



Modbus Interface Specification

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Document Conventions

The following typographic conventions are used in this document.

Convention	Description
Bold	Used to denote: emphasis Used for names of menus, menu options, toolbar buttons
<i>Italics</i>	Used to denote: references to other parts of this document or other documents. Used for the result of an action

The following icons may be used in this document

Convention	Description
	Caution: This icon is used to indicate that there is a danger to equipment. The danger could be loss of data, physical damage, or permanent corruption of configuration details.
	Warning: This icon is used to indicate that there is a danger of electric shock. This may lead to death or permanent injury.
	Warning: This icon is used to indicate that there is a danger of inhaling dangerous substances. This may lead to death or permanent injury.

Contact Us

The Americas	+1 781 740 2223
Asia	+852 2916 8894
Australia and New Zealand	+61 3 9936 7000
Continental Europe	+32 56 24 19 51
UK and the Middle East	+44 1442 242 330
www.xtralis.com	

Codes and Standards Information for Air Sampling Gas Detection

We strongly recommend that this document is read in conjunction with the appropriate local codes and standards for gas detection and electrical safety. This document contains generic product information and some sections may not comply with all local codes and standards. In these cases, the local codes and standards must take precedence. The information below was correct at time of printing but may now be out of date, check with your local codes, standards and listings for the current restrictions.

FCC Compliance Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, the user is encouraged to try to correct the interference by one or more of the following measures; re-orientate or relocate the receiving antenna, increase the separation between the equipment and receiver, connect the equipment to a power outlet which is on a different power circuit to the receiver or consult the dealer or an experienced radio/television technician for help

Canada

This Class B digital apparatus complies with Canadian ICES-003.
Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

EU Directive 2004/108/EC – EMC Directive

This equipment has been independently tested for compliance with the requirements of the harmonized standard

EN 50270:2006 - Electromagnetic Compatibility – Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen.

Electrical Safety

The ECO Detector has been designed to meet the performance requirements of the following standards for electrical safety.

EN 61010-1:2001 - Safety requirements for electrical equipment for measurement, control and laboratory use. General Requirements

Gas Detection

The ECO Detector has been designed to meet the performance requirements of the following standards for gas detection.

- EN 50271:2002 - Electrical apparatus for the detection and measurement of combustible gases, toxic gases or Oxygen – Requirements and tests for apparatus using software and/or digital technologies.
- EN 50104:2002 - Electrical apparatus for the detection and measurement of Oxygen – Performance requirements and test methods
- EN 45544:2000 - Workplace atmospheres – Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours

Terms and Abbreviations

The following is a list of common terms and conditions relating the product and gas detection in general that may be used in connection with this document.

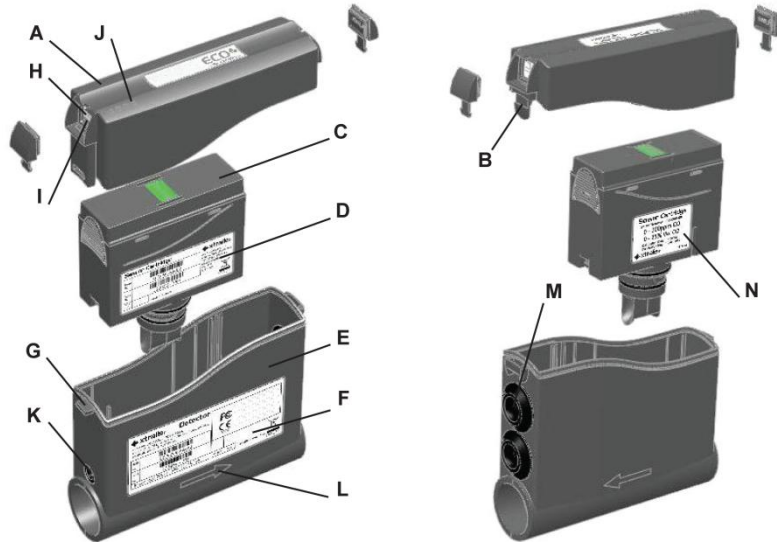
ASD	Aspirating Smoke Detector
Analogue Output	A controlled current output, where the level is set to indicate a measured gas value on a linear scale
Bump Testing	A periodic application of gas to the product to verify its function
BSP	British Standard Pipe
CE	Product Mark that Indicates compliance to all relevant European directives.
CSA	Cross sectional area
EMC	Electromagnetic Compatibility. A measure of an electrical products susceptibility to and emission of EMI.
EMI	Electromagnetic Interference
EU	European Union
IEC	The International Electro-technical Committee, publishes internationally recognized product design standards.
LED	Light Emitting Diode, an indicating device which emits light of a specific colour when powered
LEL	Lower Explosive Limit, the minimum concentration, expressed as a percentage of volume, of a flammable gas in air that will generate an explosion if ignited. Also referred to as the LFL. This value is different for each type of flammable gas, and is defined by the appropriate local regulations for explosive atmospheres.
%LEL	An indication of a gas concentration expressed as a percentage of the LEL
LFL	Lower Flammable Limit, see LEL
%LFL	An indication of the gas concentration as a percentage of the LFL
LTEL	Long Term Exposure Limit, the limit of exposure for a person to a gas over a period typically between 8 and 24 hours, calculated as a TWA value.
Modbus	A serial communications protocol published by the ModbusIDA for use with programmable logic controllers (PLCs). It is a commonly available means of connecting industrial electronic devices.
ppm	Parts per million, an indication of gas concentration as a fraction of the overall sample. 10000 ppm is the equivalent of 1% of volume.
RFI	Radio Frequency Interference
%RH	Relative Humidity, the limit of exposure for a person to a gas over a period typically between 5 and 20 minutes, calculated as a continuous average.
RoHS	Restrictions of Hazardous Substances, EU Commission directive 2002/95/EC on the restrictions of usage of specified chemicals in the production of electronic products and components
RTC	Real Time Clock. An internal clock which maintains a count of the current date and time, including during periods when the unit is unpowered.
RTU	Remote Terminal Unit, a transmission method used by the Modbus Communications Protocol
STEL	Short Term Exposure Limit, the limit of exposure for a person to a gas over a period typically between 5 and 20 minutes, calculated as a continuous average.
T _{xx} Time	The response time of the gas sensor to a step change in the input gas level to "XX"% of the final reading, e.g. T ₉₀ is the time taken for the measurement to reach 90% of a step change in the gas input level.
TWA	Time Weighted Average.
UL	Underwriters Laboratory, approval and certification of products in North America
USB	Universal Serial Bus, a serial interface standard for connecting PCs to peripheral devices
% v/v	An expression of the gas concentration as a percentage of the overall volume, also referred to as % Vol. or % Volume.
WEEE	Waste Electronic and Electrical Equipment, EU Commission directive 2002/96/EC on the disposal of electrical and electronic equipment

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Overview

This specification describes the implementation of the Modbus interface on the ICAM ECO Aspirated Gas Detector product. The ICAM ECO Detector is a dual channel gas detector designed for use in aspirated sampling systems. With respect to the Modbus interface, connection is made to the product via either the RS485 connection terminals supplied on the Main IO PCB contained within the Enclosure Cover, or the USB interface connector located at the end of the enclosure cover. Details of the RS485 connection can be found in the installation section of the ECO Product Guide.



- | | | | |
|---|------------------------|---|-----------------------|
| A | Enclosure Cover | H | USB Connection |
| B | Enclosure Cover Latch | I | microSD Card location |
| C | Sensor Cartridge | J | Status Indicators |
| D | Sensor Cartridge Label | K | Gas Test Port |
| E | Enclosure Body | L | Flow indication Arrow |
| F | Main Product Label | M | Cable Entry |
| G | Enclosure Cover Hinge | N | Calibration Label |

The purpose of this specification is to provide details of the Modbus interface implementation made within the ECO product with respect to the register mapping, data types and data limits. For details of the functional use and reporting of the ECO and the data variables listed within this document, please refer to the Principles of Operation section of the ECO Product Guide.

Modbus Interface

The Modbus interface as implemented in the ECO product is defined by the Modbus-IDA organization in the following standards.

Modbus Application Protocol, V1.1a – 2004
Modbus Over Serial Line, V1 – 2002

Physical Interface

The physical connection to the ECO Modbus interface can be made either via the RS485 interface terminals or the USB connection provided. Details of the electrical connections to the RS485 terminals are provided in the ECO Product Guide supplied with the ECO. Connection via the USB port requires a standard mini-B USB cable connector and a Virtual Com Port Driver, as explained in the ECO Product Guide.

Communications Settings

The Modbus interface of the ECO Detector is implemented using the RTU mode of operation as defined in the above specifications. The default communications settings for the ECO are as follows.

Modbus Address	1
Baud Rate	19200 Baud
Data Bits	8
Parity	Even
Stop Bits	1

These are only applicable when communicating via the RS485 serial interface on the ECO. All communications settings and Modbus addresses are transparent when using the USB interface. Refer to the Modbus Interface Configuration Registers on page 14 for details of the configuration of these settings

Modbus Functions Supported

Not all of the Command codes defined in the Modbus standard are currently supported by the ECO device. Those that are supported are as follows

Function No.	Function Name
04	Read Input Registers
03	Read Holding Registers
06	Write Single Register
16	Write Multiple Registers
05	Write Single Coil

Data Types

The registers within the ECO Modbus map support variables with a number of different data types. Each of these data types has a defined format and range of values it can represent. Most of these are standard formats widely recognized in the engineering industry, being defined in the ANSI/ISO C language standard. There are also a number of ECO specific data types which are defined to encode specific ECO data variables.

The standard Modbus register type is a 16 bit (2 Byte) word. Any of the data types listed below which are equal to or less than 16 bits will therefore be contained in a single register location. Those data types which are larger than 16 bits use as many consecutive register locations as are required to hold the data. e.g. a Floating Point data type requires 32 bits (4 bytes) and will therefore be contained in two consecutive register locations.

When transmitting or receiving data using the Modbus protocol, for each register that is transmitted/received the high byte is transmitted first followed by the low byte. When a data type is one that is contained in more than one register, the first register sent/received will be the MOST significant word of the data type. The last register sent/received will be the LEAST significant word. As a result the transmission order of any data type will be Most Significant Byte first.

Generic Data Types

The following are standard data types

Unsigned Char	:	8 Bit Integer, value range from 0 to 255 Referenced using one 16 bit Modbus Register, held in the LS Byte of the register
Signed Char	:	8 Bit Integer, value range from -128 to 127 Referenced using one 16 bit Modbus Register, held in the LS Byte of the register
Unsigned Short	:	16 Bit Integer, value range from 0 to 65535 Referenced using one 16 bit Modbus Register
Signed Short	:	16 Bit Integer, value range from -32768 to 32767 Referenced using one 16 bit Modbus Register
Unsigned Long	:	32 Bit Integer, value range from 0 to 4294967295 Referenced using two 16 bit Modbus Registers
Signed Long	:	32 Bit Integer, value range from - 2147483648 to 2147483647 Referenced using two 16 bit Modbus Registers
Float	:	32 Bit Floating Point Number encoded according to IEE754 standard. Value range of $\pm 1 \times 10^{38}$ Referenced using two 16 bit Modbus Registers
Double	:	64 Bit Double Precision Floating Point Number encoded according to IEE754 standard. Value range of $\pm 1 \times 10^{308}$ Referenced using four 16 bit Modbus Registers

ECO Specific Data Types

The following are data types specifically defined for the ECO interface

Software Version	:	The Software version data type is encoded in an Unsigned Long standard data type as defined above. Within this 32 bit value the Software Version is encoded as follows. Most Significant Byte of First (Most Significant) 16 Bit Word – Software Major Version Least Significant Byte of First (Most Significant) 16 Bit word – Software Minor Version Second (Least Significant) 16 bit Word – Software Sub Version
Hardware Version	:	The Hardware version data type is encoded in an Unsigned Long standard data type as defined above. Within this 32 bit value the Hardware Version is encoded as follows. First (Most Significant) 16 Bit Word – PCB Drawing Number Most Significant Byte of Second (Least Significant) 16 Bit word – PCB Drawing Revision Least Significant Byte of Second (Least Significant) 16 bit Word – PCB Build Version
Time	:	The Time data type is encoded in an Unsigned Long standard data type as defined above. Within this 32 bit value the date and time is encoded as a count (in seconds) from 00:00 on 1 st January 2000. This value does not take account of time zones or daylight savings time, so these must be set appropriately for the installation location.
String	:	The String data type is an array of Unsigned Short standard data types as defined above. Each unsigned short, and therefore Modbus Register, in the array contains a UTF-16 format character. The size of the array depends on the specific variable being referenced.
Array	:	The Array data type is a group of data types of a specified size held in consecutive register locations. The decoding of the data types is specific to the register definition.

ECO Modbus Interface

The Modbus interface implemented in the ECO product complies with the requirements of the previously noted Modbus specifications. In these specifications there are a number of aspects of the implementation that are left to the interpretation of the designer in order to best fit the product being designed.

Register Map Structure

The register map for the ECO product, as detailed in the following sections, is organized so that there are no common register numbers between the different register types (Input/Holding/Coils/Discrete Inputs etc). The overall structure of the ECO Modbus Register map is arranged to provide a consistent and intuitive structure with space for future expansion should it be required.

System Holding Registers	00000	Gas Sensor 1 Holding Registers	11000
	00399		11399
System Input Registers	00400	Gas Sensor 1 Input Registers	11400
	00699		11799
System Command Coils	00800	Gas Sensor 1 Command Coils	11800
	00999		11999
Relay 1 Registers	01100	Gas Sensor 2 Holding Registers	12000
	01199		12399
Relay 2 Registers	01200	Gas Sensor 2 Input Registers	12400
	01299		12799
Relay 3 Registers	01300	Gas Sensor 2 Command Coils	12800
	01399		12999
Relay 4 Registers	01400	Reserved	13000
	01499		19999
Reserved	01500	Reserved	20000
	01999		59999
Analogue Output 1 Registers	02100	Reserved	60000
	02199		65535
Analogue Output 2 Registers	02200		
	02299		
Reserved	02300		
	09999		

Access Permissions

Most of the configuration variables within the ECO are protected by password access to ensure that only suitably authorized personnel can re-configure the unit. There are three levels of Password access

- User
- Administrator
- Distributor

Each password level has a unique number associated with it which must be sent to the "Login " holding register (see page 8) to gain permission to modify the associated configuration settings.

Changing Configuration Data

The Modbus protocol provides a number of “Exception” conditions to communicate when invalid requests are made, these are commonly

- “Illegal Function” – The Modbus function is not valid or not supported by this device (see page 2 above)
- “Illegal Data Address” – The register Address requested is invalid.
- “Illegal Data Value” – The data type requested is invalid, by implication this is the number of registers requested.

The Modbus protocol does not have an exception response for cases where a change to the contents of a holding register is outside of the defined limits for that register. The validation of transmitted values is solely the responsibility of the application using the Modbus interface. In the case of the ECO the internal firmware will check a received value against the access permission for that register (see above) and its Minimum and Maximum permissible limits. The limits of some of the configuration settings within the ECO are dependent on the value of other settings.

In the following section the access permissions and limits for each configuration setting are documented. When a received value fails any of these validity tests the ECO will set the “Write Failed” minor fault flag (see page 9) and reject the received value. This flag will remain set until the next successful (valid) configuration change is made.

Command Coils

The ECO Modbus interface implementation uses the “Write Single Coil” function to initiate actions and control commands for such things as calibration and configuration. The value written is not significant (0 or 1) but like all of the configuration settings the command coil addresses are protected by the access passwords as described above.

ECO Register Structure

Identification Data Registers

ECO Serial Number : Register Number - 2
 Register Type - Holding Register
 Data Type - Unsigned Long (2 registers)

The Device Serial Number is a unique 32 bit number allocated to the ECO, also indicated on the exterior label of the device.

ECO Unique ID : Register Number - 4
 Register Type - Holding Register (Read Only)
 Data Type - Array (6 registers)

The Device Unique ID is a unique 96 bit value hard coded into the microcontroller used within the Main IO PCB of the ECO device.

Manufacturer : Register Number - 10
 Register Type - Holding Register
 Data Type - String x32 (32 registers)

The Manufacturer registers contain a 32 character UTF-16 string of the manufacturer's name, configured during manufacture.

ECO Date of Manufacture : Register Number - 42
 Register Type - Holding Register
 Data Type - Time (2 registers)

The Date of Manufacture is a record of the date of manufacture of the product.

ECO Software Version : Register Number - 44
 Register Type - Holding Register (Read Only)
 Data Type - Software Version (2 registers)

The Software Version register is a record of the firmware release revision currently programmed into the Main IO PCB.

ECO Hardware Version : Register Number - 46
 Register Type - Holding Register (Read Only)
 Data Type - Hardware Version (2 registers)

The Hardware Version register is a record of the drawing number, Revision and build of the Main IO PCB fitted within the ECO product.

ECO Sensor Cartridge Serial Number : Register Number - 48
 Register Type - Holding Register
 Data Type - Unsigned Long (2 registers)

The Sensor Cartridge Serial Number is a unique 32 bit number allocated to the ECO Sensor cartridge, also indicated on the exterior label of the cartridge and the main ECO enclosure.

ECO Sensor Cartridge	Register Number	-	50
Unique ID	Register Type	-	Holding Register (Read Only)
	Data Type	-	Array (6 registers)

The Sensor Cartridge Unique ID is a unique 96 bit value hard coded into the microcontroller used within the ECO Sensor Cartridge.

ECO Sensor Cartridge	Register Number	-	56
Date of Manufacture	Register Type	-	Holding Register
	Data Type	-	Time (2 registers)

The Date of Manufacture is a record of the date of manufacture of the Sensor Cartridge fitted within the ECO product.

ECO Sensor Cartridge	Register Number	-	58
Software Version	Register Type	-	Holding Register (Read Only)
	Data Type	-	Software Version (2 registers)

The Sensor Cartridge Software Version register is a record of the firmware release revision currently programmed into the Sensor Cartridge.

ECO Sensor Cartridge	Register Number	-	60
Hardware Version	Register Type	-	Holding Register
	Data Type	-	Hardware Version (2 registers)

The Sensor Cartridge Hardware Version register is a record of the drawing number, revision and build of the PCB assembly fitted within the Sensor Cartridge.

Location	Register Number	-	62
	Register Type	-	Holding Register
	Data Type	-	String x32 (32 registers)
	Default Value	-	'UNKNOWN'
	Access Permission	-	Administrator

A text field provided to the user for labeling of the installation location of the ECO.

Login	Register Number	-	100
	Register Type	-	Holding Register
	Data Type	-	Unsigned Long (2 registers)
	Minimum Value	-	0
	Maximum Value	-	4294967295

The login register is used to enter a password to enable the appropriate write access permissions to the required registers (Refer to page 5 for further details).

Device Time	Register Number	-	200
	Register Type	-	Holding Register
	Data Type	-	Time (2 registers)
	Minimum Value	-	0
	Maximum Value	-	4294967295
	Access Permission	-	Administrator

The current system time of the ECO device.

Status Registers

Counter	:	Register Number	-	400
		Register Type	-	Input Register
		Data Type	-	Unsigned Long (2 registers)

The counter register is a value which increments continually to enable users to ensure that when read along with the status and fault register values, that the data being transmitted is being correctly updated by enforcing a change in the checksum calculation result. When in normal and correct operation the Status and Fault flags will not be changing, and thus the transmitted data, if read individually, will always be the same

System Status Flags	:	Register Number	-	402
		Register Type	-	Input Register
		Data Type	-	Unsigned Long (2 registers)

The 32 binary digits of the status flags registers represent 32 flags which indicate the functional status of the ECO device. Not all of these are currently defined.

Bit	Flag Function
0	Sensor 1 Status - Indicates one of the Sensor 1 Status flags is set, refer to page 30
1	Sensor 2 Status - Indicates one of the Sensor 2 Status flags is set, refer to page 30
2	NOT USED
3	NOT USED
4	NOT USED
5	System Store - A change to the ECO system configuration has occurred and a "Store System Configuration" action is pending.
6	Module Store - A change to the ECO Sensor Cartridge configuration has occurred and a "Store Sensor Module Configuration" action is pending. The sensor cartridge will automatically save outstanding changes after 10 seconds.
7	USB Connected – Indicates that a connection has been made to the USB port on the side of the ECO
8	User Password Active – The device has received a valid User Login password
9	Administrator Password Active – The device has received a valid Administrator Login password
10	Distributor Password Active – The device has received a valid Distributor Login password
11	NOT USED
12	Digital Input State – The current state of the digital input (Active Low , 0)
13	NOT USED
14	NOT USED
15	SD Card Present – When set to 1 this flag indicates that there is an SD Card fitted
16	Flow Normalization – A Flow Normalization operation has been initiated and is in progress
17	NOT USED
18	Module Failure – Internal communications with the sensor cartridge have failed
19	Power Up Inhibit – This flag is set after the power on startup delay period has expired, indicating that Alarm processing is now active and calibration is permitted
20	Relay 1 Energized – Indicates the state of Relay 1, 0 = De-energized, 1 = Energized
21	Relay 2 Energized – Indicates the state of Relay 2, 0 = De-energized, 1 = Energized
22	Relay 3 Energized – Indicates the state of Relay 3, 0 = De-energized, 1 = Energized
23	Relay 4 Energized – Indicates the state of Relay 4, 0 = De-energized, 1 = Energized
24	Event Records – Event log data is available
25	NOT USED
26	NOT USED
27	NOT USED
28	NOT USED
29	NOT USED
30	Module OK – The internal sensor cartridge is connected and functioning
31	NOT USED

System Minor Fault Flags :	Register Number	-	404
	Register Type	-	Input Register
	Data Type	-	Unsigned Long (2 registers)

The 32 binary digits of the Minor Fault flags registers represent 32 flags which indicate warning conditions present within of the ECO device. Warnings are those instrument conditions that **DO NOT** directly affect the measurement and/or indication of gas levels and/or alarm conditions. Not all of these are currently defined.

Bit Flag Function

0	Sensor 1 Minor Fault - Indicates one of the Sensor 1 Minor Fault flags is set, refer to page 31
1	Sensor 2 Minor Fault - Indicates one of the Sensor 2 Minor Fault flags is set, refer to page 31
2	NOT USED
3	NOT USED
4	NOT USED
5	Power Event – The power supply to the device has been interrupted.
6	Re-boot Event – The device software has performed a restart not caused by power supply fluctuation or disturbance.
7	Write Failed – An attempt to modify a configuration variable has failed due to lack of access permission or an invalid value has been transmitted.
8	Calibration Failed – The last attempt to re-calibrate the device failed, due to noise or readings outside of specified range
9	Flow Normalization Failed – The attempt to perform a flow normalization operation has failed, due to insufficient or excessive flow, or a fault in the Flow measurement system.
10	NOT USED
11	NOT USED
12	Voltage Input Over-Range – The Input supply voltage to the device is in excess of the maximum specified supply voltage.
13	Voltage Input Under-Range – The Input supply voltage to the device is in less than the minimum specified supply voltage.
14	Current Input Over-Range – The Input supply current to the device is in excess of the maximum specified supply current, indicating that a fault is present.
15	NOT USED
16	NOT USED
17	Minor High Air Flow – The normalized flow reading is greater than the Minor Flow high threshold
18	Minor Low Air Flow – The normalized flow reading is less than the Minor Flow low threshold
19	NOT USED
20	NOT USED
21	NOT USED
22	NOT USED
23	NOT USED
24	NOT USED
25	NOT USED
26	NOT USED
27	SDCard Not Fitted
28	SD Card space low. The data log is approaching the maximum capacity of the micro SD Card
29	System RAM Configuration Error – The system configuration held in RAM has been corrupted and reloaded from memory
30	Sensor Cartridge RAM Configuration Error – The Sensor Cartridge configuration held in RAM has been corrupted and reloaded from memory
31	Sensor Cartridge Re-boot Event – The internal Sensor Cartridge software has performed a restart.

System Major Fault Flags :	Register Number	-	406
	Register Type	-	Input Register
	Data Type	-	Unsigned Long (2 registers)

The 32 binary digits of the Major Fault flags registers represent 32 flags which indicate fault conditions present within the ECO device. Faults are those instrument conditions that directly affect the measurement and/or indication of gas levels and/or alarm conditions. Not all of these are currently defined.

Bit Flag Function

0	Sensor 1 Major Fault - Indicates one of the Sensor 1 Major Fault flags is set, refer to page 32
1	Sensor 2 Major Fault - Indicates one of the Sensor 2 Major Fault flags is set, refer to page 32
2	NOT USED
3	NOT USED
4	NOT USED
5	System ROM – The cyclical system validation process has found a corruption of the program memory of the ECO main processor firmware.
6	System RAM – The cyclical system validation process has found a fault in one or more RAM memory locations of the ECO main processor
7	System Configuration Write Failed – An attempt to save the device configuration to non –volatile memory has failed
8	System Configuration read Failed – An attempt to load the device configuration from non –volatile memory has failed, if this occurs at startup the default settings will be applied to prevent erroneous operation of the unit.
9	System Software Failure – An error has occurred in the operation of the ECO main processor software
10	Sensor Cartridge ROM – The cyclical system validation process has found a corruption of the program memory of the ECO Sensor Cartridge processor firmware.
11	Sensor Cartridge RAM – The cyclical system validation process has found a fault in one or more RAM memory locations of the ECO Sensor Cartridge processor
12	Sensor Cartridge Configuration Write Failed – An attempt to save the Sensor Cartridge configuration to non –volatile memory has failed
13	Sensor Cartridge Configuration read Failed – An attempt to load the Sensor Cartridge configuration from non –volatile memory has failed, if this occurs at startup the default settings will be applied to prevent erroneous operation of the unit.
14	Sensor Cartridge Software Failure – An error has occurred in the operation of the ECO Sensor Cartridge processor software
15	Sensor Module Not Present – The ECO main PCB cannot detect the presence of a Sensor Cartridge.
16	SD Card Failed – The system is unable to access the SD Card fitted to the product.
17	Major High Air Flow – The normalized flow reading is greater than the Major Flow high threshold
18	Major Low Air Flow – The normalized flow reading is less than the Major Flow low threshold
19	NOT USED
20	Relay 1 Failure – The monitored state of relay 1 does match the requested condition, Open/Closed.
21	Relay 2 Failure – The monitored state of relay 1 does match the requested condition, Open/Closed.
22	Relay 3 Failure – The monitored state of relay 1 does match the requested condition, Open/Closed.
23	Relay 4 Failure – The monitored state of relay 1 does match the requested condition, Open/Closed.
24	NOT USED
25	NOT USED
26	Flow Sensor Failure – The sensor and/or circuit used to measure the flow in the device has failed
27	NOT USED
28	NOT USED
29	Module Configuration Different – The Module has been changed to a different type. This must be acknowledged by the user by Resetting the Factory defaults .
30	NOT USED
31	Detector Isolated – The Function of the Relays and Current outputs has been suspended.

Command Coils

Reset System : Coil Number - 800
Configuration to Defaults : Access Permission - Administrator

Writing to this coil address will reset the System Configuration settings to the default values.

Store System : Coil Number - 801
Configuration : Access Permission - Administrator

Writing to this coil address will store the current system configuration into non-volatile memory

Load System : Coil Number - 802
Configuration : Access Permission - Administrator

Writing to this coil address will load the last configuration stored in non-volatile memory into the system configuration.

Reset Status Flags : Coil Number - 815
 Access Permission - User

Writing to this command coil will clear all latched Alarm and Fault flags.

Isolate : Coil Number - 817
 Access Permission - User

Writing to this command coil will toggle the isolate feature of the ECO. When the device is "Isolated" . i.e. when the "Detector Isolated" flag is set in the system status Flags register (see page 10), the function of the of the Current Outputs and Relays is suppressed.

Normalize Air Flow : Coil Number - 818
 Access Permission - Administrator

Writing to this command coil will initiate a "Flow" normalization operation; this will set ECO to scale the current flow rate to give a reading of 100.

Modbus Interface Configuration Registers

When communicating via the USB connector these values are not used. For this reason the USB connection is the best method for setting and checking the RS485 bus configuration as it will not be affected by mismatches in the system. The default values stated are those required by the Modbus specification.

Modbus Address	:	Register Number	-	110
		Register Type	-	Holding Register
		Data Type	-	unsigned char (1 register)
		Default Value	-	1
		Minimum Value	-	1
		Maximum Value	-	247
		Access Permission	-	Administrator

The address of the device on the RS485 Modbus Bus. The limits and reserved values are defined by the Modbus specification.

Baudrate	:	Register Number	-	111
		Register Type	-	Holding Register
		Data Type	-	unsigned char (1 register)
		Default Value	-	1 (19200 Baud)
		Minimum Value	-	0 (9600 Baud)
		Maximum Value	-	4 (115200 Baud)
		Access Permission	-	Administrator

The value in this register defines the transmission rate on the Modbus RS485 connection. Power to the unit must be recycled to apply the change to the port. The permissible values from 0 to 4 represent the standard baud-rates 9600, 19200, 38400, 57600 and 115200.

Parity	:	Register Number	-	112
		Register Type	-	Holding Register
		Data Type	-	unsigned char (1 register)
		Default Value	-	1 (EVEN)
		Minimum Value	-	0 (NONE)
		Maximum Value	-	2 (ODD)
		Access Permission	-	Administrator

The value in this register defines the parity checking used on the Modbus RS485 connection. Power to the unit must be recycled to apply the change to the port. The number of stop bits will be set according to whether there is parity (1 stop bit) or not (2 stop bits) to maintain a consistent character length (11 bits).

Flow, Temperature and Humidity Registers

Temperature	:	Register Number	-	408
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register contains the measured air temperature (°C) of the air sample flow within the ECO

Humidity	:	Register Number	-	410
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register contains the measured Relative Humidity (as %RH) of the air sample flow within the ECO.

Flow	:	Register Number	-	412
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register contains the measured flow rate of the air sample within the ECO, normalized from 0 – 100 but not scaled to any specific units.

Urgent High Airflow	:	Register Number	-	128
		Register Type	-	Holding Register
		Data Type	-	Unsigned Char (1 register)
		Default Value	-	130
		Minimum Value	-	105
		Maximum Value	-	200
		Access Permission	-	Administrator

This register contains the flow threshold above which an Urgent High Flow Fault is activated.

Minor High Airflow	:	Register Number	-	129
		Register Type	-	Holding Register
		Data Type	-	Unsigned Char (1 register)
		Default Value	-	120
		Minimum Value	-	105
		Maximum Value	-	200
		Access Permission	-	Administrator

This register contains the flow threshold above which a Minor High Flow Fault is activated.

Urgent Low Airflow	:	Register Number	-	130
		Register Type	-	Holding Register
		Data Type	-	Unsigned Char (1 register)
		Default Value	-	70
		Minimum Value	-	25
		Maximum Value	-	95
		Access Permission	-	Administrator

This register contains the flow threshold below which an Urgent Low Flow Fault is activated

Minor Low Airflow	:	Register Number	-	131
		Register Type	-	Holding Register
		Data Type	-	Unsigned Char (1 register)
		Default Value	-	80
		Minimum Value	-	25
		Maximum Value	-	95
		Access Permission	-	Administrator

This register contains the flow threshold below which a Minor Low Flow Fault is activated

Flow Significant Change	:	Register Number	-	152
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)
		Default Value	-	5
		Minimum Value	-	0
		Maximum Value	-	100
		Access Permission	-	Administrator

This register contains the flow change threshold above which a change of the Flow reading is logged to the SDCard.

Urgent Flow Alarm Delay	:	Register Number	-	155
		Register Type	-	Holding Register
		Data Type	-	Unsigned Short (1 register)
		Default Value	-	300
		Minimum Value	-	0
		Maximum Value	-	600
		Access Permission	-	Administrator

This register contains the delay that is applied after detecting an Urgent Flow Faults before asserting the related fault flag. This is used to prevent short interruptions in flow from generating unwanted errors.

Minor Flow Alarm Delay	:	Register Number	-	156
		Register Type	-	Holding Register
		Data Type	-	Unsigned Short (1 register)
		Default Value	-	300
		Minimum Value	-	0
		Maximum Value	-	600
		Access Permission	-	Administrator

This register contains the delay that is applied after detecting a Minor Flow Faults before asserting the related fault flag. This is used to prevent short interruptions in flow from generating unwanted errors.

Max. Temperature Record	:	Register Number	-	133
		Register Type	-	Holding Register (Read Only)
		Data Type	-	Float (2 registers)

This register contains a record of the Maximum temperature measured by the sensor cartridge during its operational life.

Min. Temperature Record:	Register Number	-	135
	Register Type	-	Holding Register (Read Only)
	Data Type	-	Float (2 registers)

This register contains a record of the Minimum temperature measured by the sensor cartridge during its operational life.

Relay Configuration Registers

The relay configuration registers are located in the 1xxx region of the Modbus Register map, grouped by relay as 1nXX where “n” is the relay number (1,2,3,4 etc).

Activation Mask	:	Register Number	-	1101, 1201, 1301, 1401
		Register Type	-	Holding Register
		Data Type	-	Unsigned Long (2 registers)
		Default Value	-	Relay Dependent
		Minimum Value	-	0
		Maximum Value	-	4294967295
		Access Permission	-	Administrator

This register contains a bit mask of the Alarm conditions which will activate this relay. The bit definitions are as follows. Set the appropriate bits in the word to link the relay operation to the required Alarm conditions

Bit	Flag	Function
0	Sensor 1 Low Alarm	(Sensor 1 Oxygen Falling Pre-Alarm)
1	Sensor 1 High Alarm	(Sensor 1 Oxygen Falling Alarm)
2	NOT USED	(Sensor 1 Oxygen Rising Pre-Alarm)
3	NOT USED	(Sensor 1 Oxygen Rising Alarm)
4	Sensor 2 Low Alarm	(Sensor 2 Oxygen Falling Pre-Alarm)
5	Sensor 2 High Alarm	(Sensor 2 Oxygen Falling Alarm)
6	NOT USED	(Sensor 2 Oxygen Rising Pre-Alarm)
7	NOT USED	(Sensor 2 Oxygen Rising Alarm)
8	Major Fault Flags	
9	Major & Minor Fault Flags	
10	NOT USED	
11	NOT USED	
12	NOT USED	
13	NOT USED	
14	NOT USED	
15-31	NOT USED	

Active State	:	Register Number	-	1103, 1203, 1303, 1403
		Register Type	-	Holding Register
		Data Type	-	Unsigned Char (1 register)
		Default Value	-	Relays 1-3, 0 (Energized) Relay 4, 1 (De-Energized)
		Minimum Value	-	0 (Energized)
		Maximum Value	-	1 (De-Energized)
		Access Permission	-	Administrator

The setting of the Active State register determines whether the associated Relay will be energized or de-energized when the activating alarm condition occurs.

Device Status Latching :	Register Number	-	126
	Register Type	-	Holding Register
	Data Type	-	Unsigned Long (2 registers)
	Default Value	-	0 (Unlatched)
	Minimum Value	-	0 (Unlatched)
	Maximum Value	-	1 (Latched)
	Access Permission	-	Administrator

This register contains the setting for the latching operation of the Fault condition. If this register is set to "latched" (1), the Major Fault condition flags will remain set when the after the fault conditions have passed. As a result, to clear the Fault condition flags, the user must send a "Reset Status Flags" command using Coil 815, as indicated on page 13.

Analog Output Configuration and Status Registers

The analog outputs control registers are located in the 2xxx region of the Modbus Register map, grouped by output as 2nXX where “n” is the output number (1,2,3,4 etc).

Output Mode	:	Register Number	-	2100, 2200
		Register Type	-	Holding Register
		Data Type	-	Unsigned Char (1 register)
		Default Value	-	0 (ONLINE)
		Minimum Value	-	0 (ONLINE)
		Maximum Value	-	1 (OFFLINE)
		Access Permission	-	User

The Output mode register for each Analog output is used to isolate each output such that it does not respond to changes in the source gas reading.

Output Source Mode	:	Register Number	-	2101, 2201
		Register Type	-	Holding Register
		Data Type	-	Unsigned Char (1 register)
		Default Value	-	1 (Source Reading)
		Minimum Value	-	1 (Source Reading)
		Maximum Value	-	2 (Simulated Output)
		Access Permission	-	User

By setting this register to a value of “2” (Simulated Output) the user can provide a simulated gas input reading to registers 2117 & 2217 (see below) to generate the equivalent current output level.

Output Source	:	Register Number	-	2102, 2202
		Register Type	-	Holding Register
		Data Type	-	Unsigned Char (1 register)
		Default Value	-	0 (Sensor 1) for 2102, 1 (Sensor 2) for 2202
		Minimum Value	-	0 (Sensor 1)
		Maximum Value	-	5 (Flow)
		Access Permission	-	User

The contents of this register permit the user to select the source reading for transmission on the Analog output. The available selections are

- 0 = Sensor 1
- 1 = Sensor 2
- 2 = NOT USED
- 3 = NOT USED
- 4 = NOT USED
- 5 = Flow

Output Sub-Source	:	Register Number	-	2103, 2203
		Register Type	-	Holding Register
		Data Type	-	Unsigned Char (1 register)
		Default Value	-	0 (Gas Reading)
		Minimum Value	-	0 (Gas Reading)
		Maximum Value	-	4 (LTEL/TWA)
		Access Permission	-	User

When one of the gas sensors is selected as the Output Source, the sub-source register can be used to select one of the following sub-measurements

- 0 = Primary Gas Reading
- 1 = Gas Sensor Temperature
- 2 = Peak Gas Reading
- 3 = STEL (Short Term Exposure Limit) Average
- 4 = LTEL (Long Term Exposure Limit) Time Weighted Average

Output Fault Mode	:	Register Number	-	2104, 2204
		Register Type	-	Holding Register
		Data Type	-	Unsigned Char (1 register)
		Default Value	-	1 (3.5mA)
		Minimum Value	-	0 (Disabled)
		Maximum Value	-	2 (22mA)
		Access Permission	-	User

The contents of this register permit the user to specify the action that the Analog Output will take when a Major Fault condition occurs within the unit (see page 12), either 0 (No Action), 1 (fix output to 3.5mA) or 2 (fix output to 22mA)

Output Fault Mask	:	Register Number	-	2105, 2205
		Register Type	-	Holding Register
		Data Type	-	Unsigned Long (2 registers)
		Default Value	-	4294967295
		Minimum Value	-	0
		Maximum Value	-	4294967295
		Access Permission	-	User

The Output Fault Mask permits the user to select which of the Major Fault flags will initiate the action selected by the Fault Mode setting (above). Each Bit (binary digit) of the mask is associated with the same Flag bit in the Major Fault status register (see page 12). When the relative mask bit is set (1), the Fault mode will act on the presence of the related Major Fault flag. When reset (0), the fault mode will ignore the presence of the related Major Fault flag.

4mA Level	:	Register Number	-	2109, 2209
		Register Type	-	Holding Register
		Data Type	-	Float (2 register)
		Default Value	-	0.0
		Minimum Value	-	-10000.0
		Maximum Value	-	10000.0
		Access Permission	-	Administrator

This register contains the source reading which equates to a current output of 4mA. This value is used by the system to interpolate the measured source value into the appropriate analog output level in conjunction with the 20mA Level setting (below).

20mA Level	:	Register Number	-	2111, 2211
		Register Type	-	Holding Register
		Data Type	-	Float (2 register)
		Default Value	-	100.0
		Minimum Value	-	-10000.0
		Maximum Value	-	10000.0
		Access Permission	-	Administrator

This register contains the source reading which equates to a current output of 20mA. This value is used by the system to interpolate the measured source value into the appropriate analog output level in conjunction with the 4mA Level setting (above).

User 4mA Correction	:	Register Number	-	2113, 2213
		Register Type	-	Holding Register
		Data Type	-	Float (2 register)
		Default Value	-	0.0
		Minimum Value	-	-4.0
		Maximum Value	-	4.0
		Access Permission	-	Administrator

This register permits the user to add an offset correction (in mA) to the factory defined 4mA level when required to interface to third party systems. Used in conjunction with the User 20mA correction (below) to allow user adjustment of the offset and slope of the analog output.

User 20mA Correction	:	Register Number	-	2115, 2215
		Register Type	-	Holding Register
		Data Type	-	Float (2 register)
		Default Value	-	0.0
		Minimum Value	-	-4.0
		Maximum Value	-	4.0
		Access Permission	-	Administrator

This register permits the user to add an offset correction (in mA) to the factory defined 20mA level when required to interface to third party systems. Used in conjunction with the User 4mA correction (above) to allow user adjustment of the offset and slope of the analog output.

Simulated Input	:	Register Number	-	2117, 2217
		Register Type	-	Holding Register
		Data Type	-	Float (2 register)
		Default Value	-	0.0
		Minimum Value	-	0.0
		Maximum Value	-	10000.0
		Access Permission	-	User

When "Simulated" is selected as the output source mode above, then the value stored in this register is used to set the current output to a fixed level within the range of the current output 4-20mA level settings above.

Output Demand	:	Register Number	-	2142, 2242
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

These registers contain the calculated result of the required current output level (in mA) to be transmitted by the unit. Used by the system to determine that the current output is functioning properly in association with the Output Feedback level (above).

Gas Sensor Registers

The gas sensor registers are located in the 1xxxx region of the Modbus Register map, grouped by module as 1nXXX where “n” is the gas sensor number (1,2,3,4 etc). The “number of sensors” value, as defined on page **Error! Bookmark not defined.**, should be used to determine which register addresses are available.

Sensor Technology	:	Register Number	-	11001, 12001
		Register Type	-	Holding Register
		Data Type	-	unsigned char (1 register)

The sensor technology register is used to determine what method of measurement is being used by the sensor module, the defined types being

- 0 = Electrochemical (Toxic)
- 1 = Electrochemical (Oxygen)
- 2 = Pellistor
- 3 = Infrared (Toxic)
- 4 = Infrared (Flammable)
- 5 = Thermal Conductivity (TC)
- 6 = Photo Ionization Detector (PID)
- 7 = Flame Ionization Detector (FID)
- 8 = Ion Mobility Sensor (FAIMS)

Sensor Gas Name	:	Register Number	-	11002, 12002
		Register Type	-	Holding Register
		Data Type	-	String x32 (32 registers)

This register contains a 32 character UTF-16 string indicating the common name of the gas which the detector measures.

Sensor Gas Formula	:	Register Number	-	11034, 12034
		Register Type	-	Holding Register
		Data Type	-	String x32 (32 registers)

This register contains a 32 character UTF-16 string indicating the molecular formula of the gas which the detector measures.

Display Units	:	Register Number	-	11066, 12066
		Register Type	-	Holding Register
		Data Type	-	String x16 (16 registers)

This register contains a 16 character UTF-16 string indicating the units by which the gas measurement is scaled. e.g. 'ppm' or '%LEL'

Sensor Maximum Range	:	Register Number	-	11098, 12098
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)

This register contains the maximum specified measurement limit of the gas sensor.

Sensor Minimum Range	:	Register Number	-	11100, 12100
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)

This register contains the minimum specified measurement limit of the gas sensor.

Zero Calibration Gas Applied :	Register Number	-	11102, 12102
	Register Type	-	Holding Register
	Data Type	-	Float (2 registers)
	Default Value	-	Sensor Dependant
	Minimum Value	-	Sensor Minimum Range
	Maximum Value	-	Sensor Maximum Range
	Access Permission	-	Administrator

This register contains the concentration of the gas applied during a zero calibration, subsequently used by the system to determine the slope and offset of the gas reading. This value should be checked before initiating a zero calibration operation.

Span Calibration Gas Applied :	Register Number	-	11104, 12104
	Register Type	-	Holding Register
	Data Type	-	Float (2 registers)
	Default Value	-	Sensor Dependant
	Minimum Value	-	Sensor Minimum Range
	Maximum Value	-	Sensor Maximum Range
	Access Permission	-	Administrator

This register contains the concentration of the gas applied during a span calibration, subsequently used by the system to determine the slope and offset of the gas reading. This value should be checked before initiating a span calibration operation.

Zero Calibration Level :	Register Number	-	11106, 12106
	Register Type	-	Holding Register (Read Only)
	Data Type	-	Float (2 registers)

This register contains the result of the zero calibration operation, the raw gas reading that equates to the Zero Gas concentration applied (see above).

Span Calibration Level :	Register Number	-	11108, 12108
	Register Type	-	Holding Register (Read Only)
	Data Type	-	Float (2 registers)

This register contains the result of the span calibration operation, the raw gas reading that equates to the Span Gas concentration applied (see above).

Calibration Date :	Register Number	-	11110, 12110
	Register Type	-	Holding Register (Read Only)
	Data Type	-	Time (2 registers)

This register contains the Date and Time stamp of the last calibration operation. Used in conjunction with the Calibration Period to determine the Calibration Due Date.

Calibration Due Date :	Register Number	-	11112, 12112
	Register Type	-	Holding Register (Read Only)
	Data Type	-	Time (2 registers)

This register contains the Due date for the next calibration, calculated by adding the Calibration Period to the Calibration Date. This value is also used to generate the "Calibration Due" and "Calibration Out of Date" fault flags (see sensor Status and Fault flag definitions below).

Low Alarm Threshold	:	Register Number	-	11114, 12114
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)
		Default Value	-	Sensor Dependant
		Minimum Value	-	Low Alarm Clear Threshold
		Maximum Value	-	Low Alarm Threshold Maximum Limit
		Access Permission	-	Administrator

This register contains the threshold above which the unit will generate a Low Alarm condition for this sensor.

High Alarm Threshold	:	Register Number	-	11116, 12116
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)
		Default Value	-	Sensor Dependant
		Minimum Value	-	High Alarm Clear Threshold
		Maximum Value	-	High Alarm Threshold Maximum Limit
		Access Permission	-	Administrator

This register contains the threshold above which the unit will generate a High Alarm condition for this sensor.

STEL Period	:	Register Number	-	11122, 12122
		Register Type	-	Holding Register
		Data Type	-	Unsigned Short (1 register)
		Default Value	-	15
		Minimum Value	-	1
		Maximum Value	-	60
		Access Permission	-	Administrator

This register contains the averaging time (in minutes) over which the STEL value is calculated.

TWA Weighting Period	:	Register Number	-	11123, 12123
		Register Type	-	Holding Register
		Data Type	-	Unsigned Short (1 register)
		Default Value	-	8
		Minimum Value	-	1
		Maximum Value	-	24
		Access Permission	-	Administrator

This register contains the time (in hours) over which the LTEL TWA calculation is weighted.

TWA Accumulation Period	:	Register Number	-	11124, 12124
		Register Type	-	Holding Register
		Data Type	-	Unsigned Short (1 register)
		Default Value	-	24
		Minimum Value	-	1
		Maximum Value	-	24
		Access Permission	-	Administrator

This register contains the time (in hours) over which the gas reading is accumulated for the calculation of the LTEL TWA value.

Sensor Date of Manufacture :	Register Number	-	11128, 12128
	Register Type	-	Holding Register
	Data Type	-	Time (2 registers)

The Sensor Date of Manufacture is a record of the date of the manufacture of the sensor module.

Sensor Serial Number :	Register Number	-	11130, 12130
	Register Type	-	Holding Register
	Data Type	-	Unsigned Long (2 registers)

The Sensor serial number is a unique number applied to each sensor module, used for traceability and internal configuration validation.

Calibration Rise Time Delay :	Register Number	-	11132, 12132
	Register Type	-	Holding Register
	Data Type	-	Unsigned Short (1 register)
	Default Value	-	Sensor Dependant
	Minimum Value	-	1
	Maximum Value	-	600
	Access Permission	-	Administrator

This register contains delay period (in seconds) that the unit makes before sampling the gas input during a calibration operation. This permits the gas reading to reach a stable level before the calibration sampling begins.

Calibration Sampling Period :	Register Number	-	11133, 12133
	Register Type	-	Holding Register
	Data Type	-	Unsigned Short (1 register)
	Default Value	-	Sensor Dependant
	Minimum Value	-	1
	Maximum Value	-	600
	Access Permission	-	Administrator

This register contains sample period (in seconds) over which the unit averages the measured gas level during the calibration operation.

Sensor Life :	Register Number	-	11134, 12134
	Register Type	-	Holding Register
	Data Type	-	Unsigned Short (1 register)

This register contains sensor operational life (in months) which is used in conjunction with the Date of Manufacture to determine the remaining life of the sensor and initiate the related Fault flags if appropriate.

Low Alarm Clear Threshold :	Register Number	-	11140, 12140
	Register Type	-	Holding Register
	Data Type	-	Float (2 registers)
	Default Value	-	Sensor Dependant
	Minimum Value	-	Low Alarm Threshold Minimum Limit
	Maximum Value	-	Low Alarm Threshold
	Access Permission	-	Administrator

This register contains the threshold below which the unit will clear the Low Alarm condition for this sensor. This value is limited to being less than the Low Alarm threshold to provide some hysteresis for the initiation and cancellation of the Low Alarm condition.

High Alarm Clear Threshold :

Register Number	-	11142, 12142
Register Type	-	Holding Register
Data Type	-	Float (2 registers)
Default Value	-	Sensor Dependant
Minimum Value	-	High Alarm Threshold Minimum Limit
Maximum Value	-	High Alarm Threshold
Access Permission	-	Administrator

This register contains the threshold below which the unit will clear the High Alarm condition for this sensor. This value is limited to being less than the High Alarm threshold to provide some hysteresis for the initiation and cancellation of the High Alarm condition.

Alarm Latching Mode :

Register Number	-	11144, 12144
Register Type	-	Holding Register
Data Type	-	Unsigned Long (2 registers)
Default Value	-	0
Minimum Value	-	0
Maximum Value	-	4294967295
Access Permission	-	Administrator

This register contains the settings for the latching operation of the Alarm conditions. If the relative latch bit indicated below is set, the Alarm condition flag in the Status Flags register will remain set when the gas level returns below the Alarm Clear Threshold for that Alarm condition. To clear the Alarm condition flag, the user must send a "Reset Status Flags" command using Coil 815, as indicated on page 13.

Bit	Function
0	Low Alarm Latch
1	Alarm Latch
2	NOT USED
3-31	NOT USED

Significant Change :

Register Number	-	11146, 12146
Register Type	-	Holding Register
Data Type	-	Float (2 registers)
Default Value	-	Sensor Dependant
Minimum Value	-	Minimum Significant Change
Maximum Value	-	Maximum Significant Change
Access Permission	-	Administrator

This register contains the threshold for logging gas level change events

High Temperature Limit :

Register Number	-	11150, 12150
Register Type	-	Holding Register
Data Type	-	Float (2 registers)

This register contains the maximum operational temperature limit for the sensor, from which the Temperature Over-range Fault condition is determined.

Low Temperature Limit :

Register Number	-	11152, 12152
Register Type	-	Holding Register
Data Type	-	Float (2 registers)

This register contains the minimum operational temperature limit for the sensor, from which the Temperature Under-range Fault condition is determined.

High Humidity Limit	:	Register Number	-	11154, 12154
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)

This register contains the maximum operational humidity limit for the sensor, from which the Humidity Over-range Fault condition is determined.

Low Humidity Limit	:	Register Number	-	11156, 12156
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)

This register contains the minimum operational humidity limit for the sensor, from which the Humidity Under-range Fault condition is determined.

Sensor Calibration Period	:	Register Number	-	11158, 12158
		Register Type	-	Holding Register
		Data Type	-	Unsigned Short (1 register)
		Default Value	-	Sensor Dependant
		Minimum Value	-	1
		Maximum Value	-	12
		Access Permission	-	Administrator

This register contains the required period (in months) after which it is recommended to re-calibrate the gas sensor. It is used in conjunction with the Calibrate Date to determine the Calibration Due Date and initiate the related calibration warning flags if appropriate.

Sensor Hardware Version	:	Register Number	-	11162, 12162
		Register Type	-	Holding Register
		Data Type	-	Hardware Version (2 registers)

This register contains the full hardware version information for the sensor module, containing the drawing number, drawing revision and build revision.

Maximum Significant Change	:	Register Number	-	11164, 12164
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)

This register contains the maximum permitted value for the setting of the Significant Change value.

Minimum Significant Change	:	Register Number	-	11166, 12166
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)

This register contains the minimum permitted value for the setting of the Significant Change value.

Dead Band	:	Register Number	-	11168, 12168
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)
		Default Value	-	Sensor Dependant
		Minimum Value	-	Sensor Range Zero
		Maximum Value	-	Sensor Range Span
		Access Permission	-	Administrator

This register contains the setting for the Dead Band noise suppression. The Dead band noise suppression is the limit either side of a zero reading within which the Gas reading is forced to 0 by the ECO. This is used to suppress noise around the zero gas level.

Minimum Low Alarm Threshold	:	Register Number	-	11200, 12200
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)

This register contains the minimum permitted value for the setting of the Low Alarm Threshold.

Maximum Low Alarm Threshold	:	Register Number	-	11202, 12202
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)

This register contains the maximum permitted value for the setting of the Low Alarm Threshold.

Minimum High Alarm Threshold	:	Register Number	-	11204, 12204
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)

This register contains the minimum permitted value for the setting of the High Alarm Threshold.

Maximum High Alarm Threshold	:	Register Number	-	11206, 12206
		Register Type	-	Holding Register
		Data Type	-	Float (2 registers)

This register contains the maximum permitted value for the setting of the High Alarm Threshold.

Sensor Status Flags	:	Register Number	-	11400,12400
		Register Type	-	Input Register
		Data Type	-	Unsigned Long (2 registers)

The 32 binary digits of the status flags registers represent 32 flags which indicate the functional status of the sensor. Not all of these are currently defined.

Bit	Flag Function
0	Low Alarm
1	High Alarm
2	NOT USED
3	NOT USED
4	Simulation Mode Active
5	Sensor Store – Save of a configuration variable change to Non-volatile memory is pending
6	Zero Calibration in Progress
7	Span Calibration in Progress
8	Calibration awaiting Stabilization
9	Calibration Averaging of Sensor Reading
10	Sensor In Startup State – After Power is applied the sensor module will delay for a fixed period before supplying a valid gas reading to ensure that the system has started correctly. During this period the Sensor Startup flag will be set.
11	Sensor In Warm-up State – When the Startup-up period, above, is completed the sensor will enter a fixed warm-up period, during which the Peak detection and averaging calculations will be inhibited to permit the sensor reading to stabilize sufficiently. During this time the Sensor Warm-up State flag will be set.
12	NOT USED
13	Sensor Module Zero Calibration in Progress
14	Sensor Module Span Calibration in Progress
15	NOT USED
16	NOT USED
17	NOT USED
18	NOT USED
19	Pellistor Saver – The Pellistor sensor module has been exposed to an excess gas level and has as a result been placed in the Pellistor Saver mode to prevent damage to it. In this mode the Sensor reading will be fixed to 120% of range.
20	NOT USED
21	NOT USED
22	NOT USED
23	NOT USED
24	NOT USED
25	NOT USED
26	NOT USED
27	NOT USED
28	NOT USED
29	NOT USED
30	NOT USED
31	NOT USED

Sensor Minor Fault Flags:	Register Number	-	11402,12402
	Register Type	-	Input Register
	Data Type	-	Unsigned Long (2 registers)

The 32 binary digits of the Minor Fault flags registers represent 32 flags which indicate warning conditions present within the sensor module. Minor Faults are those sensor conditions that **DO NOT** directly affect the measurement and/or indication of gas levels and/or alarm conditions. Not all of these are currently defined.

Bit Flag Function

0	Gas Over-Range – the gas reading is greater than 100% of the maximum sensor reading
1	Sensor Life – Less than 30 days of sensor life is remaining
2	Zero Calibration Failed – The last Zero Calibration operation failed.
3	Span Calibration Failed – The last Span Calibration operation failed
4	Calibration Due – The calibration of the sensor is due within 2 weeks
5	Calibration Out of Date – The due date for re-calibrating the sensor has passed
6	Gas Under-Range – the measured Gas reading is more than 5% (of range) below its minimum measurement range
7	Write to Sensor Module configuration failed due to Access permission or Value outside of permitted limits
8	NOT USED
9	Span Calibration Noise – The gas reading during the last calibration operation was too noisy
10	Span Calibration Over-Range – The gas reading during the last calibration operation was greater than the plausible limits of the Span Gas Applied setting.
11	Span Calibration Under-Range – The gas reading during the last calibration operation was less than the plausible limits of the Span Gas Applied setting.
12	Zero Calibration Noise – The gas reading during the last calibration operation was too noisy
13	Zero Calibration Over-Range – The gas reading during the last calibration operation was greater than the plausible limits of the Zero Gas Applied setting.
14	Zero Calibration Under-Range – The gas reading during the last calibration operation was less than the plausible limits of the Zero Gas Applied setting.
15	NOT USED
16	NOT USED
17	NOT USED
18	NOT USED
19	NOT USED
20	NOT USED
21	NOT USED
22	NOT USED
23	NOT USED
24	Sensor Watchdog – The sensor firmware has detected a reset event initiated by the “Watchdog” mechanism
25	NOT USED
26	NOT USED
27	NOT USED
28	NOT USED
29	NOT USED
30	NOT USED
31	NOT USED

Sensor Major Fault Flags:	Register Number	-	11404,12404
	Register Type	-	Input Register
	Data Type	-	Unsigned Long (2 registers)

The 32 binary digits of the Major Fault flags registers represent 32 flags which indicate fault conditions present within the sensor module. Faults are those sensor conditions that directly affect the measurement and/or indication of gas levels and/or alarm conditions. Not all of these are currently defined.

Bit	Flag Function
0	Sensor Temperature Over-Range
1	Sensor Temperature Under-Range
2	Sensor ROM Error – The sensor module has detected an error in its program memory.
3	Sensor RAM Error – The sensor module has detected an error in its data memory.
4	Sensor Configuration Error – The sensor module has detected an error in its stored configuration
5	NOT USED
6	Gas Under-Range – the measured Gas reading is more than 10% (of range) below its minimum measurement range
7	Sensor Software Fault – The sensor module has detected an error in the execution of its software.
8	NOT USED
9	NOT USED
10	NOT USED
11	Sensor Communications Error – The Sensor cartridge processor cannot communicate with the sensor module
12	NOT USED
13	NOT USED
14	Serial Number Mismatch – The Serial number of the installed module is not the same as that which was originally installed with the unit. Sensor Modules should not be replaced in the field
15	NOT USED
16	NOT USED
17	NOT USED
18	NOT USED
19	Sensor Life Elapsed – The operational life of the sensor has expired.
20	Configuration 1 CRC Error – Sensor Module Internal Configuration error detected
21	Configuration 2 CRC Error – Sensor Module Internal Configuration error detected
22	Configuration 3 CRC Error – Sensor Module Internal Configuration error detected
23	Configuration 4 CRC Error – Sensor Module Internal Configuration error detected
24	NOT USED
25	NOT USED
26	NOT USED
27	NOT USED
28	NOT USED
29	NOT USED
30	Sensor Configuration Write Failed – Attempt to write sensor configuration to non-volatile memory has failed
31	Sensor Configuration Read Failed – An attempt to read the sensor configuration from non-volatile memory has failed. Another copy may have been able to be loaded, but check settings.

Gas Reading	:	Register Number	-	11406, 12406
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register contains the measured gas reading.

Sensor Temperature	:	Register Number	-	11408, 12408
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register contains the measured Gas sensor Temperature.

Peak Gas Reading	:	Register Number	-	11410, 12410
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register contains the peak gas reading. The peak reading can be reset by writing to the Reset Sensor Peak command coil (see below)

STEL	:	Register Number	-	11412, 12412
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register contains the calculated STEL average of the Gas reading. The STEL & LTEL averaging can be restarted by writing to the Reset Sensor TWA command coil (see below)

LTEL (TWA)	:	Register Number	-	11414, 12414
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register contains the calculated LTEL Time weighted average of the Gas reading. The STEL & LTEL averaging can be restarted by writing to the Reset Sensor TWA command coil (see below)

Sensor Life Remaining	:	Register Number	-	11416, 12416
		Register Type	-	Input Register
		Data Type	-	Unsigned Long (2 registers)

This register contains the remaining operational life (in seconds) of the gas sensor.

Simulation Waveform	:	Register Number	-	11900, 12900
		Register Type	-	Holding Register
		Data Type	-	Unsigned Short (1 register)
		Default Value	-	0 (Disabled)
		Minimum Value	-	0 (Disabled)
		Maximum Value	-	6 (Noise)
		Access Permission	-	Administrator

This register contains simulation mode setting. When this value is not 0, the simulation output is used in preference to the actual gas reading. The values are non-volatile so will therefore be disabled at power up. The mode settings provide a number of predefined waveforms for the simulated sensor reading. The cycle period of the waveform is 50 seconds. The amplitude of the simulated signal is defined by the Simulation Magnitude setting below, and offset by the Simulation Offset setting below. The possible simulation mode settings are

- 0 = Disabled
- 1 = DC Offset (using the Simulation offset setting below)
- 2 = Sine wave
- 3 = Square Wave
- 4 = Triangular Wave
- 5 = Saw tooth Waveform
- 6 = Pseudo Random Noise signal

Simulation Magnitude	:	Register Number	-	11901, 12901
		Register Type	-	Holding Register
		Data Type	-	Unsigned Short (1 register)
		Default Value	-	100
		Minimum Value	-	1
		Maximum Value	-	100
		Access Permission	-	Administrator

Determines the magnitude (as a percentage of the sensor range) of the simulated sensor signal.

Simulation Offset	:	Register Number	-	11902, 12902
		Register Type	-	Holding Register
		Data Type	-	Unsigned Short (1 register)
		Default Value	-	0
		Minimum Value	-	0
		Maximum Value	-	100
		Access Permission	-	Administrator

Determines the Offset (as a percentage of the sensor range) of the simulated sensor signal

Sensor Specific Commands

Zero Gas Calibration : Coil Number - 11800, 12800
 Access Permission - Administrator

Writing to his Coil address will initiate a Zero calibration in the selected gas sensor. Before initiating this action the user should ensure that the Calibration Sample Delay, Calibration Sample Period and Zero Calibration Gas Applied register for the sensor are set correctly and that the correct gas concentration is being applied to the unit.

Span Gas Calibration : Coil Number - 11801, 12801
 Access Permission - Administrator

Writing to his Coil address will initiate a Span calibration in the selected gas sensor. Before initiating this action the user should ensure that the Calibration Sample Delay, Calibration Sample Period and Zero Calibration Gas Applied register for the sensor are set correctly and that the correct gas concentration is being applied to the unit.

Reset Peak Reading : Coil Number - 11802, 12802
 Access Permission - Administrator

Writing to this coil address will reset the Peak reading detected to 0.

Reset TWA Averaging : Coil Number - 11803, 12803
 Access Permission - Administrator

Writing to this coil address will reset the TWA averages for the selected sensor, restarting the averaging process.

Diagnostic Registers

Supply Voltage Input	:	Register Number	-	600
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register provides a measurement of the Voltage, ranged in Volts, applied to the ECO device by the incoming power supply. This value is used to determine the state of the Voltage Input under and Over range flags in the System Minor Fault flags register.

Supply Current Input	:	Register Number	-	602
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register provides a measurement of the current, ranged in milliamps, being drawn by the ECO device from the incoming power supply. This value is used to determine the state of the Current Input under and Over range flags in the System Minor Fault flags register.

Internal Voltage	:	Register Number	-	604
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register provides a measurement of the Voltage, ranged in Volts, of the derived power supply within the ECO device.

Internal Current	:	Register Number	-	606
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register provides a measurement of the current, ranged in milliamps, being drawn from the derived power supply rail within the ECO device.

Raw Flow	:	Register Number	-	610
		Register Type	-	Input Register
		Data Type	-	Float (2 registers)

This register provides the raw flow reading as indicated by the Sensor Cartridge before normalization is applied by the Main PCB software interface.

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Temperature

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Transmit Counter

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The Americas +1 781 740 2223 **Asia** +852 2916 8894 **Australia and New Zealand** +61 3 9936 7000
Continental Europe +32 56 24 19 51 **UK and the Middle East** +44 1442 242 330

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