CalScan Services

Standard and Enron ModBus™ Driver Development Guide 1v16

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1.0 Modicon MODBUS™

1.10 The Modicon ModBus Protocol

MODBUS® Protocol is a messaging structure developed by Modicon in 1979, used to establish master-slave/client-server communication between intelligent devices. It is a de facto standard, truly open and the most widely used network protocol in the industrial manufacturing environment.

This is a brief description of the ModBus protocol. If you are writing a ModBus master interface from scratch you should get the document, *ModBus Application Protocol v1,* from www.modbus.org for complete information.

1.11 Data Encoding

MODBUS uses a '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. So for example

Register size	**Value**
16 – bit	0x1234 The first byte sent is 0x12 then 0x34

1.11 Transmission Modes

The original ModBus specification included two possible transmission modes: ASCII and RTU. ModBus RTU mode is the most common implementation and the only one that the Hawk supports. RTU using binary coding and CRC error-checking as opposed to ASCII which is less efficient and uses less effective LRC error checking.

1.12 MODBUS data model

MODBUS bases its data model on a series of tables that have distinguishing characteristics. The four primary tables are:

Primary Tables	Object Type	Type of Access	Comments
Discrete Inputs	Single bit	Read-Only	This type of data can be provided by an I/O system
Coils	Single bit	Read-Write	This type of data can be alterable by an application program
Input Registers	16-bit word	Read-Only	This type of data can be provided by an I/O system
Holding Registers	16-bit word	Read-Write	This type of data can be alterable by an application program

The distinctions between inputs and outputs, and between bit-addressable and word-addressable data items, do not imply any application behavior. It is perfectly acceptable, and very common, to regard all four tables as overlaying one another, if this is the most natural interpretation on the target machine in question. For each of the primary tables, the protocol allows individual selection of 65536 data items, and the operations of read or write of those items are designed to span multiple consecutive data items up to a data size limit which is dependent on the transaction function code. It's obvious that all the data handled via MODBUS (bits, registers) must be located in device application memory. But physical address in memory should not be confused with data reference. The only requirement is to link data reference with physical address.

MODBUS logical reference number, which are used in MODBUS functions, are unsigned integer indices starting at zero.

1.13 Function Codes Supported

The Hawk supports the following ModBus Function Codes:

03 (0x03) - Read Holding Registers
04 (0x04) - Read Input Registers is supported
16 (0x10) - Write Holding Registers

These function codes are used to read from 1 to 50 contiguous input registers in a remote device. The ModBus packet specifies the starting register address and the number of registers. Registers are addressed starting at zero.

The register data in the response message are packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits. At the end of each transmission is a 16 bit CRC.

Request

Address	1 Byte	0x01 to 0xFF
Function code	1 Byte	**0x04**
Starting Address	2 Bytes	0x0000 to 0xFFFF
Quantity of Input Registers	2 Bytes	0x0001 to 0x0032
16 Bit CRC	2 Bytes	

Request Example: 01 04 00 63 00 02 81 D5 - Read two input register starting at address 100

Response

Address	1 Byte	0x01 to 0xFF
Function code	1 Byte	**0x04**
Byte count	1 Byte	2 x **N***
Input Registers	**N*** x 2 Bytes	
16 Bit CRC	2 Bytes	

***N** = Quantity of Input Registers

Response Example: 01 04 04 47 AE 42 CE 3F E5 – Send back four bytes

Error

Address	1 Byte	0x01 to 0xFF
Error code	1 Byte	**0x84**
Exception code	1 Byte	01 or 02 or 03 or 04
16 Bit CRC	2 Bytes	

1.14 Floating Point Byte Order

There are quite a few methods of sending a IEEE float using ModBus registers. Each implementation sends the byte order in different ways. The Hawk uses the byte order on standard Modicon Systems.

If in the above response example the two registers were holding a float**.**

HH MH ML LL

47 AE 42 CE = IEEE Float = 103.14 = 42 CE 47 AE (High to Low byte 0x42CE47AE)

So the byte order in a ModBus float is: ML – LL – HH – MH

1.2 MODBUS™ Exception Codes

The following is a list of the standard ModBus error codes and their meaning:

Code	Name	Meaning
01	ILLEGAL FUNCTION	The function code received in the query is not an allowable action for the slave. If a Poll Program Complete command was issued, this code indicates that no program function preceded it.
02	ILLEGAL DATA ADDRESS	The data address received in the query is not an allowable address for the slave.
03	ILLEGAL DATA VALUE	A value contained in the query data field is not an allowable value for the slave.
04	SLAVE DEVICE FAILURE	An unrecoverable error occurred while the slave was attempting to perform the requested action.
05	ACKNOWLEDGE	The slave has accepted the request and is processing it, but a long duration of time will be required to do so. This response is returned to prevent a timeout error from occurring in the master. The master can next issue a Poll Program Complete message to determine if processing is completed.
06	SLAVE DEVICE BUSY	The slave is engaged in processing a long–duration program command. The master should retransmit the message later when the slave is free.
07	NEGATIVE ACKNOWLEDGE	The slave cannot perform the program function received in the query. This code is returned for an unsuccessful programming request using function code 13 or 14 decimal. The master should request diagnostic or error information from the slave.
08	MEMORY PARITY ERROR	The slave attempted to read extended memory, but detected a parity error in the memory. The master can retry the request, but service may be required on the slave device.

1.3 Sensor Error codes

Hawks with version 4.57 or higher firmware have a sophisticated error detection system that can help both the operator and our technicians quickly fix faults. On each screen and via ENRON or standard Modbus, the error codes will show up indicating there is a problem.

Values below -1000 are error codes by setting a alarm in your SCADA system for values below -1000 makes it easy to alert an operator that something is wrong. See Application Note AN-003 “Hawk Alarms and Sensor Error Codes “ for more details on what each error code means.

1.4 MODBUS™ CRC Sample Code

Here is an example of C code to generate the CRC of a ModBus packet

```
/*******************************************************************************
              Compute the crc of a ModBus packet

input :
-------
Packet : packet with the crc
length : length of the packet WITHOUT the crc

01 02 00 63 00 02 : crc = 0xD581     values in hex

*******************************************************************************/

unsigned short Calculate_ModbusCRC( char* Packet, char length )
{
        unsigned short crc;
        char i,j;

        crc = 0xffff;

        for (i=0;i<length;i++)
        {
                crc = crc ^ Packet[i];

                for (j=0;j<8;j++)
                {
                        if(crc & 0x0001)
                        {
                                crc = crc >> 1;
                                crc = crc^0xa001;
                        }
                        else
                                crc = crc >> 1;
                }
        }

        return crc;

}
```

1.5 Standard MODBUS™ Register List (04 & 03)

It is important to note that these address are NOT offset either internal or external to the device. Most MODBUS™ drivers will subtract one or require that 3000 or 30000 (3001 or 30001) be added to the address provided by the operator. These drivers will strip away these extra operations when preparing the RTU packet. The operator must be sure that the out going packets have the address exactly as *Table 1.00*.

All the registers are accessed using the ModBus Query : *04 - Read Input Registers* or the ModBus Query. Table 1.00 shows all the real-time registers available. Table 1.10 shows the registers used to access any record stored in the Hawk. It is used in conjunctions with the holding register 100 in Table 1.20.

Register Numbers can be thought of as location names since they do not appear in the actual messages transmitted. The Data Location values are what are actually transmitted in a ModBus message.

The maximum size of ModBus packet is 100 registers (200 bytes).

Note:
Any register that holds yesterday's values will have a value of 0.0 until the end of the day has been reached. At this point the yesterday's daily averages are updated with the new data. The end of the day is not necessarily midnight, it's a programmable setting that is between 0:00am and 10:00 am

Register Number	Data Location (hex decimal)	Name	Format	Description
100	0x64	RTU Time	32 – Bit	Time in seconds since Jan 1, 1990 00:00
102	0x65	Pressure Units	16 – Bit	0 = kPa, >0 psi
103	0x66	Pressure Mode	16 – Bit	0 = Absolute, >0 Gauge
104	0x67	Temperature Units	16 – Bit	0 = Celsius, >0 Fahrenheit
105	0x68	4- 20 mA typically Differential Pressure	16 –Bit	0 = kPa, >0 inH_20
106	0x69	Liquid Turbine Rate Units	16 – Bit	See table 1.10
107	0x6A	Gas Volume and Rate Units	16 – Bit	0 = 10^3sm^3 / day 1 = mscf / day 2 = scf / min 3 = sm^3 / min 4 = sm^3 / hour 5 = sm^3 / day 6 = scf / hour 7 = scf / day The accumulation unit is the volume unit of the rate, ie: sm^3/min = sm^3
108	0x6B	Low Power Differential Unit	16 - Bit	0 = psi, 1 = kPa, 2 = inH_20
109	0x6C	Sample Rate	16 - Bit	Seconds. Writeable value between 1 and 120, Hawk9000 only
110	0x6D	Pressure Channel 1	IEEE Float	Units set by register 102 and 103 Static Flowing Pressure
112	0x6F	Pressure Channel 1 Temperature	IEEE Float	Units set by register 104
114	0x71	Pressure Channel 2	IEEE Float	Units set by register 102 and 103
116	0x73	Pressure Channel 2 Temperature	IEEE Float	Units set by register 104
118	0x75	External RTD1	IEEE Float	Units set by register 104 Gas Flow Meter Temperature
120	0x77	4/20 mA Input	IEEE Float	Units set by register 105

122	0x79	Turbine 1 Liquid Accumulated Volume	IEEE Float	Units set by register 106
124	0x7B	Turbine 1 Liquid Current Flow Rate	IEEE Float	Units set by register 106
126	0x7D	Turbine 2 Liquid Accumulated Volume	IEEE Float	Units set by register 106
128	0x7F	Turbine 2 Liquid Current Flow Rate	IEEE Float	Units set by register 106
130	0x81	Turbine 3 Liquid Accumulated Volume	IEEE Float	Units set by register 106
132	0x83	Turbine 3 Liquid Current Flow Rate /day	IEEE Float	Units set by register 106
134	0x85	External RTD2 Temperature	IEEE Float	Units set by register 104
136	0x87	External RTD3 Temperature	IEEE Float	Units set by register 104
138	0x89	Current SRO Pressure Ch1	IEEE Float	Units set by register 102 and 103
140	0x8B	Current SRO Internal Temperature	IEEE Float	Units set by register 104
142	0x8D	Current SRO External Temperature	IEEE Float	Units set by register 104
144	0x8F	Turbine 4 Liquid Accumulated Volume	IEEE Float	Units set by register 106
146	0x91	Turbine 4 Liquid Current Flow Rate	IEEE Float	Units set by register 106
148	0x93	Differential Low Power	IEEE Float	Units set by register 108
150	0x95	AGA Gas Flow Rate /day	IEEE Float	Units set by register 107
152	0x97	AGA Gas Accumulated Volume So far today	IEEE Float	Units set by register 107
154	0x99	Flow Time Today So far today	16 - Bit	Minutes
155	0x9A	Flow Time Yesterday	16 - Bit	Minutes
156	0x9B	AGA Gas Accumulated Yesterdays Total Volume	IEEE Float	Units set by register 107
158	0x9D	Flow Yesterdays Average Static Pressure	IEEE Float	Units set by register 102
160	0x9F	Flow Yesterdays Average Temperature	IEEE Float	Units set by register 104
162	0xA1	Flow Yesterdays Average Differential Pressure	IEEE Float	Units set by register 102
164	0xA3	Contract hour (0 – 23)	16 - Bit	Hours
165	0xA4	Sample Rate Seconds	16 - Bit	Seconds
166	0xA5	Last Sample Time	32 - Bit	Last Sample Time in seconds since Jan 1, 1990 00:00
168	0xA7	Yesterday’s Volume Turbine 1	IEEE Float	Units set by register 106
170	0xA9	Yesterday’s Volume Turbine 2	IEEE Float	Units set by register 106
172	0xAB	Yesterday’s Volume Turbine 3	IEEE Float	Units set by register 106
174	0xAD	Quartz Pressure Ch1	IEEE Float	Units set by register 102 and 103 Static Flowing Pressure
176	0xAF	Quartz Pressure Ch2	IEEE Float	Units set by register 102 and 103 Static Flowing Pressure
178	0xB1	SRO Pressure Ch2	IEEE Float	Units set by register 102 and 103
180	0xB3	SRO Internal Temp Ch2	IEEE Float	Units set by register 104
182	0xB5	SRO External Temp Ch2	IEEE Float	Units set by register 104
184	0xB7	RPN 0 Output	IEEE Float	
186	0xB9	RPN 1 Output	IEEE Float	
188	0xBB	RPN 2 Output	IEEE Float	
190	0xBD	RPN 3 Output	IEEE Float	
192	0xBF	RPN 4 Output	IEEE Float	
194	0xC1	RPN 5 Output	IEEE Float	

196	0xC3	RPN 6 Output	IEEE Float	
198	0xC5	RPN 7 Output	IEEE Float	
200	0xC7	% Full Data Flash Memory	IEEE Float	Hawk 9000 only

Table 1.00
Real-Time Input Registers

High Byte								Low Byte								Description
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	**Turbine Accumulation**
							x									US Gallon
						x										** Not defined
					x											US Barrel
				x												** Not defined
			x													Liter
		x														** Not defined
	x															Cubic Meter
x																** Not defined
																Turbine Rates
															x	US Gallon
														x		US Barrel
													x			Liter
												x				Cubic Meter
											x					/sec
										x						/min
									x							/hour
								x								/day

Table 1.10
Liquid Turbine Units

2.0 ENRON MODBUS™

Enron or Enron/Daniels ModBus is Standard Modicon ModBus with a few vendor Extensions. There is defined 32bit support, an Event/Alarm Log and provisions for hourly and daily logging of any data. The logs are used to meet an industry standard for how data should be stored by the American Petroleum Institute (API): Manual of Petroleum Measurement Standards Chapter 21 – Flow measurement Using Electronic Metering Systems or API21 for short. The logging features in Enron ModBus are used in the oil industry to allow remote SCADA systems to gather any logs from a remote RTU.

ENRON 32bit Registers 5XXX and 7XXX

Enron-MB defines two special holding register in these ranges:

- 5001 to 5999 are assumed 32-bit long integers (4-bytes per register)
- 7001 to 7999 are assumed 32-bit floating points (4-bytes per register)

Dealing with 32-bit values in ModBus is not unique to Enron ModBus. However, Enron ModBus takes the step of returning 4-bytes per register instead of the 2-bytes implied by the term "holding register" in the ModBus specification. This means a poll of registers 5001 and 5002 in Enron ModBus returns 8-bytes or two 32-bit integers, whereas Standard ModBus would only return 4-bytes or one 32-bit integer treated as two 16-bit integers. In addition, polling register 5010 in Enron ModBus returns the tenth 32-bit long integer, where as Standard ModBus would consider this 1/2 of the fifth 32-bit long integer in this range.

ENRON Event/Alarm Log Register

Register 33 is special register when read transfer a Event Log back to the user. The event log format is detailed below but essentially creates an audit trail by logging any settings to the device, such gas composition changes, which can effect the flow calculations. This audit trail can then be used to correct the data if a programming error has occurred, as per API21.

ENRON Archive Logs

Registers 701 and 702 are used to retrieve the hourly and daily logs of all the onboard sensors. These logs are used by the API21 Audit trail to give a certain minimum information of past flow conditions. Depending on how the RTU is configured the logs can very in size.

For further information on Enron ModBus the original document “Specifications and Requirements for an Electronic Flow Measurement Remote Terminal Unit” Enron Corp July 18,1990 revised December 5,1994. should be used.

2.10 Difference between Register Numbers and Data Location

Register Numbers can be thought of as location names since they do not appear in the actual messages transmitted. The Data Location values are what is actually transmitted in an Enron ModBus message. The difference between these two values is the one. For example register 7001 the Manufactures ID, from Table 2.50, has a value 0x1B58 (decimal 7000) in the ModBus packet if its polled. This register is a good way of testing the ModBus Master Driver code as it always replies with the value 9000.

Why is it setup this way? Standard ModBus by convention had offsets associate with certain ranges, most Enron ModBus drivers written for PC’s use this convention.

2.11 Enron MODBUS™ Exception Codes

Enron ModBus uses the same standard ModBus error codes repeated below:

Code	Name	Meaning
01	ILLEGAL FUNCTION	The function code received in the query is not an allowable action for the slave. If a Poll Program Complete command was issued, this code indicates that no program function preceded it.
02	ILLEGAL DATA ADDRESS	The data address received in the query is not an allowable address for the slave.
03	ILLEGAL DATA VALUE	A value contained in the query data field is not an allowable value for the slave.
04	SLAVE DEVICE FAILURE	An unrecoverable error occurred while the slave was attempting to perform the requested action.
05	ACKNOWLEDGE	The slave has accepted the request and is processing it, but a long duration of time will be required to do so. This response is returned to prevent a timeout error from occurring in the master. The master can next issue a Poll Program Complete message to determine if processing is completed.
06	SLAVE DEVICE BUSY	The slave is engaged in processing a long–duration program command. The master should retransmit the message later when the slave is free.
07	NEGATIVE ACKNOWLEDGE	The slave cannot perform the program function received in the query. This code is returned for an unsuccessful programming request using function code 13 or 14 decimal. The master should request diagnostic or error information from the slave.
08	MEMORY PARITY ERROR	The slave attempted to read extended memory, but detected a parity error in the memory. The master can retry the request, but service may be required on the slave device.

2.20 ENRON Event and Alarm Log Register

The Event and Alarm Log records any user changeable quantity which could effect the volume calculations. They are part of the system to make sure the flow computer is API 21 compliant.

Register Number	Data Location (hex decimal)	Access	Name	Description
33	0x20	Read/Write	Event or Alarm Records	Set register 33 using ModBus Function 05 to reset event pointer. Maximum Buffer Size 5120 Events

Table 2.11
ENRON Event/Alarm Log

A master needs to request that the slave sends any events since the last collection using the standard ModBus function code 03 on register 33. In this request the number or registers are ignored by the Hawk but a number is needed to maintain ModBus format compatibility. The slave will respond with up to a

maximum of 12 events or less. A response message containing no data is sent to the back to the master if no events have occurred since the last slave event collection.
After the host confirms the return packet is okay, the master needs to send a Set Single Boolean Function 05 to register 33. After the slave receives the acknowledge packet it will rest its event pointer to the next packet of events to send. When the pointer has been set the master cannot go back and collect the previous events. The process is repeated unit the lave event buffer is empty of all events that occurred since the last collection.

Field	Units	Size	Type	Description
Operator Event Type	16 bit	2	Short	Mask that describes the Event Type. See "Operator Event Type Decoding"
Register #	Register #	2	Short	ModBus register number effected
Time Stamp	HHMMSS	4	Float	Time (HHMMSS)
Date Stamp	MMDDYY	4	Float	Date of log (MMDDYY)
Old Value		4	Float	Units depend of register
New Value		4	Float	Units depend of register
		20		

Table 2.12
Event Log Format

Operator Event Type Decoding

Operator Change Map:

Bit	Value Changed
0	Fixed Value
1	Zero Scale
2	Full Scale
3	Operator entry work value
4	Boolean fixed bit
5	Fixed/variable flag
6	Table entry change
7	System Command Change
8	Not assigned
9	Operator Change Identifier Bit
10	LoLo limit
11	Lo limit
12	Hi limit
13	HiHi limit
14	Rate of change limit
15	Not assigned

Alarm Change Map:

Bit	Value Changed
0-7	Unassigned
8	Sensor Failure (Non standard ENRON bit)
9	Operator Change Identifier Bit
10	LoLo limit
11	Lo limit
12	Hi limit
13	HiHi limit
14	Rate of change limit
15	Set/reset Alarm (1=set 0=reset)

```
#define UPDATEFLOAT_CHANGEMAP 0x0208

Example Codes:

Updated 7182 High High Static Pressure Alarm

Actual Record
4B21DF29 08220E1C 536FAC48 278B574A

#1C0E2208
```

2.21 ENRON Event List

Most event codes correspond to the equivalent Enron ModBus register. Registers above 61440 (0xF000) are internal events that cannot be directly mapped to an equivalent ModBus register. These ModBus registers will never be used for actual data, this frees them up for used for internal invents.

Calibration files are large and the event log simply tells the operator they have been changed, not the values themselves.

Event Code decimal	Event Code hex	Description
7004	0x1B5C	Date update
7005	0x1B5D	Time Update
7006	0x1B5E	Contract Hour
7013	0x1B65	Sample Rate Change
7070	0x1B9E	Station Pressure (Absolute to Gauge conversion offset)
7148	0x1BEC	Gas Alarms active update via Modbus
		Gas User Settable Alarms Tripped values are in Programmed Units
7178	0x1C0A	Flow Rate HiHi
7179	0x1C0B	Flow Rate Hi
7180	0x1C0C	Flow Rate Lo
7181	0x1C0D	Flow Rate LoLo
7182	0x1C0E	Static Pressure HiHi
7183	0x1C0F	Static Pressure Hi
7184	0x1C10	Static Pressure Lo
7185	0x1C11	Static Pressure LoLo
7186	0x1C12	Differential Pressure HiHi
7187	0x1C13	Differential Pressure Hi
7188	0x1C14	Differential Pressure Lo
7189	0x1C15	Differential Pressure LoLo
7190	0x1C16	Flowing Temperature HiHi
7191	0x1C17	Flowing Temperature LoLo
		Gas Composition Well #1
7200	0x1C20	Methane
7201	0x1C21	Nitrogen
7202	0x1C22	Carbon dioxide
7203	0x1C23	Ethane
7204	0x1C24	Propane
7205	0x1C25	Water
7206	0x1C26	Hydrogen sulfide
7207	0x1C27	Hydrogen
7208	0x1C28	Carbon monoxide
7209	0x1C29	Oxygen

7210	0x1C2A	iso-Butane
7211	0x1C2B	n-Butane
7212	0x1C2C	iso-Pentane
7213	0x1C2D	n-Pentane
7214	0x1C2E	n-Hexane
7215	0x1C2F	n-Heptane
7216	0x1C30	n-Octane
7217	0x1C31	n-Nonane
7218	0x1C32	n-Decane
7219	0x1C33	Helium
7220	0x1C34	Argon
7225	0x1C39	Isentropic Value
7226	0x1C3A	Viscosity Value
7227	0x1C3B	Orifice Size
7228	0x1C3C	Orifice Linear Coefficient of Thermal expansion
7229	0x1C3D	Orifice Reference Temperature
7230	0x1C3E	ProRatio Factor
7231	0x1C3F	Differential Zero Flow Setting
7232	0x1C40	Stabilization Time
7233	0x1C41	Minimum Test Time
7234	0x1C42	Turbine 1 Forward Liquid K-Factor Override
7235	0x1C43	Turbine 2 Forward Liquid K-Factor Override
7236	0x1C44	Turbine 3 Forward Liquid K-Factor Override
61440	0xF000	System Reset: 0 = Power On reset 1=Watchdog Timer Reset
61441	0xF001	FILO Store Fail
61442	0xF002	Firmware Upgrade
61443	0xF003	Erased FILO Data Memory
61444	0xF004	Erased Log Memory
61445	0xF005	Enter Field Calibration Mode
61446	0xF006	Leave Field Calibration Mode
61447	0xF007	ModBus AGA8/WARK Update Failure: Sum of Mole Fractions not 1
61448	0xF008	Tool Network Started
61449	0xF009	Tool Button Started
61450	0xF00A	Tool First Sample
61451	0xF00B	Tool Stopped
61452	0xF00C	Schedule Restarted
61453	0xF00D	SD Card Error
61454	0xF00E	Sensor Failure
61455	0xF00F	Main Power Failure
61456	0xF010	Internal Battery Low
61696	0xF100	Pressure 1 Calibration Update (Static)
61697	0xF101	Pressure 2 Calibration Update
61698	0xF102	Pressure Differential Update
61699	0xF103	Pressure SRO Calibration Update
61700	0xF104	Pressure Quartz Calibration Update
61701	0xF105	Internal Temperature RTD Pressure 1
61702	0xF106	Internal Temperature RTD Pressure 2
61703	0xF107	External Temperature RTD 1 Calibration Update (Meter)
61704	0xF108	External Temperature RTD 2 Calibration Update
61705	0xF109	External Temperature RTD 3 Calibration Update
61706	0xF10A	SRO Internal Temperature

61707	0xF10B	SRO External Temperature
61708	0xF10C	Quartz Temperature
61709	0xF10D	4-20mA Calibration Update
61710	0xF10E	Turbine 1 Forward Gas Calibration Update
61711	0xF10F	Turbine 1 Forward Liquid Calibration Update
61712	0xF110	Turbine 1 Reverse Gas Calibration Update
61713	0xF111	Turbine 1 Reverse Liquid Calibration Update
61714	0xF112	Turbine 2 Forward Gas Calibration Update
61715	0xF113	Turbine 2 Forward Liquid Calibration Update
61716	0xF114	Turbine 2 Reverse Gas Calibration Update
61717	0xF115	Turbine 2 Reverse Liquid Calibration Update
61718	0xF116	Turbine 3 Forward Gas Calibration Update
61719	0xF117	Turbine 3 Forward Liquid Calibration Update
61720	0xF118	Turbine 3 Reverse Gas Calibration Update
61721	0xF119	Turbine 3 Reverse Liquid Calibration Update
61722	0xF120	Turbine 4 Forward Liquid Calibration Update
61952	0xF200	Turbine 1 Serial Number Update
61953	0xF201	Turbine 2 Serial Number Update
61954	0xF202	Turbine 3 Serial Number Update
61955	0xF203	SRO Serial Number Update
61956	0xF204	Quartz Serial Number Update
62208	0xF300	Pressure Unit 0=kPa else psi
62209	0xF301	Pressure Mode 0 = Absolute else gauge
62210	0xF302	Temperature unit 0= Celsius else Fahrenheit
62211	0xF303	Liquid Turbine Rate
62212	0xF304	Liquid Turbine Accum
62213	0xF305	Gas Accumulation Unit 0=10^3m^3 1 = mcf 2 = scf else mcf
62214	0xF306	Energy Unit 0 = GJ 1=MMBTU
62215	0xF307	Depth 0 = Meters else Feet
62216	0xF308	Differential Measurement Change. Convert to a 8 bit char and decode bits find out what changed. See table 2.32 for details
62217	0xF309	Tool Option2
62218	0xF30A	Tool Option1 0000 1000 reserved = 0 0001 0000 reserved = 0 1000 0000 reserved = 0 **Gas Compressibility On or Off** 0010 0000 1- Off 0- On **Gas Compressibility Equation of State** 0000 00X0 00 – AGA8 Gross 0X00 0000 01 – AGA8-92 Detailed 10 – WARK (RK Redlich-Kwong with WA Wichert-Aziz) 11 – Reserved **Gas Actual Flow Source** 0000 0100 1- Flow Prover 0- Orifice Differential 0000 000X 00 - Turbine1 000X 0000 01 – Orifice 4/20mA 1 10 – Orifice Press2 11 – Reserved
62219	0xF30B	Power Communication and Gas Alarm Update

2.30 ENRON Hour and Day Archive Logs

The hour logs describe the conditions of the measurement site on an hourly basis and are recorded on the first sample after a new hour. Over 42 days worth of hourly logs are recorded within the flow computer. Once the buffer has been filled the data will start to wrap around and the oldest hours will be lost.

The Day logs are recorded after the first sample after the contract hour. The on board flash memory will store 2.8 years worth of daily data will be stored in the flow computer, after which the data will wrap and the oldest information will be erased.

Values such as temperature and pressure are the average value when there is flow. This means the average will only updated when gas flow is present as per API 21. If there is no flow during a hour or daily period the current temperature and pressures will be used when the hour or daily flow log is taken as the average. This will help provide additional information for the operator figure if the no flow condition is due to some kind of well condition.

Access to daily and hourly logs are read using ModBus function code 03 on register 701 and 702. The record number is passed in the quantity field of the read request.

Register Number	Data Location (hex decimal)	Access	Name	Description
701	0x2BC	Read/Write	AGA7 Day Log	Maximum Buffer Size 1024 Days
702	0x2BD	Read	AGA7 Hour Log	Maximum Buffer Size 1024 Hours

Table 2.20
ENRON Archive Logs Registers

When writing an Enron compliant driver the programmer must keep a few things in mind when accessing the Archive Logs.

- A ModBus illegal data value will be returned if the range is outside 1 to 1024.
- The most recent or last record stored is shown in register 7007 for Day and 7008 for Hour log.
- A value of 0 in register 7007 or 7008 indicates that the logs have been recently erased and holds no valid information.
- Once all the logs from 1 to 1024 have been filled the data will wrap and start at location 1. The record after the last record number will be the oldest still stored in the unit. If the data hasn't wrapped yet, access to records above the latest values will return a ModBus illegal data value.
- One daily or hourly record may be read per request. Unlike standard registers a poll of one hour or day logs returns more than one value, described in table 2.21 below. So for example a poll or record 1 would return 32 bytes of data or 8 floats.
- When reading a day log via Modbus the time returned is the time when the log was taken, since this time is always Midnight or sometime in the morning, the date is one day ahead.

  For instance, if the contract hour was 1:00 am and Day log returned June 27, 2009 that log would be from June 26, 2009 1:00am to June 27, 2009 1:00am. In CalWin the date reported back is for June 26 since that is when the majority of time the data was collected and in the case where the contract hour is midnight, all the data collected would be on June 26.

Field	Units	Size	Type	Description
Date	MMDDYY	4	Float	The date field is the date of the start of the daily/hourly log. Maximum size of the log is 1024 days/hours.
Time	HHMMSS	4	Float	The time field is the time of the start of the daily/hourly log.
FlowTime	Minutes	4	Float	
Static Pressure	Reg 3006 & 3007	4	Float	Average Pressure during the flow
Gas Temperature	Reg 3008	4	Float	Average Temperature during the flow
Accumulated Uncorrected Volume	Reg 3011	4	Float	
Accumulated Volume	Reg 3011	4	Float	
Accumulated Energy	Reg 3012	4	Float	
Differential Pressure	Reg 3009	4	Float	Average Differential Pressure (4v52+)
		36		

Table 2.21
AGA7 Day/Hour Archive Flow Format

2.40 ENRON Register 1000 Boolean Registers

Not supported yet

2.50 ENRON Register 3000 Short (16 bit) Registers

Care must be taken when reading the LSD, registers 3028 to 3059, as the LSD characters are 16 Unicode 3.0 character, not simple 8 bit ASCII characters. This allows for multilanguage support for the LSD name. The Meter ID is only ASCII, and since a register is 16bits each register hold 2 ASCII characters.

Register Number	Data Location (hex decimal)	Access	Name	Description
3001	0x0BB8	Read	Contract Hour	Contract hour is always in Standard time. Does NOT take into account Daylight savings time
3002	0x0BB9	Read	Daylight Savings (DST)	0= Off else On
3003	0x0BBA	Read	Spare	Return 0
3004	0x0BBB	Read	Spare	Return 0
3005	0x0BBC	Read	Spare	Return 0
3006	0x0BBD	Read	Pressure Units	0 = kPa, >0 psi
3007	0x0BBE	Read	Pressure Mode	0 = Absolute, >0 Gauge
3008	0x0BBF	Read	Temperature Units	0 = Celsius, >0 Fahrenheit
3009	0x0BC0	Read	Differential Pressure LP	0 = psi, 1 = kPa, 2 = inH_20
3010	0x0BC1	Read	Liquid Turbine Units	See Table 3.31
3011	0x0BC2	Read	Gas Volume and Rate Units	0 = 10^3sm^3 / day 1 = mscf / day 2 = scf / min 3 = sm^3 / min 4 = sm^3 / hour 5 = sm^3 / day 6 = scf / hour 7 = scf / day The accumulation unit is the volume unit of the rate, ie: sm^3/min = sm^3

3012	0x0BC3	Read	Gas Energy Units	0= GJ else MMBTU
3013	0x0BC4	Read	Differential Measurement Options	See Table 2.32 value is from 0 to 255
3014	0x0BC5	Read	Equation of State Type	0 = AGA8 Detailed 1= AGA 8 Gross 2 = WARK 3 = Steam
3015	0x0BC6	Read	Spare	Return 0
3016	0x0BC7	Read	Turbine 1 CRC	16bit CRC of the calibration info
3017	0x0BC8	Read	Turbine 2 CRC	16bit CRC of the calibration info
3018	0x0BC9	Read	Turbine 3 CRC	16bit CRC of the calibration info
3019	0x0BCA	Read	Turbine 4 CRC	16bit CRC of the calibration info
3020	0x0BCB	Read	Meter ID Character 1	ASCII Characters 1 & 2
3021	0x0BCC	Read	Meter ID Character 2	ASCII Characters 3 & 4
3022	0x0BCD	Read	Meter ID Character 3	ASCII Characters 5 & 6
3023	0x0BCE	Read	Meter ID Character 4	ASCII Characters 7 & 8
3024	0x0BCF	Read	Meter ID Character 5	ASCII Characters 9 & 10
3025	0x0BD0	Read	Meter ID Character 6	ASCII Characters 11 & 12
3026	0x0BD1	Read	Meter ID Character 7	ASCII Characters 13 & 14
3027	0x0BD2	Read	Meter ID Character 8	ASCII Characters 15 & 16
3028	0x0BD3	Read	UWI/LSD Character 1	Unicode UCS-2
3029	0x0BD4	Read	UWI/LSD Character 2	Unicode UCS-2
3030	0x0BD5	Read	UWI/LSD Character 3	Unicode UCS-2
3031	0x0BD6	Read	UWI/LSD Character 4	Unicode UCS-2
3032	0x0BD7	Read	UWI/LSD Character 5	Unicode UCS-2
3033	0x0BD8	Read	UWI/LSD Character 6	Unicode UCS-2
3034	0x0BD9	Read	UWI/LSD Character 7	Unicode UCS-2
3035	0x0BDA	Read	UWI/LSD Character 8	Unicode UCS-2
3036	0x0BDB	Read	UWI/LSD Character 9	Unicode UCS-2
3037	0x0BDC	Read	UWI/LSD Character 10	Unicode UCS-2
3038	0x0BDD	Read	UWI/LSD Character 11	Unicode UCS-2
3039	0x0BDE	Read	UWI/LSD Character 12	Unicode UCS-2
3040	0x0BDF	Read	UWI/LSD Character 13	Unicode UCS-2
3041	0x0BE0	Read	UWI/LSD Character 14	Unicode UCS-2
3042	0x0BE1	Read	UWI/LSD Character 15	Unicode UCS-2
3043	0x0BE2	Read	UWI/LSD Character 16	Unicode UCS-2
3044	0x0BE3	Read	UWI/LSD Character 17	Unicode UCS-2
3045	0x0BE4	Read	UWI/LSD Character 18	Unicode UCS-2
3046	0x0BE5	Read	UWI/LSD Character 19	Unicode UCS-2
3047	0x0BE6	Read	UWI/LSD Character 20	Unicode UCS-2
3048	0x0BE7	Read	UWI/LSD Character 21	Unicode UCS-2
3049	0x0BE8	Read	UWI/LSD Character 22	Unicode UCS-2
3050	0x0BE9	Read	UWI/LSD Character 23	Unicode UCS-2
3051	0x0BEA	Read	UWI/LSD Character 24	Unicode UCS-2
3052	0x0BEB	Read	UWI/LSD Character 25	Unicode UCS-2
3053	0x0BEC	Read	UWI/LSD Character 26	Unicode UCS-2
3054	0x0BED	Read	UWI/LSD Character 27	Unicode UCS-2
3055	0x0BEE	Read	UWI/LSD Character 28	Unicode UCS-2
3056	0x0BEF	Read	UWI/LSD Character 29	Unicode UCS-2
3057	0x0BF0	Read	UWI/LSD Character 30	Unicode UCS-2
3058	0x0BF1	Read	UWI/LSD Character 31	Unicode UCS-2
3059	0x0BF2	Read	UWI/LSD Character 32	Unicode UCS-2
3060	0x0BF3	Read	Spare	Return 0

Table 2.30
ENRON3000 Short Input Registers

High Byte	Low Byte	Description

7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	**Turbine Accumulation**
							x									US Gallon
						x										** Not defined
					x											US Barrel
				x												** Not defined
			x													Liter
		x														** Not defined
	x															Cubic Meter
x																** Not defined
																Turbine Rates
															x	US Gallon
														x		US Barrel
													x			Liter
												x				Cubic Meter
											x					/sec
										x						/min
									x							/hour
								x								/day

Table 2.31
Liquid Turbine Units

```
Value from 0 to 255. To decode Differential Measurement options check the following bits:

XXXX 0000 : 0 -  Orifice with flange tapings (aga3 & ISO5167)
XXXX 0001 : 1 -  Orifice with corner tapings  (ISO5167)
XXXX 0010 : 2 -  Orifice with D and D/2 tapings
XXXX 0011 : 3 -  Classical Venturi tube machined inlet (ISO5167)
XXXX 0100 : 4 -  Classical Venturi tube roughcast inlet (ISO5167)
XXXX 0101 : 5 -  Classical Venturi tube rough-welded sheet-iron inlet (ISO5167)
XXXX 0110 : 6 -  Long radius nozzle (ISO5167)
XXXX 0111 : 7 -  ISA 1932 nozzle (ISO5167)
XXXX 1000 : 8 -  Venturi nozzle (ISA inlet) (ISO5167 )
XXXX 1001 : 9 -  Reserved
XXXX 1010 : 10 - Accelabar (AGA3 only, meter size determines type)
XXXX 1011 : 11 – V-Cone Averaged Cd
XXXX 1100 : 12 – Wafer-Cone Averaged Cd
XXXX 1101 : 13 – V-Cone Fitted Cd ?
XXXX 1110 : 14 – Wafer-Cone Fitted Cd ?
XXXX 1111 : 15 - Reserved

0001 XXXX : 1 = ISO5167    0=AGA3 1990
0010 XXXX : reserved
0100 XXXX : 0 = Upstream   1 = Downstream
1000 XXXX : Reserved

Examples:

0x00 = 0000 0000 = 0  = AGA3 Upstream Orifice with flange tapings
0x40 = 0100 0000 = 64 = AGA3 Downstream Orifice with flange tapings
0x0B = 0000 1011 = 11 = V-cone Average Cd Upstream
0x10 = 0001 0000 = 16 = ISO5167 Upstream Orifice with flange tapings
```

Table 2.32
Differential Measurement Options

2.60 ENRON 5000 Long 32bit Registers

Register Number	Data Location (hex decimal)	Access	Name	Description
5001	0x1388	Read/Write	CalScan Time	Seconds since Jan 1, 1990 00:00:00 Always in standard time not Daylight savings time.
5002	0x1389	Read	Pressure Ch1 EU Max psig	psig (Static Pressure)
5003	0x138A	Read	Pressure Ch1 EU Min psig	psig
5004	0x138B	Read	Pressure Ch2 EU Max psig	psig
5005	0x138C	Read	Pressure Ch2 EU Min	psig
5006	0x138D	Read	Temperature Ch1 & Ch2 EU Max	°C (Calibrated Maximum Temperature of Pressure sensors)
5007	0x138E	Read	Temperature Min All Sensors	°C (Calibrated Minimum Temperature of all sensors)
5008	0x138F	Read	Temperature Ext RTD1 EU Max	°C (Meter Temperature)
5009	0x1390	Read	Temperature Ext RTD3 EU Max	°C
5010	0x1391	Read	Temperature Ext RTD3 EU Max	°C

Table 2.40
ENRON5000 Long Input Registers

2.70 ENRON 7000 Floating Point Registers

See section **2.10 Difference between Register Number and Data Location** to make sure you are polling the correct register. When first writing a driver poll register 7001 that always reads back 9000.0 to ensure how you are sending the ModBus Register correctly.

Register Number	Data Location (hex decimal)	Access	Name	Description
7001	0x1B58	Read	Manufacture ID number	Always 9000.0
7002	0x1B59	Read	ToolType	DCR1000 = 9017.0 Hawk9500 = 9018.0
7003	0x1B5A	Read	Firmware Version Number	4.XX
7004	0x1B5B	Read/Write	System Date (MMDDYY)	ENRON Year starts in 1980 Feb 25,2001 = 022521 This register can be updated in two ways. If both the time and date (7004 & 7005) are written to in the same ModBus command or if the system time is updated within 1 minute of the System Date update. If it isn't the new system date data is cleared.
7005	0x1B5C	Read/Write	System Time (HHMMSS)	Register 7004 and 7005 takes into account Daylight savings time. If there is a new system date pending after writing to register 7004 the new date will be written at the same time as the new system time. You cannot set the time back more than 15 minutes; you can set it any amount forward in time. All data in the unit is time stamped, going backwards in time means the unit cannot sample until it reaches the old time.
7006	0x1B5D	Read	Contract Hour	Contract hour is always in Standard time. Does NOT take into account Daylight savings time
7007	0x1B5E	Read	Day Log Record Position	Empty = 0 (Just been erased) Valid Last Record = 1 to 1024
7008	0x1B5F	Read	Hour Log Record Position	Empty = 0 (Just been erased) Valid Last Record = 1 to 1024
7009	0x1B60	Read	Number of events left since last Acknowledge	No New Events to download = 0
7010	0x1B61	Read	Spare	Return 0
Current Values				
7011	0x1B62	Read	Current Operating Voltage	volts
7012	0x1B63	Read	Current External Voltage	volts
7013	0x1B64	Read	Current Sample Rate	seconds
7014	0x1B65	Read	Current Storage Rate	How many samples before storing
7015	0x1B66	Read	Current Well Number	
7016	0x1B67	Read	Current Pressure Ch1	This is your Static (flowing pressure) when measuring gas
7017	0x1B68	Read	Current Pressure Ch2	
7018	0x1B69	Read	Current Differential Pressure	This is the Low power Diff
7019	0x1B6A	Read	Current Ext Quartz Pressure	
7020	0x1B6B	Read	Current SRO Pressure Ch1	SRO = Surface Readout
7021	0x1B6C	Read	External RTD1	This is your meter (flow) temperature when measuring gas
7022	0x1B6D	Read	External RTD2	
7023	0x1B6E	Read	External RTD3	

7024	0x1B6F	Read	Current Temperature Pressure Ch1	
7025	0x1B70	Read	Current Temperature Pressure Ch2	
7026	0x1B71	Read	Current Ext Quartz Temperature	
7027	0x1B72	Read	Current SRO Internal Temperature Ch1	
7028	0x1B73	Read	Current SRO External Ch1 Temperature	
7029	0x1B74	Read	Current 4-20mA input	In programmed units
7030	0x1B75	Read	Current contract day Gas Flowtime minutes (MMMM.SS)	Flowtime accumulates if there is either forward or reverse gas flow
7031	0x1B76	Read	Current AGA Gas Flow Rate	
7032	0x1B77	Read	Current Uncorrected Gas Flow Rate	
7033	0x1B78	Read	Current Energy rate	GJ/Day or MMBTU/Day see Register 3012
7034	0x1B79	Read	Current contract day Forward gas Accumulation AGA	Forward Gas
7035	0x1B7A	Read	Current contract day Gas Forward Accumulation uncorrected	Forward Gas
7036	0x1B7B	Read	Current contract day Forward Energy Accumulation	Forward Gas
7037	0x1B7C	Read	Current contract day Reverse gas Accumulation AGA	Reverse Gas
7038	0x1B7D	Read	Current contract day Gas Reverse Accumulation uncorrected	Reverse Gas
7039	0x1B7E	Read	Current contract day Reverse Energy Accumulation	Reverse Gas
7040	0x1B7F	Read	Current day Turbine 1 Rate	Liquid
7041	0x1B80	Read	Current contract day Turbine 1 FL Accumulation	Forward Liquid
7042	0x1B81	Read	Current contract day Turbine 1 RL Accumulation	Reverse Liquid
7043	0x1B82	Read	Current day Turbine 2 Rate	Liquid
7044	0x1B83	Read	Current contract day Turbine 2 FL Accumulation	Forward Liquid
7045	0x1B84	Read	Current contract day Turbine 2 RL Accumulation	Reverse Liquid
7046	0x1B85	Read	Current day Turbine 3 Rate	Liquid
7047	0x1B86	Read	Current contract day Turbine 3 FL Accumulation	Forward Liquid
7048	0x1B87	Read	Current day Turbine 4 Rate	
7049	0x1B88	Read	Current contract day Turbine 4 FL Accumulation	
7050	0x1B89	Read	Previous Day AGA Forward Gas accumulation	
7051	0x1B8A	Read	Current SRO Pressure Ch2	SRO = Surface Readout
7052	0x1B8B	Read	Current SRO Internal Temperature Ch2	
7053	0x1B8C	Read	Current SRO External Ch2	
7054	0x1B8D	Read	Spare	Return 0
7055	0x1B8E	Read	Spare	Return 0
7056	0x1B8F	Read	Flow Viscosity	pas
7057	0x1B90	Read	Flow Isentropic Exponent	
7058	0x1B91	Read	Vcone_Average_Cd	
7059	0x1B92	Read	Vcone_Recovery_Cd	
7060	0x1B93	Read	Vcone_LiquidDensity_kgpm3	Kg/m^3
7061	0x1B94	Read	Spare	Return 0
7062	0x1B95	Read	OrificePlate Diameter_inch	Inches
7063	0x1B96	Read	OrificePlate ThermExpansion	m/m-K
7064	0x1B97	Read	OrificePlate ThermReference_K	Kelvin
7065	0x1B98	Read	Meter I.D. (All differential meters)	Inches
7066	0x1B99	Read	Meter Thermal Expansion Factor	m/m-K
7067	0x1B9A	Read	Meter Tube Thermal Reference K	Kelvin
7068	0x1B9B	Read	Base Pressure	psia
7069	0x1B9C	Read	Base Temperature	deg C

7070	0x1B9D	Read	AGA Barometric Pressure	
7071	0x1B9E	Read	Previous Hour AGA Gas accumulation	
7072	0x1B9F	Read	Previous Hour Uncorrected Gas accumulation	
7073	0x1BA0	Read	Previous Hour Energy Gas accumulation	
7074	0x1BA1	Read	Previous Hour Average Press (Static) Ch1	
7075	0x1BA2	Read	Previous Hour Average Press Ch2	*** Return 0 for now
7076	0x1BA3	Read	Previous Hour Average Diff Ch1	
7077	0x1BA4	Read	Previous Hour Average Ext Quartz Ch1	*** Return 0 for now
7078	0x1BA5	Read	Previous Hour Average SRO Ch1	*** Return 0 for now
7079	0x1BA6	Read	Previous Hour Average Meter Temp RTD1	
7080	0x1BA7	Read	Previous Hour Average Temp RTD2	*** Return 0 for now
7081	0x1BA8	Read	Previous Hour Average Temp RTD3	*** Return 0 for now
7082	0x1BA9	Read	Previous Hour Turbine 1 Forward liquid Accumulation	
7083	0x1BAA	Read	Previous Hour Turbine 2 Forward liquid Accumulation	
7084	0x1BAB	Read	Previous Hour Turbine 3 Forward liquid Accumulation	
7085	0x1BAC	Read	Previous Hour Total Gas Flowtime	Flowtime accumulates if there is either forward or reverse gas flow
7086	0x1BAD	Read	Previous Day AGA Forward Gas accumulation	
7087	0x1BAE	Read	Previous Day Uncorrected Forward Gas accumulation	
7088	0x1BAF	Read	Previous Day Energy Forward Gas accumulation	
7089	0x1BB0	Read	Previous Day Average Press (Static) Ch1	
7090	0x1BB1	Read	Previous Day Average Press Ch2	*** Return 0 for now
7091	0x1BB2	Read	Previous Day Average Diff Ch1	
7092	0x1BB3	Read	Previous Day Average Ext Quartz Ch1	*** Return 0 for now
7093	0x1BB4	Read	Previous Day Average SRO Ch1	*** Return 0 for now
7094	0x1BB5	Read	Previous Day Average Meter Temp RTD1	
7095	0x1BB6	Read	Previous Day Average Temp RTD2	*** Return 0 for now
7096	0x1BB7	Read	Previous Day Average Temp RTD3	*** Return 0 for now
7097	0x1BB8	Read	Previous Day Turbine 1 Forward Liquid Accumulation	
7098	0x1BB9	Read	Previous Day Turbine 2 Forward Liquid Accumulation	
7099	0x1BBA	Read	Previous Day Turbine 3 Forward Liquid Accumulation	
7100	0x1BBB	Read	Previous Day Gas Flowtime	Flowtime accumulates if there is either forward or reverse gas flow
7101	0x1BBC	Read	Previous Hour AGA Reverse Gas accumulation	
7102	0x1BBD	Read	Previous Hour Uncorrected Reverse Gas accumulation	
7103	0x1BBE	Read	Previous Hour Energy Reverse Gas accumulation	
7104	0x1BBF	Read	Previous Day AGA Reverse Gas accumulation	
7105	0x1BC0	Read	Previous Day Uncorrected Reverse Gas accumulation	
7106	0x1BC1	Read	Previous Day Energy Reverse Gas accumulation	
7107	0x1BC2	Read	Previous Hour Turbine 1 reverse liquid Accumulation	
7108	0x1BC3	Read	Previous Hour Turbine 2	

			Reverse liquid Accumulation	
7109	0x1BC4	Read	Previous Day Turbine 1 Reverse liquid Accumulation	
7110	0x1BC5	Read	Previous Day Turbine 2 Reverse liquid Accumulation	
7111	0x1BC6	Read	Previous Hour Turbine 4 liquid Accumulation	Return 0
7112	0x1BC7	Read	Previous Day Turbine 4 liquid Accumulation	Return 0
7113	0x1BC8	Read	Telemetry 1	User Defined / Recovery DP
7114	0x1BC9	Read	Telemetry 2	Return 0
7115	0x1BCA	Read	Telemetry 3	Return 0
7116	0x1BCB	Read	Telemetry 4	Return 0
7117	0x1BCC	Read	Telemetry 5	Return 0
7118	0x1BCD	Read	Telemetry 6	Return 0
7119	0x1BCE	Read	Telemetry 7	Return 0
7120	0x1BCF	Read	Telemetry 8	Return 0
7121	0x1BD0	Read	Spare	Return 0
7122	0x1BD1	Read	Spare	Return 0
7123	0x1BD2	Read	Spare	Return 0
7124	0x1BD3	Read	Spare	Return 0
7125	0x1BD4	Read	Spare	Return 0
7126	0x1BD5	Read	Spare	Return 0
7127	0x1BD6	Read	Spare	Return 0
7128	0x1BD7	Read	Spare	Return 0
7129	0x1BD8	Read	Reserved	Return 0
7130	0x1BD9	Read	RPN 0 Output	Return 0
7131	0x1BDA	Read	RPN 1 Output	Return 0
7132	0x1BDB	Read	RPN 2 Output	Return 0
7133	0x1BDC	Read	RPN 3 Output	Return 0
7134	0x1BDD	Read	RPN 4 Output	Return 0
7135	0x1BDE	Read	RPN 5 Output	Return 0
7136	0x1BDF	Read	RPN 6 Output	Return 0
7137	0x1BE0	Read	RPN 7 Output	Return 0
7138	0x1BE1	Read	Spare	Return 0
7139	0x1BE2	Read	Spare	Return 0
7140	0x1BE3	Read	Spare	Return 0
7141	0x1BE4	Read	Spare	Return 0
7142	0x1BE5	Read	Spare	Return 0
7143	0x1BE6	Read	Spare	Return 0
7144	0x1BE7	Read	Spare	Return 0
7145	0x1BE8	Read	Spare	Return 0
7146	0x1BE9	Read	Spare	Return 0
7147	0x1BEA	Read/Write	Gas Alarms Active	Alarms are active if != 0 set to anything but 0 to activate
7148	0x1BEB	Read/Write	Accum Test Mode 9500	Test Mode active if != 0. Set to > 0 to activate. Clears all accumulation every time this is written to > 0. Disables 24log display if active. Current accumulations are now the test accumulations. Mode set to 0 (off) when reprogrammed, mode stays the same on reset. HK9000 setting to one clears accums only.
7149	0x1BEC	Read	Spare	Return 0
Monthly Gas & Liquid Accumulations				
7150	0x1BED	Read	Current Month AGA Forward Gas accumulation	All monthly totals are updated once a day at the contract hour
7151	0x1BEE	Read	Current Month Uncorrected Forward Gas accumulation	
7152	0x1BEF	Read	Current Month Energy Forward Gas accumulation	
7153	0x1BF0	Read	Current Month AGA Reverse Gas accumulation	
7154	0x1BF1	Read	Current Month Uncorrected Reverse Gas accumulation	
7155	0x1BF2	Read	Current Month Energy Reverse	

			Gas accumulation	
7156	0x1BF3	Read	Current Month Turbine 1 Forward Accumulation	
7157	0x1BF4	Read	Current Month Turbine 1 Reverse Accumulation	
7158	0x1BF5	Read	Current Month Turbine 2 Forward Accumulation	
7159	0x1BF6	Read	Current Month Turbine 2 Reverse Accumulation	
7160	0x1BF7	Read	Current Month Turbine 3 Forward Accumulation	
7161	0x1BF8	Read	Current Month Turbine 4 Forward Accumulation	
7162	0x1BF9	Read	Current Month RPN 7 Accumulation	
7163	0x1BFA	Read	Current Month RPN 8 Accumulation	
7164	0x1BFB	Read	Previous Month AGA Forward Gas accumulation	
7165	0x1BFC	Read	Previous Month Uncorrected Forward Gas accumulation	
7166	0x1BFD	Read	Previous Month Energy Forward Gas accumulation	
7167	0x1BFE	Read	Previous Month AGA Reverse Gas accumulation	
7168	0x1BFF	Read	Previous Month Uncorrected Reverse Gas accumulation	
7169	0x1C00	Read	Previous Month Energy Reverse Gas Accumulation	
7170	0x1C01	Read	Previous Month Turbine 1 Forward Accumulation	
7171	0x1C02	Read	Previous Month Turbine 1 Reverse Accumulation	
7172	0x1C03	Read	Previous Month Turbine 2 Forward Accumulation	
7173	0x1C04	Read	Previous Month Turbine 2 Reverse Accumulation	
7174	0x1C05	Read	Previous Month Turbine 3 Forward Accumulation	
7175	0x1C06	Read	Previous Month Turbine 4 Forward Accumulation	
7176	0x1C07	Read	Previous Month RPN 7 Accumulation	
7177	0x1C08	Read	Previous Month RPN 8 Accumulation	
Alarm Set Points				
Gas Alarms : Register 7147 turns the Gas alarm feature on or off. Uninitialized alarms set points will return a -1001 “Value not Initialized” and will not cause a Gas Alarm to trigger until set.				
7178	0x1C09	Read/Write	Flow Rate HiHi	All set points are in the
7179	0x1C0A	Read/Write	Flow Rate Hi	current unit used by the Hawk
7180	0x1C0B	Read/Write	Flow Rate Lo	Scf
7181	0x1C0C	Read/Write	Flow Rate LoLo	
7182	0x1C0D	Read/Write	Static Pressure HiHi	psia
7183	0x1C0E	Read/Write	Static Pressure Hi	
7184	0x1C0F	Read/Write	Static Pressure Lo	
7185	0x1C10	Read/Write	Static Pressure LoLo	
7186	0x1C11	Read/Write	Differential Pressure HiHi	Psi
7187	0x1C12	Read/Write	Differential Pressure Hi	
7188	0x1C13	Read/Write	Differential Pressure Lo	
7189	0x1C14	Read/Write	Differential Pressure LoLo	
7190	0x1C15	Read/Write	Flowing Temperature HiHi	Deg C
7191	0x1C16	Read/Write	Flowing Temperature LoLo	

Table 2.50
ENRON7000 Float Input Registers

2.71 Gas Composition Registers

All updates to the Gas composition values via ModBus come into effect one-minute after the last change gas composition change. If the gas composition values are read back, they will show the updated values, though the headunit will still be using the old values for the all the gas flow and equation of state calculations. This allows the ModBus master up to one minute between the gas composition register updates. After the one-minute has passed since the *last* register update, the offline calculations of all the gas algorithms for the new values will be activated. This can take up to 10 seconds to process. The Gas Update flag will give the status of the update. When it is greater than zero the headunit is still waiting for the one-minute delay to finish before updating or its currently updating.

It is up to the ModBus master to insure that the gas composition values themselves fall into proper ranges and that they will all add up to 100%. If not unpredictable results can occur, and the Gas Update flag will show a -1 to indicate a failure.

There are up to 20 separate Gas Composition entrees in the Hawk . Each one can be separately accessed.

Register Numbers	Data Location (hex decimal)	Access	Name	Description
Well 1				
7200	0x1C1F	Read/Write	Methane	
7201	0x1C20	Read/Write	Nitrogen	
7202	0x1C21	Read/Write	Carbon dioxide	
7203	0x1C22	Read/Write	Ethane	
7204	0x1C23	Read/Write	Propane	
7205	0x1C24	Read/Write	Water	
7206	0x1C25	Read/Write	Hydrogen sulfide	
7207	0x1C26	Read/Write	Hydrogen	
7208	0x1C27	Read/Write	Carbon monoxide	
7209	0x1C28	Read/Write	Oxygen	
7210	0x1C29	Read/Write	iso-Butane	
7211	0x1C2A	Read/Write	n-Butane	
7212	0x1C2B	Read/Write	iso-Pentane	
7213	0x1C2C	Read/Write	n-Pentane	
7214	0x1C2D	Read/Write	n-Hexane	
7215	0x1C2E	Read/Write	n-Heptane	
7216	0x1C2F	Read/Write	n-Octane	
7217	0x1C30	Read/Write	n-Nonane	
7218	0x1C31	Read/Write	n-Decane	
7219	0x1C32	Read/Write	Helium	
7220	0x1C33	Read/Write	Argon	
7221	0x1C34	Read	Specific Gravity	Specific Gravity of gas mixture
7222	0x1C35	Read	Zb	Compressibility of gas mixture at Base Conditions
7223	0x1C36	Read	Energy	GigaJoules per Standard Cubic Feet: GJ\scf
7224	0x1C37	Read	Gas Offline Coefficient Update Flag	-1 = Gas Update Failure: Sum of Mole Fractions < 0.98 or > 1.02 old values used (4v54) 0 = Gas Coefficients Updated 1 = Gas Update pending or in progress
7225	0x1C38	Read	Isentropic Value	<= -10 Automatically Calculated
7226	0x1C39	Read	Viscosity Value	<= -10 Automatically Calculated
7227	0x1C3A	Read/Write	Orifice Size	For well 1 this is also the V-Cone and Accelabar Cone O.D. size
7228	0x1C3B	Read/Write	Orifice Linear Coefficient of Thermal expansion	
7229	0x1C3C	Read/Write	Orifice Reference Temperature	
7230	0x1C3D	Read/Write	ProRatio Factor	>= 0.75 and <= 1.25 If you write a value below 0.75 it will force it to 0.75. If you write a value

				greater than 1.25 it will force it to 1.25
7231	0x1C3E	Read/Write	Differential Zero Flow Setting	>=0 and < 1 in PSI
7232	0x1C3F	Read	Stabilization Time	seconds
7233	0x1C40	Read	Minimum Test Time	seconds
7234	0x1C41	Read/Write	Turbine 1 Forward Meter Factor	>0.5 and < 1.5
7235	0x1C42	Read/Write	Turbine 2 Forward Meter Factor	>0.5 and < 1.5
7236	0x1C43	Read/Write	Turbine 3 Forward Meter Factor	>0.5 and < 1.5
7237	0x1C44	Read	Spare	
7238	0x1C45	Read	Spare	
7239	0x1C46	Read	Spare	
Well 2				
7240	0x1C47	Read/Write	Methane	Registers repeat like well one
Well 3				
7280	0x1C6F	Read/Write	Methane	Registers repeat like well one
Well 4				
7320	0x1C97	Read/Write	Methane	Registers repeat like well one
Well 5				
7360	0x1CBF	Read/Write	Methane	Registers repeat like well one
Well 6				
7400	0x1CE7	Read/Write	Methane	Registers repeat like well one
Well 7				
7440	0x1D0F	Read/Write	Methane	Registers repeat like well one
Well 8				
7480	0x1D37	Read/Write	Methane	Registers repeat like well one
Well 9				
7520	0x1D5F	Read/Write	Methane	Registers repeat like well one
Well 10				
7560	0x1D87	Read/Write	Methane	Registers repeat like well one
Well 11				
7600	0x1DAF	Read/Write	Methane	Registers repeat like well one
Well 12				
7640	0x1DD7	Read/Write	Methane	Registers repeat like well one
Well 13				
7680	0x1DFF	Read/Write	Methane	Registers repeat like well one

Well 14				
7720	0x1E27	Read/Write	Methane	Registers repeat like well one
Well 15				
7760	0x1E4F	Read/Write	Methane	Registers repeat like well one
Well 16				
7800	0x1E77	Read/Write	Methane	Registers repeat like well one
Well 17				
7840	0x1E9F	Read/Write	Methane	Registers repeat like well one
Well 18				
7880	0x1EC7	Read/Write	Methane	Registers repeat like well one
Well 19				
7920	0x1EEF	Read/Write	Methane	Registers repeat like well one
Well 20				
7960	0x1F17	Read/Write	Methane	Registers repeat like well one

Table 2.51
ENRON7000 Float Input Register Gas Compositions

2.72 Settable Alarms

All updates to the Gas composition values via ModBus come into effect one-minute after the last change gas comp