Model IR400

Infrared Point Detector for Hydrocarbon Gas Applications

Instruction Manual **05-11**

Part No. **MANIR400-EU**
Revision **D/05-11**

General Monitors
Model IR400

E C Declaration of Conformity in accordance with EC & ATEX Directives

We at General Monitors Ireland Ltd., Ballybrit Business Park, Galway, Republic of Ireland, hereby declare that the equipment described below, both in its basic design and construction, and in the version or versions marketed by us, conforms to the relevant safety and health related requirements of the appropriate EC Directives, only as follows:

a) Conforms to the protection requirements of EMC Council Directive 89/336/EEC
Report Number C70111K3 (Dated2/07) by Compatible Electronics, 19131 EI Toro Road, Lake, Forest CA 92676.

Relevant Standard:
EN 55011
EN 50270

b) Sira Certification Service, notified body number 0518 in accordance with Article 9 of Directive 94/9/EC of 23 March 1994, certifies that this equipment has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment intended for use in potentially explosive atmospheres given in Annex II to the Directive. Certificate No. SIRA 07ATEX1253.

Relevant Standards:

EN60079-0:2006	EN61779-1:2000
EN60079-1:2007	EN61779-4:2000

This declaration shall cease to be valid if modifications are made to the equipment without our approval.

PRODUCT: IR400 Point IR Combustible Gas Detection

It is ensured through internal measures and our ISO9001: 2000 certifications that series production units conform at all times to the requirements of these current EC Directives and relevant standards.

Note: The Following Information applies to ATEX.

This equipment has been assured for use as a safety related device under the terms of Directive 94/9/EC EHSR 1.5
General Monitors Ireland Ltd. in order to comply with ATEX, will provide this Instruction Manual in a European Language required to operate the product upon request. Should this be necessary, General Monitors Ireland Ltd. should be notified of this request to allow adequate time to process the request.

ATEX Certificate Markings.

II 2 G D **SIRA 07ATEX1253**

CE 0518 **Exd IIB+H_2 T5 (Ta -40° C to +75°C)**
Ex A21 D T100°C

Responsible Person: Date: 07-12-09

Cecil Lenihan
General Manager European Operations

The signatory acts on behalf of company management, and with full power of attorney

Table of Contents

TABLE OF FIGURES ..... **V**

TABLE OF TABLES ..... **V**

QUICK-START GUIDE **2**

1.0 INTRODUCTION **5**

1.1 Protection for Life 5
1.2 Special Cautions and Warnings 5
1.3 Installation, Operation, and Maintenance 5

2.0 PRODUCT DESCRIPTION **6**

3.0 INSTALLATION **8**

3.1 Attaching the IR400 to a Junction Box, IR4000S, or IR4000M 9
3.2 Mounting Instructions 10
3.3 Wiring Connections 13
3.4 Applying Power 15

4.0 OPERATION AND CONFIGURATION **17**

4.1 Zeroing, Gas Check Tests, and Calibration 17
4.2 IR400 Stand-alone Operation and Configuration 20
4.3 HazardWatch Mode 23
4.4 Gas Check Mode 23
4.5 Detector Response Time 23

5.0 MAINTENANCE **25**

5.1 Developing a Maintenance Schedule 25
5.2 Gas Checks, Zeroing and Recalibration 25
5.3 Cleaning and Lubricating the IR400 and IR4000 Units 26
5.4 Storage 26

6.0 TROUBLESHOOTING **27**

7.0 MODBUS INTERFACE **29**

8.0 CUSTOMER SUPPORT **30**

9.0 APPENDIX 31

9.1 Warranty 31
9.2 Principle of Operation 32
9.3 Specifications 33
9.4 Environmental Specifications 36
9.5 Communications 36
9.6 Engineering Documentation 37
9.7 Ordering Information 38

IR400 HART COMMUNICATION

IR400 MODBUS PROGRAMMING

Table of Figures

Figure 1a: IR400 with Junction Box 2
Figure 1b: IR400 with European Junction Box 2
Figure 2: Wiring Diagram from IR400 to Control Equipment 4
Figure 3: Model IR400 6
Figure 4a: Model IR400 with a junction box 9
Figure 4b: Model IR400 with a European junction box 9
Figure 5a. IR400 Mounting Dimensions 10
Figure 5b IR400 Mounting Dimensions with a European Box 11
Figure 6a: IR400 with Junction Box 15
Figure 6b: IR400 with European Junction Box 15
Figure 7: Wiring Diagram from IR400 to Control Equipment 16
Figure 8. IR400 Zero Switch / LED During Zeroing and Calibration 21
Figure 9 IR400 Optical Window Locations 26

Table of Tables

Table 1: Wiring Chart 3
Table 2: Wiring Chart 13
Table 3: IR400 without HART Option 19
Table 4: IR400 with HART Option 19
Table 5: GM Locations 30
Table 6: Analog Current Output 35
Table 7: Maximum Distance between IR400 and Power Source 35
Table 8: Maximum Distance between IR400 and 500-Ohm Input Impedance 35

Quick-Start Guide

Mounting and Orientation

The Model IR400 should be mounted horizontally (Figure 1a/Figure 1b) to reduce the likelihood of dirt and dust build-up on the windows. For optimum performance, the splashguards should be located on the top and bottom as shown in Figure 1a/Figure 1b. Apply the supplied thread lubricant/sealant to all conduit entries before use to prevent binding.

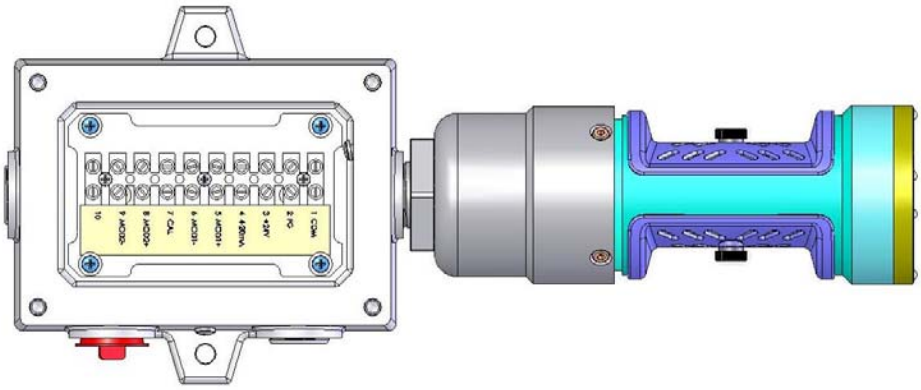


Figure 1a: IR400 with Junction Box

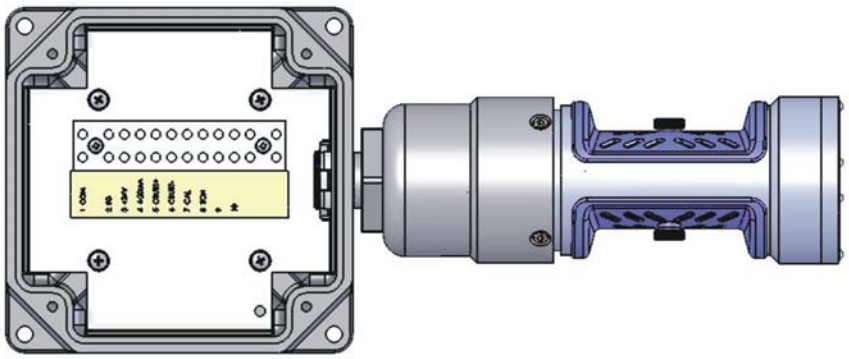


Figure 1b: IR400 with European Junction Box

Wiring Connections

TERMINAL	WIRE COLOR	SIGNAL
1	BLACK	COM
2	GREEN	FIELD GROUND (FG)
3	RED	+24 V
4	WHITE	4-20 mA
5	BLUE	MOD1+
6	WHT/BLU	MOD1 -
7	BROWN	CAL
8	-	MOD2+ (no connection for IR400)
9	-	MOD2 - (no connection for IR400)
10	-	No Connection

Table 1: Wiring Chart

- **NOTE:** Power should remain disconnected until all other wiring connections are made.

Power Connections

To supply power to the IR400, connect the red lead from the IR400 to the +24 VDC terminal on the power supply. Connect the black lead from the IR400 to the power supply Common. Refer to the manual of the power source being used, for more detailed instructions.

- **NOTE:** If the Model IR400 is being used with a +24 VDC power supply and an industrial analog to digital (A/D) converter, then the negative supply (Common) of all three must be connected.

Applying Power

Before applying power to the system for the first time, all wiring connections should be checked for correctness. Upon initial power-up or after a fault condition has been corrected, the unit will enter a start-up mode for 2 minutes before normal operation. IR400 Ethylene start-up can take up to 10 minutes. As a unit warms up, output may briefly be negative.

After power is applied, the IR400 should be allowed to stabilize for approximately 60 minutes while the unit attains the proper operating temperature. After stabilization, it is recommended that the IR400 be zeroed, per the procedure in section 4.1 (step 1 only). A gas check should then be performed to ensure that the unit is operating properly. Use the General Monitors Gas Check Kit (P/N 32548) to perform this check.

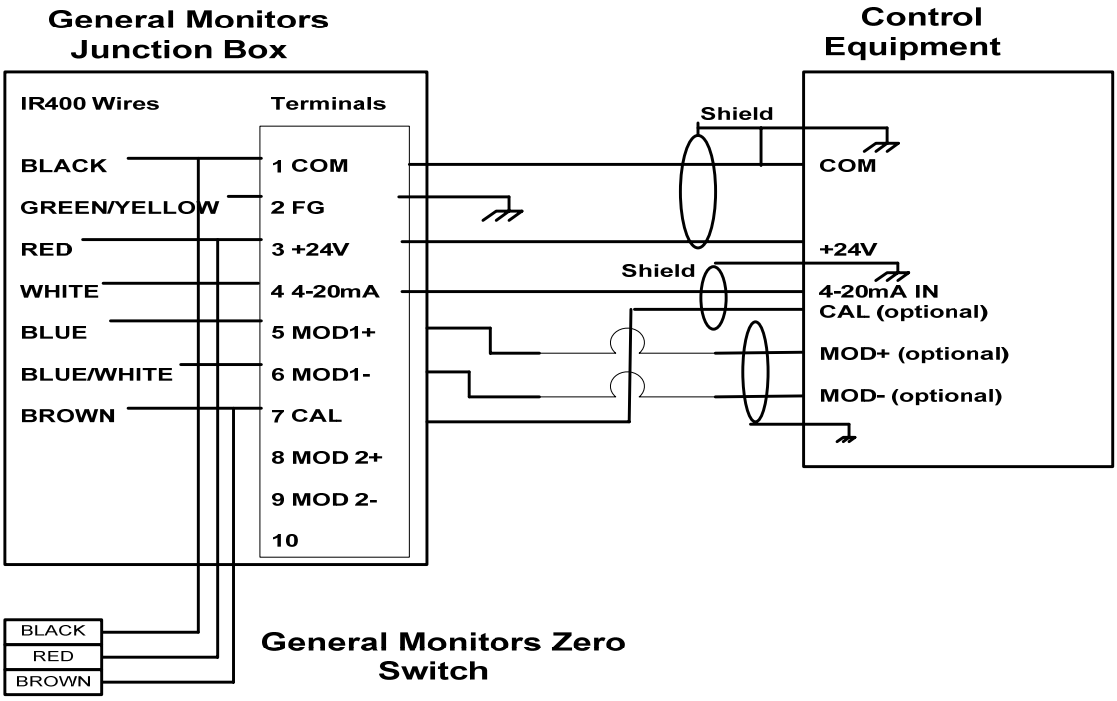


Figure 2: Wiring Diagram from IR400 to Control Equipment

The instrument is now ready to operate. Please further consult this manual for more information on the instrument's many features.

1.0 Introduction

1.1 Protection for Life

General Monitors' mission is to benefit society by providing solutions through industry-leading safety products, services and systems that save lives and protect capital resources from the dangers of hazardous flames, gases and vapors.

The safety products you have purchased should be handled carefully and installed, calibrated and maintained in accordance with this instruction manual. Remember, these products are for your safety.

1.2 Special Cautions and Warnings

This instruction manual includes numerous cautions and warnings that are included to prevent injury to personnel and prevent damage to equipment.

WARNING: TOXIC, COMBUSTIBLE, AND FLAMMABLE GASES AND VAPORS ARE VERY DANGEROUS. USE EXTREME CAUTION WHEN THESE HAZARDS ARE PRESENT.

1.3 Installation, Operation, and Maintenance

Before power up, verify wiring, terminal connections and stability of mounting for all integral safety equipment.

Proper system operation should be verified by performing a full, functional test of all component devices of the safety system, ensuring that the proper levels of alarming occur. Fault/malfunction circuit operation should be verified.

Periodic testing/calibrating should be performed per the manufacturer's recommendations and instructions.

When testing produces results outside of the manufacturer's specifications, re-calibration or repair/replacement of the suspect device(s) should be performed as necessary. Calibration intervals should be independently established through a documented procedure, including a calibration log maintained by plant personnel, or third party testing services.

2.0 Product Description

General Description

The Model IR400 infrared (IR) point detector is a microprocessor-based combustible gas detector, is calibrated at the factory and needs no routine field calibration. Applying a test gas to the unit can check the sensitivity of the IR400. It is also relatively maintenance free, requiring only a periodic cleaning of the windows and re-zeroing to ensure dependable performance.

The IR400 continuously monitors combustible gases in the lower explosive limit (LEL) range and provides a 4 to 20 mA analog signal proportional to the 0 to 100% LEL concentration. Gas calibration is available to LEL values defined by ISO 10156/NFPA 325 and IEC 61779-1. A Modbus communications interface is also provided for informational / programming purposes. Sensor data and status information from the IR400 can be transmitted to a variety of General Monitors' readout units.

The IR400 operates from an unregulated +24 volt DC supply, which can be supplied by the customer, or is supplied by General Monitors' Model DC130 readout units.

Figure 3: Model IR400

Features and Benefits

This is a partial list of features and benefits for the Model IR400 infrared point detector:

- No routine calibration required
- Fail-to-safe operation
- 4-20 mA output
- Modbus communications link
- Optional HART interface
- Heated optics eliminate condensation
- Dirty optics indication
- Reading not affected by air velocity
- Immune to typical poisons (e.g. silicones, halides, lead, sulfur)
- Works in oxygen deficient environments
- Able to operate in constant hydrocarbon environment without adverse effects
- IP66 & Type 4X
- Interfaces directly with existing DC110, DC130 controllers & TA102A trip amplifiers
- Expanded capabilities when used with IR4000S Single and IR4000M Multi-Point monitors

3.0 Installation

Receipt of Equipment

All equipment shipped by General Monitors is packaged in shock absorbing containers, which provide considerable protection against physical damage. The contents should be carefully removed and checked against the packing list. If any damage has occurred or there is any discrepancy in the order, please notify General Monitors as soon as possible. All subsequent correspondence with General Monitors must specify the equipment part number and the serial number.

Detector Location Considerations

There are no standard rules for detector placement, since the optimum detector location varies with the application. The customer must evaluate conditions at the facility to make this determination. If practical, the Model IR400 infrared point detector should be easily accessible for occasional integrity checks. The unit should be mounted horizontally so that dirt and dust do not build-up on the windows. Although the IR400 is EMI/RFI resistant, it should not be mounted close to radio transmitters, high magnetic or electrical fields or similar equipment. Proper wiring and grounding is essential for optimum performance. Snap-on ferrite filters can provide additional resistance to electromagnetic and radio frequency interference.

- **NOTE:** The Model IR400 cannot detect hydrogen (H_2) gas.

Some other factors to consider when selecting a detector location:

- Emission temperature and vapor density of the gas. The IR400 should be located near the floor for gas vapors that are heavier than air.
- Do not locate the IR400 in areas that exceed the maximum operating temperature of the unit, such as gas turbine exhaust.
- Locate the IR400 where prevailing air currents contain the maximum concentration of gas.
- Locate the IR400 as near as possible to the likely source of a gas leak.
- Observe the temperature range of the IR400 and locate the unit away from concentrated sources of heat or light.
- Mount the IR400 away from sources of excessive vibration.

WARNING: Each IR400 is completely tested at the factory. However, a complete system checkout is required upon initial installation and start-up to ensure system integrity.

- **NOTE:** The Model IR400 is factory calibrated and needs no routine calibration. However, if the IR400 is to be installed at altitudes greater than 1000 ft (300m), it must be re-calibrated on-site (Section 4.1).

3.1 Attaching the IR400 to a Junction Box, IR4000S, or IR4000M

Before you can mount an IR400 device, you must first attach it to an IR400 junction box, IR4000S single point monitor, or an IR4000M multi-point monitor.

CAUTION: To prevent damage by static electricity, avoid contact with PCB components. All wire connections should be made to the terminal blocks.

To Attach an IR400 to a Junction Box, IR4000M, or IR4000S

1. Apply the supplied thread lubricant/sealant to all conduit entries of the IR400, junction box, IR4000M, or IR4000S, as needed to prevent binding.

   Remove the cover from the junction box, IR4000M, or IR4000S by loosening the four captive screws with a 5 mm Allen wrench, and lifting the cover straight up.

   Strip and trim the wires from the IR400 as needed and thread them into either the right or left wiring conduit of the junction box, IR4000M, or IR4000S.

   Once the wires are threaded into the enclosure, screw the IR400 securely into the junction box, IR4000M, or IR4000S. An example is shown below.

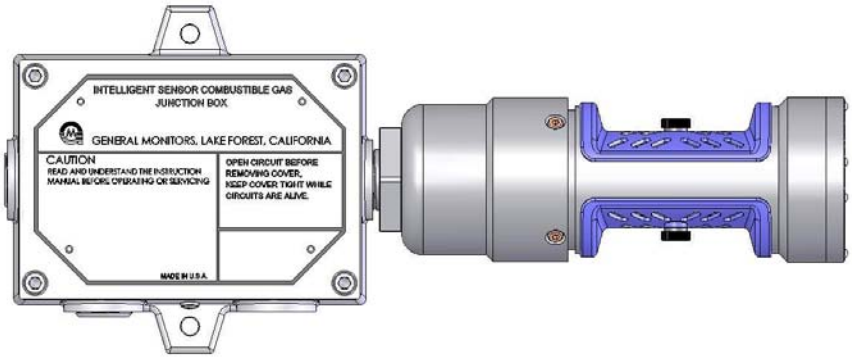


Figure 4a: Model IR400 with a junction box

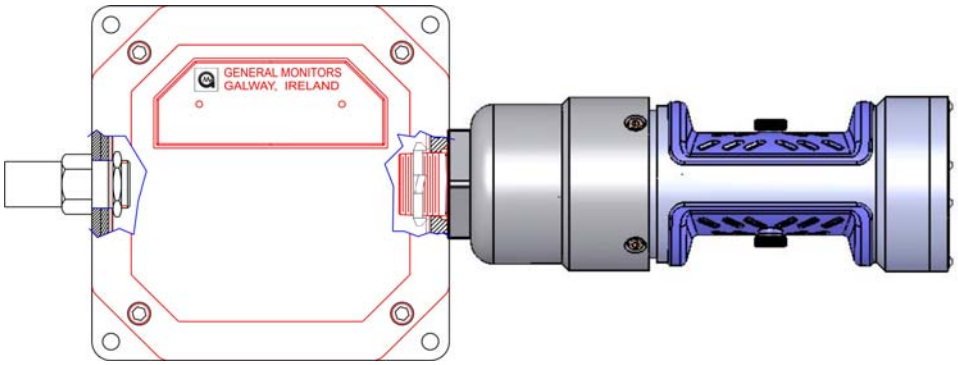


Figure 4b: Model IR400 with a European junction box

Fasten the IR400 wires to a wiring connector inside the junction box, IR4000M or IR4000S enclosure. Once the two units are attached, you may replace the cover on the enclosure attached to the IR400 using the four captive screws, or leave it off until additional cabling from the enclosure is completed.

3.2 Mounting Instructions

The IR400 is mounted using the bolt holes on an attached junction box, IR4000M or IR4000S enclosure. The IR4000M(S) is often mounted remote from the IR400 units, in order to locate it within easy reach and at eye level.

3.2.1 Mounting an IR400 with an Attached Enclosure

The following figure shows the overall and mounting dimensions for the Model IR400 with an attached junction box / IR4000M(S) enclosure.

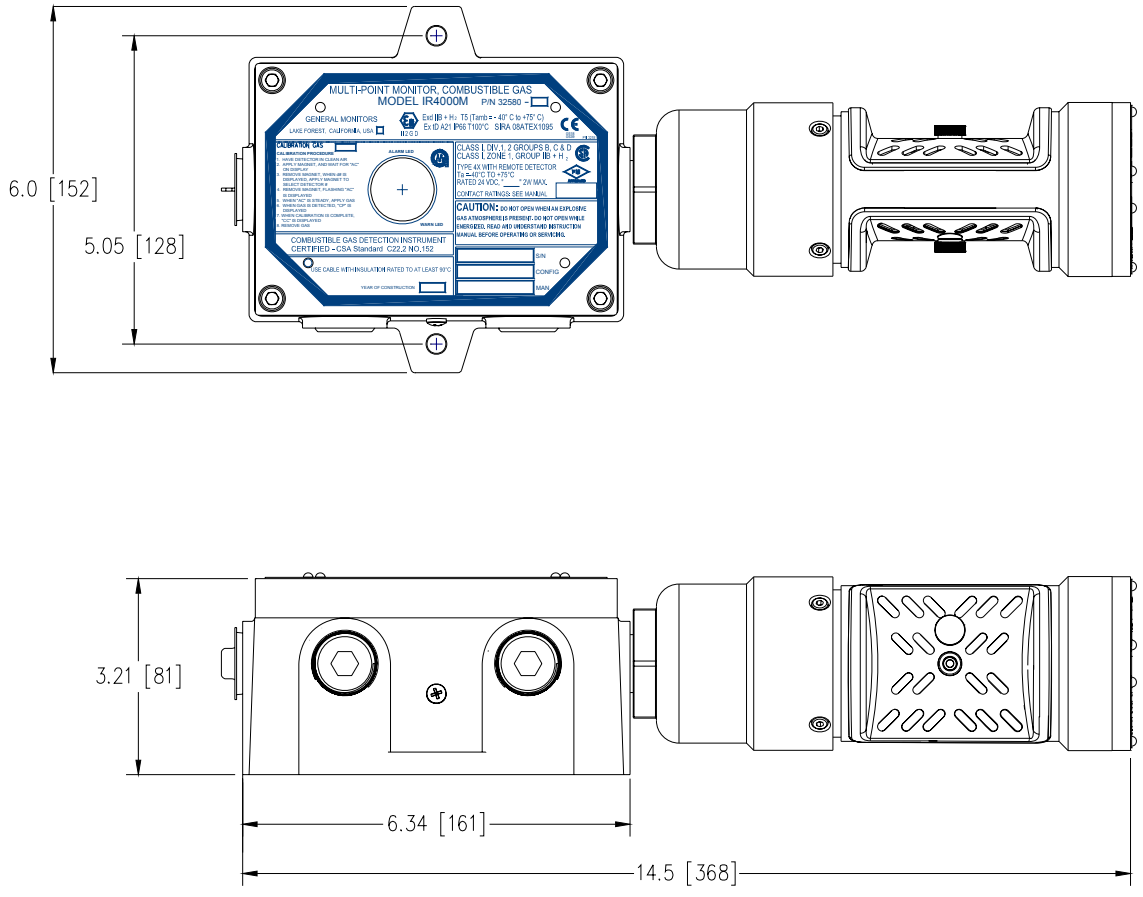


Figure 5a. IR400 Mounting Dimensions

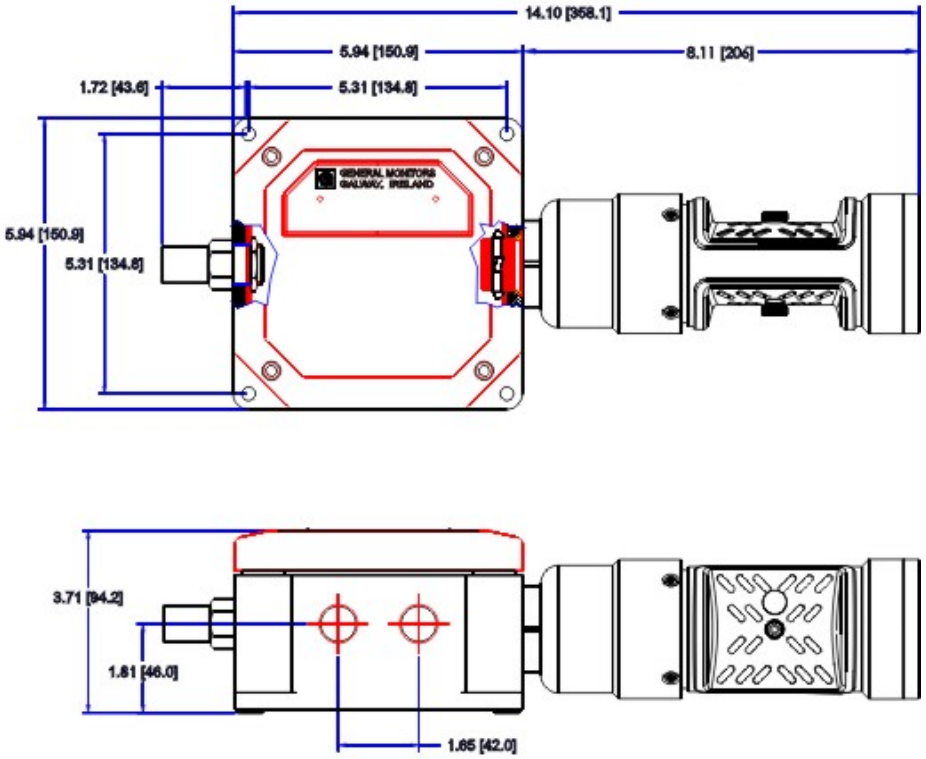


Figure 5b IR400 Mounting Dimensions with a European Box

To Mount the IR400

The IR400 must rest horizontally to reduce the possibility of dirt and dust building up on the lens.

- The open slots of the gas passage must be straight up and down for the gas to rise up and through the unit.
- If the detector is installed with the metal section blocking the gas flow, it will slow down the detector's response.

Mount the attached junction box or IR4000M(S) enclosure using the two bolt holes.

- **NOTE:** There is also a duct mounting kit available from General Monitors with separate instructions.

3.2.2 Cabling Safety Notices

CAUTION: The Model IR400 detector and Model IR4000M(S) monitor system contain components that can be damaged by static electricity. Special care must be taken when wiring the system to ensure that only the connection points are touched.

WARNING: Under **NO** circumstances should equipment be connected or disconnected when under power. This is contrary to hazardous area regulations and may also lead to serious damage to the equipment. Equipment damaged in this manner is not covered under warranty.

3.2.2.1 European Union (EU) Approved Cable Armor and Screens

Interconnecting cables must have an overall screen or screen and armor. Cable BS5308 Part 2, Type 2, or equivalent is suitable. Note that the terms 'screen' and 'shield' are equivalent for the purpose of this manual. The cable armor must be terminated in a suitable cable gland at the detector to ensure a positive electrical connection.

3.2.2.2 Cable Termination in Non-Hazardous Areas

- The cable **armor** must be connected to **safety earth** in the safe area.
- The cable screen (drain wire) must be connected to an instrument earth in the safe area.
- The power supply 0V return must be connected to an instrument earth in the safe area.
- The interconnecting cables should be segregated from power and other noisy cables. Avoid proximity to cables associated with radio transmitters, welders, switch mode power supplies, inverters, battery chargers, ignition systems, generators, switch gear, arc lights and other high frequency or high power switching process equipment.
- In general, maintain separation of at least 1 meter between instrument and other cables. Greater separations are required where long parallel cable runs are unavoidable. Avoid running instrument cable trenches close to lightning conductor earthing pits.
- Complete all cable insulation testing before connecting the cable at either end.

3.2.3 Applying Sealants to Conduit Entries

Please keep the following warnings and cautions in mind when you install the IR400 and IR4000 units, to make sure that the equipment maintains the appropriate seals for a Class I hazardous location.

WARNING: Each conduit run from an IR400 junction box or display unit within a hazardous location (and from a hazardous to a non-hazardous location) must be sealed so that gases,

vapors, and/or flames cannot pass beyond the seal. The purpose of seals in a Class I hazardous location is to prevent the passage of gases, vapors, or flames from one electrical installation to another through the conduit system. For information on Class I location seals, see NEC Articles 501-5 and 500-3d.

WARNING: Unused cable entry holes in each IR400 junction box and IR4000M(S) must be sealed with approved explosion-proof stopping plugs. Red caps supplied by General Monitors are for dust protection only, and must not be left on the unit when installed.

CAUTION: Acetic acid will cause damage to metal components, metal hardware, ceramic ICs, etc. If damage results from the use of a sealant that contains acetic acid (RTV silicone), the warranty will be void.

CAUTION: To prevent corrosion due to moisture or condensation, it is recommended that the conduit connected to the display unit housing be sealed or contain a drain loop.

3.3 Wiring Connections

WIRE	WIRE COLOR	SIGNAL
1	BLACK	COM
2	GREEN	FIELD GROUND (FG)
3	RED	+24 V
4	WHITE	4-20 mA
5	BLUE	MOD1+
6	WHT/BLU	MOD1-
7	BROWN	CAL
8	-	MOD2+ (no connection for IR400)
9	-	MOD2 - (no connection for IR400)
10	-	No Connection

Table 2: Wiring Chart

The IR400 operates on nominal power of +24 VDC. The customer must provide primary DC voltage power, unless a General Monitors readout/relay display module with an internal power supply is used. Since the IR400 is designed to continuously monitor for leaks of hydrocarbon gas, a power switch is not included to prevent accidental system shut down.

- **NOTE:** Power should remain disconnected until all other wiring connections are made.

The maximum distance between the IR400 and the power source is specified in Section 9.3.3.

3.3.1 Power Connections

To supply power to the Model IR400 connect the red lead from the IR400 to the +24 VDC terminal on the power supply. Connect the black lead from the IR400 to the power supply Common. Refer to the manual of the power source being used, for more detailed instructions.

- **NOTE:** If the IR400 is being used with a +24 VDC power supply and an industrial analog to digital (A/D) converter, then the negative supply (Common) of all three must be connected.

An internal diode protects the system in the event of inadvertent supply reversal.

3.3.2 4- 20 mA Output

A 4 to 20 mA output signal is provided by the Model IR400 and can be sent to a General Monitors' readout/relay display module or any industrial device that can accept a 4 to 20 mA signal for computer based multi-point monitoring. The Analog Output connection provides a signal for use in displaying current LEL readings, special operation or fault conditions. The maximum distance between the IR400 and the device connected to the Analog Output signal is specified in Section 9.3.5.

To access the 4-20 mA signal, connect the white lead from the IR400 to the signal-in terminal of the input unit. Refer to the manual of the display or other device being used for detailed instructions.

Connect the black lead from the IR400 to the device Common. The Common connection serves both the analog signal and the power connections.

3.3.3 Dual Modbus Interface

To access the Modbus (Modbus-RTU) interface, connect the blue lead from the IR400 to the Modbus (+) terminal and the blue/white lead to the Modbus (-) terminal on the customer's Modbus capable device. For a description of the data available from the IR400 and the programming interface, please refer to the separate IR400 Modbus manual.

3.3.4 HART Interface

A standard HART interface is available which provides a digital data channel at 1200 baud over the 4-20 mA current loop. See the IR400 HART Manual Addendum for additional information.

3.3.5 Magnetic Switch

The IR400 also provides a lead for connecting a +24 VDC powered magnetic switch. The brown lead from the IR400 must be connected to the powered side of the switch so that when the switch is activated, the brown lead is grounded. General Monitors can supply a junction box with an integral magnetic switch to ease the connection of the IR400 in the field (Figure).

3.4 Applying Power

Before applying power to the system for the first time, all wiring connections should be checked for correctness. Upon initial power-up or after a fault condition has been corrected, the unit will enter a start-up mode for 2 minutes before normal operation. IR400 Ethylene start-up can take up to 10 minutes. As a unit warms up, output may briefly be negative.

After power is applied, the IR400 should be allowed to stabilize for approximately 60 minutes while the unit attains the proper operating temperature. After stabilization, it is recommended that the IR400 be zeroed, per the procedure in Section 4.1 (step 1 only). A gas check should then be performed to ensure that the unit is operating properly. Use the General Monitors gas check kit (P/N 32548-x) to perform this check. If the unit does not respond properly, calibrate per the procedure in Section 4.1.4 (steps 1-4).

- When connecting the IR400 to a safety system, the +24 VDC (red) wire should be the last wire connected and first wire disconnected when removing the unit to protect the system from shorting.
- If the analog (4-20 mA) output is not used, then the white signal wire must be connected to ground to prevent a fault condition.

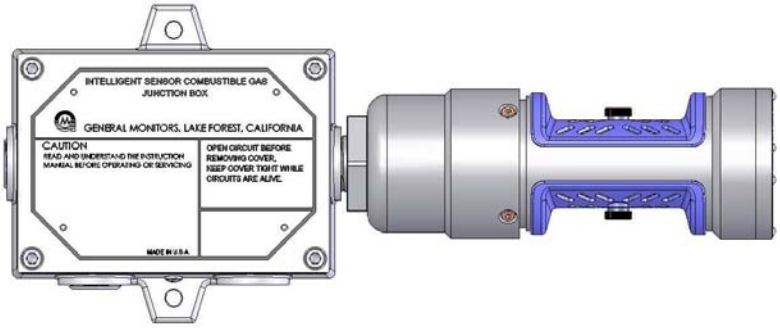


Figure 6a: IR400 with Junction Box

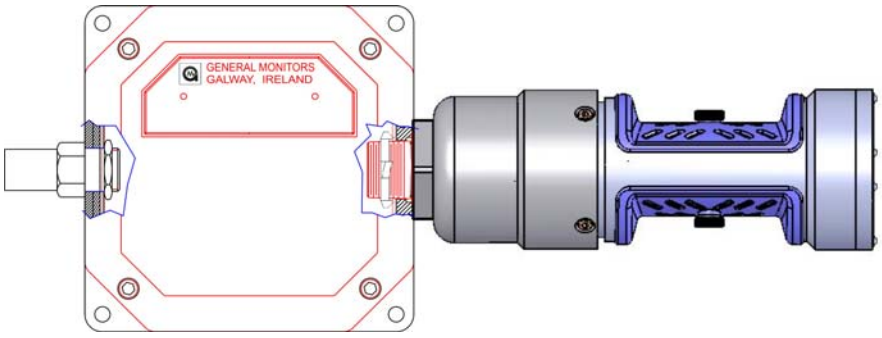


Figure 6b: IR400 with European Junction Box

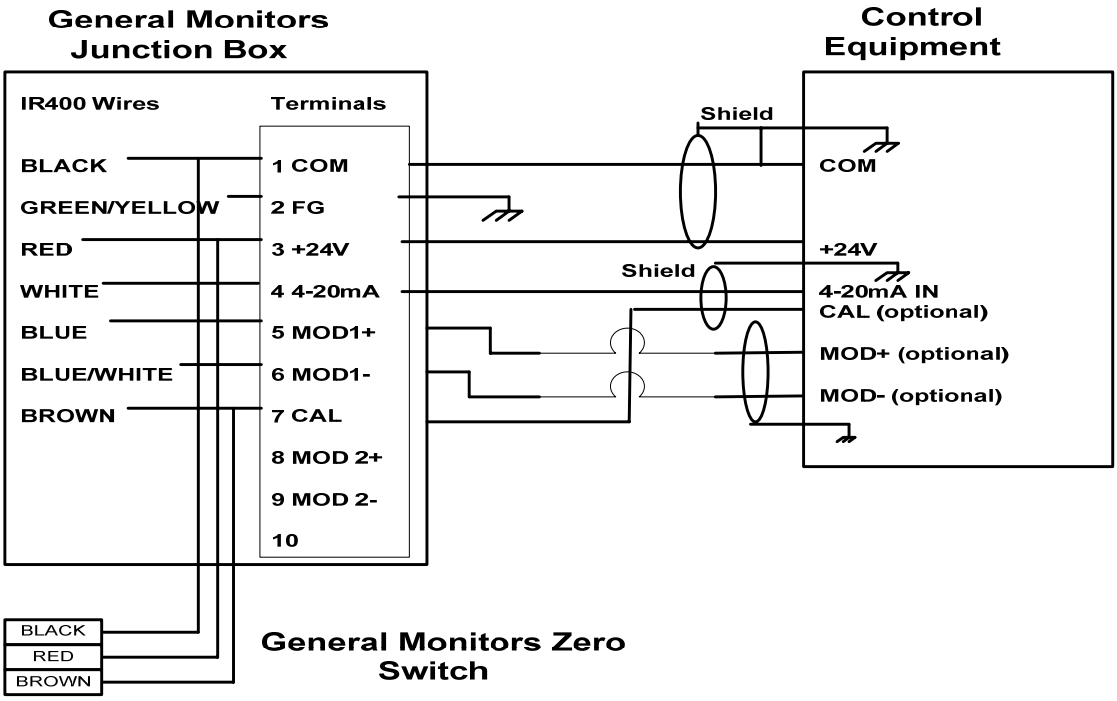


Figure 7: Wiring Diagram from IR400 to Control Equipment

4.0 Operation and Configuration

The methods used to operate and configure the IR400 will vary depending on whether you are using the IR400 as part of an IR4000M monitoring system, or as a stand-alone unit attached to a junction box and control room devices, or to an IR4000S. Separate instructions are provided in this chapter for each situation.

- *If your IR400 is part of an IR4000M system*, you can operate and configure both the IR400 and the IR4000 using the IR4000 menu options and LED display. You can also send Modbus or HART commands to the IR4000 from connected control room devices, to perform all the menu-driven functions, plus additional ones.
- *If your IR400 is a stand-alone unit attached to a junction box*, you can use the magnetic switch attached to the junction box for zeroing and calibration. You can also send Modbus or HART commands to the IR400 from control room devices to perform zero, calibration, gas checks and configuration tasks.
- *If your IR400 is a stand-alone unit attached to an IR4000S display device*, then you can use the IR4000S menus for operation and configuration.

- **NOTE:** This chapter describes how to use the junction box magnetic switch for stand-alone IR400 operation; the IR4000 manual describes how to use the IR4000 menus for IR400 system operation and configuration.

4.1 Zeroing, Gas Check Tests, and Calibration

Each IR400 is calibrated at the factory. However they will need occasional zeroing as well as gas check tests and calibration after initial installation to make sure they are working properly. Before zeroing or calibration, always check that the optics path is clear and the windows are clean. These are the most important operations to ensure that the IR400 is measuring accurately.

Depending on your system configuration, you can use menus, Modbus/HART commands or magnetic switch selection to initiate zeroing, gas checks and calibration, as described later in this chapter. Some general guidelines are provided here that are useful no matter what method is used.

- **NOTE:** The IR400 is factory calibrated and needs no initial calibration. However, if the unit is to be installed at altitudes greater than 1000 ft (308 m), it must be re-calibrated on-site.

- **NOTE:** Entering Gas Check, Zeroing, or Calibration mode sends a 1.5 mA output signal that disables the IR4000M and IR4000S Warning and Alarm relay circuits.

4.1.1 Using Zero Air

If you suspect that combustible gasses are present, it is necessary to purge the sensor environment with zero air before zeroing the unit, starting the gas check, or starting calibration.

4.1.2 Zeroing Guidelines

Zeroing the IR400 detector is necessary periodically in order to eliminate any background gas fluctuations. You may wish to purge the sensor environment with zero air before zeroing the unit.

4.1.3 Gas Check Test Guidelines

Running a gas check test enables you to verify whether the detector is functioning correctly, by applying a known gas concentration and monitoring the % LEL reading while keeping the alarm and warning relays disabled. To apply gas or a gas simulation during the test, you can use the General Monitors gas check kit with portable purge calibrator equipment.

- **NOTE:** You cannot run a gas check test from an FMD or IR4000S attached to an IR400. The FMD and IR4000S have a relay inhibit mode that will turn off the Warn and Alarm relay but the current loop will still transmit the gas concentration level. This could cause alarms on control room equipment.

4.1.3.1 Portable Purge Calibrator Equipment

The portable purge calibrator is a compact, accurate and safe system containing a non-explosive gas concentration. The lecture bottle is filled with a standard 50% LEL mixture of gas/air. Using a known gas/air mixture reduces the likelihood of error in field calibration.

The hose and cup adapter that are included allow for quick calibrations and gas checks. Pre-mixed calibration gases at approximately 50% LEL are available in lecture bottles.

- Butane $_{C4H10}$
- Ethylene $_{C2H4}$
- Methane $_{CH4}$
- Propane $_{C3H8}$
- Ethane $_{C2H6}$
- Hexane $_{C6H14}$
- Pentane $_{C5H12}$

Spare bottles containing these gases may be ordered. Methane lecture bottles may be returned to General Monitors for refilling with the standard 2.5% by volume methane (50% LEL per ISO 10156 and NFPA 325).

4.1.4 Calibration Guidelines

Calibrating the detector corrects any errors that may be affecting the % LEL measurement that is taking place. You should use the General Monitors gas check kit for calibration. Section 4.1.3.1 describes the gas check kit equipment in more detail. You may need to calibrate the IR400 detector under several circumstances.

- If the gas check test indicates that the detector needs adjustment.
- If you are reconfiguring the IR400 to detect a different type of gas.
- If you are moving the detector to a higher altitude location (every 1000 feet difference in altitude requires recalibration).

General Monitors configures the IR400 with three calibration input options: magnetic switch (default), manual solenoid, and automatic remote gas calibration device (ARGC). To use the manual solenoid or ARGC, purchase a factory configured IR400 or change the calibration input via Modbus or HART.

4.1.5 IR400 Analog Output (AO) Interpretation

Current Level (mA)	Meaning
0	Startup mode and critical fault for non HART unit
1.5	Zero, Calibration and Gas Check Mode
2	Non critical fault
4 – 20	0 – 100% LEL or % by Volume
20.1 – 21.7	Over range

Table 3: IR400 without HART Option

Current Level (mA)	Meaning
0	Startup mode and critical fault for non HART unit
1.25	Startup mode and critical fault if current range is low
1.5	Zero, Calibration and Gas Check Mode
2	Non critical fault
3.5	All faults and startup if unit is configured with current range set to “high”
4 – 20	0 – 100% LEL or % by volume
20.1 – 21.7	Over range

Table 4: IR400 with HART Option

4.1.6 IR400 Zero Switch / LED flashing patterns

Flashing Pattern (ms)	Description
1000 on, 1000 off	Zero
950 on, 50 off	Zero complete, calibration pending
100 on, 400 off	Calibration, apply gas
500 on, 1000 off	Gas present, calibration in progress
980 on, 20 off	Calibration complete; remove gas
100 on, 100 off	Fault

- **NOTE:** This table is for Zero Switch / LED calibration input configurations only.

4.2 IR400 Stand-alone Operation and Configuration

The IR400 does not have built-in operation and configuration menus without an IR4000. However, zeroing and calibration can be accomplished using the Zero (magnetic) Switch / LED on the junction box that is directly attached to the IR400. You should 'zero' the Model IR400 detectors occasionally to eliminate any background gas fluctuations. Calibration is necessary if gas check readings show the unit is reading inaccurately.

In addition, many operational functions are available using the Modbus/HART interface from a control room device, as described in separate General Monitors' manuals (available from our website).

4.2.1 To Zero and Calibrate a Stand-alone IR400 Using a Magnetic Switch

This procedure describes how to use the IR400 junction box magnetic switch to zero and calibrate the IR400. Once zeroing or calibration begins, the alarm and warning relays are automatically kept disabled, and the analog signal is held at 1.5 mA. As you follow the procedure steps, refer to the figure shown below for the LED indicator.

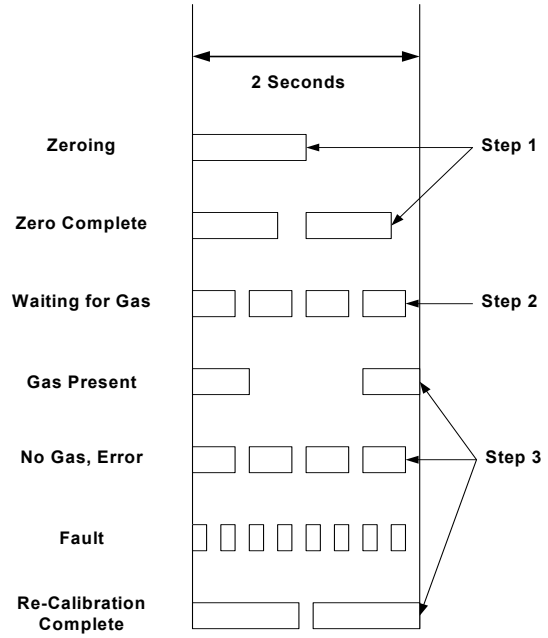


Figure 8. IR400 Zero Switch / LED During Zeroing and Calibration

Review the general guidelines in Section 4.1 on Zeroing, Gas Check Tests, and Calibration. Make sure the windows are clean and there is nothing blocking the optical beam.

4.2.2 Zero Only Calibration

The junction box used with the IR400 is fitted with a zero switch which eliminates any background gas fluctuation.

Zero the Unit. Apply the General Monitors magnet that was included with the unit to the Zero Switch / LED for approximately three seconds. The LED in the switch will light to show proper placement.

- Remove the magnet and the LED will flash on for one second and off for one second to indicate that the unit is attaining a zero value (*Zeroing* in the figure).
- When the unit has finished zeroing, the LED will turn on and flash off quickly once per second for 30 seconds (*Zero Complete* in Figure).

- **NOTE:** If an error occurs during the zeroing/calibration sequence, the LED will flash on and off rapidly (*Fault*).

4.2.3 Full Span Calibration

If a full span calibration is required, a zero calibration must first be performed to eliminate any background gas fluctuation. When the zero calibration is complete, a full span calibration may optionally be performed.

1. **Zero the Unit**. Apply the General Monitors magnet that was included with the unit to the Zero Switch / LED for approximately three seconds. The LED in the switch will light to show proper placement.
   - Remove the magnet and the LED will flash on for one second and off for one second to indicate that the unit is attaining a zero value (*Zeroing* in the figure).
   - When the unit has finished zeroing, the LED will turn on and flash off quickly once per second for 30 seconds (*Zero Complete* in Figure).

   - **NOTE:** If an error occurs during the zeroing/calibration sequence, the LED will flash on and off rapidly (*Fault*).

2. **Return to Normal Operation or Start Calibration.** If the magnet is not applied again, the unit will return to normal operation. To continue on and calibrate, apply the magnet again and the unit will enter the calibration mode.

   The LED will flash off quickly once every half-second while the unit is waiting for gas to be applied (Waiting for Gas).
3. **Apply Gas**. Apply a 50% LEL gas using a Gas Check Kit with portable purge calibrator equipment (or 50% by volume of the gas being detected in nitrogen for units designed for monitoring 0 to 100% by volume).
   - When the unit detects the gas, the LED will flash on for a half second every one and one-half seconds (*Gas Present*).
   - If the unit does not detect the gas, the LED will flash off quickly once every half-second while the unit is still waiting for gas to be applied (*No Gas Error*).
   - Once calibration has been completed, the LED will turn on and flash off once every second (*Calibration Complete*).
4. **Return to Normal Operation**. Remove the gas and the unit will return to normal operation once the gas has fallen below 5% of full scale.

4.3 HazardWatch Mode

The IR400 is compatible with the General Monitors HazardWatch System and can be calibrated via the system interface for HazardWatch. To support calibrations initiated in HazardWatch, the IR400 must be configured in the HazardWatch Mode. This mode prevents aborted calibrations from being recorded as successful calibrations and ensures accurate logging in the HazardWatch System.

To use this feature, purchase a HazardWatch-configured IR400 or change the mode via Modbus. See the Modbus manual available from the General Monitors website for Modbus commands.

4.4 Gas Check Mode

1. Send Modbus or HART gas check command.
2. When the unit enters gas check mode, AO will be kept at 1.5 mA. Apply a 50% LEL gas using a gas check kit with portable purge calibrator equipment.

- **NOTE:** If the manual solenoid calibration input is configured, send the Modbus or HART command to turn on the solenoid.

3. Once the detector is placed in gas check mode and the gas is applied, monitor the % LEL reading for the detector to see if it is functioning properly using the FMD or IR4000S display or Modbus/HART commands. When the reading is stabilized, it should be 50% LEL if the gas from the check kit is applied.
4. Remove the gas.

- **NOTE:** If the manual solenoid calibration input is configured, send the Modbus or HART command to turn off the solenoid.

The unit will return to normal operation when the concentration drops below 5% full-scale. Since the IR400 zeros before calibrating, you must remove the gas completely before going to calibration mode.

4.5 Detector Response Time

A valid response time of a gas detector must take into account a static gas presence as it occurs in the field with a gas leak. Tests performed on site use a flow method to verify detector function only as gas enters the optical path, with its splashguard in place, slowly. With regard to the specified time response stated on page 3 of the manual, this specification is obtained by testing the gas detector, with a splashguard, in accordance with CSA performance requirements. A chamber is filled with a known concentration of gas (static) and the IR400 is then exposed to the gas. This method is defined by the approval agencies and allows us to fill instantaneously the optical path of detector to achieve the stated response times for the IR400. It is not practical to perform this type of test in the field since a potentially explosive gas (100% LEL) is used.

T response times: According to CSA C22.2, T50 equals time to 50% of full-scale meaning 50% LEL and T90 which is 90% of the final reading.

CSA C22.2 Section 6.9 states:

Beginning with the gas sensing element in clean air it shall be suddenly exposed to a prepared mixture of gas in air having a concentration corresponding to 100% of the full scale gas

concentration. From the instant of exposure to this gas mixture the instrument shall respond to provide an indication within the time specified as follows: 50% of full scale gas concentration in 10 sec, and 90% of maximum indicated gas concentration in 30 sec. The products offered by GM are not for the purpose of testing T response time, but as a method to allow a user to check that the unit is responding to gas and that final response is within tolerance.

The products offered by GM are not for the purpose of testing T response time, but as a method to allow a user to check that the unit is responding to gas and/or that final response is within tolerance. If it's required to demonstrate a reading of 50% LEL at site this can be achieved using the calibration cup, however it should be noted that you need to apply the test gas for approximately three minutes to get a reading of 50% LEL. This time is due to the ambient air located in the optical path of the detector having to be replaced progressively by the test gas. This replacement of ambient air is quicker at the beginning but longer for the last percentage because it is linked to the slow replacement of air dilution by the test gas. This test is only to indicate a gas level of 50% LEL within the calibration cup and is not a reflection of the response time of the detector.

5.0 Maintenance

The Model IR400 is calibrated at the factory and is fail-to-safe; once it is correctly installed and calibrated upon start-up, it requires little maintenance other than periodic cleaning, gas checks, zeroing and recalibration to ensure system integrity. Integrity checks can be performed using General Monitors' Gas Check Kit (P/N 32548).

WARNING: Disconnect or inhibit external devices such as Trip Amplifiers, PLC's, or DCS systems before performing any maintenance.

- **NOTE:** If an optical fault still occurs after cleaning and re-zeroing of an IR400 detector is complete, then you must return the unit to the factory for service. The system's full two-year warranty will be voided if customer personnel or third parties damage the system during repair attempts or maintenance activities. Gassing into the screened splashguard will not provide a stable or accurate reading.

5.1 Developing a Maintenance Schedule

Maintenance requirements will vary with each installation; General Monitors recommends that a schedule for periodic maintenance be established and followed, and that a maintenance logbook be kept for each unit in operation.

More frequent cleaning and calibration checks are recommended if the equipment is impacted by unusual environmental conditions such as mud collecting on the sensor head, sensors accidentally being painted over, etc.

General Monitors is not implying that the customer should expect problems with sensor life or stability, but calibration checks ensure the integrity of the life protecting equipment.

5.2 Gas Checks, Zeroing and Recalibration

The Model IR400 is calibrated at the factory and needs only occasional recalibration after initial installation and start-up.

- For detailed instructions on initiating gas checks, zeroing and calibration using the IR4000 menus, see the user manual for the IR4000.
- For instructions on zeroing and recalibrating a stand-alone IR400 using the magnetic switch on an attached junction box, see Section 4.2.1.
- For information on the Modbus IR400 and IR4000 register *Operating Mode* commands for gas checks, zeroing and calibration, refer to the separate Modbus manuals.

5.3 Cleaning and Lubricating the IR400 and IR4000 Units

5.3.1 Cleaning the IR400 and IR4000 Units

The IR400 optical windows can be cleaned by removing the splashguard that covers them, then gently wiping them with a soft, clean cloth or cotton swab that has had a commercial window cleaning solution applied; water or ethanol are examples of suitable solvents. You can remove particulate matter from the IR400, detector accessories, and IR4000 units using an appropriate halogen-free solvent, such as water or ethanol. Accessories should be thoroughly dried with compressed air, if necessary, before refitting them to the detector.

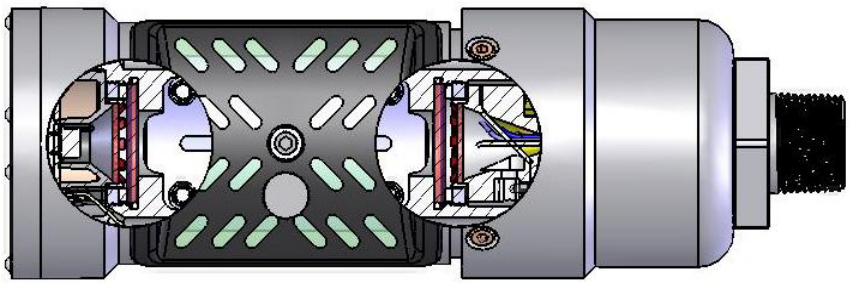


Figure 9 IR400 Optical Window Locations

- **NOTE:** Do not clean the windows while an IR400 unit is zeroing or in recalibration mode. The unit must be re-zeroed after cleaning.

5.3.2 Lubricating IR400 and IR4000 Units

If the neoprene rubber gasket (O-ring) in the cover of the IR4000 enclosure is found dry, it should also be lubricated with the lubricant/sealant that is included with the IR400/IR4000 units, or is available on order from General Monitors (P/N 916-062).

As an alternative to grease, PTFE (Teflon) tape may be used.

5.4 Storage

The Model IR400 Gas Detector and IR4000 Monitor System should be stored in a clean, dry area, and within the temperature and humidity ranges noted for environmental specifications in Section 9.3.3 Electrical Specifications for the IR400, and the separate user manual for the IR4000. Insert the red dust caps into any vacant cable entry holes while the unit is stored.

6.0 Troubleshooting

The IR400 will alert the operator that there are problems in a number of ways. The table on the following page shows the value for the analog output, the value read through Modbus register 2 (if Modbus is being used), and the fault code, shown as F and a number, on the IR4000 display (if connected).

If the IR400 is connected to a zero switch, then the LED in the zero switch will blink at a rate of 5 flashes per second to show that the detector needs attention.

HART Troubleshooting

1. Verify that the IR400 is configured for HART
2. Verify that the HART modem or HART handheld device (375 or 475) is working by checking it against another HART field device
3. Verify that the HART software or handheld device has the DD for the IR400. If the DD is not present, download it from the HART Communication Foundation (HCF) website.
4. Verify the IR400 wiring
5. Verify that power is off when removing or attaching wires
   - Red to power
   - Black to common
   - White to a 250 ohm resistor, and the other end of resistor to common. Resistor tolerance should be +/-5% or less.
   - Verify HART modem or 475 wiring: Leads are across the 250 ohm resistor
   - After verifying the IR400 wiring, verify that power is on to the IR400 and to the HART modem or handheld device
6. Verify IR400 4-20mA output. When no gas and no faults are present, a voltmeter across the 250 ohm resistor will read 1.0 volt DC.

Table showing the fault conditions and corrective action required:

FAULT CODE	MODBUS FAULT FLAG REGISTER 2	ANALOG OUTPUT (mA)		DESCRIPTION	POSSIBLE CAUSE	CORRECTIVE ACTION
		HART	non-HART			
F0	Bits 3 & 14	2mA for 30s then 1.25mA	2mA for 30s then 0mA	Gas Concentration is Excessively Negative	1)Fouling of the detector windows or beam path is excessive and requires attention	1) Clean detector beam path and windows.
F1	Bits 0 & 1	2	2	Gas Concentration is Negative	1) Detector windows or beam path are beginning to be obscurred.	1) Clean detector beam path and windows.
F2	Bit 6	1.25	0	Failed to Complete Calibration	1) Cal bottle empty and time-out occurred 2) Failed to remove gas at end of CAL and time-out occurred. 3) Leaky CAL cup resulting in unstable signal. 4) Attempted to CAL with too much wind resulting in unstable signal.	1) Obtained filled CAL bottle and re-CAL. 2) Remove gas when directed. 3a) Check CAL cup for proper seating on unit. 3b) Check CAL cup seal and replace CAL cup if damaged. 4) Calibrate at a much less windy time or shield the unit and CAL cup from the wind.
F3	Bit 2	2mA for 30s then 1.25mA	2mA for 30s then 0mA	Beam Block	1) Detector windows or beam path are blocked by dirt, spider webbing or other foreign matter. 2) Detector or source failure.	1) Clean detector beam path and windows. 2) The IR400 must be returned to the factory or authorized service center for repair.
F4		1.25	0	Communications Fault (Applies to IR4000M display only)	1) Incorrect communications set-up. 2) Communications wiring open. 3) Communications wiring shorted.	1) Ensure baud rate, data format and address matches at both the IR400 and the bus master. 2) Check and correct wiring. 3) Check and correct wiring.
F5	Bit 4	1.25	0	CAL Wire (brown) Shorted	1) CAL Wire (brown) not in connector	1) Check and ensure proper connection of wire to board connector
F6	Bit 5	1.25	0	Low Supply Voltage	1) Power supply not outputing greater than 20VDC. 2) Voltage loss due to wiring.	1) Check the supply voltage and replace power supply if necessary 2) Check the supply voltage at the IR400 field and adjust supply to +24VDC at the IR400 or replace wiring with larger gauge.
F7	Bits 9 - 13 & 15	1.25	0	Electronics Error	1) Internal memory glitch 2) Internal error with the electronics.	1) Cycle power, wait 2 minutes, if the fault clears then check all menu settings and recalibrate the IR400. 2) Call your local General Monitors representative for advice.
F8	Bit 7	1.25	0	Failed to Zero	1) Unstable signal due to gas present.	1) Ensure clean air is available for zeroing or provide zero air to the IR400 during zeroing.
F9	Bit 8	1.25	0	CAL Check Period Exceeded	1) Test gas still present after gas check completed.	1) Remove the gas

7.0 Modbus Interface

The IR400 has a single Modbus compatible interface for connection to control room equipment such as programmable logic controllers (PLCs). The Modbus interface is also used to connect IR400 detectors to the IR4000M multi-point monitor.

A separate manual for the IR400 Modbus registers and a programming guide is available from the General Monitors' website.

8.0 Customer Support

Area	Phone/Fax/Email
UNITED STATES	
	Toll Free: +1-800-446-4872
Corporate Office:	Phone: +1-949-581-4464
26776 Simpatica Circle	Fax: +1-949-581-1151
Lake Forest, CA 92630	Email: info@generalmonitors.com
	Phone: +1-281-855-6000
9776 Whithorn Drive	Fax: +1-281-855-3290
Houston, TX 77095	Email: gmhou@generalmonitors.com
UNITED KINGDOM	
Heather Close	Phone: +44-1625-619-583
Lyme Green Business Park	Fax: +44-1625-619-098
Macclesfield, Cheshire,	Email: info@generalmonitors.co.uk
United Kingdom, SK11 0LR	
IRELAND	
Ballybrit Business Park	Phone: +353-91-751175
Galway	Fax: +353-91-751317
Republic of Ireland	Email: info@gmil.ie
SINGAPORE	
No. 2 Kallang Pudding Rd.	Phone: +65-6-748-3488
#09-16 Mactech Building	Fax: +65-6-748-1911
Singapore 349307	Email: genmon@gmpacifica.com.sg
MIDDLE EAST	
LOB12, #G20	
P.O. Box 61209	Phone: +971-4-8815751
Jebel Ali, Dubai	Fax: +971-4-8817927
United Arab Emirates	Email: gmme@emirates.net.ae

Table 5: GM Locations

9.0 Appendix

9.1 Warranty

General Monitors warrants the Model IR400 to be free from defects in workmanship or material under normal use and service within two (2) years from the date of shipment.

General Monitors will repair or replace without charge any such defective equipment found to be defective during the warranty period. Full determination of the nature of, and responsibility for, defective equipment will be made by General Monitors' personnel.

Defective or damaged equipment must be shipped prepaid to General Monitors' plant or representative from which shipment was made. In all cases this warranty is limited to the cost of the equipment supplied by General Monitors. The customer will assume all liability for the misuse of this equipment by its employees or other personnel.

- **NOTE:** The Model IR400 Infrared Point Detector is easy to install; however, you should read and understand this manual before attempting to install or operate the device. It includes important safety information.

All warranties are contingent upon proper use in the application for which the product was intended and do not cover products which have been modified or repaired without General Monitors' approval, or which have been subjected to neglect, accident, improper installation or application, or on which the original identification marks have been removed or altered.

Except for the express warranty stated above, General Monitors disclaims all warranties with regard to the products sold, including all implied warranties of merchantability and fitness and the express warranty stated herein are in lieu of all obligations or liabilities on the part of General Monitors for damages including, but not limited to, consequential damages arising out of/or in connection with the use or performance of the product.

9.2 Principle of Operation

Most gases absorb infrared radiation in specific wavelengths or bands that are characteristic of the chemical structure of molecules in the gas. All hydrocarbon gases absorb infrared radiation, but to differing degrees. Gases, to be infrared active, must have an electric dipole moment. The Model IR400 is based on measuring absorption of infrared radiation passing through a volume of gas.

Absorption of the radiation follows the Beer - Lambert Law, which states “the transmittance T of radiation through an absorbing medium decreases exponentially by the product of the extinction coefficient A, the concentration C and the path length L”:

T = exp(-ACL)

The Model IR400 uses a dual source, single detector measurement method. One source operates at a wavelength where absorption of a specific gas (or gases) occurs (the active wavelength). The reference source operates at a wavelength that is adjacent to the active wavelength but not absorbed by the gas (or gases). By comparing the signals from these two sources the concentration of the gas can be measured using the differential absorption technique.

This method of gas detection comes under what is commonly known as the non-dispersive infrared (NDIR) absorption principle. The reference wavelength is chosen suitable to compensate for any interference that can otherwise occur from atmospheric variation (e.g. humidity, dust, snow, fog, steam, temperature, etc.).

Control Electronics

The Model IR400 operates from an unregulated +24 VDC (nominal) input, which is fed to an onboard power-supply that produces all of the necessary voltages within the unit. The microprocessor constantly monitors the infrared wavelengths and performs mathematical operations on these values in conjunction with values obtained during the factory set-up process.

The microprocessor generates output information and feeds it to the digital analog converter to produce a 4 to 20 milliampere (mA) signal that is proportional to the 0 to 100% LEL (or methane % by volume) concentration of gas at the sensor. The microprocessor program also monitors other conditions such as the supply voltage and the optical path integrity.

The Model IR400 provides a two-wire RS-485 addressable communications link conforming to the Modbus protocol that is used to monitor the IR400’s status and settings in order to simplify installation and maintenance.

9.3 Specifications

9.3.1 System Specifications

Detector Type:	Infrared absorption
Detector Life:	Greater than 5 years
Measuring Range:	0 to 100% LEL
Zero Drift:	< 2% per year
Response Time: *(With 100% LEL methane applied)* *(With 100% LEL ethylene applied)*	 T50 ≤ 7 seconds, T60 ≤ 8 seconds T90 ≤ 10 seconds T50 ≤ 5 seconds, T60 ≤ 6 seconds T90 ≤ 11 seconds
Accuracy @ 25º C:	±3% FS ≤ 50% FS, ±5% FS > 50% FS
Gas Calibrations	Methane, propane, ethane, ethylene, butane, hexane, pentane at LEL levels defined by ISO 10156/NFPA 325 and at levels defined by IEC 61779-1. *Consult factory for other calibrations.*
Readout/Relay Display Modules:	DC110: Multi-Channel, Rack Mounted[1] DC130: Dual Channel, Rack Mounted[2] TA102A: Single Channel, Zero Two Series[3] IR4000 display and relay alarms
Malfunctions Monitored:	Re-calibration Error Optics Failure/Blockage Low Supply Voltage Reference or Active Lamp Failure Heater Failure Time to Re-zero unit Program Memory Checksum Error (EPROM) Data Non-Volatile Memory Checksum Error (EEPROM) Short Circuit on CAL_IO Wire
Warranty:	Two years
Approvals:	CSA FM CE Marking ATEX IECEx SIL 3 suitable

FM required statement: “This Approval does not include or imply Approval of apparatus to which the subject instrumentation may be connected. In order to maintain an FM Approved system, the apparatus to which this instrument is connected, must also be Approved by FM Approvals.”

[1] DC110 is not approved for use in ATEX installations
[2] DC130 is not approved for use in ATEX installations
[3] Rev E S/W and up for EU installations

9.3.2 Mechanical Specifications

Length:	8.87 inches (225 mm)
Diameter:	2.9 in (74 mm)
Weight:	3 lbs (1.35 kg) for aluminum 6 lbs (2.7 kg) for stainless steel
Mounting:	3/4" NPT threads
Enclosure:	Marine Aluminum or Stainless Steel; Explosion proof, IP66, Type 4X

9.3.3 Electrical Specifications

Input Power:

absolute min	20 V
nominal	24 V
absolute max	36 V
max. wattage	4.8 W @ +24 VDC
max. current	200 mA @ +24 VDC
ripple maximum allowed	1 V pk-pk

- **NOTE:** Customer supplied PSU must meet requirements IEC 1010-1 limiting current to 8A under Fault conditions, in order to comply with CE Marking requirements.

Analog Signal:

Range	0 - 21.7 mA
Load (max. resistance)	600 Ω

Current Level (mA)

0	Startup mode and critical fault for non HART unit
1.25*	Startup mode and critical fault for HART unit
1.5*	Zero, Calibration and Gas Check Mode
2*	Dirty Optics
4 – 20	0 – 100% LEL
20.1 – 21.7	Over range

* HART units can be configured to never output current less than 3.5 mA if the host equipment is incapable of working below this level.

Area Classification:	Class I, Divisions 1 & 2, Groups B, C and D (Ta = -40°C to +75°C), (Ta = -40°C to +60°C for ethylene only), IP66, Type 4X Ex d, IIB+H_2 T5 Gb, IP66 (Ta = -60°C to +75°C) Ex t IIIC T100°C Db
RFI/EMI Protection:	Complies with EN50270, EN61000-6-4

9.3.4 Analog Current Output

The following table shows the values of the analog output when in certain modes or fault conditions.

Condition Type	Non-HART Units	HART Units	HART Override Mode*
Start Up, Fault	0 mA	1.25 mA	3.5 mA
Zero, Gas Check or Cal	1.5 mA	1.5 mA	3.5 mA
Dirty Optics	2.0 mA	2.0 mA	3.5 mA
0-100% LEL	4 – 20 mA	4 – 20 mA	4 – 20 mA
Over-range	21.7 mA	21.7 mA	21.7 mA

Table 6: Analog Current Output

** HART units can be configured to never output current less than 3.5 mA if the host equipment is incapable of working below this level.*

9.3.5 Recommended Cable Lengths

Power – The maximum distance between the IR400 and the power source varies according to the wire size. Maximum cable resistance = V drop / I device = 4.0 V / 0.20 A = 20 Ω, where V drop = V supply – V device and V supply =+24 VDC.

AWG	Stranded Cable (Ω/1000 ft)	Feet	Meters
12	1.71	5800	1700
14	2.73	3600	1100
16	4.35	2200	700
18	6.92	1400	440
20	10.9	910	270

Table 7: Maximum Distance between IR400 and Power Source

Analog Output Signal – The maximum total distance between the IR400 and a device with a 500-Ohm input impedance varies according to the wire size.

AWG	Stranded Cable (Ω/1000 ft)	Feet	Meters
14	2.525	9000	2740
16	4.016	5200	1585
18	6.385	3800	1160
20	10.15	2400	730

Table 8: Maximum Distance between IR400 and 500-Ohm Input Impedance

9.4 Environmental Specifications

Temperature Range:	
Operating	-40°F to +167°F (-40°C to +75°C)
(Ethylene only)	-40°F to +140°F (-40°C to +60°C)
Storage	-76°F to +185°F (-60°C to +85°C)
Humidity Range:	5 to 99% RH non-condensing Accuracy is not affected by humidity as long as no condensation accumulates on the windows

9.5 Communications

9.5.1 RS-485 Interface

The Model IR400 has built-in serial communications in the form of a half duplex RS-485 digital serial interface designed to conform to EIA-485 specifications. The format is in binary data transferred at 9600 baud with 1 start bit, 8 data bits, 1 stop bit and no parity.

The “bus master” sends a command message to the IR400, which is comprised of 5 bytes of data in the following format: The first byte is the address of the slave device (IR400). The second byte is the Command Word. The third byte is the Command Data. The last two bytes are a 16-bit checksum calculated by performing a 16-bit addition of the first three bytes of the message and placing the result in the check sum bytes.

A “1" in the most significant bit of the Command Word (byte 2), tells the IR400 to change the settings to those given in the Command Data (byte 3).

A ”0" in the most significant bit of the Command Word (byte 2), tells the IR400 to return to the current settings. In this case the Command Data (byte 3) will be all “0’s”.

The IR400 then responds by sending back a 5-byte message in the following format: The first byte is the address of the IR400. The second byte is an echo of the Command Word sent by the “bus master”. The third byte is the data requested by the Command Word. The last two bytes are the 16- bit check sum.

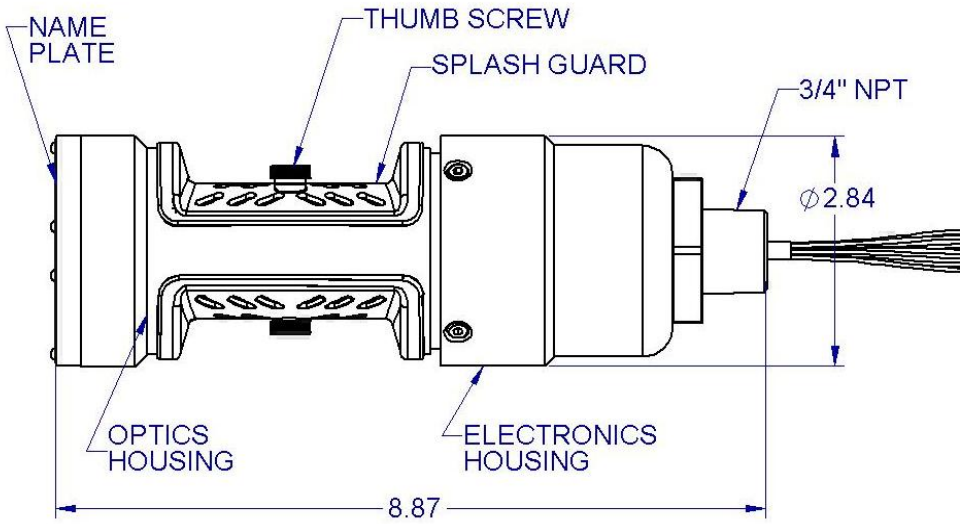
9.5.2 Modbus RTU

A programming manual is available from the General Monitors website that gives details on all the available Modbus RTU commands.

9.5.3 HART

The IR400 HART Field Device Specification provides details on HART commands. The specification is available from the General Monitors website.

9.6 Engineering Documentation



9.7 Ordering Information

9.7.1 System Components

Description	Part Number
Model IR400 Infrared Point Detector Standard (Methane)	**IR400**
Instruction Manual - Model IR400	**MANIR400**
DC110 Eight Channel Readout/Relay Display Module, Rack Mounted	**DC110**
DC130 Dual Channel Readout/Relay Display Module, Rack Mounted	**DC130**
TA102A Single Channel Zero Two Series Trip Amplifier	**TA102A**
IR4000 multi-point monitor for up to 8 IR400s connected via Modbus	**IR4000M**
IR4000 single-point monitor connected using analog output and CAL signal	**IR4000S**

9.7.2 Spare Parts and Accessories

To order spare parts and/or accessories, please contact the nearest General Monitors representative, or General Monitors directly, and give the following information:

1. Part Number
2. Description
3. Quantity

9.7.3 Recommended Spare Parts for One (1) Year

31037-1 Double-Magnet Assembly if a zero switch is used

9.7.4 Accessories

31305-1	Junction Box with magnetic switch, CSA/FM
31421-3	Junction Box with magnetic switch, ATEX
31305-2	Junction Box without magnetic switch, CSA/FM
31421-4	Junction Box without magnetic switch, ATEX
32554-1	Calibration Cup / Flow Block
32545-1	Splash Guard standard
32545-2	Splash Guard for use with remote cal
32545-3	Splash Guard with no screen for areas with occasional moisture
32545-4	Splash Guard with no screen for remote cal
31306-1	Duct Mount Junction Box
32548-Specify Gas	Gas bottle with regulator and calibration cup
31420-1	Flow Block for gas sampling system
31545-1	Rain Guard Assembly

ADDENDUM
Product Disposal Considerations

This product may contain hazardous and/or toxic substances.

EU Member states shall dispose according to WEEE regulations. For further General Monitors' product WEEE disposal information please visit: www.generalmonitors.com/customer_support/faq_general.html

All other countries or states: please dispose of in accordance with existing federal, state and local environmental control regulations.

Model IR400

HART Field Device
Specification for
Point IR Gas Detector

Table of Contents

1.0 INTRODUCTION 1
Scope 1
Purpose 1
Who should use this document? 1
References 1

2.0 DEVICE IDENTIFICATION 2

3.0 PRODUCT OVERVIEW 2

4.0 PRODUCT INTERFACES 2
Process Interface 2
Sensor Input Channels 2
Host Interface 2
Local Interfaces, Jumpers, and Switches 3

5.0 DEVICE VARIABLES 3

6.0 DYNAMIC VARIABLES 3
Primary Variable = Percent of Lower Explosive Limit 3
Secondary, Tertiary, and Quaternary Variables: Not Applicable 3

7.0 STATUS INFORMATION 4

8.0 UNIVERSAL COMMANDS 5

9.0 COMMON PRACTICE COMMANDS 5
Supported Commands 5
Catch Device Variable 6

10.0 DEVICE SPECIFIC COMMANDS 6
Command #131: Do Abort 6
Command #136: Set Alarm Level 7
Command #137: Set Warn Level 7
Command #143: Read Event Logging Counters 8
Command #144: Clear Event Logging Counters 9
Command #145: Read Warning Event Log 9
Command #146: Read Alarm Event Log 10
Command #147: Read Fault Event Log 10
Command #148: Read Maintenance Event Log 11
Command #149: Set Clock 12
Command #150: Read Clock 13
Command #151: Set Run Time Meter 13

Command #152: Read Run Time Meter 14
Command #154: Set Event Index 14
Command #155: Get Event Index 15
Command #156: Read Calibration Event Log 15
Command #163: Get Fast Changing Information 16
Command #164: Get Slow Changing Information 17
Command #165: Get Set Up Information 18
Command #170: Set Current Range 19
Command #185: Set Gas ID or sensor type 20
Command #186: Set Cal IO type 20
Command #187: Set Solenoid State 21
Command #188: Read Solenoid State 22
Command #190: Set Calibration Level 22
Command #191: Do Zero 23
Command #192: Do Calibration 23
Command #193: Do Zero/Calibration 24
Command #195: Do Gas Check 24

11.0 TABLES 25

IR400 – Device Specific Commands Summary 25
IR400 – Operating Mode Values 26
Fault Event Log – Cause Description 26

12.0 PERFORMANCE 27

Sampling Rates 27
Power-up 27
Device Reset 27
Self-Test 27
Command Response Delay 27
Busy and Delayed-Response 27
Long Messages 27
Non-Volatile Memory 27
Operating Modes 27
Write Protection 27

ANNEX A. CAPABILITY CHECKLIST 28

ANNEX B. DEFAULT CONFIGURATION 29

Table of Tables

Table 1: Field Device Identification Data 2
Table 2: Error Status Information 4
Table 3: IR400 – Common Practice Commands 5
Table 4: IR400 – Device Specific Commands 25
Table 5: IR400 - Operating Mode Values 26
Table 6: Fault Event Log – Cause Description 26
Table 7: Command Response Times 27
Table 8: Capability Checklist 28
Table 9: Default Configuration 29

1.0 Introduction

Scope

The IR400 Combustible Gas detector complies with HART Protocol Revision 6.0. This document specifies all of the device specific features and documents HART Protocol implementation details. The functionality of this Field Device is described sufficiently to allow its proper application in a process and its complete support in HART capable Host Applications.

Purpose

This specification is designed to complement the IR400 Instruction Manual by providing a complete description of this field device from a HART Communications perspective.

Who should use this document?

This specification is designed to be a technical reference for HART capable host application developers, system integrators, and knowledgeable end users.

References

DOCUMENT NAME	DOCUMENT RELATIONSHIP
HART Communications Protocol Specifications	This is used to insure compliance with the HART Communication Protocol.
IR400 Instruction Manual	This is the General Monitors, Inc. IR400 Product Instruction Manual.

2.0 Device Identification

The following Table 1 is the Field Device Identification Data for the instrument.

Manufacturer's Name	General Monitors, Inc.	Model Number	IR400
HART ID Code	223 (DF Hex)	Device Type Code:	131 (83 Hex)
HART Protocol Revision	6.0	Device Revision:	1
Number of Device Variables	0		
Physical Layers Supported	1		
Physical Device Category	FSK		

Table 1: Field Device Identification Data

3.0 Product Overview

The IR400 is an Infrared Combustible Gas Detector from General Monitors. The IR400 accurately measures combustible gas and reports the measurement as a percent of the Lower Explosive Limit (%LEL) of the gas.

4.0 Product Interfaces

Process Interface

This section describes all interfaces between the devices and the measured process.

Sensor Input Channels

Host Interface

The HART interface uses the 4 – 20mA current loop. Refer to the Installation Manual for connection details.

1.1.1 Analog Output: Percent of Lower Explosive Limit (LEL)

1.1.2 The primary variable is proportional to the percent lower explosive limit. 4.0mA output current corresponds to zero LEL. 20.0mA output current corresponds to 100% LEL.

Local Interfaces, Jumpers, and Switches

Refer to the Installation Manual for connection details.

1.1.3 Local Controls And Displays

1.1.4 There are neither local controls nor displays in the IR400 unit.

1.1.5 Internal Jumpers And Switches

1.1.6 There are no internal jumpers or switches in the IR400 unit.

5.0 Device Variables

There are no device variables exposed to the user.

6.0 Dynamic Variables

There is only one Dynamic Variable exposed to the user.

Primary Variable = Percent of Lower Explosive Limit

1.1.7 The primary variable is proportional to the percent lower explosive limit. 4.0mA output current corresponds to zero LEL. 20.0mA output current corresponds to 100% LEL. The device mode is the variable, which corresponds to the Modbus register 0x00.

Secondary, Tertiary, and Quaternary Variables: Not Applicable

There are none defined for the IR400 product.

7.0 Status Information

The error status, which is returned via Common Practice Command #48, is shown in Table and corresponds to Modbus register 0x02.

Byte	Bit	Description	Class	Device Status Bits Set
LSB	0	IR Close to Low	Error	4,7
	1	Negative Drift	Error	4,7
	2	IR is Low	Error	4,7
	3	IR is High	Error	4,7
	4	Brown Wire Short	Error	4,7
	5	Low Line Voltage	Error	4,7
	6	Failed to Calibrate	Error	4,7
	7	Failed to Zero	Error	4,7
MSB	0	Gas Check Timeout	Error	4,7
	1	Active Lamp Fault	Error	4,7
	2	Reference Lamp Fault	Error	4,7
	3	Heater Failure	Error	4,7
	4	FLASH Checksum Error	Error	4,7
	5	RAM Checksum Error	Error	4,7
	6	Excess Negative Drift	Error	4,7
	7	EEPROM Checksum Error	Error	4,7

Table 2: Error Status Information

These bits may be set at power up to indicate an instrument failure. They may also be set by a failure detected during continuous background diagnostic testing.

8.0 Universal Commands

Command 3 returns the current loop variable and the primary variable for a total of 9 bytes returned. Command 9 returns the PV only.

9.0 Common Practice Commands

The following common practice commands are implemented.

Supported Commands

The following common-practice commands shown in Table are implemented:

Command Number	Byte Number	Meaning
Command 38	N/A	Reset Configuration Changed Flag.
Command 48	0	Returns Priority Fault, High Byte
Command 48	1	Returns Priority Fault, Low Byte
Command 48	2	Returns error status (same as Modbus register x02), High Byte
Command 48	3	Returns error status (same as Modbus register x02), Low Byte
Command 48	4	Returns Power Cycled Flag
Command 48	5	Returns Event Happened Flag
Command 48	6	Value = 0: All OK; Bit 0: Maintenance Required; Bit 1: Critical Fault
Command 48	7	Returns 0

Table 3: IR400 – Common Practice Commands

Burst Mode

The IR400 does not support Burst Mode.

Catch Device Variable

This Field Device does not support Catch Device Variable.

10.0 Device Specific Commands

The Device Specific commands are used strictly for the unique features of the IR400 and at the discretion of General Monitors. They are described here in section 10.0 and are summarized in Table .

Command #131: Do Abort

This sends the unit to Run mode.

Request Data Bytes

Byte	Format	Description
0	N/A	N/A

Response Data Bytes

Byte	Format	Description
0	N/A	N/A

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

Command #136: Set Alarm Level

This sets the Alarm level.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Alarm level, % of FS

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Alarm level, % of FS

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 – 2	N/A	Undefined
3	Error	Passed Parameter Too Large
4	N/A	Undefined
5	Error	Too Few Data Bytes Received
6 – 15	N/A	Undefined
16	Error	Access Restricted
17 – 127	N/A	Undefined

Command #137: Set Warn Level

This sets the Warn level.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Alarm Warn level, % of FS

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Alarm Warn level, % of FS

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 – 2	N/A	Undefined
3	Error	Passed Parameter Too Large
4	N/A	Undefined
5	Error	Too Few Data Bytes Received
6 – 15	N/A	Undefined
16	Error	Access Restricted
17 – 127	N/A	Undefined

Command #142: Reset Event Happened Flag

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
None	N/A	N/A

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

Command #143: Read Event Logging Counters

Reads the 5 event logging counters.

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description

0 - 1	Unsigned-16	Warning Event Counter
2 - 3	Unsigned-16	Alarm Event Counter
4 - 5	Unsigned-16	Fault Event Counter
6 - 7	Unsigned-16	Maintenance Event Counter
8 - 9	Unsigned-16	Calibrate Event Counter

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #144: Clear Event Logging Counters

This resets the 5 event logging counters to zero.

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
None	N/A	N/A

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #145: Read Warning Event Log

This reads the Warning Event Log as specified by the event log number. Event 0 is the most recent event. Event 1 is the one just before that and so forth.

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description

0 - 3	Unsigned-32	Event Running Time (in Seconds)
4– 6	Date	Event Date: Day, Month, Year – 1900
7	Unsigned-8	Event Hour
8	Unsigned-8	Event Minute
9	Unsigned-8	Event Second
10-13	Unsigned-8	Reserved = 0

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #146: Read Alarm Event Log

This reads the Alarm Event Log as specified by the event log number. Event 0 is the most recent event. Event 1 is the one just before that and so forth.

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
0 - 3	Unsigned-32	Event Running Time (in Seconds)
4– 6	Date	Event Date: Day, Month, Year – 1900
7	Unsigned-8	Event Hour
8	Unsigned-8	Event Minute
9	Unsigned-8	Event Second
10-13	Unsigned-8	Reserved = 0

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #147: Read Fault Event Log

This reads the Fault Event Log as specified by the event log number. Event 0 is the most recent event.

Event 1 is the one just before that and so forth.

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
0 - 3	Unsigned-32	Event Running Time (in Seconds)
4– 6	Date	Event Date: Day, Month, Year – 1900
7	Unsigned-8	Event Hour
8	Unsigned-8	Event Minute
9	Unsigned-8	Event Second
Byte	**Format**	**Description**
10-11	Unsigned-8	Priority Fault
12-13	Unsigned-16	Event Cause – See device specific table

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #148: Read Maintenance Event Log

This reads the Maintenance Event Log as specified by the event log number. Event 0 is the most recent event. Event 1 is the one just before that and so forth.

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Event Log Number
0 - 3	Unsigned-32	Event Running Time (in Seconds)
4– 6	Date	Event Date: Day, Month, Year – 1900
7	Unsigned-8	Event Hour

8	Unsigned-8	Event Minute
9	Unsigned-8	Event Second
10-11	Unsigned-16	Reserved = 0
12-13	Unsigned-16	Code

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #149: Set Clock

This sets the internal real-time clock.

Request Data Bytes

Byte	Format	Description
0 – 2	Date	Date: Day, Month, Year-1900
3	Unsigned-8	Hours
4	Unsigned-8	Minutes
5	Unsigned-8	Seconds

Response Data Bytes

Byte	Format	Description
0 – 2	Date	Date: Day, Month, Year-1900
3	Unsigned-8	Hours
4	Unsigned-8	Minutes
5	Unsigned-8	Seconds

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6 - 127		Undefined

Command #150: Read Clock

This reads the internal real-time clock setting.

Request Data Bytes

Byte	Format	Description
0	N/A	N/A

Response Data Bytes

Byte	Format	Description
0 – 2	Date	Date: Day, Month, Year-1900
3	Unsigned-8	Hours
Byte	**Format**	**Description**
4	Unsigned-8	Minutes
5	Unsigned-8	Seconds

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #151: Set Run Time Meter

This sets the internal run time meter.

Request Data Bytes

Byte	Format	Description
0 - 3	Unsigned-32	Run Time Meter Value

Response Data Bytes

Byte	Format	Description
0 - 3	Unsigned-32	Run Time Meter Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received

Code	Class	Description
6 - 127		Undefined

Command #152: Read Run Time Meter

This reads the internal run time meter.

Request Data Bytes

Byte	Format	Description
0	N/A	N/A

Response Data Bytes

Byte	Format	Description
0 - 3	Unsigned-32	Run Time Meter Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #154: Set Event Index

This sets the index of logged event to read. 0 – latest event

Request Data Bytes

Byte	Format	Description
0	Unsigned - 8	Sets index of logged event to read using commands 143 – 146. Range 0 – 9.

Response Data Bytes

Byte	Format	Description
0	Unsigned - 8	Event Index

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4		Undefined
5	Error	Too Few Data Bytes Received
6 - 127		Undefined

Command #155: Get Event Index

This reads event logged index.

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
0	Unsigned - 8	Event index

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #156: Read Calibration Event Log

This reads Calibration Event Log as specified by the event log number. Event 0 is the most recent event. Event 1 is the one just before that and so forth.

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
0-3	Unsigned-32	Event Running Time (in Seconds)
4-6	Date	Event Date: Day, Month, Year – 1900
7	Unsigned-8	Event Hour
8	Unsigned-8	Event Minute
9	Unsigned-8	Event Second
10 - 11	Unsigned-16	Reserved = 0
12 - 13	Unsigned-16	1 - Zero, 2 - Calibration

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #163: Get Fast Changing Information

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
0 - 1	Unsigned-16	Mode
2 - 3	Unsigned-16	Sub Mode
4 – 7	Float	AO
8 - 9	Unsigned-16	Priority fault
10 – 11	Bit map	Error status
12	Unsigned-8	Reserved = 0
13	Unsigned-8	Reserved = 0
14	Unsigned-8	Reserved = 0
15	Unsigned-8	Power cycled flag
16	Unsigned-8	Event happened flag
17	Integer-8	% of FS
18-21	Integer-32	Reserved = 0

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #164: Get Slow Changing Information

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
0 - 1	signed-16	Temperature
2 - 5	float	Voltage
6 - 7	unsigned-16	% Beam Blockage

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Command #165: Get Set Up Information

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Gas ID
1	Enumerated	Measured Units
2- 5	Unsigned-32	Full Scale
6	Unsigned-8	Alarm level, % of FS
7	Unsigned-8	Reserved = 0
8	Unsigned-8	Reserved = 0
9	Unsigned-8	Warn level, % of FS
10	Unsigned-8	Reserved = 0
11	Unsigned-8	Reserved = 0
12	Unsigned-8	Reserved = 0
13	Unsigned-8	Reserved = 0
14	Unsigned-8	Reserved = 0
15	Unsigned-8	Reserved = 0
16	Unsigned-8	Reserved = 0
17	Unsigned-8	Cal IO type: 0 – zero switch, 1 – manual solenoid, 2 – automatic solenoid
18-19	Unsigned-8	Reserved = 0
20	Unsigned-16	Reserved = 0
21	Unsigned-8	Reserved = 0
22	Unsigned-8	Cal level, % of FS.
23	Unsigned-8	Reserved = 0
24	Unsigned-8	Current Range: 0 = 3.5 – 20mA, 1 = 1.25 – 20mA

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

Gas Selection Codes

Code to read / write	Gas Type
0	Methane
1	Propane
2	N Butane
3	Hexane
4	% by volume Methane
5	Special Order
6	Ethane
7	Pentane

Command #170: Set Current Range

This sets the current range to be either one of 2 possible selections.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	0 – Range 3.5mA - 20mA, 1 -- Range 1.25 - 20mA

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	0 – Range 3.5mA - 20mA, 1 -- Range 1.25 - 20mA

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4		Undefined
5	Error	Too Few Data Bytes Received
6 - 127		Undefined

Command #185: Set Gas ID or sensor type

Request Data Bytes

Byte	Format	Description
0	Unsigned 8	Gas ID or sensor type

Response Data Bytes

Byte	Format	Description
0	Unsigned 8	Gas ID or sensor type

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6 - 127		Undefined

Gas Selection Codes

Code to read / write	Gas Type
0	Methane
1	Propane
2	N Butane
3	Hexane
4	% by volume Methane
5	Special Order
6	Ethane
7	Pentane

Command #186: Set Cal IO type

Request Data Bytes

Byte	Format	Description
0	Unsigned 8	0 – zero switch, 1 – manual solenoid, 2 – automatic solenoid

Response Data Bytes

Byte	Format	Description
0	Unsigned 8	0 – zero switch, 1 – manual solenoid, 2 – automatic solenoid

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6 - 127		Undefined

Command #187: Set Solenoid State

Request Data Bytes

Byte	Format	Description
0	Bits	Solenoid State: 1 - off, 2 - on

Response Data Bytes

Byte	Format	Description
0	Bits	Solenoid State: 1 - off, 2 - on

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6 - 127		Undefined

Command #188: Read Solenoid State

Request Data Bytes

Byte	Format	Description
None	N/A	N/A

Response Data Bytes

Byte	Format	Description
0	Unsigned -8	Solenoid State: 0 = disabled, 1 - off, 2 - on

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 127		Undefined

Command #190: Set Calibration Level

Request Data Bytes

Byte	Format	Description
0	Unsigned 8	Cal level, % of FS

Response Data Bytes

Byte	Format	Description
0	Unsigned 8	Cal level, % of FS

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6 - 127		Undefined

Command #191: Do Zero

This sends the unit to Zero mode.

Request Data Bytes

Byte	Format	Description
0	N/A	N/A

Response Data Bytes

Byte	Format	Description
0	N/A	N/A

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

Command #192: Do Calibration

This sends the unit to Calibration mode.

Request Data Bytes

Byte	Format	Description
0	N/A	N/A

Response Data Bytes

Byte	Format	Description
0	N/A	N/A

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

Command #193: Do Zero/Calibration

This sends the unit to Zero/Calibration mode.

Request Data Bytes

Byte	Format	Description
0	N/A	N/A

Response Data Bytes

Byte	Format	Description
0	N/A	N/A

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

Command #195: Do Gas Check

This sends the unit to Gas Check mode.

Request Data Bytes

Byte	Format	Description
0	N/A	N/A

Response Data Bytes

Byte	Format	Description
0	N/A	N/A

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

11.0 Tables

IR400 – Device Specific Commands Summary

The following Table 4 is a summary of the IR400 Device Specific Commands.

Command Number	Byte Number	Meaning
131		Do Abort
136		Set Alarm Level
137		Set Warn Level
142		Reset Event Happening Flag
143		Read Event Logging Counters
144		Clear Event Logging Counters
145		Read Warning Event Log
146		Read Alarm Event Log
147		Read Fault Event Log
148		Read Maintenance Log
149		Set Time Clock
150		Read Time Clock
151		Set Running Time
152		Read Running Time
154		Set Event Index
155		Read Event Index
156		Read Calibrate Event Log
163		Get Fast Changing Information
164		Get Slow Changing Information
165		Get setup Information
185		Set Gas ID
186		Set Cal_IO_Type
187		Set Solenoid State
188		Read Solenoid State
190		Set Calibration Level
191		Do Zero
192		Do Calibration
193		Do Zero/Calibration
195		Do Gas Check

Table 4: IR400 – Device Specific Commands

IR400 – Operating Mode Values

The following Table 5 is a summary of the IR400 Operating Mode Values:

Operating Mode	Value in Hex
Run Mode	0x0001
Calibration Mode	0x0002
Zero Mode	0x0004
Calibration Pending Mode	0x0008
Calibration Apply Gas Mode	0x0010
Calibration Complete Mode	0x0020
Startup Mode	0x0040
Temperature Correction “Slope” Mode	0x0080
Gas Check Mode	0x0200
Zero Cal Mode	0x0400
Lamp Adjust Mode	0x0800

Table 5: IR400 - Operating Mode Values

Fault Event Log – Cause Description

The following Table 6 describes the cause as reported by the read event log commands:

Bits	Cause
0x0000	No Fault
0x0001	IR Close to Low
0x0002	Negative Drift
0x0004	IR is Low
0x0008	IR is High
0x0010	Brown Wire Short
0x0020	Low Line Voltage
0x0040	Failed to Calibrate
0x0080	Failed to Zero
0x0100	Gas Check Timeout
0x0200	Active Lamp Fault
0x0400	Reference Lamp Fault
0x0800	Heater Failure
0x1000	FLASH Checksum Fault
0x2000	RAM Checksum Fault
0x4000	Excess Negative Drift
0x8000	EEPROM Checksum Fault

Table 6: Fault Event Log – Cause Description

12.0 Performance

Sampling Rates

The IR400 samples each detector at 1 msec intervals.

Power-up

On power up, the IR400 executes a self-test procedure, which requires approximately 15 seconds. During this time, the analog output is set to 3.5mA. After the self-test is satisfactorily completed, the unit sets the PV to a value representing the mode of the instrument.

Device Reset

The IR400 cannot be reset by any command. The unit only resets when power is cycled.

Self-Test

The IR400 goes through a self-test upon power cycle. Should any of the tests fail, the unit immediately reports a fault condition.

Command Response Delay

The IR400 responds as follows:

Response Type	Response Time
Minimum	20 ms
Typical	50 ms
Maximum	100 ms

Table 7: Command Response Times

Busy and Delayed-Response

The IR400 does not use delayed-response times.

Long Messages

The largest data field used by the IR400 is in response to Command 20 & 22 (Read/Write Long Tag): 34 bytes including the two status bytes.

Non-Volatile Memory

The IR400 uses EEPROM to hold the device's configuration parameters. New data is written to this memory immediately on execution of a write command.

Operating Modes

The IR400 reports percent of lower explosive limit detected while in RUN mode. Various other modes are used to support the calibration of the instrument.

Write Protection

The IR400 does not support any write protection mode.

Annex A. Capability Checklist

Manufacturer, model, and revision	General Monitors, Inc., IR400, Revision 1
Device type	Infrared Combustible Gas Detector
HART revision	6.0
Device Description available	Yes
Number and type of sensors	1 Internal Infrared
Number and type of actuators	0
Number and type of host side signals	1: 4 - 20mA analog
Number of Device Variables	0
Number of Dynamic Variables	1
Mappable Dynamic Variables?	No
Number of common-practice commands	2
Number of device-specific commands	30
Bits of additional device status	8
Alternative operating modes?	No
Burst mode?	No
Write-protection?	Mfg Only

Table 8: Capability Checklist

Annex B. Default Configuration

Parameter	Default value
Lower Range Value	0% LEL
Upper Range Value	100% LEL
PV Units	Percent Lower Explosive Limit
Sensor type	Infrared Detector
Number of wires	3
Damping time constant	N/A
Fault-indication jumper	N/A
Write-protect jumper	N/A
Number of response preambles	5

Table 9: Default Configuration

Model IR400

Infrared Point Detector for
Hydrocarbon Gas Applications
Modbus programming guide

Table of Contents

10.0MODBUS RTU 1
10.1 Serial Communications Protocol for IR400 1
10.1.1 Baud Rate 1
10.1.2 Data Format 1
10.1.3 Modbus Read Status Protocol (Query/Response) 1
10.1.4 Modbus Write Command Protocol (Query/Response) 2
10.1.5 Modbus Write Response Message 2
10.2 Function Codes Supported 3
1.2.1 Exception Responses and Exception Codes 3
10.3 IR400 Command Register Locations 5
10.4 IR400 Command Register Details 10
10.4.1 Analog 10
10.4.2 Operating Mode (Read/Write) 10
10.4.3 Status Error (0x0002) 11
10.4.4 Gas Selection (0x0003) 13
10.4.5 Model Type (0x0004) 13
10.4.6 Software Rev (0x0005) 13
10.4.7 Gain (0x0006) 13
10.4.8 Calibration IO type (0x0007) 13
10.4.9 Solenoid On/Off (0x0008) 14
10.4.10 Address (0x0009) 14
10.4.11 Baud Rate (0x000B) 14
10.4.12 Data Format (0x000C) 15
10.4.13 Priority Fault (0x000D) 15
10.4.14 Hazard Watch Options (0x0016) 15
10.4.15 Alarm Level (0x0018) 16
10.4.16 Warn Level (0x0019) 16
10.4.17 HART Configuration (0x001A) 16
10.4.18 Total Receive Errors (0x0020) 16
10.4.19 Function Code Errors (0x0022) 16
10.4.20 Starting Address Errors (0x0023) 16
10.4.21 CRC Hi Errors (0x0025) 16
10.4.22 CRC Lo Errors (0x0026) 16
10.4.23 Overrun Errors (0x0027) 16
10.4.24 Framing Errors (0x0029) 16
10.4.25 Clear Communication Errors (0x002D) 16
10.4.26 Beam Block Percentage (0x0054) 17
10.4.27 Gas ID (0x008D) 17
10.4.28 Reset Events (0x00B0) 17
10.4.29 Running Time in seconds hi word (0x00B1) 17
10.4.30 Running Time in seconds lo word (0x00B2) 18
10.4.31 Real-time Clock Year, Month (0x00B3) 18
10.4.32 Real-time Clock Day, Hour (0x00B4) 18
10.4.33 Real-time Clock Minute, Second (0x00B5) 18
10.4.34 Power Cycle Flag (0x00B7) 18
10.4.35 Event Index (0x00B7) 18
10.4.36 Warning Running Time in Seconds, Hi Word (0x00B8) 19

10.4.37 Warning Running Time in Seconds, Low Word (0x00B9) 19
10.4.38 Warning Clock Time: Year, Month (0x00BA) 19
10.4.39 Warning Clock Time: Day, Hour (0x00BB) 19
10.4.40 Warning Clock Time: Minute, Second (0x00BC) 19
10.4.41 Total Warning Event Counter (0x00BF) 19
10.4.42 Alarm Running Time in Seconds, Hi Word (0x00C0) 19
10.4.43 Alarm Running Time in Seconds, Low Word (0x00C1) 19
10.4.44 Alarm Clock Time: Year, Month (0x00C2) 19
10.4.45 Alarm Clock Time: Day, Hour (0x00C3) 19
10.4.46 Alarm Clock Time: Minute, Seconds (0x00C4) 19
10.4.47 Total Alarm Event Counter (0x00C7) 19
10.4.48 Fault Running Time in Seconds, Hi Word (0x00C8) 20
10.4.49 Fault Running Time in Seconds, Low Word (0x00C9) 20
10.4.50 Fault Clock Time: Year, Month (0x00CA) 20
10.4.51 Fault Clock Time: Day, Hour (0x00CB) 20
10.4.52 Fault Clock Time: Minute, Seconds (0x00CC) 20
10.4.53 Fault Code (0x00CD) 20
10.4.54 Total Fault Event Counter (0x00CF) 20
10.4.55 Maintenance Running Time in Seconds, Hi Word (0x00D0) 20
10.4.56 Maintenance Running Time in Seconds, Low Word (0x00D1) 20
10.4.57 Maintenance Clock Time: Year, Month (0x00D2) 20
10.4.58 Maintenance Clock Time: Day, Hour (0x00D3) 20
10.4.59 Maintenance Clock Time: Minute, Seconds (0x00D4) 20
10.4.60 Total Maintenance Event Counter (0x00D6) 20
10.4.61 Calibration Running Time in Seconds, Hi Word (0x00D8) 21
10.4.62 Calibration Running Time in Seconds, Low Word (0x00D9) 21
10.4.63 Calibration Clock Time: Year, Month (0x00DA) 21
10.4.64 Calibration Clock Time: Day, Hour (0x00DB) 21
10.4.65 Calibration Clock Time: Minute, Seconds (0x00DC) 21
10.4.66 Calibration Code (0x00DD) 21
10.4.67 Total Calibration Event Counter (0x00DF) 21

1.0 MODBUS RTU

1.1 Serial Communications Protocol for IR400

The default Modbus setup from the factory is 9600 baud, 8-n-1 format. The default Modbus ID is 1. These defaults can be restored at any time by connecting the CAL_IO wire (brown) to power supply common and then turn on the power to the IR400. After 10 seconds the CAL_IO wire should be disconnected from the power-supply.

1.1.1.1 Baud Rate

The Baud Rate is a selectable setting via the Modbus Communications Interface. The selectable baud rates are 19200, 9600, 4800, or 2400 bits per second.

1.1.2 Data Format

The Data Format is a selectable setting via the Modbus Communications Interface. The selectable data formats are as follows:

Data Bits	Parity	Stop Bit	Format
8	None	1	8-N-1
8	Even	1	8-E-1
8	Odd	1	8-O-1
8	None	2	8-N-2

Table 1: Data Format

1.1.3 Modbus Read Status Protocol (Query/Response)

1.1.3.1 Modbus Read Query Message

Byte	Modbus	Range	Referenced to IR400
1st	Slave Address	1-247* (Dec)	IR400 ID (Address)
2nd	Function Code	03	Read Holding Registers
3rd	Starting Address Hi**	00	Not Used by IR400
4th	Starting Address Lo**	00-FF (Hex)	IR400 Commands
5th	No. of Registers Hi	00	Not Used by IR400
6th	No. of Registers Lo	01	No. of 16 Bit Registers
7th	CRC Hi	00-FF (Hex)	CRC Hi Byte
8th	CRC Lo	00-FF (Hex)	CRC Lo Byte

Table 2: Modbus Read Query Message

- *__NOTE:__ Address 0 is reserved for broadcast mode and will not be supported at this time.
- **__NOTE:__ Start Address can be a maximum of 9999 Address Locations (0000-270E)

1.1.3.2 Modbus Read Response Message

Byte	Modbus	Range	Referenced to IR400
1st	Slave Address	1-247* (Dec)	IR400 ID (Address)
2nd	Function Code	03	Read Holding Registers
3rd	Byte Count	02	No. of Data Bytes
4th	Data Hi	00-FF (Hex)	IR400 Hi Byte Status Data
5th	Data Lo	00-FF (Hex)	IR400 Lo Byte Status Data
6th	CRC Hi	00-FF (Hex)	CRC Hi Byte
7th	CRC Lo	00-FF (Hex)	CRC Lo Byte

Table 3: Modbus Read Response Message

1.1.4 Modbus Write Command Protocol (Query/Response)

1.1.4.1 Modbus Write Query Message

Byte	Modbus	Range	Referenced to IR400
1st	Slave Address	1-247* (Dec)	IR400 ID (Address)
2nd	Function Code	06	Preset Single Register
3rd	Register Address Hi	00	Not Used by IR400
4th	Register Address Lo	00-FF (Hex)	IR400 Commands
5th	Preset Data Hi	00-FF (Hex)	IR400 Hi Byte Command Data
6th	Preset Data Lo	00-FF (Hex)	IR400 Lo Byte Command Data
7th	CRC Hi	00-FF (Hex)	CRC Hi Byte
8th	CRC Lo	00-FF (Hex)	CRC Lo Byte

Table 4: Modbus Write Query Message

- *__NOTE:__ Address 0 is reserved for broadcast mode and will not be supported at this time.
- **__NOTE:__ Start Address can be a maximum of 9999 Address Locations (0000-270E)

1.1.5 Modbus Write Response Message

Byte	Modbus	Range	Referenced to IR400
1st	Slave Address	1-247* (Dec)	IR400 ID (Address)
2nd	Function Code	06	Preset Single Register
3rd	Register Address Hi	00	Not Used by IR400
4th	Register Address Lo	00-FF (Hex)	IR400 Commands
5th	Preset Data Hi	00-FF (Hex)	IR400 Hi Byte Command Data
6th	Preset Data Lo	00-FF (Hex)	IR400 Lo Byte Command Data
7th	CRC Hi	00-FF (Hex)	CRC Hi Byte
8th	CRC Lo	00-FF (Hex)	CRC Lo Byte

Table 5: Modbus Write Response Message

1.2 Function Codes Supported

Function Code 03 (Read Holding Registers) will be used to read status from the slave unit.

Function Code 06 (Preset Single Register) will be used to write a command to the slave unit.

1.2.1 Exception Responses and Exception Codes

1.2.1.1 Exception Response

In a normal communications query and response, the master device sends a query to the IR400 and the IR400 receives the query without a communications error and handles the query normally within the master device's allowable timeout. The IR400 then returns a normal response to the master. An abnormal communications produces one of four possible events:

4. If the IR400 does not receive the query due to a communications error, then no response is returned from the IR400 and the master device will eventually process a timeout condition for the query.
5. If the IR400 receives the query, but detects a communication error (CRC, etc.), then no response is returned from the IR400 and the master device will eventually process a timeout condition for the query.
6. If the IR400 receives the query without a communications error, but cannot process the response to the master within the master's timeout setting, then no response is returned from the IR400 and the master device will eventually process a timeout condition for the query. In order to prevent this condition from occurring, the maximum response time for the IR400 is 200 milliseconds. Therefore the MASTER'S Timeout Setting should be set to 200 milliseconds or greater.
7. If the IR400 receives the query without a communications error, but cannot process it due to reading or writing to a non-existent IR400 command register, then the IR400 will return an exception response message informing the master of the error.

The exception response message (ref. No. 4 above) has two fields that differentiate it from a normal response:

Byte	Modbus	Range	Referenced to IR400
1st	Slave Address	1-247* (Dec)	IR400 ID (Address)
2nd	Function Code	83 or 86 (Hex)	MSB is set with Function Code
3rd	Exception Code	01 - 06 (Hex)	Appropriate Exception Code (See Below)
4th	CRC Hi	00-FF (Hex)	CRC Hi Byte
5th	CRC Lo	00-FF (Hex)	CRC Lo Byte

Table 6: IR400 Exception Response Message Exception Code

Exception Code Field: In a normal response, the IR400 returns data and status in the data field, which was requested in the query from the master. In an exception response, the IR400 returns an exception code in the data field, which describes the IR400

condition that caused the exception. Below is a list of exception codes that are supported by the IR400:

Code	Name	Description
01	Illegal Function	The function code received in the query is not an allowable action for the IR400.
02	Illegal Data Address	The data address received in the query is not an allowable address for the IR400.
03	Illegal Data Value	A value contained in the query data field is not an allowable value for the IR400.
04	Slave Device Failure	An unrecoverable error occurred while the IR400 was attempting to perform the requested action.
05	Acknowledge	The IR400 has accepted the request and is processing it, but a long duration of time will be required to do so. This response is returned to prevent a timeout error from occurring in the master.
06	Device Busy	The IR400 is engaged in processing a long-duration program command. The master should retransmit the message later when the slave is free.

Table 7: IR400 Exception Codes

1.3 IR400 Command Register Locations

Register Address (Hex)	Parameter	Function	Data Type	Data Range	Access
0000H	**Analog Output**	0-20 mA analog output	Numeric Value	0-65535 Dec, (scale to range 0-21.7mA)	R
0001h	**Operating Mode**	Set/View operating mode	Bit Map	See Table	R/W
0002h	**Error Status**	View present error	Bit Map	See Table	R
0003h	**Gas ID**	Type of gas	Numeric Value	See The register can be written with the index numbers 0 to 7 or with the Gas ID. The Gas ID codes will not change in future versions and are consistent across General Monitors products. To read the Gas ID use register 0x008D. Table 9	R/W
0004H	**Model Number**	View Model ID	Numeric Value	2104 , etc	R
0005h	**Software Rev**	Software Revision ID	2 ASCII characters	A, B, etc.	R
0006h	**Gain**	Shows detector gain	Numeric Value	0-5000	R
0007h	**Cal IO type**	Set/View Cal IO type	code	0 – LED switch, 1 –manual solenoid , 2 - ARGC	R/W
0008h	**Solenoid state**	Turn solenoid ON/OFF, read solenoid state	Code	10 – ON, 20 – OFF, 30 – disabled	R/W
0009h	**Modbus unit address**	Set/View Modbus address	Numeric Value	1-247 decimal	R/W
000Ah	**Adjusted ratio**	Adjusted ratio	Numeric Value	0-65535	R
000Bh	**Modbus Baud**	Set/View Baud Rate (2400, 4800, 9600	Code	0, 1, 2, 3	R/W

	Rate	19200)			
000Ch	**Modbus Data Format**	Set/View Data Format (8N1, 8E1, 801, 8N2)	Code	0, 1, 2, 3	R/W
000Dh	**Priority fault**	Main fault for the unit	Bit Map	See Table	R
000Eh	**% of full scale**	Read gas concentration in % of Full Scale	Numeric Value	-9 – (+)106%	R
• 000Fh	**Full scale, hi**	Read hi word of full scale	Numeric Value	0	R
• 0010h	**Full scale, lo**	Read lo word of full scale	Numeric Value	100 %	R
• 0011h	**Gas measurement units**	Read gas measurement units	Code	0 - % lel, 1 –ppm	R
• 0012h	**PPM value, hi**	Read hi word of gas concentration in ppm	Numeric Value	0-65535	R
0013h	**PPM value, low**	Read low word of gas concentration in ppm	Numeric Value	0-65535	R
0014h	**Duplicate detector gain**	For GM usage	Numeric Value	0-5000	R
0015h	**Reserved**	N/A	N/A	N/A	R
0016h	• **Hazard Watch Mode**	Set/View Hazard Watch Mode	Code	0 – disabled, 1 - enabled	R/W
0017h	**Reserved**	N/A	N/A	N/A	R
0018h	• **Alarm level**	Set/View Alarm level for event logging	Numeric Value	5-95	R/W
0019h	• **Warn level**	Set/View Warn level for event logging	Numeric Value	5-95	R/W
001Ah	**HART configuration**	Hi byte – AO range; Lo byte – HART enabled/disabled	Hi byte – AO range; Lo byte – HART enabled / disabled	Hi byte: 0 – hi range, 1 – lo range, Low byte: 0 – disabled, 1 – HART enabled	R/W
001Bh	**Reserved**	N/A	N/A	N/A	R
001Ch	**Reserved**	N/A	N/A	N/A	R
001Dh	**Reserved**	N/A	N/A	N/A	R
001Eh	**Reserved**	N/A	N/A	N/A	R
001Fh	**Reserved**	N/A	N/A	N/A	R
0020h	**Total Receive Errors**	Number of Receive errors	Numeric Value	0-65535 decimal	R
0021h	**Reserved**	N/A	N/A	N/A	R
0022h	• **Function code errors**	Number of function code errors.	Numeric Value	0-65535 decimal	R

0023h	• **Starting Register Address errors**	Number of Starting Register Address errors.	Numeric Value	0-65535 decimal	R
0024h	**Reserved**	N/A	N/A	N/A	N/A
0025h	• **CRC errors HI**	Number of CRC HI errors	Numeric Value	0-65535 decimal	R
0026h	• **CRC errors LO**	Number of CRC LO errors	Numeric Value	0-65535 decimal	R
0027h	• **Overrun errors**	Number of Overrun errors	Numeric Value	0-65535 decimal	N/A
0028h	**Reserved**	N/A	N/A	N/A	N/A
0029h	• **Framing errors**	Number of framing errors	Numeric Value	0-65535 decimal	R
002Ah	**Reserved**	N/A	N/A	N/A	N/A
002Bh	**Reserved**	N/A	N/A	N/A	N/A
002Ch	**Reserved**	N/A	N/A	N/A	N/A
002Dh	• **Clear Comm. errors**	Clears communication errors	Numeric Value	See description	W
002E-008Ch	**Reserved**	N/A	N/A	N/A	N/A
008D	**Gas ID #**	Read unique Gas Identification Number	Numeric Value	See table for register 0x0003	R
008E – 00AF	**Reserved**	N/A	N/A	N/A	N/A
00B0h	• **Reset Events**	Clears events of resets event flag	Numeric Value	0- Clear Events, 1 – Resets Event Happened flag	W
00B1h	• **Run Time hi**	High word of Run Time in Seconds	Numeric Value	0-65535 decimal	R/W
00B2h	• **Run Time low**	Low word of Run Time in Seconds	Numeric Value	0-65535 decimal	R/W
00B3h	**Real Time Clock Year, Month**	Read/Set year and month of RTC	Numeric Value	1 –99 year, 1– 12 month	R/W
00B4h	**Real Time Clock Day, Hour**	Read/Set day and hour of RTC	Numeric Value	1 – 31 day, 0 – 23 hour	R/W
00B5h	**Real Time Clock Minute, Second**	Read/Set minutes and seconds of RTC	Numeric Value	0 – 59 minutes 0 – 59 seconds	R/W
00B6h	**Power Cycled Flag**	Time Reset After power Cycled	Numeric Value	0 = Time not Reset, 1 = Time Reset	R
00B7h	**Event Index**	Index of Logged Events	Numeric Value	0 - 9	R/W
00B8h	**Running Time Hi**	Running Time Hi for Warning Event log entries	Numeric Value	0 - 65535	R

00B9h	**Running Time Low**	Running Time Low for Warning Event log entries	Numeric Value	0 - 65535	R
00Bah	**Clock Time Hi**	Hi byte = year, Lo byte month: Warning clock time	Numeric Value	1 –99 year, 1– 12 month	R
00BBh	**Clock Time Mid**	Hi byte = Day, Lo byte Hour: Warning clock time	Numeric Value	1 – 31 day, 0 – 23 hour	R
00BCh	**Clock Time Low**	Hi byte = Minute, Lo byte second: Warning clock time	Numeric Value	0 – 59 minutes 0 – 59 seconds	R
00BDh	**Reserved**	Reserved	Numeric Value	0	R
00BEh	**Reserved**	Reserved	Numeric Value	0	R
00BFh	**Warning Event Count**	Total Warning Event Count	Numeric Value	0 - 65535	R
00C0h	**Running Time Hi**	Running Time Hi for Alarm Event log entries	Numeric Value	0 - 65535	R
00C1h	**Running Time Low**	Running Time Low for Alarm Event log entries	Numeric Value	0 - 65535	R
00C2h	**Clock Time Hi**	Hi byte = year, Lo byte month: Alarm clock time	Numeric Value	1 –99 year, 1– 12 month	R
00C3h	**Clock Time Mid**	Hi byte = Day, Lo byte Hour: Alarm clock time	Numeric Value	1 – 31 day, 0 – 23 hour	R
00C4h	**Clock Time Low**	Hi byte = Minute, Lo byte second: Alarm clock time	Numeric Value	0 – 59 minutes 0 – 59 seconds	R
00C5h	**Reserved**	Reserved	Numeric Value	0	R
00C6h	**Reserved**	Reserved	Numeric Value	0	R
00C7h	**Alarm Event Count**	Total Alarm Event Count	Numeric Value	0 - 65535	R
00C8h	**Running Time Hi**	Running Time Hi for Fault Event log entries	Numeric Value	0 - 65535	R
00C9h	**Running Time Low**	Running Time Low for Fault Event log entries	Numeric Value	0 - 65535	R
00CAh	**Clock Time Hi**	Hi byte = year, Lo byte month: Fault clock time	Numeric Value	1 –99 year, 1– 12 month	R
00CBh	**Clock Time Mid**	Hi byte = Day, Lo	Numeric	1 – 31 day,	R

		byte Hour: Fault clock time	Value	0 – 23 hour	
00CCh	**Clock Time Low**	Hi byte = Minute, Lo byte second: Fault clock time	Numeric Value	0 – 59 minutes 0 – 59 seconds	R
00CDh	**Fault Code**	See	Numeric Value	0	R
00CEh	**Reserved**	Reserved	Numeric Value	0	R
00CFh	**Fault Event Count**	Total Fault Event Count	Numeric Value	0 - 65535	R
00D0h	**Running Time Hi**	Running Time Hi for Maintenance Event log entries	Numeric Value	0 - 65535	R
00D1h	**Running Time Low**	Running Time Low for Maintenance Event log entries	Numeric Value	0 - 65535	R
00D2h	**Clock Time Hi**	Hi byte = year, Lo byte month: Maintenance clock time	Numeric Value	1 –99 year, 1– 12 month	R
00D3h	**Clock Time Mid**	Hi byte = Day, Lo byte Hour: Maintenance clock time	Numeric Value	1 – 31 day, 0 – 23 hour	R
00D4h	**Clock Time Low**	Hi byte = Minute, Lo byte second: Maintenance clock time	Numeric Value	0 – 59 minutes 0 – 59 seconds	R
00D5h	**Reserved**	Reserved	Numeric Value	0	R
00D6h	**Reserved**	Reserved	Numeric Value	0	R
00D7h	**Maintenance Event Count**	Total Maintenance Event Count	Numeric Value	0 - 65535	R
00D8h	**Running Time Hi**	Running Time Hi for Calibration Event log entries	Numeric Value	0 - 65535	R
00D9h	**Running Time Low**	Running Time Low for Calibration Event log entries	Numeric Value	0 - 65535	R
00DAh	**Clock Time Hi**	Hi byte = year, Lo byte month: Calibration clock time	Numeric Value	1 –99 year, 1– 12 month	R
00DBh	**Clock Time Mid**	Hi byte = Day, Lo byte Hour: Calibration clock time	Numeric Value	1 – 31 day, 0 – 23 hour	R

00DCh	**Clock Time Low**	Hi byte = Minute, Lo byte second: Calibration clock time	Numeric Value	0 – 59 minutes 0 – 59 seconds	R
00DDh	**Calibration code**	Calibration code	Numeric Value	1 – zero, 2 - calibration	R
00DEh	**Reserved**	Reserved	Numeric Value	0	R
00DFh	**Calibration Event Count**	Total Calibration Event Count	Numeric Value	0 - 65535	R

Table 8: List of Modbus Registers

1.4 IR400 Command Register Details

1.4.1 Analog

A read returns a value, which is proportional to the 0-20mA output current. The current is based on a 16-bit value. The master scaling is 0 - 65535 Decimal which corresponds to the IR400 scaling which is 0 - 21.7mA.

1.4.2 Operating Mode (Read/Write)

This register reports on the current operating mode for the IR400 detector. A Read command returns the present IR400 mode, represented by the enabled bit. The following table shows the mode represented by each bit in the 16-bit register.

Table 9: Bitmap for Operating Mode Register (Read-Only Access)

Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Mode	Not Used	Initial Mode	Remove Gas (CAL Finished)	Apply Gas	CAL Pending	Zero Mode	CAL Mode	Run Mode
Bit Value	**80 hex 128 decimal**	**40 hex 64 decimal**	**20 hex 32 decimal**	**10 hex 16 decimal**	**8 hex 8 decimal**	**4 hex 4 decimal**	**2 hex 2 decimal**	**1 hex 1 decimal**

Bit	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**
Mode	Not Used	Not Used	Not Used	Not Used	Not Used	Zero & CAL Mode	Gas Check Mode	Not Used
Bit Value	**8000 hex 32768 decimal**	**4000 hex 16384 decimal**	**2000 hex 8192 decimal**	**1000 hex 4096 decimal**	**800 hex 2048 decimal**	**400 hex 1024 decimal**	**200 hex 512 decimal**	**100 hex 256 decimal**

1.4.2.1 Mode Descriptions (0x0001)

A Read command returns the present IR400 mode, represented by the enabled bit. Descriptions of the modes are provided below.

- **Run Mode:** IR400 normal operation mode, with LEL measurement taking place. Writing 1 to mode register allows to abort zero/calibration/gas check, if gas concentration is less then 5% of Full Scale
- **CAL Mode:** Calibration in progress at 50% LEL. Can write 0x0002 only during CAL pending mode, which lasts 30 sec
- **Zero Mode:** Zeroing of the IR400 in progress. Writing 0x0004 to mode register sends the unit to zero mode.
- **CAL Pending**: If 0x0002 is written to mode register during this stage, the unit starts calibration, otherwise the unit returns to run mode in 30 seconds.
- **Apply Gas:** Waiting for 50% LEL gas to proceed with calibration
- **Remove Gas (CAL finished):** IR400 calibration has finished, remove gas.
- **Startup Mode:** IR400 is initializing during powerup.
- **Gas Check Mode:** IR400 gas check is in progress
- **Zero and CAL Mode:** Zeroing directly following by calibration. Writing 0x4000 to mode register will send the unit to zeroing mode, then to calibration, bypassing calibration pending stage.

1.4.3 Status Error (0x0002)

A Read returns the bit map for any error that is presently occurring. The following table shows the errors that are represented by each bit in the register.

Table 10: Bitmap for Status Error Delayed

Bit Position	**3**	**2**	**1**	**0**
Error	**IR High**	**Beam Block**	**Clean Windows (Negative Gas Reading)**	**Partial Beam Block**
Bit Value	8 hex / 8 decimal	4 hex / 4 decimal	2 hex / 2dec	1 hex / 1 decimal

Bit Position	**7**	**6**	**5**	**4**
Error	**Failed to Zero**	**Calibration Mode Fail**	**Low Line Condition**	**Wire Shortage**
Bit Value	80 hex / 128 decimal	40 hex / 64 decimal	20 hex / 32 decimal	10 hex / 16 decimal

Bit Position	11	10	9	8
Error	Heater problem	Ref. Lamp Problem	Active Lamp Prob.	Test forgotten (remove gas)
Bit Value	800 hex / 2048 decimal	400 hex / 1024 decimal	200 hex / 512 decimal	100 hex / 256 decimal

Bit Position	16	15	14	13
Error	EEPROM Error	Excess Neg. Gas Reading	Misc. fault	Clipping fault
Bit Value	8000 hex / 32768 decimal	4000 hex / 16384 decimal	2000 hex / 8192 decimal	1000 hex / 4096 decimal

1.4.4 Gas Selection (0x0003)

Reads/Sets gas selection for the detector. This register is compatible with IR2100 Modbus. The register can be written with the index numbers 0 to 7 or with the Gas ID. The Gas ID codes will not change in future versions and are consistent across General Monitors products. To read the Gas ID use register 0x008D.

Table 9. Gas Selection Codes

Index	Gas Type	Gas ID
0	Methane	100 ISO / 114 IEC
1	Propane	101 ISO / 115 IEC
2	N Butane	104 ISO / 120 IEC
3	Hexane	103 ISO / 121 IEC
4	% by volume Methane	106
5	Special Order	Unique for Each Gas
6	Ethane	102 ISO / 116 IEC
7	Pentane	105 ISO / 117 IEC

1.4.5 Model Type (0x0004)

A Read returns the model type for the detector, which is 2104 in Decimal format.

1.4.6 Software Rev (0x0005)

A read returns the software revision of the IR400 in 2 ASCII characters. The most significant byte is the first character, the least significant byte is the second character. For example, if this register reads 0x2042 then the first digit is 0x20 (a space character) and the second is 0x42 (the character B). So in this example the firmware version is " B".

1.4.7 Gain (0x0006)

A read returns the value of the gain. The difference between the initial value and the present value indicates the dirt on the windows. This register is provided for compatibility with the IR2100. A new register 0x0054 gives a beam block percentage which is scaled in a much more convenient way.

1.4.8 Calibration IO type (0x0007)

When the Cal IO type is set to LED Magnet switch, LED is blinking during zeroing/calibration and when the unit is in fault. Solenoid is disabled. If it is set to manual solenoid or ARGC, the LED driver is disabled from blinking error codes etc. It then can be used to drive a solenoid. A write command enables/disables the normal LED function. The solenoid function cannot be used until the LED function is disabled.

Function	Value (Decimal)
Magnet LED Switch	0
Manual solenoid	1
AGRG	2

Table 12: Cal IO types

Cal IO type can't be change is solenoid is ON.

1.4.9 Solenoid On/Off (0x0008)

This feature is used for Calibration and Gas check. If Cal IO type is Magnet LED Switch, solenoid is disabled.

A write command can be used only if Cal IO type is set to manual solenoid. In case of ARGC solenoid turns on and off automatically.

Function	Value (Decimal)	Access
On	10	Read/Write
Off	20	Read/Write
Normal Operation	30	Read

Table 13: Solenoid On/Off

Exception – If a value other than 10 or 20 is used in write command, then the Exception Code 03 is returned.

1.4.10 Address (0x0009)

A read returns the address of the IR400. A write changes the address to the requested address. The range of the address is 1 to 247.

- **NOTE:** By grounding the RESET input during power-up cycle (10 seconds), the Address will default to 1.

1.4.11 Baud Rate (0x000B)

A read returns the baud rate of the IR400. A write changes the baud rate to the requested baud rate. After the baud rate has been changed to the addressed unit, the Modbus communications will cease because the baud rate has changed; therefore the master will have to change its baud rate to the slave's new baud rate in order to re-start the communications. The factory default is 9600.

Baud Rate Codes

Code	Function	Access
1. 03	19200	Read/Write
02	9600	Read/Write
01	4800	Read/Write
00	2400	Read/Write

This function is indicated on the Low Data Byte and the High Data Byte is not used.

Exception – If the baud rate is not in range an Illegal data value (03) is returned.

- **NOTE:** By grounding the magnetic switch (holding a magnet over the switch) input during power-up cycle (10 seconds), the IR400 Baud Rate will default to 19600.

1.4.12 Data Format (0x000C)

A read returns the data format of the IR400. A write will change the data format to the requested data format. After the data format has been changed, the addressed unit may cease or start producing Comm. errors because the data format has changed; therefore, the master will have to change its data format to the slave's new data format in order to re-start or provide proper communications.

Data	Parity	Stop	Format	Low Data Byte	Access
8	None	1	8-N-1	00	Read/Write
8	Even	1	8-E-1	01	Read/Write
8	Odd	1	8-O-1	02	Read/Write
8	None	2	8-N-2	03	Read/Write

Table 10: Data Format

This function is indicated on the Low Data Byte and the High Data Byte is not used.

- **NOTE:** By grounding the magnetic switch input during power-up cycle (10 seconds), the IR400 Data Format will default to 8-N-1.

Exception – If the baud rate is not in range an Illegal data value (03) is returned.

1.4.13 Priority Fault (0x000D)

A read returns the primary fault currently happening on the device. See Table .

1.4.14 Hazard Watch Options (0x0016)

A read returns the state enabled or disabled. A write of (1) enables Hazard Watch mode. A write of (0) disables Hazard Watch mode.

1.4.15 Alarm Level (0x0018)

Sets/reads minimum gas concentration level in % of Full Scale, when alarm event is logged

1.4.16 Warn Level (0x0019)

Sets/reads minimum gas concentration level in % of Full Scale, when warn event is logged

1.4.17 HART Configuration (0x001A)

0 in low byte means HART disabled, 1 – HART enabled. 0 in high byte means low current range (1.25 -20 mA), 1 - high current range (3.5 – 20mA).

1.4.18 Total Receive Errors (0x0020)

A read indicates the total Modbus Comm. Receive Errors that occurred in the slave device. The maximum count is 65,535; the counter will roll over to zero and begin counting again. The total errors are an accumulation of the individual Comm. errors listed below.

1.4.19 Function Code Errors (0x0022)

A read indicates the number of Function Code Errors that occurred in the slave device. The maximum count is 65,535 the counter will roll over to zero and begin counting again.

1.4.20 Starting Address Errors (0x0023)

The counter is incremented for illegal register address.

A read indicates the number of Starting Address Errors that occurred in the slave device. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

1.4.21 CRC Hi Errors (0x0025)

A read indicates the number of CRC Hi Byte Errors that occurred in the slave device. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

1.4.22 CRC Lo Errors (0x0026)

A read indicates the number of CRC Lo Byte Errors that occurred in the slave device. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

1.4.23 Overrun Errors (0x0027)

A read indicates the number of Overrun Errors that occurred in the slave device. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

1.4.24 Framing Errors (0x0029)

A read indicates the number of Framing Errors that occurred in the slave device. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

1.4.25 Clear Communication Errors (0x002D)

A read or write resets all the Modbus Comm. Error counters to zero.

1.4.26 Beam Block Percentage (0x0054)

This register returns a value from 0-100. When the optical path of the IR400 is clear, the reading is 0% blocked. When the register reads near 100 the optical path is blocked and must be cleaned immediately. At 100% the IR400 indicates a fault condition and is no longer capable of detecting gas. This register can be used for predictive maintenance.

1.4.27 Gas ID (0x008D)

This register provides a way to read the unique Gas ID number for the currently selected gas. The table below shows the numbers for the gasses available in the IR400. This list will be extended as more gasses are made available and will be consistent across General Monitors' product range.

Gas ID number (decimal)	Gas Type
100	Methane
101	Propane
102	Ethane
103	Hexane
104	n-Butane
105	Pentane
106	% by volume Methane
108	Ethylene
109	Benzene
114	Methane IEC
115	Propane IEC
116	Ethane IEC
117	Pentane IEC
120	n-Butane IEC
121	Hexane IEC

1.4.28 Reset Events (0x00B0)

Writing 0 to this register clears all event counters, writing 1 – resets event happened flag.

1.4.29 Running Time in seconds hi word (0x00B1)

This sets/reads hi word of device running time in seconds. This value must be read/written prior to running time low byte (register 0x00B2).

1.4.30 Running Time in seconds lo word (0x00B2)

This sets/reads hi word of device running time in seconds. This value must be read/written after running time hi byte (register 0x00B1).

Table 15: Real Time Clock Time Format

Item Number	Description
1	Hi Byte =Year, Low Byte = Month
2	Hi Byte = Day, Low Byte = Hour
3	Hi Byte = Minute, Low Byte = Second

1.4.31 Real-time Clock Year, Month (0x00B3)

This is used to read/write the real time clock. The high byte will be the year minus 2000. The low byte will be a value from 1 to 12. To get or set real time, read or write year/month (0x00B3) first, then day/hour (0x00B4), then min/sec (0x00B5)

1.4.32 Real-time Clock Day, Hour (0x00B4)

This is used to read/write the real time clock. The high byte will be the day of the month from 1 to 31. The low byte will be the hour from 0 to 23. To get or set real time, read or write year/month (0x00B3) first, then day/hour (0x00B4), then min/sec (0x00B5)

1.4.33 Real-time Clock Minute, Second (0x00B5)

This is used to read/write the real time clock. The high byte will be the minute from 0 to 59 and the low byte will be the seconds from 0 to 59. To get or set real time, read or write year/month (0x00B3) first, then day/hour (0x00B4), then min/sec (0x00B5)

1.4.34 Power Cycle Flag (0x00B7)

This reads whether the time of day clock has been reset after a power has been re-cycled to the unit. If the time has been reset, this flag will be = 0; otherwise the flag will = 1.

1.4.35 Event Index (0x00B7)

This is used to indicate which of the stored events the user would like to read. There are 5 event logs: Warning events, Alarm events, Fault events, Calibration events and Maintenance events. Each of these event logs consist of 10 of their most recent occurrences. The user is able to read the logs of each of these by setting this event index followed by a reading of the desired event log. The event index is a number from 0 to 9. Zero refers to the most recent event and 9 refers to the least recent event stored in the log. For example to read time of the most recent Warning event in the Warning event log, set this register to 0 and then read registers 0xB8 and 0xB9 (for the running time in seconds) or read registers 0xBA, 0xBB, and 0xBC (for the clock time).

1.4.36 Warning Running Time in Seconds, Hi Word (0x00B8)

This register reads hi word of the running time in seconds when the warning event occurred. This time is in seconds since January 1, 2000.

1.4.37 Warning Running Time in Seconds, Low Word (0x00B9)

This register reads the low word of the running time in seconds when the warning event occurred. This time is in seconds since January 1, 2000.

The values from the above table should be read in order: first item 1, then item 2, & then item 3.

1.4.38 Warning Clock Time: Year, Month (0x00BA)

These registers are described in Table as item number 1.

1.4.39 Warning Clock Time: Day, Hour (0x00BB)

These registers are described in Table as item number 2.

1.4.40 Warning Clock Time: Minute, Second (0x00BC)

These registers are described in Table as item number 3.

1.4.41 Total Warning Event Counter (0x00BF)

This reads the total number of warning events have been stored in the unit.

1.4.42 Alarm Running Time in Seconds, Hi Word (0x00C0)

This register reads the high word of the running time in seconds when the alarm event occurred. This time is in seconds since January 1, 2000.

1.4.43 Alarm Running Time in Seconds, Low Word (0x00C1)

This register reads the low word of the running time in seconds when the alarm event occurred. This time is in seconds since January 1, 2000.

1.4.44 Alarm Clock Time: Year, Month (0x00C2)

These registers are described in Table as item number 1.

1.4.45 Alarm Clock Time: Day, Hour (0x00C3)

These registers are described in Table as item number 2.

1.4.46 Alarm Clock Time: Minute, Seconds (0x00C4)

These registers are described in Table as item number 3.

1.4.47 Total Alarm Event Counter (0x00C7)

This reads the total number of alarm events have been stored in the unit.

1.4.48 Fault Running Time in Seconds, Hi Word (0x00C8)

This register reads the high word of the running time in seconds when the fault event occurred. This time is in seconds since January 1, 2000.

1.4.49 Fault Running Time in Seconds, Low Word (0x00C9)

This register reads the low word of the running time in seconds when the fault event occurred. This time is in seconds since January 1, 2000.

1.4.50 Fault Clock Time: Year, Month (0x00CA)

These registers are described in Table as item number 1.

1.4.51 Fault Clock Time: Day, Hour (0x00CB)

These registers are described in Table as item number 2.

1.4.52 Fault Clock Time: Minute, Seconds (0x00CC)

These registers are described in Table as item number 3.

1.4.53 Fault Code (0x00CD)

This register is described in Table .

1.4.54 Total Fault Event Counter (0x00CF)

This reads the total number of fault events have been stored in the unit.

1.4.55 Maintenance Running Time in Seconds, Hi Word (0x00D0)

This register reads the high word of the running time in seconds when the gas check event occurred. This time is in seconds since January 1, 2000.

1.4.56 Maintenance Running Time in Seconds, Low Word (0x00D1)

This register reads the low word of the running time in seconds when the gas check event occurred. This time is in seconds since January 1, 2000.

1.4.57 Maintenance Clock Time: Year, Month (0x00D2)

These registers are described in Table as item number 1.

1.4.58 Maintenance Clock Time: Day, Hour (0x00D3)

These registers are described in Table as item number 2.

1.4.59 Maintenance Clock Time: Minute, Seconds (0x00D4)

These registers are described in Table as item number 3.

1.4.60 Total Maintenance Event Counter (0x00D6)

This reads the total number of gas check events have been stored in the unit

1.4.61 Calibration Running Time in Seconds, Hi Word (0x00D8)

This register reads the high word of the running time in seconds when the calibration event occurred. This time is in seconds since January 1, 2000.

1.4.62 Calibration Running Time in Seconds, Low Word (0x00D9)

This register reads the low word of the running time in seconds when the calibration event occurred. This time is in seconds since January 1, 2000.

1.4.63 Calibration Clock Time: Year, Month (0x00DA)

These registers are described in Table as item number 1.

1.4.64 Calibration Clock Time: Day, Hour (0x00DB)

These registers are described in Table as item number 2.

1.4.65 Calibration Clock Time: Minute, Seconds (0x00DC)

These registers are described in Table as item number 3.

1.4.66 Calibration Code (0x00DD)

This returns 1 for zero events and 2 for calibration events.

1.4.67 Total Calibration Event Counter (0x00DF)

This reads the total number of calibration events have been stored in the unit.