# Report Title :
# IRmax Public Modbus Interface

| Approvals | 1: | Date: |
|---|---|---|
| | 2: | Date: |
| | 3: | Date: |
| | 4: | Date: |

# Change History

| Issue | Change | Author | Date |
|---|---|---|---|
| 1 | First release | Dennis Culver | 24/04/2009 |
| 2 | Release to coincide with release V1 i1.02 B02 (Host) | Dennis Culver | 11/11/2009 |
| 3 | Release to coincide with release V1 i1.03 B02 | Dennis Culver | 19/01/2010 |
| 4 | Release to coincide with V2 i1.03/V5 i2.06 | Dennis Culver | 20/08/2010 |
| 5 | Clarify header page | Dennis Culver | 28/02/2012 |
| 6 | Correct and expand examples in section 7. Add missing status codes for STATUS_ID_TEMP_ERR and STATUS_ID_AOUT_FEEDBACK | Dennis Culver | 28/01/2020 |
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# Contents

# 1. Introduction

This document describes the public modbus interface for the IRmax product. This document is suitable for distribution to customers.

# 2. Modbus Interface

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

The IRmax has a standard implementation of modbus. The section describes specific details of the implementation for IRmax.

The IRmax is always addressed as a slave device.

## 2.1 Slave Address

At power-on the IRmax will always initialise itself to respond on modbus address 1. This can be changed using the IR 2009.Net software available from Crowcon.

## 2.2 Data Format

The IRmax will always initialise (at power-on) to the data format described below:

| | |
|---|---|
| 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: | 9600 nominal, adjustable 1200 to 19200. |
| Message turn-around delay: | 50mS 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. |

## 2.3 Implemented Function Codes

IRmax only recognises a limited number of function codes, as elaborated in the table below:

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

## 2.4 Data Timing

Standard MODBUS defines a silent interval of 3.5 characters times to delimit data packets. However, a silent interval of 5mS is used to define the termination of a data packet – this assists PC software in interpreting data packets.

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 period of at least 50mS before transmission will commence. Again, there may be timing problems on PC systems if this restriction is not applied.

## 2.5 Modbus Data Types

The following data types may be used:

UINT16 Two bytes, unsigned integer (16 bits), one word long, most significant byte first.

UINT32 Four bytes, unsigned 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 least significant byte of last word if needed.

FLOAT Floating point number, in IEEE-754 format.

ENUM Data enumeration. A UINT16 where each number (counting from 0) refers to an option from a list of possibilities. In the Register map notes below, enumerations and their meanings are listed and may be different for read and write operations on the same register.

## 2.6 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:

R/W Read and write allowed. (Holding Registers)

R Read only. The information cannot be modified via Modbus (Input Registers).

## 2.7 Note on Message Processing

It is always guaranteed that registers in a message will be processed sequentially from message start to message end.

The IREX Host has a 256 byte modbus buffer. This buffer is large enough to contain the largest valid modbus message.

## 2.8 Modbus Start-up Response

The IRmax will respond to modbus as soon as it has reset. This allows for immediate polling of identification registers 1 to 6 (inclusive).

The IRmax will immediately enter an initialisation phase. During this phase other registers in the map will be populated. Unpopulated data will read as 0. This phase can be detected by reading register 100. It will return 65535 (or 0xffff in hexadecimal) whilst initialisation is in progress.

The next phase is warm-up. This is normally 30 seconds. During this phase the instrument will be in start-up inhibit mode. During the warm-up phase the instrument cannot be gas zeroed or calibrated (as the IRmax is waiting for the gas readings to stabilise). Analogue output adjustment (zero trim, span adjustment) is still possible during the warm-up phase. It is not possible to control inhibit mode whilst the IRmax is in start-up inhibit mode.

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

For further information on inhibit see the note on inhibit in section 10, Analogue Output.

# 3. Modbus Data Model

As described by reference [1], elements in the modbus data model start from 1, whilst the data elements that are referred to by this data model start from 0. Crowcon generally refers to the elements in the data model as registers.

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 7, Example Modbus Messages.

## 3.1 Identification Data

Basic identification of instrument.

| Register | Name | Words | R/W | Data Type | Notes |
|---|---|---|---|---|---|
| 1 | Instrument identification | 8 | R | STRING16 | "IRmax " |
| 2 | Manufacturer | 8 | R | STRING16 | "Crowcon" |
| 3 | Software version of Host (instrument) | 8 | R | STRING16 | "V1 i1.00" |
| 4 | Serial number of Host (instrument) | 8 | R | STRING16 | |
| 5 | Date of manufacture | 4 | R | STRING8 | Enough characters for 24/10/02 or 24-10-02 or 24102002 date format |
| 6 | Identification string/Tag number | 16 | R | STRING16 | |
| 7 | Software version of iModule | 8 | R | STRING16 | "V4 i2.00" |
| 8 | Serial number of iModule | 8 | R | STRING16 | |

The Identification string/Tag number can be updated using IR 2009.Net software available from Crowcon.

### 3.1.1 Runtime Data

Live instrument data. Data is updated 1/second.

| Register | Name | Words | R/W | Data Type | Notes |
|---|---|---|---|---|---|
| 100 | Warm-up/initialisation state | 1 | R | UINT16 | 0=operational; n=seconds or warm-phase remaining; 0xffff=initialisation phase |
| 101 | Gas level | 2 | R | FLOAT | Gas level in measurement units. The status flags should always be polled |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | with the gas level to check the validity of the gas level. |
| 102 | Obscuration level | 2 | R | FLOAT | As percentage (-999.9 when in warm-up) |
| 103 | Supply voltage | 2 | R | FLOAT | In mV |
| 104 | Status flags 1 | 2 | R | BIT32 | See later section, Status Flags |
| 105 | Status flags 2 | 2 | R | BIT32 | See later section, Status Flags |
| 106 | Analogue output feedback | 2 | R | FLOAT | In mV/mA by instrument type |
| 107 | Inhibit status | 1 | R | ENUM 2 | 0=operational;1=inhibited (See note on inhibit in section 3.1.3, Analogue Output). |
| 108 | Raw signal level | 1 | R | UINT16 | (un-calibrated) |

Register 101, gas level, represents the level actually output by the instrument (on the analogue output). Normally this will be the gas level. When the instrument is some alternate mode (e.g. inhibit, warning due to obscuration) then this register will give the gas level that corresponds to the analogue output. For example, for a 0 to 100% LEL instrument with the obscuration warning level set to -12.5% (of output range, or 2mA) then when the unit is obscured the analogue output will give 2mA and register 101 will respond with -12.5. For a 0 to 20% LEL instrument with the obscuration warning level set to -12.5% (of output range, or 2mA) then when the unit is obscured the analogue output will give 2mA and register 101 will respond with -2.5%.

The status of the instrument should always be polled along with the measured gas level. See the section on Status Bits and Severity Level later in this document. If there are status bits with severity level other than OK then the gas level read in register 101 may not be reliable.

### 3.1.2 Gas Configuration

Information on gas (and range), and zero and calibration control and information.

| Register | Name | Words | R/W | Data Type | Notes |
|---|---|---|---|---|---|
| 200 | Gas name | 8 | R | STRING8 | |
| 201 | Gas units | 8 | R | STRING8 | |
| 202 | Gas range | 2 | R | FLOAT | |
| 203 | Gas zero control | 1 | R/W | ENUM | Write: 0=do nothing;1=zero module<br>Read: 0=ok;1=busy;2=warm up;3=signal error; 4=gain warning;5=lamp failure;6=detector failure;7=optics obscured;8,9=not implmented;10=error in iModule response; 11=generic failure |
| 204 | Time of last zero | 2 | R/W | UINT32 | Recommended data: seconds from 1/1/1970 |
| 205 | Last zero performed by | 8 | R/W | STRING8 | |
| 206 | Gas calibration level | 2 | R/W | FLOAT | In measurement units |
| 207 | Gas calibration control | 1 | R//W | ENUM | Write: 0=do nothing;1=calibrate module<br>Read: 0=ok;1=busy;2=warm up;3=signal error;4=obscured; |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 5=insufficient gas;6=gain error;7=gain low;8=gain high;9=prod. cal. not performed yet; 10=lamp failure;11=detector failure 12=error in iModule response; 13=generic failure |
| 208 | Time of last calibration | 2 | R/W | UINT32 | Recommended data: seconds from 1/1/1970 |
| 209 | Last calibration performed by | 8 | R/W | STRING8 | |
| 210 | Zero/calibration operation complete timer | 1 | R | UINT16 | In seconds, time to zero/calibration completion |

The Gas name and Gas units will have a sensible default name. These fields can be updated using the IR 2009.Net software available from Crowcon.

To perform a zero write 1 to the Gas Zero register. Poll the register to check the result of the zero operation. The last zero time and last zero operator registers are for information only and can be written with any compatible information desired. A successful zero will always set the last zero time to 0 and the last zero operator data to all 0's

To perform a calibration write the desired calibration level to the Gas calibration level register then write 1 to the Gas calibration control register. Poll the register to check the result of the calibration operation. The last calibration time and last calibration operator registers are for information only and can be written with any compatible information desired. A successful calibrate will always set the last calibration time to 0 and the last calibration operator data to all 0's.

It would be usual to place the instrument into inhibit mode before applying gas to calibrate an IRmax and to remove inhibit mode once the calibration gas has been purged from the instrument.

The Zero/calibration operation complete timer register gives the number of seconds until the zero/calibration operation is complete. If an error that invalidates the zero/calibration operation occurs whilst the operation is in progress then this register will immediately revert to 0 to indicate the operation has completed. No matter what this register does, always poll the Gas zero control or Gas calibrate control (as appropriate) to determine the result of the zero/calibration operation.

### 3.1.3 Analogue Output

| Register | Name | Words | R/W | Data Type | Notes |
|---|---|---|---|---|---|
| 300 | Zero (trim) adjust | 2 | R/W | FLOAT | In mV/mA by instrument type |
| 301 | Span (range) adjust | 2 | R/W | FLOAT | In mV/mA by instrument type |
| 302 | Inhibit mode | 1 | R/W | ENUM 2 | Read: 0=operational;1=in inhibit mode<br>Write: 0=normal operational mode; 1=enter inhibit mode |
| 303 | Ramp output | 2 | R/W | FLOAT | Ramp (manual test mode) output, % LEL to output |

#### 3.1.3.1 Analogue Adjustment Notes

Zero adjustment shifts the whole output up or down by the specified amount. So, if, for example, the instrument reads 3.9 (0% gas) to 20.3mA (100% gas) then a positive adjustment of 0.1mA will make the instrument now read 4.0 to 20.4mA.

The span adjustment alters the gain of the analogue output. The output is linear, so continuing the above example: at 50% scale the output would read 12.2mA. Adjusting the span down by 0.2mA will mean the instrument will now read 4.0 to 20.2mA, and 12.1mA at 50% scale.

A maximum adjustment of 3mA is allowed on both of these parameters. Attempting to adjust either parameter by more than this amount will result in a modbus error, with the written data being rejected.

#### 3.1.3.2 Inhibit and Ramp Mode Notes

Inhibit mode cannot be set or cleared until the IRmax has completed its warm-up phase. See section 2.8, Modbus Start-up Response for details of the warm-up phase.

Operational inhibit has an automatic timeout of 300 seconds (5 minutes). This means that once inhibit mode is set using register 302 the IRmax will automatically revert to operational mode after 300 seconds. If there is a need to terminate operational mode quicker than this then use register 302 to set the IRmax back to operational mode. If there is a need for the IRmax to remain in inhibit mode longer than 300 seconds then setting register 302 to inhibit mode again will reset the 300 second timeout.

The start-up and operation inhibit level and operational inhibit timeout level can be configured using the IR 2009.Net software available from Crowcon.

Ramp output, register 303, allows manual ramping of the analogue output, set in percentage of scale (i.e. normally %LEL). Like inhibit mode there is an automatic timeout of 300 seconds (5 minutes). A write to register 303 will re-trigger this timeout. To cancel ramp mode before the timeout expires write 0 to register 302 (inhibit control) to set the instrument back to normal operating mode. A read of register 302 (inhibit mode) will return 1 to indicate that the output does not represent the gas level.

### 3.1.4 Alarm Configuration

| Register | Name | Words | R/W | Data Type | Notes |
|---|---|---|---|---|---|
| 400 | Alarm 1 | 2 | R/W | FLOAT | >0.0, in measurement units |
| 401 | Alarm 2 | 2 | R/W | FLOAT | >0.0, in measurement units |
| 402 | Alarm 3 | 2 | R/W | FLOAT | >0.0, in measurement units |

Alarms should be configured so that alarm 3 > alarm 2 > alarm 1. If new alarm levels are set then the changed alarm level will be saved automatically by the instrument.

Alarms only set status bits when triggered. Alarms will be triggered at the configured alarm level, and will clear at 1 measurement unit below the configured alarm level.

# 4. Exception Codes

This section gives a general description of the Modbus error codes as they relate to the IRmax:

| Code | Name | Meaning |
|---|---|---|
| 1 | Illegal function | Function code not supported (i.e. not 3 or 16), see section 2.3, Implemented Function Codes |
| 2 | Illegal data address | invalid/unknown register address, invalid number of registers, invalid number of words for the specified registers, write to read only register |
| 3 | Illegal data value | Number out of range – the registers are valid, but an attempt is being made to put invalid data into the register. |
| 4 | Slave device failure | Not implemented. |
| 5 | Acknowledge | Not implemented. |
| 6 | Slave device busy | Attempt to perform at action that cannot be performed at this time – e.g. attempt to adjust inhibit mode whilst still in start-up inhibit. |
| 7 | Negative acknowledge | Not implemented. |

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# 5. Zero and Calibration Status Codes

Explanation of zero and calibration status codes:

| Code | Explanation |
|---|---|
| OK | Operation completed successfully. |
| Busy | Still busy from pervious zero or calibration request – try again in few seconds. |
| Warm-up | Instrument still in start-up warm-up phase – check Warm-up/initialisation state and try again when completed. |
| Signal error | Raw detector reading under/over range – instrument is in fault, return to Crowcon for servicing. |
| Gain warning | Not implemented in IRmax. |
| Lamp failure | Failure of gas or reference lamp detected at lamp start-up or during lamp calibration process – instrument is in fault, return to Crowcon for servicing. |
| Detector failure | No measurable output from the detector. Check that the gas chamber is not completely blocked. If it is clear it, otherwise the instrument is in fault, return to Crowcon for servicing. |
| Obscured | Obscuration level exceeds defined error level. Refer to Operating Instructions for corrective action. |
| Insufficient gas | It does not look like sufficient gas has been applied to instrument. Check applied gas and configured calibration level is correct. Try re-zeroing instrument before calibration. |
| Gain error | Not implemented in IRmax. |
| Gain low | Applied gas level is too high. Check applied gas and configured calibration level is correct. Try re-zeroing instrument before calibration. |
| Gain high | Applied gas level is too low. Check applied gas and configured calibration level is correct. Try re-zeroing instrument before calibration. |
| Prod. cal. error | Instrument requires servicing. Please return to Crowcon with a full explanation of the problem. |
| Error in iModule response | Internal fault in IRmax – instrument is in fault, return to Crowcon for servicing. |
| Generic failure | Backwards compatibility error. Will never occur in IRmax. |

# 6. Status Bits

Each status bit has its own individual meaning. In addition each status bit is given a severity that indicates the overall status of the instrument. Severity levels are, in order, from a good state to most severe: OK, Warning, Fatal, Low-Power or Assert.

The overall status of the instrument is the most severe status of the status bits that are set.

If the overall status of the instrument is OK then the instrument will be measuring and reporting gas levels correctly on its analogue output (excepting use of the RAMP or INHIBIT feature).

If the overall status of the instrument is Warning then the instrument will give an analogue output indicating the instrument is in a Warning state. Check for obscuration error and if this is the case clear the error and check the instrument readings (in clean air and with gas). Zero and calibrate as necessary. If the error persists try power-cycling the instrument and verify the instrument's configuration.

If the overall status of the instrument Fatal, Low-Power or Assert then perform checks as per Warning status as described above. Check the instrument supply is correct.

Note that alarm status bits do not affect the overall status of the instrument.

## 6.1 Status Bits

| Bit | ID | Severity |
|---|---|---|
| 0x00 00 00 01 | STATUS_ID_IMODULE_OLD_VERSION | FATAL |
| 0x00 00 00 02 | STATUS_ID_IMODULE_CHANGED | WARNING |
| 0x00 00 00 04 | STATUS_ID_IMODULE_MISSING | FATAL |
| 0x00 00 00 08 | STATUS_ID_IMODULE_RESPONSE | FATAL |
| 0x00 00 00 10 | STATUS_ID_IMODULE_SENSOR | FATAL |
| 0x00 00 00 20 | STATUS_ID_OPTICS_OBSCURED | WARNING |
| 0x00 00 00 40 | STATUS_ID_IMODULE_ERROR | FATAL |
| 0x00 00 00 80 | STATUS_ID_CFG_CHARACTER | FATAL |
| 0x00 00 01 00 | STATUS_ID_CFG_IMODULE | FATAL |
| 0x00 00 02 00 | STATUS_ID_CFG_PRODUCTION | FATAL |
| 0x00 00 04 00 | STATUS_ID_CFG_RAMCFG_INIT | FATAL |
| 0x00 00 08 00 | STATUS_ID_NVM_VERIFY | FATAL |
| 0x00 00 10 00 | STATUS_ID_RAMCFG_NVM | FATAL |
| 0x00 00 20 00 | STATUS_ID_RAMCFG_RAM | FATAL |
| 0x00 00 40 00 | STATUS_ID_RAM_CHECK | FATAL |
| 0x00 00 80 00 | STATUS_ID_ROM_CHECK | FATAL |
| 0x00 01 00 00 | STATUS_ID_VCCLOW | FATAL |
| 0x00 02 00 00 | STATUS_ID_VCCHIGH | FATAL |
| 0x00 04 00 00 | STATUS_ID_BRIDGELOW | FATAL |
| 0x00 08 00 00 | STATUS_ID_BRIDGEHIGH | FATAL |
| 0x00 10 00 00 | STATUS_ID_LOW_POWER | LOW_POWER |
| 0x00 20 00 00 | STATUS_ID_WARMUP | OK |

| | | |
|---|---|---|
| 0x00 40 00 00 | STATUS_ID_ASSERT | ASSERT |
| 0x00 80 00 00 | STATUS_ID_IMODULE_ASSERT | ASSERT |
| 0x01 00 00 00 | STATUS_ID_ALARM_1 | OK |
| 0x02 00 00 00 | STATUS_ID_ALARM_2 | OK |
| 0x04 00 00 00 | STATUS_ID_ALARM_3 | OK |
| 0x08 00 00 00 | STATUS_ID_OPTICS_OBSCURED_WARN | WARNING |
| 0x10 00 00 00 | STATUS_ID_TEMP_ERR | FATAL |
| 0x20 00 00 00 | STATUS_ID_AOUT_FEEDBACK | FATAL |

## 6.2 Explanation

| ID | Meaning |
|---|---|
| STATUS_ID_IMODULE_OLD_VERSION | Attached iModule of config, version 3 or less |
| STATUS_ID_IMODULE_CHANGED | iModule type changed from last switch on (different UID) |
| STATUS_ID_IMODULE_MISSING | No iModule detected at switch on (no response or invalid response to initial poll) |
| STATUS_ID_IMODULE_RESPONSE | iModule communications error after initial successful poll of iModule. If the iModule asserts then it will stop responding. |
| STATUS_ID_IMODULE_SENSOR | iModule sensor error. This can include readings under/over range on the gas or reference channel, zero (e.g. reading less than -10% of range) or span limit errors, or lamp failure |
| STATUS_ID_OPTICS_OBSCURED_ERR | iModule obscuration error |
| STATUS_ID_IMODULE_ERROR | Other iModule error. Some internal fault in the iModule, including configuration, power supply or internal memory faults |
| STATUS_ID_CFG_CHARACTER | Characterisation configuration error |
| STATUS_ID_CFG_IMODULE | iModule configuration error in Host – this will trigger a re-load of information from the iModule to the Host. |
| STATUS_ID_CFG_PRODUCTION | Production configuration error |
| STATUS_ID_CFG_RAMCFG_INIT | Error in RAM copy of standard configuration/calibration data at initialisation |
| STATUS_ID_NVM_VERIFY | NVM write/read back verification fail |
| STATUS_ID_RAMCFG_NVM | Error in NVM copy of standard configuration/calibration data whilst operational |
| STATUS_ID_RAMCFG_RAM | Error in RAM copy of standard configuration/calibration data whilst operational |
| STATUS_ID_RAM_CHECK | RAM write/read-back check failed |
| STATUS_ID_ROM_CHECK | ROM checksum self-test fail |
| STATUS_ID_VCCLOW | Self-test measurement of processor Vcc low |
| STATUS_ID_VCCHIGH | Self-test measurement of processor Vcc high |
| STATUS_ID_BRIDGELOW | Bridge supply voltage high |
| STATUS_ID_BRIDGEHIGH | Bridge supply voltage low |

| | |
|---|---|
| STATUS_ID_LOW_POWER | Low supply voltage (stabilisation current low) |
| STATUS_ID_WARMUP | iModule in warm-up phase |
| STATUS_ID_ASSERT | Software assert failure |
| STATUS_ID_IMODULE_ASSERT | iModule has asserted |
| STATUS_ID_ALARM_1 | Alarm 1 active |
| STATUS_ID_ALARM_2 | Alarm 2 active |
| STATUS_ID_ALARM_3 | Alarm 3 active |
| STATUS_ID_OPTICS_OBSCURED_WARN | Optics obscured warning (obscuration level greater than obscuration warning threshold and gas level below warning output threshold) |
| STATUS_ID_TEMP_ERR | Temperature limits exceeded (top or bottom scale). |
| STATUS_ID_AOUT_FEEDBACK | Analogue output feedback does not match the set output. Note: This error only clears by power cycling the unit. |

## 6.3 Severity Levels

The various severity levels indicate the instrument state by the application of a special output on the output signal. This special level can be changed, except for the Assert severity, using the IR 2009.Net software available from Crowcon.

### 6.3.1 Ok

Instrument is functioning correctly. Status bits simply indicate state of instrument. The output signal represents the gas measured level.

### 6.3.2 Warning

Instrument is in a state that can be simply corrected by operator action. Refer to the instrument operating manual for corrective action. The warning state will be indicated by application of < -10% level of the gas range on the output signal. If the warning is iModule changed then power-cycling the instrument will correct the status. If the warning is optics obscured then the gas reading may not be reliable.

### 6.3.3 Fatal

Instrument is in fault. Refer to the instrument operating manual for corrective action. The fatal state will be indicated by application of < -10% level of the gas range on the output signal. The gas reading could be unreliable.

### 6.3.4 Low-Power Status

This fault does not occur in IRmax – it is an IREX fault only and is left here for completeness. The fatal state will be indicated by application of < -10% level of the gas range on the output signal. The gas reading is unreliable.

### 6.3.5 Assert

Undefined instrument fault. Try power cycling instrument. If problem persists note the situation in which the error occurs and contact Crowcon with the details. This state is indicated by application of the minimum output level the instrument is capable of on the analogue output. This output level cannot be configured.

# 7. Example Modbus Messages

## 7.1 Read Gas Level

Read register 100, 2 words.

Sent message:

01 03 00 64 00 02 85 D4

Response:

01 03 04 42 2D AB BF 40 C2

This equates to a gas level of 43.42 %LEL

## 7.2 Set Inhibit Mode

Write 1 to register 302.

Sent message:

01 10 01 2D 00 01 02 00 01 71 2D

Response:

01 10 01 2D 00 01 90 3C

## 7.3 Read Inhibit State

Read register 302, 1 word.

Sent message:

01 03 01 2D 00 01 15 FF

Response:

01 03 02 00 01 79 84

The gives the response data of 00 01.

## 7.4 Read Status

Red register 104, 2 words:

Sent message:

01 03 00 67 00 02 75 D4

Response:

01 03 04 00 20 00 40 FA 09

This gives the data as 00 20 00 00, giving STATUS_ID_WARMUP.

# 8. References

[1] Modbus_Application_Protocol_V1_1b.pdf, available from http://www.modbus-IDA.org

[2] Modbus_over_serial_line_V1_02.pdf, available from http://www.modbus-IDA.org

# 9. Change History

## 9.1 Issue 1

First release.

## 9.2 Issue 2

Section 3.1.3: Add register 303, Ramp output.

Section 3.1.3.2: Expand with detail on ramp mode.

## 9.3 Issue 3

Section 3.1.1: Add note on status bits and reliability of gas readings.

Add section 3.1.4, Alarm Configuration.

Section 6: Add explanation of Severity levels. Add alarm status bits and explanation.

## 9.4 Issue 4X

Section 3.1.1, Runtime data: Add not on the meaning of gas level, register 101.

Section 3.1.2, gas configuration: Add Zero/calibration operation complete timer register.

Section 6, Status Bits: Add obscuration warning. Simplify the status bits explanation.

## 9.5 Issue 5X

Update header page.

## 9.6 Issue 6X

Correct examples in section 7.1. Add new example for reading status.

Add missing status codes for STATUS_ID_TEMP_ERR and STATUS_ID_AOUT_FEEDBACK.

# 10. Appendix 1 – Physical Interface Details

The electrical interface to the IRmax uses an RS485 transceiver, with the 'B' signal on pin 1 and the 'A' signal on pin 2. The bus is referenced the IRmax negative supply, which means that the common mode voltage on the bus signals must be within -7V to +12V of the IRmax negative supply. The data format is described in section 2.2. 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 each end with a terminating resistor of no less than 110 ohms. The IRmax 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.