CROWCON
Detecting Gas Saving Lives

XgardIQ

Intelligent Gas Detector and Transmitter

Modbus Field Device Specification

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Synopsis:
This document describes the public Modbus interface for the XgardIQ transmitter.

Contents

1. Glossary of Terms

Term	Glossary
CRC	Cyclic Redundancy Check – a message postfix used to determine if the message packet has been received without corruption.
Detectors Pro	PC software available from Crowcon for the configuration and maintenance of the XgardIQ.
RTU	Remote Terminal Unit – a Modbus data format which requires the receiver to decode it to a human understandable form. It is normally binary encoded rather than ASCII.
UI	User interface. In the case of the XgardIQ, this consists of a graphic OLED and 3 buttons.

2. References

Reference	Document	Revision
1	Modbus_Application_Protocol_V1_1b.pdf, available from http://www.Modbus.org	1.1b3
2	Modbus_over_serial_line_V1_02.pdf, available from http://www.Modbus.org	1.02

3. Modbus Interface

Refer to [1] and [2] listed in the Reference section for details of the Modbus protocol. This document does assume an understanding of the Modbus protocol.

The XgardIQ has a standard implementation of Modbus. This document describes details specific to the Modbus implementation in XgardIQ.

The XgardIQ is always addressed as a slave device.

3.1 Slave Address

Each instrument on a communications loop requires a unique address in the range 1 – 247. By default an XgardIQ will be configured to Modbus address 1. This can be changed through the instrument's UI or by using Detectors Pro.

The broadcast address (address 0) is not implemented in the XgardIQ. Broadcast messages will simply be ignored.

3.2 Data Format

The default data format for the XgardIQ is:

Data format	1 start bit; 8 data bits, least significant bit first; no parity bit; 2 stop bits
Transmission mode	RTU (Remote Terminal Unit)
Error check	Cyclic redundancy check (CRC)
Baud rate	38400
Message turn-around delay	25mS turn around delay (guaranteed minimum) – this is an extension to standard Modbus
Data encoding	Big-endian representation for addresses and data items. This means that when a numerical quantity larger than a single byte is transmitted

	the most significant byte is sent first.
Modbus address	1

The address, baud rate, parity and turn-around delay can be modified in the instrument's configuration, either through Modbus (see section 5.6.6, Communications) or through the UI.

3.3 Implemented Function Codes

The XgardIQ only recognises a limited number of function codes, as given in the table below:

Function Code	Function code Definition
3	Read Holding Registers
16	Write Multiple Registers

3.4 Data Timing

The error condition described in [1] when there is a delay of 1.5 character times but less than 3.5 character times between data is not implemented – this can, apparently, cause problems with legacy systems and PC timings.

On receipt of a message requiring a response the instrument will pause for a guaranteed turn-around delay period (default: 25mS) before transmission will commence. Again, there may be timing problems on PC systems if this restriction is not applied. The instrument will be in state ready to receive the next query packet as soon as the response packet transmission is complete.

3.5 Modbus Data Types

In the Modbus Data model that follows, the following data types may be used:

Type	Meaning
UINT8	Single byte, unsigned data (8 bits), null padded in most significant byte to create a word.
INT8	Single byte, signed data (8 bits), null padded in most significant byte to create a word.
UINT16	Two bytes, unsigned integer (16 bits), one word long, most significant byte first.
INT16	Two bytes, signed integer (16 bits), one word long, most significant byte first.
BIT16	Two bytes, each bit signifying a different status or code.
UINT32	Four bytes, unsigned integer (32 bits), 2 words, most significant word first.
INT32	Four bytes, signed integer (32 bits), 2 words, most significant word first.
BIT32	Four bytes each bit signifying a different status or code.
STRING nn	Text string, nn characters long, packed 2 characters per word, of length nn/2 words. Ordered with first character in high byte of first word. Null padded in all unused words, and in least significant byte of last word if needed.
FLOAT	Four bytes, floating point number, in IEEE-754 format.
ENUM nn	Data enumeration. A UINT16 where each number (counting from 0) refers to an option from a list of 'nn' possibilities that can be selected. For read only registers this is the number of different options that may be returned; for read/write registers this refers to the number of different options that may be written, whilst the number of options that may be returned could be different.
DATE	Time/date in seconds from 1/1/1970 (Unix time)

3.6 Register Permissions

It is not necessarily possible to read or write every register in the Modbus register map. The permissions used in the Modus map are:

Permission	Meaning
R/W	Read and write allowed. (Holding Registers).
R	Read only. The information cannot be modified via Modbus (Input Registers).
R/W(C)	Read allowed: writes allowed only if configuration is open (see section 5.6, Configuration for details).

3.7 Note on Message Processing

It is always guaranteed that the registers in a message will be processed sequentially from message start to message end. If the data is a message is erroneous in some way then the validation of the message will fail at the first error.

The XgardIQ has a 256 byte Modbus buffer. This buffer is large enough to contain the largest valid Modbus message.

3.8 Modbus Start-Up Response

The XgardIQ will respond to Modbus as soon as it has reset. This allows for immediate polling of identification registers 1 to 5 (inclusive).

The XgardIQ will enter an initialisation phase when first powered. During this phase information in sections 5.1.2, Sensor and 5.2.1, Main Status, is populated. Reading register 500, Sensor ready, can be used to determine if this information has been fully populated.

The next phase is warm-up. This phase lasts a minimum of 30 seconds, but may be longer depending on the sensor fitted. During this phase the instrument will be in power-on inhibit mode. During the warm-up phase the instrument cannot be zeroed, calibrated or bump tested (as the XgardIQ is waiting for the gas readings to stabilise). Analogue output adjustment (zero trim, span adjustment) is possible during the warm-up phase. It is not possible to control inhibit mode whilst the XgardIQ is in start-up inhibit mode.

Once the warm-up phase is completed the instrument will be functioning normally.

4. Modbus Data Model

The standard Modbus specification [1] talks of 16 bit (one word) registers and numbers of data bytes. The interpretation of registers and words used in this document (and used by other Crowcon products using Modbus, but perhaps with different terminology) is as follows:

A register will refer to the address of a piece of data within the register map. A register may consist of one or more 16-bit words. Registers are uniquely identified by their register address.

The size of a register (sometimes also confusingly referred to as the number of registers) - that is the amount of data at a particular register address - is referred to by the number of words it contains.

Restated, we have uniquely addressed registers referring to one or more words of data.

Holding registers and Input registers are often referred to in the range 4XXXX. In the terminology used in this document, register 1 would be referred to as 40001 and would be addressed as register 0000 in the data address field of the Modbus message. The ‘4XXXX’ reference is implicit in this Modbus Data Model.

This will be made clear by the example messages and responses given in section 0,

ID	Name	Notes
1	Illegal function	Function code not supported (i.e. not 3 or 16); see section 3.3,

		Implemented Function Codes
2	Illegal data address	Invalid/unknown register address, invalid number of registers, invalid number of words for the specified registers, or write to read only register.
3	Illegal data value	Invalid number or enumeration code or data type – the registers are valid, but an attempt is being made to put invalid data into the register.
4	Slave device failure	Used internally only to flag a buffer write failure in a transaction.
5	Acknowledge	Message has been accepted and is currently being processed.
6	Slave device busy	A write has been made requesting an action that the XgardIQ cannot currently perform because it is busy.
7	Negative acknowledge	The instrument cannot perform the function received in the query.

Example Modbus Messages.

5. Modbus Map

5.1 Identification Data

5.1.1 Transmitter

Register	Name	Words	R/W	Data Type	Notes
1	Instrument identification	8	R	STRING16	“XgardIQ ”
2	Manufacturer	8	R	STRING16	“Crowcon"
3	Transmitter firmware version	8	R	STRING16	e.g. “V1.00”
4	Transmitter serial number	8	R	STRING16	
5	Transmitter secondary firmware version	8	R	STRING16	e.g. “V1.00” Reads “---“ if not initialised

5.1.2 Sensor

Sensor identification data.

Register	Name	Words	R/W	Data Type	Notes
100	Sensor ready	1	R	UINT16	0 = sensor missing or not detected yet; 1 = sensor detected but invalid or waiting for acknowledge; 2 = sensor initialising; 3 = sensor ready
101	Sensor firmware version	8	R	STRING16	e.g. “V1.00” Reads “---“ if not initialised or sensor not fitted
102	Sensor serial number	8	R	STRING16	Reads “---“ if not initialised or sensor not fitted
103	Sensor Technology ID	1	R	ENUM 9	Bits 0-6: 0 = no sensor attached to transmitter; 1 = electrochemical toxic; 2 = electrochemical oxygen; 3 = biased electrochemical toxic; 4 = pellistor; 5 = non-IRmax IR sensor; 6 = MOS; 7 = PID; 8 = IRmax iModule Bit 7: 0 = non CO2; 1 = CO2. Extra information bit to identify CO2 sensor (as CO2

					sensors could be implemented on more than one technology).
104	Gas name	8	R	STRING16	Target gas name as (displayed on UI)
105	Gas units	8	R	STRING16	Target gas units as (displayed on UI)
106	Sensor range	2	R	FLOAT	Measurement range of sensor; reads as 0 if no sensor fitted
107	Calibrate due date	2	R	DATE	
108	Calibration reminder date	2	R	DATE	
109	Bump due date	2	R	DATE	
110	Last zero time	2	R	DATE	Time of last successful zero
111	Last zero by?	8	R	STRING16	
112	Last cal. time	2	R	DATE	Time of last successful calibration
113	Last cal. by?	8	R	STRING16	
114	Last bump time	2	R	DATE	Time of last successful bump test
115	Last bump by?	8	R	STRING16	
116	Number of cross calibration	1	R	ENUM 3	Only relevant to flammable (pellistor and non-IRmax IR) sensors. (Sensor types 4 and 5, register 103). 0 = No cross calibrations available 1, 2 = 1 or 2 cross calibrations available
117	Cross calibration 1 gas name	8	R	STRING16	Gas name of cross calibration 1
118	Cross calibration 1 gas units	8	R	STRING16	Gas units of cross calibration 1
119	Cross calibration 1	2	R	FLOAT	Cross calibration gas level (level of cross cal. gas to apply)

	gas level				
120	Cross calibration 2 gas name	8	R	STRING16	Gas name of cross calibration 2
121	Cross calibration 2 gas units	8	R	STRING16	Gas units of cross calibration 2
122	Cross calibration 2 gas level	2	R	FLOAT	Cross calibration gas level (level of cross cal. gas to apply)
123	Sensitivity	2	R	FLOAT	Estimate of sensor sensitivity based on change of gain, as a percentage. Updated on successful calibration.
124	Sensitivity quality	1	R	ENUM 3	0 = unknown, low; 1 = unknown, high; 2 = OK If a calibration fails for gain reasons (gain error, gain high or gain low) then the sensor gain is suspect (failed calibration because of failed sensor?). If the failure looks like it is due to low sensor sensitivity then the quality is set to unknown, low. If the failure looks like it is due to high sensor sensitivity then the quality is set to unknown, high. Other calibration failures are unrelated to sensor sensitivity so do not change the data quality.

5.1.3 Fitted Options

Allows for polling of what optional hardware components are fitted to the XgardIQ.

Register	Name	Words	R/W	Data Type	Notes
200	Relay module	1	R	ENUM 2	0 = not fitted; 1 = fitted
201	HART enabled	1	R	ENUM 2	0 = not fitted; 1 = fitted

5.2 Operational Data

5.2.1 Main Status

Main registers associated with gas measurement and instrument status.

Register	Name	Words	R/W	Data Type	Notes
300	Raw gas level	1	R	INT16	The raw gas reading, before the application any zero or calibration data, linearization or temperature compensation.
301	Sensor warm up	1	R	UINT16	Sensor warm up time countdown (in seconds)

	count down				
302	Measured value	2	R	FLOAT	Calibrated gas reading, e.g. 23.7, in display units
303	Obscuration	2	R	FLOAT	Reads 0.0 if unless Sensor Technology is 5 or 8 (see register 103) when optical obscuration will be read as a percentage)
304	Instrument status	1	R	ENUM 3	0 = OK; 1 = Reminder; 2 = Warning; 3 = Fault. Overall state of instrument. See section 6.1, Severity Levels, for details
305	Alarm 1 state	1	R	ENUM 2	0 = inactive; 1 = in alarm or latched alarm
306	Alarm 2 state	1	R	ENUM 2	0 = inactive; 1 = in alarm or latched alarm
307	Status flags 1	2	R	BIT32	See section 6, Status.
308	Status flags 2	2	R	BIT32	See section 6, Status.
309	Feedback mA	2	R	FLOAT	mA loop current feedback
310	Supply voltage	2	R	FLOAT	In V
311	+ve safety	2	R	BIT32	See section 7, +ve Safety

5.2.2 Time and Date

Time and date is maintained by a real time clock.

Register	Name	Words	R/W	Data Type	Notes
400	Time and date	2	R/W	DATE	
401	Time and date of last time/date set	2	R	DATE	Instrument recorded time/date at which time/date was last set

5.3 Gas Control

Register	Name	Words	R/W	Data Type	Notes
500	Cross calibration gas selection	1	R/W	ENUM n	Selects the target gas (n = 0) or cross calibration gas (n = 1 or 2) to use with calibration. Only relevant to flammable (pellistor and non-IRmax IR) sensors. (Sensor types 4 and 5, register 103). When set to a cross-calibration gas, the gas level displayed on the operational screen will not be scaled (i.e. target gas level will be displayed correctly and if a

					cross-calibration gas is applied then the target gas equivalent of the cross-calibration gas level will be displayed); in the zero and calibration UI wizards the gas level displayed will be the level scaled by the cross-calibration scaling factor, so the displayed level will be the level of the cross-calibration gas applied.
501	Zero control	1	R/W	ENUM 2	Zero the gas reading in the absence of target gas – note that this means, in the case of O_2 and CO_2, the sensors should be purged with nitrogen. Write: 0 = do nothing; 1 = zero gas reading Read: 0 = ok; 1 = busy; 2 = warm up; 3 = signal error; 4 = gain warning; 5 = lamp failure; 6 = sensor failure; 7 = optics obscured; 8 = temp. limits exceeded; 9 = pellistor saver; 10 = supply error; 11 = operation aborted (sensor); 12 = O_2 sensor not purged with nitrogen; 13 = internal failure; 14 = operation aborted (transmitter); 15 = Zero error too large; 16 = Sensor missing Re-triggering a zero whilst a zero is already in operation will do nothing – the current zero operation will be completed normally.
502	Calibration level	2	R/W	FLOAT	Gas level to calibrate to. Calibration level must be between 10% of the signal range and 100% of the sensor range.
503	Calibrate control	1	R/W	ENUM 2	Write: 0=do nothing; 1 = calibrate gas reading Read: 0 = ok; 1 = busy; 2 = warm up; 3 = signal error; 4 = optics obscured; 5 = sensor calculation failure; 6 = gain error; 7 = gain low; 8 = gain high; 9 = process failure; 10 = lamp failure; 11 = sensor failure; 12 = temp. limits exceeded; 13 = pellistor saver; 14 = supply error; 15 = operation aborted (sensor); 16 = internal failure; 17 = operation aborted (transmitter); 18 = sensor module missing; 19 = cal. level invalid (see reg. 502) Re-triggering a calibration whilst a calibration is already in operation will do nothing – the current calibrate operation will be completed normally.
504	Countdown to zero/cal. complete	1	R	UINT16	Time to zero/cal. operation completion (in seconds)
505	Calibration inhibit	1	R/W	ENUM 2	0 = no inhibit; 1 = inhibit analogue output and alarm relays When in Inhibit state pellistor saver is also disabled

506	Last zero by?	8	R/W	STRING16	Free form string for last zero info. Data transferred to and saved in sensor module.
507	Last cal. by?	8	R/W	STRING16	Free form string for last cal. info. Data transferred to and saved in sensor module.

The last zero time and last calibration time will be set to the current instrument time on a successful zero or calibration operation. The calibration due and calibration reminder date will be set to the current instrument time plus the appropriate interval on a successful calibration.

The 'last … by' data must be set manually if required; by default the data will be set to "Modbus" if the operation is performed through multi-drop Modbus communications.

5.3.1 Status Codes

The following table explains the various status codes can be obtained when perform a zero or calibration operation. Note that some of these codes are used internally, and practically will never been seen when performing an operation via multi-drop communications.

Status Code	Explanation
Busy	Busy from zero or calibration request. Requested operation in progress.
Calibration level invalid	Calibration level less than 10% or signal range or more than 100% of sensor range.
Gain error	Like Gain Warning, except this error may occur at calibration.
Gain high	Software gain to high (with respect to ideal for production cal., or original cal. for field cal.)
Gain low	Software gain to low (with respect to ideal for production cal., or original cal. for field cal.)
Gain warning	With the zero and gain data the full sensor measurement range cannot be achieved. The error occurs when zeroing; it means that a calibration is now required. The new zero data is accepted.
Lamp failure	Failure of gas or reference lamp detected at lamp start-up or during lamp calibration process. (IR sensor only).
Internal failure	Internal fault within XgardIQ.
Ok	Operation completed successfully.
Operation aborted (sensor)	Attempt to trigger zero (calibration) operation whilst the sensor module is still busy performing a zero or calibration.
Operation aborted (transmitter)	Attempt to trigger zero (calibration) operation whilst the XgardIQ considers the sensor module is still busy performing a zero or calibration or a bump test is in progress.

Optics obscured	Obscuration level exceeds defined error level. (IR sensor only).
Pellistor saver	Attempt to calibrate a pellistor whilst it is saver mode.
Process failure	Internal process failure – return sensor to Crowcon.
Sensor calculation failure	Internal failure in sensor module.
Sensor failure	Detector output 'flat-lined' (IR sensor), heater failure (MOS) or other sensor failure.
Sensor missing	No sensor module fitted to zero or calibrate.
Signal error	Raw detector reading under/over range.
Supply error	Supply voltage to sensor module or internal Vcc diagnostic out of limits.
Temp. limits exceeded	Ambient temperature outside limits for sensor.
Warm-up	Instrument still in start-up warm-up phase.
Zero error too large	Attempt to perform a zero through the UI when the error in the reading is too far from the clean air level.

5.3.2 Zero and Calibration Process Notes

When performing a zero or calibration it would be usual to follow a process like this:

5.3.2.1 Zero

5.3.2.1.1 Non-O_2 Sensor

1. If the sensor is a CO_2 sensor, then purge the sensor with N_2.
2. Poll register 302 to ensure in clean air (clear or target gas).
3. Start the zero with register 501; polling this register will return the current status. Register 504 can be used to monitor countdown to process completion

5.3.2.1.2 O_2 Sensor

O_2 sensors are zeroed on N_2 (i.e. in the absence to target gas).

1. If an O_2 sensor is being zeroed on N_2, use register 505 to inhibit outputs (prevent false alarms).
2. Apply N_2 and poll register 302 to check the gas application and monitor for stability.

3. Start the zero with register 501; polling this register will return the current status. Register 504 can be used to monitor countdown to process completion.
4. When the zero has completed remove the N_2 and use register 302 to poll for clean air.
5. Once the gas has cleared sufficiently use register 505 to remove the inhibit.

5.3.2.2 Calibration

1. Use register 505 to inhibit outputs (prevent false alarms).
2. If a cross calibration is to be performed (only possible on pellistors and IR sensors with cross calibrations pre-configured), select the cross calibration with register 500, otherwise set the calibration level with register 502.
3. Apply the correct calibration gas and poll register 302 to check the gas application and monitor for stability.
4. Start the calibration with register 503; polling this register will return the current status. Register 504 can be used to monitor countdown to process completion.
5. When the calibration has completed remove the calibration gas and use register 302 to poll for clean air.
6. Once the gas has cleared sufficiently use register 505 to remove the inhibit.

5.4 Analogue Output Control

Register	Name	Words	R/W	Data Type	Notes
600	Zero trim control	1	R/W	ENUM 4	Write: 0 = do nothing; 1 = start trim; 2 = end trim (save change); 3 = quit trim (do not save change) Read: 0 = none; 1 = zero trim; 2 = span adjust Starting zero trim (write 1) sets the output to 4mA; end or quit will revert the analogue output to representing the gas level. Ending zero trim (write 2) will save the zero trim such that the data will be retained if the instrument loses power.
601	Zero trim	2	R/W	FLOAT	In mA. Limit +/- 3mA. Data is accumulative such that if the current zero trim is *n* then writing *m* will set the zero trim to *n* + *m*. Changing the zero trim shifts the mA output up or down by the given amount; the gain of the mA output is not affected.
602	Span adjust control	1	R/W	ENUM 4	Write: 0 = do nothing; 1 = start adjust; 2 = end adjust (save change); 3 = quit adjust (do not save change) Read: 0 = none; 1 = zero trim; 2 = span adjust Starting span adjust (write 1) sets the output to 20mA; end or quit will revert the

					analogue output to representing the gas level. Ending span adjust (write 2) will save the span adjust such that the data will be retained if the instrument loses power.
603	Span adjust	2	R/W	FLOAT	In mA. Limit +/- 3mA. Data is accumulative such that if the current span adjust is *n* then writing *m* will set the zero trim to *n* + *m*. Changing the span adjust shifts the 20mA output point up or down by the given amount without altering the 4mA point (i.e. the gain of the output is altered).
604	Ramp level	2	R/W	FLOAT	In measured units; when Ramp mode is selected this sets the output level and resets the Ramp mode timeout. If no sensor is present then the range (for the purposes of calculating measured units) will be the range by 100.
605	Ramp control	1	R/W	ENUM 3	Read: 0 = no ramp; 1 = basic; 2 = with alarm test; 3 = analogue output not operational (start up) Write: 0 = do nothing (cancel ramp); 1 = basic; 2 = with alarm test The Ramp level should be set before the Ramp control to ensure that the Ramp control starts from a defined state. This would normally be 0 except for CO_2 (0.04) and O_2 (20.9). Note that alarm test includes alarm on/off times and hysteresis and relay triggering; if no sensor is present then ramp with alarm is not allowed. Ramp mode with alarm is not allowed if a valid sensor is not fitted. Enter and exit of Ramp mode with alarm test always resets both alarms to the clean air state and resets all alarm delays. Ramp basic does not affect alarms in any way. Ramp mode is considered a special state, and the special state timeout applies. Timeout from Ramp mode can be re-triggered by writing this register or the Ramp level register.
606	Ramp test timeout remaining	1	R	UINT16	Seconds until the ramp test will timeout and the mA signal will reflect the gas level

5.5 Alarm and Relay Control

Register	Name	Words	R/W	Data Type	Notes

700	Alarm relay test	1	R/W	ENUM 2	0 = test inactive; 1 = both relays off; 2 = test alarm relay 1; 3 = test alarm relay 2; 4 = test alarm relay 1 & 2 Relay test will remain active until timeout/alarm or manually taken out of test.
701	Fault relay test	1	R/W	ENUM 2	0 = test inactive; 1 = fault relay off; 2 = fault relay on Relay test will remain active until timeout/alarm or manually taken out of test.
702	Alarm relay test timeout remaining	1	R	UINT16	Seconds until the alarm relay test will timeout and the relays will reflect the alarm state.
703	Fault relay test timeout remaining	1	R	UINT16	Seconds until the fault relay test will timeout and the relay will reflect the fault state.
704	Alarm latch state	1	R/W	ENUM 2	Read: 0 = neither alarm latched; 1 = one or both alarms latched Write: 0 = do nothing; 1 = acknowledge both alarms.

Alarm relay control works, in order of priority: inhibit; test; alarm state.

5.6 Configuration

To perform a configuration update the configuration must be opened (writing 1 to register 800, Configuration control), the appropriate configuration data written and then the configuration closed (writing 2 to register 800, Configuration control). Closing the configuration commits all changes to memory. It is possible to discard all changes by writing 3 to register 800, Configuration control. Writing to configuration data is not possible until the configuration has been opened.

Once configuration is open for writing all configuration updates are buffered. **Changes will only be saved and used when the configuration is closed.**

Once the configuration has been opened for write all configuration updates must be completed within 15 minutes (without loss of power) of the configuration open, otherwise it is assumed that the configuration update has failed for some reason. In this case all changes made will be lost and the XgardIQ will warn that an update has failed. This warning will persist at every power-on until a configuration update succeeds – this requires a configuration open followed by a close as a minimum.

Reading a configuration register will normally return the data that is saved and used by the XgardIQ. If the configuration is open then a read will either return the data that is saved and used by the XgardIQ, or the data that has been set if a modification has been made.

5.6.1 Control

Register	Name	Words	R/W	Data Type	Notes
800	Configuration control	1	R/W	ENUM 2	Write: 0 = do nothing; 1 = open for write; 2 = close (save data); 3 = close (discard changes) Read: 0 = ok; 1 = busy with write; 2 = open for write; 3 = write error

					Opening configuration for update when it is already open will re-start the 15 minute timeout, but otherwise will do nothing.

5.6.2 Miscellaneous

Register	Name	Words	R/W	Data Type	Notes
810	Identification string	16	R/W(C)	STRING32	Free-form identification string; displayed at start-up and available in the Information menu.
811	Action on sensor module change	1	R/W(C)	ENUM 2	0 = Accept same gas type only with acknowledgement; 1 = accept same gas type only without acknowledgement; 2 = all changes allowed with acknowledgement; 3 = accept same gas type without acknowledgement and changed gas type with acknowledgement. Acknowledgement means the sensor change must be positively accepted or rejected. Until the sensor is positively accepted the instrument will remain in the power-on inhibit state.
812	Zero suppression	1	R/W(C)	ENUM 4	0 = none; 1 = light; 2 = medium; 3 = heavy Suppresses gas level close to the clean air level to the clean air level
813	Gas name	8	R/W(C)	STRING16	Free-form string; used for display of gas name
814	Gas units	8	R/W(C)	STRING16	Free-form string; used for display of gas units

5.6.3 Analogue output

Register	Name	Words	R/W	Data Type	Notes
820	Signal range	2	R/W(C)	FLOAT	Must be between 5% and 100% of sensor range (register 106); scales 4-20mA output
821	Fault level	1	R/W(C)	ENUM 3	0 = 1mA; 1 = 2mA; 2 = 3mA
822	Warning level	1	R/W(C)	ENUM 3	0 = 1mA; 1 = 2mA; 2 = 3mA
823	Inhibit level	1	R/W(C)	ENUM 4	0 = 1mA; 1 = 2mA; 2 = 3mA; 3 = clean air (4mA, 4.13mA for 0-5% vol. CO_2, 17.6mA for 0-25% vol. O_2)
824	Power-on Inhibit	1	R/W(C)	ENUM 4	0 = 1mA; 1 = 2mA; 2 = 3mA; 3 = clean air (4mA, 4.13mA for 0-5% vol. CO_2, 17.6mA for 0-25% vol. O_2)

825	Zero limit	2	R/W(C)	FLOAT	1-4mA; gas outputs are limited at the low end at this level.
826	Mode	1	R/W(C)	ENUM 3	0 = source; 1 = sink; 2 = auto-detect Changing the mode to sink or source will force that mode (when configuration is successfully closed, see register 800); changing to auto-detect will not change the mode until next power-on.

5.6.4 Alarm

Register	Name	Words	R/W	Data Type	Notes
830	Alarm 1 on threshold	2	R/W(C)	FLOAT	In measured units, <= sensor range (register 106)
831	Alarm 1 off threshold	2	R/W(C)	FLOAT	In measured units, <= sensor range (register 106)
832	Alarm 1 direction	1	R/W(C)	ENUM 2	0 = falling; 1 = rising
833	Alarm 1 latching	1	R/W(C)	ENUM 2	0 = latching; 1 = non latching
834	Alarm 1 relay drive	1	R/W(C)	ENUM 2	0 = normally de-energized; 1 = normally energized
835	Alarm 1 on delay	1	R/W(C)	INT16	0-300 seconds
836	Alarm 1 off delay	1	R/W(C)	INT16	0-300 seconds
837	Alarm 2 on threshold	2	R/W(C)	FLOAT	In measured units, <= sensor range (register 106)
838	Alarm 2 off threshold	2	R/W(C)	FLOAT	In measured units, <= sensor range (register 106)
839	Alarm 2 direction	1	R/W(C)	ENUM 2	0 = falling; 1 = rising
840	Alarm 2 latching	1	R/W(C)	ENUM 2	0 = latching; 1 = non latching
841	Alarm 2 relay drive	1	R/W(C)	ENUM 2	0 = normally de-energized; 1 = normally energized
842	Alarm 2 on delay	1	R/W(C)	INT16	0-180 seconds
843	Alarm 2 off delay	1	R/W(C)	INT16	0-180 seconds

5.6.5 Calibration and Bump Test

Register	Name	Words	R/W	Data Type	Notes
850	Calibrate due interval	2	R/W(C)	UINT32	In seconds, 1 day to 12 months
851	Calibration reminder interval	2	R/W(C)	UINT32	In seconds, 1 day to 12 months
852	Calibration due action	1	R/W(C)	ENUM 3	0 = none; 1 = reminder; 2 = warning; 3 = fault Setting to None or Reminder disables the separate calibration due reminder feature. Setting the calibration due feature to None effectively disables calibration due.
853	Bump test response to gas timeout	1	R/W(C)	UINT16	0 to 300 seconds
854	Bump test time	1	R/W(C)	UINT16	0 to 300 seconds
855	Smart bump test limit, lower	2	R/W(C)	FLOAT	0 to Sensor range (register 301)
856	Smart bump test limit, upper	2	R/W(C)	FLAOT	0 to Sensor range (register 301)
857	Bump due interval	2	R/W(C)	UINT32	In seconds, 1 day to 12 months
858	Bump due action	1	R/W(C)	ENUM 3	0 = none; 1 = reminder; 2 = warning; 3 = fault

5.6.6 Communications

Note that changed communications data will be set after the response to the message.

Register	Name	Words	R/W	Data Type	Notes
870	Modbus address	1	R/W(C)	UINT8	1-247
871	Modbus baud rate	1	R/W(C)	ENUM 9	0 = 9600; 1 = 14400; 2 = 19200; 3 = 28800; 4 = 38400, default 38400
872	Modbus message turn around delay	1	R/W(C)	UINT16	mS, 0 to 100, default 25

6. Status

Status flags are set to indicate conditions (including faults) within the instrument.

6.1 Severity Levels

Status flags indicate the conditions present within instrument. Each condition has a severity. The overall condition of the instrument is the highest severity of all status conditions that are set. The severity levels are, in increasing order:

Severity	Meaning
OK	Status is informational only.
Reminder	Status indicates that there is a minor issue that may require attention. The safety function of the device has probably not been compromised.
Warning	Status is a warning that indicates the safety integrity of the instrument may be compromised – an indication is given on the display and the analogue output is set to the warning level. Generally warnings indicate that some event has occurred (e.g. instrument has been exposed to temperature outside of its rated maximum) that may have compromised the instrument; the instrument should be checked.
Fault	Status indicates there is a definite problem with the instrument and that the safety integrity of the instrument is probably compromised – an indication is given on the display, the analogue output is set the fault level and the fault relay is de-energised.

6.2 Flags

6.2.1 Flag Set 1

Bit	ID	Severity	Explanation
0x00 00 00 01	SENSOR_HARDWARE	Fault	Hardware failure – Vcc, CPU EEPROM or other CPU fault, supply voltage fault or hardware/firmware mismatch.
0x00 00 00 02	MAIN_HARDWARE	Fault	Hardware failure – Vcc, RTC failure, logging flash or CPU EEPROM fault
0x00 00 00 04	SENSOR_FIRMWARE	Reminder	Firmware self-check, assert or watchdog failure.
0x00 00 00 08	MAIN_FIRMWARE	Reminder	Firmware self-check, assert or watchdog failure.
0x00 00 00 10	SENSOR_UNDEFINED	Fault	Undefined fault in sensor module (i.e. undefined status bit set).
0x00 00 00 20	UNUSED_1	N/A	Unused – for future use.
0x00 00 00 40	PRODUCTION	Fault in main or sensor; reminder in display	Production process incomplete/failed

0x00 00 00 80	MAIN_AOUT_FAIL	Fault	Analogue output feedback failure
0x00 00 01 00	SENSOR_FAILURE	Fault	Under or over range, detector failure or other sensor failure
0x00 00 02 00	DISPLAY_WATCHDOG	Reminder	Watchdog test appears to have failed (as IQ-Display not reset)
0x00 00 04 00	UNUSED_2	N/A	Unused – for future use.
0x00 00 08 00	MAIN_SENSOR_VER	Fault	Sensor module of configuration version too old
0x00 00 10 00	MAIN_SENSOR_MISSING	Fault	Sensor module missing (or not communicating with XgardIQ)
0x00 00 20 00	UNUSED_3	N/A	Unused – for future use.
0x00 00 40 00	UNUSED_4	N/A	Unused – for future use.
0x00 00 80 00	SENSOR_CALREQD	Warning	Calibration required (after a successful zero)
0x00 01 00 00	UNUSED_5	N/A	Unused – for future use.
0x00 02 00 00	SENSOR_CFG_CALIB	Fault	Error detected in calibration data.
0x00 04 00 00	SENSOR_CFG_CHARACTER	Fault	Error detected in characterisation data
0x00 08 00 00	UNUSED_6	N/A	Unused – for future use.
0x00 10 00 00	UNUSED_7	N/A	Unused – for future use.
0x00 20 00 00	SENSOR_TEMP	Warning	Sensor temperature outside allowed limits (too cold or too hot)
0x00 40 00 00	SENSOR_ZEROERR	Fault	Measurement zero error (reading too low).
0x00 80 00 00	SENSOR_SPANERR	Fault	Measurement span error (reading exceeds [optional] configured fault level)
0x01 00 00 00	SENSOR_OBSCURED	Fault	Optics obscured (IR sensors only)
0x02 00 00 00	SENSOR_OVERRANGE	Reminder	Measurement over-range – gas exceeds range of sensor by 5% or more
0x04 00 00 00	UNUSED_8	N/A	Unused – for future use.
0x10 00 00 00	UNUSED_9	N/A	Unused – for future use.
0x08 00 00 00	MAIN_CFG_CALIB	Fault	Error detected in analogue output calibration data
0x20 00 00 00	MAIN_CFG_CHARACTER	Fault	Error detected in characterisation data.
0x40 00 00 00	UNUSED_10	N/A	Unused – for future use.
0x80 00 00 00	UNUSED_11	N/A	Unused – for future use.

6.2.2 Flag Set 2

Bit	ID	Severity	Explanation
0x00 00 00 01	MAIN_SUPPLY_LOW	Fault	Supply voltage below specification.
0x00 00 00 02	MAIN_SUPPLY_HIGH	Fault	Supply voltage above specification.
0x00 00 00 04	MAIN_TEMP	Warning	Ambient temperature out of specification.
0x00 00 00 08	MAIN_SYSTEM	Reminder	Internal comms. issue detected in transmitter
0x00 00 00 10	SENSOR_SYSTEM	Reminder	Internal comms. issue detected in sensor (first poll, indicative of unexpected sensor reset).
0x00 00 00 20	MAIN_LOG_CORRUPT	Warning	Error detected in event log during initialisation – log data lost
0x00 00 00 40	MAIN_LOG_DATA_LOST	Reminder	One or more events failed to be logged (log too busy or verification of data written failed)
0x00 00 00 80	UNUSED_12	N/A	Unused – for future use.
0x00 00 01 00	DISPLAY_ERROR	Reminder	Display fault (missing) or Display firmware too old
0x00 00 02 00	DISPLAY_HARDWARE	Reminder	Hardware failure – Vcc, EEPROM or supply voltage
0x00 00 04 00	DISPLAY_FIRMWARE	Reminder	Firmware self-check or assert failure.
0x00 00 08 00	DISPLAY_CFG_CHARACTER	Reminder	Error detected in characterisation data.
0x00 00 10 00	DISPLAY_TEMP	Reminder	Ambient temperature out of specification.
0x00 00 20 00	DISPLAY_SYSTEM	N/A	Internal comms. issue detected in display (first poll, indicative of unexpected display reset).
0x00 00 40 00	UNUSED_13	N/A	Unused – for future use.
0x00 00 80 00	SENSOR_BIAS_BATT	Reminder	Biased battery failure (increased warm-up time for sensor)
0x00 01 00 00	MAIN_SENSOR_GAS_CHANGED	Fault	Sensor changed; measures different target gas
0x00 02 00 00	MAIN_SENSOR_CHANGED_SN	Reminder	Sensor changed; measures same target gas
0x00 04 00 00	MAIN_SENSOR_UNACCEPTED	Fault	Sensor changed; change unaccepted
0x00 08 00 00	MAIN_OBSC_WARNING	Warning	Optics warning (IR sensors only)

0x00 10 00 00	UNUSED_14	N/A	Unused – for future use.
0x00 20 00 00	MAIN_RTC_FAILURE	Warning	Time/date lost or failure of RTC.
0x00 40 00 00	MAIN_CAL_DUE	Fault	Calibration due
0x00 80 00 00	MAIN_CAL_REMINDER	Reminder	Calibration reminder
0x01 00 00 00	MAIN_BUMP_DUE	Configurable	Bump test due. Set to reminder, warning or fault by configuration
0x02 00 00 00	MAIN_FLT_ON_INHIBIT	Fault	Fault relay active as inhibited and configured this way.
0x04 00 00 00	UNUSED_15	N/A	Unused – for future use.
0x08 00 00 00	MAIN_DISPLAY_DATA_ERR	Reminder	Data set by display rejected.
0x10 00 00 00	MAIN_PSAFETY	Reminder	+ve safety data lost
0x20 00 00 00	MAIN_DOWNLOAD_INTERRUPTED	Reminder	Modbus download started but not completed
0x40 00 00 00	UNUSED_16	N/A	Unused – for future use.
0x80 00 00 00	UNUSED_17	N/A	Unused – for future use.

7. +ve Safety

A +ve Safety condition is considered to be present if the instrument is in any service condition. In addition, the following +ve safety conditions are recorded:

Bit	**ID**	**Explanation**	**Cleared…**	**Stored by sensor module…**
0x00 00 00 01	PELLISTORSAVER	Pellistor saver has occurred	…by successful bump test or calibration	Yes
0x00 00 00 02	OBSCURED_ERR	Obscuration error has occurred (IR sensor only, normally obscuration > 90%)	…by successful bump test or calibration (and note: neither of these will pass unless a production zero has also been performed)	Yes
0x00 00 00 04	OBSCURED_WARNING	Obscuration warning has occurred (IR sensor only, normally obscuration between 75% and 90%)	…by successful bump test or calibration	Yes
0x00 00 00 08	ZERO	Zero fault (negative gas reading) fault has occurred	…by successful bump test or	Yes

			calibration	
0x00 00 00 10	OVER_GASSED	Over-gas fault has occurred (electrochemical sensors only)	…by successful bump test or calibration	Yes
0x00 00 00 20	SENSOR_TEMP_LOW	Sensor temperature exceeded low threshold	…by successful bump test or calibration	Yes
0x00 00 00 40	SENSOR_TEMP_HIGH	Sensor temperature exceeded high threshold	…by successful bump test or calibration	Yes
0x00 00 00 80	CAL_REMINDER	Calibration reminder	…by valid calibration	Yes – as last calibration date
0x00 00 01 00	BUMP_DUE	Bump test due	…by successful bump test or calibration	Yes – as last bump date
0x00 00 02 00	DOWNLOAD_INTERRUPTED	Modbus download started but not completed	…performing a Modbus download of configuration	No
0x00 00 04 00	LOOP_MODE_DISABLED	Current loop mode enabled for HART multi-drop communications.	…by updating the HART communications mode	No
0x00 00 08 00	SPECIAL_STATE	Analogue output and alarm relays (if fitted) not representing gas level	…clear function causing special state	No
0x00 00 10 00	FAULT	Instrument is in fault state. Note: If a fault also sets a +ve safety condition, both that condition and this will be indicated in the +ve safety menu.	…clear associated fault condition	No
0x00 00 20 00	WARNING	Instrument is in warning state. Note: If a warning also sets a +ve safety condition, both that condition and this will be indicated in the +ve safety menu.	…clear associated warning condition	No
0x00 00 40 00	CAL_DUE	Calibration due	…by valid calibration	Yes – as last calibration date

+ve Safety conditions require action to clear them (e.g. set the time/date or perform a calibration).This is elaborated in the Cleared… column in the above table.

Some +ve Safety conditions are stored in the Sensor, either explicitly (a flag to indicate the event has occurred) or implicitly (e.g. a calibration due time).

Note that some of these +ve Safety bits appear, in some respects, to be redundant. For example, an obscuration error or warning should be persistent in the Sensor. These bits are retained here as they could have been caused by a transient error or may have been only partially corrected (e.g. physical obscuration cleared but instrument not properly serviced).

8. Modbus Exception Responses

The XgardIQ will respond to errors as described in [1], with the following exception codes being supported:

ID	Name	Notes
1	Illegal function	Function code not supported (i.e. not 3 or 16); see section 3.3, Implemented Function Codes
2	Illegal data address	Invalid/unknown register address, invalid number of registers, invalid number of words for the specified registers, or write to read only register.
3	Illegal data value	Invalid number or enumeration code or data type – the registers are valid, but an attempt is being made to put invalid data into the register.
4	Slave device failure	Used internally only to flag a buffer write failure in a transaction.
5	Acknowledge	Message has been accepted and is currently being processed.
6	Slave device busy	A write has been made requesting an action that the XgardIQ cannot currently perform because it is busy.
7	Negative acknowledge	The instrument cannot perform the function received in the query.

9. Example Modbus Messages

9.1 Read Gas Level

Read register 302, 2 words.

Sent message:

01 03 01 2D 00 02 55 FE

Response:

01 03 04 41 A7 71 FE FA 3C

This equates to a gas level of 20.91.

9.2 Set Inhibit Mode

Write 1 to register 505.

Sent message:

01 10 01 F8 00 01 02 00 01 62 E8

Response:

01 10 01 F8 00 01 81 C4

10. Physical Interface Details

The electrical interface to the XgardIQ transmitter uses an RS485 transceiver, with:

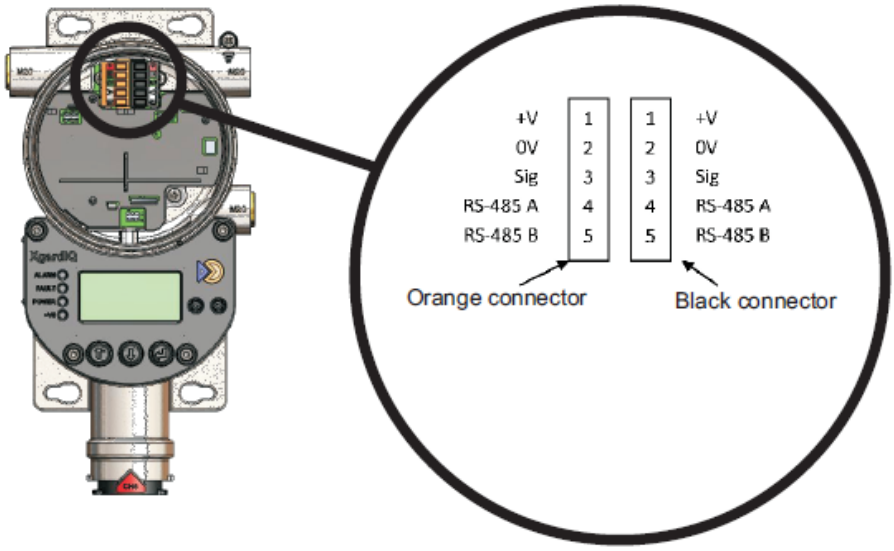
- ‘A’ signal on pin 4 of the field cable connector (see diagram on next page)
- ‘B’ signal on pin 5 of the field cable connector (see diagram on next page)

The bus is referenced to the XgardIQ negative supply, which means that the common mode voltage on the bus signals must be within -7V to +12V of the XgardIQ negative supply.

Wiring for the RS485 bus should conform to standard practice, with all devices connected in a linear chain. The wires for the ‘A’ and ‘B’ pair must be a twisted pair, which should have a characteristic impedance of 100 to 130 ohms. The bus should be terminated at the controller end

with a terminating resistor of 120 ohms. Termination at the XgardIQ end can be provided by connecting the link GJ400 on the main board.

The XgardIQ presents a load of 1/8 unit (one eighth), allowing a maximum of 255 devices on the bus. The maximum length of the bus is nominally 1km, although the actual length is dependent on the number of devices on the bus.



Further information on connecting XgardIQ via Modbus is available in the XgardIQ Installation, operating and maintenance instructions, part number M070030.

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