1.2
HI Sample/Reference Ratio	0.0	1.2
Internal Temperature	User-set alarm min value	User-set alarm max value
Bench Temperature	User-set alarm min value	User-set alarm max value
Bench Pressure	User-set alarm min value	User-set alarm max value
Sample Flow	User-set alarm min value	User-set alarm max value
Intensity	User-set alarm min value	User-set alarm max value
Motor Speed	User-set alarm min value	User-set alarm max value
Bias Voltage	User-set alarm min value	User-set alarm max value
O ₂ %	Zero (0)	100 % O ₂
O ₂ Sensor Temp	Zero (0)	100 Degrees C
Everything Else	0 Units	10 Units

Choose Signal to Output

This section displays a sub-menu list of the analog output signal group choices that are tied to the selected analog output channel. See the following table for a list of choices. The corrected concentration items are only displayed if the O₂ compensation option is enabled and the O₂ sensor measurement items are only displayed if the internal O₂ sensor option is installed.

- In the Main Menu, choose > Instrument Controls > I/O Configuration > Analog Output Config > select Channel > **Choose Signal to Output.**

```

CHOOSE SIGNAL TYPE:
>CONCENTRATIONS
CORRECTED CONCENTRATIONS
OTHER MEASUREMENTS
ANALOG INPUTS

RANGE  AVG  DIAGS  ALARM
    
```

```

CHOOSE SIGNAL -      CONC
SELECTED OUTPUT:    V1
CURRENTLY: NO
SET TO: NONE        ?

↑↓ CHANGE VALUE    ← SAVE

RANGE  AVG  DIAGS  ALARM

```

Table. Signal Type Group Choices

Concentrations	Corrected Concentrations	Other Measurements	Analog Inputs	
None	None	None	None	I/O Expansion Board installed
CO (single/auto range only)	CO COR (single/auto range only)	Sample/Reference	Analog Input 1	I/O Expansion Board installed
LO CO (dual range only)	LO CO COR (dual range only)	LO Sample/Reference	Analog Input 2	I/O Expansion Board installed
HI CO (dual range only)	HI CO COR (dual range only)	HI Sample/Reference	Analog Input 3	I/O Expansion Board installed
Range Status (auto range only)		Internal Temperature	Analog Input 4	I/O Expansion Board installed
O ₂ %		Bench Temperature	Analog Input 5	I/O Expansion Board installed
		Bench Pressure	Analog Input 6	I/O Expansion Board installed
		Sample Flow	Analog Input 7	I/O Expansion Board installed
		Intensity	Analog Input 8	I/O Expansion Board installed
		Motor Speed		
		Bias Supply		
		Scrubber Eff		
		Ext Alarms		
		O ₂ Sensor Temp		

Diagnosics Menu

The O₂ Sensor Readings screen is only displayed if the internal O₂ sensor option is installed.

- In the Main Menu, choose **Diagnosics**.

```

DIAGNOSTICS:
>PROGRAM VERSIONS
VOLTAGES
TEMPERATURES
PRESSURE
FLOW
↓
RANGE  AVG  DIAGS  ALARM

SAMPLE/REF RATIO
AGC INTENSITY
MOTOR SPEED
O2 SENSOR READINGS
ANALOG INPUT READINGS
ANALOG INPUT VOLTAGES
DIGITAL INPUTS
RELAY STATES
TEST ANALOG OUTPUTS
INSTRUMENT CONFIGURATION
CONTACT INFORMATION

```

O₂ Sensor Readings

The O₂ Sensor Readings screen (read only) displays the measured oxygen concentration (in percent) and the oxygen sensor temperature (in degrees C). This screen is only visible if the internal O₂ sensor option is installed.

- In the Main Menu, choose > Diagnostics > **O2 Sensor Readings**.

```

O2 CONC:      15.02 %
TEMP:         30.2 °C
RANGE  AVG  DIAGS  ALARM

```

Instrument Configuration

The Instrument Configuration screen displays information on the hardware configuration of the instrument.

- In the Main Menu, choose > Diagnostics > **Instrument Configuration**.

```

INSTRUMENT CONFIGURATION:
>I/O EXPANSION BOARD  YES
ZERO SPAN VALVES      YES
ZERO AIR SCRUBBER     NO
WHEEL PURGE           NO
DILUTION              YES ↓
RANGE  AVG  DIAGS  ALARM

AUTO CALIBRATION      YES
O2 SENSOR             YES

```

Alarms Menu

The O₂ Concentration Alarm menu item is only displayed if the internal O₂ sensor option is installed.

- In the Main Menu, choose **Alarms**.

```
ALARMS:
ALARMS DETECTED          0
>INTERNAL ALARM          OK
BENCH TEMP               OK
PRESSURE                 OK
SAMPLE FLOW              OK↓

RANGE  AVG  DIAGS  ALARM

BIAS VOLTAGE             OK
AGC INTENSITY            OK
MOTOR SPEED              OK
ZERO CHECK               OK
SPAN CHECK               OK
ZERO AUTOCAL             OK
SPAN AUTOCAL             OK
SCRUBBER GAS CONC        OK
SCRUBBER EFF             OK
SCRUBBER TEST DONE      OK
CONCENTRATION            OK
O2 CONCENTRATION        OK
EXTERNAL ALARMS         OK
MOTHERBOARD STATUS      OK
INTERFACE STATUS        OK
I/O EXP STATUS           OK
```

O₂ Concentration

The O₂ Concentration Alarm screen displays the current oxygen concentration and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 0.00 to 100.00 % with defaults of 25.00% (minimum and maximum). If the O₂ concentration goes above either the minimum or maximum limit, an alarm is activated. This alarm is only visible if the internal O₂ sensor option is installed.

- In the Main Menu, choose Alarms > **O2 Concentration**.

```
O2 CONCENTRATION:
ACTUAL                   15.02 %
>MIN                     25.00 %
MAX                       25.00 %
MIN TRIGGER              CEILING

RANGE  AVG  DIAGS  ALARM
```


Min and Max O₂ Concentration Limits

The Minimum O₂ Concentration alarm limit screen is used to change the minimum oxygen concentration alarm limit. The minimum and maximum O₂ concentration screens function the same way.

- In the Main Menu, choose Alarms > O₂ Concentration > **Min** or **Max**.

```
O2 CONCENTRATION:
ACTUAL MIN:      25.00 %
SET MIN TO:     10.00 % ?

      ↑↓ INC/DEC
      ← SAVE VALUE

RANGE  AVG  DIAGS  ALARM
```

Min Trigger

The Minimum Trigger screen allows the user to view and set the O₂ concentration alarm trigger type to either floor or ceiling.

- In the Main Menu, choose Alarms > O₂ Concentration > **Min Trigger**.

```
MIN TRIG<CEILING/FLOOR:
ACTUAL TRIGGER: CEILING
SET TRIGGER TO:  FLOOR ?

      ← TOGGLE AND SAVE VALUE

RANGE  AVG  DIAGS  ALARM
```

Service Menu

The O₂ Correction Concentration menu item is only displayed if the O₂ correction option is installed.

- In the Main Menu, choose **Service**.

```
SERVICE:
>RANGE MODE SELECT
PRESSURE CALIBRATION
FLOW CALIBRATION
INITIAL S/R RATIO
SCRUBBER TEST

RANGE  AVG  DIAGS  ALARM
```

```
MULTIPOINT CAL
LO MULTIPOINT CAL
HI MULTIPOINT CAL
```

```

PREAMP BOARD CAL
TEMPERATURE CALIBRATION
ANALOG OUT CAL
ANALOG INPUT CAL
O2 CORRECTION CONC
DILUTION RATIO
SETUP RUN SCREENS
DISPLAY PIXEL TEST
RESTORE USER DEFAULTS

```

O₂ Correction Concentration

The O₂ Correction Concentration screen is used to set the oxygen correction concentration. Acceptable values range from 0 to 20.9%. When O₂ compensation is enabled, the following equation is applied to all of the concentration values to generate corrected values (CO COR). The corrected values may be output on the analog outputs, stored in logging memory, or output as streaming data. The corrected values are not displayed on the Run screen on the front panel, only the non-corrected values:

$$C_{comp} @ O2_{corr} = C * \left(\frac{20.9 - O2_{corr}}{20.9 - O2_{meas}} \right)$$

Abbreviations: C is the measured concentration, O_{2_{corr}} is the oxygen concentration that C is corrected to (this value is set by the user in the SERVICE > O₂ CORRECTION CONC menu and defaults to 15%). O_{2_{meas}} is the measured O₂ concentration, which is clamped at 20.8% to prevent divide-by-zero errors. C_{comp} is the corrected concentration (CO COR) that may be used for analog outputs or datalogging.

- In the Main Menu, choose > Instrument Controls > **O₂ Correction Conc.**

```

O2 CORRECTION CONC:
CURRENTLY:          15.55 %
SET TO:             16.00 % ?

      ←→ MOVE CURSOR
↑↓ CHANGE VALUE   ← SAVE

RANGE  AVG  DIAGS  ALARM

```

Troubleshooting

This section shows the board-level connection diagram along with the connector pin descriptions for the optional internal O₂ sensor that apply to the “Troubleshooting” chapter.

- Board-Level Connection Diagram
- Connector Pin Descriptions

Board-Level Connection Diagram

The following figure “Board-Level Connection Diagram – Measurement System” shows the board-level connection for the measurement system and the connection for the optional internal O₂ sensor (J12).

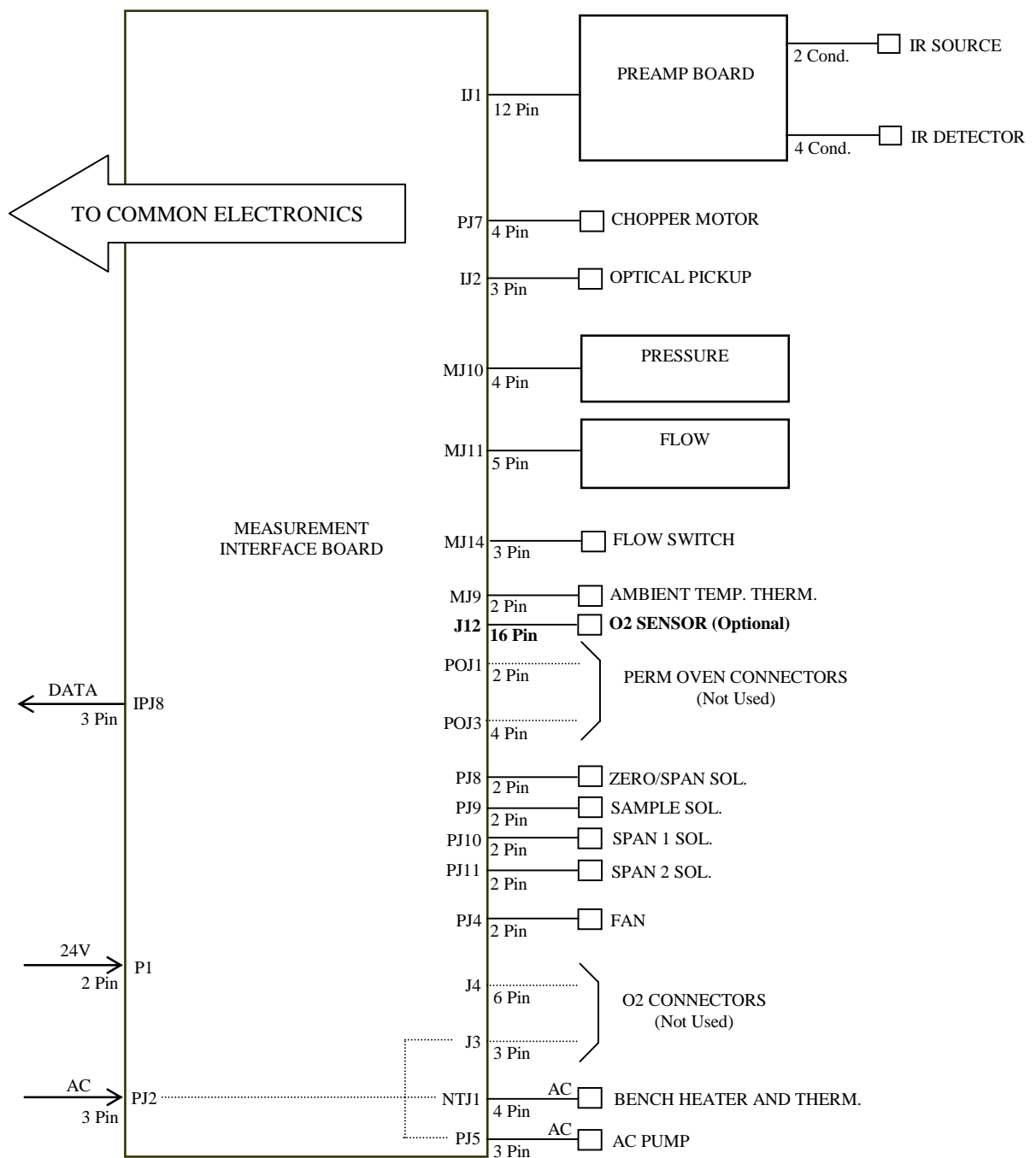


Figure. Board-Level Connection Diagram - Measurement System

Connector Pin Descriptions

The connector pin description in the following table “Measurement Interface Board Connector Pin Descriptions” can be used along with the board-level connection diagram to troubleshoot board-level faults.

Table. Measurement Interface Board Connector Pin Descriptions

Connector Label	Reference Designator	Pin	Signal Description
O2 SENS	J12	1	NC
		2	NC
		3	NC
		4	NC
		5	Ground
		6	+5V
		7	NC
		8	NC
		9	Ground
		10	Analog Input O2 Sensor
		11	NC
		12	NC
		13	NC
		14	Analog Input O2 Sensor Temperature
		15	NC
		16	+5V

Servicing

This section describes the following parts information and replacement procedure for the optional internal O₂ sensor that apply to the “Servicing” chapter.

- Replacement Parts
- Cable List
- Component Layout
- Internal O₂ Sensor (Optional) Replacement

Replacement Parts List

Add “104678-00, O₂ Sensor” to the “Replacement Parts List” table. Add part number for 4119: “Capillary, 0.008-inch ID (O₂ Sensor Option)”.

Cable List

Add “104686-00, Cable, O₂ Sensor (optional)” to the “Cable List” table.

Component Layout

The following figure shows the location of the optional internal O₂ sensor with the Model 48*i* and Model 48*i* High Level.

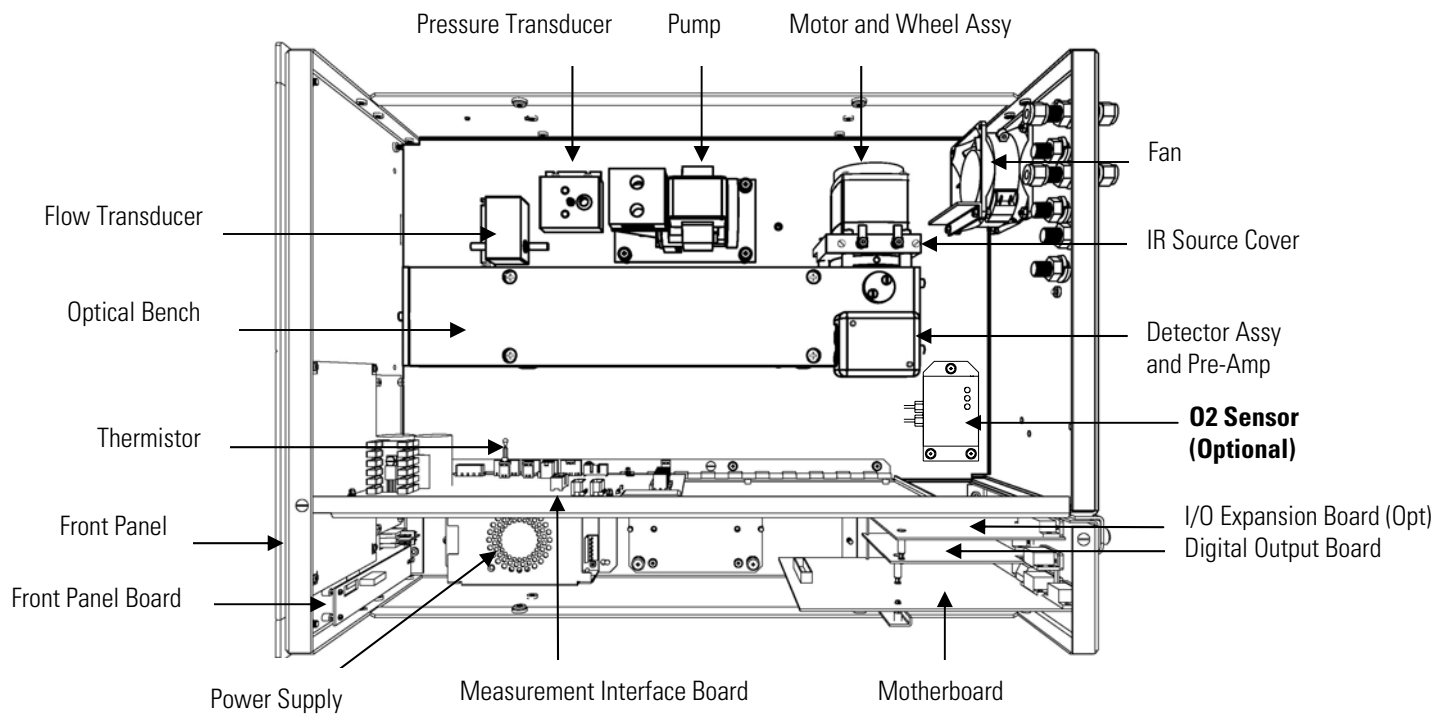


Figure. Component Layout

Internal O₂ Sensor (Optional) Replacement

Use the following procedure to replace the optional internal O₂ sensor (see Figure).

Equipment Required:

O₂ sensor

Philips screwdriver

Wrench, 7/16-inch



Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. ▲

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Disconnect the oxygen sensor ribbon cable.
3. Disconnect all plumbing connections from the oxygen sensor.
4. Loosen the four captive screws holding the converter to the floor plate and move it to the front of the case.
5. Loosen the three captive screws holding the oxygen sensor to the floor plate and remove the oxygen sensor.
6. Install new oxygen sensor by following the previous steps in reverse.

Optional Equipment

The Internal Oxygen (O₂) Sensor option provides a paramagnetic sensor for O₂ concentration measurement and CO correction. This option allows the user to correct the CO readings for the amount of oxygen in the sample. Selectable O₂ concentrations can be used as the correction factor.

The following figure shows how this option is integrated with the Model 48*i* and Model 48*i* High Level, both with and without the zero/span option.

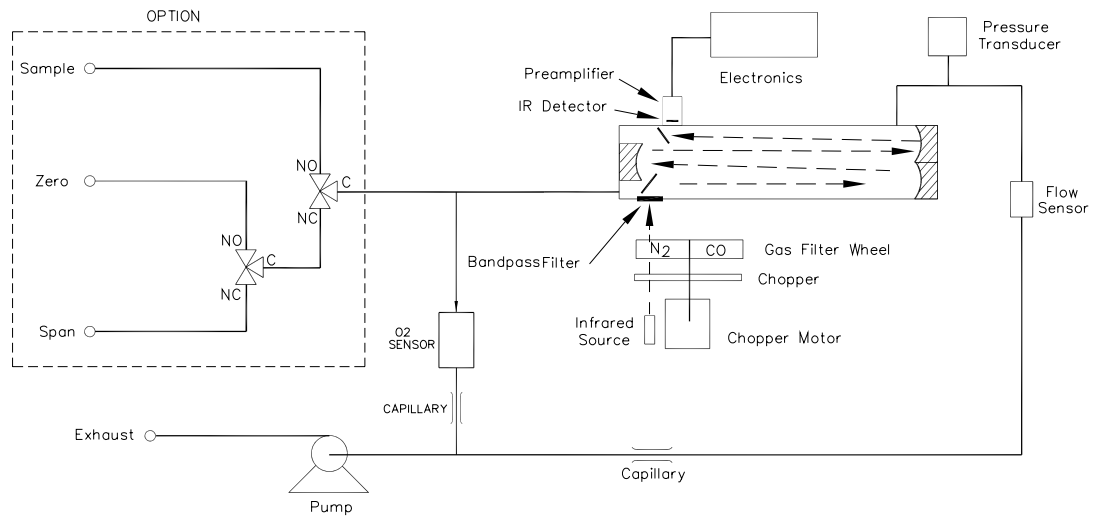


Figure. Flow Diagram, Internal O₂ Sensor Option

C-Link Protocol Commands

This section describes the C-Link protocol commands added to support the optional internal O₂ sensor that apply to the “C-Link Protocol Commands” appendix. Add the following commands to the “Commands List” table:

Table. C-Link Protocol Commands

Command	Description
alarm conc o2 max	Reports/sets current oxygen concentration alarm maximum value
alarm conc o2 min	Reports/sets current oxygen concentration alarm minimum value
alarm trig conc o2	Reports/sets current O ₂ concentration alarm warning value
bkg o2	Reports/sets current O ₂ background
cal bkg o2	Sets/auto-calibrates O ₂ background
cal coef o2	Sets/auto-calibrates O ₂ coefficient
coef o2	Reports/sets current O ₂ coefficient
o2	Reports the oxygen concentration percent
o2 corr	Reports/sets oxygen correction (compensation) on or off
o2 corr conc	Reports/sets the corrected concentration of oxygen
o2 gas	Reports/sets O ₂ span gas concentration
o2 temp	Reports temperature of the oxygen sensor
oc	Reports/sets oxygen correction (compensation) on or off

alarm conc o2 min

alarm conc o2 max

These commands report the current oxygen concentration alarm minimum and maximum value settings. The following example reports that the O₂ concentration alarm minimum value is 10%.

```
Send:      alarm conc o2 min
Receive:   alarm conc o2 min 10.00 %
```

set alarm conc o2 min *value*

set alarm conc o2 max *value*

These commands set the oxygen concentration alarm minimum and maximum values to *value*, where *value* is a floating-point number representing the oxygen concentration alarm limits in percent. The following example sets the O₂ concentration alarm maximum value to 100.00%.

```
Send:      set alarm conc o2 max 100
Receive:   set alarm conc o2 max 100 ok
```

alarm trig conc o2

This command reports the O₂ concentration alarm trigger action for minimum alarm, current setting, to either floor or ceiling. The following example shows the O₂ concentration minimum alarm trigger set to ceiling, according to the following table.

Send: alarm trig conc o2
Receive: alarm trig conc o2 1

set alarm trig conc o2 value

This command sets the O₂ concentration alarm minimum *value*, where *value* is set to either floor or ceiling, according to the following table. The following example sets the O₂ concentration minimum alarm trigger to ceiling.

Send: set alarm trig conc o2 1
Receive: set alarm trig conc o2 1 ok

Table. Alarm Trigger Values

<i>Value</i>	Alarm Trigger
00	Floor
01	Ceiling

bkg o2

This command reports the oxygen background concentration in percent. The following example reports that the current O₂ background concentration is 1.5%.

Send: bkg o2
Receive: bkg o2 1.50 %

set bkg o2

This command is used to set the oxygen background concentration in percent. The example below sets the O₂ background concentration to 1.5%.

Send: set bkg o2 1.5
Receive: set bkg o2 1.5 ok

cal bkg o2

This command will auto-calibrate the O₂ background so the O₂ concentration reads 0.00%. The example below shows a successful auto-calibration of the O₂ background.

Send: set cal bkg o2
Receive: set cal bkg o2 ok

cal coef o2

This command will auto-calibrate the O₂ coefficient based on O₂ span gas concentrations. The example below shows a successful auto-calibration of the O₂ coefficient.

Send: set cal coef o2
Receive: set cal coef o2 ok

coef o2

This command reports the O₂ coefficient. The example below reports that the O₂ coefficient is 1.000.

Send: coef o2
Receive: coef o2 1.000

set coef o2 *value*

This command sets the O₂ coefficient to user-defined values, where *value* is a floating-point representation of the coefficient. The example below sets the O₂ coefficient to 1.005.

Send: set coef o2 1.005
Receive: set coef o2 1.005 ok

o2

This command reports the oxygen concentration in percent. The following example reports that the current O₂ concentration is 15%.

Send: o2
Receive: o2 15.00 %

oc

o2 corr

These command report whether oxygen correction (compensation) is on or off. The following example reports that the O₂ correction is on.

Send: o2 corr
Receive: o2 corr on

set oc *onoff*

set o2 corr *onoff*

onoff = | on | off |

These commands turn the oxygen correction (compensation) *on* or *off*. The following example turns the O₂ correction off.

Send: set oc off
Receive: set oc off ok

o2 corr conc

This command reports the oxygen correction concentration in percent. The following example shows that the O₂ correction concentration is 15%.

Send: o2 corr conc
Receive: o2 corr conc 15.00 %

set o2 corr conc *value*

value = 0 to 20.9

This command sets the oxygen correction concentration value to *value*, where *value* is a floating-point number representing the oxygen correction concentration in percent. The following example sets the O₂ corrected concentration value to 15.00%.

Send: set o2 corr conc 15
Receive: set o2 corr conc 15 ok

o2 gas

This command reports the O₂ span gas concentrations used to auto-calibrate O₂ coefficients. The example below reports that the O₂ span gas concentration is 20.8%.

Send: o2 gas
Receive: o2 gas 20.8 %

set o2 gas *value*

This command sets the O₂ span gas concentration used by the auto-calibration routine to *value*, where *value* is a floating-point representation of the gas concentration in percent. The gas units are the same as those chosen by the user. The example below sets the O₂ span gas concentration to 20.8 %.

Send: set o2 gas 20.8
Receive: set o2 gas 20.8 ok

o2 temp

This command reports the current oxygen sensor temperature, in degrees C. The following example reports that the O₂ sensor temperature is 31 °C.

Send: o2 temp
Receive: o2 temp 31.0 deg C

MODBUS Protocol

This section updates the Read Coils, Read Registers, and Write Coils tables to support the optional internal O₂ sensor that apply to the “MODBUS Protocol” appendix. Update the following tables:

Table. Read Coils

Coil Number	Status
1	AUTORANGE
2	LOCAL/REMOTE
3	SERVICE
4	UNITS
5	ZERO MODE
6	SPAN MODE
7	SAMPLE MODE
8	GEN ALARM
9	CONC MAX ALARM
10	CONC MIN ALARM
11	INTERNAL TEMP ALARM
12	BENCH TEMP ALARM
13	PRESSURE ALARM
14	SAMPLE FLOW ALARM
15	INTENSITY ALARM
16	MOTOR SPEED ALARM
17	BIAS VOLTAGE ALARM
18	MB STATUS ALARM
19	INTERFACE BD STATUS ALARM
20	I/O EXP BD STATUS ALARM
21	CONC ALARM
22	PURGE MODE
23	SCRUB TEST MODE
24	ZERO CHK/CAL ALARM
25	SPAN CHK/CAL ALARM
26	NOT USED
27	NOT USED
28	NOT USED

Coil Number	Status
29	NOT USED
30	NOT USED
31	NOT USED
32	NOT USED
33	NOT USED
34	EXT ALARM 1
35	EXT ALARM 2
36	EXT ALARM 3

Table. Read Registers

Register Number	Variable
40001&40002	CO
40003&40004	LO CO
40005&40006	HI CO
40007&40008	RANGE STATUS
40009&40010	S/R
40011&40012	LO S/R
40013&40014	HI S/R
40015&40016	INT TEMP
40017&40018	BENCH TEMP
40019&40020	NOT USED
40021&40022	NOT USED
40023&40024	NOT USED
40025&40026	BENCH PRES
40027&40028	SAMPLE FLOW
40029&40030	INTENSITY
40031&40032	MOTOR SPEED
40033&40034	ANALOG IN 1
40035&40036	ANALOG IN 2
40037&40038	ANALOG IN 3
40039&40040	ANALOG IN 4
40041&40042	ANALOG IN 5
40043&40044	ANALOG IN 6

Register Number	Variable
40045&40046	ANALOG IN 7
40047&40048	ANALOG IN 8
40049&40050	NOT USED
40051&40052	NOT USED
40053&40054	NOT USED
40055&40056	BIAS SUPPLY
40057&40058	NOT USED
40059&40060	NOT USED
40061&40062	NOT USED
40063&40064	SCRUBBER EFF
40065&40066	NOT USED
40067&40068	EXT ALARMS
40069&40070	O ₂ %*
40071&40072	O ₂ SENS TEMP*
40073&40074	NOT USED
40075&40076	NOT USED
40077&40078	NOT USED
40079&40080	CO COR*
40081&40082	LO CO COR*
40083&40084	HI CO COR*
40085&40086	NOT USED
40087&40088	NOT USED
40089&40090	NOT USED

*If internal O₂ Sensor is installed.

Table. Write Coils

Coil Number	Action Triggered
101	ZERO MODE
102	SPAN MODE
103	SET BACKGROUND
104	CAL TO LOW SPAN
105	AOUTS TO ZERO
106	AOUTS TO FS
107	CAL TO HIGH SPAN
108	SCRUBBER TEST
109	NOT USED
110	NOT USED
111	ZERO/PURGE CAL
112	SPAN/PURGE CAL
113	ZERO/SPAN/PURGE
114	EXT ALARM 1
115	EXT ALARM 2
116	EXT ALARM 3
117	PURGE MODE