Ultima OPIR-5 Modbus

Infrared Open-Path Detector
for Hydrocarbon Gases
Modbus programming guide

Instruction Manual Modbus

Part No. **MANOPIR5M**
Revision **0**

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1. Modbus Communication Interface

Modbus is a standard RS-485-based protocol used for serial communication with the Ultima OPIR-5 Detector. The Ultima OPIR-5 Detector has a two-channel Modbus (or single Modbus and single HART) compatible interface for communication with the control room equipment such as programmable logic controllers (PLCs).

By default from the factory, Ultima OPIR-5 Detector Modbus interface is set at the baud rate of 9600 bits per second, data format of 8-N-1, and with a unit address of 1 on the serial channel CH1 and 2 - on the serial channel CH2. These settings can be configured through the display user interface by navigating to the relevant setup ("SE") menu items using an MSA magnet.

The communication defaults can also be restored at any time by connecting the RESET (brown) wire to the power supply common, and, subsequently, turning on the power to the Ultima OPIR-5 Detector. Ten seconds after the power-up, the RESET wire should be disconnected from the power supply to prevent a wire shortage fault.

1.1 Baud Rate

The baud rate is a selectable parameter on the Ultima OPIR-5 Detector Modbus communication interface. The available baud rate settings of 2400, 4800, 9600, 19200 and 38400 bits per seconds can be selected and configured via either Ultima OPIR-5 Detector display or Modbus interface.

1.2 Data Format

The data format is a selectable setting via the Ultima OPIR-5 Detector Modbus communication interface. The selectable data formats are as follows:

Table 1: Data Format

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

1.3 Unit Address

Every Ultima OPIR-5 Detector unit with a Modbus capability has a unit address assigned to it for communication. The available Modbus unit addresses for external communication can range between 1 and 247.

2. Message Structure

The following subsections within this section of the document describe the message details for Ultima OPIR-5 Detector Modbus communication with external instruments.

2.1 Modbus Read Status Query/Response Messages

Table 2: Modbus Read Query Message

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

*__NOTE:__ Address 0 is reserved for broadcast mode and will not be supported at this time.

__**NOTE:__ Start Address can be a maximum of 9999 Address Locations (0000-270E)

Table 3: Modbus Read Response Message

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

2.2 Modbus Write Query/Response Messages

Table 4: Modbus Write Query Message

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

*__NOTE:__ Address 0 is reserved for broadcast mode and will not be supported at this time.

**NOTE: Start Address can be a maximum of 9999 Address Locations (0000-270E)

Table 5: Modbus Write Response Message

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

2.3 Message Function Codes

The Ultima OPIR-5 Detector Modbus interface supports the following standard function codes for communication with external instruments:

- Function code 03 (Read Holding Registers) for reading single or multiple registers;
- Function code 06 (Preset Single Register) for writing to a single register.

2.4 Exception Response

In a normal communications query and response, the master device sends a query to the Ultima OPIR-5 Detector and the Ultima OPIR-5 Detector receives the query without a communications error and handles the query normally within the master device's allowable timeout. The Ultima OPIR-5 Detector then returns a normal response to the master. An abnormal communications produces one of four possible events:

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

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

Table 6: Ultima OPIR-5 Detector Exception Response Message

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

2.5 Exception Codes

Exception Code Field: In a normal response, the Ultima OPIR-5 Detector returns data and status in the data field, which was requested in the query from the master. In an exception response, the Ultima OPIR-5 Detector returns an exception code in the data field, which describes the Ultima OPIR-5 Detector condition that caused the exception. Below is a list of exception codes that are supported by the I Ultima OPIR-5 Detector:

Table 7: Ultima OPIR-5 Detector Exception Codes

Code	Name	Description
01	Illegal Function	The function code received in the query is not an allowable action for the Ultima OPIR-5 Detector.
02	Illegal Data Address	The data address received in the query is not an allowable address for the Ultima OPIR-5 Detector.
03	Illegal Data Value	A value contained in the query data field is not an allowable value for the Ultima OPIR-5 Detector.
04	Slave Device Failure	An unrecoverable error occurred while the Ultima OPIR-5 Detector was attempting to perform the requested action.
05	Acknowledge	The Ultima OPIR-5 Detectorhas accepted the request and is processing it, but a long duration of time will be required to do so. This response is returned to prevent a timeout error from occurring in the master.
06	Device Busy	The Ultima OPIR-5 Detector is engaged in processing a long-duration program command. The master should retransmit the message later when the slave is free.

3. Ultima OPIR-5 Modbus Command Registers

This section provides detailed information on the Ultima OPIR-5 Modbus command registers, their functionality, type, range and accessability (read or write).

Table 8: Ultima OPIR-5 User Command Registers

Addr. (Hex)	Name	Function	Data Type	Data Range	R/W
GENERAL USER REGISTERS					
0000h	Analog Output 1	LEL-m scale 0-20 mA current output for	Numeric Value	0 – 21.7mA represented in uA	R
0001h	Operating Mode	Set/View operating mode	Bit Map	See register description	R/W
0002h	Error Status	View present error	Bit Map	See register description	R
0003h	Reserved	N/A	N/A	N/A	N/A
0004h	Model Number	View Model ID	Numeric Value	Constant 5500	R
0005h	Software Rev	Software Revision	2 ASCII chars	A, B, etc.	R
0006h	Beam Block Percentage	Shows percentage of IR beam blockage (gain change)	2 ASCII chars	1-10000 representing 0.1 – 1000.0	R
0007h	Reserved	N/A	N/A	N/A	R
0008h	Reserved	N/A	N/A	N/A	R
0009h	Address for CH1	Set/View CH1 address	Numeric Value	1-247 decimal	R/W
000Ah	Adjusted ratio	Adjusted ratio	Numeric Value	0-65535	R
000Bh	Baud Rate for CH1	Set/View CH1 Baud Rate (2400, 4800, 9600 19200, 38400)	Code	0, 1, 2, 3, 4	R/W
000Ch	Data Format for CH1	Set/View CH1 Data Format (8N1, 8E1, 801, 8N2)	Code	0, 1, 2, 3	R/W
000Dh	% ppm-m Gas Concentration	Read gas concentration in % of ppm-m Full Scale	Numeric Value	-9 – (+)106%	R
000Eh	% LEL-m Gas Concentration	Read gas concentration in % of LEL-m Full Scale	Numeric Value	-9 – (+)106%	R
000Fh	Reserved	N/A	N/A	N/A	R
0010h	Reserved	N/A	N/A	N/A	R
0011h	Gas Units	Gas concentration measurement units (LEL-m or ppm-m)	Numeric Value	0 – LEL-m 1 – ppm-m	R
0012h	ppm-m value High	Read hi word of gas concentration in ppm	Numeric Value	0-65535	R
0013h	ppm-m value Low	Read low word of gas concentration in ppm	Numeric Value	0-65535	R

Addr. (Hex)	Name	Function	Data Type	Data Range	R/W
0014h	Reserved	N/A	N/A	N/A	R
0015h	Reserved	N/A	N/A	N/A	R
0016h	Reset Alarm	Resets latching alarms	Numeric Value	0	R/W
0017h	Reserved				
0018h	LEL-m Alarm Set Point	Set/View Alarm level as % full scale	Numeric Value	Warn level –60% LEL-m full scale	R/W
0019h	LEL-m Warn Set Point	Set/View Warn level as % full scale	Numeric Value	10 - 60% LEL-m full scale	R/W
001Ah	ppm·m Warn Set Point	Set/View Warn level as % full scale ppm·m	Numeric Value	40 – 90% ppm-m full scale	R/W
001Bh	Miscellaneous Fault	Shows misc. faults, i.e. with code checksum, temperature sensor, etc.	Bit Map	See register description	R
001Ch	LEL-m Adjusted Ratio	Adjusted ratio for LEL-m scale	Numeric Value	0-65535 decimal	R
001Dh	Address for CH2	Set/View CH2 address	Numeric Value	1-247 decimal	R/W
001Eh	Baud Rate for CH2	Set/View CH2 Baud Rate (2400, 4800, 9600 19200, 38400)	Code	0, 1, 2, 3, 4	R/W
001Fh	Data Format for CH2	Set/View CH2 Data Format (8N1, 8E1, 801, 8N2)	Code	0, 1, 2, 3	R/W
0020h	Ch1 Receive Errors	Number of Modbus CH1 total receive errors	Numeric Value	0-65535 decimal	R
0021h	Reserved	N/A	N/A	N/A	R
0022h	Ch1 Function Code Errors	Number of Modbus CH1 function code errors.	Numeric Value	0-65535 decimal	R
0023h	Ch1 Register Address Errors	Number of CH1 Starting Register Address errors.	Numeric Value	0-65535 decimal	R
0024h	Reserved	N/A	N/A	N/A	R
0025h	Ch1 CRC Errors	Number of Modbus CH1 CRC errors	Numeric Value	0-65535 decimal	R
0026h	Ch1 Framing Errors	Number of Ch1 UART framing errors	Numeric Value	0-65535 decimal	R
0027h	Ch1 Overrun Errors	Number of Ch1 UART overrun errors	Numeric Value	0-65535 decimal	R
0028h	Reserved	N/A	N/A	N/A	R
0029h	Ch2 Receive Errors	Number of Modbus CH2 total receive errors	Numeric Value	0-65535 decimal	R
002Ah	Display ASCII High	High byte – status LED Bit Low byte – most significant digit	ASCII Chars	0 – 65535 decimal	R
002Bh	Display ASCII Low	High byte – middle digit Low byte – least significant digit	ASCII chars	0 – 65535 decimal	R
002Ch	Analog Output 2	ppm-m scale 0-20 mA current output for	Numeric Value	0 – 21.7mA represented in uA	R

Addr. (Hex)	Name	Function	Data Type	Data Range	R/W
002Dh	Clear Com Errors	Clears communication error counters	Numeric Value	0 – channel 1 1 – channel 2	W
002Eh	Beam Block Fault Delay	Number of minutes before beam block fault is enabled	Numeric Value	0 – 60 min	R/W
002Fh	Beam Block AO Delay	Number of sec before current drops to 0 mA to indicate beam block fault	Numeric Value	0 – 60 sec	R/W
0030h	LEL Analog Output	LEL range analog output in microamps	Numeric Value	0-65535 decimal	R
0031h	ppm-m Analog Output	ppm-m range analog output in microamps	Numeric Value	0-65535 decimal	R
0032h	HART Minimum AO	Minimum analog output for a HART-enabled unit	Numeric Value	0 – 3.5 mA 1 – 1.25 mA	R/W
0033h	HART Enable / Disable	Enables / disables HART protocol in software	Numeric Value	0 – disable 1 – enable	R/W
0034h	Operating Submode	Substage of operating mode (alarm, warn, etc.)	Bit Map	See register description	R
0035h	Alignment Number	Percentage of transmitter signal observed by receiver	Numeric Value	0 – 100	R
0036h	Hardware Revision	Hardware Revision	2 ASCII chars	A, B, etc.	R
0037h	Ch2 Function Code errors	Number of Modbus Ch2 function code errors.	Numeric Value	0-65535 decimal	R
0038h	CH2 Register Address Errors	Number of Ch2 Starting Register Address errors.	Numeric Value	0-65535 decimal	R
0039h	Ch2 CRC Errors	Number of Modbus Ch2 CRC errors	Numeric Value	0-65535 decimal	R
003Ah	Ch2 Framing Errors	Number of Ch2 UART framing errors	Numeric Value	0-65535 decimal	R
003Bh	Ch2 Overrun Errors	Number of Ch2 UART overrun errors	Numeric Value	0-65535 decimal	R
003Ch – 008C	Reserved	N/A	N/A	N/A	N/A
008Dh	Gas ID	Identification number for gas calibration	Numeric Value	0-65535 decimal	R
008Eh – 00AE	Reserved	N/A	N/A	N/A	N/A
EVENT LOGGING REGISTERS					
00AFh	Event Happened Flag	Indicates whether any kind of event was logged or not	Numeric Value	0 – no events 1 – event logged	R
00B0h	Event Log User Reset	Clears events	Numeric Value	0 – clear events 1 – clear event happened flag	R/W
00B1h	Run Time High	High word of Run Time in Seconds	Numeric Value	0-65535 decimal	R/W
00B2h	Run Time Low	Low word of Run Time in Seconds	Numeric Value	0-65535 decimal	R/W

Addr. (Hex)	Name	Function	Data Type	Data Range	R/W
00B3h	Real Time Clock Year, Month	Read/Set year and month of Real-Time Clock (RTC)	Numeric Value	1 –99 year, 1– 12 month	R/W
00B4h	Real Time Clock Day, Hour	Read/Set day and hour of RTC	Numeric Value	1 – 31 day, 0 – 23 hour	R/W
00B5h	Real Time Clock Minute, Second	Read/Set minutes and seconds of RTC	Numeric Value	0– 59 minutes 0 – 59 seconds	R/W
00B6h	Power Cycled Flag	Time Reset After power Cycled	Numeric Value	0 = Time not Reset, 1 = Time Reset	R
00B7h	Event Index	Index of Logged Events	Numeric Value	0 - 9	R
Warn Event Log					
00B8h	Running Time High	Running Time Hi for Warning Event log entries	Numeric Value	0 - 65535	R
00B9h	Running Time Low	Running Time Low for Warning Event log entries	Numeric Value	0 - 65535	R
00BAh	Clock Time Hi	Hi byte = year, Lo byte month: Warning clock time	Numeric Value	1 –99 year, 1– 12 month	R
00BBh	Clock Time Mid	Hi byte = Day, Lo byte Hour: Warning clock time	Numeric Value	1 – 31 day, 0 – 23 hour	R
00BCh	Clock Time Low	Hi byte = Minute, Lo byte second: Warning clock time	Numeric Value	0 – 59 minutes 0 – 59 seconds	R
00BDh	Reserved	Reserved	Numeric Value	0	R
00BEh	Reserved	Reserved	Numeric Value	0	R
00BFh	Warning Event Count	Total Warning Event Count	Numeric Value	0 - 65535	R
Alarm Event Log					
00C0h	Running Time High	Running Time Hi for Alarm Event log entries	Numeric Value	0 - 65535	R
00C1h	Running Time Low	Running Time Low for Alarm Event log entries	Numeric Value	0 - 65535	R
00C2h	Clock Time Hi	Hi byte = year, Lo byte month: Alarm clock time	Numeric Value	1 –99 year, 1– 12 month	R
00C3h	Clock Time Mid	Hi byte = Day, Lo byte Hour: Alarm clock time	Numeric Value	1 – 31 day, 0 – 23 hour	R
00C4h	Clock Time Low	Hi byte = Minute, Lo byte second: Alarm clock time	Numeric Value	0 – 59 minutes 0 – 59 seconds	R
00C5h	Reserved	Reserved	Numeric Value	0	R
00C6h	Reserved	Reserved	Numeric Value	0	R
00C7h	Alarm Event Count	Total Alarm Event Count	Numeric Value	0 - 65535	**R**

Addr. (Hex)	Name	Function	Data Type	Data Range	R/W
Fault Event Log					
00C8h	Running Time High	Running Time High for Fault Event log entries	Numeric Value	0 - 65535	**R**
00C9h	Running Time Low	Running Time Low for Fault Event log entries	Numeric Value	0 - 65535	**R**
00CAh	Clock Time Hi	Hi byte = year, Lo byte month: Fault clock time	Numeric Value	1 –99 year, 1– 12 month	**R**
00CBh	Clock Time Mid	Hi byte = Day, Lo byte Hour: Fault clock time	Numeric Value	1 – 31 day, 0 – 23 hour	**R**
00CCh	Clock Time Low	Hi byte = Minute, Lo byte second: Fault clock time	Numeric Value	0 – 59 minutes 0 – 59 seconds	**R**
00CDh	Fault Code	ULTIMA OPIR-5 Fault Code	Numeric Value	Bitmap	**R**
00CEh	Reserved	Reserved	Numeric Value	0	**R**
00CFh	Fault Event Count	Total Alarm Event Count	Numeric Value	0 - 65535	**R**
Maintenance Event Log					
00D0h	Running Time High	Running Time Hi for Maint. Event log entries	Numeric Value	0 - 65535	R
00D1h	Running Time Low	Running Time Low for Maint. Event log entries	Numeric Value	0 - 65535	R
00D2h	Clock Time Hi	Hi byte = year, Lo byte month: Maint. clock time	Numeric Value	1 –99 year, 1– 12 month	R
00D3h	Clock Time Mid	Hi byte = Day, Lo byte Hour: Maint. clock time	Numeric Value	1 – 31 day, 0 – 23 hour	R
00D4h	Clock Time Low	Hi byte = Minute, Lo byte second: Maint. clock time	Numeric Value	0 – 59 minutes 0 – 59 seconds	R
00D5h	Reserved	Reserved	Numeric Value	0	R
00D6h	Reserved	Reserved	Numeric Value	0	R
00D7h	Alarm Event Count	Total Maint. Event Count	Numeric Value	0 - 65535	R
Calibration Event Log					
00D8h	Running Time High	Running Time Hi for Cal Event log entries	Numeric Value	0 - 65535	R
00D9h	Running Time Low	Running Time Low for Cal Event log entries	Numeric Value	0 - 65535	R
00DAh	Clock Time Hi	Hi byte = year, Lo byte month: Cal clock time	Numeric Value	1 –99 year, 1– 12 month	R
00DBh	Clock Time Mid	Hi byte = Day, Lo byte Hour: Cal clock time	Numeric Value	1 – 31 day, 0 – 23 hour	R
00DCh	Clock Time Low	Hi byte = Minute, Lo byte second: Cal clock time	Numeric Value	0 – 59 minutes 0 – 59 seconds	R
00DDh	Calibration Event Code	Calibration code	Numeric Value	1 – zero, 2 - calibration	R
00DEh	Reserved	Reserved	Numeric Value	0	R

Addr. (Hex)	Name	Function	Data Type	Data Range	R/W
00DFh	Alarm Event Count	Total Alarm Event Count	Numeric Value	0 - 65535	R
00E0h – 00FF	Reserved	N/A	N/A	N/A	N/A

3.1 Analog Output 1 (0x0000)

A read returns a value of the LEL output current in microamps.

3.2 Operating Mode (0x0001)

This read/write accessible register reports the current operating mode for the Ultima OPIR-5 Detector. A Read command returns the present Ultima OPIR-5 Detector mode, represented by the enabled bit. The following table shows the mode represented by each bit in the 16-bit register.

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

Bit Position	7	6	5	4	3	2	1	0
Mode Description	Not Used	Startup Mode	Not Used	Not Used	Not Used	Zero Mode	Not Used	Run Mode
Hex Value	0x0080	0x0040	0x0020	0x0010	0x0008	0x0004	0x0002	0x0001
Decimal Value	128	64	32	16	8	4	2	1

Bit Position	15	14	13	12	11	10	9	8
Mode Description	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Gas Check	Align Mode
Hex Value	0x8000	0x4000	0x2000	0x1000	0x0800	0x0400	0x0200	0x0100
Decimal Value	32768	16384	8192	4096	2048	1024	512	256

A Read command returns the present ULTIMA OPIR-5 mode, represented by the enabled bit. Descriptions of the modes are provided below.

- **Run Mode:** Ultima OPIR-5 Detector normal operation mode, with LEL measurement taking place. Writing 1 to mode register allows to abort zero/calibration/gas check, if gas concentration is less then 5% of Full Scale
- **Zero Mode:** Zeroing of the Ultima OPIR-5 Detector in progress. Writing 0x0004 to mode register sends the unit to zero mode.
- **Startup Mode:** Ultima OPIR-5 Detector is initializing during powerup.
- **Alignment Mode:** Ultima OPIR-5 Detector is in alignment mode. This is used during installation to align the receiver and transmitter. At the end of alignment mode, the mode switches to Zero Mode to compensate for background gas levels.

- **Gas Check Mode:** Ultima OPIR-5 Detector gas check is in progress. During gas check the analog outputs are held at 1.5mA and the alarm relays are disabled, but the display shows the gas concentration.

3.3 Status Error (0x0002)

A Read returns the bit map for any error that is present after the application of fault stage time delays. The following table shows the errors that are represented by each bit in the register.

Table 10: Bitmap for Status Error (Read-Only Access)

Bit Position	7	6	5	4	3	2	1	0
Fault Description	Zero	Calib-ration	Low Line	Wire Short	High IR	Beam Block	Dirty Lens	Partial Beam Block
Hex Value	0x0080	0x0040	0x0020	0x0010	0x0008	0x0004	0x0002	0x0001
Decimal Value	128	64	32	16	8	4	2	1
Display 'F' Code	**" F8"**	**" F2"**	**"F6"**	**"F10"**	**" F0"**	**" F3"**	**" F1"**	**" F1"**

Bit Position	15	14	13	12	11	10	9	8
Fault Description	Memory Check-sum	Excess Drift	Misc	Setup Menu	Heater	Trans-mitter	Over Temp.	Gas Left
Hex Value	0x8000	0x4000	0x2000	0x1000	0x0800	0x0400	0x0200	0x0100
Decimal Value	32768	16384	8192	4096	2048	1024	512	256
Display 'F' Code	**" F7"**	**" F0"**	**" F7"**	**" F5"**	**" F7"**	**"tF7"**	**" ot"**	**" F9"**

3.4 Product Model (0x0004)

A read-only register returns the model type for the detector, a constant "5500" in decimal format.

3.5 Software Revision (0x0005)

A read returns the software revision of the Ultima OPIR-5 Detector in 2 ASCII characters. The most significant byte is the first character, the least significant byte is the second character. For example, if this register reads 0x2042 then the first digit is 0x20 (a space character) and the second is 0x42 (the character B). So in this example the firmware version is " B".

3.6 Percentage Beam Block (0x0006)

This register returns a value from 0-100. When the optical path of the Ultima OPIR-5 Detector is clear, the reading is 0% blocked. When the register reads near 100 the optical path is blocked and must be cleared immediately. At 100% the Ultima OPIR-5 Detector indicates a fault condition and is no longer capable of detecting gas. This register can be used for predictive maintenance.

3.7 Serial Channel 1 Unit Address (0x0009)

A read returns the address of the Ultima OPIR-5 Detector. A write changes the address to the requested address. The range of the address is 1 to 247.

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

3.8 Serial Channel 1 Baud Rate (0x000B)

A read returns the baud rate of the Ultima OPIR-5 Detector. A write changes the baud rate to the requested baud rate. After the baud rate has been changed to the addressed unit, the Modbus communication will cease because the baud rate has changed; therefore the master will have to change its baud rate to the slave's new baud rate in order to re-start the communications. The factory default is 9600 bps.

Table 11: ULTIMA OPIR-5 Baud Rate Codes

Register Code	Baud Rate (bps)	Register Access
04	38400	Read/Write
03	19200	Read/Write
02	9600	Read/Write
01	4800	Read/Write
00	2400	Read/Write

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

NOTE: By grounding the RESET input during power-up cycle (10 seconds), the Ultima OPIR-5 Detector Baud Rate will default to 9600.

3.9 Serial Channel 1 Data Format (0x000C)

A read returns the data format of the Ultima OPIR-5 Detector. A write will change the data format to the requested data format. After the data format has been changed, the addressed unit may cease or start producing communication errors because the data format has changed; therefore, the master will have to change its data format to the slave's new data format in order to re-start or provide proper communications.

Table 12: Data Format

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

NOTE: By grounding RESET input during power-up cycle (10 seconds), the ULTIMA OPIR-5 Data Format will default to 8-N-1.

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

3.10 Gas concentration as percentage of ppm-m full scale (0x000D)

A read returns the gas concentration observed by the detector as a percentage (0 – 100) on ppm-m full scale.

3.11 Gas concentration as percentage of LEL-m full scale (0x000E)

A read returns the gas concentration observed by the detector as a percentage (0 – 100) on LEL-m full scale.

3.12 Gas Measurement Units (0x0011)

A read returns the gas measurement units based on a standard HART Primary Variable (PV) Units Code. The PV unit code for LEL-m is a constant 161, and ppm-m is a constant 139.

3.13 Reset Alarms (0x0016)

A write to this register will reset the latching alarm and warning status LED as well as LEL-m alarm, LEL-m warn and ppm-m warn relays.

3.14 Quick Fault (0x0017)

A read from this register returns a bitmap of immediate status errors without any time delay applied. Please note that in some cases, quick fault may not result in 0 mA output immediately.

3.15 LEL·m Alarm Relay Configuration (0x0018)

The low byte of this register contains LEL·m high alarm set point value, while the high byte contains latch/non-latch and energize/de-energize configuration settings. A structure of a standard Ultima OPIR-5 Detector alarm/relay configuration register is shown in Table 13.

Table 13: Standard Alarm/Relay Configuration Register

Byte	Function	Bit Position	Access
High	Not Used	15 MSB	Read
	Not Used	14	Read
	Not Used	13	Read
	Not Used	12	Read
	Not Used	11	Read
	Not Used	10	Read
	Latching/Non-Latching	9	R/W
	Energized/De-Energized Relays	8	R/W
Low	Set point	(7-0)	R/W

A write to this register will not be allowed and a device will return an exception code if an alarm condition is present.

A read request returns the present LEL·m high alarm settings of the Ultima OPIR-5 Detector. A write command changes the settings to the requested values. The set points are programmable in steps of 1% of full scale.

NOTE: The maximum alarm setting for the Ultima OPIR-5 Detector is 60% full scale which is 3.0 LEL·m for methane detectors and 0.6 LEL·m for heavy hydrocarbon detectors.

A 1 in the 9th bit position means the output is Latching, a 0 means it is Non-Latching. A 1 in the 8th bit position means the output is normally Energized a 0 means it is normally De-Energized. The high alarm set point cannot be set below the low alarm (warning) set point.

3.16 LEL·m Warn Relay Configuration (0x0019)

The low byte of this register contains LEL·m low alarm set point value, while the high byte contains latch/non-latch and energize/de-energize configuration settings for LEL·m warning relay. A structure of a standard Ultima OPIR-5 Detector alarm/relay configuration register is shown in Table 13.

A write to this register will not be allowed and a device will return an exception code if an alarm or a warning condition is present.

A read request returns the present LEL·m low alarm settings of the Ultima OPIR-5 Detector. A write command changes the settings to the requested values. The set points are programmable in steps of 1% of full scale.

Factory default is 30% FS, non-latching, de-energized.

NOTE: The maximum low alarm (warning) setting for the Ultima OPIR-5 Detector is the lower of high alarm set point or 60% of full scale, while minimum low alarm (warning) setting is 10% of full scale.

A 1 in the 9th bit position means the output is Latching, a 0 means it is Non-Latching. A 1 in the 8th bit position means the output is normally Energized a 0 means it is normally De-Energized. The low alarm set point cannot be set above the high alarm set point.

3.17 ppm·m Warn Relay Configuration (0x001A)

The low byte of this register contains ppm·m warning set point value, while the high byte contains latch/non-latch and energize/de-energize configuration settings for ppm·m warning relay. A structure of a standard Ultima OPIR-5 alarm/relay configuration register is shown in Table 13.

A write to this register will not be allowed and a device will return an exception code if an alarm or a warning condition is present.

A read request returns the present ppm·m warning settings of the Ultima OPIR-5 Detector. A write command changes the settings to the requested values. The set points are programmable in steps of 1% of full scale on ppm·m scale.

NOTE: The maximum low alarm (warning) setting for the Ultima OPIR-5 Detector is the lower of high alarm set point or 60% of full scale, while minimum low alarm (warning) setting is 10% of full scale.

A 1 in the 9th bit position means the output is Latching, a 0 means it is Non-Latching. A 1 in the 8th bit position means the output is normally Energized a 0 means it is normally De-Energized. The ppm·m warning set point can be set between 40% and 90% of ppm·m full scale.

3.18 Total COM Receive Errors for Channel 1 (0x0020)

A read indicates the total Modbus communication receive errors detected by the Ultima OPIR-5 Detector slave unit on serial channel 1. The maximum count is 65,535; the counter will roll over to zero and begin counting again. The total errors are an accumulation of the individual communication errors listed below.

3.19 Function Code Errors for Channel 1 (0x0022)

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

3.20 Starting Address Errors for Channel 1 (0x0023)

The counter is incremented for illegal register address requested on Channel 1. A read indicates the number of Starting Address Errors that occurred in the slave device. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

3.21 RXD CRC Errors Hi for Channel 1 (0x0025)

A read indicates the number of RXD CRC Errors that occurred in the slave device. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

3.22 RXD CRC Errors Lo for Channel 1 (Same as Hi) (0x0026)

NOTE: Hi and Lo CRC errors are now reported in the same word. A read from either Hi or Lo will return the same count.

3.23 Overrun Errors for Channel 1 (0x0027)

A read indicates the number of Overrun Errors that occurred on the serial channel 1 of the Ultima OPIR-5 Detector. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

3.24 Framing Errors for Channel 1 (0x0028)

A read indicates the number of Framing Errors that occurred on the serial channel 1 of the Ultima OPIR-5 Detector. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

3.25 Total COM Receive Errors for Channel 2 (0x0029)

A read indicates the total Modbus communication receive errors detected by the Ultima OPIR-5 Detector slave unit on serial channel 2. The maximum count is 65,535; the counter will roll over to zero and begin counting again. The total errors are an accumulation of the individual communication errors listed below.

3.26 Clear Communication Errors (0x002D)

A read or write resets all the Modbus communication error counters to 0.

3.27 Function Code Errors for Channel 2 (0x0037)

A read indicates the number of Function Code Errors that occurred on the Channel 2. The maximum count is 65,535 the counter will roll over to zero and begin counting again.

3.28 Starting Address Errors for Channel 2 (0x0038)

The counter is incremented for illegal register address requested on Channel 2. A read indicates the number of Starting Address Errors that occurred in the slave device. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

3.29 RXD CRC Errors for Channel 2 (0x0039)

A read indicates the number of RXD CRC Errors that occurred in the Channel 2. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

3.30 Overrun Errors for Channel 2 (0x003A)

A read indicates the number of Overrun Errors that occurred on the serial channel 2 of the Ultima OPIR-5 Detector. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

3.31 Framing Errors for Channel 2 (0x003B)

A read indicates the number of Framing Errors that occurred on the serial channel 2 of the Ultima OPIR-5 Detector. The maximum count is 65,535; the counter will roll over to zero and begin counting again.

3.32 Gas Identification (0x008D)

Reads calibration gas identification number.

Table 14: Gas Identification Codes

Code	Gas Type
100	Methane ISO/NFPA
101	Propane ISO/NFPA
114	Methane IEC
115	Propane IEC

3.33 Event Logging Registers (0x00AF – 0x00DF)

3.33.1 Event Happened Flag (0x00AF)

This is a binary flag that indicates whether any kind of event was logged on the instrument or not.

3.33.2 Reset Events (0x00B0)

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

3.33.3 Running Time in seconds hi word (0x00B1)

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

3.33.4 Running Time in seconds lo word (0x00B2)

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

Table 15: Real Time Clock Time Format

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

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

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

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

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

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

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

3.33.8 Power Cycle Flag (0x00B6)

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

3.33.9 Event Index (0x00B7)

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

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

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

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

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

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

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

These registers are described in Table 15 as item number 1.

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

These registers are described in Table 15 as item number 2.

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

These registers are described in Table 15 as item number 3.

3.33.15 Total Warning Event Counter (0x00BF)

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

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

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

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

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

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

These registers are described in Table 15 as item number 1.

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

These registers are described in Table 15 as item number 2.

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

These registers are described in Table 15 as item number 3.

3.33.21 Total Alarm Event Counter (0x00C7)

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

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

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

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

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

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

These registers are described in Table 15 as item number 1.

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

These registers are described in Table 15 as item number 2.

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

These registers are described in Table 15 as item number 3.

3.33.27 Fault Code (0x00CD)

This register is described in **Error! Reference source not found.**.

3.33.28 Total Fault Event Counter (0x00CF)

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

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

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

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

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

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

These registers are described in Table 15 as item number 1.

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

These registers are described in Table 15 as item number 2.

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

These registers are described in Table 15 as item number 3.

3.33.34 Total Maintenance Event Counter (0x00D6)

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

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

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

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

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

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

These registers are described in Table 15 as item number 1.

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

These registers are described in Table 15 as item number 2.

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

These registers are described in Table 15 as item number 3.

3.33.40 Calibration Code (0x00DD)

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

3.33.41 Total Calibration Event Counter (0x00DF)

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