F-901B Reference Manual

March 2019

Version 1.3

1554 NE 3rd Ave, Camas, WA 98607, USA
Phone: (360) 833-8835
www.felixinstruments.com

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IMPORTANT SAFEGUARDS

To reduce the risk of fire, electrical shock, injury to persons or permanent damage to this device, these safety precautions should always be followed:

- Use the included 12VDC power supply or specified power connector to operate this device. Inappropriate voltage supply or power connector could cause irreparable damage to this device. See Cables Assembly.
- Make sure power plug and Modbus cable are plugged in and secured before powering up device. Power connector will not make connection to GND if not fully plugged into socket.
- If sampling via tubing, make sure that the tubes are securely attached to the device before operating. Use included hydrophobic filter to prevent liquid water entering device. See Cables and Tubes Installation.
- Do not operate the device with an obstructed flow path. Obstruction during air sampling will damage the internal micropump.
- Do not expose this device to any liquids.
- Sensors must not be exposed to temperature, humidity and pressure that are outside the operating range. See sensor Specifications.
- Lifetime of up to 2 years for C2H4/O2 sensor and 5 years for CO2 sensor can be expected for discontinuous sampling. Continuous exposure to relative humidity >90% or <15% and Volatile Organic Compounds (VOCs) over long period of time must be avoided. See Operating mode.

F-901B Specifications

Measurements	C2H4, CO2, O2, RH, Temperature, Barometric Pressure
Air Sampling Rate	120 mL/min in Continuous Mode
Measuring Rate	1 second intervals in Continuous Mode
Communication	Modbus via RS485, RJ45 connector
Sampling Port	Inlet/outlet with Luer lock fittings
Operating environment	0°C - 50°C, 15-90% relative humidity non-condensing
Power Input	12VDC regulated
Avg. Power Consumption	2.5W
Dimensions	172mm x 103mm x 55mm
Weight	0.98kg
Enclosure	Powder coated aluminum

Ethylene (C2H4) sensor

Type	Electrochemical
Nominal Range	0-1000 ppm
Accuracy	±5% ± 5ppm
Lower Detection Limit	2 ppm
Response Time (T90)	< 3 minutes
Temperature Range	0 °C to 50 °C
Pressure Range	1013mbar ± 10 %
Relative Humidity Range	15 % to 90 % R.H. non-condensing
Long Term Output Drift	< 5 % per month in continuous exposure
Lifetime	2 years

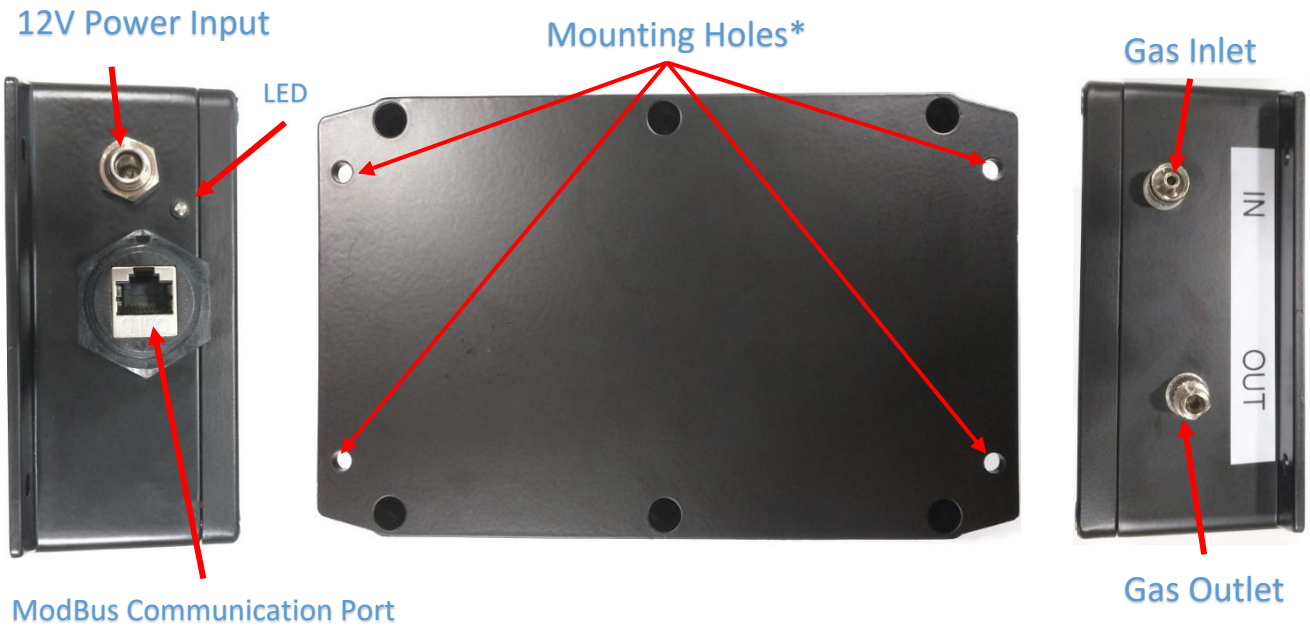
Carbon Dioxide (CO2) sensor

Type	NDIR (non-dispersive infrared)
Nominal Range	0-100%
Accuracy	±3% ± 300ppm
Lower Detection Limit	100ppm
Response Time (T90)	< 20s
Warm Up Time	< 1 minute
Pressure Range	950mbar to 10000mbar
Temperature Range	0 °C to 50 °C
Relative Humidity Range	0 to 90 % R.H. non-condensing
Lifetime	5 years

Oxygen (O2) Sensor

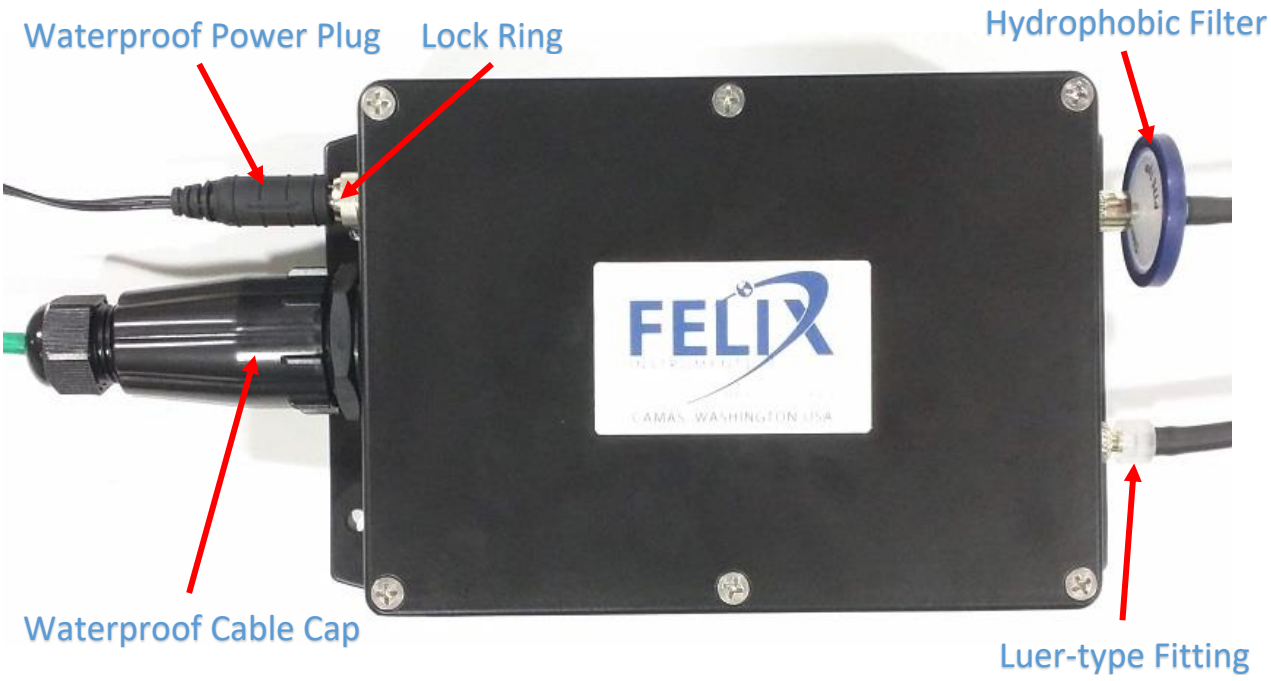
Type	Electrochemical
Nominal Range	0-100%
Accuracy	±2% ± 100ppm
Lower Detection Limit	0.1%
Response Time (T90)	< 5s
Temperature Range	0 °C to 50 °C
Pressure Range	500mbar to 2000mbar
Relative Humidity Range	0 % to 99 % R.H. non-condensing
Lifetime	2 Years

Instrument Overview



*accepts M5 or #10 screw

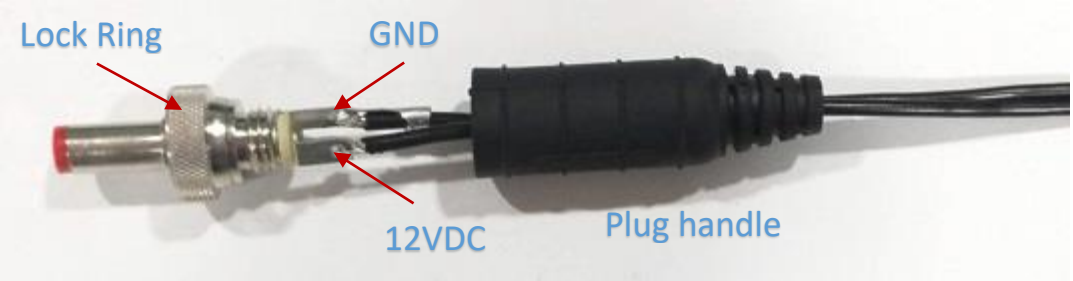
Cables and Tubes Installation

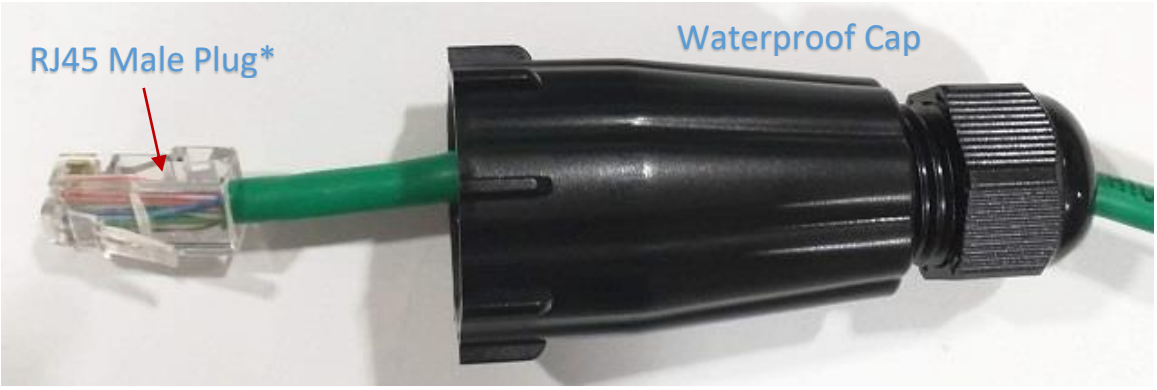


IMPORTANT:

- USE ONLY SPECIFIED POWER PLUG AND CABLE CAP
- MAKE SURE POWER CABLE AND MODBUS CABLE ARE **SECURED** BEFORE POWERING UP DEVICE
- MAKE SURE THERE IS NO FLOW OBSTRUCTION AT INLET/OUTLET BEFORE POWERING UP DEVICE

Cables Assembly





*See Pin Description for correct wiring

Connector Mating Parts (not supplied):

Part number	Description	Manufacture
767KS12	DC Power Plug Sealed IP68	Switchcraft
630125673867	Patch Cable Cap IP67 water and dust protection	InstallerParts

Principle of Operation

Flow cycle

There are two flow cycles during the F-901B operation:

- Sampling Cycle: air from inlet port is pulled into sensors chamber by a micropump, then expelled out to the outlet port.

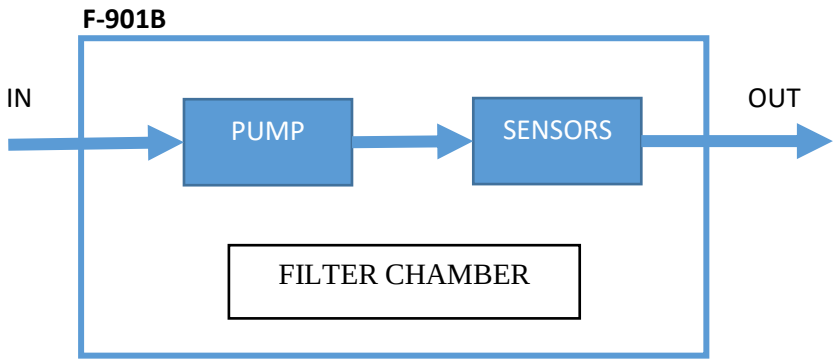


Figure 1 sampling cycle

- Cleaning Cycle: Air is circulated inside the F-901B through the sensor and filter chamber. Sensors is now isolated from outside air.

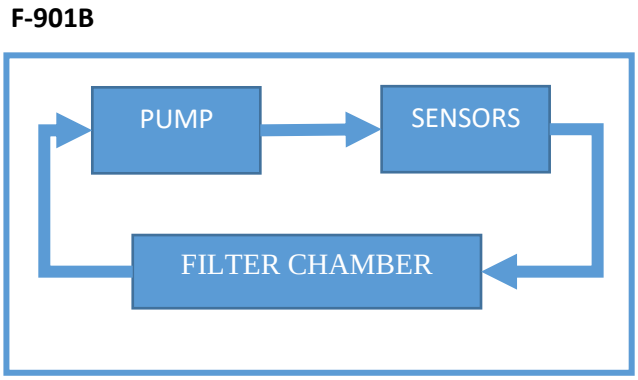


Figure 2 cleaning cycle

Operating modes

- **Continuous measurement mode**: during this mode, air is sampling continuously as shown in Figure 1. Sensor readings are updated every second.
- **Trigger measurement mode:** during this mode, device alternates between sampling (Figure 1) and cleaning cycle (Figure 2). Sampling cycle lasts for 35 seconds then immediately followed by cleaning cycle for 30 seconds. The whole routine will then repeat after some idle time. Final sensor readings are updated at the end of sampling cycle and remain the same until the next update (see TRIGGER_INTEVAL). Use this measurement mode to increase sensors lifetime and prevent baseline drift, especially when operating in high VOC/humidity environments. The rule of thumb is the less exposure, the longer sensor lifetime. This is the default operating mode (5-minutes interval).

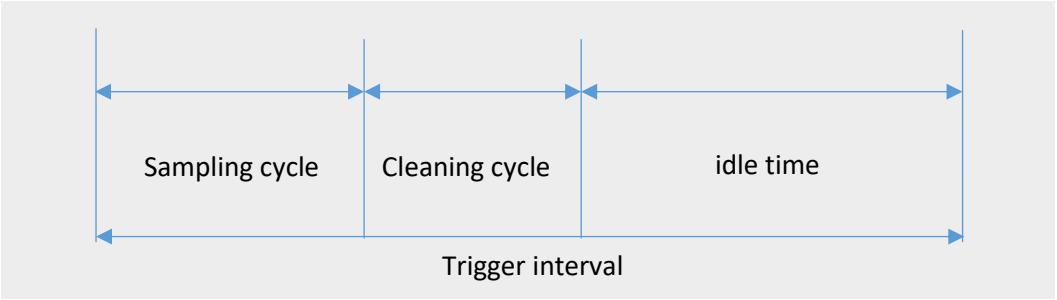


Figure 3 Trigger measurement timing

Recommended operation for using the F-901B in closed-loop control application:

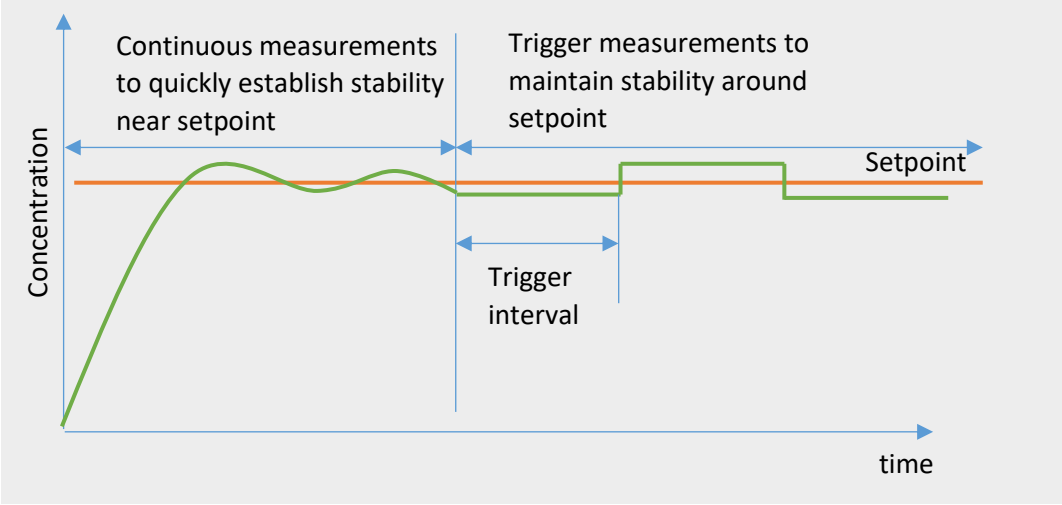
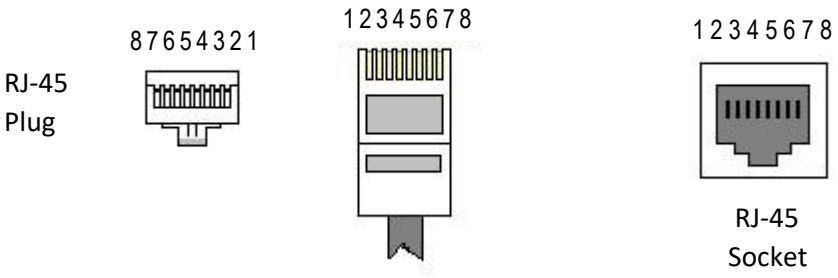


Figure 4 Closed-loop control example

- During control's stability, estimate the trigger measurement interval based on how often gas concentration fluctuates due to venting or purging events.
- Switch to continuous measurement to re-establish stability if concentration is out of stability threshold or setpoint changed.

MODBUS

RJ45 Connector (RS485 configuration)



Pin Description

Pin	Name	Type	Description
1	3.3V	Reference potential	3.3V Reference Voltage
2	GND	Reference potential	Local device ground
3	UART_TX	Digital Output	Firmware update interface
4	B (D-)	Bus In/Out	Driver output and receiver input
5	A (D+)	Bus In/Out	Driver output and receiver input
6	UART_RX	Digital Input	Firmware update interface
7	BOOT	Digital Input	Firmware update interface
8	RESET	Digital Input	Microcontroller reset input (Active-Low) Firmware update interface

Note: use pin 4,5 (B/A) and GND for Modbus RS485 communication. Pin 3,6,7,8 are reserved for firmware updating and are **3.3V** tolerant.

Absolute Maximum Rating

Voltage range at A or B ..... -8V to 12V
Voltage range at pin 3,6,7,8 ..... -0.3V to 4V
Electrostatic discharge at A and B ..... ±8kV

RS485 Modbus Parameters

Parameter	Value
Baud Rate	19200
Data bits	8
Parity	Even
Stop bits	1

F-901B MODBUS Specifications

- Operates as a slave, half-duplex mode
- Modbus functions supported:
  - 0x01 - Read Coils
  - 0x03 - Read Holding Registers
  - 0x04 - Read Input Registers
  - 0x05 - Write Single Coil
  - 0x06 - Write Single Register
  - 0x0F - Write Multiple Coils
  - 0x10 - Write Multiple Registers
- Exception messages supported
- Default address: 50

Input Registers

Mode: Read-only, size: 16 bits

Name	Address	Description
C2H4	0	C2H4 measurement x 10, ppm
CO2	1	CO2 measurement x 100, %
O2	2	O2 measurement x 10, %
TEMPERATURE	3	Temperature measurement x 10, C
RELATIVE HUMIDITY	4	Relative Humidity measurement x 10, %
BAROMETER	5	Barometric pressure measurement x 10, mbar
VAPOR PRESSURE	6	Vapor pressure measurement x 10, mbar
ERROR STATUS	9	0 = OK. 1 = C2H4 offset error, Sensor over-exposed or KMnO4 filter needs replacement.
C2H4_RAW	10	C2H4 raw measurement, count
O2_RAW	11	O2 raw measurement, count
DEV_TYPE	100	Default device type ID: 9011
FIRMWARE	101	Firmware version

Holding Registers

Mode: Read/Write, size: 16 bits

Name	Address	Default	Description
PUMP_POWER	0	50	Internal pump power 0-100%
C2H4_SPAN	1		C2H4 span calibration parameter, calculated as follow: C2H4_SPAN = C2H4_CUR*C2H4_SPAN_CUR/C2H4_CAL Note: C2H4_CAL: expected calibration concentration C2H4_SPAN_CUR: Current span value C2H4_CUR: Current C2H4 measurement
C2H4_ZERO	2		C2H4 zero calibration parameter
O2_SPAN	3		O2 span calibration parameter, calculated as follow: O2_SPAN = O2_CUR*O2_SPAN_CUR/O2_CAL Note: O2_CAL: expected calibration concentration O2_SPAN_CUR: Current span value O2_CUR: Current O2 measurement
O2_ZERO	4		O2 zero calibration parameter
CO2_SPAN	5		CO2 span calibration parameter, calculated as follow: CO2_SPAN = CO2_CAL*CO2_SPAN_CUR/CO2_CUR Note: CO2_CAL: expected calibration concentration CO2_SPAN_CUR: Current span value CO2_CUR: Current CO2 measurement
CO2_ZERO	6		CO2 zero calibration parameter
TRIGGER_INTERVAL	20	0	Interval between Trigger measurements in seconds. Writing a value greater than 0 to this register enables Trigger mode (see Operating modes). Writing a 0 to this register disables the Trigger mode (switches to Continuous mode after finishing any on-going Trigger measurement). Note that a single Trigger mode measurement takes at least 65 seconds.
SLAVE_ADDR	30	50	Device default Modbus slave address. Update this register to change the slave address (note: device will immediately reboot after this change). Valid slave addresses: 0-99

IMPORTANT: backup calibration parameters before overwriting their values (performing a calibration) or update device firmware (all parameters will be erased). All F-901B comes with factory calibration using standard certified gases.

Note:

- Values written to the above holding registers remain after Power-off/Reset
- To perform a span calibration for **CO2**, **C2H4** or **O2** sensor:
    - Put device in Continuous measurement mode (write 0 to TRIGGER_INTERVAL register)
    - Apply *Calibration gas* at device inlet
    - Wait until reading stabilized (C2H4 >= 7 minutes, O2/CO2 >= 2 minutes)
    - Read sensor's current measurement on Input Registers and sensor's SPAN value on Holding Registers
    - Calculate Span value using the provided formula and round this value to nearest integer
    - Write new span value back to the sensor's SPAN register
- To perform a zero calibration for **C2H4** or **O2** sensor (see also zero calibration with coils setting bellow):
    - Put device in Continuous measurement mode (write 0 to TRIGGER_INTERVAL register)
    - Apply *Zero gas* at device inlet
    - Wait until reading stabilized (C2H4 >= 7 minutes, O2 >= 2 minutes)
    - Read sensor RAW value on Input Registers
    - Write this value to the according ZERO register

Coils

Mode: Read/Write, size: 1 bit

Name	Address	Default	Description
ZERO_C2H4	4	False	Request to zero C2H4 sensor
ZERO_O2	5	False	Request to zero O2
ZERO_CO2	6	False	Request to zero CO2 sensor
ZERO_CONF	7	False	Confirmation of zero action
FLOW_MODE	8	True	Set the air flow configuration. True: flow in sampling cycle False: flow in cleaning cycle
RESET	9	False	True: (software) reset device False: no action

IMPORTANT: backup calibration parameters before performing a zero calibration. A zero calibration will overwrite the factory zero calibration parameter in Holding register.

Note:

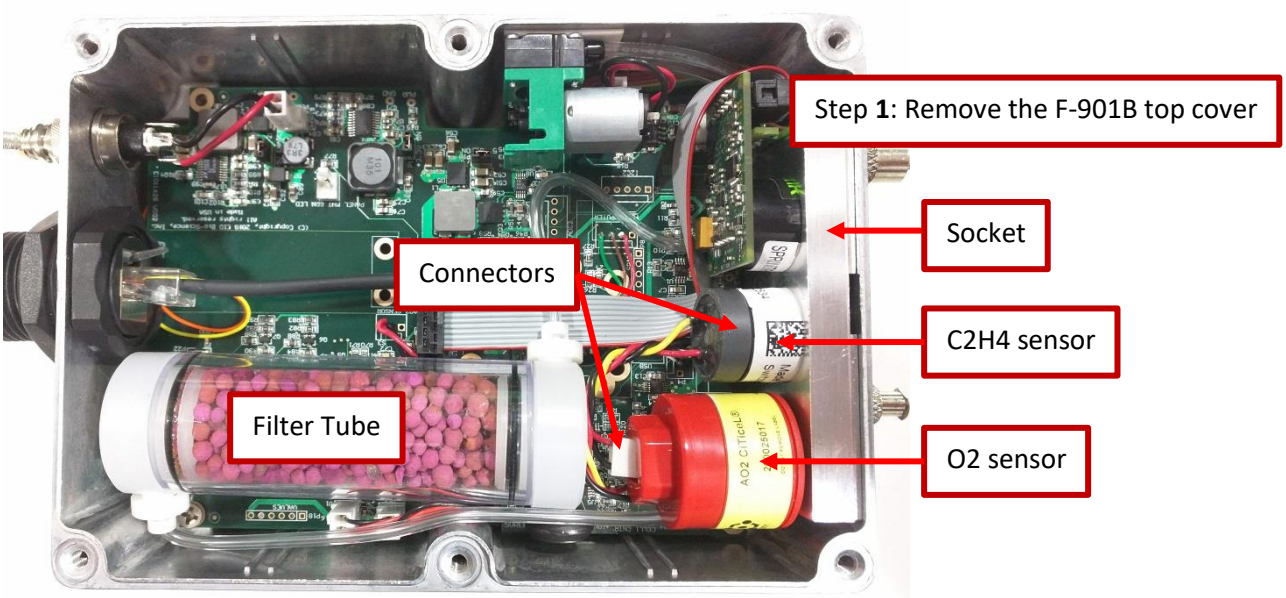
- To perform a zero calibration using coils for **CO2**, **C2H4** or **O2** sensor
    - Put device in Continuous measurement mode (write 0 to TRIGGER_INTERVAL register)
    - Apply Zero *gas* at device inlet
    - Wait until reading stabilized (C2H4 >= 7 minutes, CO2/O2 >= 2 minutes)
    - Set ZERO_[*SENSOR*] coil (ZERO_C2H4/ZERO_O2/ZERO_CO2) to request zero action
    - Set ZERO_CONF coil to confirm. After confirmation, device will perform zero action with the current gas and automatically reset the ZERO_[*SENSOR*] and ZERO_CONF coil. New zero values will also be updated on Holding Registers

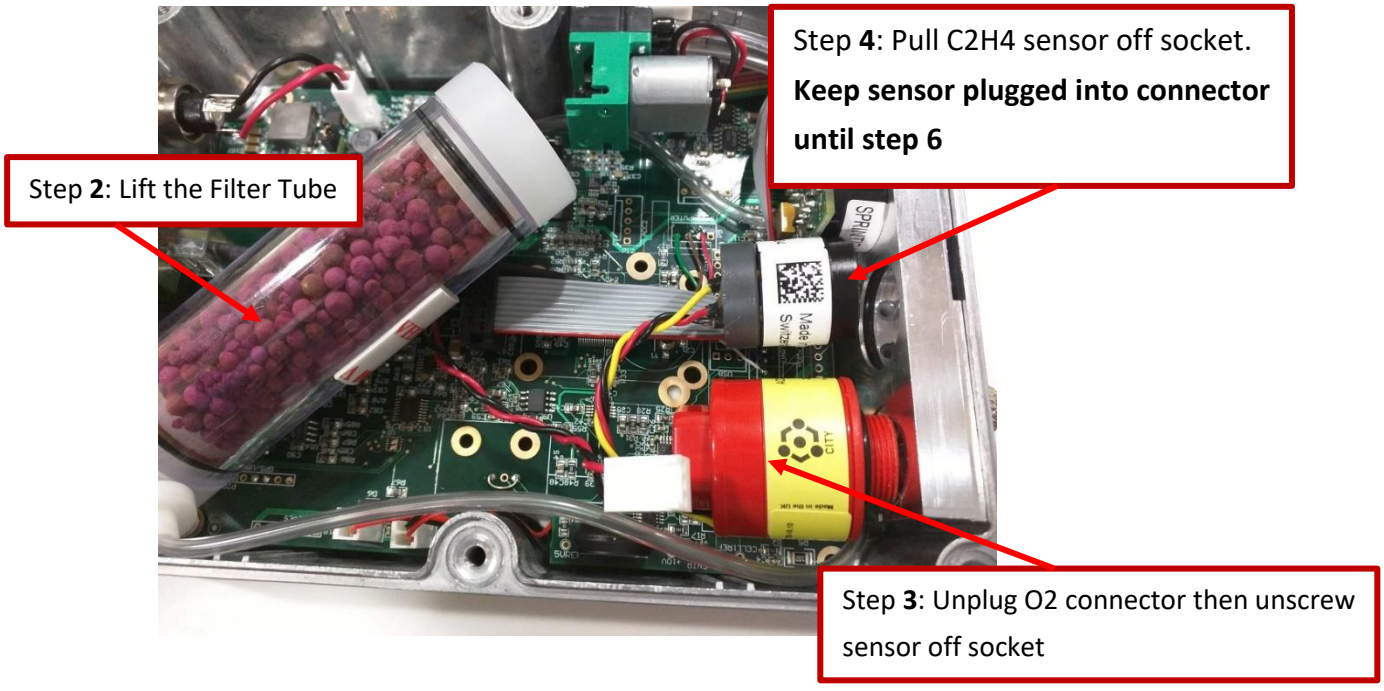
Maintenance of the F-901B

Replacing the Ethylene (C2H4), Oxygen (O_2) Sensor and Potassium Permanganate Filter (KMnO4)

IMPORTANT:

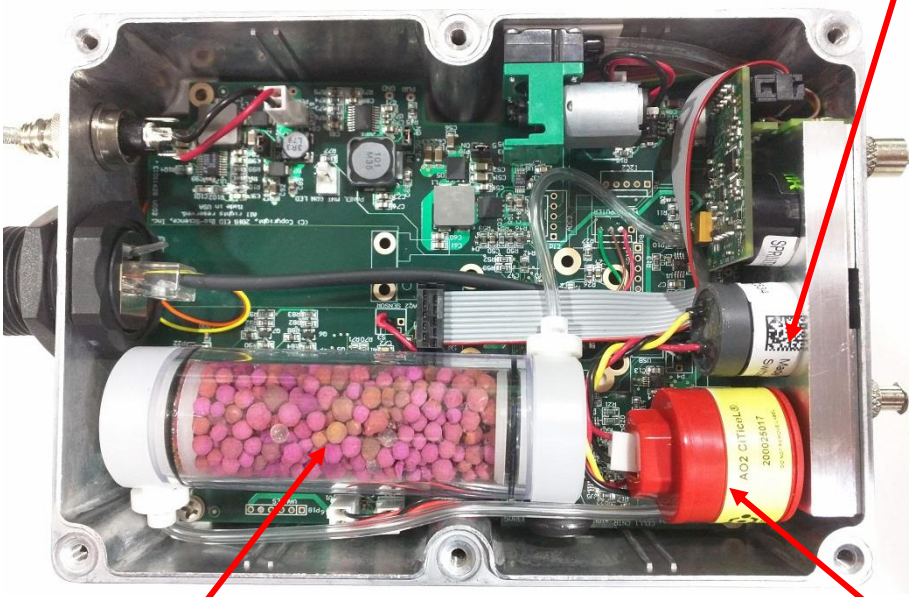
- **Power off device before you proceed**
- Make sure you have sufficient ESD (electrostatic discharge) protection
- Follow the below steps carefully to ensure proper sensor installations





Step **5**: remove short-cutting spring from new C2H4 sensor. (the spring keeps sensor from sensitivity/baseline drift during storage. Save it later for your old sensor)

Step **6**: remove old C2H4 sensor from connector, Plug in the new C2H4 sensor then push into socket



Step **8**: replace the Filter tube

Step **7**: screw new O2 sensor into socket then plug in connector

Note: Replace the KMnO4 filter when beads color turns to dark brown. Filter lifetime of >1.5 year can be expected when setting TRIGGER_INTERVAL > 10 minutes.

Calibration

All units are shipped factory-calibrated. Over time all sensors require recalibration to ensure accuracy. There are several options for calibration:

- You can ship your F-901B or individual sensor back to us for calibration
- You can order pre-calibrated sensors from us to replace your current sensors
- You can calibrate the sensors yourself

The performance of a sensor or the whole instrument should be checked regularly with calibration gas. Replace sensor when its sensitivity (span) is below 50 % of its initial value. The calibration interval depends on number of factors including application, environmental conditions, regulations and accuracy requirements.

User calibration

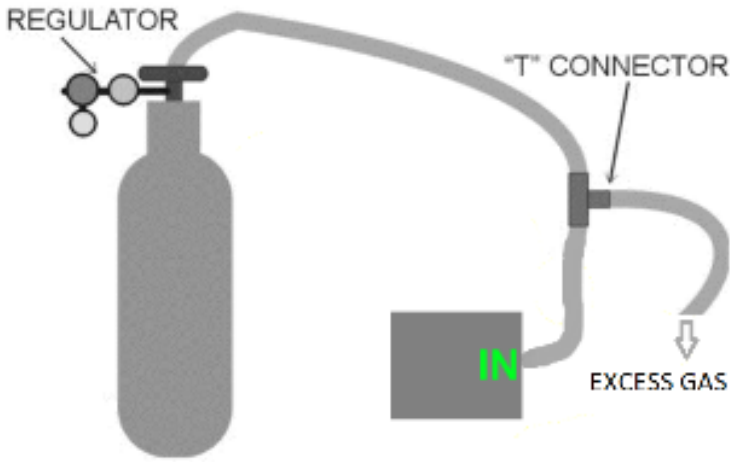
Follow the instructions in the Modbus Holding Registers and Coils description to calibrate the F-901B sensors.

Sensor calibration typically involves a zero (baseline) and a span (sensitivity) calibration. Zero calibration commonly uses "zero gas" such as 100% N2 while span calibration uses target gas for calibration. Below are recommended calibration gases for the F-901B:

Sensor	Zero	Span
C2H4	100% N2 or Fresh ambient air + KMnO4 filter	200ppm or 500ppm C2H4
CO2	100% N2 or Fresh ambient air + Soda-lime filter	20% or 90% CO2
O2	100% N2	Fresh ambient air (20.9%) or 50% O2

Note:

- When calibrating CO2 sensor, both zero and span calibration need to be performed (with zero calibration first). On C2H4 and O2 sensor, zero calibration is not required during calibration process.
- If possible, calibrate the device with the gas sensor at conditions similar to the intended usage. Use a gas mixture representing the gas matrix in the application then perform the span calibration with the target gas. In some rare cases the cross-sensitivity to a different gas can be used.
- If you use pressurized gas bottle and pressure-controlled regulator, follow the setup below to properly applying gas to the device.



Warranty Information

Seller's Warranty and Liability:

Felix Instruments- Applied Food Science warrants new equipment of its own manufacturing against defective workmanship and materials for a period of one year from date of sale. The results of ordinary wear and tear, neglect, misuse, accident and excessive deterioration due to corrosion from any cause is not to be considered a defect.
Felix Instruments' liability for repairing or replacing defective parts during the warranty period is contingent on examination by a Felix Instruments authorized representative. Felix Instruments liability will not extend beyond repairing or replacing parts from the factory where they were originally manufactured. Repair or alteration by an unauthorized technician voids warranty.
Material and equipment which is not manufactured by Felix Instruments is to be covered only by the warranty of its manufacturer. Felix Instruments will not be liable to the Buyer for loss, damage, or injury to persons or to property by the use of equipment manufactured by other companies.

Buyer accepts the terms of warranty through use of this instrument and any accessory equipment. There are no understandings, representations, or warranties of any kind, express, implied, statutory, or otherwise (including, but without limitation, the implied warranties of merchantability and fitness for a particular purpose), not expressly set forth herein.

All instrument repairs or replacement covered under warranty require a Returned Material Authorization (RMA) number. Please contact Felix Instruments technical support department at support@felixinstruments.com to obtain an RMA number before shipping instrument to CID Bio-Science, Inc.

Buyer is responsible for shipping charges to Felix Instruments headquarters:

1554 NE 3rd Ave.
Camas, WA 98607
USA

Felix Instruments is responsible for return shipping charges on repairs and/or replacement covered by warranty.

Warranty Registration Card

1554 NE 3rd Ave, Camas, WA 98607, USA
Phone: (360) 833-8835 Fax: (360) 833-1914 e-mail: sales@felixinstruments.com Web: www.felixinstruments.com

PRODUCT REGISTRATION CARD

Please complete and return this form to Felix Instruments within 30 days to validate your Warranty on Parts & Labor.

Registration Information:

Your Name:_____ Title:_____

Company/University:_____

Address:_____

City:_____ State:_____ Zip:_____

Country:_____Email_____

Phone:_____ Fax:_____

Felix Instruments Serial Number(s):_____

Purchase Date:_____Purchase Price:_____

Your opinions will help improve our service. Please answer the following questions.

1. What was the basis of your product selection?

□ Representative Recommendation
□ Product Features
□ Technical Specifications
□ Warranty
□ Other _____
□ Price
□ Product Design
□ Brand Name
□ Service

2. What other competing brands did you consider? _____

3. Where did you first learn of this product?

□ Advertisement in _____
□ Friend/Colleague
□ Other _____
□ Representative
□ Exhibit

4. Who selected this product?

□ I did
□ University Department
□ Other _____
□ Research Group
□ Purchasing

5. Comments/Suggestions:

_____