GUIDANT

Smith Meter® microLoad.net™

Modbus Communications Manual

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Table of Contents

Proprietary Notice 2

Section I – Introduction 3

Section II – Implementing Remote Host Functionality
- Polling for Status 5
- Monitoring Delivery Data 6
- Host Automation Functions 7
- Transaction, Event, and Audit Log Entry Retrieval 11

Section III – microLoad.net Modbus Register Reference
- Coil Data (Functions 1, 2, 5, 15) 12
- Holding Registers (Functions 3, 6, 16) 13
- Status Registers (Function 4) 17

Appendix – Modbus Communications Primer 22

Related Publications 32

Caution

The default or operating values used in this manual and in the program of the microLoad.net are for factory testing only and should not be construed as default or operating values for your metering system. Each metering system is unique and each program parameter must be reviewed and programmed for that specific metering system application.

Disclaimer

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Introduction

The Modbus protocol was developed by Modicon, Inc. to be a concise method of transferring data to/from programmable logic controllers (PLCs). It has become a de-facto standard in many areas of industrial automation where supervisory control or remote data collection is required. In a Modbus system, a host (master) communicates with one or multiple field devices (slaves). The microLoad.net acts as a slave device only; an external host must act as the master to query or control the microLoad.net. Each microLoad.net must have a unique communication address in the range of 1 to 99. It is recommended that communications ports 2 or 3 on the microLoad.net be used for Modbus communications. Host messages to address 0 (the Modbus broadcast address) are not currently supported (are ignored) by the microLoad.net. For more information regarding Modbus communications specifics, refer to the Modbus Communications primer in the Appendix.

Modbus/TCP

Modbus/TCP is a standard that defines a TCP/IP based version of the Modbus protocol for use over communications links such as Ethernet, etc.

All requests are sent via TCP on registered **port 502**.

Requests are normally sent in half-duplex fashion on a given connection. That is, there is no benefit in sending additional requests on a single connection while a response is outstanding. Devices which wish to obtain high peak transfer rates are instead encouraged to establish multiple TCP connections to the same target, however some existing client devices are known to attempt to 'pipeline' requests. Design techniques which allow a server to accommodate this behavior are described in Appendix A.

The Modbus 'slave address' field is replaced by a single byte 'Unit Identifier' which may be used to communicate via devices such as bridges and gateways which use a single IP address to support multiple independent end units.

The original Modbus protocol request and response are prefixed by six bytes in Modbus/TCP as follows:

byte 0: transaction identifier - copied by server - usually 0
byte 1: transaction identifier - copied by server - usually 0
byte 2: protocol identifier = 0
byte 3: protocol identifier = 0
byte 4: length field (upper byte) = 0 (since all messages are smaller than 256)
byte 5: length field (lower byte) = number of bytes following
byte 6: unit identifier (previously 'slave address')
byte 7: Modbus function code
byte 8 and up: data as needed

So an example transaction 'read 1 register at offset 4 from UI 9' returning a value of 5 would be

request: 00 00 00 00 00 06 09 03 00 04 00 01

response: 00 00 00 00 00 05 09 03 02 00 05

Designers familiar with Modbus should note that the 'CRC-16' or 'LRC' check fields are NOT needed in Modbus/TCP. The TCP/IP and link layer (eg. Ethernet) checksum mechanisms instead are used to verify accurate delivery of the packet.

For detailed specifications on the Modbus protocol refer to the following website: www.modbus.org.

Floating Point Endian Control

Floating-point numbers are not defined in the Modbus specification; there are nearly as many variations of how it is supported as there are vendors.Most often, Modbus registers are combined sequentially to make up an IEEE single precision or double precision floating point number; this is the case in the microLoad.net. Two registers are needed for single precision and four for double precision numbers. There are, however, several ways to map floating point values to Modbus registers. To assure compatibility with off-the-shelf drivers, three popular variations of byte ordering for floating point numbers are supported (see system program code 727).

Communications Control Selections

This program code defines the level of control the associated communications port commands. Poll and Program, and Host Control are valid with host communications options. XON/XOFF is valid with printer options. Selections are as follows:

None – No communications control on this port.

Poll & Program – For use with demonstration/microMate ports. Allows full program access but does not affect transaction control (acts like a standalone unit).

Host Control – Full programming and prompting control. plus transaction control (requiring authorization from host). Allows use of AU or AP (Authorize, Authorize to Preset) or SB (Set Batch) to enter the preset remotely.

Xon/Xoff – For printer ports only. Xon/Xoff flow control.

PTB-FX – For printer ports only. Security level designed to support PTB compliant printers.

PTB-LQ – For printer ports only. Security level designed to support PTB compliant printers.

Critical: Comm port not configured for host communications.

Critical: Comm port not configured for printer.

Note: *No entry if corresponding function = Not Used.*

Help: Select the degree of control for this communications port.

Configuring the microLoad.net for Modbus Communications Via Serial Port

- Press <Enter> at the Ready screen to access the Main Menu
- From the Main Menu, select Program Mode Menu and press <Enter>
- Enter the Access Code when prompted and press <Enter>
- From the Program Mode, select Comm Directory and press <Enter>
- Select Comm Port Config and press <Enter>
- From the Comm Port Config menu, select the desired port
- From the chosen communications port, set up the following items:

  Baud Rate – the rate at which the Modbus device is sending data.

  Data Parity – typical or standard setting is 8/None.

  Control – can be Host Control, but standard is Poll and Program due to access being granted at the microLoad.net to start/stop batches (refer to Comm. Control Settings in previous section).

  Timeout – dependent on Modbus host polling rate and number of slave devices in the loop.

  Mode – dependent on EIA 232/EIA 485 wiring configuration. Must match the master device.

- Return to the Main Menu by pressing the <Clear> key.

Configuring the microLoad.net for Modbus Communications via TCP/IP (Ethernet or SLIP)

- Press <Enter> at the Ready screen to access the Main Menu
- From the Main Menu, select Program Mode Menu and press <Enter>
- Enter the Access Code when prompted and press <Enter>
- From the Program Mode menu, select Comm. Directory and Press <Enter>
- Select Host Interface and press <Enter>
- From the Host interface Menu set the following items:

Host Interface
IP Address: 192.168.0.1
Net mask: 255.255.255.0
Gateway: 192.168.0.10
Ethernet Control: Poll and Program
-->Comm Link: Level 3

- Return to the Main Menu using the <Clear> key

To access Modbus/TCP on microLoad.net – connect to the standard Modbus/TCP port 502 via the Ethernet port or a serial port configured for SLIP.

Implementing Host Status Polling

To implement routine polling loops, the following coils should be periodically read. These coils represent the critical states that a host should monitor.

Coil	State
0	*In Program Mode* – Set when Program mode is accessed, via communications or keypad
1	*Checking Entries* – Active when exiting Program mode, during the validation phase
2	*Program Mode Value Changed*[1] – Active after exiting Program mode when changes made
3	*Power-fail Occurred*[1] – Set on powerup
4	*Printing in Progress* – Set when printing a report (if a port is configured as a Printer)
5	*Card Status* – Set when a card is presented at the reader
6	*Card Valid* – Set when a presented card is found in the microLoad.net card database

Coil	State
256	*microLoad Authorized* – All host requirements have been met to deliver
257	*microLoad Released* – The valve has been commanded to open
258	*Transaction in Progress* – This flag is active from Released until Transaction Done
259	*Batch Done*[1] – Active upon completion of a preset amount
260	*Transaction Done*[1] – Active after Print pressed (or host ends transaction) until cleared by host
261	*Keypad Data Pending* – Active when operator responds to a host prompt via the keypad
262	*Delayed Prompt in Effect* – Active when a delayed prompt is sent by the host
263	*Delayed Message Timeout* – Active when a delayed prompt has timed out (see Prompting)
264	*Alarm Active*[2] – Active when an alarm condition is present
265	*Stop Delay in Effect* – Active when Stop pressed but Delay to Open timer has not yet expired
266	*Injectors Authorized* – Active if the host has overridden the default injector mask
267	*Proving in Progress* – Active when proving
268	*Product Flowing* – Active when the flow rate is nonzero
269	*Permissive Not Met* – Active when the transaction is in progress but a permissive input is de-asserted

1 – These flags are clearable by writing a 0 to the coil using Modbus Function 5 or 15.

2 – Writing a zero to the Alarm Active coil will effectively clear all active alarms (assuming the condition no longer exists).

Implementing Host Run Data Monitoring

During delivery, a host will likely want to monitor the batch progress, including data such as volume, rate, temperature, etc. During delivery, the run data values are accessed primarily via Modbus Function 4 (read status registers).

Single precision I.E.E.E. Floating point values (2 registers each):

0B00 (2816) Load Average Meter Factor
0B02 (2818) Load Average Temperature
0B04 (2820) Load Average Density
0B06 (2822) Load Average Pressure
0B08 (2824) Average CTL
0B0A (2826) Average CPL
0B0C (2828) Preset Amount

Double precision I.E.E.E. Floating point values (4 registers each):

0C00 (3072) Indicated Volume (IV)
0C04 (3076) Gross Volume (GV)
0C08 (3080) Gross @ Std Temp Volume (GST)
0C0C (3084) Gross @ Std Temp & Press (GSV)
0C10 (3088) Mass
0C14 (3092) Remaining Amount
0C18 (3096) Additive 1 Volume
0C1C (3100) Additive 2 Volume
0C20 (3104) Additive 3 Volume
0C24 (3108) Additive 4 Volume Implementing Host Control (Automation) Interface via Modbus

At transaction end, there are two options for data retrieval... one is to read the same data as read during delivery (run data). The other option is to read the transaction log entry for the completed transaction.

Implementing Host Control (Automation) Interface via Modbus

Special Modbus registers for Host Control

Certain registers are 'trigger' registers that invoke a host automation command such as a prompting function or a remote authorization function. These registers are listed here. Note that some of these 'trigger' registers require other registers have valid argument values prior to invoking the command trigger.

Registers that are 'trigger' registers will be designated with the superscript symbol † in the appendix. Registers that act as arguments for a trigger register are in italics.

Host Command Result Status Register

For each write to a trigger register that implements a host command, the result of the operation will be left in the Host Result register (Function 4, register 3594). If the command was executed successfully the value in this register will be 254. Otherwise the value in the register will be set to one of the following error codes indicating the operation was not completed for the reason described below:

01 In Program Mode
02 Released
03 Value Rejected
04 Flow Active
05 No Transaction Ever Done
06 Operation Not Allowed
07 Wrong Control Mode
08 Transaction In Progress
09 Alarm Condition
10 Storage Full
11 Operation out of Sequence
12 Power Failed During Transaction
13 Already Authorized
14 Program Code Not Used
15 Display/Keypad in Remote mode
16 Ticket Not In Printer
17 No Keypad Data Pending
18 No Transaction In Progress
19 Option Not Installed/Enabled
20 Start After Stop Delay in Effect
21 Permissive Not Met
22 Print Request Pending
23 No Meter Enabled
24 Must be In Program Mode
25 Ticket Alarm During Transaction
26 Volume Type Not Available
27 Exactly One Recipe Must Be Enabled
28 Batch Limit Reached
29 Checking Entries
30 Product/Recipe/Additive not Assigned to this Arm
31 Operation Conflicts with Arm Configuration
32 No Key Ever Pressed
33 Active Arm Limit Already Met
34 Transaction Not Standby
35 Swing Arm Out of Position
36 Card-In Required
37 Data Not Available
38 Too Many Shared Additives
39 No Current Batch on This Arm
40 Must Use Minicomputer Protocol For This Operation
91 Communications Buffer Allocation Error
92 Keypad Locked
93 Data Recall Error

94 Not In Program Mode
95 Security Access Not Available
96 Internal Error

Program Mode Interface – Entering Program Mode via Modbus

Entry to Program mode via Modbus is done by simply writing a value to a configuration register in the map (assuming all security requirements are met). Each write to the configuration restarts the auto-logout timer. If three seconds transpire with no additional updates (writes), it is assumed by the microLoad.net that the host has completed the Program Mode session and the changes will be accepted and used (if all were valid). See the Operator Reference manual for detailed descriptions of the various Program Codes available for configuration of the microLoad.net.

Program Mode Interface – Explicit Logout command

Register: 40577 (Function 6/16 – Write Holding Register) – word data

If it is not desired to wait for the three second period to expire, it is possible to force the unit to exit program mode immediately by writing to the above register. If the value 1 is written, the preceding changes will be accepted and used. If the value 2 is written, any changes made will be abandoned and the original values prior to entry into Program mode by the Modbus host will continue to be used.

Note: *this immediate logout functionality is also assumed implicitly when host commands like Allocate Recipes or Set Batch are issued when in Program mode via Modbus.*

Set Time/Date

To set the date and time via Modbus, write the following holding registers (Function 3):

7688 (30344) *Time Set – Year, 4 digit*
7689 (30345) *Time Set - Month*
768A (30346) *Time Set - Day*
768B (30347) *Time Set - Hour*
768C (30348) *Time Set - Minute*
768D (30349) *Time Set - Seconds*
768E (30350)† Time Set (0=MIL,1=AM,2=PM)

Alarm Clearing

Force the Alarm Status coil Off (Write a 0 to coil 264 using Modbus Function 5/15) to clear all active alarms.

Other Host clearable flags (Program Change, Power Fail, Transaction/Batch Done, etc.)

Force the status flag Off (Write a 0 to coil using Modbus Function 5/15) to clear the flag.

Coil #	Status Flag Cleared on Write of 0
2	Program Mode Value Changed
3	Power-fail Occurred
259	Batch Done
260	Transaction Done

Prompting

Performing host prompting requires two separate areas be written for each prompt line – one for the text desired, and one for the additional arguments and trigger register:

Text: Function 16, starting register 38912, from 1 to 21 characters (1 to 11 registers)

9800 (38912) *Wx - Host Prompt Text*

Additional Arguments and Trigger:

9E85 (40581) *Wx - Host Prompt, Line number (1-7)*
9E86 (40582) *Wx - Host Prompt, timeout (0-999)*
9E87 (40583) *Wx - Host Prompt, wait for set key option (0-immediate, 1-wait for Set)*

9E88 (40584) *Wx - Host Prompt, expected response length (0-9, add 40 to allow partial)*
9E89 (40585) *Wx - Host Prompt, security echo option (0-normal echo, 1-echo with 'X's)*
9E8A (40586)† Wx - Display host prompt using specified input option:
0 – No Enter required to initiate ('&' option)
1 – Enter required to initiate ('[' option)
2 – No Enter required to initiate (']' option)
3 – No Enter required to initiate, resets input field only but does not clear the other display lines ('-' option; for re-prompting on input error)

Note: *the communications port Control must be set to Host Control for the Prompting function.*

Retrieving Prompt Response Data

When the 'Keypad Data Pending' status flag is indicated, the prompt response can be read at the following holding register location:

9810 (38928) Host Prompt Response

Set Max Transaction Amount

Write the maximum total amount allowed for the transaction when host authorization of type AU/AP will be issued (i.e. the operator/driver will determine batch sizes):

9F00-9F01 (40704-40705)† TA - Set Transaction Maximum Amount (unsigned long integer)

Range is 0-99,999

Note: *the communications port Control must be set to Host Control for the Set Max Transaction Amount function.*

Allocate Recipes

9F06-9F07 (40710-40711)† AB - Recipe Mask (unsigned long integer)

The value written to this register is determined via a bitmap. Each bit represents a recipe, with the bit value being determined by the formula $2^{(r-1)}$ where r is the recipe number (1-12). Hence, the least significant bit (2^0 or 1) represents Recipe 1.

Value	Representation
1	Recipe 1
2	Recipe 2
3	Recipes 1 and 2
4	Recipe 3
5	Recipes 1 and 3
6	Recipes 2 and 3
7	Recipes 1, 2 and 3
etc...	

Bit#	Bit 31	. . .	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Value			16	8	4	2	1
Recipe	N/A		R5	R4	R3	R2	R1

Example: If recipes 3 and 5 are the only valid recipes for this load, the value to write to this register prior to authorization would be:

$2^{(5-1)} + 2^{(3-1)}$
$= 2^4 + 2^2$
$= 16 + 4$
$= 20$

Range is 0-4095

Note: *the communications port Control must be set to Host Control for the Allocate Blend Recipes function.*

Batch Preset/Authorization Options

Remote batch control and authorization can be controlled via the following registers. Note that not all parameters are used for each command type written to the trigger register.
9F02-9F03 (40706-40707) *Batch Amount for SB/SF (unsigned long integer, 2 registers)*
9F04-9F05 (40708-40709) *Additive Mask for AU/AP/SB/SF (0-15) (unsigned long integer, 2 registers)*

9E82 (40578)† AU/AP/SB/SF - Host Authorize
Write the following value to perform the indicated action:
0 – Authorize; allows transaction to start, preset sequence initiated with 'Set' key
1 – Authorize to Preset; allows transaction, proceeds directly to preset screen
2 – Set Batch; allows batch to start, proceeds directly to preset screen
3 – Set Fixed Batch; allows batch to start, proceeds directly to preset screen, batch size cannot be modified

A 'transaction' is a series of batches by the same operator (e.g. multiple compartments) that are stored by the microLoad.net as a group and printed on a single transaction report. The host may wish to allow multiple batches per transaction (options 1 and 2) if it is not known in advance how many compartments (batches) a particular driver/operator will need to load.

In situations where the host wants full remote control of individual batches, then options 2 and 3 should be used. Note the only difference between options 2 and 3 is that with option 2, the specified batch amount may be modified (to a smaller amount only) by the driver/operator.

Note: *the communications port Control must be set to Host Control for the Host Authorize functions.*

Start/Stop

9E83 (40579)† Host Start/Stop (SA/ST)

Write the following values to this register to perform the indicated action:

0 – Stop; command valve to close and stop flow
1 – Start; command valve to open (after any programmed valve delay)

Terminate Batch/Transaction/Prompt Sequence etc.

9E84 (40580)† Host Terminate Batch/Transaction/Prompt Sequence (EB/ET/DA)

Write the following values to perform the indicated action:

0 - End Batch
1 - End Transaction
2 - End Prompt Sequence

Note: *the communications port Control must be set to Host Control for the Host Authorize functions.*

Read Transaction Log

The transaction data is read from the same Modbus locations for both current and historical transactions. Hence, historical transaction data should only be requested during idle periods. Also, to read current data the Transaction Select register MUST BE SET TO 0. After reading historic transaction log data, be sure to set the host transaction select register back to 0 to be able to read current run data.

To retrieve transaction data:

Write host transaction select register - 0=current, 1 or greater = number back in storage
Function 6, register 40587† (unsigned integer)

Read Modbus host command result to assure the retrieval was successful

Function 4, register 3594 (254 on success, an error code from 1-99 otherwise)

Read the transaction data areas as you would for a current transaction
Example- read transaction header info – end time text, start time text
Function 4, registers 2432-2447 (text)
Function 4, registers 2448-2463 (text)

Example 2 - read unsigned character batch run data – recipe number
Function 4, register 5632 (unsigned integer)

Read Event Log

To read historical events from the event log, the following steps are used. The most recent event log entry's sequence number is available via Function 4, registers 1792-1793 (unsigned long integer).

To read an entry:

- Write desired event's sequence number to request register (Function 16; registers 30464-30465)†
- Read text for event from Event/Audit Log Text registers (Function 4, registers 48-96, Text)

If an error occurs (such as invalid seq #, etc.) the Host Result Register will be set to a value other than 254 indicating the error. On success, the Host Result Register will contain the value 254.

Read Audit Log

Reading from the Audit Log uses the same procedure as reading from the Event Log. Replace the register numbers for the most recent entry and the request with the Audit Log equivalents; the entry itself is read from the same location for both the Event and Audit logs: The most recent Audit Log entry's sequence number can be read via Function 4, registers 1794-1795 (unsigned long integer).

To read an entry:

- Write desired entry sequence number to request register (Function 16; registers 30466-30467)†
- Read text for event from Event/Audit Log Text registers (Function 4, registers 48-96, Text)

If an error occurs (such as invalid seq #, etc.) the Host Result Register will be set to a value other than 254 indicating the error. On success, the Host Result Register will contain the value 254.

Modbus Register Reference

INPUT (STATUS) COILS - Function 2

Dec. Hex. Description

Directory: SYS_RUN_DATA

Data Type: BOOL

Start Address: 0

0 (0000) In Program Mode
1 (0001) Checking Entries
2 (0002) Program Mode Value Changed
3 (0003) Power fail Occurred
4 (0004) Printing in Progress
5 (0005) Card Status
6 (0006) Card Valid
7 (0007) Printer Standby

Directory: TRAN_RUN_DATA

Data Type: BOOL

Start Address: 256

256 (0100) microLoad Authorized
257 (0101) microLoad Released
258 (0102) Transaction in Progress
259 (0103) Batch Done
260 (0104) Transaction Done
261 (0105) Keypad Data Pending
262 (0106) Delayed Prompt in Effect
263 (0107) Delayed Message Timeout Out
264 (0108) Alarm Active
265 (0109) Stop Delay in Effect
266 (010A) Injectors Authorized
267 (010B) Proving in Progress
268 (010C) Product Flowing
269 (010D) Permissive Not Met
270 (010E) Printer Standby Reports Locked
271 (010F) Printer Standby Report Storage Full
272 (0110) BS&W Limit Exceeded
273 (0111) Diverting

Directory: DIG_RUN_DATA

Data Type: BOOL

Start Address: 1536

1536 (0600) Current Digital I/O State

Directory: SYSTEM_ALARMS

Data Type: BOOL

Start Address: 2560

2560 (0A00) DA: ROM Bad
2561 (0A01) DA: RAM Bad
2562 (0A02) DA: Flash Memory Error
2563 (0A03) DA: RAM Corrupt on Power-up
2564 (0A04) DA: Flash Corrupt on Power-up
2565 (0A05) DA: Watchdog Alarm
2566 (0A06) DA: Program Error
2567 (0A07) DA: Passcodes Reset
2568 (0A08) PA: Power fail Alarm
2569 (0A09) U1: User Alarm 1
2570 (0A0A) U2: User Alarm 2
2571 (0A0B) U3: User Alarm 3
2572 (0A0C) U4: User Alarm 4
2573 (0A0D) U5: User Alarm 5
2574 (0A0E) CM: Communications Alarm
2575 (0A0F) TK: Ticket Alarm
2576 (0A10) ZF: Zero Flow Alarm
2577 (0A11) OA: Overrun Alarm
2578 (0A12) CA: Additive Clean Line Alarm
2579 (0A13) PS: Pulse Security Alarm
2580 (0A14) VF: Valve Fault Alarm
2581 (0A15) BP: Back Pressure Alarm
2582 (0A16) TP: Temperature Probe Alarm
2583 (0A17) DR: Density Transducer Failure
2584 (0A18) PR: Pressure Transducer Fail
2585 (0A19) HF: High Flow Alarm
2586 (0A1A) HT: High Temperature Alarm
2587 (0A1B) HD: High Density Alarm
2588 (0A1C) HP: High Pressure Alarm
2589 (0A1D) LF: Low Flow ALarm
2590 (0A1E) LT: Low Temperature Alarm
2591 (0A1F) LD: Low Density Alarm
2592 (0A20) LP: Low Pressure Alarm
2593 (0A21) MF: Mass Meter Comm Fail
2594 (0A22) MO: Mass Meter Overdrive
2595 (0A23) MT: Mass Meter Tube Fail
2596 (0A24) PP: PTB Printer Failure
2597 (0A25) SP: Shared Printer Failure
2598 (0A26) PM: Promass Alarm
2599 (0A27) RP: Report Storage Full
2600 (0A28) NP: Network Printer Alarm
2601 (0A29) SW: BS&W Transducer Fail
2602 (0A2A) DT: Divert Timeout Alarm

Directory: INJECTOR_ALARMS

Data Type: BOOL

Start Address: 3584***

3584 (0E00) AC: Additive Communications
3585 (0E01) CR: Injector Command Rejected
3586 (0E02) FA: Additive Feedback Alarm
3587 (0E03) GA: Additive Injector Error
3588 (0E04) KA: Low Additive Volume
3589 (0E05) MA: Excess Additive Pulses
3590 (0E06) NA: No Additive Pulses Alarm
3591 (0E07) OR: Overspeed Injector
3592 (0E08) RA: Additive Frequency Alarm
3593 (0E09) UA: Add Unauthorize Failed

*** ADD 32 to get to Injector #2, add 64 to get to Injector #3, add 96 to get to Injector #4

OUTPUT COILS - Function 1/5/15

Directory: DIGITAL_CMDS

Data Type: BOOL

Start Address: 4096

4096 (1000) Set Digital Output 1 Value
4097 (1001) Set Digital Output 2 Value
4098 (1002) Set Digital Output 3 Value
4099 (1003) Set Digital Output 4 Value
4100 (1004) Set Digital Output 5 Value
4101 (1005) Set Digital Output 6 Value

Program Configuration, etc. - HOLDING REGISTERS - Function 3,6,16 table:

Dec. Hex. Parameter # and Description

Directory: DIGITAL_DIR

Data Type: UN_CH

Start Address: 3584

3584 (0E00) 201 Input 1 (DC) Function Select
3585 (0E01) 202 Input 2 (DC) Function Select
3586 (0E02) 203 Input 3 (DC) Function Select
3587 (0E03) 301 Output 1 (DC) Function Select
3588 (0E04) 302 Output 2 (DC) Function Select
3589 (0E05) 303 Output 3 (AC) Function Select
3590 (0E06) 304 Output 4 (AC) Function Select
3591 (0E07) 305 Output 5 (AC) Function Select
3592 (0E08) 306 Output 6 (AC) Function Select

Directory: ANALOG_DIR

Data Type: FLOAT

Start Address: 4864

4864 (1300) 402 Analog I/O 1 RTD Offset
4866 (1302) 412 Analog I/O 2 (4-20ma) Low Value
4868 (1304) 413 Analog I/O 2 (4-20ma) High Value

Directory: ANALOG_DIR

Data Type: UN_CH

Start Address: 5632

5632 (1600) 401 RTD Function
5633 (1601) 411 4-20 ma Function

Directory: SYSTEM_DIR

Data Type: TEXT

Start Address: 6144

6144 (1800) 101 Date{O}
6160 (1810) 102 Time{O}
6176 (1820) 112 Flow Rate Descriptor
6192 (1830) 114 Volume Descriptor
6208 (1840) 116 Mass Descriptor
6224 (1850) 691 User Alarm 1 Message
6240 (1860) 692 User Alarm 2 Message
6256 (1870) 693 User Alarm 3 Message
6272 (1880) 694 User Alarm 4 Message
6288 (1890) 695 User Alarm 5 Message
6304 (18A0) 812 Additive Units Descriptor
6320 (18B0) 813 Additive Totals Units

Directory: SYSTEM_DIR

Data Type: FLOAT

Start Address: 6912

6912 (1B00) 102 Pulse Out 1 Pulses/Amount
6914 (1B02) 104 Pulse Out 1 Max Frequency
6916 (1B04) 323 Maximum Preset
6918 (1B06) 324 Minimum Preset
6920 (1B08) 325 Auto Preset
6922 (1B0A) 326 Auto Preset Increment
6924 (1B0C) 402 Reference Temperature
6926 (1B0E) 814 Inject to Totals Convert
6928 (1B10) 822 Add Injector Stop Amount
6930 (1B12) 823 Clean Line Additive

Directory: SYSTEM_DIR

Data Type: UN_CH

Start Address: 7680

7680 (1E00) 101 Pulse Output Function
7681 (1E01) 103 Pulse Output Units
7682 (1E02) 111 Flow Rate Time
7683 (1E03) 113 Volume Units
7684 (1E04) 115 Mass Units
7685 (1E05) 123 Run Display Options
7686 (1E06) 124 Display Resolution
7687 (1E07) 125 Decimal/Comma Select
7688 (1E08) 126 Default/Translated Literals
7689 (1E09) 131 Dynamic Display Timeout
7690 (1E0A) 132 Auto Reset Time
7691 (1E0B) 141 Batches per Transaction
7692 (1E0C) 142 Recipes per Transaction
7693 (1E0D) 143 Start Key Disable
7694 (1E0E) 144 Transaction Termination
7695 (1E0F) 302 Pulse In Type
7696 (1E10) 303 Channel Select
7697 (1E11) 321 Preset Amount Type
7698 (1E12) 322 Delivered Amount Type
7699 (1E13) 331 Auto Prove
7700 (1E14) 332 Proving Counters
7701 (1E15) 401 Temperature Units
7702 (1E16) 411 Density Units
7703 (1E17) 501 Pressure Units
7704 (1E18) 601 Driver Alarm Clearing
7705 (1E19) 602 Powerfail Alarm
7706 (1E1A) 725 Comm Link Programming
7707 (1E1B) 751 Card ID Validation
7708 (1E1C) 752 Card Data Valid Timeout
7709 (1E1D) 811 Add Injector Pacing Units
7710 (1E1E) 821 Add Injector Stop Option
7711 (1E1F) 824 Piston Feedback Errors
7712 (1E20) 825 Piston Stop Action
7713 (1E21) 724 Ethernet Host Control
7714 (1E22) 145 Auto Start
7715 (1E23) 727 Modbus Endian Select
7716 (1E24) 739 User Text Archived
7717 (1E25) 740 Printer Standby
7718 (1E26) 741 Auto Reprint
7719 (1E27) 133 Interval Totals Start Hour

Directory: SYSTEM_DIR

Data Type: UN_LG

Start Address: 7936

7936	(1F00)	721	IP Address
7938	(1F02)	722	Netmask
7940	(1F04)	723	Gateway

Directory: SECURITY_DIR

Data Type: UN_IN

Start Address: 9856

9856	(2680)	161	Level 1 Access Code
9857	(2681)	162	Level 2 Access Code
9858	(2682)	163	Level 3 Access Code
9859	(2683)	164	Level for Security Input
9860	(2684)	165	Level for Diagnostics Dir.

Directory: PROMPT_DIR

Data Type: TEXT

Start Address: 10240

10240	(2800)	764	Prompt 1 Message
10256	(2810)	767	Prompt 2 Message
10272	(2820)	770	Prompt 3 Message
10288	(2830)	773	Prompt 4 Message
10304	(2840)	776	Prompt 5 Message

Directory: PROMPT_DIR
Data Type: UN_CH
Start Address: 11776

11776	(2E00)	761	Prompts Used
11777	(2E01)	762	Prompt Timeout
11778	(2E02)	763	Prompt Validation
11779	(2E03)	765	Prompt 1 Input Type
11780	(2E04)	766	Prompt 1 Length
11781	(2E05)	768	Prompt 2 Input Type
11782	(2E06)	769	Prompt 2 Length
11783	(2E07)	771	Prompt 3 Input Type
11784	(2E08)	772	Prompt 3 Length
11785	(2E09)	774	Prompt 4 Input Type
11786	(2E0A)	775	Prompt 4 Length
11787	(2E0B)	777	Prompt 5 Input Type
11788	(2E0C)	778	Prompt 5 Length

Directory: ALARM_DIR

Data Type: UN_CH

Start Address: 13824

13824	(3600)	611	Communications Alarm
13825	(3601)	612	Ticket Alarm
13826	(3602)	621	High Flow Alarm
13827	(3603)	622	Low Flow Alarm
13828	(3604)	623	Back Pressure Alarm
13829	(3605)	624	Overrun Alarm
13830	(3606)	625	Valve Fault Alarm
13831	(3607)	626	Zero Flow Alarm
13832	(3608)	635	High Temperature Alarm
13833	(3609)	636	Low Temperature Alarm
13834	(360A)	637	Temp Transducer Alarm
13835	(360B)	638	High Density Alarm
13836	(360C)	639	Low Density Alarm
13837	(360D)	640	Density Transducer Alarm
13838	(360E)	641	High Pressure Alarm
13839	(360F)	642	Low Pressure Alarm
13840	(3610)	643	Pres Transducer Alarm
13841	(3611)	651	Pulse Security Alarm
13842	(3612)	652	Mass Mtr Comm Alarm
13843	(3613)	653	Mass Mtr Overdrive Alarm
13844	(3614)	654	Mass Mtr Tube Alarm
13845	(3615)	665	Additive Feedback Error
13846	(3616)	666	Additive Comm Failure
13847	(3617)	667	Low Additive Alarm
13848	(3618)	668	Excess Additive Pulses
13849	(3619)	669	No Additive Pulses Alarm
13850	(361A)	670	Additive Frequency Alarm
13851	(361B)	671	Add Unauthorize Fail
13852	(361C)	672	Add Inj Error
13853	(361D)	673	OverRev Metered Inj
13854	(361E)	674	Injector Command Rejected
13855	(361F)	675	Additive Clean Line
13856	(3620)	613	PTB Printer Failure
13857	(3621)	614	Shared Printer Failure
13858	(3622)	655	Promass Meter Alarm
13859	(3623)	615	Report Storage Full Alarm
13860	(3624)	616	Network Printer Alarm
13861	(3625)	644	BS&W Transducer Alarm
13862	(3626)	627	Divert Timeout Alarm

Directory: USER_ALARM_DIR

Data Type: UN_CH

Start Address: 15872

15872	(3E00)	681	User Alarm 1
15873	(3E01)	682	User Alarm 2
15874	(3E02)	683	User Alarm 3
15875	(3E03)	684	User Alarm 4
15876	(3E04)	685	User Alarm 5

Directory: COMM_PORT_DIR

Data Type: UN_CH

Start Address: 17920

17920	(4600)	701	Comm 1 Function
17921	(4601)	707	Comm 2 Function
17922	(4602)	713	Comm 3 Function
17923	(4603)	702	Comm 1 Baud Rate
17924	(4604)	708	Comm 2 Baud Rate
17925	(4605)	714	Comm 3 Baud Rate
17926	(4606)	703	Comm 1 Data/Parity
17927	(4607)	709	Comm 2 Data/Parity
17928	(4608)	715	Comm 3 Data/Parity
17929	(4609)	704	Comm 1 Control
17930	(460A)	710	Comm 2 Control
17931	(460B)	716	Comm 3 Control
17932	(460C)	706	Comm 1 Mode
17933	(460D)	712	Comm 2 Mode
17934	(460E)	718	Comm 3 Mode

Directory: COMM_PORT_DIR

Data Type: UN_IN

Start Address: 18048

18048 (4680)	705	Comm 1 Timeout
18049 (4681)	711	Comm 2 Timeout
18050 (4682)	717	Comm 3 Timeout
18051 (4683)	726	Ethernet Host Timeout

Directory: INJ_DIR

Data Type: FLOAT

Start Address: 19200

19200 (4B00)	831	Metered Inj K Factor
19202 (4B02)	832	Metered Inj Meter Fac
19204 (4B04)	833	Metered Inj High Tol
19206 (4B06)	834	Metered Inj Low Tol

Directory: INJ_DIR

Data Type: UN_CH

Start Address: 19968

19968 (4E00)	801	Additive Injector 1 Type
19969 (4E01)	802	Additive Injector 2 Type
19970 (4E02)	803	Additive Injector 3 Type
19971 (4E03)	804	Additive Injector 4 Type
19972 (4E04)	835	Metered Inj Max Tol Err

Directory: INJ_DIR

Data Type: UN_IN

Start Address: 20096

20096 (4E80)	841	Add Injector 1 Address
20097 (4E81)	842	Add Injector 2 Address
20098 (4E82)	843	Add Injector 3 Address
20099 (4E83)	844	Add Injector 4 Address

Directory: LOAD_ARM_DIR

Data Type: TEXT

Start Address: 20480

20480 (5000)	121	Position ID
20496 (5010)	122	Ready Message
20512 (5020)	152	Permissive 1 Message
20528 (5030)	155	Permissive 2 Message
20544 (5040)	737	Summary Report Print Time

Directory: LOAD_ARM_DIR

Data Type: FLOAT

Start Address: 21248

21248 (5300)	202	Low Flow Start Rate
21250 (5302)	203	Low Flow Start Amount
21252 (5304)	204	Low Flow Start % of Batch
21254 (5306)	223	Overrun Alarm Limit
21256 (5308)	241	Sample Rate
21258 (530A)	243	BS&W Maint Val
21260 (530C)	244	BS&W Limit

Directory: LOAD_ARM_DIR

Data Type: UN_CH

Start Address: 22016

22016 (5600)	151	Permissive 1 Sense
22017 (5601)	153	Permissive 1 Restart
22018 (5602)	154	Permissive 2 Sense
22019 (5603)	156	Permissive 2 Restart
22020 (5604)	205	Low Flow Start Condition
22021 (5605)	231	Valve Delay to Open
22022 (5606)	233	Pump Delay to Off
22023 (5607)	234	Zero Flow Timer
22024 (5608)	235	Valve Fault Timeout
22025 (5609)	731	Report Select
22026 (560A)	732	Report Total Resolution

Directory: LOAD_ARM_DIR

Data Type: UN_IN

Start Address: 22144

22144 (5680)	232	Start After Stop Delay
22145 (5681)	738	Summary Report Interval
22146 (5682)	242	Sampler Minimum Pulse Width
22147 (5683)	245	Divert Delay
22148 (5684)	246	Divert Minimum Time
22149 (5685)	247	Divert Time at Start
22150 (5686)	248	Divert Maximum Cycle Count
22151 (5687	249	Sale Pump Delay to On

Directory: METER_DIR

Data Type: FLOAT

Start Address: 23296

23296 (5B00)	301	K Factor
23298 (5B02)	306	DP Flow Rate Cutoff
23300 (5B04)	363	SMASS Coefficient Ka
23302 (5B06)	364	SMASS Coefficient Kb
23304 (5B08)	365	SMASS Coefficient Kc

Directory: METER_DIR

Data Type: UN_CH

Start Address: 24064

24064 (5E00)	201	Valve Type
24065 (5E01)	305	Dual Pulse Error Reset
24066 (5E02)	307	Pulse Security Alarm Amount
24067 (5E03)	308	Pulse Period Sample Count
24068 (5E04)	361	Mass Meter Type
24069 (5E05)	367	Mass Meter Pulse Multiplier
24070 (5E06)	368	Mass Meter Low Flow Cutoff
24071 (5E07)	369	Mass Meter Tube Material
24072 (5E08)	370	Mass Meter Model
24073 (5E09)	309	Pulse Multiplier

Directory: METER_DIR

Data Type: UN_IN

Start Address: 24192

24192 (5E80)	304	Dual Pulse Error Count
24193 (5E81)	366	SMASS Density Factor

Directory: METER_DIR

Data Type: UN_LG

Start Address: 24320

24320 (5F00) 362 Mass Meter Sequence Number

Directory: PRODUCT_DIR
Data Type: TEXT
Start Address: 24576

24576 (6000) 733 HM Class Part 1
24592 (6010) 734 HM Class Part 2
24608 (6020) 735 HM Class Part 3
24624 (6030) 736 HM Class Part 4

Directory: PRODUCT_DIR
Data Type: FLOAT
Start Address: 25344

25344 (6300) 206 Minimum Flow Rate
25346 (6302) 207 High Flow Rate
25348 (6304) 208 2nd High Flow Rate
25350 (6306) 209 Flow Tolerance %
25352 (6308) 210 Flow Tolerance Rate
25354 (630A) 211 1st Trip Amount
25356 (630C) 212 2nd Trip Amount
25358 (630E) 221 Excess High Flow Rate
25360 (6310) 222 Low Flow Alarm Limit
25362 (6312) 341 Meter Factor 1
25364 (6314) 342 Flow Rate 1
25366 (6316) 343 Meter Factor 2
25368 (6318) 344 Flow Rate 2
25370 (631A) 345 Meter Factor 3
25372 (631C) 346 Flow Rate 3
25374 (631E) 347 Meter Factor 4
25376 (6320) 348 Flow Rate 4
25378 (6322) 349 Master Meter Factor
25380 (6324) 350 Linear Factor Deviation
25382 (6326) 352 Mtr Factor % Change Per Degree
25384 (6328) 353 Mtr Factor Variation Ref Temp
25386 (632A) 403 Maintenance Temperature
25388 (632C) 404 High Temperature Alarm
25390 (632E) 405 Low Temperature Alarm
25392 (6330) 413 Reference Density
25394 (6332) 414 High Density Alarm
25396 (6334) 415 Low Density Alarm
25398 (6336) 502 Maintenance Pressure
25400 (6338) 503 Pressure Coefficient
25402 (633A) 504 High Pressure Alarm Limit
25404 (633C) 505 Low Pressure Alarm Limit
25406 (633E) 512 BP Percent Reduction
25408 (6340) 513 Min BP Flow Rate
25410 (6342) 515 Differential Pressure
25412 (6344) 516 BP Flow Recovery Pressure
25414 (6346) 522 Vapor Pressure 1
25416 (6348) 523 Vapor Press Temp 1
25418 (634A) 524 Vapor Pressure 2
25420 (634C) 525 Vapor Press Temp 2
25422 (634E) 526 Vapor Pressure 3
25424 (6350) 527 Vapor Press Temp 3

Directory: PRODUCT_DIR
Data Type: UN_CH
Start Address: 26112

26112 (6600) 213 2nd Trip Auto Adjust
26113 (6601) 351 Meter Factor Variation Select
26114 (6602) 412 API Table
26115 (6603) 511 Min BP Flow Timer
26116 (6604) 514 BP Flow Recovery Timer
26117 (6605) 521 Vapor Pressure Calc Method

Directory: RECIPE_DIR
Data Type: TEXT
Start Address: 26624

26624 (6800) 002 Recipe Name

Directory: RECIPE_DIR
Data Type: FLOAT
Start Address: 27392

27392 (6B00) 011 Add Inj 1 Amount/Cycle
27394 (6B02) 013 Add Inj 2 Amount/Cycle
27396 (6B04) 015 Add Inj 3 Amount/Cycle
27398 (6B06) 017 Add Inj 4 Amount/Cycle
27400 (6B08) 012 Add Injector 1 Rate
27402 (6B0A) 014 Add Injector 2 Rate
27404 (6B0C) 016 Add Injector 3 Rate
27406 (6B0E) 018 Add Injector 4 Rate

Directory: RECIPE_DIR
Data Type: UN_CH
Start Address: 28160

28160 (6E00) 001 Recipe Used

Directory: SYSTEM_CMDS
Data Type: UN_CH
Start Address: 30208

30208 (7600) Set User Alarm
30209 (7601) Card Reader Command

Directory: SYSTEM_CMDS
Data Type: UN_IN
Start Address: 30336

30336 (7680) Tenth Second Timer Set
30337 (7681) Tenth Second Timer Set
30338 (7682) One Second Timer Set
30339 (7683) One Second Timer Set
30340 (7684) One Minute Timer Set
30341 (7685) One Minute Timer Set
30342 (7686) One Hour Timer Set
30343 (7687) One Hour Timer Set
30344 (7688) Time Set - Year
30345 (7689) Time Set - Month

30346 (768A) Time Set - Day
30347 (768B) Time Set - Hour
30348 (768C) Time Set - Minute
30349 (768D) Time Set - Seconds
30350 (768E) Time Set - 0=MIL,1=AM,2=PM

Directory: SYSTEM_CMDS
Data Type: UN_LG
Start Address: 30464

30464 (7700) Request Event Log Entry
30466 (7702) Request Audit Log Entry

Directory: ALGEBOOL_DATA
Data Type: FLOAT
Start Address: 33536

33536 (8300) User Float Register

Directory: ALGEBOOL_DATA
Data Type: UN_CH
Start Address: 34304

34304 (8600) User Boolean Register

Directory: ALGEBOOL_DATA
Data Type: UN_IN
Start Address: 34432

34432 (8680) 1/10 Second Timer 1 Value
34433 (8681) 1/10 Second Timer 2 Value
34434 (8682) 1 Second Timer 1 Value
34435 (8683) 1 Second Timer 2 Value
34436 (8684) 1 Minute Timer 1 Value
34437 (8685) 1 Minute Timer 2 Value
34438 (8686) 1 Hour Timer 1 Value
34439 (8687) 1 Hour Timer 2 Value

Directory: ARM_CMDS
Data Type: TEXT
Start Address: 38912

38912 (9800) Wx - Host Prompt Text
38928 (9810) RK - Host Prompt Response
38944 (9820) BR S/BW S - User Text 1
38960 (9830) BR S/BW S - User Text 2
38976 (9840) BR S/BW S - User Text 3
38992 (9850) BR S/BW S - User Text 4
39008 (9860) BR S/BW S - User Text 5
39024 (9870) BR S/BW S - User Text 6
39040 (9880) BR S/BW S - User Text 7
39056 (9890) BR S/BW S - User Text 8

Directory: ARM_CMDS
Data Type: UN_IN
Start Address: 40576

40576 (9E80) PP - Print to Printer
40577 (9E81) LO - Program Mode Logout
40578 (9E82) AU/AP/SB/SF - Host Authorize
40579 (9E83) SA/ST/SP - Host Start/Stop
40580 (9E84) EB/ET/DA - Host Terminate Batch/ Transaction/Prompt Sequence
40581 (9E85) Wx - Host Prompt, Line # argument
40582 (9E86) Wx - Host Prompt, timeout argument
40583 (9E87) Wx - Host Prompt, wait for set key option
40584 (9E88) Wx - Host Prompt, expected response length option
40585 (9E89) Wx - Host Prompt, security echo option
40586 (9E8A) Wx - Display host prompt using specified input option
40587 (9E8B) Archived Transaction Retrieval - Num ber Back (0=current)
40588 (9E8C) Batch index to read (0=current batch)
40589 (9E8D) Recipe Index to Read/Write (1-12)

Directory: ARM_CMDS
Data Type: UN_LG
Start Address: 40704

40704 (9F00) TA - Set Transaction Maximum Amount
40706 (9F02) SB - Set Batch Amount
40708 (9F04) Additive Mask for AU/AP/SB/SF (0-15)
40710 (9F06) AB - Recipe Mask (0-4095)
40712 (9F08) Reserved - future

********Start of Function 4***** - STATUS REGISTERS - Function 4 table:**

Dec. Hex. Description

Directory: SYS_RUN_DATA
Data Type: TEXT
Start Address: 0

0 (0000) Card Data Pt 1
16 (0010) Card Data Pt 2
32 (0020) Time of Last Power Fail
48 (0030) Requested Audit/Event Log Entry Pt 1
64 (0040) Requested Audit/Event Log Entry Pt 2
80 (0050) Requested Audit/Event Log Entry Pt 3

Directory: SYS_RUN_DATA
Data Type: UN_CH
Start Address: 1536

1536 (0600) Current time type (Mil,AM,PM)
1537 (0601) Last Key Pressed

Directory: SYS_RUN_DATA
Data Type: UN_IN
Start Address: 1664

1664 (0680) Current year
1665 (0681) Current month
1666 (0682) Current day
1667 (0683) Current week day
1668 (0684) Current seconds
1669 (0685) Current minutes
1670 (0686) Current hour

Directory: SYS_RUN_DATA
Data Type: UN_LG
Start Address: 1792

1792 (0700) Most Recent Event Sequence Number
1794 (0702) Most Recent Audit Trail Sequence Number

Directory: TRAN_RUN_DATA
Data Type: TEXT
Start Address: 2048

2048 (0800) 1st Alarm in Transaction
2064 (0810) 2nd Alarm in Transaction
2080 (0820) 3rd Alarm in Transaction
2096 (0830) 4th Alarm in Transaction
2112 (0840) 5th Alarm in Transaction
2128 (0850) 6th Alarm in Transaction
2144 (0860) 7th Alarm in Transaction
2160 (0870) 8th Alarm in Transaction
2176 (0880) 9th Alarm in Transaction
2192 (0890) 10th Alarm in Transaction
2208 (08A0) 11th Alarm in Transaction
2224 (08B0) 12th Alarm in Transaction
2240 (08C0) 13th Alarm in Transaction
2256 (08D0) 14th Alarm in Transaction
2272 (08E0) 15th Alarm in Transaction
2288 (08F0) 16th Alarm in Transaction
2304 (0900) 17th Alarm in Transaction
2320 (0910) 18th Alarm in Transaction
2336 (0920) 19th Alarm in Transaction
2352 (0930) 20th Alarm in Transaction
2368 (0940) Reserved
2384 (0950) Transaction Card Data Pt 1
2400 (0960) Transaction Card Data Pt 2
2416 (0970) Transaction Card Data Pt 3
2432 (0980) Transaction End Time
2448 (0990) Transaction Start Time
2464 (09A0) Alphanumeric Prompt Response 1
2480 (09B0) Alphanumeric Prompt Response 2
2496 (09C0) Alphanumeric Prompt Response 3
2512 (09D0) Alphanumeric Prompt Response 4
2528 (09E0) Alphanumeric Prompt Response 5
2544 (09F0) Meter Prove Time
2560 (0A00) Card Field 1
2576 (0A10) Card Field 2
2592 (0A20) Card Field 3
2608 (0A30) Card HID Facility Code
2624 (0A40) Card HID Number
2640 (0A50) User Text 1 (Archived)
2656 (0A60) User Text 2 (Archived)
2672 (0A70) User Text 3 (Archived)
2688 (0A80) User Text 4 (Archived)
2704 (0A90) User Text 5 (Archived)
2720 (0AA0) User Text 6 (Archived)
2736 (0AB0) User Text 7 (Archived)
2752 (0AC0) User Text 8 (Archived)

Directory: TRAN_RUN_DATA
Data Type: FLOAT
Start Address: 2816

2816 (0B00) Load Average Meter Factor
2818 (0B02) Load Average Temperature
2820 (0B04) Load Average Density
2822 (0B06) Load Average Pressure
2824 (0B08) Average CTL
2826 (0B0A) Average CPL
2828 (0B0C) Preset Amount

2830 (0B0E) Prover Coefficient of Expansion
2832 (0B10) Prove New Meter Factor
2834 (0B12) Prove Old Meter Factor
2836 (0B14) Prove Meter Factor Flow Rate
2838 (0B16) Archived User Float Register 46
2840 (0B18) Archived User Float Register 47
2842 (0B1A) Archived User Float Register 48
2844 (0B1C) Archived User Float Register 49
2846 (0B1E) Archived User Float Register 50
2848 (0B20) Load Average BS&W

Directory: TRAN_RUN_DATA
Data Type: DOUBLE
Start Address: 3072

3072 (0C00) Indicated Volume (IV)
3076 (0C04) Gross Volume (GV)
3080 (0C08) Gross @ Std Temp Volume (GST)
3084 (0C0C) Gross @ Std Temp & Press (GSV)
3088 (0C10) Mass
3092 (0C14) Remaining Amount
3096 (0C18) Additive 1 Volume
3100 (0C1C) Additive 2 Volume
3104 (0C20) Additive 3 Volume
3108 (0C24) Additive 4 Volume

Directory: TRAN_RUN_DATA
Data Type: UN_CH
Start Address: 3584

3584 (0E00) ROM Major Version #
3585 (0E01) ROM Minor Version #
3586 (0E02) Batch Status
3587 (0E03) Pump Status
3588 (0E04) Prove Meter Factor #
3589 (0E05) Prove # Batches Used
3590 (0E06) Prove Meter Factor Stored
3591 (0E07) Current Batch Index
3592 (0E08) Current Recipe Index
3593 (0E09) Batch Presetting in Progress
3594 (0E0A) Result of last Host Command
3595 (0E0B) Archived User Boolean Register 46
3596 (0E0C) Archived User Boolean Register 47
3597 (0E0D) Archived User Boolean Register 48
3598 (0E0E) Archived User Boolean Register 49
3599 (0E0F) Archived User Boolean Register 50

Directory: TRAN_RUN_DATA
Data Type: UN_IN
Start Address: 3712

3712 (0E80) Transaction Number
3713 (0E81) Total Number of Batches
3714 (0E82) Transaction start year
3715 (0E83) Transaction start month
3716 (0E84) Transaction start day
3717 (0E85) Transaction start week day
3718 (0E86) Transaction start seconds
3719 (0E87) Transaction start minutes
3720 (0E88) Transaction start hour
3721 (0E89) Transaction end year
3722 (0E8A) Transaction end month
3723 (0E8B) Transaction end day
3724 (0E8C) Transaction end week day
3725 (0E8D) Transaction end seconds
3726 (0E8E) Transaction end minutes
3727 (0E8F) Transaction end hour

Directory: TRAN_RUN_DATA
Data Type: UN_LG
Start Address: 3840

3840 (0F00) ROM CRC
3842 (0F02) Prompt Response Data 1
3844 (0F04) Prompt Response Data 2
3846 (0F06) Prompt Response Data 3
3848 (0F08) Prompt Response Data 4
3850 (0F0A) Prompt Response Data 5
3852 (0F0C) Current Prompt Response Data 1
3854 (0F0E) Current Prompt Response Data 2
3856 (0F10) Current Prompt Response Data 3
3858 (0F12) Current Prompt Response Data 4
3860 (0F14) Current Prompt Response Data 5

Directory: BATCH_RUN_DATA
Data Type: TEXT
Start Address: 4096

4096 (1000) 1st Alarm in Batch
4112 (1010) 2nd Alarm in Batch
4128 (1020) 3rd Alarm in Batch
4144 (1030) 4th Alarm in Batch
4160 (1040) 5th Alarm in Batch
4176 (1050) 6th Alarm in Batch
4192 (1060) 7th Alarm in Batch
4208 (1070) 8th Alarm in Batch
4224 (1080) 9th Alarm in Batch
4240 (1090) 10th Alarm in Batch

Directory: BATCH_RUN_DATA
Data Type: FLOAT
Start Address: 4864

4864 (1300) Average Flow Rate
4866 (1302) Load Average Meter Factor
4868 (1304) Load Average Temperature
4870 (1306) Load Average Density
4872 (1308) Load Average Pressure
4874 (130A) Average CTL
4876 (130C) Average CPL
4878 (130E) Average CCF
4880 (1310) Average Reference Density
4882 (1312) Average Relative Density
4884 (1314) Average API @ Ref Temp
4886 (1316) Average Vapor Pressure
4888 (1318) Prover CTSP

4890 (131A) Prover CTLP
4892 (131C) Prove CTLM
4894 (131E) Prover IV
4896 (1320) Prove Meter IV
4898 (1322) Prover Temperature
4900 (1324) Prove Meter Temperature
4902 (1326) Prove New Meter Factor
4904 (1328) Prove Average Flow Rate
4906 (132A) Prove Average Density
4908 (132C) Average CTPL
4910 (132E) Avg Rel Dens@60F &Prs (E Tables CPL Only)
4912 (1330) Avg Reference Density @ Ref Dens Temp
4914 (1332) Avg General Purpose Analog
4916 (1334) Average BS&W

Directory: BATCH_RUN_DATA
Data Type: DOUBLE
Start Address: 5120

5120 (1400) Total Pulses
5124 (1404) Indicated Volume (IV)
5128 (1408) Gross Volume (GV)
5132 (140C) Gross Volume @ Std Temp (GST)
5136 (1410) Gross @ Std Temp & Press (GSV)
5140 (1414) Mass Total
5144 (1418) Additive 1 Volume
5148 (141C) Additive 2 Volume
5152 (1420) Additive 3 Volume
5156 (1424) Additive 4 Volume

Directory: BATCH_RUN_DATA
Data Type: UN_CH
Start Address: 5632

5632 (1600) Recipe Number
5633 (1601) Batch #
5634 (1602) Prove Batch Accepted

Directory: BATCH_RUN_DATA
Data Type: UN_LG
Start Address: 5888

5888 (1700) Additive Mask

Directory: PRD_RUN_DATA
Data Type: FLOAT
Start Address: 6912

6912 (1B00) Current Product Flow Rate
6914 (1B02) Current Product Flow Rate Per Hour
6916 (1B04) Current Product Flow Rate Per Min
6918 (1B06) Current Product Meter Factor
6920 (1B08) Current Product Temperature
6922 (1B0A) Current Product Density
6924 (1B0C) Current Product Pressure
6926 (1B0E) Current Product Vapor Pressure
6928 (1B10) Current Product BS&W

Directory: PRD_RUN_DATA
Data Type: DOUBLE
Start Address: 7168

7168 (1C00) Prd Indicated Non-resettable Volume
7172 (1C04) Prd Gross Non-resettable Volume
7176 (1C08) Prd GST Non-resettable Volume
7180 (1C0C) Prd GSV Non-resettable Volume
7184 (1C10) Prd Mass Non-resettable Total

Directory: PRD_RUN_DATA
Data Type: UN_LG
Start Address: 7936

7936 (1F00) Product Current Pulse Count

Directory: INJ_RUN_DATA
Data Type: FLOAT
Start Address: 11008

11008 (2B00) Current Injector 1 Rate
11010 (2B02) Current Injector 2 Rate
11012 (2B04) Current Injector 3 Rate
11014 (2B06) Current Injector 4 Rate
11016 (2B08) Current Add 1 Amount/Injection
11018 (2B0A) Current Add 2 Amount/Injection
11020 (2B0C) Current Add 3 Amount/Injection
11022 (2B0E) Current Add 4 Amount/Injection

Directory: INJ_RUN_DATA
Data Type: DOUBLE
Start Address: 11264

11264 (2C00) Additive 1 Non-resettable Total
11268 (2C04) Additive 2 Non-resettable Total
11272 (2C08) Additive 3 Non-resettable Total
11276 (2C0C) Additive 4 Non-resettable Total

Directory: INJ_RUN_DATA
Data Type: UN_CH
Start Address: 11776

11776 (2E00) Injector 1 Selected
11777 (2E01) Injector 2 Selected
11778 (2E02) Injector 3 Selected
11779 (2E03) Injector 4 Selected

Directory: INJ_RUN_DATA
Data Type: UN_IN
Start Address: 11904

11904 (2E80) Inj 1 Current # of Injections, batch
11905 (2E81) Inj 2 Current # of Injections, batch
11906 (2E82) Inj 3 Current # of Injections, batch

11907 (2E83) Inj 4 Current # of Injections, batch
11908 (2E84) Inj 1 Current Feedback Errors
11909 (2E85) Inj 2 Current Feedback Errors
11910 (2E86) Inj 3 Current Feedback Errors

Directory: ANA_RUN_DATA

Data Type: FLOAT

Start Address: 15104

15104 (3B00) Analog I/O #1 Analog Counts
15106 (3B02) Analog I/O #1 Analog Raw Value (mA or volts)
15108 (3B04) Analog I/O #1 Analog Engineering Value
15136 (3B20) Analog I/O #2 Analog Counts
15138 (3B22) Analog I/O #2 Analog Raw Value (mA or volts)
15140 (3B24) Analog I/O #2 Analog Engineering Value

Directory: RECIPE_RUN_DATA

Data Type: DOUBLE

Start Address: 17408

17408 (4400) Recipe Indicated Non-resettable Volume
17412 (4404) Recipe Gross Non-resettable Volume
17416 (4408) Recipe GST Non-resettable Volume
17420 (440C) Recipe GSV Non-resettable Volume
17424 (4410) Recipe Mass Non-resettable Total

Directory: METER_RUN_DATA

Data Type: Double

Start Address: 19456

19456 (4C00) Current Hourly GV Delta Value
19460 (4C04) Current Hourly GSV Delta Value
19464 (4C08) Current Daily GV Delta Value
19468 (4C0C) Current Daily GSV Delta Value
19472 (4C10) Current Weekly GV Delta Value
19476 (4C14) Current Weekly GSV Delta Value
19480 (4C18) Current Monthly GV Delta Value
19484 (4C1C) Current Monthly GSV Delta Value
19488 (4C20) Previous Hourly GV Delta Value
19492 (4C24) Previous Hourly GSV Delta Value
19496 (4C28) Previous Daily GV Delta Value
19500 (4C2C) Previous Daily GSV Delta Value
19504 (4C30) Previous Weekly GV Delta Value
19508 (4C34) Previous Weekly GSV Delta Value
19512 (4C38) Previous Monthly GV Delta Value
19516 (4C3C) Previous Monthly GSV Delta Value

Directory: METER_RUN_DATA

Data Type: UN_CH

Start Address: 19968

19968 (4E00)

Modbus Communications Primer

The microLoad.net Modbus interface is designed to conform to a subset of the "Modicon Modbus Protocol Reference Guide" PI-MBUS-300 Rev. D (Modicon, Inc., Industrial Automation Systems). Modbus can be implemented on various transmission mediums (such as RS-232 or RS-485 communication ports). Transmission of data is serial and asynchronous. It is recommended that communications ports 2 or 3 on the microLoad.net be used for Modbus communications.

The Host Message: The host transmits a message on the communications line that represents a specific query or command. The address specifies which slave device is to act on the message. The function in the query tells the addressed slave device what kind of action to perform. The register word specifies what particular internal state/value of the slave is of interest to the host. The data bytes contain any additional information that the slave will need to perform the function. For example, function code 03 will query the slave to read holding registers and respond with their contents. The register field must contain information telling the slave which register(s) to read and the data field specifies how many registers to read. The error check or CRC (cyclical redundancy check) field enables the slave to validate the integrity of the message contents.

The Response: If the slave makes a normal response, the function byte in the response is an echo of the function in the query. The data bytes contain the data collected by the slave, such as register values or status. If an error occurs, the function code is modified to indicate that the response is an error response, and the data bytes contain a code that describes the error. The error check field allows the master to confirm that the message contents are valid.

RTU Framing

Every Modbus message begins with a silent interval of at least 3.5 character times. Multiply the character times by the current network baud rate to determine the length of the silent interval (see T1-T2-T3-T4 in the figure below). Next, the microLoad.net address field is transmitted.

Characters for all fields are transmitted as binary bytes. In this manual, characters are represented by hexadecimal 0-9, A-F. All networked devices constantly monitor the network bus. This monitoring occurs even during silent intervals. As each microLoad.net receives the first field (the address field), it decodes it to determine if it is the microLoad.net being addressed.

A second silent interval of at least 3.5 character times follows the last transmitted character of each message, after which a new message can begin. The new message must be transmitted as a continuous stream, with no silent interval in excess of 3.5 character times. If an excessively long silent interval occurs before completion of the frame, the receiving microLoad.net will disregard the entire incomplete message and wait for the address field of the next new message.

If a silent interval is less than 3.5 character times, the receiving microLoad.net will be unable to recognize it as the start of a new message and will attempt to read it as a part of the prior message. These combined messages will result in an invalid value in the final CRC field, and an error will result. A typical message frame is shown below.

3.5 char. time delay	ADDRESS	FUNCTION	REGISTER	DATA	CRC	3.5 char. time delay
	1 byte	1 byte	2 bytes	n bytes	2 bytes	

The starting 3.5 character time ending delay for one message may be the same actual delay as the starting 3.5 character time for the next message (there is no need for the master to delay twice between messages as long as the duration exceeds the specified delay).

How Characters are Transmitted Serially

When messages are transmitted on standard Modbus serial networks, each character or byte is sent in this order (left to right):

With Parity Checking (8 bit word, 1 stop)

Start	1	2	3	4	5	6	7	8	Par	Stop

Without Parity Checking (8 bit word, 2 stop)

Start	1	2	3	4	5	6	7	8	Stop	Stop

Data Addresses in Modbus Messages

All data addresses in Modbus messages are referenced to zero; the first occurrence of a data item is addressed as item number zero.

Modbus Functions

The following Modbus functions have been implemented in the microLoad.net.

Code	Function	Description
01	Read Relay Status	Reads the binary data from the (read/write) set of variables.
02	Read Input Status	Reads the binary data from the "inputs" (read only) set of variables.
03	Read Integer Registers (Read/Write Register Set)	Retrieves the current data from the requested registers.
04	Read Integer Registers (Read Only Register Set)	Retrieves the current data from the requested registers.
05	Force Single Relay	Changes the state of a binary (read/write).
06	Write (Preset) Single Register	Places a specific value into a (read/write) register.
08	Loop Back Diagnostic Text	Diagnostic test message sent to the microLoad.net to evaluate communications processing. ***Note:*** *Only the return Query Data diagnostic code is supported.*
15	Force Multiple Relays	Changes the state of multiple binary (read/write).
16	Write (Preset) Multiple Registers	Places specific values into a series of consecutive (read/write) registers.

Master/Slave Communications

The master communicates with the microLoad.net by sending messages containing function codes. Function codes indicate the actions the microLoad.net is to perform.

The microLoad.net's response to the master uses the function code field to report on the status of the task it was assigned. The two possible reports are (1) a normal, error-free response or (2) an exception response, indicating an error. A normal response repeats the original function code. An exception response returns a code that corresponds to the original function code, with its most significant bit set to a logic 1.

For example, a master directs an microLoad.net to read a group of holding registers by sending the following function code:

0000 0011 (Hexadecimal 03)

If the microLoad.net completes the action without error, its response echoes the original command. If an error occurs, the microLoad.net returns the following message:

1000 0011 (Hexadecimal 83)

The microLoad.net augments its exception response by adding a code in the data field that indicates what type of error occurred. The exception response is handled according to the parameters of the application program controlling the master device.

For example, if the relay address is absent in the microLoad.net device, the microLoad.net will return the exception response with the exception code shown (02). This response indicates an invalid data address for the microLoad.net.

A listing of the exception codes appears below.

Code	Name	Meaning
01	Illegal Function	The function code received in the query is not an allowable action for the slave. If a Poll Program Complete command was issued, this code indicates that no program function preceded it.
02	Illegal Data Address	The data address received in the query is not an allowable value for the microLoad.net.
03	Illegal Data Value	A value contained in the query data field is not an allowable value for the microLoad.net.
04	Command Error	An unrecoverable error occurred while the microLoad.net was attempting to perform the requested action.

Contents of the Data Field

The data field consists of sets of two hexadecimal digits, in the range of 00 to FF hexadecimal.

The microLoad.net reads the data field sent by the master to perform the actions indicated by the function code. The data field contains information such as discrete and register addresses, the number of items to be handled, and the count of actual data bytes in the field.

If, for example, the master directs an microLoad.net to read a group of holding registers (function code 03), the data field sent by the master must also indicate the starting register and the number of registers to be read. If the master writes to a group of registers in the slave (function code 10 hexadecimal), the data field sent by the master must also indicate the starting register, the number of registers to be written, the count of data bytes to follow in the data field, and the data to be written into the registers.

Assuming that no error in communication interferes, the data field of a response from a slave to a master contains the requested data. If an error does occur, the field contains an exception code that the application controlling the master can use to determine the next action to be taken.

Beginning Register

This register identifies the beginning register from which the master is requesting information. This two byte field lists the most significant digit first and the least significant digit last.

Number of Requested Registers

This field identifies the number of consecutive registers from which the master is requesting information. This two byte field lists the most significant digit first and the least significant digit last. The response is limited to 250 bytes of information.

Error Check (CRC16)

This field allows the microLoad.net and the supervisory system to check for errors in the transmission of commands and responses. Electrical noise or other interference may cause changes in transmitted data. The capacity to check for errors prevents the receiving device from responding to a message that has changed.

Error checking in RTU mode is built on the Cyclical Redundancy Check (CRC) method. The entire message is subject to scrutiny by the CRC field, and the CRC is applied regardless of any other parity check method that might be in effect.

The CRC consists of a two byte field containing a 16-bit binary value. The transmitting device calculates the CRC value and adds the CRC to the message. The receiving device then recalculates the CRC when the message is received, and compares the first value with the second. An error results when the two message values are unequal.

The CRC is initiated by pre-loading a 16-bit register to all 1's. Successive 8-bit bytes of the message are then applied to the current contents of the register. The CRC is generated only by the eight bits of data in each character. Start and stop bits, and the parity bit if one is used, are not taken into account.

When the CRC is generated, each 8-bit character is exclusive ORed with the register contents. The result is then shifted toward the least significant bit (LSB), and a zero added to the most significant bit (MSB) position. The LSB is extracted and examined. Assuming the LSB was a 1, the register is then exclusive ORed with a preset, fixed value. If the LSB was a 0, there will be no exclusive OR.

The process consists of eight shifts. After the eighth and final shift, the next 8-bit byte is exclusive ORed with the register's current value. The process is then repeated for an additional eight shifts. The final content of the register, after all the bytes of the message have been applied, is the CRC value.

Placing the CRC into the Message

When the 16-bit CRC (2 8-bit bytes) is transmitted in the message, the low-order byte will be transmitted first, followed by the high-order byte. For example, if the CRC value is 1241 hex (0001 0010 0100 0001):

Addr	Func	Data Count	Data	Data	Data	Data	CRC Lo	CRC Hi
							41	12

Field Contents in Modbus Messages

Examples of a Modbus query message and normal response are shown in the tables on the following page. The field contents in both examples are displayed in hexadecimal.

In this example, the master sends a Read Holding Registers request to microLoad.net address 06. The microLoad.net is specifically directed to return data from three holding registers, starting with address 0107 (006B hex).

As is the case in any normal response, the microLoad.net first echoes the function code sent by the master. The microLoad.net then transmits the byte count field, indicating the number of 8-bit data items being returned. Finally, the microLoad.net returns the 8-bit bytes containing the requested data.

How to Use the Byte Count Field: When constructing responses in buffers, use a byte count value that equals the count of 8-bit bytes in the message data. The value is exclusive of all other field contents, including the byte count field. The microLoad.net response example illustrates a typical byte count field in a normal response.

Master Query		
Field Name	Example (Hex)	RTU 8-Bit Field
Header		None
microLoad.net Address	06	0000 0110
Function	03	0000 0011
Starting Address Hi	00	0000 0000
Starting Address Lo	6B	0110 1011
No. of Registers Hi	00	0000 0000
No. of Registers Lo	03	0000 0011
Error Check		CRC (16 bits)
	Total Bytes:	8

microLoad.net Response		
Field Name	Example (Hex)	RTU 8-Bit Field
Header		None
microLoad.net Address	06	0000 0110
Function	03	0000 0011
Byte Count	06	0000 0110
Data Hi	02	0000 0010
Data Lo	2B	0010 1011
Data Hi	00	0000 0000
Data Lo	00	0000 0000
Data Hi	00	0000 0000
Data Lo	63	0110 0011
Error Check		CRC (16 bits)
	Total Bytes:	11

The microLoad.net monitors the amount of time between the receipt of characters. If three and one-half character times elapse without the microLoad.net seeing a new character or the end of a frame, the message is flushed and the next characters received will be viewed as an address. If the address is for that microLoad.net, it will respond. If the address is not for that microLoad.net, the message will be flushed and it will look for the next message.

Address

The address is the first field in the frame and consists of one byte (eight bits) of information. The address is the unique identification of the microLoad.net (slave) that is to receive the message that is sent via the supervisory system (master). Each microLoad.net address must be unique so that only the addressed slave will respond to a query. The address is also part of the response message sent back to the master from the microLoad.net when data is requested. By returning the address as part of the response, the master can tell which of the microLoad.nets the data is coming from.

Query Responses

The first two fields of the response to the read only message are identical to the command. The microLoad.net returns the address and the function code that was transmitted to the unit. The next field is the byte count.

Byte Count

The byte count is sent to the master (supervisory system) indicating how much data is being sent from the microLoad.net. In the example shown, the command requested data from these registers and each register contains two bytes of data.

Data Register

Each of the data registers of unsigned characters contains two bytes of data. The response message returns the data with the most significant byte of data first and the least significant byte second. Data can be requested and returned from a number of registers with a single interrogation message. The limit on the amount of data returned from the microLoad.net to the master is 256 bytes. The data lengths for the data types currently used by the microLoad.net are as follows:

Data Length	
Type	Binary
Double	8 bytes
Integer	2 bytes
Long Integer	4 bytes
Text String	variable length
Character	2 bytes (high order byte set to zero)
CRC-16	2 bytes
Float	4 bytes
Unsigned Integer	2 bytes
Unsigned Long	4 bytes
Unsigned Character	2 bytes (high order byte set to zero)

The error checking sequence is the same as described in the paragraph under Read Only Message.

01 Read Relay Status

Description

Reads the ON/OFF status of discrete variables in the microLoad.net. The maximum number of "coils" per response is 256 in the microLoad.net.

Query

The query message specifies the starting register and quantity of registers to be read.

There are now no variables to read from this group.

If there were, this is an example of a request to read variables 20 through 56 from microLoad.net device 17:

Query	
Field Name	Example (Hex)
microLoad.net Address	0x11
Function	0x01
Starting Address Hi	0x00
Starting Address Lo	0x13
No. of Points Hi	0x00
No. of Points Lo	0x25
Error Check (CRC)	(calculated)

Response

A response message consists of a relay status packed as one relay per bit of the data field. Status is indicated by means of the following code: 0 = OFF; 1 = ON. The first data byte is contained in the LSB, and specifies the relay addressed in the query. All other relays follow from "low order to high order" in subsequent bytes.

The returned relay quantity must be a multiple of eight; otherwise, it will be padded with zeros toward the high order end of the byte. The assembled bytes of data are specified in the byte count field.

An example of a response to the preceding query appears below.

Response	
Field Name	Example (Hex)
microLoad.net Address	0x11
Function	0x01
Byte Count	0x05
Data (Relays 27-20)	0xCD
Data (Relays 35-28)	0x6B
Data (Relays 43-36)	0xB2
Data (Relays 51-44)	0x0E
Data (Relays 56-52)	0x1B
Error Check (CRC)	(calculated)

The status of relays 27 through 20 is shown as the byte value CD hex, or binary 1100 1101. Relay 27 is the MSB of the byte, and relay 20 is the LSB. The status of relays 27 through 20 is expressed from left to right as ON-ON-OFF-OFF-ON-ON-OFF-ON.

Bits within a byte are shown with the MSB to the left and the LSB to the right; therefore, the relays in the first byte are “27 through 20,” from left to right. Relays “35 through 28" are contained in the next byte, again from left to right. As the bits are transmitted serially, they flow from LSB to MSB (i.e., 20 through 27, 28 through 35, and so on).

In the last data byte, the status of relays 56 through 52 is shown as the byte value 1B hex, or binary 0001 1011. Relay 56 is in the fourth bit position from the left, and relay 52 is the LSB of this byte. The status of relays 56 through 52 is expressed as ON-ON-OFF-ON-ON. The three remaining bits toward the high order end are padded with zeros.

02 Read Input Status

Description

Reads the ON/OFF status of discrete "inputs" (read only binary references) in the microLoad.net. The maximum number of parameters supported by microLoad.net is limited to 256 per query.

Query

The query message specifies the starting "input" and quantity of "inputs" to be read. "Inputs" are addressed starting at zero: inputs 1 through 16 are addressed as 0 through 15.

An example of a request to read the states of inputs 1024 to 1033 from microLoad.net 17 is shown below:

Query	
Field Name	Example (Hex)
microLoad.net Address	0x11
Function	0x02
Starting Address Hi	0x00
Starting Address Lo	0xC4
No. of Points Hi	0x00
No. of Points Lo	0xOA
Error Check (CRC)	(calculated)

Response

The input status is packed in the response message as one input per bit of the data field. Status is indicated as 0 = OFF; 1 = ON. The input addressed in the query appears in the LSB of the first data byte. The other inputs follow toward the high order end of this byte, and from low order to high order in all subsequent bytes.

The returned input quantity must be a multiple of eight; otherwise, the remaining bits in the final data byte will be padded with zeros toward the high order end of the byte. The quantity of complete bytes of data is indicated in the byte count field.

An example of a response to the preceding query appears below.

Response	
Field Name	Example (Hex)
microLoad.net Address	0x11
Function	0x02
Byte Count	0x02
Data (Inputs 1031-1024)	0xAC
Data (Inputs 1033-1032)	0x01
Error Check (CRC)	(calculated)

The status of inputs 1031 through 1024 is shown as the byte value AC hex, or binary 1010 1100. Input 1031 is the MSB of this byte and input 1024 is the LSB. The status of inputs 1031 through 1024 is expressed as ON-OFF-ON-OFF-ON-ON-OFF-OFF, from left to right.

The status of inputs 1033 through 1032 are shown as the byte value 01 hex, or binary 0000 0001. Input 1033 is in the seventh bit position from the left and input 1032 is the LSB. The status of inputs 1033 through 1032 is OFF-ON. The six remaining bits toward the high order end are padded with zeros, since the returned input quantity must be a multiple of eight.

03 Read Holding Registers

Description

Reads the binary contents of holding registers (read/write registers).

Query

The query message specifies the starting register and quantity of registers to be read. Registers are addressed starting at zero.

An example of a request to read registers 107 through 109 from microLoad.net 17 is shown below.

Query	
Field Name	Example (Hex)
microLoad.net Address	0x11
Function	0x03
Starting Address Hi	0x00
Starting Address Lo	0x6B
No. of Points Hi	0x00
No. of Points Lo	0x03
Error Check (CRC)	(calculated)

Response

Each register data in the response message contains two bytes. The binary contents are right justified within each byte. Within each register, the first byte contains the high order bits and the second byte contains the low order bits.

An example of a response to the preceding query is shown below.

Response	
Field Name	Example (Hex)
microLoad.net Address	11
Function	03
Byte Count	06
Data Hi (Register 107)	02
Data Lo (Register 107)	2B
Data Hi (Register 108)	00
Data Lo (Register 108)	00
Data Hi (Register 109)	00
Data Lo (Register 109)	64
Error Check (CRC)	--

04 Read Input Registers

Description

This function reads the binary contents of "input registers" in the microLoad.net. These are "read-only" values; they cannot be written.

Query

The query message specifies the starting register and quantity of registers to be read. Registers are addressed starting at zero.

An example of a request to read register 8 from microLoad.net 17 appears below.

Query	
Field Name	Example (Hex)
microLoad.net Address	11
Function	04
Starting Address Hi	00
Starting Address Lo	08
No. of Points Hi	00
No. of Points Lo	01
Error Check (CRC)	--

Response

Each register data in the response message contains two bytes. The binary contents are right justified within each byte. Within each register, the first byte contains the high order bits and the Second byte contains the low order bits.

An example of a response to the preceding query appears below.

Response

Field Name	Example (Hex)
microLoad.net Address	11
Function	04
Byte Count	02
Data Hi (Register 30009)	00
Data Lo (Register 30009)	0A
Error Check (CRC)	--

05 Force Single Relay

Description

Forces a single relay either ON or OFF.

Query

The query message specifies the relay reference to be forced. Relays are addressed starting at zero.

A constant in the query data field indicates the required ON/OFF state. A value of FF 00 hex directs the relay to be ON. A value of 00 00 directs the relay to be OFF. No other value is valid, nor will it affect the relay.

An example of a request to force relay 150 ON in microLoad.net 17 appears below. (Reset User Alarm #9)

Query	
Field Name	Example (Hex)
microLoad.net Address	11
Function	05
Relay Address Hi	00
Relay Address Lo	96
Force Data Hi	FF
Force Data Lo	00
Error Check (CRC)	--

Response

An echo of the query, returned after the relay status has been forced, indicates a normal response.

An example of a response to the preceding query appears below.

Response	
Field Name	Example (Hex)
microLoad.net Address	11
Function	05
Relay Address Hi	00
Relay Address Lo	96
Force Data Hi	FF
Force Data Lo	00
Error Check (CRC)	--

06 Preset Single Register

Description

Presets a value into a single holding register.

Query

The query message specifies the register reference to be preset. Registers are addressed starting at zero. The requested preset value is specified in the query data field.

An example of a request to preset register 1 to 0x0003 (hex) in microLoad.net 17 appears below.

Query	
Field Name	Example (Hex)
microLoad.net Address	11
Function	06
Register Address Hi	00
Register Address Lo	01
Preset Data Hi	00
Preset Data Lo	03
Error Check (CRC)	--

Response

An echo of the query, returned after the register contents have been preset, is a normal response.

An example of a response to the preceding query appears below.

Response	
Field Name	Example (Hex)
microLoad.net Address	11
Function	06
Register Address Hi	00
Register Address Lo	01
Preset Data Hi	00
Preset Data Lo	03
Error Check (CRC)	--

15 (0F Hex) Force Multiple Relays

Description

Forces each relay in a sequence of relays to either ON or OFF. The maximum number of parameters by microLoad.net is limited to 256 per query.

Query

The query message specifies the relay references to be forced. Relays are addressed starting at zero; thus, relay 1 is addressed as 0.

The contents of the query data field specify whether a state is ON or OFF. A logical “1” in a bit position of the field requests the corresponding relay to be ON. A logical “0” requests that the relay be OFF.

An example of a request to force a series of ten relays starting at address 15, or OF hex in microLoad.net 17, appears below.

The query data content consists of two bytes: CD 01 hex (1100 1101 0000 0001 binary). The binary bits correspond to the relays as shown below.

Bit:	1	1	0	0	1	1	0	1		0	0	0	0	0	0	0	1
Relay:	22	21	20	19	18	17	16	15		-	-	-	-	-	-	24	23

The first byte transmitted (CD hex) addresses relays 22 through 15, with the least significant bit corresponding to the lowest relay (15) in this set.

The next byte transmitted (01 hex) addresses relays 24 to 23, with the least significant bit corresponding to the lowest relay (23) in this set. Unused bits in the last data byte are padded with zeros.

Query	
Field Name	Example (Hex)
microLoad.net Address	11
Function	0F
Relay Address Hi	00
Relay Address Lo	0F
Quantity of Relays Hi	00
Quantity of Relays Lo	0A
Byte Count	02
Force Data Hi (Relays 27-20)	CD
Force Data Hi (Relays 29-28)	01
Error Check (CRC)	--

Response

The normal response consists of the slave address, function code, starting address, and number of relays forced.

An example of a response to the preceding query appears below.

Response	
Field Name	Example (Hex)
microLoad.net Address	11
Function	0F
Relay Address Hi	00
Relay Address Lo	01
Quantity of Relays Hi	00
Quantity of Relays Lo	0A
Error Check (CRC)	--

16 (10 Hex) Preset Multiple Registers

Description

Presets values into a sequence of holding registers.

Query

The query message specifies the register references to be preset. Registers are addressed beginning with zero.

An example of a request to preset two registers starting at 1 to 0x000A and 0x0102 (hex), in microLoad.net 17, appears below.

Query	
Field Name	Example (Hex)
microLoad.net Address	11
Function	10
Starting Address Hi	00
Starting Address Lo	01
No. of Registers Hi	00
No. of Registers Lo	02
Byte Count	04
Data Hi	00
Data Lo	0A
Data Hi	01
Data Lo	02
Error Check (CRC)	--

Response

A normal response consists of the slave address, function code, starting address, and quantity of registers preset.

An example of a response to the preceding query appears below.

Response	
Field Name	Example (Hex)
microLoad.net Address	11
Function	10
Starting Address Hi	00
Starting Address Lo	01
No. of Registers Hi	00
No. of Registers Lo	02
Error Check (CRC)	--

Exception Responses

When a master device sends a query to an microLoad.net device, there are three possible outcomes:

1. The microLoad.net receives the query with no communication errors, handles the query normally, and returns a normal response.
2. A communication error bars the microLoad.net from receiving the query, so no response is returned. The master program eventually processes a timeout condition for the query.
3. The microLoad.net receives the query without error, but returns no response. The master program eventually processes a timeout condition for the query.

Two fields in the exception response message differentiate it from a normal response:

Function Code Field: An microLoad.net normally echoes the function code of the original query in the function code field of the response. Because the values of all function codes are below 80 hexadecimal, all function codes have a most significant bit (MSB) of 0. In an exception response, however, the slave sets the MSB of the function code to 1. The value of the function code in an exception response is therefore 0x80 (hex) higher than the value for a normal response.

Accordingly, the application program controlling the master can quickly recognize the exception response and derive the exception code from the data field.

Data Field: A normal response consists of any data or statistics in the data field requested by the query. An exception response consists of an exception code in the data field. The code indicates the microLoad.net condition that caused the exception.

An example of a master query and microLoad.net exception response is shown in the table below. The field examples are given in hexadecimal.

Query		
Byte	Contents	Example
1	microLoad.net Address	0A
2	Function	01
3	Starting Address Hi	28
4	Starting Address Lo	0A
5	No. of Relays Hi	00
6	No. of Relays Lo	01
7	CRC	--
Exception Response		
Byte	Contents	Example
1	microLoad.net Address	0A
2	Function	81
3	Exception Code	02
4	CRC	--

Here, the master addresses a query to microLoad.net 10. The function code (01) is for a Read Relay Status operation that requests the status of the relay at address 10250 (0x280A hex). The number of relays field (0001) specifies that only one relay is to be read.

Accessing Double-Precision (64 bit) Floating Point Values with Modbus when the host application supports only Single Precision (32 bit) Values

Internally, the microLoad stores many data values in IEEE-754 standard double-precision format to meet the range and resolution required for the application. Many Modbus host software packages handle a variety of encoding methods for floating point values, but there are also some that have little or no support for floating point and many of those cannot handle the double-precision representation at all.

When forced to use non-compatible host systems with the microLoad, one workaround is to save each double precision register of interest to the microLoad's 'user float' registers using a custom equation. The microLoad will then handle the conversion from double-precision to single-precision floating point value. (Be aware however that some precision is lost when converting to single precision since there are fewer mantissa bits in the 32-bit representation.)

Here is an example equation line created using the microMate equation editor:

USERFLOAT1 = ARM1 TRANSACTION DATA INDICATED VOLUME(IV)

The 'Indicated Volume' value is stored internally in the microLoad as a double precision (64-bit) value; as mentioned some Modbus software packages could be unable to read it directly. Using the equation above will enable the desired Indicated Volume value to be read as a single precision floating point value via Modbus from the User Float 1 register in the microLoad.

There are 50 user float registers in the microLoad. They are 32-bit single precision values (capable of being read using Modbus). Registers #46-50 get archived with transaction data for use after the transaction has ended. User float registers #1-45 do NOT get archived.

Related Publications

Application Bulletin (LACT/Loading/Unloading).....Bulletin AB06100
Specification ..... Bulletin SS06045
MicroMate for microLoad.net..... Bulletin SS06046
Installation .....Bulletin MN06150
microLoad.net Operator Reference .....Bulletin MN06148
Communications.....Bulletin MN06147
Operations .....Bulletin MN06149
MicroMate for microLoad.net Installation/Operation.....Bulletin MN06152
Modbus and Modbus/TCP Communications .....Bulletin MN06155

Revisions included in MN06155 Issue/Rev. 0.3 (1/17):
Page 31: Text updated and rewritten.

The specifications contained herein are subject to change without notice and any user of said specifications should verify from the manufacturer that the specifications are currently in effect. Otherwise, the manufacturer assumes no responsibility for the use of specifications which may have been changed and are no longer in effect.

USA Operation
1602 Wagner Avenue
Erie, Pennsylvania 16510 USA
P:+1 814.898.5000

Germany Operation
Smith Meter GmbH
Regentstrasse 1
25474 Ellerbek, Germany
P:+49 4101 304.0

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