User's Guide
OFS-2000F
Optical Flow Sensor
(Extended)

Optical Scientific Inc.

May 11, 2007

OPTICAL SCIENTIFIC INC
Tel: 301-963-3630

205 Perry Parkway, Suite 14
Gaithersburg, MD 20877 USA

Revision Log

Rev Date	Description of Changes
3/23/2004	Production Release
3/24/2005	Change on pages 3, 14 and 27
6/8/05	Change the interface board from single current loop to dual current loops.
10/9/06	Release Model 2000W with Automatic Transmitter Power Feedback Control
5/11/07	Add Installation Procedure Summary in Appendix B.

OFS-2000F Certifications

- UL 3101-1:1993
- CSA C22.2 No. 1010.1:92
- IEC 61010:1999

OSi is an ISO-9001 Registered Company

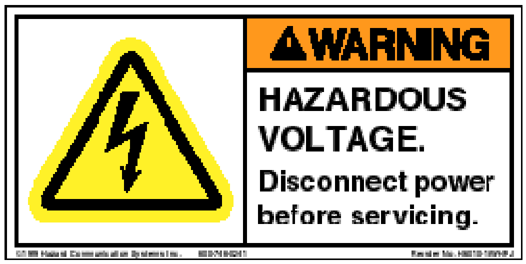
Table of Contents

Cautions & Warnings

This equipment does not contain any operator replaceable parts.

Only trained personnel are allowed to service this equipment.

The OFS shall only be used in a manner specified by the manufacturer.



This equipment contains hazardous voltages. Disconnect AC power before servicing.

Caution: Read the entire User's Guide before proceeding with installation or maintenance of the OFS!

OFS-2000F Description

The OFS-2000F is an advanced tool for airflow measurement. The sensor's optical technology provides a path-averaged velocity measurement in an industrial setting. This reading can be made in a smokestack, duct, vent, or other confined space. The unit consists of an optical transmitter, optical receiver, and control box. The LED emitter transmits an optical beam to the receptors in the receiver. The receiver sends the results to the control box for processing before relaying the data to a PC, PLC, CEM, or other data collection device. Nothing so innovative and high performance as the OFS-2000F has ever been available to those in need of accurate airflow measurements until now.

Among some of the best applications for the OFS-2000F include: 1) environmental monitoring for smokestacks and 2) process control. The OFS measures the velocity at which pollution moves out of a smokestack. Power companies, petrochemical plants, steel manufacturers, and other emissions regulated industries can use this information combined with other results to calculate volumetric flow and thus save money on emissions penalties or fines.

Plant managers or control engineers want to know the efficiency of their industrial process whether it is melting raw aluminum or making automobiles or other industrial work. The OFS-2000F can be placed at an exhaust duct or vent to measure the speed of the moving exhaust from an industrial process. This velocity can be correlated to the rate of production giving the engineer a better idea of how efficiently the plant is running. As a result, companies can save money on their manufacturing or processing costs with the help of OFS-2000F.

The OFS-2000F uses many powerful features to enhance its performance. First, the OFS uses the concept of scintillation to measure airflow velocity. Scintillation is the behavior of light through pockets of air with different temperature and density. The best is example is when looking at a star twinkling in the sky. The OFS is unique in the marketplace because of this proven technology. This velocity measurement is completely independent of temperature and pressure unlike the Pitot tube and ultrasonic techniques. Second, the product uses DSP (Digital Signal Processing) - a faster, more efficient way to process data. Third, the OFS uses self-testing and diagnostics to monitor its own performance. Fourth, the sensor complies with EPA sanctioned tests for a 40 CFR Part 75 flow sensor. And fifth, the instrument can link with a PC, PLC, CEM (Continuous Emissions Monitor) or other data collection device, which accepts analog 4-20 ma or serial digital output.

OFS-2000F Optical Flow Sensor represents a major breakthrough in flow sensing technology. Designed specifically for stacks and ducts, the OFS is based on EPA Method 14 approved technology. The unique design allows non-intrusive measurement - the OFS light signals pass through the media via optical windows on the sensor.

The OFS determines flow velocity by measuring the movement of turbulence found naturally in exhaust gases. It is not designed to operate in intake vents that do not have sufficient turbulence (i.e. laminar flow). The OFS TX and RX Units contain vibration damping but the user should endeavor to minimize the vibration at the OFS installation.

OFS-2000F Specifications

Flow Performance

Technique	Optical scintillation
Range	0.03 to 100 m/s velocity
Accuracy	2% of reading
Resolution	0.1 m/s
Response Time	User selectable 3 sec to 600 sec
Long Term Drift	<1% >6 months
Media Temperature	No limit
Stack/Duct Diameter	0.3 – 10 m standard, other ranges available
Light Source	670 nm red LED
Beam Divergence	5 degrees
Optics	quartz
Purge	Factory-supplied purged air with 1-2 CFM (optional)

Maintenance

Calibration	Automatic 2- or 3-point calibration once per day or as requested by External Calibration Request
Diagnostics	Continuous monitoring of sensor status including power supply voltage check, performance check, optics contamination, etc
Indicators	TX Optical Unit - LEDs indicating power ON & correct operation RX Optical Unit - LEDs indicating power ON & correct operation Control Box - LEDs indicating correct operation

Operational Environment

Ambient Temperature	-40 to 60 C
Dust Intrusion	IP65
Moisture	0-100% condensing if dry purge air supplied

Data Output

Dual 4-20 ma optically isolated outputs -- Main Loop: Scalable; Auxiliary Loop: fixed 0-10m/s
Two relays for fault and calibration indications
RS-232 ASCII, fixed data string - 2 types
Short with only velocity and P/F status
Long with all velocity and status data
- Optional Limited Distance Modem (LDM)
- Optional Fiber Optic Modem (FOM)

User Selectable with Integral Key Pad & Display including …
Sensor ID Baud rate (9600 standard) Averaging Time Units of Measure

Power Requirements	Fuse, Surge, & EMI protected
Transmitter Unit	Universal 100-240 VAC, 50/60 Hz, 12 VA
Control Box	Universal 100-240 VAC, 50/60 Hz, 40 VA

Physical Characteristics

Weight	TX & RX Optical Units	5 kg ea
	Control Box	7 kg (nema-4), 6 kg (rack mount)
	Extender	3 kg ea
	Gate Valve	14 kg ea
Dimensions	TX & RX Optical Units	15 x 15 x 14 cm ea
	Control Box	30 x 40 x 25 cm (nema-4), 13x43x51 cm (rack)
	Extender	standard 4” pipe flange (9” diameter), 7” (18 cm) long ea
	Gate Valve	standard 4” pipe flange (9” diameter), 5” (13 cm) long ea
Materials	TX & RX Optical Units	Aluminum with powder-coat paint
	Control Box	Aluminum with powder-coat paint (nema-4) Steel and Aluminum (rack mount)
	Extender	Aluminum with powder-coat paint
	Gate Valve	Cast Iron

Description of Units

The OFS-2000F is composed of three main elements, the Transmitter (TX) Unit (P/N 1910-100), the Receiver (RX) Unit (P/N 1910-200), and the Control Box (P/N 1910-301 for nema-4, P/N 1910-500 for rack mount). The relationship of units is shown in Figure 1.

The TX and RX Units use identical packaging to house the optical and electronic subsystems. All parts are made from aluminum and are painted with powder-coat type paint for durability. Both housings have nominal 1-inch diameter holes for the user to make power and signal connections. The use of 1/2-inch flex conduit is recommended to protect the wiring from the harsh industrial environment.

There are two kinds of Control Box – NEMA-4 and Rack Mount. The box houses the DSP processor, power supply, and interface components. The Box is connected to the RX Unit via a shielded cable (P/N 1910-217) supplied with the OFS. The NEMA-4 Control Box has nominal 1-inch diameter holes for the user to make power and signal/communications connections. The rack-mount Control Box has a power cord socket and a terminal block for the user to make signal/communication connections. The user normally supplies signal and communication cables. The use of 1/2-inch flex conduit is recommended to protect the wiring from the harsh industrial environment.

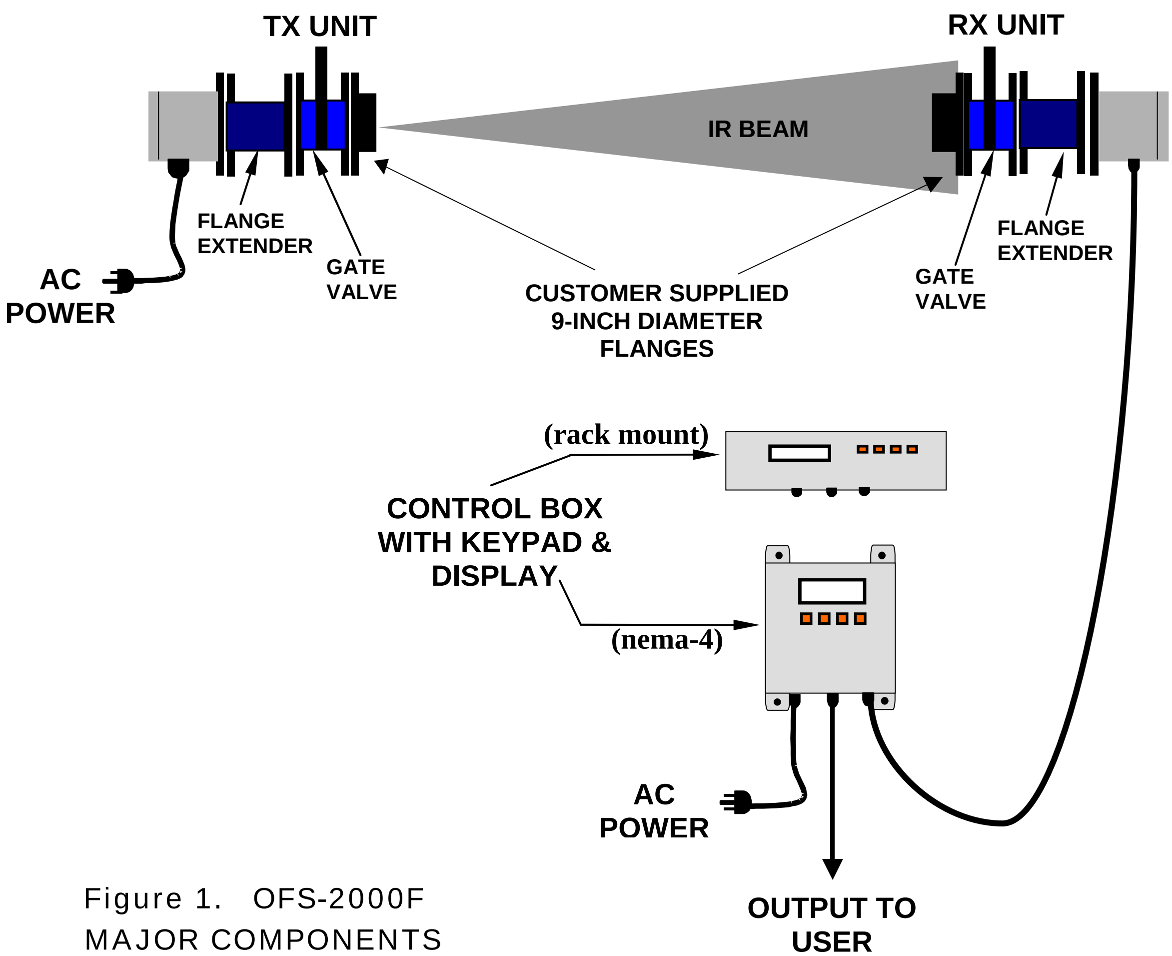


Figure 1. OFS-2000F MAJOR COMPONENTS

Transmitter (TX) Unit

The TX Unit, P/N 1910-100, consists of three major parts, housing unit, flange extender, and gate valve. The three major parts are mounted from the user supplied mating flange in the sequence of gate valve, flange extender, and the house. Figure 2 illustrates the major components inside the TX housing unit.

The flange on the housing unit is an industry standard 4-inch pipe flange with an outside diameter of 9 inches. The four mounting holes allow the user to mount to the flange extender. The flange has a hole in the center to allow the optical signal to pass through. The 7-inch long flange extender and the gate valve are inserted between the housing and the user supplied mating flange to help separate the transmitter window from the flow. There are two ¼ inch holes on the flange extender to provide air shield for negative pressure stacks and thereby help reduce window contamination. To further assist with keeping the optical window clean, the two holes can be connected to a clean, dry, oil-free factory purged air. A 9-inch diameter Kevlar gasket is installed between the housing and the flange extender to provide a weather-tight seal. A 9-inch diameter Kevlar gasket is provided for the user to place between the flange extender and the user supplied mating flange. Complete sealing of the flange is critical for proper operation; see Installation Considerations section.

The housing contains the transmitter optics and electronics subassemblies. The optics assembly is pre-aligned in the factory and needs no focusing or adjustment except to aim the infrared beam at the RX Unit on the opposite side of the stack or duct. The electronics are contained on a removable PCB on the left side of the housing. This PCB contains a universal (100 - 240 VAC) power supply, 1A, 250 V, Type 3AG fuse, transmit power switch, and modulation & drive circuitry for the light source. The transmit power switch is a four position switch that allows the user to set the optimal transmit power for the distance across the stack or duct. Two indicator lights are provided on the PCB to indicate correct operation of the TX Unit. The lower red LED is ON when AC power is supplied. The upper green LED is ON when the power setting is from 1 to 4. In normal operation, both LEDs should be ON. A user supplied AC power cable connects to the three position terminal block on the PCB.

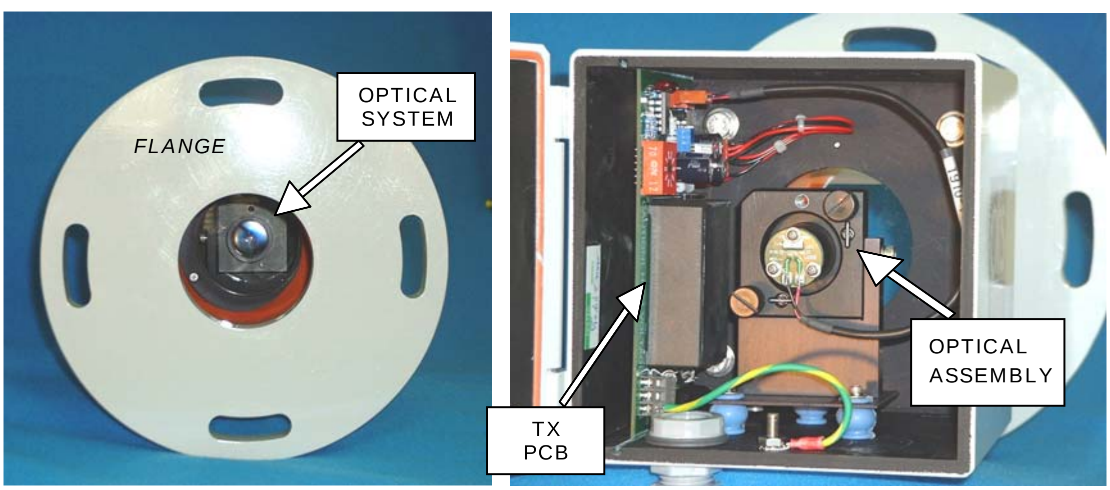


Figure 2

Receiver (RX) Unit

The RX Unit, P/N 1910-200, consists of three major parts, housing unit, flange extender, and gate valve. The three major parts are mounted from the user supplied mating flange in the sequence of gate valve, flange extender, and the house. Figure 3 illustrates the major components inside the RX housing unit.

The flange on the housing unit is an industry standard 4-inch pipe flange with an outside diameter of 9 inches. The four mounting holes allow the user to mount to the flange extender. The flange has a hole in the center to allow the optical signal to pass through. The 7-inch long flange extender and gate valve are inserted between the housing and the user supplied mating flange to help separate the receiver window from the flow. There are two ¼ inch holes on the flange extender to provide air shield for negative pressure stacks and thereby help reduce window contamination. To further assist with keeping the optical window clean, the two holes can be connected to a clean, dry, oil-free factory purged air. A 9-inch diameter Kevlar gasket is installed between the housing and the flange extender to provide a weather-tight seal. A 9-inch diameter Kevlar gasket is provided for the user to place between the flange extender and the user supplied mating flange. Complete sealing of the flange is critical for proper operation; see Installation Considerations section.

The housing contains the receiver optics and preamplifier electronics subassemblies. The optics assembly is pre-aligned in the factory and needs no focusing or adjustment in the field unless the stack or duct is not vertical. As shown in the figure, the major axis of flow is in the direction of the white arrows on the round PCB of the optics assembly. In normal operation in a vertical stack, the RX Unit is mounted vertically and the arrow points upward indicating a positive (+) flow. If measuring in a horizontal duct, the RX Unit still mounts in the vertical direction but the major flow axis must be aligned to be horizontal to be in line with the flow. The preamplifier electronics are contained on a removable PCB on the left side of the housing. Two indicator lights are provided on the PCB to indicate correct operation of the RX Unit. The lower red LED is ON when DC power is supplied from the Control Box. The upper green LED is ON when the infrared light is being received from the TX Unit is in the normal strength range. In normal operation, both LEDs should be ON. A shielded power and signal cable connects the RX Unit to the Control Box (supplied with the OFS).

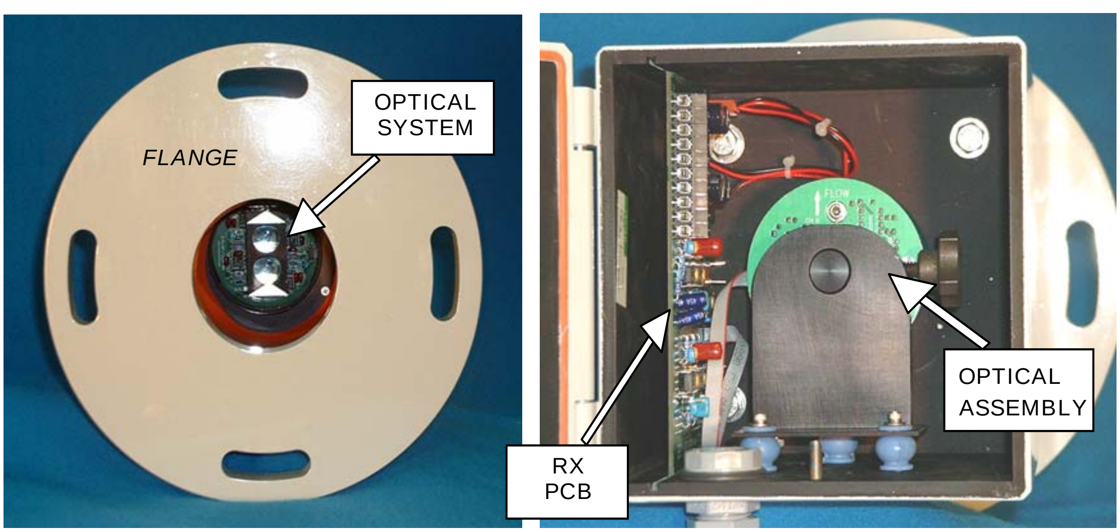


Figure 3

Control Box (nema-4)

The Control Box, P/N 1910-301, contains the processing, power, and communications sections of the OFS. The enclosure is made from aluminum with powder-coat paint. Inside the aluminum door is a secondary cover that houses the integral keypad, display and microprocessor. Figures 4a and 4b illustrate the major components of the Control Box.

Power Distribution – The OFS contains a universal AC power supply that operates with input voltages from 100 to 240 VAC, 50/60 Hz. This allows the unit to operate with all line voltages found around the world automatically. The power supply contains a 3.15 A, 250 V, 5x20 mm fuse. Line voltages are applied to an AC Surge Protection Module to protect the OFS from transients and surges. The Surge Module also acts as the terminal board for the user AC connections.

Microcontroller, Keypad & Display Module – This module is mounted to the back of the secondary Control Box cover. A 2-20 character high brightness EL type display and 4-position keypad are available on the front of the secondary cover for ease of OFS set-up and to display real time flow readings. The microprocessor board is used to calculate engineering units, set averaging time, and other user definable features.

Digital Signal Processor (DSP) – The DSP board is a state of the art digital processor used to process the optical data from the RX Unit into flow readings. Flow data is transmitted to the microcontroller for further processing.

RS-232/4-20 ma Interface Board – As shown in figure 5, the standard Interface PCB, P/N 1910-321, houses all of the interconnections for the OFS sensor. A 12-pin terminal Block (TB2) is provided to connect the Control Box to the RX Unit. A 25-pin DB type connector (J2) is for RS-232 connection to the user interface. It can also connect to optional FOM or LDM modules. A 12-pin terminal Block (TB3) is provided to connect the Control Box to the user data acquisition system for the 4-20 ma current loop, fault relay, calibration relay, and calibration request. The board also contains EMI and surge protection on all lines to reduce interference.

Control Box (rack mount)

The Control Box, P/N 1910-500, contains the processing, power, and communications sections of the OFS. The enclosure is a 3U (5.25-inch) high, 20-inch deep, 19 inch rack mountable box. The front panel contains a digital display and a 4-key keypad. Figures 6a and 6b illustrate the major components of the Control Box.

Power Distribution – The OFS contains a universal AC power supply that operates with input voltages from 100 to 240 VAC, 50/60 Hz. This allows the unit to operate with all line voltages found around the world automatically. The power supply contains a 3.15 A, 250 V, 5x20 mm fuse. Line voltages are applied to an AC Surge Protection Module to protect the OFS from transients and surges.

Microcontroller, Keypad & Display Module – The microcontroller board is used to calculate engineering units, set averaging time, and other user definable features. The output is shown on a 2-20 character high brightness EL type display for real time flow readings. A 4-position keypad is available on the front panel for ease of OFS set-up.

Digital Signal Processor (DSP) – identical to the DSP description above.

RS-232/4-20 ma Interface Board – identical to the interface board description above.

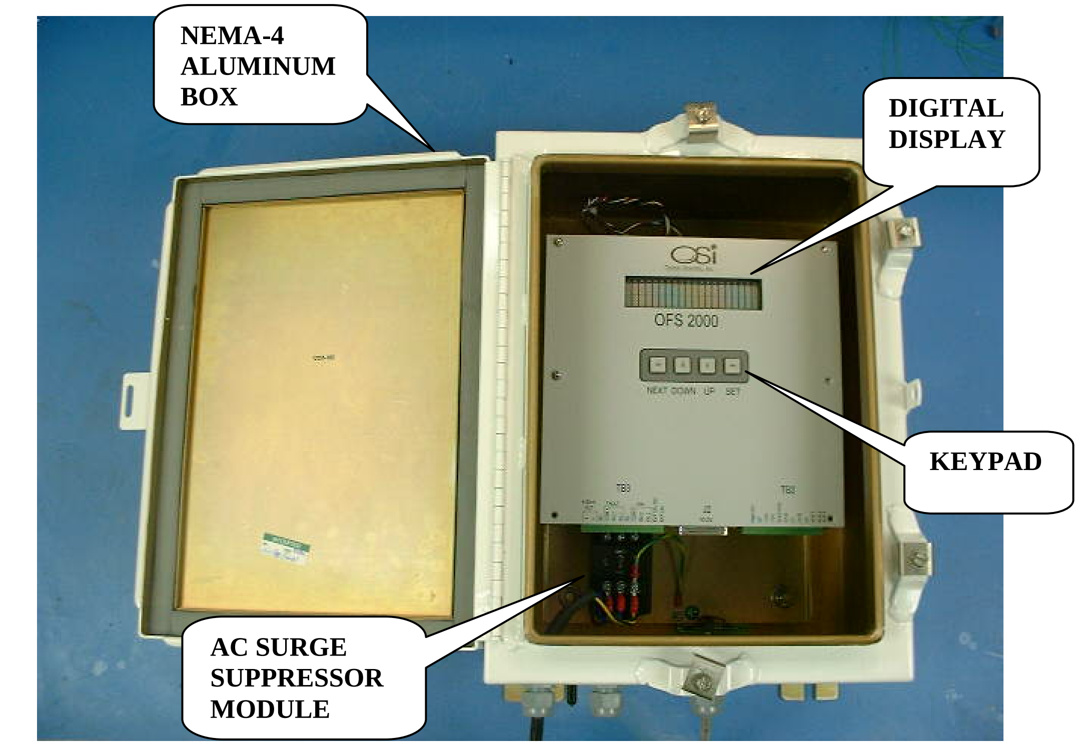


Figure 4a

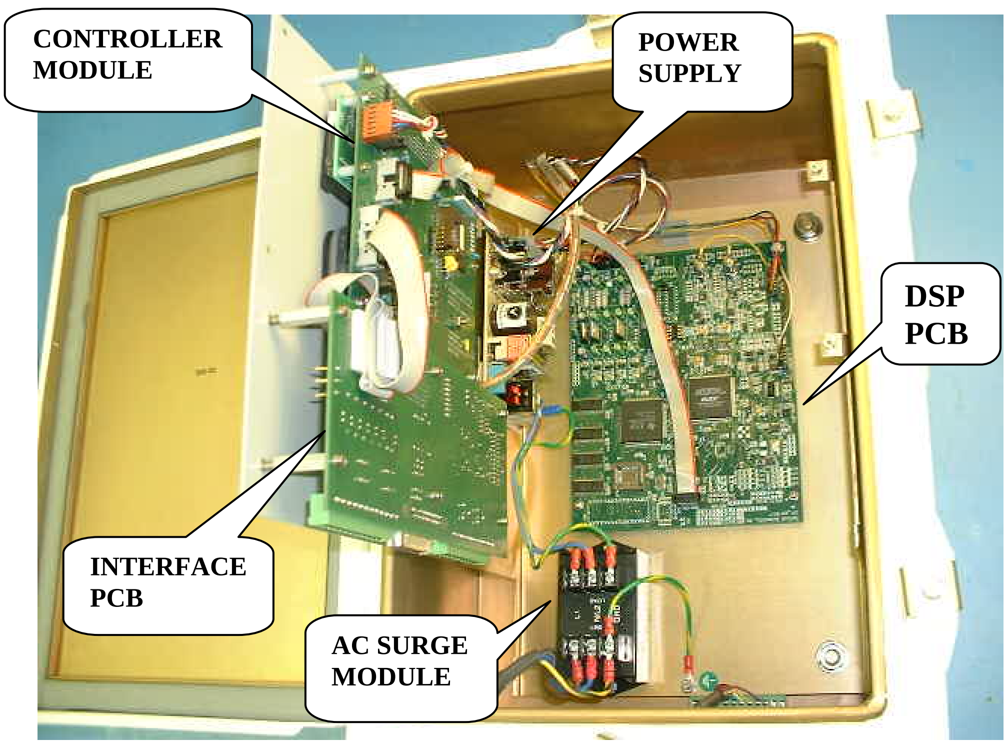
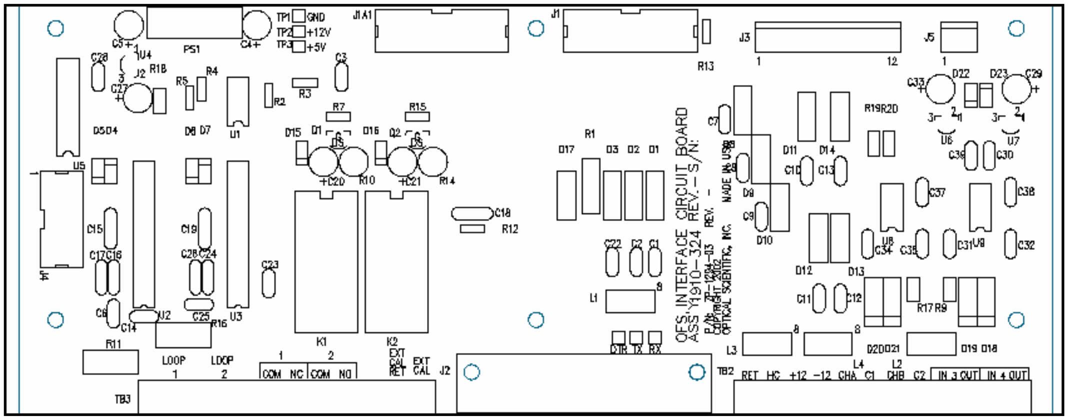


Figure 4b



TB3 CONNECTION TO 4-20 MA & RELAYS

J2 CONNECTION TO SERIAL COMM.

TB2 CONNECTION TO RECEIVER UNIT

Figure 5

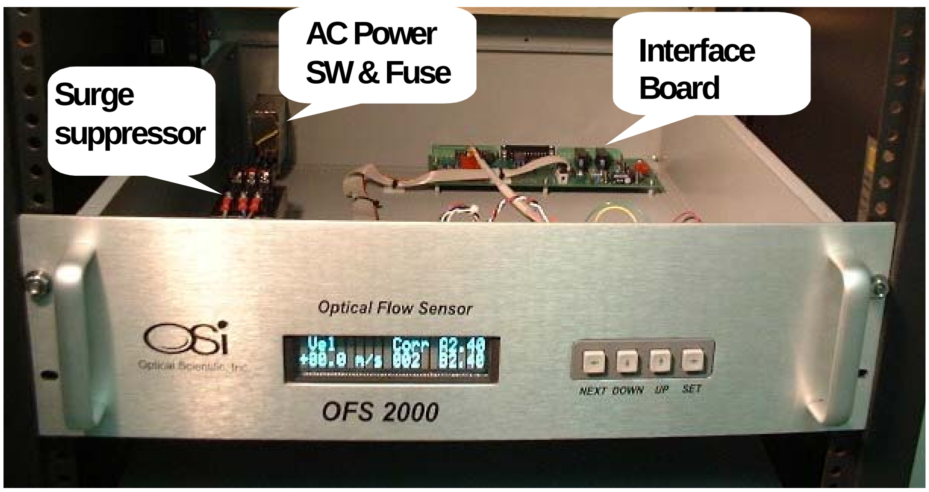


Figure 6a

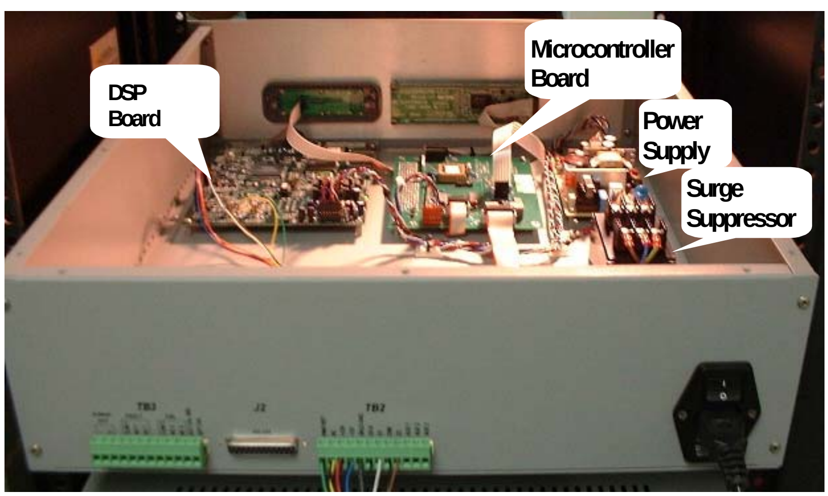


Figure 6b

Installation

General installation is described here. Appendix B details step-by-step installation procedures.

Installation Considerations

The TX and RX Units should be installed in an area of average flow of the stack or duct. Typical installations to a vertical stack and horizontal duct are shown in Figures 7 & 8.

Customer supplied flanges must be installed such that the OFS TX and RX Units mount opposite each other and perpendicular to the movement the media. The flanges may be made from commercially available 4-inch Schedule 40 pipe and flanges as shown in Figure 9.

The TX and RX Units have a 4-inch pipe flange (9-inch diameter) that mounts to an identical flange supplied by the user. A 9-inch diameter Kevlar flange gasket supplied with the OFS must be installed between the two flanges. The units must be installed with the door hinge on the left - this orients the internally optics assemblies mounting correctly.

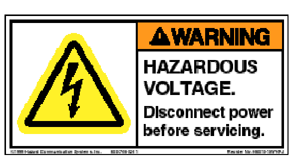
Air infiltration through improperly sealed flanges or from double walled stacks with dead space between the inner and outer walls may cause incorrect velocity readings. Figure 10 illustrates the incorrect (top) and correct (bottom) methods of installing the OFS. Insure that the mounting flange is well sealed to the stack wall (arrow 1), the OFS flange is well sealed to the stack flange with the supplied gasket (arrow 2), and that any dead space between double walled stacks is penetrated with pipe (arrow 3).

Required by User at Transmitter Location:

1. 4-inch pipe flange (9 inch diameter)
2. Single phase, 100-240 VAC, 50/60 Hz @ 1 A power with appropriately rated and approved power disconnect device adjacent to OFS
3. Clean, dry, oil-free factory air (optional)
4. 1/2-inch conduit from TX housing to AC power junction box

Required by User at Receiver & Control Box Location:

1. 4-inch pipe flange (9 inch diameter)
2. Clean, dry, oil-free factory air (optional)
3. Single phase, 100-240 VAC @ 1 A power with appropriately rated and approved power disconnect device adjacent to OFS
4. Control Box Mounting Hardware
5. 1/2-inch conduit from OFS Control Box to AC power junction box
6. 1/2-inch conduit from OFS RX housing to OFS Control Box
7. 1/2-inch conduit from OFS Control Box to user computer
8. 4-conductor shielded cable for connection of OFS Control Box to user computer or duplex fiber optical cable for FOM option



This equipment contains hazardous voltages. Disconnect AC power before servicing. Read the entire User's Guide before proceeding with installation or maintenance!

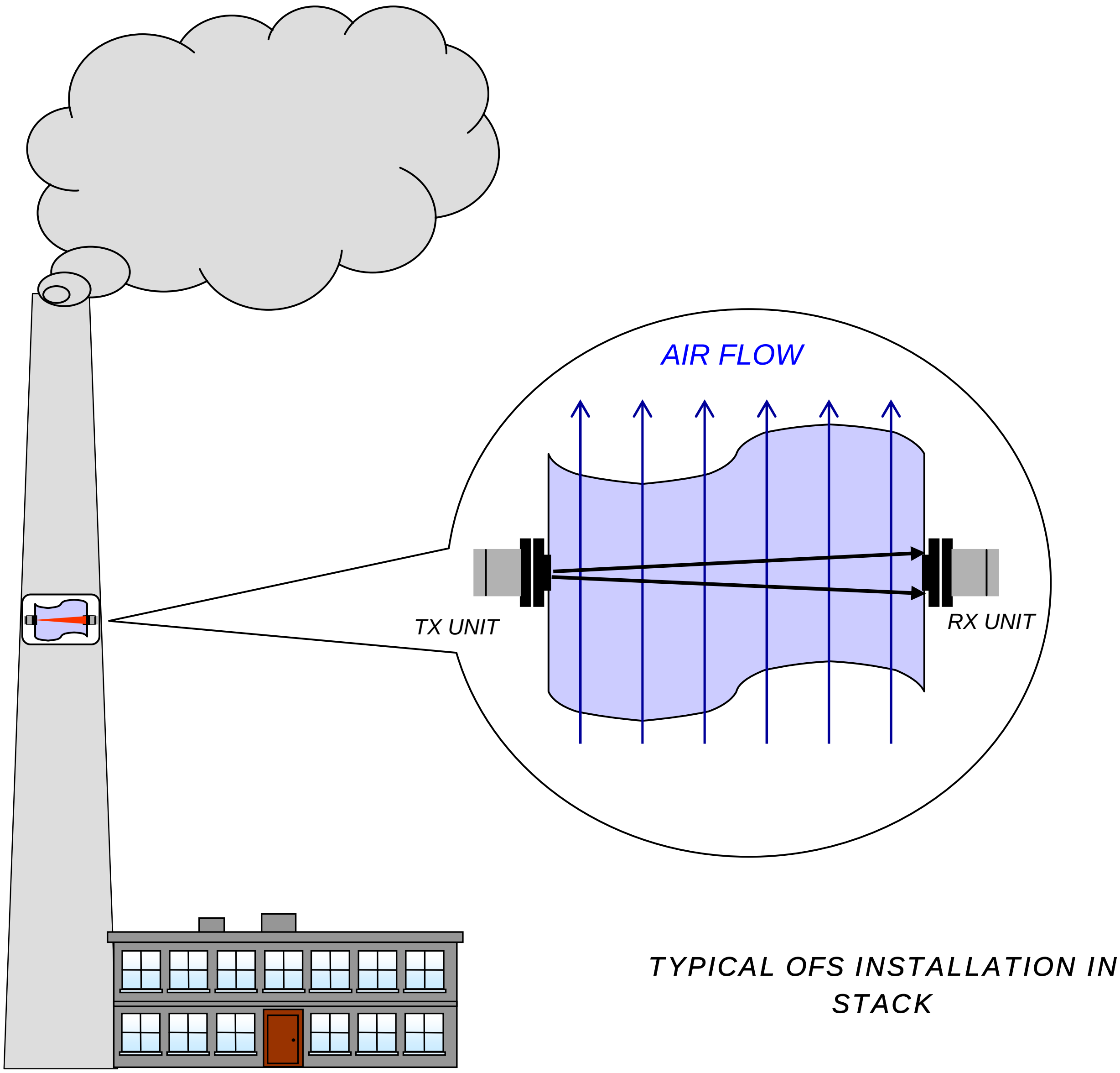


Figure 7

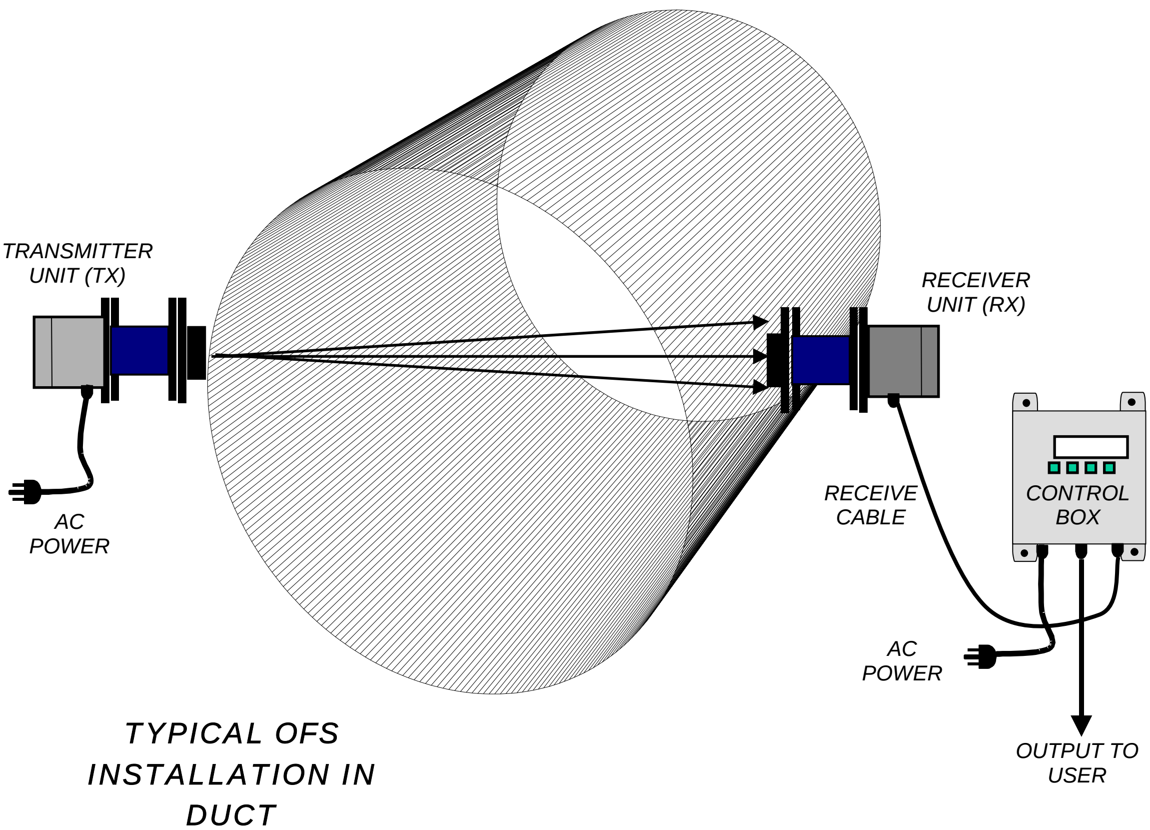

TRANSMITTER
UNIT (TX)
RECEIVER
UNIT (RX)
AC
POWER
RECEIVE
CABLE
CONTROL
BOX
AC
POWER
OUTPUT TO
USER
TYPICAL OFS
INSTALLATION IN
DUCT

Figure 8

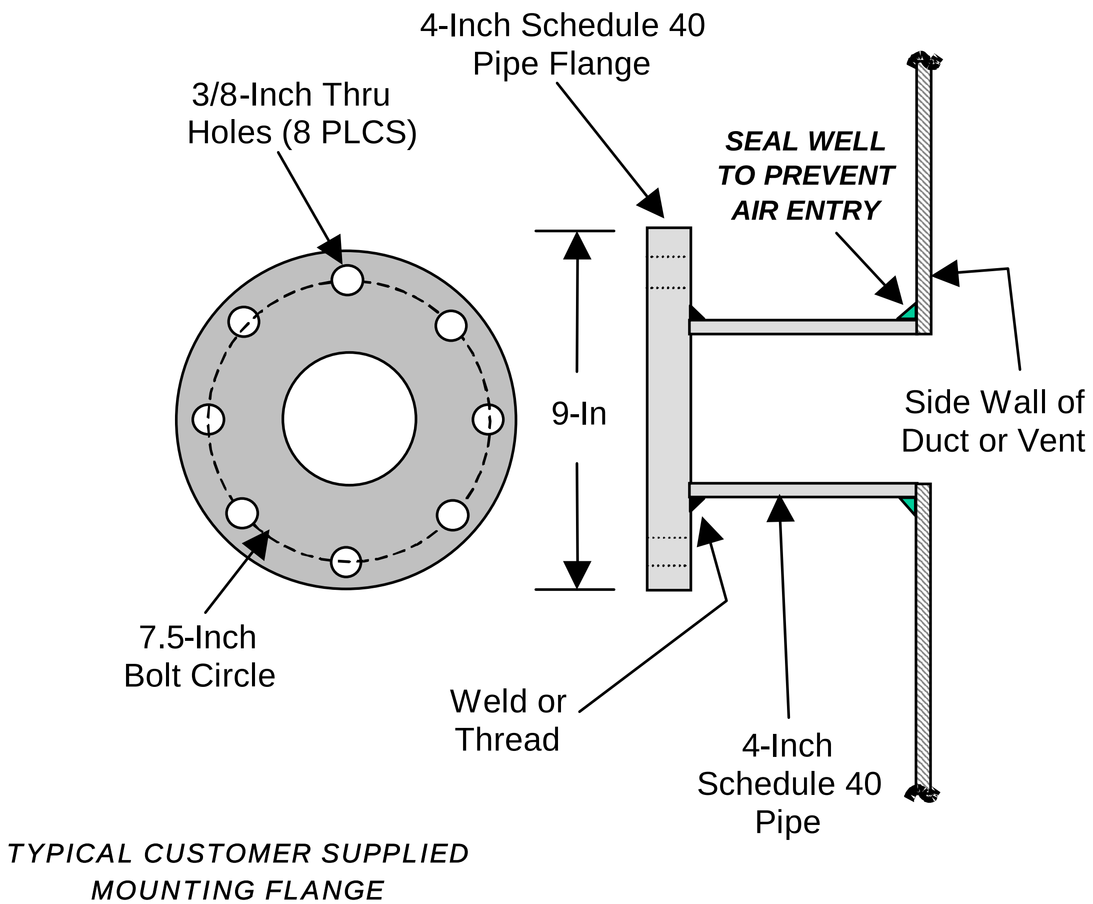
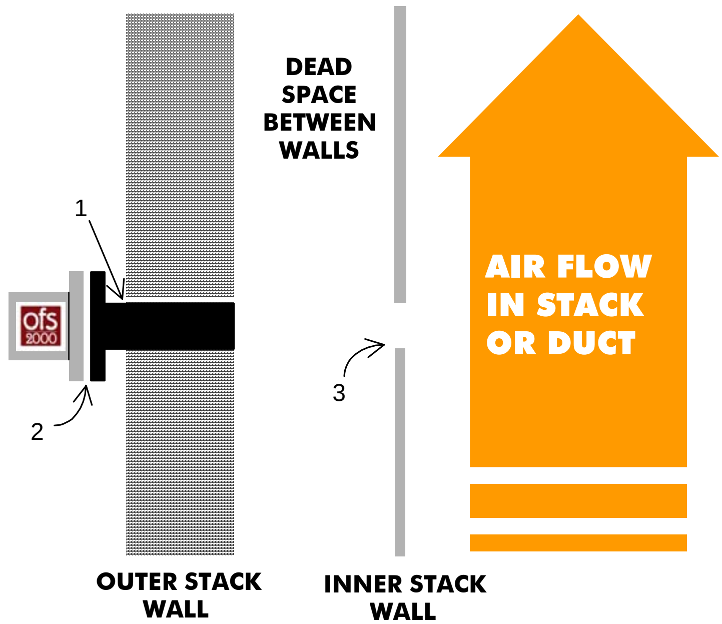
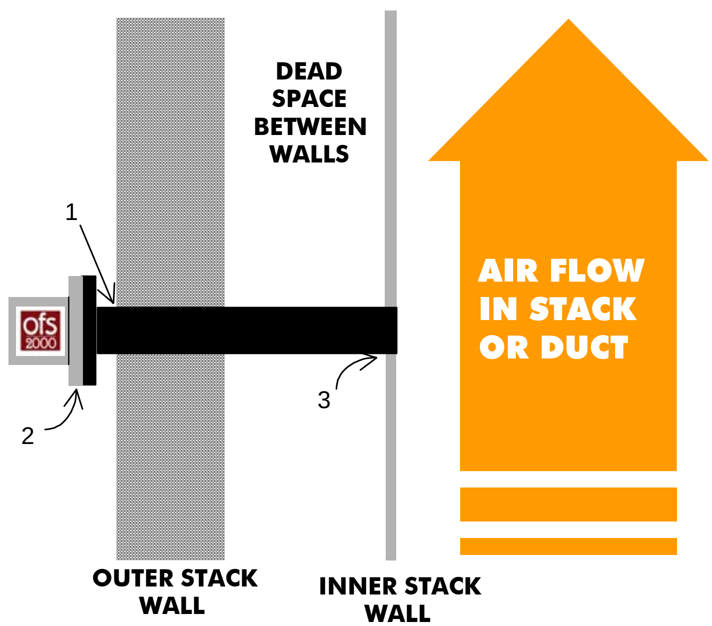

4-Inch Schedule 40
Pipe Flange
3/8-Inch Thru
Holes (8 PLCS)
SEAL WELL
TO PREVENT
AIR ENTRY
9-In
Side Wall of
Duct or Vent
7.5-Inch
Bolt Circle
Weld or
Thread
4-Inch
Schedule 40
Pipe
TYPICAL CUSTOMER SUPPLIED
MOUNTING FLANGE

Figure 9



Improper installation allows external air to contaminate true air velocity shown as arrows 1, 2, & 3



Proper installation prevents external air from contaminating true air velocity shown as arrows 1, 2, & 3

Figure 10

Mechanical

TX/RX Units

Attach the OFS TX & RX Units to the user-supplied flanges using the hardware as shown in Figure 11a. Match the OFS, extender, and stack flanges at the 12-clock position so that the housing door hinge is vertical before tightening the four bolts. Mounting hardware for installation of the units is included. The top view with dimensions in inches for the TX/RX head with Flange Extender is shown in Figure 11b.

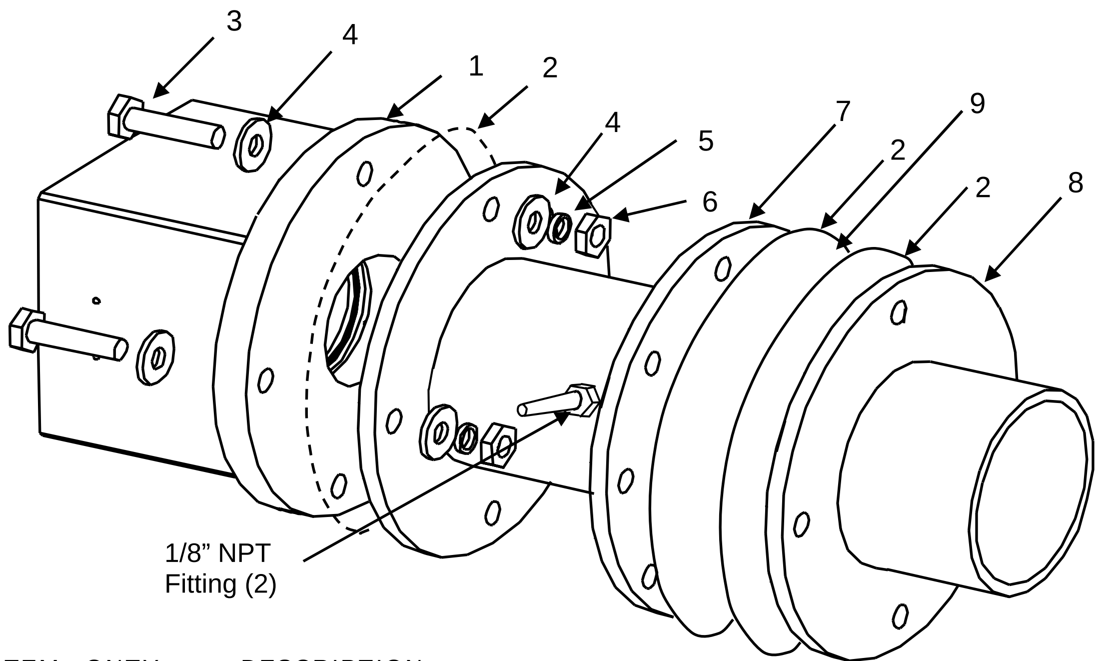
The flange extenders each have two 1/8” NPT purge holes and are supplied with barbed nipples sized for ¼” ID hose. The flanges must be oriented so that a line drawn between the two holes is perpendicular (NOT PARALLEL) to the direction of the flow measurement. The purge holes should be left open to provide passive air purge for negative pressure stacks / ducts. If the stack/duct pressure is positive or the media being measured is excessively dirty, it may be necessary to apply a small amount of compressed instrument-grade air through the NPT fittings. The exact amount of air needed is site dependent, but should not exceed a maximum of 0.5 PSI or 2.0 SCFM. It is recommended that a regulator be installed near the OFS heads to control the airflow. If media pressure is too high, it may be necessary to either plug these purge holes or use a sight glass to seal the test port and isolate the sensor from the media. Contact OSI’s customer service for additional assistance if this is your situation.

The description of the flange gasket (item #2 in Figure 11a) is as follows.

OSI Part number:	FS-1456-00
Material:	Premium-grade Kevlar fibers with a Nitrile binder.
Outside Diameter:	9”
Inside Diameter:	4.5”
Thickness:	1/16”
Temperature Range:	-40° to +400° F.
Max. Pressure:	1000 PSI
Resistant to:	Water, oils, gasoline, and hydrocarbons.
Color:	Blue.

For high temperature applications, the OFS is equipped with a flanged gate valve between the OFS and the customer supplied mating flange. It contains a pull-handle that lets the user to quickly open and close the valves, while the set screw locks the blade in position. The characteristics of the gate valve are as follows.

OSI Part number:	HZ-1481-00
Body:	Cast iron
O.D.	9”
Pipe Size	4”
Bolt Circle	7-1/2”
No. Bolt Holes:	8
Bolt Size:	5/8”
Valve Blade:	Type 304 stainless steel.
Maximum Pressure:	10 PSI (differential)
Max. Temperature:	-40 to +600 F



ITEM	QNTY	DESCRIPTION
1	1	OFS TX OR RX UNIT
2	3	OFS FLANGE GASKET
3	4	3/8-16X2 INCH SS HEX BOLT
4	8	3/8 INCH SS FLAT WASHER
5	4	3/8 INCH SS LOCK WASHER
6	4	3/8-16 INCH SS HEX NUT
7	1	FLANGE EXTENDER
8	1	CUSTOMER SUPPLIED MATING FLANGE
9	1	GATE VALVE (inserted here)

Figure 11a: OFS TX / RX UNIT MOUNTING INSTALLATION

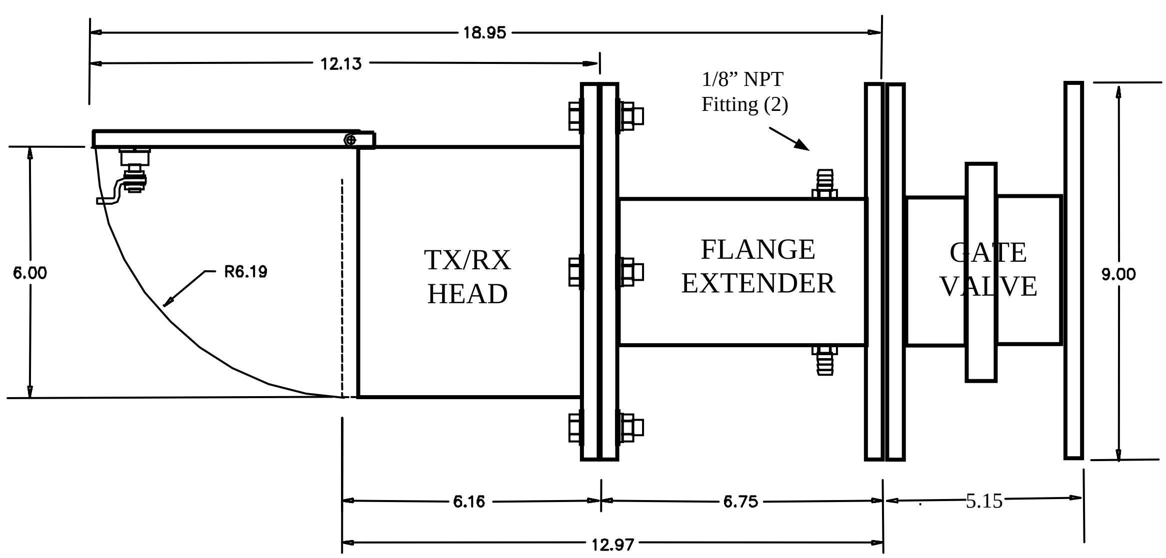


Figure 11b: Top View Dimensions (inches) of OFS TX/RX Head with Extender

Control Box (nema-4)

The Control Box may be mounted to a wall or other surface with user-supplied hardware. It should be located within 15 feet of the RX Unit if the standard P/N 1910-217 cable was ordered. Figure 12a illustrates the Control Box mounting hole pattern.

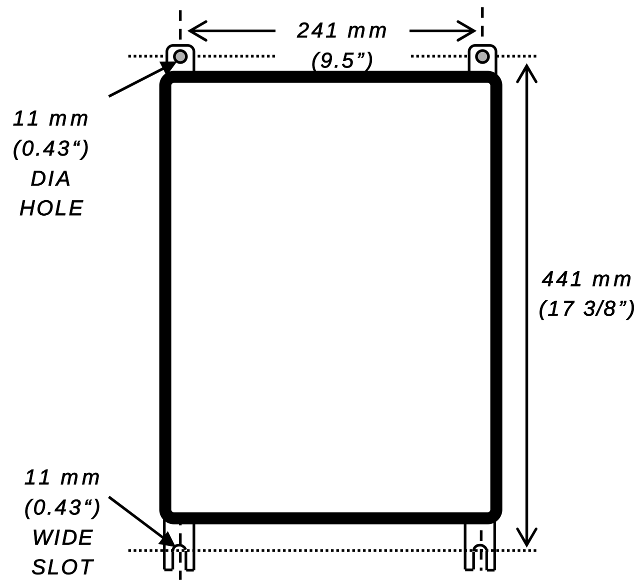


Figure 12a. OFS Control Box Mounting Hole Pattern

Control Box (rack mount)

The Control Box can be mounted to any standard 19-inch rack. It should be located within 15 feet of the RX Unit if the standard P/N 1910-217 cable was ordered. Figure 12b illustrates the Control Box mounting hole pattern.

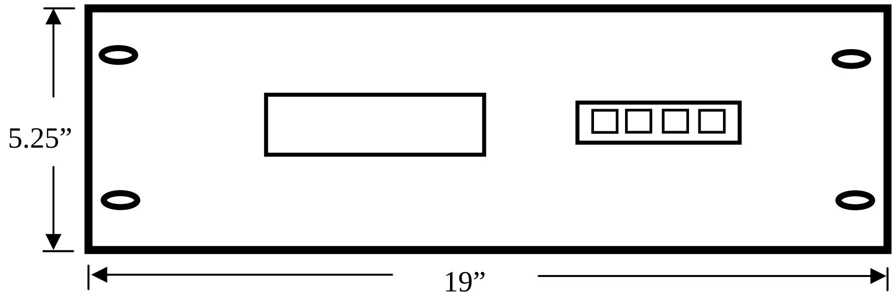


Figure 12b. OFS 19" Rack Mountable Control Box

Electrical

The OFS electrical connections are very simple. It is recommended that the user make the connections in the order shown (sensor interconnections, communications wiring, and AC power connections).

A licensed electrician may be required to make the AC power connections depending on the work and safety rules at your facility. Check with your supervisor before proceeding.

Sensor Interconnections

The OFS Sensor Control Box must be connected to the RX Unit with the P/N 1910-217 shielded cable provided with the system. The standard cable length is 15-feet long but additional cable may be ordered for longer lengths. Shorter cables are preferred to reduce noise pickup. Connect the cable to the terminal board as shown in Figure 13 below. It is recommended that ½-inch flex conduit be used between the RX Unit and Control Box to protect the cable from damage and noise pickup. If desired, the customer may provide the interconnect cable. 10 wire 18-22 AWG, shielded cable is recommended such as Manhattan M2480. The recommended maximum cable length is 90 m (300 feet).

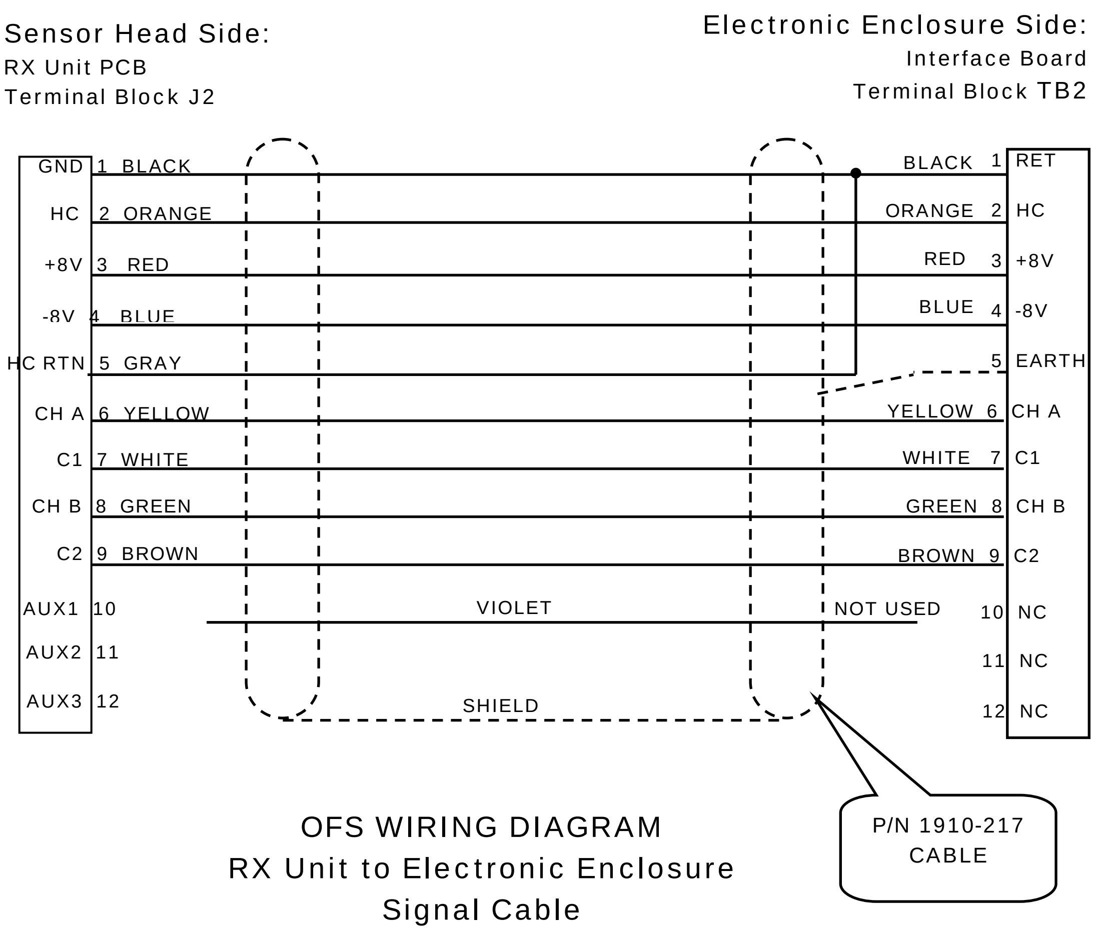
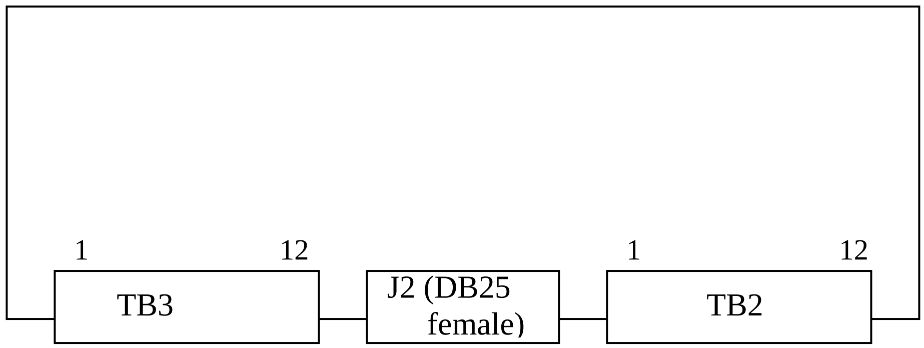


Figure 13

User Interface Connections

The OFS has two communications means on the interface board that are supplied with the standard OFS. The dual 4-20ma current loops are provided with the terminal block TB3 on pins 1 to 4. The RS-232 link is provided with the DB25 female socket J2 in the middle of the interface board. Others such as Limit Distance Modem (LDM) and Fiber Optic Modem (FOM) can be provided as DS25 socket to the RS-232 connector. Wiring information is shown in figure 14.



4-20ma/RS-232 Interface Board

TB3: 12 pins Terminal Block to customer interface (See Section: <u>4-20ma & Relay Connections</u>, page 21)

J2: DB-25 female connector for RS-232 interface

TB2: 12 pins Terminal Block connecting to the receiver head.

Figure 14

RS-232 Connections

The OFS Interface Board has an RS-232 socket J2, a female DB25 connector, which is configured as a DCE device and has the following pin designation

Pin 2:	RX
Pin 3:	TX
Pins 1 and 7:	Return

For a typical Personal Computer, the serial port is through a DB-25 male connector that is treated as a DTE device with the following pin designation

Pin 2:	TX
Pin 3:	RX
Pin 7:	Return

A DB-25 male (OFS side) to DB-25 female (PC side) cable should provide adequate communication link because it has pin-to-pin straight connection.

For a typical Laptop computer, the serial port is through a DB-9 male connector that has following configuration

Pin 2:	RX
Pin 3:	TX
Pin 5:	Return

A DB-25 male (OFS side) to DB-9 female (PC side) cable should provide adequate communication link because it has a crossover between Pins 2 and 3, and pin 5 of DB-9 is connected to pin 7 of DB-25.

Limit Distance Modem (LDM) Connections

The LDM option is available for installations where the Control Box must be installed more than 100 feet from the user's computer. The LDM converts the RS-232 levels to current loops for noise free, long distance transmission. Using 24 AWG wire, the LDM will transmit over 3 miles at 9600 baud.

LDMs are used in pairs, one installed in the Control Box and one at the remote computer. The user must supply a 2 twisted pair cable with shield to connect between the LDMs. As shown in Figure 15, the pairs are installed in a crossed pattern with the TX of one LDM connecting to the RX of the other LDM, and vice versa.   Since OFS is configured as a DCE device and the user's computer is configured as DTE, the LDM connected to OFS should be set as DTE and the LDM connected to computer should be set as DCE.

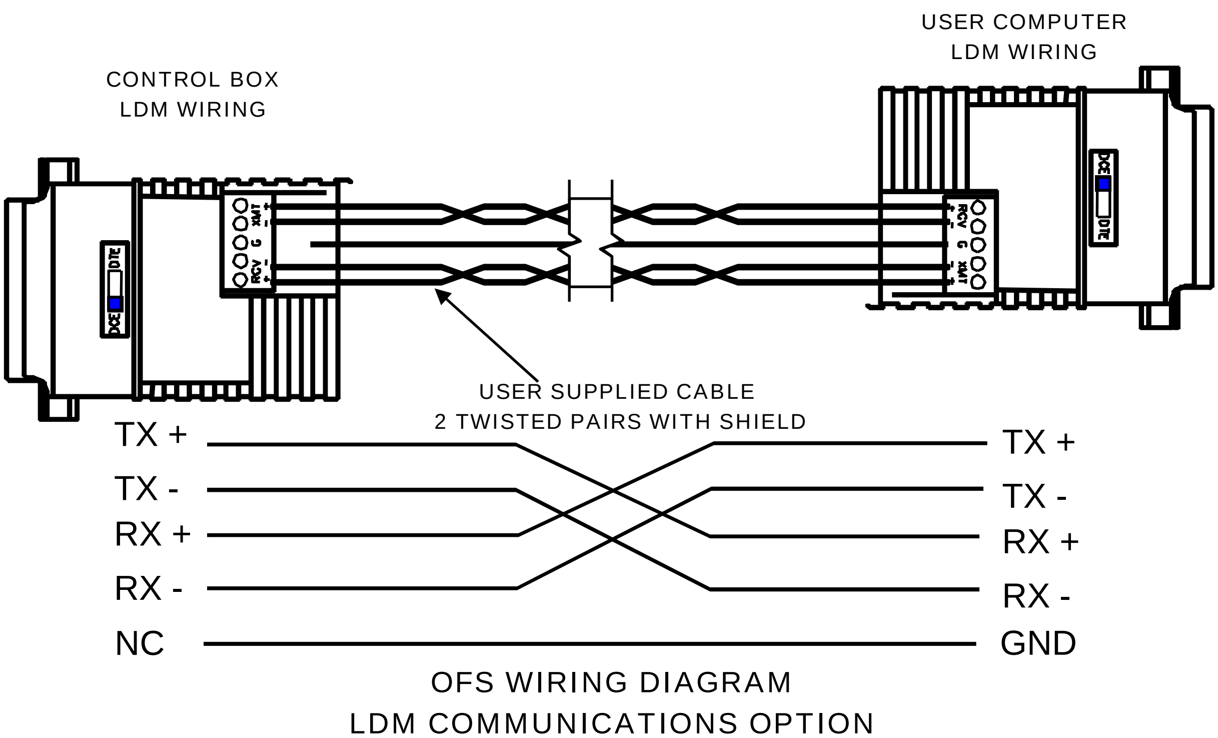


Figure 15

Fiber Optic Modem (FOM) Connections

The FOM option is available for installations where the Control Box must be connected via a fiber to the user's computer. The FOM converts the RS-232 levels to light pulses for noise free, long distance transmission. Using two multi-mode fibers (62.5/125), the FOM will transmit over 1 mile at 28.8 kbps.

FOMs are used in pairs, one DB-25 male connector is plugged in J2 on the Control Box and one at the remote computer. Since OFS is configured as a DCE device and the user's computer is configured as DTE, the FOM at the OFS side should be configured as DTE and the FOM at the user's computer side should be configured as DCE for proper data communication. The user must supply dual multi-mode 62/152 fibers with ST type connectors to connect between the FOMs. As shown in Figure 16, the fibers are installed in a crossed pattern with the TX (Out) of one FOM connecting to the RX (In) of the other FOM, and vice versa.

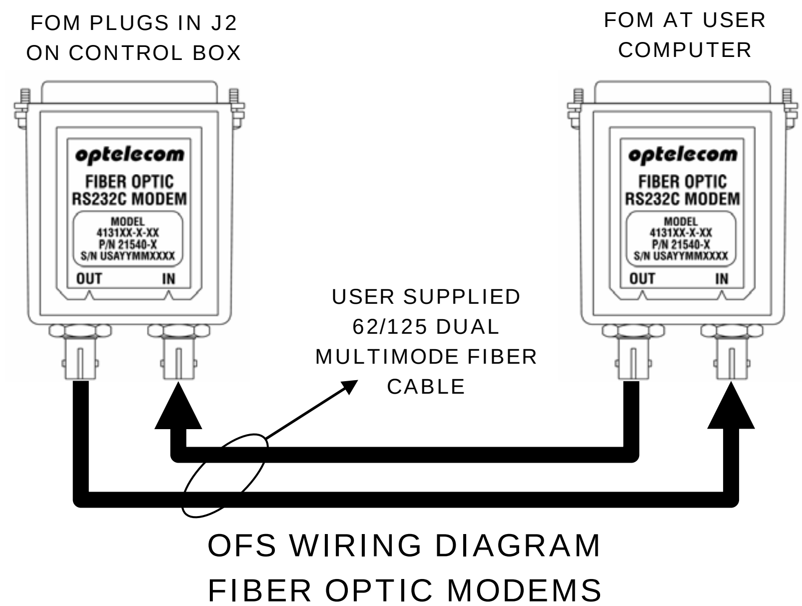


Figure 16

4-20 ma and Relays Connections

The terminal block TB3 of the interface board contains an isolated 4-20 ma circuitry, diagnostic relay, calibration relay and calibration request interface. The pin designation is as follows.

Pin 1: Current Loop –
Pin 2: Current Loop +
Pin 3: Auxiliary Current Loop –
Pin 4: Auxiliary Current Loop +
Pin 5: No Connection
Pin 6: Fault Relay Common (COM1)
Pin 7: Fault Relay Normally Closed (NC1)
Pin 8: Calibration Relay Common (COM2)
Pin 9: Calibration Relay Normally Open (NO2)
Pin 10: No Connection
Pin 11: External Calibration Return
Pin 12: External Calibration (ext_cal)

Pins 1 and 2 are for the current loop connection. The maximum loop resistance is ~600 ohms. This includes the cable resistance and the load resistor in the customer data acquisition system. Pins 3 and 4 are for Auxiliary Current Loop connections that has fixed full scale of 0 to 10 m/s.

Pins 6 and 7 are connected to the fault relay for diagnostic monitoring. A SPDT normally open/normally closed (NO/NC) relay rated at 30V/5A-250 VAC/8A is used. The relay is activated during normal operation (NC1 open) and deactivated during CH A/CH B voltages out of range, power failures, or when the OFS fails a self-test (NC1 shorts to COM1).

Pins 8 and 9 are connected to the calibration relay for calibration mode indication. A SPDT normally open/normally closed (NO/NC) relay rated at 30V/5A-250 VAC/8A is used. The relay is deactivated during normal operation (NO2 open). The relay is activated (NO2 shorts to COM2) during automatic self-calibration or when there is external calibration request. The external calibration request is activated when pin 12 is shorted to pin 11 for more than 0.1 seconds.

Use the OFS Keypad & Display Set-Up procedure to set the full-scale calibration and other 4-20 ma features.

To convert the current loop readings to velocity, use the following formula:

$$\textbf{Velocity (m/s)} = (\textbf{ma} - 4) * (\textbf{F.S.}/16)$$

where ma is the measured loop current and F.S. is the full-scale velocity selected

AC Power Connections

<u>TX Unit</u> (Note: for model 2000w with automatic transmitter power control, see appendix)

AC power connections to the TX Unit are made to TB1 of the TX Electrical Assy located on the left inside of the TX housing. If optional power cords were ordered with the OFS, the power cords and weather-tight cord grips are included with the order. If the user is supplying the power directly from an electrical panel, it is recommended to use ½-inch flex conduit between the TX Unit and electrical panel to protect the cable from damage and noise pickup.

Connect the single phase, 100-240 VAC, 50/60 Hz @ 1 A power from a customer supplied, appropriately rated and approved power, disconnect device adjacent to the OFS Transmitter Unit. The recommended supply wiring size is as follows:

1.0 mm^2 (16 AWG) or 0.75 mm^2 (18 AWG)

Connect the AC power as shown in Figure 17. Note that the green/yellow earth wire from the user supplied AC power cord should be connected to the earth ground stud in the TX Unit. The OFS is supplied with an internal green/yellow ground wire from this stud to the ground terminal on the TX Electrical Assy. Customer supplied protective earth wires must be green/yellow in color and be of the same size (gage) as the incoming mains supply conductors.

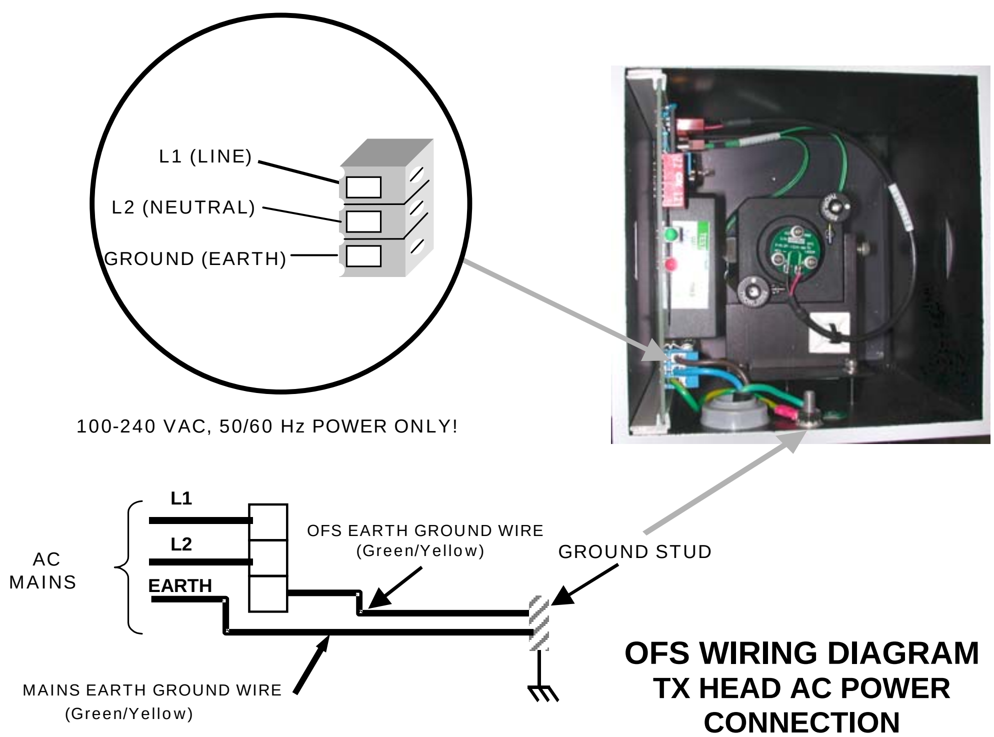


Figure 17

Control Box (nema-4)

AC power connections to the Control Box are made to AC surge protection module located in the lower left of the Control Box housing. If optional power cords were ordered with the OFS, the power cords and weather-tight cord grips are included with the order. If the user is supplying the power directly from an electrical panel, it is recommended to use ½-inch flex conduit between the Control Box and electrical panel to protect the cable from damage and noise pickup.

Connect the single phase, 100-240 VAC, 50/60 Hz @ 1 A power from a customer supplied, appropriately rated and approved power, disconnect device adjacent to the OFS Control Box. The recommended supply wiring size is as follows:

1.0 mm^2 (16 AWG) or 0.75 mm^2 (18 AWG)

Connect the AC power as shown in Figure 18. Note that the green/yellow earth wire from the user supplied AC power cord should be connected to the earth ground stud in the Control Box. The OFS is supplied with an internal green/yellow ground wire from this stud to the ground terminal on the Surge Protection Module. Customer supplied protective earth wires must be green/yellow in color and be of the same size (gage) as the incoming mains supply conductors.

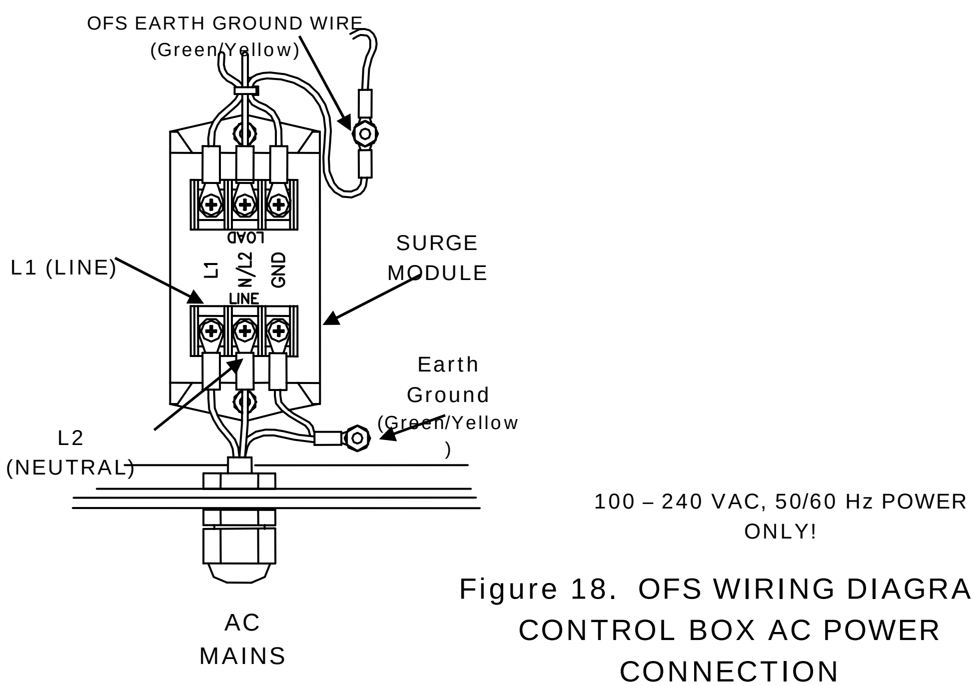


Figure 18. OFS WIRING DIAGRAM CONTROL BOX AC POWER CONNECTION

Control Box (rack mount)

The OFS comes with the standard North American AC power socket. Make certain the power switch is off before plugging power cord. Then plug the power cord into your OFS AC socket and the other end to a single phase, 110-120 VAC, 50/60 Hz @ 1 A power from a customer supplied, appropriately rated and approved power.

The fuse box below the power socket has default set to 110-120 VAC operation. For 220-240 VAC operation, use a flat screwdriver and push into the slot to ply open the fuse box. Flip around the fuse box and push the box in so the 220-240 VAC white arrow is aligned with the black arrow on the socket frame. The power supply fuse is rated 3.15 A, 250 VAC, type 5x20mm.

AC power connections to the Control Box are made to AC surge protection module, rated 240 VAC 6 Amp located inside the control box housing.

Connection to Computer

The default OFS interface is set for RS-232 protocol. The user should set up their serial port as follows:

9600 baud, 1 start bit, 8 data bits, 0 parity, and 1 stop bit

The OFS responds to a single character ASCII poll issued by the user computer. The maximum poll rate is 3 seconds but a 60-second poll rate is recommended for most applications. Note that the OFS commands are case sensitive and unless otherwise noted, require the use of capital letters.

The OFS uses comma delimited data frames for ease of analysis with spreadsheet programs such as Excel and Quattro Pro.

"A" Poll - Short Data String

In response to an "A" poll the OFS will respond with the following short 11-byte data frame:

Format:	±	w	w	w	w	,	u	u	u	,	s
	|	|	|	|	|	|	|	|	|	|	|
Byte:	1	2	3	4	5	6	7	8	9	10	11

Description of "A" Poll Response Bytes

Byte	Description	Field Symbol	Description
1	Flow Direction	+	"+" represents flow in direction of arrow in RX Unit.
2-5	Flow Data	wwww	Represents air velocity expressed in units of measure selected by customer
6		,	Comma delimiter
7-9	U/M	uuu	User selected units of measure such as m/s or fps
10		,	Comma delimiter
11	System Status	s	"P" indicates system self-test pass, "F" indicates system failure, “C” indicates ongoing calibration, and “R” indicates system restart

"C" Poll - Long Data String

The OFS responds to "C" poll with the following byte 1 to byte 59 data stream if 2-point calibration is selected, or responds with byte 1 to byte 66 (extra 7 bytes) data stream if 3-point calibration is selected.

Format:	W	,	±	w	w	w	w	,	u	u	u	,	A	,	a	a	a	a	,
Byte:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Format:	B	,	b	b	b	b	,	S	,	s	s	s	s	,	L	,	±	l	.
Byte:	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Format:	l	,	H	,	±	h	.	h	,	R	,	r	r	r	,	U	,	u	u
Byte:	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Format:	u	u	,	M	,	±	m	.	m			3-point calibration only for the extra medium calibration point							
Byte:	58	59	60	61	62	63	64	65	66										

Description of "C" Poll Response Bytes is as follows.

Byte	Description	Field Symbol	Details
1	Wind Indicator	W	Fixed Field – Velocity
2		,	Comma delimiter
3	Wind Direction	±	"+" represents flow in direction of arrow in RX Unit
4-7	Wind Data	wwww	Represents air velocity expressed in units of measure selected by customer
8		,	Comma delimiter
9-11	Unit of Measure	uuu	User selected units of measure such as m/s or fps
12		,	Comma delimiter
13	Detector "A"	A	Fixed Field – Detector A Signal Strength
14		,	Comma delimiter
15-18	Carrier Level	aaaa	Represents detector "A" carrier strength in volts from 0.10 to 9.99 volts
19		,	Comma delimiter
20	Detector "B"	B	Fixed Field – Detector B Signal Strength
21		,	Comma delimiter
22-25	Carrier Level	bbbb	Represents detector "B" carrier strength in volts from 0.10 to 9.99 volts
26		,	Comma delimiter
27	System Status	S	Fixed Field – Status Codes
28		,	Comma delimiter
29-32	Status Indicator	ssss	OFS status indicators (as described in section below)
33		,	Comma delimiter
34	Low Cal Point	L	Fixed Field – Low Calibration Point
35		,	Comma delimiter
36		+ or -	"+" indicates calibration value is greater than reference, "-" indicates calibration value is less than reference.
37-39	Offset Percentage	l.l	Last calibration value compared to low reference value (~10% span), in %
40		,	Comma delimiter

41	High Cal Point	H	Fixed Field – High Calibration Point
42		,	Comma delimiter
43		+ or -	"+" indicates calibration value is greater than reference, "-" indicates calibration value is less than reference.
44-46	Offset Percentage	h.h	Last calibration value compared to high reference value (~60% span), in %
47		,	Comma delimiter
48	Correlation	R	Fixed Field – A & B Signal Correlation
49		,	Comma delimiter
50-52		rrr	Signal correlation, >30 typical
53		,	Comma delimiter
54	Unprocessed Vel	U	Fixed Field-Unprocessed Velocity
55		,	Comma delimiter
56-59		uuuu	Unprocessed Value
60		,	Comma delimiter
61	Mid Cal Point	M	Fixed Field – Medium Calibration Point
62		,	Comma delimiter
63		+ or -	"+" indicates calibration value is greater than reference, "-" indicates calibration value is less than reference.
64-66	Offset Percentage	m.m	Last calibration value compared to medium reference value (~30% span), in %

Description of Byte 29-32 Status Indicator Codes is as follows.

Byte	Unit of Measure	Description
29	0	m/s
	1	kph
	2	mph
	3	fps

Byte	Averaging Time	Description (sec)
30	0	10
	1	30
	2	60
	3	120
	4	300
	5	600
	6	3*

Byte	Operation Mode	Description
31	0	Normal Operation
	1	A/B out of range
	2	Velocity out of the range defined by Byte 32
	3	N/A
	4	Calibration Mode
	5, 6, 7	N/A
	8	OFS reset
	9	Clean Windows

Byte	Full Scale Range	Description
32	0	0-40 m/s
	1	0-20 m/s
	2	0-10 m/s
	3	0-5 m/s
	4	0-100 m/s

* Note: 3 second time constant is used for testing only and is not recommended for operation.

Optical Alignment

The goal of optical alignment is to adjust the beam position to the center of the receiver. Before the RX Unit being mounted, the beam position can be checked with a piece of paper at the RX flange opening.

Rough TX Unit Alignment

Install the TX unit at the TX flange but leave the RX unit flange open at the moment. Open the rear cover of the TX Unit and look above the TX Optical Assembly (see figure 19). There should be enough space from the top edge of the TX assembly and TX window edge to look through to the receiver port. To verify that you are correctly aligned, the beam should fully illuminate the receiver port.

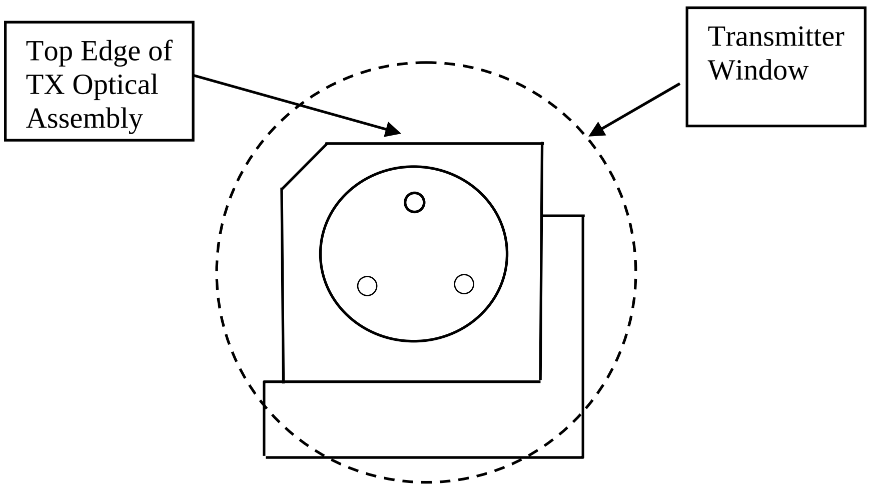


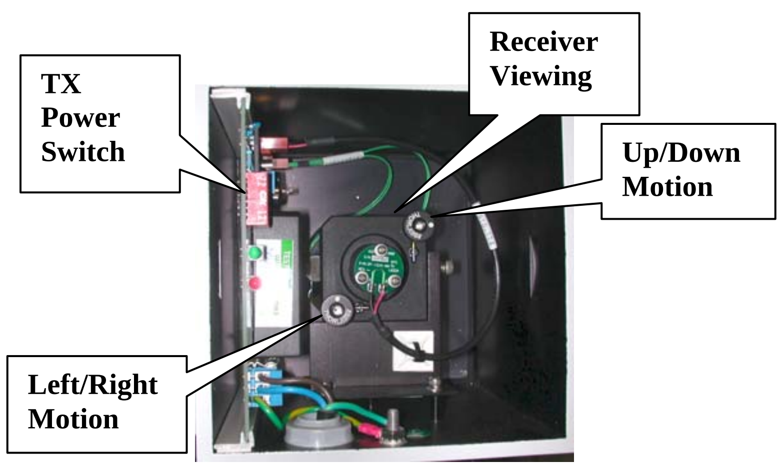
Figure 19

Place a white paper at the opening of the receive flange. The red beam should fully illuminate the opening of the RX flange if perfectly aligned. If not, use the two knurled knobs shown in Figure 20 on the adjuster to move the beam up/down and left/right. The knobs on the adjuster work as follows:

Top right knob moves the beam up (ccw) and down (cw)

Bottom left knob moves the beam left (ccw) and right (cw)

It is important that the beam is fully illuminating the receiver port, not partially. The installer may move the beam up and down, left and right and have someone looking at the paper on receiver site to make sure the beam is centered. There is some cross coupling between the knobs depending on how far from the neutral position. Look at the target and adjust accordingly. To prevent optical beam interference, insure that the cables inside the TX and RX Units are not in front of the optical assembly lenses.



TX Unit Optical Alignment

Figure 20

Final RX & TX Adjustment

RX Unit

Install RX unit to the receive flange. After roughly centering the TX beam towards the RX unit, one should be able to see a red reflection from the RX optics assembly.

The RX Optical Assembly must be aligned such that the optical detectors are inline with the direction of airflow. If the flow is from right to left, the optical detectors must be oriented with the alignment arrow on the detector PCB pointing left. The alignment arrow is shown in Figure 3 for clarity. To adjust the alignment, open the rear access door of the RX Unit. Loosen the large hex nut on the rear of the RX optical Assembly and rotate the round detector board until the white arrow is pointing in the same direction as the airflow. Hand-tighten the hex nut and close the rear door.

TX Unit

The last step involves monitoring the output on the Control Box digital display and optimizing the channel A and B parameter. The range of the A and B parameter is from 0.10 to 9.99. If either A or B falls outside this range the Signal Presence LED (upper) on the RX Unit will turn off and the velocity data field will be dashed out (-----). When both A and B is above 0.10 the Signal Presence LED located above the Power On LED on the RX Unit should be illuminated.

With the TX power switch on maximum (position 1) check the A and B voltages. If both are less than 7 then move the vertical TX beam adjustment knob slightly one way while monitoring the A & B voltages. Continue moving in that direction until the readings start to decrease. Then reverse direction until the maximum is reached. Repeat the same procedure with the horizontal TX beam adjustment. If at the beginning or during the procedure the A or B reaches 7 then turn the power setting switch on the TX Electrical Assembly to the next lower setting (from max to min; position 1 to position 4). Operate the OFS at the power setting that A and B values will be peaked and balanced when optically aligned. This will provide the most dynamic range without saturating the signals. **For operation, the desired A & B values fluctuate between 2 and 7 volts** (between 1 and 8 volts are acceptable but not higher than 8 volts)**.**

The A & B voltages do not have to be identical for the OFS to operate correctly. This is not a problem since the velocity measurement is not dependent on the absolute amplitude of the A & B channels. If the A & B values are off by more than 30% of each other, further adjust the TX position knobs slightly to make the two numbers closer but does not require identical A & B numbers.

Note: Do not adjust the TX position knobs too much to prevent the beam center moved away from the receivers. It should be noted that it is more important to keep the beam centered at the receivers than to achieve equal A & B values or maximize A & B values.

Operation & Quick Check

This section of the User's Guide is designed to be performed by both operators and maintenance personnel. There are no operator replaceable parts in the OFS.

Operators may check perform the following steps:

1. Check visual indicators
2. Perform the OFS power-up initialization
3. Initiate an OFS auto calibration
4. Set-up using keypad & display

Trained maintenance personnel must take any additional troubleshooting and corrective action steps.

Visual Indicators

TX Unit - When AC power is applied to the TX Unit; observe that the two LEDs on the left side of the square housing are illuminated. The upper green LED indicates that the infrared light transmit circuitry is operating correctly and the lower red LED indicates that AC power is being applied.

If the LEDs are not illuminated correctly, contact trained maintenance staff.

RX Unit - When AC power is applied to the Control Box, internally generated DC power supply voltages are sent to the RX Unit via the receive interconnection cable. Observe the two LEDs on the left side of the square housing are illuminated. The upper green LED indicates that the RX Unit is receiving adequate signal strength from the TX Unit and the lower red LED indicates that DC power is being applied from the Control Box. If the green LED is off or flickering, this indicates that the TX / RX Units are not correctly aligned or the signal strength is too low due to obstruction of the light beam across the path. When the received signal strength is adequate, the green LED will be fully illuminated.

If the LEDs are not illuminated correctly, contact trained maintenance staff.

Control Box - When AC power is supplied to the Control Box, observe that five green LEDs on the DSP Board are illuminated. To view these LEDs, for nema-4 box, open the cover of the Control Box and open the secondary inner door by loosening the 2 captive screws. For rack mountable box, open the top cover of the control box. The LEDs indicate that the various power supplies are operational. Figure 21 illustrates the location and function of the LEDs.

If the LEDs are not illuminated correctly, contact trained maintenance staff.

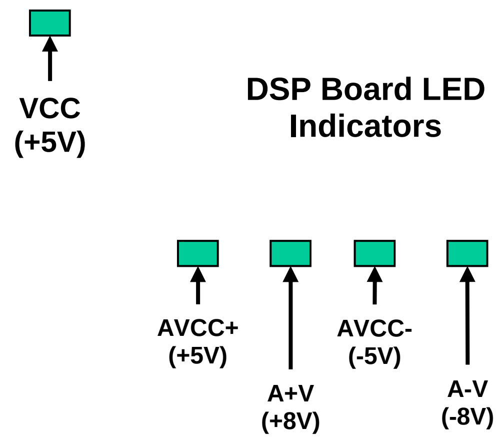


Figure 21

OFS Initialization

When the OFS is first powered on, the front panel digital display will show an initialization message. During normal operation, the OFS will display the standard data on the digital display. Upon power up, the following screens will appear:

	O	p	t	i	c	a	l		T	e	c	h	n	o	l	o	g	y	
							O	F	S										

C	o	p	y	r	i	g	h	t		2	0	0	0	-	2	0	0	1	
	O	p	t	i	c	a	l		T	e	c	h	n	o	l	o	g	y	

R	e	s	t	a	r	t				C	o	r	r		A	a	.	a	a
w	w	w	w		m	/	s			r	r	r			B	b	.	b	b

The following screen is the normal operation data display. The “wwww” characters are the flow velocity in the units of measure shown (m/s in this example). The “rrr” characters are the signal correlation (typically in the range of 30 to 999). The 4 bytes of data beginning with A are the received signal strength of optical channel A (0.1 to 9.99 volts). The 4 bytes of data beginning with B are the received signal strength of optical channel B (0.1 to 9.99 volts).

	V	e	l						C	o	r	r			A	a	.	a	a
w	w	w	w		m	/	s		r	r	r				B	b	.	b	b

Press the NEXT (🡐) key once to display the time since last calibration (HH:MM).

T	i	m	e		S	i	n	c	e		C	a	l		0	0	:	0	0

Press again to display the calibration errors (% error from standard value) when 2-point calibration is selected.

C	a	l	i	b	r	a	t	I	o	n		V	a	l	u	e	s		
L	o	w	+	0	.	0		H	i	g	h		+	0	.	0			

If 3-point calibration is selected, the following is displayed

C	a	l	i	b	r	a	t	I	o	n		V	a	l	u	e	s		
L	+	0	.	0			M	+	0	.	0			H	+	0	.	0	

Pressing the key one more time returns it to the normal display.

Automatic Calibration

The OFS is equipped with a calibration system that operates once per day automatically. It may also be activated by sending an ASCII “R” character over the serial interface, by following the steps in the OFS set-up using the keypad and display.

During calibration cycle, the OFS injects precise phase shifted frequency pairs that represent default 10% of the full range (Zero Calibration), 30% of the full range (Mid Calibration) and 60% of the full range (Span Calibration). For example, at 40 m/s full scale,

Zero Calibration = 40 m/s * 10% = 4.0 m/s
Mid Calibration = 40 m/s * 30% = 12.0 m/s
Span Calibration = 40 m/s * 60% = 24.0 m/s

At the beginning of the calibration, OFS goes into Zero calibration for duration of 30 to 270 seconds as set up by the user. It is followed by Medium and Span calibrations for the same duration each. To get a stable calibration reading, we recommend sampling the data at 10 seconds before the end of each calibration period. If any of the calibration values are outside the range of ±3% of standard value, the calibration is treated as failure.

For 2-point calibration, only the zero and span calibrations apply.

The same applies to other units chosen. The full-scale ranges in other units are

m/s	Kph	mph	Fps
0 - 100 m/s	360	230	330
0 - 40 m/s	144	92	132
0 - 20 m/s	72	46	66
0 - 10 m/s	36	23	33
0 - 5 m/s	18	11.5	16.5

During calibration the following will occur:

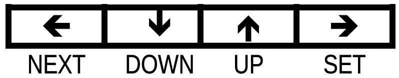
- Byte 31 of the “C” poll ASCII data string is changed from a 0 to a 4 to an 8 data.
- Byte 11 of the “A” poll short data string is set to C.
- For 4-20 ma users, the calibration relay is activated to alert the user that calibration takes place.

In the event of a calibration failure, byte 43 of the “C” poll ASCII data string is set to either a 5 or 6 to indicate an error.

The time since last calibration and the latest calibration error values may be observed on the OFS Control Box digital display. Press the NEXT (🡐) key once to display the time since last calibration (HH:MM) and twice to display the calibration errors (% error from standard value). Pressing the key one more time returns it to the normal display.

Set-Up Using OFS Keypad & Display

The OFS has several parameters that may be selected by the user. The Control Box contains a digital display module and 4-position keypad that may be used to enter all user parameters. The keypad is shown below:



The NEXT (←) key is used to accept the selection and move to the next available parameter. The SET (→) key is used to accept the selection and exit to operational mode. The ↓ and ↑ keys to move down and up to the available choices of a given parameter such as 9600 baud, 14,400 baud, etc.

The tables describe each user selectable parameter, the available choices, and how to use the keypad to navigate within the parameter.

Units of Measure	Press ↓ or ↑ keys to select a new unit of measure. Press NEXT to select and advance to the next parameter or SET to select and exit set-up function.
Meters per Second	Default
Km per Hour	
Miles per Hour	
Feet per Second	

Averaging Time	Press ↓ or ↑ keys to select a new averaging time. Press NEXT to select and advance to the next parameter or SET to select and exit set-up function.
10 Seconds	
30 Seconds	
60 Seconds	Default
2 Minutes	
5 Minutes	
10 Minutes	
3 Seconds	

Baud Rate	Press ↓ or ↑ keys to select a new baud rate. Press NEXT to select and advance to the next parameter or SET to select and exit set-up function.
300 Baud	
1200 Baud	
2400 Baud	
4800 Baud	
9600 Baud	Default
14,400 Baud	
19,200 Baud	
28,800 Baud	

Unit ID Code	Press ↓ or ↑ keys to select an ID code. Press NEXT to select and advance to the next parameter or SET to select and exit set-up function. *(This function is only used if the RS-485 Interface Type is selected below)*
#00 ID Not Enabled	
#01	Default

│	
#99	

Output Type	Press ↓ or ↑ keys to select a new output type. Press NEXT to select and advance to the next parameter or SET to select and exit set-up function.
Continuous Short	Automatically outputs the short data string every 3 seconds.
Continuous Long	Automatically outputs the long data string every 3 seconds.
Polled Single	Default – send “A” or “C” poll to obtain short or long data string.
Polled with ID	Send “Axx” or “Cxx” poll to obtain short or long data string where “xx” is the ID code selected. *(This function is only used if the RS-485 Interface Type is selected below)*

Correction Factor 00 % (1.00)	This feature allows the user to offset the OFS velocity to match the velocity of a known standard. To increase the reported OFS velocity, press the ↑ key once for each +1% of correction desired. To decrease the reported OFS velocity, press the ↓ key once for each -1% of correction desired. Press NEXT to advance to the next parameter or SET to select and exit set-up function.

Show Curve Fitting Value Press ↑	Press ↑ key to show current OFS and Ref values up to 6 points. Press NEXT to advance to the next display.
Curve Fitting Units	Default is Meter per Second. Press ↓ or ↑ keys to select a new unit of measure. Press NEXT to advance to the next display.
Curve Fitting Values OFS1=xx.x Ref1=yy.y	The final curve fitting values are displayed line by line. Press NEXT to show the next pair values until all points are displayed.

Change Calibration Setting Press ↑ to Start	Press ↑ key to change calibration setting. Press NEXT to advance to the next menu.
24 hour Auto Calibration	Press ↑ key to toggle from Enable to Disable.
Calibration Duration	Press ↑ key to increase in 30 seconds increment up to 270 seconds. After 270 seconds, reset to 0 seconds which disable calibration.
Calibration Point Low High	Press ↑ key to toggle between 2-point calibration (Low – High) and 3-point calibration (Low – Medium – High).
Calibration Low	Press ↑ key to increase or ↓ key to decrease by 1% of the Low Calibration as percentage of full scale selected (DEFAULT is 10%).
Calibration Medium (optional)	Press ↑ key to increase or ↓ key to decrease by 1% of the Mid Calibration as percentage of full scale selected (DEFAULT is 30%).
Calibration High	Press ↑ key to increase or ↓ key to decrease by 1% of the High Calibration as percentage of full scale selected (DEFAULT is 60%).

Calibration Check Press ↑ to Start	If ↑ key pressed, calibration process will begin. If calibration is not desired, press NEXT to advance to the next parameter or SET to select and exit set-up function.
Requested	
In Progress	Continues for ~2 minutes

4-20 ma Current Loop Users Only!

Current Loop xx.x m/s Full Scale	Press ↓ or ↑ keys to select a full-scale velocity (m/s) for the current loop. Press NEXT to select and advance to the next parameter or SET to select and exit set-up function.
5 m/s	
10 m/s	
20 m/s	
40 m/s	Default
100 m/s	
Maximum Current Test	Sends 20 ma to the loop
Minimum Current Test	Sends minimum current, 0 or 4 ma, to the loop

* If using unit other than m/s, equivalent velocity in that unit shows on the menu automatically.

Current Loop 1 Data NORMAL	Press the ↑ key to toggle between Normal and Uncorrected data to drive current loop (If no curve fitting, they are the same.)

Preventative & Corrective Maintenance

This equipment does not contain any operator replaceable parts. Only trained personnel are allowed to service this equipment.

This equipment contains hazardous voltages. Disconnect AC power before servicing. Read the entire User's Guide before proceeding with installation or maintenance!

PM

The following preventative maintenance (PM) actions are recommended every 6 months or as needed.

1. Installation condition check – Inspect the TX Head, RX Head and Control Box for proper installation. Verify that all mounting bolts are installed and secure. Verify that the TX/RX Head mounting gaskets are installed, in good condition, and not leaking air. Check the power and signal cables to verify that they are tight and not frayed.

2. Visual indicator check – Verify that the LED indicators are illuminated per the “Visual Indicators” check above.

3. Window fouling check – Using the Control Box digital display, verify that the A & B voltages are > 1 volt or have not decreased significantly from the last PM check. If less than 1 volt, follow the steps in Corrective Maintenance to clean the windows.

4. Auto Calibration – Using the Control Box keypad and display, initiate a calibration cycle per “Auto Calibration” above.

CM

Corrective maintenance should be performed on an as-needed basis. If the troubleshooting steps recommended below do not resolve the problem, contact the OSi customer service department. Connect a computer to the RS-232 port to record several minutes (or hours) of the long string of data. The long string of data (C poll) contains data that can be used by OSi to diagnose your problem.

TX Unit Troubleshooting

Problem Indication	Recommended Action	Realign optics per User's Guide if denoted with *
Red LED off	Using voltmeter, verify AC voltage applied on TB1 of Transmitter PCB per Figure 17.	
	Verify F1 fuse on Transmitter PCB	
	Replace Transmitter PCB	*
Green LED off	Replace Transmitter PCB	*
	Replace TX Optical Assembly	*
Low A/B voltages at RX Head	Realign TX Optical Assembly using alignment knobs as shown in Figure 20.	
	Clean TX and RX windows per procedure below	*
No A/B voltages at RX Head	Verify TX red LED is illuminated by looking for reflection of beam on inside of TX window	
	Replace TX Optical Assembly	*

RX Unit Troubleshooting

Problem Indication	Recommended Action	Realign optics per User's Guide if denoted with *
Red LED off	Verify AC power applied to Control Box by viewing correct digital display operation	
	Using voltmeter, verify +/- 5 VDC voltages on terminal board J2 per Figure 13	
	Replace Receiver PCB	*
Green LED off	Realign TX Optical Assembly using alignment knobs	
	Clean TX and RX windows per procedure below	*
	Troubleshoot TX Head	*
Low A/B voltages at RX Head	Realign TX Optical Assembly using alignment knobs	
	Clean TX and RX windows per procedure below	*

Control Box Troubleshooting

Problem Indication	Recommended Action
Digital display not illuminated with expected format	Using voltmeter, verify AC voltage applied on Surge Suppressor Module per Figure 18.
	Verify 5 LEDs are illuminated on DSP PCB per Figure 21
	If LEDs not illuminated, replace Control Box Power Supply
	If LEDs are illuminated, replace Control Module (Digital Display/ Keypad Assembly)
RS-232 not communicating	Verify digital display is updating with corrected data
	Verify correct TX/RX wiring
	Replace Interface PCB
	Replace Control Module (Digital Display/ Keypad Assembly)
Velocity data near zero with A/B between 1 and 8 volts and correlation (R) >30	Verify that orientation arrows on RX Optical Assembly are pointing in direction of known flow.
	Replace DSP PCB
Auto Calibration reports incorrect results	Replace DSP PCB
4-20 ma not operating	Check red fault LED on 4-20 ma Interface Board in Control Box. If LED is on, the 4-20 loop is either open or the loop resistance is too high.
Reported velocity not in agreement with standards	Enter correction factor using OFS Set-Up procedure

Window Cleaning Procedure

To clean the TX & RX Windows, perform the following steps:

- Disconnect AC power at the TX Head and Control Box
- Loosen the 4 TX/RX Head mounting flange bolts shown in Figure 11
- Carefully remove the TX/RX Head
- Use commonly available glass cleaner or alcohol to flood the glass windows
- Use a soft cloth to wipe away any dirt accumulation
- Spray a thin film of Rain-X on the glass and let it dry
- Reinstall the TX/RX Heads as shown in Figure 11
- Reconnect AC power
- Perform optical alignment.

Recommended Spare Parts

For OFS installations where multiple units are installed or where it is "process critical", OSI recommends users purchase an entire unit as a spare, to allow absolute minimal downtime. For installations where a short down-time is acceptable, we have put together a list of recommended spares, shown below along with the complete table of available spares. The recommended spares list is ordered based on an industry-wide average of needed replacement modules over the past few years. So in typical order of usefulness for typical repair needs, they are:

1. **Quartz Glass Window Kit with Heater, p/n 1910-115 --** These are the only element that comes in contact with flue gas.
2. **Transmitter (TX) Driver PCB, p/n 1910-113 --** Includes power supply and LED driving circuit.
3. **Receiver (RX) Amplifier PCB, p/n 1910-213** – Includes dual channel preamp and demodulation circuits
4. **AC Surge Suppressor, p/n MZ-0383-00** – Protects unit from heavy power line surges (lightning, etc).
5. **4-20 ma / RS-232 Interface PCB, p/n 1910-324 --** All outside wires (control and power) pass through this board, with individual surge protection on all lines.

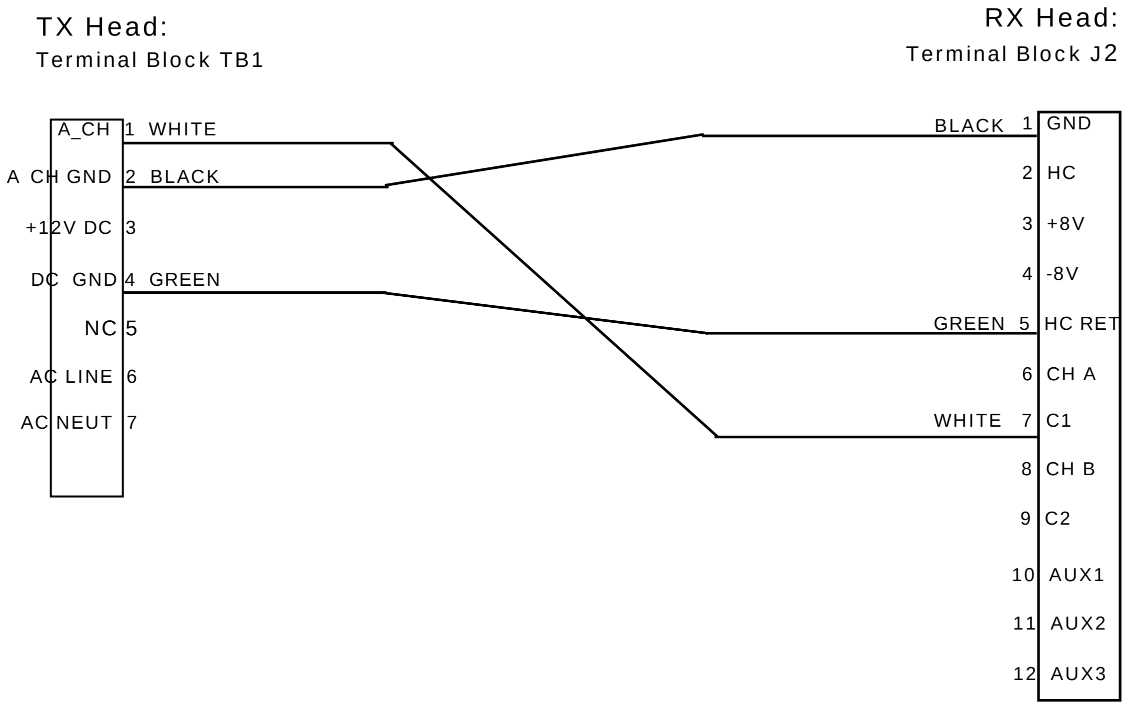
Available Spare Parts for OFS 2000F

Unit	Sub Assembly	P/N
TX Head Unit	Complete TX Head Assembly	1910-100
	TX LED Module	1910-110
	TX Adjuster Mount (incl. LED module)	1910-111
	TX Driver PCB	1910-113
RX Head Unit	Complete RX Head Assembly	1910-200
	RX Lens Assembly	1910-209
	RX Preamp Optics Assy. (incl. Lens Assy.)	1910-211
	Receiver Amplifier PCB	1910-213
TX/RX Head	TX/RX Extender Flange Mount	1910-116
	Quartz Glass Window Kit with Heater	1910-115
	4 inch Kevlar Flange Gasket (min. order 2)	FS-1456-00
Control Box	Complete Rack Mount Control Unit Assembly	1910-500
	Complete NEMA4 Control Unit Assembly	1910-301
	Control Module (Keypad/Display)	1910-309
	Control PCB	1910-311
	4 Button Keypad	MK-1290-00
	VFD Display	ML-1291-00
	DSP PCB	1910-312
	Interface PCB	1910-313
	AC Power Supply	MP-1010-00
	AC Surge Suppressor	MZ-0383-00
	4-20 ma and RS-232 Interface PCB	1910-324

Appendix A: Model 2000W - Automatic Transmitter Power Feedback Control

In some applications with high opacity occasionally, the transmitter requires high power to penetrate the stack smoke to have enough power at receiver for flow measurements. When the high opacity event is gone, the transmitter power needs to turn down to avoid saturating the receiver. This requires an automatic power control circuit at the transmitter that utilizes the received carrier power C1 of Channel A as the feedback control.

Compare to standard Model 2000 unit, Model 2000W unit contains an additional 6-wire cable (OSI Part # ZC-0934-00, Manufacturer Part # Beldon 9536) between transmitter and receiver heads. The terminal block in the transmitter head also changes from three (3) positions to eight (8) positions. Figure A-1 shows the wiring connection between the transmitter head and receiver head. For the AC power connection to the transmitter head at TB1 Positions 6, 7 and 8, follow the procedure in Section "AC Power Connections" in Page 22. As an alternative option, the user can supply a +12V DC power to Transmitter Head by hooking up a +12VDC source at pins 3 and 4.



OFS 2000W WIRING DIAGRAM
TX Head Unit to RX Head Unit for
automatic power feedback control

Appendix B: OFS Installation Procedure Summary*

B-1 PRE-INSTALLATION:

The following conditions have to be met before engineer can proceed with the installation. Check each box below to indicate completion:

1. Four inch ANSI pipe flange is mounted/fabricated at Transmitter side ------------------------------☐
2. Four inch ANSI pipe flange is mounted/fabricated at Receiver side----------------------------------☐
3. Power source (120-240 Volt 50/60 Hz) is available at Transmitter side -----------------------------☐
4. Power source (120-240 Volt 50/60 Hz) is available at Control Box side ----------------------------☐
5. If purchased from OSI, the interconnect cable (P/N 1910-217) should be routed from the Receiver Unit (P/N 1910-200) to the Control Box (P/N 1910-300 for NEMA4, 1910-500 for Rack Mount). Or if the user uses its own cable, a 10 conductor shielded cable should be routed between the Receiver Unit and the Control Box. ---☐
6. If the user is interfacing the OFS to a DAS, a data cable is routed from OSI's Control Box to the user's DAS. ---☐
7. It is vital that the stack is up and running during installation day. Thus, OSI's engineer can check the performance of the OFS with a load. ---☐

B-2 INSTALLATION

1. **The TX and RX Units should be installed in an area of average flow of the stack or duct.** Customer supplied flanges must be installed such that the OFS TX and RX Units mount opposite each other and perpendicular to the movement of the flow.

   For angled installation, a correction factor Cos( ) needed to be divided to the flow rate, i.e.,

   True Flow Rate = Measured Flow Rate / Cos (**2**)

   where **2** is the angle between the optical path and the transverse plan perpendicular to the flow, i.e., **2** = 0^o (Cos **2** =1) for optical path perpendicular to the flow direction (standard installation),. **2**= 45^o (Cos **2** = 0.707) for optical path slant at 45^o.angle relative to the flow direction

2. The TX and RX Units have a 4-inch pipe flange (9-inch diameter) that mounts to an identical flange supplied by the user. **A 9-inch diameter Kevlar flange gasket supplied with the OFS must be installed between the two flanges.** The units must be installed with the door hinge on the left - this orients the internal optical assemblies mounting correctly**.**

3. Air infiltration through improperly sealed flanges or from double walled stacks with dead space between the inner and outer walls may cause incorrect velocity readings. Insure that
   - **a. the mounting flange is well sealed to the stack wall,**
   - **b. the OFS flange is well sealed to the stack flange with the supplied gasket,**
   - **c. any dead space between double walled stacks is penetrated with pipe.**

B-3 TX/RX Heads Alignment

1. **Attach the OFS TX Units first** to the user-supplied flanges, extender, and stack flanges at the 12-clock position so that **the housing door hinge is vertical** before tightening the four bolts. Note that the flange extenders each have two 1/8" NPT purge holes and are supplied with barbed nipples sized for ¼" ID hose. The flanges must be oriented so that a line drawn between the two purge holes is **perpendicular (NOT PARALLEL)** to the direction of the flow. **The purge holes should be left open to provide passive air purge for negative pressure stacks / ducts.**

2. Adjust the beam intensity to the highest level. **Then check the beam position at the receiver side before the RX Unit being mounted**. The beam position could be checked with direct sighting into the TX beam or using a piece of paper as the target. Adjust the TX position knobs when needed. **The beam should be center at the receiving flange.**

3. Mount the RX Unit to the user-supplied flanges, extender, and stack flanges at the 12-clock position so that **the housing door hinge is vertical** before tightening the four bolts. Note that the flange extenders each have two 1/8" NPT purge holes and are supplied with barbed nipples sized for ¼" ID hose. The flanges must be oriented so that a line drawn between the two purge holes is **perpendicular (NOT PARALLEL)** to the direction of the flow. **The purge holes should be left open to provide passive air purge for negative pressure stacks / ducts.**

4. If the stack/duct pressure is positive or the media being measured is **excessively dirty**, it may be necessary to apply a small amount of **compressed instrument-grade, dry and clean air through the NPT fittings on both TX and RX purge holes**. The exact amount of air needed is site dependent, usually enough to prevent dirt/dust/dew contaminating the flow measurements. It is recommended that a regulator be installed near the OFS heads to control the airflow. **If media pressure is too high, it may be necessary to use a sight glass to seal the test port and isolate the sensor from the media.**

5. Rotate the receiver round board inside the RX head until the **arrow on the board parallel and pointed to the direction of flow.**

6. Make sure there is no obstruction in the optical beam. Check the A & B values. Adjust the TX power switch until **both A & B values are between 2 and 7 volts** (between 1 and 8 volts are acceptable but **not higher than 8 volts**).

7. Adjust the TX position knobs slightly to maximize both A & B values. If the **A & B values are off by more than 30% of each other**, further adjust the TX position knobs slightly to make the two numbers closer but does not require identical A & B numbers.

8. Repeat Steps 6 & 7 as necessary. **But do not adjust the TX position knobs too much to prevent the beam center moved away from the receivers.** It should be noted that it is more important to **keep the beam centered at the receivers than to achieve equal A & B values or maximize A & B values.**

9. **Anytime with an interruption of the optics, recycle the power or restart the OFS**.

B-4 OFS SYSTEM SET-UP

1. Set the flow rate unit to the unit preferred by the customer.

2. Set the time-constant to the **longest time-constant allowed**. Factory default is 1-minute.

3. Set the current loop limit to the **lowest range just above the highest flow rate**.

4. Perform manual calibration. Make sure **the system passes the calibration test**.

5. Leave OFS running for at least 15 minutes when the flow is passing through the optical beam. Check the **Correlation value**, if it is **steady and higher than 100**, the system should perform OK.

6. If the correlation is lower than 100 or jumping up and down, further diagnostic may be needed. **The first thing to do is to recycle the power of the OFS.**

7. If the problem persists, slightly adjust the optical beam position to see is there any improvements. **But do not adjust the TX position knobs too much to prevent the beam center moved away from the receivers.**

8. If the problem persists, **slightly rotate the receiver round board inside the RX head clockwise or counterclockwise to see is there any improvements**. **If the correlation improves, leave the round board at that position. But do not rotate the round board more than +/- 45^o off the direction of flow.** Otherwise, rotate the receiver round board back to the position for arrow on the board parallel and pointed to the direction of flow.

9. If the problem persists, and **vibration can be felt by putting hand on top of the TX or RX**, **a thicker Kevlar flange gasket may be installed between the two flanges to further damp the vibration**. Otherwise, structure modification may be needed

10. If the OFS correlation is satisfactory, observe the flow rate. For a steady flow, OFS readings should also be steady. Record the flow rate measured by OFS. Compare OFS readings to the customer's references or experience. If there is a difference, set the correction factor such that the **OFS readings agreed with the references**.

11. **Anytime with an interruption of the system, recycle the power or restart the OFS**

*Note: This procedure summary is for general practice. Special mounting requirements such as sight glass, spray ring, and gate valve are not included.