Use of Modbus® Protocol with Passive Sonar Transmitters

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1 TRANSMITTER MODBUS CONFIGURATION OVERVIEW

1.1 Introduction

Modbus is an application layer messaging protocol that provides client/server communication between devices connected on different types of buses or networks.

Modbus has been industry's serial de facto standard since 1979 and enables millions of automation devices to communicate. Support for the simple and elegant structure of Modbus continues to grow.

Modbus is a request/reply protocol and offers services specified by function codes. Modbus function codes are elements of Modbus request/reply messages.

This document describes the Modbus configuration options available in the Passive sonar transmitter.

1.1.1 Passive Sonar Transmitters That Support MODBUS

The following transmitter model numbers will support Modbus protocol:

- TB8-XX-XX-1X-XX where x can be any alpha-numeric character. The '1' indicates the transmitter firmware supports Modbus communications.

1.1.2 Modbus Variants Supported by Transmitter

The passive sonar transmitter supports the following Modbus variants:

Media
- Asynchronous serial transmission over RS-232 or RS-485

Transmission Modes
- RTU
- ASCII

Serial Settings
- 7 / 8 Data Bits
- EVEN / ODD / NO Parity
- 1 / 2 Stop Bits
- 2400 / 9600 / 19200 / 38400 / 57600 / 115200 Baud

Other Modbus Options
- Device Address (001 – 247)
- ASCII Timeout (1 – 99 Seconds)

Transmission modes, serial settings and other options are available from the transmitter front panel menu.

A configuration setting is available to swap 32 bit values (for example, floating point numbers) for compatibility with Modbus masters that may require it.

1.2 CONFIGURATION SETTINGS

1.2.1 Transmission Modes

- RTU (Default)
- ASCII

1.2.1.1 RTU

In RTU (Remote Terminal Unit) mode, each 8–bit byte in a message contains two 4–bit hexadecimal characters. The main advantage of this mode is that its greater character density allows higher data throughput than ASCII mode for the same baud rate. Each message must be transmitted in a continuous stream of characters.

The default parity mode in the transmitter is EVEN parity.

1.2.1.2 ASCII

In ASCII (American Standard Code for Information Interchange) mode, each 8–bit byte in a message is sent as two ASCII characters. This mode is used when the physical communication link or the capabilities of the device do not allow conformance with RTU mode requirements.

Note: This mode is less efficient than RTU since each byte needs two characters.

Example:

The byte 0X5B is encoded as two characters: 0x35 and 0x42 (0x35 ="5" and 0x42 ="B" in ASCII).

Even parity and no parity also are supported. The default parity mode in the transmitter is EVEN parity.

1.2.2 Serial Communications Settings

1.2.2.1 Configuration

- RS-232
- RS-485 (Default)

1.2.2.2 Data Bits

- 7 bits
- 8 bits (Default)

The Data Bits setting should match the Transmission Mode as follows. The ability to set the Data Bits independent of Transmission Mode is to allow for maximum flexibility.

- RTU 8 Data Bits
- ASCII 7 Data Bits

1.2.2.3 Parity

- EVEN (Default)
- ODD
- NONE

1.2.2.4 Stop Bits

- 1 (Default)
- 2

1.2.2.5 Baud Rate

- 2400
- 9600 (Default)
- 19200
- 38400
- 57600
- 115200

Note: The Modbus specification requires the use of 2 Stop Bits when No Parity is selected.

1.2.3 MODBUS Options

1.2.3.1 Device Address

Device Address is the address that a Modbus master will use to communicate with the transmitter.

- Range: 1 – 247 (Default = 1)

1.2.3.2 ASCII Timeout

ASCII Timeout is the amount of time in seconds the transmitter will wait before processing an ASCII Transmission Mode Modbus message before a CR/LF termination. This may be increased to allow for manual entry of an ASCII message on a terminal.

- Range: 1 – 99 Seconds (Default = 4)

1.3 Transmitter Menus

1.3.1 Serial Settings

Only the internal RS-232/RS-485 serial port on the transmitter supports Modbus.

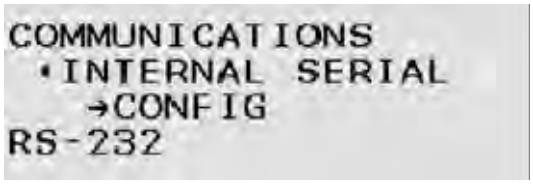

Figure 1 RS-232 / RS-485 Configuration

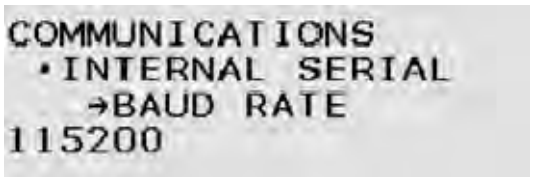

Figure 2 Baud Rate

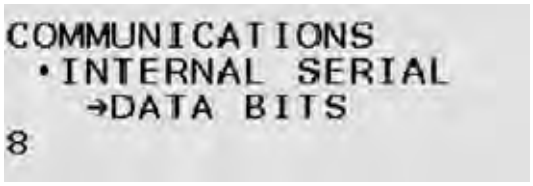

Figure 3 Data Bits

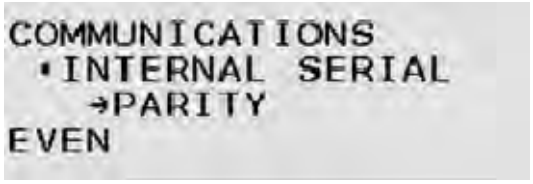

Figure 4 Parity

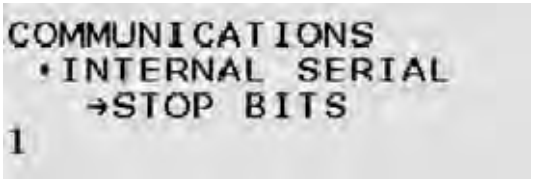

Figure 5 Stop Bits

1.3.2 Modbus Options

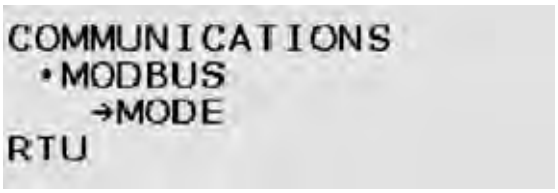

Figure 6 Transmission Mode

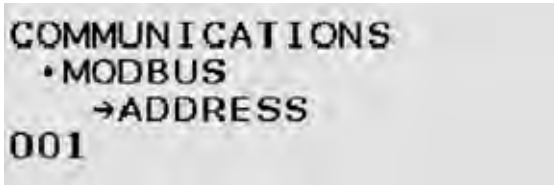

Figure 7 Device Address

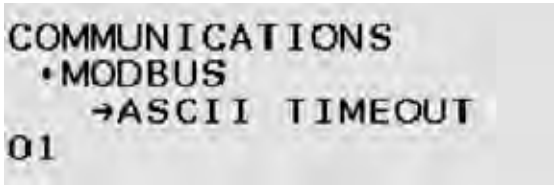

Figure 8 ASCII Timeout

2 TRANSMITTER MODBUS REGISTER OVERVIEW

2.1 Introduction

The chapter will describe the MODBUS registers available in the transmitter, and how to read and write them.

Registers are arranged in groups by format (i.e. float, char) to facilitate reading and writing in blocks, and function (User, Algorithm, Filter etc.).

Multiple register values (for example, Floating Point values) by default are arranged to conform to IEEE specifications for Floating Point numbers. There is an option available through the meter configuration to swap the two registers for compatibility.

2.2 Making and Saving Changes

In order to change Holding Registers, first write a value of 0x55AA to Holding Register 4 (the 'Run Mode' Register to 'Write Enabled'). Changes to any Holding Register(s) can then be made.

In order to validate changes and commit them to FLASH, write a value of 0xEDF1 ('Commit Changes') to the Run Mode register (address 4). An error will be returned after a Commit if any of the Holding Register changes are invalid (outside bounds, etc.).

2.3 Passwords

Password functions are available, but by default are disabled. A user would write their password to the Password Input Holding Register (Register 0) to set the access level for the session. Sessions timeout after a configurable number of seconds of no valid reads or writes. Passwords consist of single register integer values that range from 1 thru 65535 (0xFFFF hex).

All passwords are set to 0, disabling the password feature by default.

Passwords affect Read/Write access to Holding Registers. Input Registers are always readable.

The three levels of access are:

- Administrator Ability to set any passwords, as well as read or write Holding Registers
- Level 1 Ability to Read or Write any Holding Registers, as well as setting Level 1 or Level 2 passwords
- Level 2 Ability to Read Holding Registers, as well as setting the Level 2 password.

To use all three levels of access, set the Administrator password first, log in as Administrator, then set Level 1, and then Level 2.

If any password is set to something other than 0, and others are set to 0, then only the non-zero password will function. If a Level 2 password is first set, you will not be able to log in as an Administrator, but only read holding registers. In some instances this may be a desirable mode.

2.4 Transmitter MODBUS Supported Function Codes

The transmitter supports these MODBUS Function Codes:

Code	Sub Code	Function
01		Read Coils
02		Read Discrete Inputs
03		Read holding Registers
04		Read Input Registers
05		Write Single Coil
06		Write Single Registers
07		Read Exception Status (Serial only)
08		Diagnostics (Serial only)
08	00	Return Query Data
08	01	Restart Communications Option
08	02	Return Diagnostic Register
08	03	Change ASCII Input Delimiter
08	04	Force Listen Only Mode
08	10	Clear Counters and Diagnostic Register
08	11	Return Bus Message Count
08	12	Return Bus Communications Error Count
08	13	Return Bus Exception Error Count
08	14	Return Slave Message Count
08	15	Return Slave No Response Count
08	16	Return Slave NAK Count
08	17	Return Slave Busy Count
08	18	Return Bus Character Overrun Count
08	20	Clear Overrun Counter and Flag
11		Get Communications Event Counter (Serial only)
12		Get Communications Event Log (Serial only)
15		Write Multiple Coils
16		Write Multiple Registers
17		Report Slave ID (Serial only)
22		Mask Write register
23		Read/Write Multiple registers
43	14	Read Device Identification

Table 1 Supported Modbus Function Codes

The transmitter does NOT support these MODBUS Function Codes:

Code	Sub Code	Function
20		Read File Record
21		Write File Record
24		Read FIFO Queue

Table 2 Non-Supported Modbus Function Codes

2.5 Other Registers

Coils and Discreet inputs are not used in the transmitter. All configurations are performed with Holding Registers, and measurements read from Input Registers.

2.6 Diagnostics

08/02 Read Diagnostic Register

- Diagnostic Register Bits

Bit Number	Description
0	STATUS_BIT_DEFAULTS
1	STATUS_BIT_DSP_DEAD
2	STATUS_BIT_DSP_NO_RESP
3	STATUS_PREAMP_FAILURE
4	SOS_SINGULAR_MATRIX_ERR
5	VF_SINGULAR_MATRIX_ERR
6	VFCENTROID_DIV0_ERROR
7	SOSCENTROID_DIV0_ERROR
8	NO_VALID_FREQ_POINTS
9	SENSOR_OVERLOAD_ERROR
10	VF_DATA_OVERANGE
11	SOS_DATA_OVERANGE
12	unused
13	unused
14	unused
15	unused

Table 3 Diagnostic Register Bits

2.7 Other Functions

2.7.1 17 Read Slave ID

Slave ID returned by this command is based on the software revision of the transmitter as follows:

Software version V4.01.02 returns a Slave ID of 40102.

2.7.2 43/14 Read Device Identification

This function code returns three string objects as follows:

CiDRA Corp.
TB8-XX-XX-XX-XX
V4.01.02

3 MODBUS REGISTERS

3.1 Modbus Input Registers

Note: Float values may be set to QNAN if transmitter is not configured to generate those values. (QNAN means 'Quiet Not A Number', a computing term for an IEEE floating point representation for the result of a numerical operation which cannot return a valid number value.)

Table 4 Modbus Input Registers

Address	Size	Type	Value	Description	Notes
1	2	Float	Flow Rate as Displayed	Flow Rate as it appears on the LCD.	Will be set to QNAN when not displayed.
3	2	Float	Total Flow	Total Flow.	
5	2	Float	VF Quality	Measured flow quality.	
7	2	Float	Flow Rate	Measured flow rate in ft/s without any filtering applied.	As reported by DSP.
9	2	Float	GVF as Displayed	GVF as it appears on the LCD.	Will be set to QNAN when not displayed.
11	2	Float	Pressure	Pressure as used in calculation of GVF in configured units.	
13	2	Float	Temperature	Temperature as used in calculation of GVF in configured units.	
15	2	Float	SOS as Displayed	SOS as it appears on the LCD.	Will be set to QNAN when not displayed.
17	2	Float	SOS Quality	Measured SOS quality.	
19	2	Float	SOS	Measured SOS in ft/s without any filtering applied.	As reported by DSP.
21	2	Float	SOS Flow Rate as Displayed	SOS Flow Rate as it appears on the LCD.	Will be set to QNAN when not displayed.
23	2	Float	SOS Flow Rate Quality	Measured SOS flow quality.	
25	2	Float	TLF as Displayed	TLF as it appears on the LCD.	Will be set to QNAN when not displayed.
27	2	Float	Total TLF	Measured total TLF.	
29	2	Float	TLF	Measured TLF in ft/s without any filtering applied.	
31	2	Float	Band Temperature	Temperature measured by the sensor band.	

Table 4 Modbus Input Registers (continued)

Address	Size	Type	Value	Description	Notes
33	2	Float	4-20mA Input 1	Measured analog input 1 in mA.	
35	2	Float	4-20mA Input 2	Measured analog input 2 in mA.	
37	2	Float	4-20mA Channel 1	Value output on 4-20mA Channel 1.	
39	2	Float	4-20mA Channel 2	Value output on 4-20mA Channel 2.	
41	2	Float	Sensor Alpha 1	Relative scale factor between signal magnitudes acquired from each sensor.	
43	2	Float	Sensor Alpha 2	Relative scale factor between signal magnitudes acquired from each sensor.	
45	2	Float	Sensor Alpha 3	Relative scale factor between signal magnitudes acquired from each sensor.	
47	2	Float	Sensor Alpha 4	Relative scale factor between signal magnitudes acquired from each sensor.	
49	2	Float	Sensor Alpha 5	Relative scale factor between signal magnitudes acquired from each sensor.	
51	2	Float	Sensor Alpha 6	Relative scale factor between signal magnitudes acquired from each sensor.	
53	2	Float	Sensor Alpha 7	Relative scale factor between signal magnitudes acquired from each sensor.	
55	2	Float	Sensor Alpha 8	Relative scale factor between signal magnitudes acquired from each sensor.	
57	2	Float	PreAmp Charge Gain	Charge gain as read from the preamp.	
59	2	Float	PreAmp Gain 0	Preamp Gain 0 as read from the preamp.	
61	2	Float	PreAmp Gain 1	Preamp Gain 1 as read from the preamp.	
63	2	Float	PreAmp Gain 2	Preamp Gain 2 as read from the preamp.	
65	2	Float	PreAmp Gain 3	Preamp Gain 3 as read from the preamp.	
67	2	Float	Total Flow Fraction	Floating point fraction to be added to 'Total Flow Carry' * 100 to calculate full resolution total flow.	Fractional part of totalizer. Add this number to Total Flow Carry * 100 to calculate full total.

Table 4 Modbus Input Registers (continued)

Address	Size	Type	Value	Description	Notes
69	2	Float	Total TLF Fraction	Floating point fraction to be added to 'Total TLF Carry' * 100 to calculate full resolution total TLF.	Fractional part of totalizer. Add this number to Total TLF Carry * 100 to calculate full total.
71	2	Float	Output 1	Spare Output 1.	
73	2	Float	Output 2	Spare Output 2.	
75	2	Float	Output 3	Spare Output 3.	
77	2	Float	Output 4	Spare Output 4.	
1001	2	Long	System Status	Refer to manual for description of individual bits.	
1003	2	Long	Sensor 1 Max	Sensor 1 maximum in A/D bins.	
1005	2	Long	Sensor 2 Max	Sensor 2 maximum in A/D bins.	
1007	2	Long	Sensor 3 Max	Sensor 3 maximum in A/D bins.	
1009	2	Long	Sensor 4 Max	Sensor 4 maximum in A/D bins.	
1011	2	Long	Sensor 5 Max	Sensor 5 maximum in A/D bins.	
1013	2	Long	Sensor 6 Max	Sensor 6 maximum in A/D bins.	
1015	2	Long	Sensor 7 Max	Sensor 7 maximum in A/D bins.	
1017	2	Long	Sensor 8 Max	Sensor 8 maximum in A/D bins.	
1019	2	Long	Sensor 1 Min	Sensor 1 minimum in A/D bins.	
1021	2	Long	Sensor 2 Min	Sensor 2 minimum in A/D bins.	
1023	2	Long	Sensor 3 Min	Sensor 3 minimum in A/D bins.	
1025	2	Long	Sensor 4 Min	Sensor 4 minimum in A/D bins.	
1027	2	Long	Sensor 5 Min	Sensor 5 minimum in A/D bins.	
1029	2	Long	Sensor 6 Min	Sensor 6 minimum in A/D bins.	
1031	2	Long	Sensor 7 Min	Sensor 7 minimum in A/D bins.	
1033	2	Long	Sensor 8 Min	Sensor 8 minimum in A/D bins.	
1035	2	Long	Total Flow Carry	Signed long portion (* 100) to be added to 'Total Flow Fraction' to calculate full resolution total flow.	Carry part of totalizer. Add this number * 100 to Total Flow Fraction to calculate full total.
1037	2	Long	Total TLF Carry	Signed long portion (* 100) to be added to 'Total TLF Fraction' to calculate full resolution total TLF.	Carry part of totalizer. Add this number * 100 to Total TLF Fraction to calculate full total.

Table 4 Modbus Input Registers (continued)

Address	Size	Type	Value	Description	Notes
1501	16	String	Transmitter S/N	Transmitter Serial Number.	
1517	16	String	Model Number	Transmitter Model Number.	
1533	16	String	Software Revision	Transmitter Software Revision.	
1549	16	String	Alchemy Software Revision	Alchemy Software Revision.	
1565	16	String	Sensor head S/N	Sensor Head Serial Number.	
1581	16	String	PreAmp Software Revision	Preamp Software Revision.	
1597	16	String	PreAmp Serial Number	Preamp Serial Number.	
1613	16	String	DSP Hardware P/N	DSP Hardware P/N.	
1629	16	String	DSP Software P/N	DSP Software P/N.	
1645	16	String	DSP Hardware Revision	DSP Hardware Revision.	
1661	16	String	DSP Software Revision	DSP Software Revision.	
1677	16	String	FPGA Revision	FPGA Revision.	
1693	16	String	Transmitter Board S/N	Transmitter Board S/N.	
1709	16	String	Hardware P/N	Hardware P/N.	
1725	16	String	Software P/N	Software P/N.	
1741	16	String	Hardware Revision	Hardware Revision.	
1757	16	String	Alchemy Hardware Revision	Alchemy Hardware Revision.	
1773	16	String	Alchemy S/N	Alchemy S/N.	
1789	16	String	Alchemy Bootloader Revision	Alchemy Bootloader Revision.	
1805	16	String	Alchemy Bootloader P/N	Alchemy Bootloader P/N.	

Table 4 Modbus Input Registers (continued)

Address	Size	Type	Value	Description	Notes
1821	16	String	Alchemy Compatibility Revision	Alchemy Compatibility Revision.	
1837	16	String	PreAmp Software P/N	PreAmp Software P/N.	
1853	16	String	PreAmp Software Date	PreAmp Software Date.	
1869	16	String	PreAmp Hardware P/N	PreAmp Hardware P/N.	
1885	16	String	PreAmp Hardware Revision	PreAmp Hardware Revision.	
1901	16	String	PreAmp Hardware Date	PreAmp Hardware Date.	
1917	16	String	PreAmp Bootloader P/N	PreAmp Bootloader P/N.	
1933	16	String	PreAmp Bootloader Revision	PreAmp Bootloader Revision.	
2001	4	Double	Total Flow (Double Precision)	Total Flow (Double Precision).	
2005	4	Double	Total TLF (Double Precision)	Total TLF (Double Precision).	

3.2 Modbus Holding Registers

Table 5 Modbus Holding Registers

Address	Size	Type	Value	Description	Values
1	1	Char	Password Input	Password entry, when passwords are configured.	0 – 65535.
4	1	Char	Write Control	Controls ability to write and commit changes to transmitter configuration.	Write 0x55AA to enable write access, write 0xEDF1 to commit changes.
10	1	Char	Set Password 0	Sets Password 0.	0 – 65535.
11	1	Char	Set Password 1	Sets Password 1.	0 – 65535.
12	1	Char	Set Password 2	Sets Password 2.	0 – 65535.
20	1	Char	Reset Totalizers	Resets all totalizers to zero.	Any Write.
21	1	Char	Clear Alarm	Clear any existing alarms.	Any Write.
22	1	Char	Reset Data History	Clears the data history memory.	Any Write.
1001	1	Char	PIPE_DIAM_SELECT	Selects method used to set pipe dimensions.	0 = ID/Wall (Uses DISP_PIPE_DIAM and WALL_THICKNESS), 2 = Size/Sched (Uses PIPE_SS_SIZE and PIPE_SS_SCHED), 3 = OD/Wall (Uses PIPE_OD and WALL_THICKNESS).
1002	1	Char	PIPE_DIAM_UNITS	Selects units used for 'Pipe ID'.	0 = Inches, 1 = millimeters
1003	1	Char	PIPE_OD_UNITS	Selects units used for 'Pipe OD'.	0 = Inches, 1 = millimeters
1004	1	Char	PIPE_SS_SIZE	Selects pipe size. Will only be applied if 'Size / Schedule' is selected for 'Pipe Diameter Input Mode'.	0=2,1=2.5,3,3.5,5,6,8,10,12,14,16,18,20,22,24,26,28,30,32,34,36
1005	1	Char	PIPE_SS_SCHED	Selects pipe schedule. Will only be applied if 'Size / Schedule' is selected for 'Pipe Diameter Input Mode'.	0=5S,1=10,10S,20,30,40,40S,60,80,80S,STD,XS
1006	1	Char	SOS_PIPE_WALL_THICKUNITS	Selects units used for 'SOS Pipe Wall Thickness'.	0 = Inches, 1 = millimeters
1007	1	Char	SOS_PIPE_MODULUS_SEL	Selects either a pre-defined modulus or the option to enter a custom value. Select 'Custom' to enter a value in 'SOS Pipe Modulus'.	0 = 1.9305e8 kPa (SS), 1 = 2.0684e8 kPa (Steel), 2 = 3.4473e6 kPa (PVC), 3 = Custom
1008	1	Char	SOS_GAS_CONSTANT_SEL	Selects use of pre-defined SOS Gas Constant or a custom value entered in 'SOS Gas Constant'.	0 = 287 Jkg/K (Air), 1 = Custom

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
1009	1	Char	SOS_LIQUID_SPECGRAV_SEL	Selects use of pre-defined SOS Specific Gravity or a custom value entered in 'SOS Specific Gravity'.	0 = 0.997 (Water), 1 = Custom
1010	1	Char	SOS_LIQUID_SOS_SEL	Selects use of pre-defined SOS Liquid Sound Speed or a custom value* entered in 'SOS Liquid Sound Speed'	0 = 4910.4 ft/s (Water), 1 = Custom
1011	1	Char	TLF_TEMP_INPUT_SEL	Selects the source of the temperature used in GVF calculations. 'Fixed' uses 'SOS Process Temperature', 'Sensor 1' uses the 4-20mA input channel 1, 'Sensor 2' uses 4-20mA input channel 2, Protocol uses values written to register 5003.	0 = Fixed, 1 = Sensor 1, 2 = Sensor 2, 3 = Protocol
1012	1	Char	TLF_PRESS_INPUT_SEL	Selects the source of the pressure used in GVF calculations. 'Fixed' uses 'SOS Process Pressure', 'Sensor 1' uses the 4-20mA input channel 1, 'Sensor 2' uses 4-20mA input channel 2, Protocol uses values written to register 5001.	0 = Fixed, 1 = Sensor 1, 2 = Sensor 2, 3 = Protocol
1013	1	Char	SOS_TEMP_UNITS	Selects units used for input of 'SOS Process Temperature' degrees.	0 = C, 1 = F
1014	1	Char	SOS_PRESS_UNITS	Selects units used for input of 'SOS Process Pressure'.	0 = PSIg, 1 = kPAg, 2 = BARg
1015	1	Char	ALTITUDE_UNITS	Selects units used for entry of 'Altitude'.	0 = ft, 1 = m
1016	1	Char	DISP_LINE1	Selects measured value to be displayed on line 1 of the LCD.	0 = Flow Rate, 1 = Flow Rate%, 2 = Totalizer, 3 = SOS, 4 = GVF, 5 = Blank, 6 = TLF
1017	1	Char	DISP_LINE2	Selects measured value to be displayed on line 2 of the LCD.	0 = Flow Rate, 1 = Flow Rate%, 2 = Totalizer, 3 = SOS, 4 = GVF, 5 = Blank, 6 = TLF
1018	1	Char	VOL_UNITS	Selects units used to display and log flow volume.	0 = m^3, 1 = l, 2 = gal, 3 = m, 4 = ft, 5 = iga, 6 = ft^3, 7 = user
1019	1	Char	TIME_UNITS	Selects units used to display and log flow time.	0 = d, 1 = h, 2 = m, 3 = s, 4 = user
1020	1	Char	CUST_VOL_UNITS	Selects volume units used in calculation of a custom unit.	0 = m^3, 1 = l, 2 = gal, 3 = m, 4 = ft, 5 = iga, 6 = ft^3
1021	1	Char	CUST_TIME_UNITS	Selects time units used in calculation of a custom unit.	0 = d, 1 = h, 2 = m, 3 = s
1022	3	Char	CUST_VOL_LABEL	Three character string used for display and logging of a custom flow volume unit.	Any Alpha

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
1025	2	Char	CUST_TIME_LABEL	Two character string used for display and logging of a custom flow time unit.	Any Alpha
1027	1	Char	GVF_DECIMAL_PLACES	Sets the number of decimal places used to display GVF on the front panel.	0 - 6
1028	1	Char	SOS_VOL_UNITS	Selects units used to display and log SOS.	0 = ft, 1 = m
1029	1	Char	DATE_FORMAT	Selects date format	0 = US (mm/dd/yyyy), 1 = Euro (dd/mm/yyyy), 2 = International (yyyy-mm-dd)
1030	1	Char	DEBUG_SETTINGS	Selects debugging options	0 = 255
1031	1	Char	WRITE_PROTECT	Enable or disable modifications to the transmitter FLASH memory. When modifying this change only this for proper operation.	0 = Disable, 1 = Enable
1032	1	Char	Pre Amp Gain	Gain selection for the preamp. Set a value 0 thru 3 to choose gain listed by 'Preamp Gain 0', 'Preamp Gain 1', 'Preamp Gain 2,' or 'Preamp Gain 3'	0 - 3
1033	1	Char	TLF_SENSOR_INPUT_UNITS_1	Selects units used in translating the mA measured on Sensor 1 input to units used internally.	0 = None, 1 = PSIg, 2 = kPAg, 3 = BARg, 4 = C, 5 = F
1034	1	Char	TLF_SENSOR_INPUT_UNITS_2	Selects units used in translating the mA measured on Sensor 2 input to units used internally.	0 = None, 1 = PSIg, 2 = kPAg, 3 = BARg, 4 = C, 5 = F
1035	1	Char	PRESS_INPUT_UNITS	Selects units for pressure read from register 5001 - Pressure Input.	0 = None, 1 = PSIg, 2 = kPAg, 3 = BARg
1036	1	Char	TEMP_INPUT_UNITS	Selects units for temperature read from register 5003 - Temperature Input.	0 = None, 4 = C, 5 = F
1037	1	Char	EXTERN_INPUT_UNITS_0	Selects units for value read from register 5005 - External Input 1.	0 = None, 1 = PSIg, 2 = kPAg, 3 = BARg, 4 = C, 5 = F
1038	1	Char	EXTERN_INPUT_UNITS_1	Selects units for value read from register 5007 - External Input 2.	0 = None, 1 = PSIg, 2 = kPAg, 3 = BARg, 4 = C, 5 = F
1039	1	Char	EXTERN_INPUT_UNITS_2	Selects units for value read from register 5009 - External Input 3.	0 = None, 1 = PSIg, 2 = kPAg, 3 = BARg, 4 = C, 5 = F
1040	1	Char	VF_NR_MAGNITUDE_SEL	Selects flow noise reduction filter magnitude.	0 = Low, 1 = High
1041	1	Char	GVF_NR_MAGNITUDE_SEL	Selects GVF noise reduction filter magnitude.	0 = Low, 1 = High

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
1042	16	Char	SENSORHEAD_SER_NUMBER	Sensor Head Serial Number.	Any Alpha
1058	1	Char	TOT_UNITS	Selects units used to display and log total flow.	0 = gal, 1 = m3, 2 = ft3, 3 = l, 4 = VF_VOL_UNITS
1059	1	Char	TOTALIZER_MULT	Selects totalizer multiplier.	0 = 1, 1 = k, 2 = M
1060	1	Char	TOT_LOW_CUT_ENABLE	Enables or disables totalizer lowcut.	0 = Disable, 1 = Enable
1061	1	Char	TLF_TOTALIZER_INPUT_SEL	Selects source of totalizer - VF or TLF.	0 = VF, 1 = TLF
1062	1	Char	PRIMARY_420_OUT_OF_RANGE	Selects 4-20mA Channel 1 Out Of Range action.	0 = Hold, 1 = <4ma, 2 = =4ma, 3 = >20ma
1063	1	Char	PRIMARY_420_POWER_SEL	Selects 4-20mA Channel 1 External or Internal 4-20mA, power.	0 = Internal, 1 = External
1064	1	Char	PRIMARY_420_OUTPUT_SEL	Selects metric to be output on 4-20mA Channel 1.	0 = Flow Rate, 1 = SOS, 2 = GVF, 3 = Blank, 4 = TLF, 5 = Flow Quality, 6 = SOS Quality
1065	1	Char	420_OVERRANGE_MODE_01	Selects 4-20mA Channel 1 Overrange rail.	0 - Use PRIMARY_420_OUT_OF_RANGE setting when output is below/ above lowcut/highcut % (do not rail), 1 - Rail 4-20mA output if metric is below/above lowcut/highcut % for channel 1
1066	1	Char	SECONDARY_420_OUT_OF_RANGE	Selects 4-20mA Channel 2 Out Of Range action.	0 = Hold, 1 = <4ma, 2 = =4ma, 3 = >20ma
1067	1	Char	SECONDARY_420_POWER_SEL	Selects 4-20mA Channel 2 External or Internal 4-20mA power.	0 = Internal, 1 = External
1068	1	Char	SECONDARY_420_OUTPUT_SEL	Selects metric to be output on 4-20mA Channel 2.	0 = Flow Rate, 1 = SOS, 2 = GVF, 3 = Blank, 4 = TLF, 5 = Flow Quality, 6 = SOS Quality

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
1069	1	Char	420_OVERRANGE_MODE_02	Selects 4-20mA Channel 2 Overrange rail.	0 = Use PRIMARY_420_OUT_OF_RANGE setting when output is below/ above lowcut/highcut % (do not rail), 1 = Rail 4-20mA output if metric is below/above lowcut/highcut % for channel 1
1070	1	Char	PULSE_OUTPUT_SEL	Selects metric output on pulse.	0 = Flow Rate, 1 = SOS, 2 = GVF, 3 = Flow Rate %, 4 = Totalizer, 5 = TLF, 6 = Flow Quality, 7 = SOS Quality
1071	1	Char	PULSE_WIDTH	Selects pulse width.	0 = 0.5, 1 = 1, 2 = 20, 3 = 33, 4 = 50, 5 = 100
1072	1	Char	ALARM_WARN_EXPR_0	Boolean expression used for warning alarm.	0 = OFF, 1 = ON
1073	1	Char	ALARM_WARN_EXPR_1	Boolean expression used for warning alarm.	2 = Blank, 3 = TMP, 4 = SPL, 5 = VQ, 6 = SQ, 7 = LOG, 8 = OVL, 9 = FAL, 10 = FLW, 11 = GVF
1074	1	Char	ALARM_WARN_EXPR_2	Boolean expression used for warning alarm.	0 = Blank, 1 = OR, 2 = AND
1075	1	Char	ALARM_WARN_EXPR_3	Boolean expression used for warning alarm.	2 = Blank, 3 = TMP, 4 = SPL, 5 = VQ, 6 = SQ, 7 = LOG, 8 = OVL, 9 = FAL, 10 = FLW, 11 = GVF
1076	1	Char	ALARM_WARN_EXPR_4	Boolean expression used for warning alarm.	0 = Blank, 1 = OR, 2 = AND
1077	1	Char	ALARM_WARN_EXPR_5	Boolean expression used for warning alarm.	2 = Blank, 3 = TMP, 4 = SPL, 5 = VQ, 6 = SQ, 7 = LOG, 8 = OVL, 9 = FAL, 10 = FLW, 11 = GVF
1078	1	Char	ALARM_CRIT_EXPR_0	Boolean expression used for critical alarm.	0 = OFF, 1 = ON
1079	1	Char	ALARM_CRIT_EXPR_1	Boolean expression used for critical alarm.	2 = Blank, 3 = TMP, 4 = SPL, 5 = VQ, 6 = SQ, 7 = LOG, 8 = OVL, 9 = FAL, 10 = FLW, 11 = GVF

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
1080	1	Char	ALARM_CRIT_EXPR_2	Boolean expression used for critical alarm.	0 = Blank, 1 = OR, 2 = AND
1081	1	Char	ALARM_CRIT_EXPR_3	Boolean expression used for critical alarm.	2 = Blank, 3 = TMP, 4 = SPL, 5 = VQ, 6 = SQ, 7 = LOG, 8 = OVL, 9 = FAL, 10 = FLW, 11 = GVF
1082	1	Char	ALARM_CRIT_EXPR_4	Boolean expression used for critical alarm.	0 = Blank, 1 = OR, 2 = AND
1083	1	Char	ALARM_CRIT_EXPR_5	Boolean expression used for critical alarm.	2 = Blank, 3 = TMP, 4 = SPL, 5 = VQ, 6 = SQ, 7 = LOG, 8 = OVL, 9 = FAL, 10 = FLW, 11 = GVF
1084	1	Char	ALARM_MANUAL_CLR	Disables or enables manual clearing of alarms from front panel with the ESC/EXIT Key.	0 = Disable, 1 = Enable
1501	2	Float	DISP_PIPE_DIAM	Pipe Inside Diameter (ID).	
1503	2	Float	PIPE_OD	Pipe Outside Diameter (OD).	
1505	2	Float	WALL_THICKNESS	Pipe Wall Thickness.	
1507	2	Float	VISCOSITY	Viscosity in Pascal seconds of the fluid at the operating conditions. Used for Reynolds correction.	
1509	2	Float	ALTITUDE_ABOVE_SEA_LEVEL	Altitude Above Sea Level in units defined by 'ALTITUDE_UNITS'.	
1511	2	Float	LOW_FLOW_CUT_OFF	Low flow cutoff as a % of flow measurement range (defined by FLOW_MIN and FLOW_MAX). Will not display or output flow reading if flow value is below this setting.	
1513	2	Float	HIGH_FLOW_CUT_OFF	High flow cutoff as a % of flow measurement range (defined by FLOW_MIN and FLOW_MAX). Will not display or output flow reading if flow value is above this setting.	
1515	2	Float	CUST_VOL_SCALE	Multiplier for base flow units to create custom display.	
1517	2	Float	CUST_TIME_SCALE	Multiplier for base time units to create custom display.	
1519	2	Float	VF_QUALITY_DELTA	Delta change from minimum quality at minimum flow (MIN_QUALITY) to minimum quality at max flow (MIN_QUALITY+ VF_QUALITY_DELTA).	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
1521	2	Float	SOS_QUALITY_DELTA	Delta change from SOS minimum quality at minimum SOS (SOS_MIN_QUALITY) to minimum quality at max SOS (SOS_MIN_QUALITY+ SOS_QUALITY_DELTA).	
1523	2	Float	YELLOW_QUALITY_PERCENT	Percentage of VF quality or SOS quality (depending on op mode) below which the display will indicate a 3 level of 'YEL', if configured to display 3 level quality.	
1525	2	Float	TOTAL_LOW_CUT	Define low limit of totalizer. Input as % of flow rate. Readings below this value will not be totalized.	
1527	2	Float	REYNOLDSC0	Volumetric flow calibration coefficient C0.	
1529	2	Float	REYNOLDSC1	Volumetric flow calibration coefficient C1.	
1531	2	Float	REYNOLDSC2	Volumetric flow calibration coefficient C2.	
1533	2	Float	TLF_SENSOR_INPUT_SCALE_1	Sets multiplier used to scale the 4-20mA input Sensor 1.	
1535	2	Float	TLF_SENSOR_INPUT_SCALE_2	Sets multiplier used to scale the 4-20mA input Sensor 2.	
1537	2	Float	TLF_SENSOR_INPUT_OFFSET_1	Sets offset used to calculate the 4-20mA input Sensor 1 value.	
1539	2	Float	TLF_SENSOR_INPUT_OFFSET_2	Sets offset used to calculate the 4-20mA input Sensor 2 value.	
1541	2	Float	PRIMARY_420_HIGH_END	Define high (20mA) end of primary 4-20mA output.	
1543	2	Float	PRIMARY_420_LOW_END	Define low (4mA) end of primary 4-20mA output.	
1545	2	Float	PRIMARY_420_SCALE	Multiplier applied to primary 4-20mA output for calibration purposes	
1547	2	Float	PRIMARY_420_OFFSET	Constant offset applied to primary 4-20mA output for calibration purposes.	
1549	2	Float	SECONDARY_420_HIGH_END	Define high (20mA) end of primary 4-20mA output.	
1551	2	Float	SECONDARY_420_LOW_END	Define low (4mA) end of primary 4-20mA output.	
1553	2	Float	SECONDARY_420_SCALE	Multiplier applied to primary 4-20mA output for calibration purposes.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
1555	2	Float	SECONDARY_420_OFFSET	Constant offset applied to primary 4-20mA output for calibration purposes.	
1557	2	Float	PULSE_MULT	Pulse output multiplier.	
1559	2	Float	PULSE_LOW_CUT	Define measurement value below which pulse output will not be updated.	
1561	2	Float	ALARM_WARN_TEMP_<	Min band temperature threshold for warning alarm in degrees C.	
1563	2	Float	ALARM_WARN_TEMP_>	Max band temperature threshold for warning alarm in degrees C.	
1565	2	Float	ALARM_WARN_SPL_<	Min SPL threshold for warning alarm in dB.	
1567	2	Float	ALARM_WARN_SPL_>	Max SPL threshold for warning alarm in dB.	
1569	2	Float	ALARM_WARN_VF_QUAL_<	Min VF Quality threshold for warning alarm.	
1571	2	Float	ALARM_WARN_SOS_QUAL_<	Min SOS Quality threshold for warning alarm.	
1573	2	Float	ALARM_WARN_VF_<	Min Vortical Flow Rate threshold for warning alarm in %.	
1575	2	Float	ALARM_WARN_VF_>	Max Vortical Flow Rate threshold for warning alarm in %.	
1577	2	Float	ALARM_WARN_GVF_<	Min Gas Volume Fraction threshold for warning alarm in %.	
1579	2	Float	ALARM_WARN_GVF_>	Max Gas Volume Fraction threshold for warning alarm in %.	
1581	2	Float	ALARM_CRIT_TEMP_<	Min band temperature threshold for critical alarm in degrees C.	
1583	2	Float	ALARM_CRIT_TEMP_>	Max band temperature threshold for critical alarm in degrees C.	
1585	2	Float	ALARM_CRIT_SPL_<	Min SPL threshold for critical alarm in dB.	
1587	2	Float	ALARM_CRIT_SPL_>	Max SPL threshold for critical alarm in dB.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
1589	2	Float	ALARM_CRIT_VF_QUAL_<	Min VF Quality threshold for critical alarm.	
1591	2	Float	ALARM_CRIT_SOS_QUAL_<	Min SOS Quality threshold for critical alarm.	
1593	2	Float	ALARM_CRIT_VF_<	Min Vortical Flow Rate threshold for critical alarm in %.	
1595	2	Float	ALARM_CRIT_VF_>	Max Vortical Flow Rate threshold for critical alarm in %.	
1597	2	Float	ALARM_CRIT_GVF_<	Min Gas Volume Fraction threshold for critical alarm in %.	
1599	2	Float	ALARM_CRIT_GVF_>	Max Gas Volume Fraction threshold for critical alarm in %.	
2001	1	Short	IDLE_TIMEOUT_SEC	Set communications idle timeout in seconds.	
2002	1	Short	ETHERNET_IDLE_TIMEOUT	Set Ethernet communications idle timeout in seconds.	
2003	1	Short	CONTRAST	Set front panel LCD display contrast.	
2004	1	Short	STORAGE_ID_0	ID of available values to be saved in storage mode.	
2005	1	Short	STORAGE_ID_1	ID of available values to be saved in storage mode.	
2006	1	Short	STORAGE_ID_2	ID of available values to be saved in storage mode.	
2007	1	Short	STORAGE_ID_3	ID of available values to be saved in storage mode.	
2008	1	Short	STORAGE_ID_4	ID of available values to be saved in storage mode.	
2009	1	Short	STORAGE_ID_5	ID of available values to be saved in storage mode.	
2010	1	Short	STORAGE_ID_6	ID of available values to be saved in storage mode.	
2501	2	Long	MAX_SENSOR_THRESH	Sets maximum threshold for sensor health diagnostics (in A/D counts).	
2503	2	Long	MIN_SENSOR_THRESH	Sets minimum threshold for sensor health diagnostics (in A/D counts).	
2505	2	Long	STORAGE_INTERVAL	Time in seconds between storage writes.	
2507	2	Long	STORAGE_ADDR_1	Address in rabbit controller memory to save to storage.	
2509	2	Long	STORAGE_ADDR_2	Address in rabbit controller memory to save to storage.	
3001	2	Float	VF_LOW_FILTER_DELTA_ARRAY_01	Delta Filter definition for VF.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
3003	2	Float	VF_LOW_FILTER_DELTA_ARRAY_02	Delta Filter definition for VF.	
3005	2	Float	VF_LOW_FILTER_DELTA_ARRAY_03	Delta Filter definition for VF.	
3007	2	Float	VF_LOW_FILTER_DELTA_ARRAY_04	Delta Filter definition for VF.	
3009	2	Float	VF_LOW_FILTER_DELTA_ARRAY_05	Delta Filter definition for VF.	
3011	2	Float	VF_LOW_FILTER_DELTA_ARRAY_06	Delta Filter definition for VF.	
3013	2	Float	VF_LOW_FILTER_DELTA_ARRAY_07	Delta Filter definition for VF.	
3015	2	Float	VF_LOW_FILTER_DELTA_ARRAY_08	Delta Filter definition for VF.	
3017	2	Float	VF_LOW_FILTER_DELTA_ARRAY_09	Delta Filter definition for VF.	
3019	2	Float	VF_LOW_FILTER_DELTA_ARRAY_10	Delta Filter definition for VF.	
3021	2	Float	VF_LOW_FILTER_TAU_ARRAY_01	Tau Filter definition for VF.	
3023	2	Float	VF_LOW_FILTER_TAU_ARRAY_02	Tau Filter definition for VF.	
3025	2	Float	VF_LOW_FILTER_TAU_ARRAY_03	Tau Filter definition for VF.	
3027	2	Float	VF_LOW_FILTER_TAU_ARRAY_04	Tau Filter definition for VF.	
3029	2	Float	VF_LOW_FILTER_TAU_ARRAY_05	Tau Filter definition for VF.	
3031	2	Float	VF_LOW_FILTER_TAU_ARRAY_06	Tau Filter definition for VF.	
3033	2	Float	VF_LOW_FILTER_TAU_ARRAY_07	Tau Filter definition for VF.	
3035	2	Float	VF_LOW_FILTER_TAU_ARRAY_08	Tau Filter definition for VF.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
3037	2	Float	VF_LOW_FILTER_TAU_ARRAY_09	Tau Filter definition for VF.	
3039	2	Float	VF_LOW_FILTER_TAU_ARRAY_10	Tau Filter definition for VF.	
3041	2	Float	VF_HIGH_FILTER_DELTA_ARRAY_01	Delta Filter definition for VF.	
3043	2	Float	VF_HIGH_FILTER_DELTA_ARRAY_02	Delta Filter definition for VF.	
3045	2	Float	VF_HIGH_FILTER_DELTA_ARRAY_03	Delta Filter definition for VF.	
3047	2	Float	VF_HIGH_FILTER_DELTA_ARRAY_04	Delta Filter definition for VF.	
3049	2	Float	VF_HIGH_FILTER_DELTA_ARRAY_05	Delta Filter definition for VF.	
3051	2	Float	VF_HIGH_FILTER_DELTA_ARRAY_06	Delta Filter definition for VF.	
3053	2	Float	VF_HIGH_FILTER_DELTA_ARRAY_07	Delta Filter definition for VF.	
3055	2	Float	VF_HIGH_FILTER_DELTA_ARRAY_08	Delta Filter definition for VF.	
3057	2	Float	VF_HIGH_FILTER_DELTA_ARRAY_09	Delta Filter definition for VF.	
3059	2	Float	VF_HIGH_FILTER_DELTA_ARRAY_10	Delta Filter definition for VF.	
3061	2	Float	VF_HIGH_FILTER_TAU_ARRAY_01	Tau Filter definition for VF.	
3063	2	Float	VF_HIGH_FILTER_TAU_ARRAY_02	Tau Filter definition for VF.	
3065	2	Float	VF_HIGH_FILTER_TAU_ARRAY_03	Tau Filter definition for VF.	
3067	2	Float	VF_HIGH_FILTER_TAU_ARRAY_04	Tau Filter definition for VF.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
3069	2	Float	VF_HIGH_FILTER_ TAU_ARRAY_05	Tau Filter definition for VF.	
3071	2	Float	VF_HIGH_FILTER_ TAU_ARRAY_06	Tau Filter definition for VF.	
3073	2	Float	VF_HIGH_FILTER_ TAU_ARRAY_07	Tau Filter definition for VF.	
3075	2	Float	VF_HIGH_FILTER_ TAU_ARRAY_08	Tau Filter definition for VF.	
3077	2	Float	VF_HIGH_FILTER_ TAU_ARRAY_09	Tau Filter definition for VF.	
3079	2	Float	VF_HIGH_FILTER_ TAU_ARRAY_10	Tau Filter definition for VF.	
3081	2	Float	VF_DAMPING_TAU	Damping time in seconds for the damping filter for VF.	
3083	2	Float	VF_SPIKE_FILTER_ PERCENT	Defines delta of the previous measurement over the range below which the flow rate is deemed valid.	
3085	2	Float	GVF_LOW_FILTER_ DELTA_ARRAY_01	Delta Filter definition for GVF.	
3087	2	Float	GVF_LOW_FILTER_ DELTA_ARRAY_02	Delta Filter definition for GVF.	
3089	2	Float	GVF_LOW_FILTER_ DELTA_ARRAY_03	Delta Filter definition for GVF.	
3091	2	Float	GVF_LOW_FILTER_ DELTA_ARRAY_04	Delta Filter definition for GVF.	
3093	2	Float	GVF_LOW_FILTER_ DELTA_ARRAY_05	Delta Filter definition for GVF.	
3095	2	Float	GVF_LOW_FILTER_ DELTA_ARRAY_06	Delta Filter definition for GVF.	
3097	2	Float	GVF_LOW_FILTER_ DELTA_ARRAY_07	Delta Filter definition for GVF.	
3099	2	Float	GVF_LOW_FILTER_ DELTA_ARRAY_08	Delta Filter definition for GVF.	
3101	2	Float	GVF_LOW_FILTER_ DELTA_ARRAY_09	Delta Filter definition for GVF.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
3103	2	Float	GVF_LOW_FILTER_DELTA_ARRAY_10	Delta Filter definition for GVF.	
3105	2	Float	GVF_LOW_FILTER_TAU_ARRAY_01	Tau Filter definition for GVF.	
3107	2	Float	GVF_LOW_FILTER_TAU_ARRAY_02	Tau Filter definition for GVF.	
3109	2	Float	GVF_LOW_FILTER_TAU_ARRAY_03	Tau Filter definition for GVF.	
3111	2	Float	GVF_LOW_FILTER_TAU_ARRAY_04	Tau Filter definition for GVF.	
3113	2	Float	GVF_LOW_FILTER_TAU_ARRAY_05	Tau Filter definition for GVF.	
3115	2	Float	GVF_LOW_FILTER_TAU_ARRAY_06	Tau Filter definition for GVF.	
3117	2	Float	GVF_LOW_FILTER_TAU_ARRAY_07	Tau Filter definition for GVF.	
3119	2	Float	GVF_LOW_FILTER_TAU_ARRAY_08	Tau Filter definition for GVF.	
3121	2	Float	GVF_LOW_FILTER_TAU_ARRAY_09	Tau Filter definition for GVF.	
3123	2	Float	GVF_LOW_FILTER_TAU_ARRAY_10	Tau Filter definition for GVF.	
3125	2	Float	GVF_HIGH_FILTER_DELTA_ARRAY_01	Delta Filter definition for GVF.	
3127	2	Float	GVF_HIGH_FILTER_DELTA_ARRAY_02	Delta Filter definition for GVF.	
3129	2	Float	GVF_HIGH_FILTER_DELTA_ARRAY_03	Delta Filter definition for GVF.	
3131	2	Float	GVF_HIGH_FILTER_DELTA_ARRAY_04	Delta Filter definition for GVF.	
3133	2	Float	GVF_HIGH_FILTER_DELTA_ARRAY_05	Delta Filter definition for GVF.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
3135	2	Float	GVF_HIGH_FILTER _DELTA_ARRAY_06	Delta Filter definition for GVF.	
3137	2	Float	GVF_HIGH_FILTER _DELTA_ARRAY_07	Delta Filter definition for GVF.	
3139	2	Float	GVF_HIGH_FILTER _DELTA_ARRAY_08	Delta Filter definition for GVF.	
3141	2	Float	GVF_HIGH_FILTER _DELTA_ARRAY_09	Delta Filter definition for GVF.	
3143	2	Float	GVF_HIGH_FILTER _DELTA_ARRAY_10	Delta Filter definition for GVF.	
3145	2	Float	GVF_HIGH_FILTER _TAU_ARRAY_01	Tau Filter definition for GVF.	
3147	2	Float	GVF_HIGH_FILTER _TAU_ARRAY_02	Tau Filter definition for GVF.	
3149	2	Float	GVF_HIGH_FILTER _TAU_ARRAY_03	Tau Filter definition for GVF.	
3151	2	Float	GVF_HIGH_FILTER _TAU_ARRAY_04	Tau Filter definition for GVF.	
3153	2	Float	GVF_HIGH_FILTER _TAU_ARRAY_05	Tau Filter definition for GVF.	
3155	2	Float	GVF_HIGH_FILTER _TAU_ARRAY_06	Tau Filter definition for GVF.	
3157	2	Float	GVF_HIGH_FILTER _TAU_ARRAY_07	Tau Filter definition for GVF.	
3159	2	Float	GVF_HIGH_FILTER _TAU_ARRAY_08	Tau Filter definition for GVF.	
3161	2	Float	GVF_HIGH_FILTER _TAU_ARRAY_09	Tau Filter definition for GVF.	
3163	2	Float	GVF_HIGH_FILTER _TAU_ARRAY_10	Tau Filter definition for GVF.	
3165	2	Float	GVF_DAMPING_TA U	Damping time in seconds for the damping filter for GVF.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
3167	2	Float	GVF_SPIKE_FILTER_PERCENT	Defines delta of the previous measurement over the range below which the flow rate is deemed valid.	
3169	2	Float	S1_DAMPING_TAU	Damping time in seconds for the damping filter for Sensor 1 input.	
3171	2	Float	S2_DAMPING_TAU	Damping time in seconds for the damping filter for Sensor 2 input.	
3501	1	Short	S1_1ST_ORDER_DAMPING_FILTER_ENABLE	Enables or Disables damping filter for Sensor 1 4-20mA input.	0 = Disable, 1 = Enable
3502	1	Short	S2_1ST_ORDER_DAMPING_FILTER_ENABLE	Enables or Disables damping filter for Sensor 2 4-20mA input.	0 = Disable, 1 = Enable
3503	1	Short	VF_NR_FILTER_ENABLE	Enables or Disables Noise Reduction Filter of the VF Flow Rate.	0 = Disable, 1 = Enable
3504	1	Short	VF_LOW_FILTER_ARRAY_LEN	Defines the length of the delta array for VF.	
3505	1	Short	VF_HIGH_FILTER_ARRAY_LEN	Defines the length of the delta array for VF.	
3506	1	Short	VF_1ST_ORDER_DAMPING_FILTER_ENABLE	Enables or Disables 1st Order Damping Filter of the VF Flow Rate.	0 = Disable, 1 = Enable
3507	1	Short	VF_SPIKE_FILTER_ENABLE	Enables or Disables Spike Filter of the VF Flow Rate.	0 = Disable, 1 = Enable
3508	1	Short	VF_SPIKE_NO_FLOW_LEN	Number of good measures during initialization before VF spike filter passes measurements as ‘good’.	
3509	1	Short	VF_SPIKE_FILTER_LEN	Defines the number of consecutive valid measurements before displaying flow rate.	
3510	1	Short	VF_SPIKE_UP_COUNT	Number of counts to INCREMENT the VF Bad Quality counter when measured VF quality is below the minimum.	
3511	1	Short	VF_SPIKE_DOWN_COUNT	Number of counts to DECREMENT the VF Bad Quality counter when measured VF quality is below the minimum	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
3512	1	Short	VF_SPIKE_PCT_WINDOW_LEN	Number of good measures before VF spike filter passes measurements as ‘good’.	
3513	1	Short	GVF_NR_FILTER_ENABLE	Enables or Disables Noise Reduction Filter of the GVF.	0 = Disable, 1 = Enable
3514	1	Short	GVF_LOW_FILTER_ARRAY_LEN	Defines the length of the delta array for GVF.	
3515	1	Short	GVF_HIGH_FILTER_ARRAY_LEN	Defines the length of the delta array for GVF.	
3516	1	Short	GVF_1ST_ORDER_DAMPING_FILTER_ENABLE	Enables or Disables 1st Order Damping Filter of the GVF.	0 = Disable, 1 = Enable
3517	1	Short	GVF_SPIKE_FILTER_ENABLE	Enables or Disables Spike Filter of the GVF.	0 = Disable, 1 = Enable
3518	1	Short	GVF_SPIKE_NO_FLOW_LEN	Number of good measures during initialization before GVF spike filter passes measurements as ‘good’.	
3519	1	Short	GVF_SPIKE_FILTER_LEN	Defines the number of consecutive valid measurements before displaying.	
3520	1	Short	GVF_SPIKE_UP_COUNT	Number of counts to INCREMENT the GVF Bad Quality counter when measured GVF quality is below the minimum.	
3521	1	Short	GVF_SPIKE_DOWN_COUNT	Number of counts to DECREMENT the GVF Bad Quality counter when measured GVF quality is below the minimum.	
3522	1	Short	GVF_SPIKE_PCT_WINDOW_LEN	Number of good measures before GVF spike filter passes measurements as ‘good’.	
4001	2	Float	PIPE_DIAM	Define pipe ID in inches.	
4003	2	Float	SOS_PIPE_WALL_THICK	SOS pipe wall thickness measurement in units selected by 'SOS Pipe Wall Thickness Units'.	
4005	2	Float	SOS_PIPE_MODULUS	SOS pipe modulus value.	
4007	2	Float	SOS_GAS_CONSTANT	Gas constant value used in GVF calculation.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
4009	2	Float	SOS_SPECIFIC_GRAVITY	This parameter (internally multiplied by 1000 kg/m^3) is used to set the 'SOS Liquid Density'. For example, Specific Gravity = 1.1 equates to density of 1.1 * 1000 kg/m^3.	
4011	2	Float	SOS_LIQUID_SOS	Pure phase liquid SOS for process fluid in ft/sec. Used for GVF calculation. Default setting is for water and is close enough for most fluid/gas applications.	
4013	2	Float	SOS_SPECFIC_HEAT_RATIO		
4015	2	Float	SOS_LIQUID_DENSITY	Calculated from 'SOS Specific Gravity'.	
4017	2	Float	SOS_TEMPERATURE	Constant temperature for GVF calculations when 'Fixed' is selected for 'SOS Temperature Input Selection'. In configured units.	
4019	2	Float	SOS_PRESSURE	Constant pressure for GVF calculations when 'Fixed' is selected for 'SOS Pressure Input Selection'. In configured units.	
4021	2	Float	GAIN		
4023	2	Float	SPL_THRESHOLD	This value is the threshold that the Average SPL must break in order for any SOS or VF calculations to be performed. A quality of -2 is reported if this threshold is not met. Set this value to 0 to disable SPL.	
4025	2	Float	SPL_AVG	The average SPL measurement from all active sensors.	
4027	2	Float	SPL_STD_DEV	The standard deviation of the SPL measurements from all active sensors.	
4029	2	Float	SAMPLE_FREQ	Set A/D sample frequency in samples per second. Enter one of the following: 3906.25 or 2055.921.	
4031	2	Float	CHANNEL_SKEW	Flow Channel Skew.	
4033	2	Float	FREQ_MIN	Set minimum frequency for k-w processing. Normally set by DSP. User modified if using single or fixed modes or auto mode with VF_OP_MODE_SETTINGS set to 1 (FIXED_FREQUENCY). Go to Idle mode, then set this parameter, then select single/fixed.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
4035	2	Float	FREQ_MAX	Set maximum frequency for k-w processing. Normally set by DSP. User modified if using single or fixed modes or auto mode with VF_OP_MODE_SETTINGS set to 1 (FIXED_FREQUENCY). Go to Idle mode, then set this parameter, then select single/fixed.	
4037	2	Float	FLOW_MIN	Minimum valid flow rate reading in configured display units.	
4039	2	Float	FLOW_MAX	Maximum valid flow rate reading in configured display units.	
4041	2	Float	MIN_QUALITY	Minimum quality threshold for VF display and output.	
4043	2	Float	VF_NYQUIST_HIGH	Define high end of frequency range to use for determining flow velocity. Defined by: FREQUENCY_MAX = (Measured Velocity * VF_NYQUIST_HIGH) / (Sensor Spacing). Example: (10 ft/sec * 0.7) / 0.2 = 35Hz	
4045	2	Float	VF_NYQUIST_LOW	Define low end of frequency range to use for determining flow velocity. Defined by: FREQUENCY_MIN = (Measured Velocity * VF_NYQUIST_LOW) / (Sensor Spacing). Example: (10 ft/sec*0.3) / 0.2 = 15Hz	
4047	2	Float	VF_CENTROID_WIDTH	Define width of peak to use in calculation of flow rate.	
4049	2	Float	VF_SEARCH_LIMIT_LOW	Define low end of velocity search range to use for determining flow velocity. Defined by: Velocity_Min = (FREQ_MAX * Sensor Spacing) / (VF_SEARCH_LIMIT_LOW). Example: at 10ft/sec* (10 ft/sec*0.7) / 0.2 = 35Hz then (35Hz * 0.2) / 0.9 = 7.78 ft/sec.	
4051	2	Float	VF_SEARCH_LIMIT_HIGH	Define high end of velocity search range to use for determining flow velocity. Defined by: Velocity_Max = (FREQ_MIN * Sensor Spacing) / (VF_SEARCH_LIMIT_HIGH). Example: at 10ft/sec* (10 ft/sec*0.3) / 0.2 = 15Hz then (15Hz * 0.2) / 0.15 = 20 ft/sec.	
4053	2	Float	VF_NYQUIST_INIT_VAL	This parameter selects the k value (from k-w) where the algorithm initially searches for the flow rate.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
4055	2	Float	SOS_SAMPLE_FREQ	Set sample frequency for SOS mode. This parameter must be set for SOS and overrides the SAMPLE_FREQ setting if running in SOS mode. Enter one of the following: 3906.25 or 2055.921.	3906.25or 2055.921
4057	2	Float	SOS_FREQ_MIN	Minimum frequency to use for SOS calculation. Typically in the 100 to 500hz range. Depends upon the data quality as seen on the k-w plot. SOS_FREQ_MIN and SOS_FREQ_MAX set the frequency range over which the SOS calculation will be performed.	
4059	2	Float	SOS_FREQ_MAX	Maximum frequency to use for SOS calculation. Typically in the 800 to 1500hz range. Depends upon the data quality as seen on the k-w plot. SOS_FREQ_MIN and SOS_FREQ_MAX set the frequency range over which the SOS calculation will be performed.	
4061	2	Float	SOS_MIN	Minimum SOS value to search for. If too much energy (such as from a high velocity vortical ridge) causes the algorithms to calculate a sound speed below that of the main SOS ridge; this parameter may need to be increased.	
4063	2	Float	SOS_MAX	Maximum SOS value to search for. If too much energy along the 0 k value on the k-w plot and algorithms are calculating SOS_MAX even when SOS ridge indicates an SOS below this value; may need to decrease this parameter.	
4065	2	Float	SOS_MIN_QUALITY	Minimum quality threshold for SOS/GVF display and output.	
4067	2	Float	SOS_CENTROID_WIDTH	Define width of peak to use in calculation of SOS.	
4069	2	Float	SOS_FREQ_THRESH	This value selects the threshold that the second derivative of a power array (generated at a specific frequency over all k-space values) must break in order for the specific frequency point to be considered a valid frequency point.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
4071	2	Float	SOS_K_MIN	This value sets the lower limit in k-space that is used in the SOS auto frequency determination code. This value is equal to the first k-space bin after 0: PI/deltaX/50 (there are 50 bins from 0 to PI/deltaX).	
4073	2	Float	SOS_K_MAX	This value sets the upper limit in k-space that is used in the SOS auto frequency determination code. This value is equal to the last k-space bin: PI/deltaX.	
4075	2	Float	SOS_SEARCH_LIMIT	This value is the +/- percentage of the estimated SOS value (calculated using the auto frequency calculation code) that determines the lower (Estimated SOS * 0.5) and upper (Estimated SOS * 1.5) SOS search limits.	
4077	2	Float	SOS_LAMBDA_DIAMETER	Used to calculate the SOS dynamic frequency maximum used when calculating SOS. SOS Max Freq = (Max SOS search) / ((Lambda Diameter * (Pipe Diameter/12)).	
4079	2	Float	SENSOR_SPACING_1	Starting point for sensor 1. Typically 0.	
4081	2	Float	SENSOR_SPACING_2	Distance in feet between sensor 1 and sensor 2.	
4083	2	Float	SENSOR_SPACING_3	Distance in feet between sensor 1 and sensor 3.	
4085	2	Float	SENSOR_SPACING_4	Distance in feet between sensor 1 and sensor 4.	
4087	2	Float	SENSOR_SPACING_5	Distance in feet between sensor 1 and sensor 5.	
4089	2	Float	SENSOR_SPACING_6	Distance in feet between sensor 1 and sensor 6.	
4091	2	Float	SENSOR_SPACING_7	Distance in feet between sensor 1 and sensor 7.	
4093	2	Float	SENSOR_SPACING_8	Distance in feet between sensor 1 and sensor 8.	
4095	2	Float	SENSOR_SCALE_1	Scaling factor in volts per PSI for sensor 1.	
4097	2	Float	SENSOR_SCALE_2	Scaling factor in volts per PSI for sensor 2.	
4099	2	Float	SENSOR_SCALE_3	Scaling factor in volts per PSI for sensor 3.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
4101	2	Float	SENSOR_SCALE_4	Scaling factor in volts per PSI for sensor 4.	
4103	2	Float	SENSOR_SCALE_5	Scaling factor in volts per PSI for sensor 5.	
4105	2	Float	SENSOR_SCALE_6	Scaling factor in volts per PSI for sensor 6.	
4107	2	Float	SENSOR_SCALE_7	Scaling factor in volts per PSI for sensor 7.	
4109	2	Float	SENSOR_SCALE_8	Scaling factor in volts per PSI for sensor 8.	
4501	2	Long	OP_MODE	Sets operating mode of the transmitter. VF Mode = 0, SOS Mode = 1, Both Mode = 2.	
4503	2	Long	UPDATE_RATE	This parameter will set the update rate in seconds (nominally). Actual update rate (in seconds) can be calculated by taking (BLOCK_SIZE / SAMPLE_FREQ) * UPDATE_RATE (VF mode), or, (BLOCK_SIZE / SOS_SAMPLE_FREQ) * UPDATE_RATE (SOS mode).	
4505	2	Long	NUM_CHANNELS	Sets number of sensors. Always leave set to 8. Do not use this parameter to disable a sensor use NUM_SENSORS_USED parameter to set which sensors to use in calculations.	
4507	2	Long	DECIMATION	Flow Decimation.	
4509	2	Long	WINDOW_TYPE	Algorithms always use hanning window. Windows raw data samples of NFFT size then zero pads then computes FFT.	
4511	2	Long	DETREND_FLAG	Enable/disable detrend of time series data of NFFT size before windowing and zero padding.	0 = Do not detrend time series data, 1 = Detrend time series data.
4513	2	Long	VEL_NORM_FLAG	Enable/disable normalization of sensor data.	0 = No normalization, 1 = Normalize data. Normalization performed in frequency domain.
4515	2	Long	VEL_DIFF_FLAG	Enable/disable differencing of sensors.	0 = No differencing, 1 = difference sensors using first order differencing. (i.e. Ch1=S1-S2* Ch2=S2-S3...Ch7=S7-S8). 2 - second order differencing (i.e. Ch1=S1-2*S2+S3* Ch2=S2-2*S3+S4...).
4517	2	Long	FLOW_DIR	Define flow direction.	0 = reverse flow, 1 = normal flow

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
4519	2	Long	TRANSIT_TIME_MULT	Default values are normally OK. Define target number of passes through array per calculation for volumetric flow. Use with caution.	
4521	2	Long	VF_PEAK_SEARCH_MODE	0 = No differencing, 1 = difference sensors using first order differencing. (i.e. Ch1=S1-S2* Ch2=S2-S3...Ch7=S7-S8). 2 - second order differencing (i.e. Ch1=S1-2*S2+S3* Ch2=S2-2*S3+S4...).	
4523	2	Long	VF_OP_MODE_SETTINGS	0 = Dynamic frequency adjust in auto runmode (original calculation), 1 = Fixed frequency in auto run mode, 2 = Fixed blocks in auto run mode, 4 = Dynamic Nyquist calculation enable, 8 = Reserved for future use, 16 = Linear KW diff enable, 32 = Log KW diff enable.	
4525	2	Long	VF_QUALITY_MODE	0 = original VF quality calculation, 1 = new VF quality calculation.	
4527	2	Long	NUM_BLOCKS	Define number of blocks used for calculations.	
4529	2	Long	NFFT	Number of points used in FFT. Actual FFT size is next 2^n higher value. Value of NFFT is zero padded to next larger 2^n FFT size. This value is normally set by the DSP.	
4531	2	Long	WINDOW_OVERLAP	Define overlap of FFT windows. This value is normally set by DSP to half of NFFT.	
4533	2	Long	FFT_AVGS	Default values are normally OK. In general for slower flow rates use more FFT averages; for faster flow rates use fewer FFT averages. This parameter affects the number of blocks used (there is a 20 block maximum due to DSP memory limitations). Use with caution.	
4535	2	Long	SOS Total Data	Calculates SOS Samples from this value and SOS Sample Frequency: SOS Samples = SOS Total Data * SOS Sample Freq.	
4537	2	Long	SOS_FFT_POINTS	Number of FFT points to use in SOS calculation. Usually set to 1/8 or 1/4 of the sample frequency.	
4539	2	Long	SOS_WINDOW_OVERLAP	Number of sample point overlap between successive FFT's. Recommended to set this to 50% of SOS_FFT_POINTS.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
4541	2	Long	SOS_SUB_ARRAYS	SOS Sub Array Size	
4543	2	Long	SOS_NORMALIZE_FLAG	0 = NO normalization in the frequency domain. 1 = normalization in the frequency domain.	
4545	2	Long	SOS_DIFFERENCING_FLAG	0 = NO differencing in the frequency domain. 1 = 1st order differencing in the frequency domain. 2 = 2nd order differencing in the frequency domain.	
4547	2	Long	SOS_OP_MODE_SETTINGS	Determines which ridge to use for SOS calculation. Also determines which SOS parameter to leave fixed or calculate and whether or not to use Linear/Log KW diff.	0 = Use right and left ridge averaged, 1 = Use right ridge only, 2 = Use left ridge only, 4 = Enable SOS auto frequency calculation, 8 = Enable SOS power weighting to auto-frequency calculation, 16 = Linear KW diff enable, 32 = Log KW diff enable.
4549	2	Long	SOS_SELECT_NUM	SOS Selection Threshold.	
4551	2	Long	SOS_MIN_FREQ_PTS	This value selects the minimum number of frequency points that will be used in the SOS calculation. If this number is not met then the calculation is not performed and an error is reported.	
4553	2	Long	SOS_NUM_PTS_LEFT	The number of frequency points used from the left ridge of the k-w plot.	
4555	2	Long	SOS_NUM_PTS_RIGHT	The number of frequency points used from the right ridge of the k-w plot.	
4557	2	Long	AGC_THRESHOLD_HIGH	Upper threshold limit for sensor readings. Used to detect High Threshold sensor readings during AGC mode functions.	
4559	2	Long	AGC_THRESHOLD_LOW	Lower threshold limit for sensor readings. Used to detect Low Threshold sensor readings during AGC mode functions.	
4561	2	Long	AGC_PERCENT_THRESHOLD_HIGH	Represents the percentage value of High Threshold faults required to be detected before asserting an Excessive Gain condition during AGC functions.	

Table 5 Modbus Holding Registers (continued)

Address	Size	Type	Value	Description	Values
4563	2	Long	AGC_PERCENT_THRESHOLD_LOW	Represents the percentage value of Low Threshold faults required to be detected before asserting an Insufficient Gain condition during AGC functions.	
4565	2	Long	AGC_SAMPLE_WINDOW	Represents the time window in seconds during which AGC High and Low Threshold faults will be counted. This is a sliding time window when used during Auto Gain Adjust functions and a One-Shot time window during Gain Test functions.	
4567	2	Long	AGC_RUN_MODE	For future use only. This parameter will be used to specify if the AGC functions should be executed in a Continuous mode, or in Single Execution mode.	
5001	2	Float	Pressure Input	External pressure measurement input.	No write control required on these inputs, just write to them.
5003	2	Float	Temperature Input	External temperature measurement input.	No write control required on these inputs, just write to them.
5005	2	Float	External Input 1	External Input 1.	No write control required on these inputs, just write to them.
5007	2	Float	External Input 2	External Input 2.	No write control required on these inputs, just write to them.
5009	2	Float	External Input 3	External Input 3.	No write control required on these inputs, just write to them.
5501	32	Short	Softing Firmware Rev	Firmware revision of the Softing board.	
5533	32	Short	PD Tag	Fieldbus PD Tag.	
5565	32	Short	Device ID	Fieldbus Device ID.	
5597	1	Short	Node Address	Fieldbus Node Address.	
5598	1	Short	RB Block Mode	Fieldbus Resource Block Mode.	
5599	1	Short	TB Block Mode	Fieldbus Transducer Block Mode.	