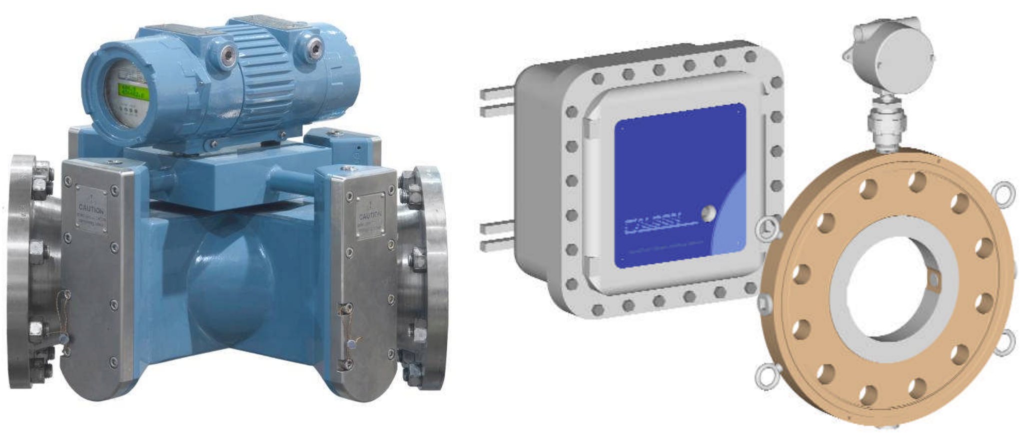
Measurement Systems

CALDON® ULTRASONICS

LEFM® 200 Modbus User Manual

Modbus Register Addresses and Parameters



LEFM200 Series and SoundTrack

Manual No. IB0147 Rev. 08

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Before performing maintenance procedures, system verification procedures, repair procedures, and troubleshooting procedures, personnel should receive general training from Sensia. Contact Sensia's Measurement Systems division for information on training programs.

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1.0 PURPOSE

This manual documents the parameters and Modbus addresses necessary for typical maintenance of the LEFM 200 transmitter. It includes the addresses and locations of typical setup configuration values and output data. It also defines the formats and ranges for these values.

This manual is for use with interfacing the LEFM 200 transmitter with other systems. If a user interface is all that is required, then use the LEFMLink interface program available from Cameron.

The parameters defined include the following:

- Flow scaling and counts factor
- Analog interface parameters
- Modbus and display interface parameters

The transmitter will accept any value in a given field (provided it is the expected format and address, for example floating point or integer and not character). However, there are values that produce illogical inputs. Therefore, this document defines and recommends ranges for all inputs based on engineering analysis.

1.1 Related Documents

The LEFM 200 and SoundTrack transmitters use the Modbus protocol for serial communication:

- Modicon Modbus Protocol Reference Guide (PI-MBUS-300 Rev. C) dated January 1991.

The following documents may also be useful:

- Cameron LEFM280C, LEFM 240C and 220C Installation and Operation Manuals
- SoundTrack Installation and Operation Manual
- Cameron LEFM 210E Installation and Operation Manual

1.2 Intended Audience

The LEFM 200 flowmeters and SoundTrack Interface detectors can be customized following the information provided in this manual. This manual is intended to be used by plant site operators, site engineers, and supervisory personnel. This manual assumes the reader is familiar with the terminology typically used with Modbus.

1.3 Procedure

Note: Always read a register’s value first in order to confirm its current value before it is changed.

1. Identify the Holding Register to be changed.
2. Read the contents of the Holding Register to confirm its as-found value.

3. Send Password to Register 2000. (The password expires after ~5 minutes.) The password is typically controlled by the site manager. If the password cannot be determined, contact Cameron's Measurement System division to determine the as-shipped password.
4. Change the register using Modbus protocol.
5. Activate the Burn and Use Register.

   The transmitter will not start using any of its new fields until the Holding Register Burn and Use (address 170) is activated. When this register is activated (by putting a 1 into the field), all the registers are burned into the transmitter's memory and the device will restart using the latest registers. This must be completed before the password expires!

2.0 Holding Registers - LEFM 240C(i), LEFM 220C(i), LEFM280C(i), and SoundTrack

The following table defines the addresses for the software setup variables used by typical users.

*Other address locations not listed here were used by Cameron to customize each meter for its manufactured dimensions.

Holding Registers are accessed from the 200 Series Electronics with Modbus Function Code 3.

Note: Integer values are limited to ±32767.

2.1 Registers to Save the Setup

Setup Variable Holding Register	Variable Definition	Address*	Notes
Command to use latest entries			
BURN AND USE	Integer	170	Activate new setup values

Save Setup Lockout (Ci Only)

To place the transmitter in lockout mode put switches 1 -6 in the on position.

In Lockout mode – all write commands (FNC16, FNC6) to holding registers and special action holding registers (burn and use) sent via Modbus are blocked. A Modbus error code indicating an illegal address is returned in response. Read commands to holding and input registers (e.g., FNC3, FNC4) are still enabled.

2.2 Registers for Scaling Flow, Flow Units and Pulse Output

Setup Variable Holding Register	Variable Definition	Address*	Notes
MINIMUM FLOW CUTOFF	Float	44	Flow rates below this value (in absolute value) are clamped to 0 (display and pulses) and the flow meter's totalizers do not update.
UNITS CONVERSION (converts default cubic feet to other units)	Float	52	Typically delivered in customer requested units: Typical Units: 0.178095238 converts to barrels 2.8317E-02 converts to cubic meters

Setup Variable Holding Register	**Variable Definition**	**Address***	**Notes**
FLOW RATE TIME UNITS (converts flow rates from per second to other time units)	Float	54	Typically delivered in customer requested units (standard is 3600 for flow per hour other choices are 1 for per second 60 for per minute)
NETORGROSS	Integer	50	0 = GROSS FLOW, Rate & Total 1 = NET FLOW, Rate & Total
Net Reference Temperature	Float	1114	Reference Temperature in Temperature Units used to Calculate Net Flow. Use the units that the system was delivered in (e.g., degF or degC)
Net Reference Pressure	Float	1116	Reference Pressure in Pressure Units used to Calculate Net Flow. Use the units that the system was delivered in. The units maybe one of the following: Kg/cm^2, PSIG, bar, kPa
Kfactor	Float	98	See LEFM 240C/220C Installation, Operation, and Maintenance manual for table of pulses per unit volume. When changing to a non-standard k-factor the desired flow range must produce an output between these values: Minimum Frequency = 3 Hz Maximum Frequency = 10 kHz
Force a Frequency Output	Integer	802	0 = Normal Operation Any other value outputs a pulse output at a frequency equal to the value entered.

Setup Variable Holding Register	Variable Definition	Address*	Notes
Totalizer Wrap-around Value	Float	100	Absolute value at which totalizers wraparound. For example if this register = 1000.0, then the totalizers would wrap around back to 0 after 999.9.

2.3 Reference Temperature and Pressure for Gross to Net Conversions and Fail State References

Setup Variable Holding Register	Variable Definition	Address*	Notes
Use External Temperature	Integer	1118	0 = Use INPUT1 for Fluid Temp 1 = Use INPUT3 for Fluid Temp
Use External Density	Integer	1119	0 = Use LEFM Calculated Density for Gross to Net conversion 1 = Use INPUT4 for Density for Gross to Net conversion
A/I Failure Default Temperature	Float	1120	Temperature used by meter if the Temperature input fails
A/I Failure Default Pressure	Float	1122	Pressure used by meter if the Pressure input fails

2.4 Display Output Screen Format Definitions

Setup Variable Holding Register	Variable Definition	Address*	Notes
FLOW FIELD WIDTH	Integer	776	See Display Notes below (page 16)
FLOW DECIMAL PRECISION	Integer	777	See Display Notes below (page 16)
DEGREES FIELD WIDTH	Integer	778	See Display Notes below (page 16)
DEGREES DECIMAL PRECISION	Integer	779	See Display Notes below (page 16)
TOTALIZER1 FIELD WIDTH	Integer	780	See Display Notes below (page 16)

Setup Variable Holding Register	Variable Definition	Address*	Notes
TOTALIZER 1 DECIMAL PRECISION	Integer	781	See Display Notes below (page 16)
TOTALIZER 2 FIELD WIDTH	Integer	782	See Display Notes below (page 16)
TOTALIZER 2 DECIMAL PRECISION	Integer	783	See Display Notes below (page 16)
FLOWUNITS	Integer	784	See Display Notes below (page 16)
TOTUNITS	Integer	785	See Display Notes below (page 16)

2.5 Modbus Protocol Setups

Setup Variable Holding Register	Variable Definition	Address*	Notes
Modbus Register Update Period	Integer	168	Period (in seconds) that Modbus registers are updated. 240C/220C Note: Value typically set to 5 seconds. Values less than 4 may adversely affect meter operation. SoundTrack Note: Value typically set to 1 second.
Modbus Communications Protocol	Integer	787	Communication Protocol Modbus RTU = 0 (Standard) Modbus ASCII = 1
Modbus Address	Integer	788	Modbus address (default as delivered is MODADDRESS = 1)
Modbus Baud Rate	Unsigned Integer	789	Allows different BAUD rates: Choices 9600 19200 38400

It is noted, that if DIP Switch 2 is ENABLED on startup, the following occur:

Modbus address defaults to “1”

BAUD rate defaults to “9600”

This default state is discontinued if the software is re-started with the DIP Switch 2 set to Disabled (down). Further, if DIP Switch 2 is ENABLED on startup, the software will wait for a setup before it starts to collect data.

2.6 Calculated Viscosity Setups

The LEFM200/SoundTrack calculates the viscosity of the fluid based on the acoustic attenuation and the VOS (sound velocity). The software will calculate a fluid ID for each fluid. There are 10 fluid IDs. Using the fluid ID, the software selects a viscosity curve with which it computes the viscosity. Each of these curves may be given an offset and/or slope in order to optimize the computation of viscosity. This viscosity is only for the customer’s reference or for a fluid property.

Setup Variable Holding Register	**Variable Definition**	**Address***	**Notes**
Fluid No. 1 - Viscosity Offset	Float	826	User offset for calibrating – Viscosity Fluid No. 1
Fluid No. 1 - Viscosity Slope	Float	828	User slope for calibrating – Viscosity Fluid No. 1
Fluid No. 2 - Viscosity Offset	Float	850	User offset for calibrating – Viscosity Fluid No. 2
Fluid No. 2 - Viscosity Slope	Float	852	User slope for calibrating – Viscosity Fluid No. 2
Fluid No. 3 - Viscosity Offset	Float	874	User offset for calibrating – Viscosity Fluid No. 3
Fluid No. 3 - Viscosity Slope	Float	876	User slope for calibrating – Viscosity Fluid No. 3
Fluid No. 4 - Viscosity Offset	Float	898	User offset for calibrating – Viscosity Fluid No. 4
Fluid No. 4 - Viscosity Slope	Float	900	User slope for calibrating – Viscosity Fluid No. 4
Fluid No. 5 - Viscosity Offset	Float	922	User offset for calibrating – Viscosity Fluid No. 5
Fluid No. 5 - Viscosity Slope	Float	924	User slope for calibrating – Viscosity Fluid No. 5
Fluid No. 6 - Viscosity Offset	Float	946	User offset for calibrating – Viscosity Fluid No. 6
Fluid No. 6 - Viscosity Slope	Float	948	User slope for calibrating – Viscosity Fluid No. 6

Setup Variable Holding Register	Variable Definition	Address*	Notes
Fluid No. 7 - Viscosity Offset	Float	970	User offset for calibrating – Viscosity Fluid No. 7
Fluid No. 7 - Viscosity Slope	Float	972	User slope for calibrating – Viscosity Fluid No. 7
Fluid No. 8 - Viscosity Offset	Float	994	User offset for calibrating – Viscosity Fluid No. 8
Fluid No. 8 - Viscosity Slope	Float	996	User slope for calibrating – Viscosity Fluid No. 8
Fluid No. 9 - Viscosity Offset	Float	1018	User offset for calibrating – Viscosity Fluid No. 9
Fluid No. 9 - Viscosity Slope	Float	1020	User slope for calibrating – Viscosity Fluid No. 9
Fluid No. 10 - Viscosity Offset	Float	1042	User offset for calibrating – Viscosity Fluid No. 10
Fluid No. 10 - Viscosity Slope	Float	1044	User slope for calibrating – Viscosity Fluid No. 10

2.7 Calculated Density Setups

The LEFM200/SoundTrack calculates the density of the fluid based on the VOS (sound velocity), temperature and pressure. The software calculates a fluid ID for each fluid using these variables. There are 10 fluid IDs. Using the fluid ID, the software selects a density curve with which it computes the density specific to that fluid. Each of these curves may be given an offset and/or slope in order to optimize the computation. This density is only for the customer's reference or for a fluid property.

Setup Variable Holding Register	Variable Definition	Address*	Notes
Fluid No. 1 - Specific Gravity Offset	Float	286	User offset for calibrating – Specific Gravity Fluid No. 1
Fluid No. 1 - Specific Gravity Slope	Float	288	User slope for calibrating – Specific Gravity Fluid No. 1
Fluid No. 2 - Specific Gravity Offset	Float	340	User offset for calibrating – Specific Gravity Fluid No. 2
Fluid No. 2 - Specific Gravity Slope	Float	342	User slope for calibrating – Specific Gravity Fluid No. 2
Fluid No. 3 - Specific Gravity Offset	Float	394	User offset for calibrating – Specific Gravity Fluid No. 3

Setup Variable Holding Register	**Variable Definition**	**Address***	**Notes**
Fluid No. 3 - Specific Gravity Slope	Float	396	User slope for calibrating – Specific Gravity Fluid No. 3
Fluid No. 4 - Specific Gravity Offset	Float	448	User offset for calibrating – Specific Gravity Fluid No. 4
Fluid No. 4 - Specific Gravity Slope	Float	450	User slope for calibrating – Specific Gravity Fluid No. 4
Fluid No. 5 - Specific Gravity Offset	Float	502	User offset for calibrating – Specific Gravity Fluid No. 5
Fluid No. 5 - Specific Gravity Slope	Float	504	User slope for calibrating – Specific Gravity Fluid No. 5
Fluid No. 6 - Specific Gravity Offset	Float	556	User offset for calibrating – Specific Gravity Fluid No. 6
Fluid No. 6 - Specific Gravity Slope	Float	558	User slope for calibrating – Specific Gravity Fluid No. 6
Fluid No. 7 - Specific Gravity Offset	Float	610	User offset for calibrating – Specific Gravity Fluid No. 7
Fluid No. 7 - Specific Gravity Slope	Float	612	User slope for calibrating – Specific Gravity Fluid No. 7
Fluid No. 8 - Specific Gravity Offset	Float	664	User offset for calibrating – Specific Gravity Fluid No. 8
Fluid No. 8 - Specific Gravity Slope	Float	666	User slope for calibrating – Specific Gravity Fluid No. 8
Fluid No. 9 - Specific Gravity Offset	Float	718	User offset for calibrating – Specific Gravity Fluid No. 9
Fluid No. 9 - Specific Gravity Slope	Float	720	User slope for calibrating – Specific Gravity Fluid No. 9
Fluid No. 10 - Specific Gravity Offset	Float	772	User offset for calibrating – Specific Gravity Fluid No. 10
Fluid No. 10 - Specific Gravity Slope	Float	774	User slope for calibrating – Specific Gravity Fluid No. 10

2.8 Password Entry

Entering the password into Holding Register 2000 enables the user to change any Holding Register's value and to save it (Burn and Use). Once an administrator password has been entered, then the passwords for up to 5 users and the administrator himself can be changed. The 5 non-administrators can change only the analog scaling and the Kfactor (LEFM200C only).

Setup Variable Holding Register	Variable Definition	Address*	Notes
Password Entry	Integer	2000	Enter Password In This Register
USER0	Integer	2001	Set Password For USER0
USER1	Integer	2002	Set Password For USER1
USER2	Integer	2003	Set Password For USER2
USER3	Integer	2004	Set Password For USER3
USER4	Integer	2005	Set Password For USER4
ADMIN5	Integer	2006	Set Password For ADMIN5

2.9 Analog Inputs

The “Units” Holding Register let’s the user select the units for the input interfaces. Typically, the meter only has an input from the meter body RTD. However, other engineering units can be used.

2.9.1 Analog Inputs – Units

Units

The Holding Register (102) scales the units as follows:

1 1 2 1
Temperature (°F=0, °C=1)
Pressure (psig =0, kg/cm2=1, bar=2, kPa=3)
Density (g/cc=0, kg/m^3=1,API=2,lbm/ft^3=3)
Velocity (ft/s - in/s=0, m/s=1)

The analog inputs are slightly different between the 200C electronics and the 200Ci electronics. For clarity, these two products are treated separately.

2.9.2 Analog Inputs – 200C Electronics Only

Each analog input is scaled using four parameters as follows:

Input Scaling - X1, Y1, X2, Y2
X1 and X2 are in volts (Min = 0; this is associated with 0 volts. Max = 5). Note: The 4 – 20 mA input is converted to 0 to 5 volts (as is the RTD input).

Y1 and Y2 are in engineering units. Where:

X1 = Minimum limit voltage
Y1 = Engineering value associated with the minimum voltage
X2 = Maximum limit voltage
Y2 = Engineering value associated with the Maximum voltage

Using the above coefficients, the transmitter does a linear scale:

Analog Input (engineering units) = Y1 +(Analog Input-X1)*(Y2-Y1)/(X2-X1)

For example, for a 100Ω RTD (-100 to 100°C), 0 volts represent -100°C and 5 volts represents 100°C.

		Holding Register Address			
Variable Description	Name	Meter Body Temp Input1	Pressure Input 2	Fluid Temp Input 3*	Density Input 4*
Minimum Voltage for Inputs	X1(j)	104	112	120	128
Minimum Engineering Value at Minimum Voltage	Y1(j)	106	114	122	130
Maximum Voltage for Inputs	X2(j)	108	116	124	132
Maximum Engineering Value at Maximum Voltage	Y2(j)	110	118	126	134

Setup Variable Holding Register	**Variable Definition**	**Address**	**Note**
Meter Body Temp	Float	1170	Use these registers to override the Analog Inputs with values from the Flow Computer or Plant Computer
Fluid Pressure	Float	1172	
Fluid Temperature	Float	1174	
Density	Float	1176	

2.9.3 Analog Inputs – 200Ci Electronics Only

Inputs 3 and 4 are not available on the 220Ci, 240Ci, and 280Ci. Further, Analog input number 1 is the only analog input available to the user. Analog input 2 is dedicated to a 4 wire RTD for the Meter Body Temperature. For Analog input 1, the following table is used to scale the input.

Variable Description – Analog Input Number 1 Only	Name	Holding Register Address
Minimum Voltage for Input	X1	104
Minimum Engineering Value at Minimum Voltage	Y1	106
Maximum Voltage for Input	X2	108
Maximum Engineering Value at Maximum Voltage	Y2	110

Using the above coefficients, the transmitter does a linear scale:

Analog Input (engineering units) = Y1 + (Analog Input-X1)*(Y2-Y1)/(X2-X1)

Since only one analog input is available to the user in the 200Ci electronics, that input can be mapped to any of the possible inputs (e.g., fluid temperature, pressure, or density). Inputs not mapped to analog input 1, are mapped either to a Modbus input or a default value according to the following table:

Setup Variable Holding Register	**Variable Definition**	**Address**	**Comment**
Fluid Pressure	Integer	3325	If set to 1, use Analog input number 1 If set to -1, use Modbus input If set to 0, use default value in setup file
Fluid Temperature	Integer	3326	If set to 1, use Analog input number 1 If set to -1, use Modbus input If set to 0, use meter body temperature
Density	Integer	3327	If set to 1, use Analog input number 1 If set to -1, use Modbus input If set to 0, use LEFM calculated density

The Modbus registers are located as for the 200C electronics in the following registers.

Setup Variable Holding Register	**Variable Definition**	**Address**	**Note**
Fluid Pressure	Float	1172	Use these registers to input with values from the Flow Computer or Plant Computer
Fluid Temperature	Float	1174	
Density	Float	1176	

Finally, the meter body temperature can be scaled (offset and slope) with the following registers.

Variable Description	Name	Holding Register Address (Float)
Temperature Offset -units are same as defined in Section 2.9.1)	Offset	3328
Temperature Slope (degrees/degrees) - units are same as defined in Section 2.9.1)	Slope	3330

2.10 Analog Outputs

The “Units” Holding Register let’s the user select the units for the output interfaces.

2.10.1 Analog Outputs – Units

Units

The Holding Register (102) scales the analog outputs as follows:

1 1 2 1
Temperature (°F=0, °C=1)
Pressure (psig =0, kg/cm2=1, bar=2, kPa=3)
Density (g/cc=0, kg/m^3=1,API=2,lbm/ft^3=3)
Velocity (ft/s - in/s=0, m/s=1)

2.10.2 Analog Outputs – 200C Electronics Only

Output Scaling B1, A1, B2, A2

B1/B2 are in engineering units and A1/A2 are in counts (0 for minimum range, 65535 for maximum range).

Analog Output (counts) = A1 +(analog engineering units-B1)*(A2-A1)/(B2-B1), Default Outputs

Output 1 Flow,

Output 2 VOS (sound velocity),

Output 3 Temperature,

Output 4 Density

The default output units are as follows:

Flow – based on units conversion and time units conversion

VOS (Sound velocity) is units of velocity – in/s or m/s

Temperature is °F or °C

Relative Density in Density Units

The outputs can also be mapped to any Modbus Input Register by putting that register value into AnalogOutputMap register, 1124 to 1127. The units are then the units of that register and the scaling must be adjusted accordingly.

Setup Variable Holding Register	**Variable Definition**	**Address**	**Note**
AnalogOutputMap1	Integer	1124	0 = Use Default Output Values Use Modbus Input Register Value to Output the Value of that Register.
AnalogOutputMap2	Integer	1125	
AnalogOutputMap3	Integer	1126	
AnalogOutputMap4	Integer	1127	

The following table defines addresses for the Analog Output setups. The variables are entered as Floats, however, the counts values are limited to integers. The equation used is as follows:

Analog Output(i) (counts) = B1 +(Output(i)-A1)*(B2-B1)/(A2-A1)

Where:

65535 is full scale (i.e., 20 mA for a 4-20 mA output)

0 is minimum scale (i.e., 4 mA for a 4-20 mA output)

For Ci Units there is only one (1) analog output and the full scale counts are configured at the factory.

		Holding Register Address			
Variable Description	Name	Output1	Output 2	Output 3	Output 4
Minimum Engineering Value	A1(j)	136	144	152	160
Minimum Count Value	B1(j)	138	146	154	162
Maximum Engineering Value	A2(j)	140	148	156	164
Maximum Count Value	B2(j)	142	150	158	166

2.10.3 Analog Outputs – 200Ci Electronics Only

Output Number 1- Scaling B1, A1, B2, A2

B1/B2 are engineering units and A1/A2 are Digital to Analog converter counts (0 for minimum range, 16383 for maximum range).

Analog Output (counts) = A1 + (analog engineering units-B1)*(A2-A1)/(B2-B1),

For Ci Units there is only one (1) analog output and the full scale counts are configured at the factory. Full scale is approximately 16383, but this value is scaled during manufacturing and should not be changed. Likewise, the minimum value is scaled during manufacturing and should not be changed.

Variable Description	Name	Holding Register Address Output1
Minimum Engineering Value	A1 (do not change)	136
Minimum Count Value	B1	138
Maximum Engineering Value	A2 (do not change)	140
Maximum Count Value	B2	142

Default Outputs

Output 1 Flow,

The default output units are as follows:

Flow – based on units conversion and time units conversion

The output can also be mapped to any Modbus <u>Input</u> Register by putting that register value into Analog Output Map register, 1124. The units are the units of the register and the scaling must be adjusted accordingly.

Setup Variable Holding Register	**Variable Definition**	**Address**	**Note**
AnalogOutputMap1	Integer	1124	0 = Use Default Output Values Use Modbus Input Register Value to Output the Value of that Register.

2.11 Display Notes

Display Units
The flow display text is for display text **only –** Units Conversion discussed previously scales the flow. The following choices select the display text:

0 – “” (no text)
1 – “CFS”
2 – “CFM”
3 – “CMS”
4 – “GPM”
5 – “BPH”
6 – “BPD”
7 – “MGD”
8 – “CMH”

The totalizer display text, likewise is for totalizers’ text only, as follows:

0 – “” (no text)
1 – “CF”
2 – “CM”
3 – “GAL”
4 – “BBL”
5 – “AF”
6 – “MGAL”

Setup Variable Holding Register	Variable Definition	Address
FLOW DISPLAY UNITS	INTEGER	784
TOTALIZER DISPLAY UNITS	INTEGER	785

2.12 Meter Data Summary Registers (For 101A639 Rev 07.xx.xx and later)

The following holding registers have “meter data”. These values are read only. Writing to these values will not change their values. These values have been added to the Holding register space in order to support OMNI flow computer communications.

Name	Variable Definition	Address	Units
Board Status	Integer	5000	N/A
Meter State	Unsigned Integer	5001	N/A
Mass Flow	Float	5002	See units
Volume Flow	Float	5004	See units
Temperature	Float	5006	See units
Pressure	Float	5008	See units

Name	Variable Definition	Address	Units
Density	Float	5010	See units
Average Velocity of Sound	Float	5012	See units
Viscosity	Float	5014	cSt
Reynolds Number	Float	5016	N/A
Path 1 Avg Gain	Float	5018	dB
Path 2 Avg Gain	Float	5020	dB
Path 3 Avg Gain	Float	5022	dB
Path 4 Avg Gain	Float	5024	dB
Path 5 Avg Gain	Float	5026	dB
Path 6 Avg Gain	Float	5028	dB
Path 7 Avg Gain	Float	5030	dB
Path 8 Avg Gain	Float	5032	dB
Path 1 Avg SNR	Integer	5034	N/A
Path 2 Avg SNR	Integer	5035	N/A
Path 3 Avg SNR	Integer	5036	N/A
Path 4 Avg SNR	Integer	5037	N/A
Path 5 Avg SNR	Integer	5038	N/A
Path 6 Avg SNR	Integer	5039	N/A
Path 7 Avg SNR	Integer	5040	N/A
Path 8 Avg SNR	Integer	5041	N/A
Path 1 Status	Integer	5042	N/A
Path 2 Status	Integer	5043	N/A
Path 3 Status	Integer	5044	N/A
Path 4 Status	Integer	5045	N/A
Path 5 Status	Integer	5046	N/A
Path 6 Status	Integer	5047	N/A
Path 7 Status	Integer	5048	N/A
Path 8 Status	Integer	5049	N/A

3.0 LEFM 210E (SINGLE PATH EXTERNAL FLOW METERS)

*Other address locations not listed here were used by Cameron to customize each meter for its manufactured dimensions.

Note: Integer values are limited to ±32767.

3.1 Registers to Save the Setup

Setup Variable Holding Register	**Variable Definition**	**Address***	**Notes**
Command to use latest entries			
BURN AND USE	Integer	170	Activate new setup values

3.2 Registers for Scaling Flow, Flow Units and Pulse Output

Setup Variable Holding Register	**Variable Definition**	**Address***	**Notes**
MINIMUM FLOW CUTOFF	Float	44	Flow rates below this value (in absolute value) are clamped to 0 (display and pulses) and the flow meter's totalizers do not update.
UNITS CONVERSION (converts default cubic feet to other units)	Float	52	Typically delivered in customer requested units: Typical Units: 0.178095238 converts to barrels 2.8317E-02 converts to cubic meters
FLOW RATE TIME UNITS (converts flow rates from per second to other time units)	Float	54	Typically delivered in customer requested units (standard is 3600 for flow per hour other choices are 1 for per second 60 for per minute)

Setup Variable Holding Register	**Variable Definition**	**Address***	**Notes**
Kfactor	Float	334	See Installation, Operation, and Maintenance manual for table of pulses per unit volume. When changing to a non-standard k-factor the desired flow range must produce an output between these values: Minimum Frequency = 3 Hz Maximum Frequency = 10 kHz
Force a Frequency Output	Integer	802	0 = Normal Operation Any other value outputs a pulse output at a frequency equal to the value entered.

3.3 Display Output Screen Format Definitions

Setup Variable Holding Register	**Variable Definition**	**Address***	**Notes**
FLOW FIELD WIDTH	Integer	776	See Display Notes below (Section 3.8)
FLOW DECIMAL PRECISION	Integer	777	See Display Notes below (Section 3.8)
FLOWUNITS	Integer	784	See Display Notes below (Section 3.8)

3.4 Modbus Protocol Setups

Setup Variable Holding Register	Variable Definition	Address*	Notes
Modbus Register Update Period	Integer	168	Period (in seconds) that Modbus registers are updated. Note: Value typically set to 5 seconds. Values less than 4 may adversely affect meter operation.
Modbus Communications Protocol	Integer	787	Communication Protocol Modbus RTU = 0 (Standard) Modbus ASCII = 1
Modbus Address	Integer	788	Modbus address (default as delivered is MODADDRESS = 1)
Modbus Baud Rate	Unsigned Integer	789	Allows different BAUD rates: Choices 9600 19200 38400

It is noted, that if DIP Switch 2 is ENABLED on startup, the following occur:

Modbus address defaults to “1”

BAUD rate defaults to “9600”

This default state is discontinued if the software is re-started with the DIP Switch 2 set to Disabled (down). Further, if DIP Switch 2 is ENABLED on startup, the software will wait for a setup before it starts to collect data.

3.5 Analog Inputs

Each analog input is scaled using four parameters as follows:

Input Scaling - X1, Y1, X2, Y2

X1 and X2 are in volts (Min = 0; this is associated with 0 volts. Max = 5). Note: The 4 – 20 mA input is converted to 0 to 5 volts (as is the RTD input).

Y1 and Y2 are in engineering units. Where:

X1 = Minimum limit voltage
Y1 = Engineering value associated with the minimum voltage
X2 = Maximum limit voltage
Y2 = Engineering value associated with the Maximum voltage

Using the above coefficients, the transmitter does a linear scale:

Analog Input (engineering units) = Y1 +(Analog Input-X1)*(Y2-Y1)/(X2-X1)

For example, for a 100Ω RTD (-100 to 100°C), 0 volts represent -100°C and 5 volts represents 100°C.

		Holding Register Address			
Variable Description	Name	Meter Body Temp Input1	Pressure Input 2	N/A Input 3	N/A Input 4
Minimum Voltage for Inputs	X1(j)	104	112	120	128
Minimum Engineering Value at Minimum Voltage	Y1(j)	106	114	122	130
Maximum Voltage for Inputs	X2(j)	108	116	124	132
Maximum Engineering Value at Maximum Voltage	Y2(j)	110	118	126	134

3.6 Analog Outputs

Output Scaling B1, A1, B2, A2
B1/B2 are in engineering units and A1/A2 are in counts (0 for minimum range, 65535 for maximum range).

Analog Output (counts) = A1 +(analog engineering units-B1)*(A2-A1)/(B2-B1),

Default Outputs

Output 1 Flow,

The following table defines addresses for the Analog Output setups. The variables are entered as Floats, however, the counts values are limited to integers. The equation used is as follows:

Analog Output(i) (counts) = B1 +(Output(i)-A1)*(B2-B1)/(A2-A1)

Where:
65535 is full scale (i.e., 20 mA for a 4-20 mA output)

0 is minimum scale (i.e., 4 mA for a 4-20 mA output)

		Holding Register Address			
Variable Description	Name	Output1	Output 2	Output 3	Output 4
Minimum Engineering Value	A1(j)	136	144	152	160
Minimum Count Value	B1(j)	138	146	154	162
Maximum Engineering Value	A2(j)	140	148	156	164
Maximum Count Value	B2(j)	142	150	158	166

3.7 Display Notes

Display Field Width and Decimal Precision
The field width variable defines the displayed field width and the decimal precision variable defines the number of characters to the right of the decimal point. For example, if the field width is 7 and the decimal precision is 4, then the field will look like:

```
XX.XXXX
```

(7 total characters, including the decimal point and 4 to the right of the decimal point).

The width variables are:

Flow field width (776) – Flow display

The decimal variables are:

Flow decimal precision (777) – Flow display

Display Units
The flow display text is for display text **only** – Units Conversion discussed previously scales the flow. The following choices select the display text:

0 – “” (no text)
1 – “CFS”
2 – “CFM”
3 – “CMS”
4 – “GPM”
5 – “BPH”
6 – “BPD”
7 – “MGD”
8 – “CMH”

4.0 DATA OUTPUTS – INPUT REGISTERS

The following table defines the addresses for the Modbus user outputs (for all systems).

Input Registers are accessed from the 200 Series Electronics with Modbus Function Code 4.

4.1 Path Transit and Delta Time Measurements

Transit Time Downstream				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
	Float	0	Nanoseconds	Path 1
	Float	2	Nanoseconds	Path 2
	Float	4	Nanoseconds	Path 3
	Float	6	Nanoseconds	Path 4
	Float	500	Nanoseconds	Path 5
	Float	502	Nanoseconds	Path 6
	Float	504	Nanoseconds	Path 7
	Float	506	Nanoseconds	Path 8

Difference in Time of flight upstream to downstream This term is linear with Velocity and Flow Rate				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
	Float	8	nanoseconds	Path 1
	Float	10	nanoseconds	Path 2
	Float	12	nanoseconds	Path 3
	Float	14	nanoseconds	Path 4
	Float	508	nanoseconds	Path 5
	Float	510	nanoseconds	Path 6
	Float	512	nanoseconds	Path 7
	Float	514	nanoseconds	Path 8

4.2 Acoustic Data Quality

Percent of data collected that is rejected due to signal to noise ratio, cross-correlation tests, or statistics				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
	Integer	16	%	Path 1
	Integer	17	%	Path 2
	Integer	18	%	Path 3
	Integer	19	%	Path 4
	Integer	516	%	Path 5
	Integer	517	%	Path 6
	Integer	518	%	Path 7
	Integer	519	%	Path 8

Measured signal to noise ratio (Average)				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
	Integer	24	N/A	Path 1 Avg
	Integer	25	N/A	Path 2 Avg
	Integer	26	N/A	Path 3 Avg
	Integer	27	N/A	Path 4 Avg
	Integer	524	N/A	Path 5 Avg
	Integer	525	N/A	Path 6 Avg
	Integer	526	N/A	Path 7 Avg
	Integer	527	N/A	Path 8 Avg

Measured signal to noise ratio				
Output Variable Input Register	**Output Variable Input Register**	**Output Variable Input Register**	**Output Variable Input Register**	**Output Variable Input Register**
	Integer	200	N/A	Path 1Up
	Integer	201	N/A	Path 2Up
	Integer	202	N/A	Path 3Up
	Integer	203	N/A	Path 4Up
	Integer	204	N/A	Path 1Dn
	Integer	205	N/A	Path 2Dn
	Integer	206	N/A	Path 3Dn
	Integer	207	N/A	Path 4Dn
	Integer	700	N/A	Path 5Up
	Integer	701	N/A	Path 6Up
	Integer	702	N/A	Path 7Up
	Integer	703	N/A	Path 8Up
	Integer	704	N/A	Path 5Dn
	Integer	705	N/A	Path 6Dn
	Integer	706	N/A	Path 7Dn
	Integer	707	N/A	Path 8Dn

Path Gain Data				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
Path Gain 1 (direct)	Float	212	dB	Average Up & DN
Path Gain 2 (direct)	Float	214	dB	Average Up & DN
Path Gain 3 (direct)	Float	216	dB	Average Up & DN
Path Gain 4 (direct)	Float	218	dB	Average Up & DN
Path Gain 5 (direct)	Float	712	dB	Average Up & DN
Path Gain 6 (direct)	Float	714	dB	Average Up & DN
Path Gain 7 (direct)	Float	716	dB	Average Up & DN
Path Gain 8 (direct)	Float	718	dB	Average Up & DN
Path Gain 1 (echo)	Float	220	dB	Average Up & DN
Path Gain 2 (echo)	Float	222	dB	Average Up & DN
Path Gain 3 (echo)	Float	224	dB	Average Up & DN
Path Gain 4 (echo)	Float	226	dB	Average Up & DN
Path Gain 5 (echo)	Float	720	dB	Average Up & DN
Path Gain 6 (echo)	Float	722	dB	Average Up & DN
Path Gain 7 (echo)	Float	724	dB	Average Up & DN
Path Gain 8 (echo)	Float	726	dB	Average Up & DN

4.3 Flow Data

Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
Flow (200 Series)	Float	38	See HR52 & HR54	
Meter Factor	Float	136	N/A	

Totalizers				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
Totalizer Number 1 (Resettable)	Float	140	See HR52	
Totalizer Number 2 (not Resettable)	Float	142	See HR52	
Totalizer (+)	Float	144	See HR52	
Totalizer (-)	Float	146	See HR52	

4.4 Analog Input Values

Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
Temperature, Body	Float	78		See Holding Register 102 for units
Pressure	Float	80		
Temperature, Fluid	Float	150		
Density, Input	Float	152		

Analog Inputs				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
AnalogInput1	Float	82	Volts	
AnalogInput2	Float	84	Volts	
AnalogInput3	Float	86	Volts	
AnalogInput4	Float	88	Volts	
Analog Input Status	Integer	210	wxyz w = A/I 1 x = A/I 2 y = A/I 3 z = A/I 4	0 = Normal 1 = Fail Low 2 = Fail High

4.5 Setup File Information

Setup File Information				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
Number of times setup has been modified	Integer	149		
CheckSum of setup file	Integer	148		

4.6 Fluid Property Data

Fluid Property Information				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
Density Calculated	Float	90	Metric (x1xx)	
Viscosity	Float	266	cS	
Fluid Acoustic Attenuation	Float	272	dB	Fluid Attenuation
Non-Fluid Attenuation	Float	270	dB	Non-Fluid Correction
Echo Paths Working and used for Viscosity	Integer	268		
ProductID	Integer	92		100 * Density ID + Viscosity ID

Path VOS (Speed of Sound)				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
	Float	40	in/s or m/s	Path 1
	Float	42	in/s or m/s	Path 2
	Float	44	in/s or m/s	Path 3
	Float	46	in/s or m/s	Path 4
	Float	540	in/s or m/s	Path 5
	Float	542	in/s or m/s	Path 6
	Float	544	in/s or m/s	Path 7
	Float	546	in/s or m/s	Path 8
	Float	208	in/s or m/s	Meter Average

4.7 Hydraulic and Velocity Data

Hydraulic Information				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
VNorm1	Float	94	N/A	Path 1
VNorm2	Float	96	N/A	Path 2
VNorm3	Float	98	N/A	Path 3
VNorm4	Float	100	N/A	Path 4
VNorm5	Float	594	N/A	Path 5
VNorm6	Float	596	N/A	Path 6
VNorm7	Float	598	N/A	Path 7
VNorm8	Float	600	N/A	Path 8
Log (Reynolds No)	Float	138	N/A	

Path Fluid Velocity				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
	Float	48	ft/s or m/s	Path 1
	Float	50	ft/s or m/s	Path 2
	Float	52	ft/s or m/s	Path 3
	Float	54	ft/s or m/s	Path 4
	Float	548	ft/s or m/s	Path 5
	Float	550	ft/s or m/s	Path 6
	Float	552	ft/s or m/s	Path 7
	Float	554	ft/s or m/s	Path 8

4.8 Meter and Path Status Data

Status Registers				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
Board Status	Integer	72	0 = Normal, 1 = Needs Setup, 2 = Board Failed Checksum, 3 = No GSS	
Path Status (0 = normal, 1 = path failing due to rejects, 6 = path is failing a speed of sound test)				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
PathStatus1	Integer	74	N/A	Path 1
PathStatus2	Integer	75	N/A	Path 2
PathStatus3	Integer	76	N/A	Path 3
PathStatus4	Integer	77	N/A	Path 4
PathStatus5	Integer	574	N/A	Path 5
PathStatus6	Integer	575	N/A	Path 6
PathStatus7	Integer	576	N/A	Path 7
PathStatus8	Integer	577	N/A	Path 8

4.9 Transducer Impedance Test Data

Transducer Impedance				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
Path 1 Ohm Up +	Float	234	kΩ	
Path 1 Ohm Up -	Float	236	kΩ	
Path 1 Ohm Dn +	Float	238	kΩ	
Path 1 Ohm Dn -	Float	240	kΩ	
Path 2 Ohm Up +	Float	242	kΩ	
Path 2 Ohm Up -	Float	244	kΩ	
Path 2 Ohm Dn +	Float	246	kΩ	
Path 2 Ohm Dn -	Float	248	kΩ	
Path 3 Ohm Up +	Float	250	kΩ	
Path 3 Ohm Up -	Float	252	kΩ	
Path 3 Ohm Dn +	Float	254	kΩ	
Path 3 Ohm Dn -	Float	256	kΩ	
Path 4 Ohm Up +	Float	258	kΩ	
Path 4 Ohm Up -	Float	260	kΩ	
Path 4 Ohm Dn +	Float	262	kΩ	
Path 4 Ohm Dn -	Float	264	kΩ	
Path 5 Ohm Up +	Float	734	kΩ	
Path 5 Ohm Up -	Float	736	kΩ	
Path 5 Ohm Dn +	Float	738	kΩ	
Path 5 Ohm Dn -	Float	740	kΩ	
Path 6 Ohm Up +	Float	742	kΩ	
Path 6 Ohm Up -	Float	744	kΩ	
Path 6 Ohm Dn +	Float	746	kΩ	
Path 6 Ohm Dn -	Float	748	kΩ	
Path 7 Ohm Up +	Float	750	kΩ	
Path 7 Ohm Up -	Float	752	kΩ	
Path 7 Ohm Dn +	Float	754	kΩ	

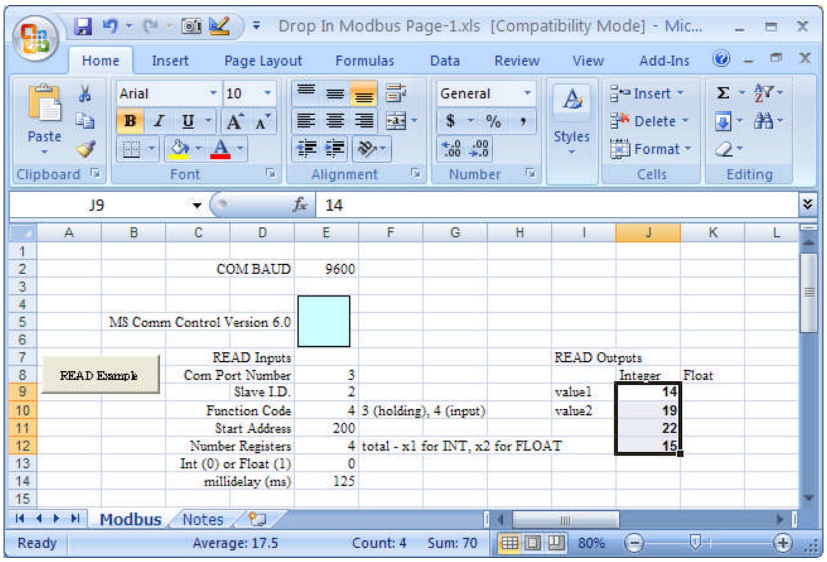
Transducer Impedance				
Output Variable Input Register	**Variable Definition**	**Address**	**Units**	**Notes**
Path 7 Ohm Dn -	Float	756	kΩ	
Path 8 Ohm Up +	Float	758	kΩ	
Path 8 Ohm Up -	Float	760	kΩ	
Path 8 Ohm Dn +	Float	762	kΩ	
Path 8 Ohm Dn -	Float	764	kΩ	

5.0 EXAMPLES

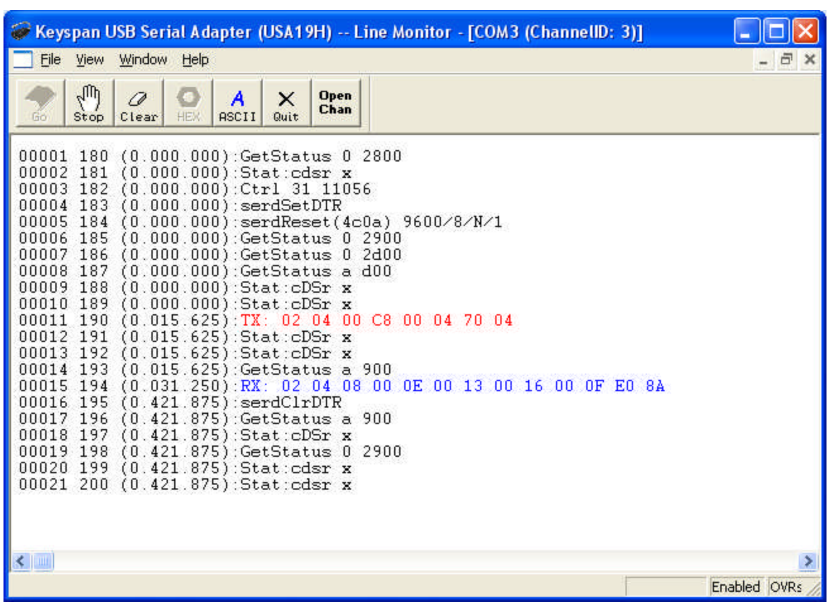
5.1 Polling Integer Input Registers

The following example shows a Modbus data transaction for four Input Register Integers between a Modbus Master and a 200 Series Electronic Unit as Slave ID 2. The Modbus transaction requests Integer type Input Registers for SNR_UP1, SNR_UP2, SNR_UP3, SNR_UP4. These correspond to Input Registers 200, 201, 202, 203. Reported values from the 200 Series Electronics are 14, 19, 22, 15.

Master Polling Device:



Trapped Serial Data:



TX message: 02 04 00 C8 00 04 70 04

02 (hex) = Slave ID 2

04 (hex) = Function Code 4, Input Registers

00 C8 (hex) = 00 (hex) * 256 + C8 (hex) = 0 (dec) * 256 + 200 (dec) = 200 (dec) = Starting Address 200

00 04 (hex) = 00 (hex) * 256 + 04 (hex) = 0 (dec) * 256 + 4 (dec) = 4 (dec) = Request 4 Registers (Words)

70 04 (hex) = CRC16 checksum

Rx message: 02 04 08 00 0E 00 13 00 16 00 0F E0 8A

02 (hex) = Slave ID 2

04 (hex) = Function Code 4, Input Registers, no error code

08 (hex) = 8 bytes to follow

00 0E (hex) = 00 (hex) * 256 + 0E (hex) = 0 (dec) + 14 (dec) = 14; SNR_UP1 (IR 200) = 14

00 13 (hex) = 00 (hex) * 256 + 13 (hex) = 0 (dec) + 19 (dec) = 19; SNR_UP2 (IR 201) = 19

00 16 (hex) = 00 (hex) * 256 + 16 (hex) = 0 (dec) + 22 (dec) = 22; SNR_UP3 (IR 202) = 22

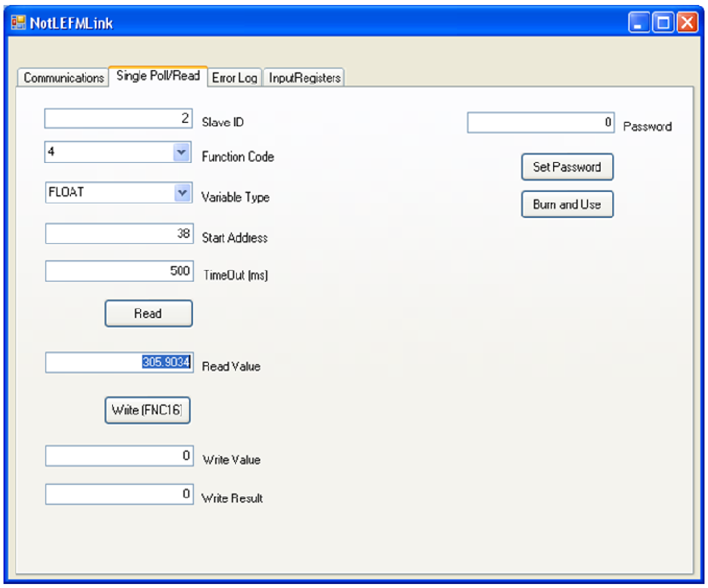
00 0F (hex) = 00 (hex) * 256 + 0F (hex) = 0 (dec) + 15 (dec) = 15; SNR_UP4 (IR 203) = 15

E0 8A (hex) = CRC16 checksum

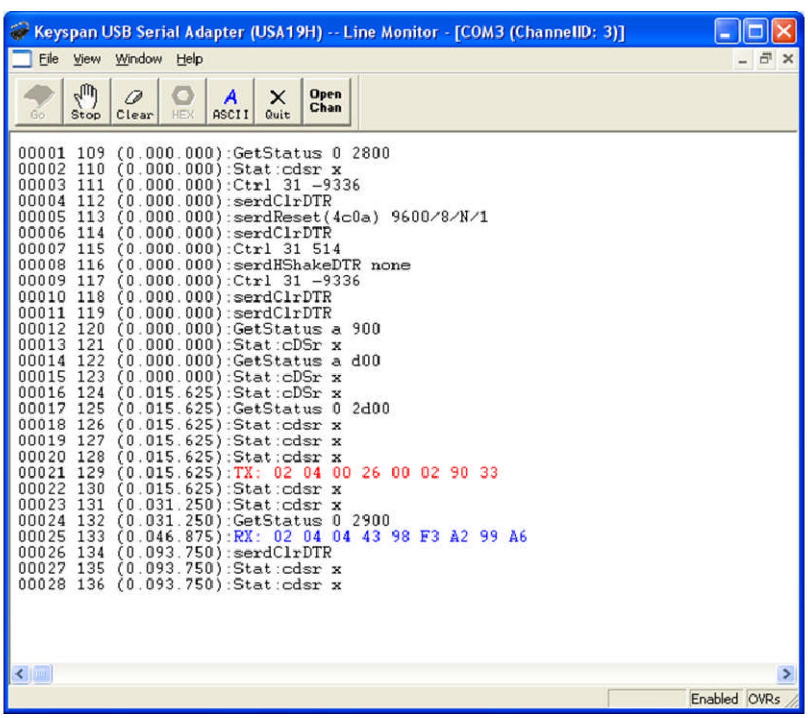
5.2 Polling Floating Point Registers

The following example shows a Modbus data transaction for an Input Register Floating Point value between a Modbus Master and a 200 Series Electronic Unit as Slave ID 2. The Modbus transaction request the Floating Point type Input Register(s) for flow. This corresponds to IR38 (and 39) as a floating point value. The 200 Series Electronics returns a value of 305.9034.

Master Polling Device:



Trapped Serial Data:



TX message: 02 04 00 26 00 02 90 33

02 (hex) = Slave ID 2

04 (hex) = Function Code 4, Input Registers

00 26 (hex) = 00 (hex) * 256 + 25 (hex) = 0 (dec) * 256 + 38 (dec) = 38 (dec) = Starting Address 38

00 02 (hex) = 00 (hex) * 256 + 02 (hex) = 0 (dec) * 256 + 2 (dec) = 2 (dec) = Request 2 Registers/Words

90 33 (hex) = CRC16 checksum

Rx message: 02 04 04 43 98 F3 A2 99 A6

02 (hex) = Slave ID 2

04 (hex) = Function Code 4, Input Registers, no error code

04 (hex) = 4 bytes to follow

43 (hex) = High byte ; 01000011 (bin)

98 (hex) = High-Mid byte; 10011000 (bin)

F3 (hex) = Low-Mid byte; 11110011 (bin)

A2 (hex) = Low byte; 10100010 (bin)

99 A6 (hex) = CRC16 checksum

To Calculate the Floating Point Value:

1. Representation: Word/Register X, Word/Register X+1
Representation: High byte High-Mid byte, Low-Mid byte Low byte

From above: 4398 F3A2 = (hex) 43 98 F3 A2 = (bin) 01000011 10011000 11110011 10100010

2. Separate into sign bit, exponent portion and mantissa. The first (from left to right) bit represents the sign, the next 8 bits represent the exponent, and the remaining 23 bits represent the mantissa.

(bin) **0** <u>1000011 1</u> **0011000 11110011 10100010**

3. Sign bit

The sign bit specifies a negative value for sign bit = 1 and positive value for sign bit = 0

0 = sign bit

4. Exponent portion

The exponent is found by taking the decimal equivalent to the 8 bit exponent portion unbiased (subtract) by 127.

10000111 = exponent portion

Exponent = dec (10000111) –127 = 135 – 127 = 8

5. Mantissa:

0011000 11110011 10100010

The mantissa is deconstructed by summing up the binary to decimal conversions of the right most 7 bits of the high-mid byte scaled by 2^7, the low-mid byte scaled by 2^15, and the low byte scaled by 2^23:

Mantissa = decimal (0011000) / 2^7 + decimal (11110011) / 2^15 + decimal (10100010) / 2^23

Mantissa = 1.875000E-01 + 7.415771E-03 + 1.931190E-05

Mantissa = 1.949351E-01

6. The floating point number can then be constructed by the following:

FLOAT = $(-1)^{\text{sign bit}} \bullet (1 + \text{Mantissa}) \bullet 2^{\text{Exponent}}$

FLOAT = $(-1)^{0} \bullet (1 + 1.949351\text{E-}01) \bullet 2^{8}$

FLOAT = $1 \bullet (1.194935) \bullet 2^{8}$

FLOAT = 305.9034

Sensia LLC
200 Westlake Park Blvd
Houston, TX 77079
+1-866-773-6742
sensiaglobal.com

sensia