Optimizing Plunger Lift Controller
Modbus Communications User Guide

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Extreme Telematics Corp.

NOTICE OF CONFIDENTIALITY AND NONDISCLOSURE

Revision History

Revision	Date	Author	Changes
1.0	18/09/2007	M. Scantlebury	Initial version
1.1	13/11/2007	M. Scantlebury	Updates to add new registers and fix incorrect and missing registers.
1.2	30/01/2008	M. Scantlebury	Minor changes to the day start time registers. Also covered up some registers that are not yet implemented.
1.3	18/03/2008	M. Scantlebury	Reverse the order of LSW and MSW to match the existing map better as well as our other products.
1.4	13/01/2009	M. Hughesman	Added Max Close and Extra Close Timers. Also renamed all instances of “Extended Close” to the new wording “Non-Arrival Close”.

Acronyms

ADC	**Analog-to-Digital Converter**
AI	**Analog Input**
ALiEn	**Artificial Lift Enhancement**
CVC	**Configurable Valve Controller**
DAC	**Digital-to-Analog Converter**
DI	**Digital Input**
DO	**Digital Output**
ESD	**Emergency Shut Down**
N/C	**Normally Closed**
N/O	**Normally Open**
PSI	**Pounds per Square Inch**
R	**Read Permission**
RTU	**Remote Terminal Unit**
R/W	**Read/Write Permission**
SCADA	**Supervisory Control And Data Acquisition**
V	**Volts**
VFD	**Vacuum Fluorescent Display**
VI	**Virtual Input**

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Figure 1 - High Level Connection Overview 1

1 Introduction

The Remote Access Interface allows access to functions which are normally accessed using the integral front panel interface.

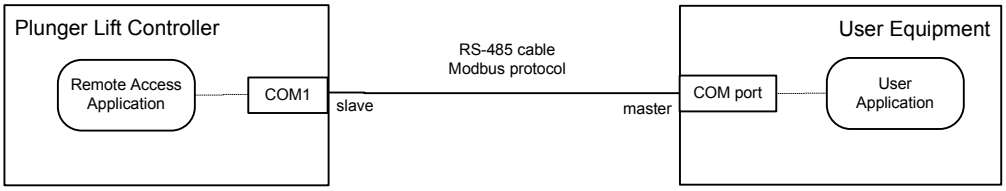

Figure 1 - High Level Connection Overview

This document describes how to use Modbus commands to operate the *Remote Access Application*. The Modbus registers and functionality described in this document are for the monitoring and modification of typical controller parameters.

1.1 References

[1] *Extreme Telematics Gas Valve Controller Installation Manual*; Revision 3; Extreme Telematics Corp.

[2] *Optimizing Plunger Lift Controller Operator's Manual*; 3; Extreme Telematics Corp.

[3] *Modicon Modbus Protocol Reference Guide*; PI-MBUS-300 Rev. J; June 1996; MODICON Inc.

[4] *Modbus Application Protocol Specification*; modbus.org; May 8, 2002.

2 Controller Setup

Access to the settings used for Modbus Communications are only available through the controller menus, The following sections give a brief overview of the initial setup required. More detailed descriptions are available in the Alien Installation and Operations Manual.

2.1 Enabling Modbus

In order to communicate using the Modbus communications protocol, you must first have the Modbus Option enabled on the specific controller that you are using. This can be activated at the factory or at a later time through the menu system.

To activate Modbus, navigate to Setup>System>ModbusOptn. If this currently says disabled, then select the field. Enter the 7 digit code that was provided by your distributor. If you do not have a code, please contact your distributor, who can arrange to get a code for you.

2.2 Communication Settings

The Modbus menu is available inside the Setup menu. This menu allows you to configure the settings of the controller. Please note that these settings must match the settings of your communications network and SCADA Host in order to function properly.

2.2.1 Station Address

The station address is a unique identifier that will be used by the host to communicate with a single controller. This address must not be duplicated within the same segment of your network. Valid addresses are 1 to 247. The default is 1.

2.2.2 Protocol

The protocol can be set to either RTU(binary) or ASCII (text). RTU is definitely more common as it takes less bits to transmit the same amount of information. This must match the same setting that is used by your SCADA Host. The default is RTU.

2.2.3 Baud Rate

The baud rate can be set to 1200, 2400, 4800, 9600, or 19200. This is used to se the bit rate of data transmitted on the communication line. This must match the same baud rate as the rest of your network. A mismatched baud rate will result in all communication being discarded at the controller. The default is 9600 bps.

2.2.4 Character Format

The character format is another property of the communication line that must be configured to match the rest of your network. It defines the bits of data and the framing that is involved. This is made up of data bits, parity, and stop bits. The default is 8N1. A full list of the available options are outlined in the next section.

3 Layer 1 Operation

The **Optimizing Plunger Lift Controller** has a single 2-wire RS-485 port (COM 1). See [1], for wiring details.

Supported bit rates: 1200, 2400, 4800, 9600, and 19,200 bps.

Supported character formats:

Table 1 - Supported Communication Rates and Formats

Data bits	Parity	Stop Bits	Protocol
7	None	2	ASCII, RTU
7	Odd	1	ASCII, RTU
7	Odd	2	ASCII, RTU
7	Even	1	ASCII, RTU
7	Even	2	ASCII, RTU
8	None	1	ASCII, RTU
8	None	2	ASCII, RTU
8	Odd	1	ASCII, RTU
8	Odd	2	ASCII, RTU
8	Even	1	ASCII, RTU
8	Even	2	ASCII, RTU

The bit rate and character format are configured using the front panel only. Tecnically, all character formats for RTU protocol support must be 11-bits in length with 8-bits of data. This allows for 1 start bit, 8 bits of data, and two bits for parity and stop. In actual practice, this is rarely followed, so all combinations are allowed.

4 Layer 2 Operation

The **Optimizing Plunger Lift Controller** supports both the Modbus ASCII and RTU protocols (see [3]). Protocol selection is configured from the front panel only, and defaults to RTU mode.

The **Optimizing Plunger Lift Controller** Modbus station address is configured using the front panel only (range: 1 – 247), but has a default value of 1. The **Optimizing Plunger Lift Controller** will act on, but not respond to, commands using the broadcast address (i.e. zero).

The maximum byte-length of Modbus commands and responses is limited to 256 characters (see [4], §4.1).

When operating in ASCII mode, the **Optimizing Plunger Lift Controller** performs the following required layer 2 checks on incoming commands:

- Parity
- LRC
- character silence period (1 second)

ASCII commands can be accepted upon silence detection without a terminating CR/LF.

When operating in RTU mode, the **Optimizing Plunger Lift Controller** performs the following required layer 2 checks on incoming commands:

- Parity
- CRC
- character timeout period (1.5 character times)
- frame silence period (3.5 character times)

5 Layer 3 Operation

The following Modbus commands are supported:

Table 2 - Supported Modbus Commands

Code	Current Terminology	Classic Terminology	Data Resolution
01	Read Coils	Read Coil Status	1-bit
02	Read Input Discretes	Read Input Status	1-bit
03	Read Multiple Registers	Read Holding Registers	16-bit
04	Read Input Registers	Read Input Registers	16-bit
05	Write Coil	Force Single Coil	1-bit
06	Write Single Register	Preset Single Register	16-bit
15	Force Multiple Coils	Force Multiple Coils	16-bit
16	Write Multiple Registers	Preset Multiple Registers	16-bit

Normal responses are issued as required by [3].

Modbus allows for exception responses to be returned under certain failure conditions. Once again, this is not typically desired in the process control industry. As such, the controller does not normally return any exception responses. This can however be enabled through the user interface if desired. The following Modbus Exception Responses are supported:

Table 3 - Supported Modbus Exception Responses

Code	Response
01	Illegal Function
02	Illegal Data Address
03	Illegal Data Value
04	Slave Device Failure

The **Optimizing Plunger Lift Controller** performs consistency checks on the following items received in commands:

- number of bytes received[1]
- *Number of Points* field
- *Byte Count* field (if present).

If any of these checks fail, an *Illegal Data Value* exception is returned.

If an *Address* field, either explicit or implicit, is outside the known range, an *Illegal Data Address* exception is returned. The *User Application* may read Input Registers 3:1001 and 3:1002 to determine the first bank and address in the command which caused the exception. No part of the command is executed.

A *Slave Device Failure* exception is used to indicate Application Layer errors. The *User Application* may read Input Registers 3:1001 and 3:1002 to determine the bank and address in

[1] In the Modbus ASCII protocol, a single byte is sent as 2 HEX-ASCII characters.

the command which caused the exception. Execution of the command terminates at this address.

5.1 Address Coding

Each register of the **Optimizing Plunger Lift Controller** is accessed via a specific Modbus operation. Each operation contains an implied address offset. The mapping between traditional Modbus address notation, the operation performed, and the address sent in Modbus messages is shown below.

Table 4 - Modbus Message Coding

Code	Operation	Modbus Address Notation	Message Address
01	Read Coils	0: *abcd*	*abcd*
02	Read Input Discretes	1: *abcd*	*abcd*
03	Read Multiple Registers	4: *abcd*	*abcd*
04	Read Input Registers	3: *abcd*	*abcd*
05	Write Coil	0: *abcd*	*abcd*
06	Write Single Register	4: *abcd*	*abcd*
15	Force Multiple Coils	0: *abcd*	*abcd*
16	Write Multiple Registers	4: *abcd*	*abcd*

For example, accessing register 4:4000 is done via the following operations: ReadMultipleRegisters, WriteSingleRegister, and WriteMultipleRegisters. All of these operations use the address value 4000. Accessing register 0:4000 is done with the following operations: ReadCoils and WriteCoils. These two operations also use the address value 4000, but access a different register.

6 Application Layer Operation

6.1 Basic Operation

The **Optimizing Plunger Lift Controller** is designed to allow concurrent operation from the front panel and Modbus interface. This requires that the front panel user (*UI Application*) and the *User Application* (via the *Remote Access Interface*) not access data at the same time or overwrite each other's data. This is achieved by allowing each application to have a copy of the **Optimizing Plunger Lift Controller** parameters to read and modify. This imposes special requirements on the *User Application*.

The information within the **Optimizing Plunger Lift Controller** is grouped into a number of data-sets. Before accessing any data within a data-set, it must be retrieved by the *Remote Access Application*. This is done so that:

- The *User Application* can read a consistent data-set: That is, one in which the data is not changing while it is being read. This means that, in general, the data-set will be out-of-date. The *User Application* should have the *Remote Access Application* retrieve a fresh copy of a data-set before each read "session".

- Changes made to a data-set will not be lost: If parameters are changed using the front panel and *User Application* at the same time, there is a potential for changes to be lost. For this reason, a lock-out mechanism is provided. The *User Application* can retrieve a data-set "for writing". This will lock-out changes to the data-set by the front panel.

6.1.1 History Logs

The **Optimizing Plunger Lift Controller** provides access to history records. These history records are provided in a format that allows various aspects of the history to be compared. One must keep in mind that the history data is constantly changing.

The controller however does not write data to the history until a predetermined even happens. For the plunger cycle logs, the history is written each time that a cycle starts (controller moves from Close to Rise). Daily production logs are modified at the specified Day Start Time. Reading the history at the exact time that the history is being updated could lead to inconsistent data. Therefore, it is best to avoid reading the history at these times.

6.1.2 Modbus Lockout

Modbus access to **Optimizing Plunger Lift Controller** can be enabled and disabled from the front panel. Disabling Modbus access in this manner restricts access to all registers on the **Optimizing Plunger Lift Controller** with the exception of the following:

- *Slave Device Access* (see register 1:0300)
- *Illegal Address* (see register 3:0300)
- *Slave Device Failure Type* (see register 3:0301)
- *Slave Device Failure Address* (see register 3:0302)

Modbus masters can check the access status of the device by reading the *Slave Device Access* register.

6.1.3 Register Set Access

A register set is defined as a fixed number of contiguous 16-bit memory locations that represent a single **Optimizing Plunger Lift Controller** parameter. For a register set to be valid it must be accessed as an aggregate from the start address.

For read operations, the *User Application* should query the starting register address and read the entire length of the register set. Register sets must be written from low to high order with no intervening write operations. The register set is validated, by the *Remote Access Application*, as an aggregate when the high order register is written.

Optimizing Plunger Lift Controller register set formats are defined in §7.1.

6.2 Automatic Dependent Parameter Update

The range of values for some control parameters depend on the current value of other parameters. This means that when a parameter is changed, its dependent parameters may become invalid. In this case, the dependent parameters are automatically changed in order to avoid an invalid configuration. Register assignments are such that dependent parameters have a higher register number than their "parent". This allows a group of parameters to be written with a single Modbus command with no undesired side-effects.

6.3 Concurrency Issues

6.3.1 Plunger Lift Controller Algorithm

Changes to plunger lift control parameters may be made while the control algorithm is running. These changes are saved when the Modbus Write Time expires, but are not applied until the start of the next plunger lift cycle or controller cycle restart.

The following Historical Logs are updated by the control algorithm:

Table 5 - Available Logs

Log	Updated
Cycle	At the end of each plunger lift cycle when the controller moves from Close to Rise.
Daily Production	Every 24 hours at the Day Start Time "Today's" daily production is updated every second at minimum.

It is possible, therefore, that the history us being updated while it is being read by the *User Application*. For example, at the end of the gas day, the Log 1 data becomes Log 2 and Log 7 data is removed. It is the responsibility of the *User Application* to manage this sliding window of log data at the gas day or plunger cycle boundary.

6.3.2 History Logs

All logs may be reset from the front panel. It is possible, therefore, that the currently selected log may be updated while it is being read by the *User Application*. It is the responsibility of the *User Application* to manage this concurrent access to log data.

6.4 Error Reporting

When a *Slave Device Failure* exception is returned, the *User Application* may read Input Register 3:1000 to determine the type of failure, as follows:

Table 6 - Supported Modbus Error Codes

Error Type	Code	Description
MODBUS_ACCESS_DENIED	01	Modbus access to registers has been lockout from the device front panel. Only registers 1:0300, and 3:0300-3:0302 are accessible.
FUNCTION_NOT_SUPPORTED	02	The specified functionality of this register is not available in this firmware version.
FEATURE_NOT_ENABLED	03	The application attempted to access a data item belonging to a disabled value-added firmware feature. These features may only be enabled from the front panel.
FUNCTION_NOT_ENABLED	04	The application attempted to access a data item that requires activation via another register.
DEVICE_NOT_ENABLED	05	The application attempted to access a real device which is not present (i.e. enabled) in the **Optimizing Plunger Lift Controller** configuration.
DATASET_NOT_LOCKED	06	The application attempted to write to a dataset which was not locked.

Error Type	Code	Description
DEPENDENT_DATASET_NOT_LOCKED	07	The application attempted to modify parameter in a locked dataset that required an auto update parameter in an unlocked dependent dataset.
DATASET_ALREADY_LOCKED	08	The application attempted to lock a dataset which is currently locked by the integral control panel user. Try the request at a later time.
VALUE_OUT_OF_RANGE	09	The preset value for a register was outside the acceptable range of values.
WRITE_SEQUENCE_ERROR	10	The registers in a register set were not written in the proper order.
LOG_NOT_SELECTED	11	The application attempted to read a data value belonging to a historical log which has not been loaded.
LOW_BATTERY	12	The request could not be performed because the **Optimizing Plunger Lift Controller** is in a low battery condition.

7 Address Assignments

The following sections outline the available register formats and the specific registers that are currently available. Please note that any registers that are grayed out have not been implemented. Writes to these registers will be ignored. Reads from these registers will return unpredictable results.

7.1 Register Formats

MSW = most significant word (16 bits)

LSW = least significant word (16-bits)

7.1.1 Date/Time Register

- Range: 0 – 4,294,967,295
- Write MSW first when writing in seconds format, followed by LSW
- Use the Time Format coil to switch the format

Table 7 - Date/Time Register Format

Number	Description (Seconds Format)	Description(H:M:S Format)
Start	Seconds since January 1, 2000 (MSW)	Year
Start + 1	Seconds since January 1, 2000 (LSW)	Month
Start + 2	Reserved	Day
Start + 3	Reserved	Hours
Start + 4	Reserved	Minutes
Start + 5	Reserved	Seconds

7.1.2 Elapsed Time Register

- Range: 0 – 3,599,999 seconds (1000 hours)
- Write LSW first when writing in seconds format
- Use the Time Format coil to switch the format

Table 8 - Elapsed Time Register Format

Number	Description (Seconds Format)	Description(H:M:S Format)
Start	Seconds (MSW)	Hours
Start + 1	Seconds (LSW)	Minutes
Start + 2	Reserved	Seconds

7.1.3 Double Word Register

Table 9 - Double Word Register Format

Number	Description
Start	MSW

Start + 1	LSW

7.2 Coils

Table 10 - Available Coils

Register	Description	Read	Write
Basic Control			
0:0001	Open Mimic the Open button functionality from the keypad.	N/A	1 – Open
0:0002	Close Mimic the Close button functionality from the keypad.	N/A	1 – Close
0:0003	Restart Controller	N/A	1 - Restart Controller
0:0004	Reset Cycle Log	N/A	1 - Reset Log
0:0005	Reset Daily Statistics Log This resets all previous days, but does not reset the current day.	N/A	1 - Reset Log
0:0006	Reset Error Logs	N/A	1 - Reset Log
0:0007	Time Format	Current Value	0 – Seconds 1 – H:M:S

7.3 Input Discretes

Table 11 - Available Input Discretes

Register	Description	Read
Controller Information		
1:0001	Operator Present	0 – No operator at the controller 1 – An operator is currently using the controller
1:0002	Slave Device Access This register may be read to determine if access to data registers in the Modbus slave device is permitted. (see §6.1.2).	0 – Modbus slave access disabled 1 – Modbus slave access enabled
1:0003	Date/Time Set	0 – date/time not set 1 - date/time set
1:0004 – 1:0010	Reserved	N/A
1:0011	Product Feature -Valve B	0 – Feature disabled 1 – Feature enabled

Register	Description	Read
1:0012	Product Feature – Modbus	0 – Feature disabled 1 – Feature enabled
1:0013	Product Feature – Pressure Based Optimization	0 – Feature disabled 1 – Feature enabled
1:0014	Product Feature – Timer Based Optimization	0 – Feature disabled 1 – Feature enabled
1:0015 – 1:0020	Reserved	N/A
Output Status		
1:0021	Valve A Status	0 - Valve A closed 1 - Valve A open
1:0022	Valve B Status This valve status is only valid when valve B is enabled.	0 - Valve B closed 1 - Valve B open
1:0023 – 1:0030	Reserved	N/A
Input Device Status		
1:0031	Battery Switch Value	0 – Battery Good 1 – Battery Low
1:0032	Line Pressure Switch Value The registers may only be read when the *Line Pressure Device* is enabled as a switch (see register 4:0241) The value returned from this register may be invalid. The validity of the reading can be determined by reading the Line Pressure Device Status (see register 3:0052).	0 – Line Pressure Reset 1 – Line Pressure Tripped
1:0033	Casing Pressure Switch Value The registers may only be read when the *Casing Pressure Device* is enabled as a switch (see register 4:0261) The value returned from this register may be invalid. The validity of the reading can be determined by reading the Casing Pressure Device Status (see register 3:0053).	0 – Casing Pressure Reset 1 – Casing Pressure Tripped
1:0034	Flow DP Switch Value The registers may only be read when the *Flow DP Device* is enabled as a switch (see register 4:0291) The value returned from this register may be invalid. The validity of the reading can be determined by reading the Flow DP Device Status (see register 3:0054).	0 – Flow DP Reset 1 – Flow DP Tripped

Register	Description	Read
1:0035	Flow Switch Value The registers may only be read when the *Flow Device* is enabled as a switch (see register 4:0311) The value returned from this register may be invalid. The validity of the reading can be determined by reading the Flow Device Status (see register 3:0055).	0 – Flow Reset 1 – Flow Tripped

7.4 Input Registers

Table 12 - Available Input Registers

Register	Description	Read
	Controller Information	
3:0001 – 3:0002	Controller Serial Number	Double Word format: 0 - 99999
3:0003	Firmware Version – Major Version	0 – 99
3:0004	Firmware Version – Minor Version	0 – 99
3:0005	Firmware Version – Fix Version	0 – 99
3:0006 – 3:0010	Reserved	N/A
3:0011	Current Controller State	0 = Afterflow 1 = Afterflow Delay 2 = Close 3 = Non-Arrival Close 4 = Extended Afterflow 5 = Rise 6 = Stopped 7 = Extra Close
3:0012 – 3:0013	Controller Status Time Remaining If the value in *Current Controller Operation* (register 3:1001) is greater than 2 the contents of these registers are undefined.	Elapsed Time format
3:00014	Reserved	N/A
3:0015 – 3:0020	Current State Begin Time	Date/Time format
3:0021	Controller Status Reason	0 = Fast Trip 1 = High Line Pressure 2 = High Casing Line Diff 3 = Low Battery 4 = Low Flow 5 = Max Open Time Expired 6 = Non-Arrival 7 = Normal Operation 8 = Operator Command 9 = Startup
3:0022 – 3:0030	Reserved	N/A

Register	Description	Read
	Input Device Value	
3:0031	Battery Voltage Value The value returned from this register may be invalid. The validity of the reading can be determined by reading the Battery Voltage Valid Flag (input discrete 1:0010).	350 – 600 (centi-volts)
3:0032	Line Pressure Value The registers may only be read when the *Line Pressure Device* is enabled as a sensor (see register 4:6030). The value returned from this register may be invalid. The validity of the reading can be determined by reading the Line Pressure Valid Flag (input discrete 1:0011).	0 – Max Line Pressure psi
3:0033	Casing Pressure Value	0 – Max Casing Pressure psi
3:0034	Flow DP Value	0 – 150 " WC
3:0035	Flow Value	0 – 500.0 e3m3/d (5000 = 500.0)
3:0036 – 3:0050	Reserved	N/A
3:0051	Battery Voltage Status The contents of this address are latched after executing a read operation of the Battery Voltage Value (register 3:0002).	1 - scan pending 2 - def change pending 3 – value under range 4 – value over range 5 – value invalid 6 – value valid
3:0052	Line Pressure Device Status The contents of this address are latched after executing a read operation of the Line Pressure Switch Value (input discrete 1:0003) or the Line Pressure Sensor Value (register 3:0003).	0 - disabled 1 – scan pending 2 - def change pending 3 – value under range 4 – value over range 5 – value invalid 6 – value valid
3:0053	Casing Pressure Device Status	0 - disabled 1 – scan pending 2 - def change pending 3 – value under range 4 – value over range 5 – value invalid 6 – value valid
3:0054	Flow DP Device Status	0 - disabled 1 – scan pending 2 - def change pending 3 – value under range 4 – value over range 5 – value invalid 6 – value valid

Register	Description	Read
3:0055	Flow Device Status	0 - disabled 1 – scan pending 2 - def change pending 3 – value under range 4 – value over range 5 – value invalid 6 – value valid
3:0056 – 3:0100	Reserved	N/A
Daily Production Log		
3:0101	Daily Production Log Count	0 - 8
3:0102 + 6(n -1) - 3:0107 + 6(n -1)	Daily Production Log - Save Time 8 Consecutive date/time registers. "n" in the register column represents the daily production log number. The first date/time register in each set is the current day stats. (n = 1 to 8)	Date/Time format
3:0150 + 3(n -1) - 3:0152 + 3(n -1)	Daily Production Log - Open Time 8 Consecutive triple registers	Elapsed Time format
3:0174 + 3(n -1) - 3:0176 + 3(n -1)	Daily Production Log - Close Time 8 Consecutive triple registers	Elapsed Time format
3:0198 + 2(n -1) - 3:0199 + 2(n -1)	Daily Production Log – Production Volume 8 Consecutive double registers	0 - 4294967296
3:0214 + (n -1)	Daily Production Log - Cycle Count 8 Consecutive single registers	0 - 65535
3:0222 + (n -1)	Daily Production Log - Normal Arrival Count 8 Consecutive single registers	0 - 65535
3:0230 + (n -1)	Daily Production Log - Non-Arrival Count 8 Consecutive single registers	0 - 65535
3:0238 + (n -1)	Daily Production Log - Fast Trip Count 8 Consecutive single registers	0 - 65535
3:0246 + (n -1)	Daily Production Log - Line Pressure Shut-in Count 8 Consecutive single registers	0 - 65535
3:0254 + (n -1)	Daily Production Log – Max Open Count 8 Consecutive single registers	0 - 65535
3:0262 + (n -1)	Daily Production Log – Low Battery Count 8 Consecutive single registers	0 - 65535

Register	Description	Read
3:0270 + (n -1)	Daily Production Log – Operator Change Count 8 Consecutive single registers	0 - 65535
3:0278 + (n -1)	Daily Production Log – Startup Count 8 Consecutive single registers	0 - 65535
3:0286 – 3:1000	Reserved	N/A
Plunger Cycle Log		
3:1001	Cycle Log Count	0 - 20
3:1002 + 6(n -1) - 3:1007 + 6(n -1)	Cycle Log Start Time 20 Consecutive date/time registers. "n" in the register column represents the cycle log number.	Date/Time format
3:1122 + (n -1)	Cycle Log Type 20 Consecutive registers	0 = Normal 1 = Fast-Trip 2 = Non-Arrival 3 = Max Open 4 = Low Battery Shutdown 5 = Operator Change 6 = Line Pressure Shut In 7 = Startup
3:1142 + 3(n -1) - 3:1144 + 3(n -1)	Cycle Log Rise Time 20 Consecutive triple registers	Elapsed Time format
3:1202 + 3(n -1) - 3:1204 + 3(n -1)	Cycle Log Afterflow Time 20 Consecutive triple registers	Elapsed Time format
3:1262 + 3(n -1) - 3:1264 + 3(n -1)	Cycle Log Close Time 20 Consecutive triple registers	Elapsed Time format
3:1322 – 3:2000	Reserved	N/A
Modbus Error Log		
3:2001	Slave Access Failure Type This register may be read to view details of the last *Slave Device Failure* or *Illegal Data Address* exception response (see §6.4).	0 – 12
3:2002	Slave Access Failure Bank Contains the Modbus bank in which the last *Slave Device Failure* or *Illegal Data Address* exception response occurred. The bank returned does not include any address information.	0 – 4

Register	Description	Read
3:2003	Slave Access Failure Register Contains the register number at which the last *Slave Device Failure* or *Illegal Data Address* exception response occurred. The address returned does not include any bank information. For example, *abcd* is returned for an error at address 0:*abcd*, 1:*abcd*, 3:*abcd*, or 4:*abcd*.	0 – 65535
3:2004 – 3:2010	Reserved	N/A
Firmware Error Log		
3:2011	Number of Log Entries	0 - 20
3:2012 + 3(n – 1)	Error Log Type 20 Available error logs. "n" in the register column represents the error log number.	1 = System Definition Error 2 = Assertion Failure 3 = Check Failure
3:2013 + 3(n – 1)	Error Log Data 1	Contact ETC for Details
3:2014 + 3(n – 1)	Error Log Data 2	Contact ETC for Details

7.5 Holding Registers

Table 13 - Available Holding Registers

Register	Description	Read/Write
General Controller Settings		
4:0001 – 4:0002	Operator ID Write either the operator ID or the Installer ID to gain access to protected registers.	Double Word format: 0 - 9999999
4:0003 – 4:0004	Slave Device Access Enable Slave access can be enabled remotely by writing a 32-bit Slave Access Enable code to this register.	32 Bit Enable Code Read Not Permitted
4:0005	Modbus Write Time The amount of time to wait after the last written value before saving all changes to the controller.	0 – 65535 seconds. Writing zero (which is the default) will save all changes as they are made.
4:0006 – 4:0011	Controller Date/Time	Date/Time
4:0012	Daylight Savings Time configuration	0 = Disabled 1 = Enabled
4:0013 – 4:0014	Day Start Time – Start of the gas day.	Elapsed Time format: 0 – 86340 (00:00: – 23:59) When in HH:MM:SS format, only Hours and Minutes are available.

Register	Description	Read/Write
4:0015– 4:0100	Reserved	N/A
Timer Settings		
4:0101 – 4:0103	Close Time	Elapsed Time format: 1 – 1,800,000 (000:00:01 – 500:00:00)
4:0104 – 4:0106	Non-Arrival Close Time	Elapsed Time format: 1 – 1,800,000 (000:00:01 – 500:00:00)
4:0107 – 4:0109	Rise Time If the *Rise Duration* is modified the following parameters *may* be auto-updated: • *Max Open Time* • *Tank Delay Time*	Elapsed Time format: 0 – 1,799,999 (000:00:00 – 499:59:59)
4:0110 – 4:0112	Tank Delay Time The maximum value for the *Tank Delay Time* parameter is the lesser of: 499h59m59s and the current *Rise Time* parameter value. Valid only if Valve B is configured as a Tank Valve and the *Arrival Sensor* is enabled.	Elapsed Time format: 0 – 1,799,999 (000:00:00 – 499:59:59)
4:0113 – 4:0115	Fast Trip Time	Elapsed Time format: 0 – 1,799,997 (000:00:00 – 499:59:57) A value of zero disables the timer.
4:0116 – 4:0118	Target Rise Time	Elapsed Time format: 1 – 1,799,998 (000:00:01 – 499:59:58)
4:0119 – 4:0121	After-Flow Delay	Elapsed Time format: 0 – 36,000 (00:00:00 – 10:00:00)
4:0122 – 4:0124	After-Flow Time	Elapsed Time format: 1 – 1,800,000 (000:00:01 – 500:00:00)
4:0125 – 4:0127	Arrival Guard Time	Elapsed Time format: 1 – 600 (000:00:00 – 00:10:00)
4:0128 – 4:0130	Extended After-Flow Time	Elapsed Time format: 0 – 1,799,999 (000:00:00 – 499:59:59)
4:0131 – 4:0133	Max Open Time If a non-zero value is selected, it must be greater than the current *Rise Time* parameter value.	Elapsed Time format: 0 – 1,800,000 (000:00:00 – 500:00:00) A value of zero disables the timer.

Register	Description	Read/Write
4:0134 – 4:0136	Extra Close Time	Elapsed Time format: 0 – 1,799,999 (000:00:00 – 499:59:59)
4:0137 – 4:0139	Max Close Time	Elapsed Time format: 0 – 1,800,000 (000:00:00 – 500:00:00)
4:0140 – 4:0150	Reserved	N/A
Virtual Sensors		
4:0151	Virtual Line Pressure Value	0 – Max Line Pressure psi
4:0152	Virtual Casing Pressure Value	0 – Max Casing Pressure psi
4:0153	Virtual Flow DP Value	0 – 150 " WC
4:0154	Virtual Flow Value	0 – 500.0 e3m3/d (5000 = 500.0)
4:0155 – 4:0170	Reserved	N/A
Exception Handling		
4:0171	Non-Arrival Count	0 – 99
4:0172	Fast-Trip Count	0 – 99
4:0173	Low Battery Fail Mode	0 – Fail Closed 1 – Fail Open
4:0174	Fast Trip Fail Mode	0 – Fail Closed 1 – Fail Open
4:0175	Non-Arrival Fail Mode	0 – Fail Closed 1 – Fail Open
4:0176 – 4:0200	Reserved	N/A
Device Configuration		
4:0201	Optimization Type Specifies the type of optimization scheme to use. Only optimization types that have been enabled are available here.	0 = Disabled 1 = Pressure Optimization 2 = After-Flow Timer Optimization 3 = Close Timer Optimization
4:0202	Timer Optimization Mode Is used to scale the adjustments that are made during the timer optimization algorithm. A more aggressive mode will mean that larger changes are made, which could lead to a more unstable response.	0 = A (Least Aggressive) 1 = B 2 = C (Most Aggressive)
4:0203 – 4:0204	Reserved	

Register	Description	Read/Write
4:0205	Valve B Configuration When the valve is enabled: • its wiring location defaults to the first free location • The valve is closed If the *Valve B configuration* is modified the following parameters *may* be auto-updated: • *Tank Delay Time*	0 = Disabled 1 = Line, Valves A and B open during After-Flow 2 = Line, Valve A only open during After-Flow 3 = Tank
4:0206 – 4:0220	Reserved	
4:0221	Arrival Sensor Configuration	0 = Disabled 1 = Enabled
4:0222	Arrival Switch Mode	0 = Normally Open 1 = Normally Closed
4:0223 – 4:0240	Reserved	
4:0241	Line Pressure Device Configuration	0 = Disabled 1 = Line Pressure Switch 2 = Line Pressure Sensor
4:0242	Line Pressure Switch Mode	0 = Normally Open 1 = Normally Closed
4:0243	Line Pressure Sensor Range If the *Line Pressure Sensor Range* is modified the following parameters *may* be auto-updated: • *Line Pressure Trip Point* • *Line Pressure Reset Point* • *Open Casing-Line Differential Pressure Trip Point* • *Open Casing-Line Differential Pressure Reset Point*	0 = 500 psi 1 = 1000 psi
4:0244	Line Pressure Trip Point A value must be entered in the range: • *current dead-band*, to • *Line Pressure Sensor Maximum Value*. Where *current dead-band = Line Pressure Trip Point –Line Pressure Reset Point* If the *Line Pressure Trip Point* is modified the following parameters will be auto-updated: • *Line Pressure Reset Point*	0 – 999 (psi)
4:0245	Line Pressure Reset Point A value must be entered in the range: • *0 to Line Pressure Trip Point* – 1.	0 – 999 (psi)
4:0246 – 4:0248	Line Pressure Stable Time	Elapsed Time format: 0 – 7199
4:0249 – 4:0260	Reserved	

Register	Description	Read/Write
4:0261	Casing Pressure Device Configuration	0 = Disabled 1 = Casing Pressure Switch 2 = Casing Pressure Sensor
4:0262	Casing Pressure Switch Mode	0 = Normally Open 1 = Normally Closed
4:0263	Casing Pressure Sensor Range If the *Casing Pressure Sensor Range* is modified the following parameters *may* be auto-updated: • *Open Casing Pressure Trip Point* • *Open Casing Pressure Reset Point* • *Close Casing Differential Pressure Trip Point* • *Close Casing Differential Pressure Reset Point* • *Open Casing-Line Differential Pressure Trip Point* • *Open Casing-Line Differential Pressure Reset Point*	0 = 500 psi 1 = 1000 psi
4:0264	Open Casing Pressure Trip Point A value must be entered in the range: • *current dead-band*, to • *Casing Pressure Sensor Maximum Value*. Where *current dead-band = Open Casing Pressure Trip Point – Open Casing Pressure Reset Point* If the *Open Casing Pressure Trip Point* is modified the following parameters will be auto-updated: • *Open Casing Pressure Reset Point*	0 – 999 (psi)
4:0265	Open Casing Pressure Reset Point A value must be entered in the range: • *0 to Open Casing Pressure Trip Point* – 1.	0 – 999 (psi)
4:0266 – 4:0268	Open Casing Pressure Stable Time	Elapsed Time format: 0 – 7199

Register	Description	Read/Write
4:0269	Close Casing Differential Pressure Trip Point A value must be entered in the range: • *current dead-band*, to • *Casing Pressure Sensor Maximum Value*. Where *current dead-band = Close Casing Differential Pressure Trip Point – Close Casing Differential Pressure Reset Point* If the *Close Casing Differential Pressure Trip Point* is modified the following parameters will be auto-updated: • *Close Casing Differential Pressure Reset Point*	0 – 999 (psi)
4:0270	Close Casing Differential Pressure Reset Point A value must be entered in the range: • *0 to Close Casing Differential Pressure Trip Point* – 1.	0 – 999 (psi)
4:0271 – 4:0273	Close Casing Differential Pressure Stable Time	Elapsed Time format: 0 – 7199
4:0274	Open Casing-Line Differential Pressure Trip Point A value must be entered in the range: • *current dead-band*, to • *Open Casing-Line Differential Pressure Sensor Maximum Value*. Where *current dead-band = Open Casing-Line Differential Pressure Trip Point – Open Casing-Line Differential Pressure Reset Point* If the *Open Casing-Line Differential Pressure Trip Point* is modified the following parameters will be auto-updated: • *Open Casing-Line Differential Pressure Reset Point*	0 – 999 (psi)
4:0275	Open Casing-Line Differential Pressure Reset Point A value must be entered in the range: • *0 to Open Casing-Line Differential Pressure Trip Point* – 1.	0 – 999 (psi)
4:0276-4:0278	Open Casing-Line Differential Pressure Stable Time	Elapsed Time format: 0 – 7199
4:0279 – 4:0290	Reserved	

Register	Description	Read/Write
4:0291	Flow DP Device Configuration	0 = Disabled 1 = Flow DP Switch 2 = Flow DP Sensor
4:0292	Flow DP Switch Mode	0 = Normally Open 1 = Normally Closed
4:0293	Flow DP Sensor Range If the *Flow DP Sensor Range* is modified the following parameters *may* be auto-updated: • *Flow DP Trip Point* • *Flow DP Reset Point*	0 = 150 " WC
4:0294	Flow DP Trip Point A value must be entered in the range: • *current dead-band*, to • *Flow DP Sensor Maximum Value*. Where *current dead-band = Flow DP Trip Point – Flow DP Reset Point* If the *Flow DP Trip Point* is modified the following parameters will be auto-updated: • *Flow DP Reset Point*	0 – 150 "WC
4:0295	Flow DP Reset Point A value must be entered in the range: • *0 to Flow DP Trip Point* – 1.	0 – 150 "WC
4:0296 – 4:0298	Flow DP Stable Time	Elapsed Time format: 0 – 7199
4:0299 – 4:0310	Reserved	
4:0311	Flow Device Configuration	0 = Disabled 1 = Flow Switch 2 = Flow Sensor
4:0312	Flow Switch Mode	0 = Normally Open 1 = Normally Closed
4:0313	Flow Sensor Range If the *Flow Sensor Range* is modified the following parameters *may* be auto-updated: • *Flow Trip Point* • *Flow Reset Point*	0 = 500 e3m3/d

Register	Description	Read/Write
4:0314	Flow Trip Point A value must be entered in the range: • *current dead-band*, to • *Flow Sensor Maximum Value*. Where *current dead-band = Flow Trip Point – Flow Reset Point* If the *Flow Trip Point* is modified the following parameters will be auto-updated: • *Flow Reset Point*	0 – 500.0 e3m3/d (5000 = 500.0)
4:0315	Flow Reset Point A value must be entered in the range: • *0 to Flow Trip Point* – 1.	0 – 500.0 e3m3/d (5000 = 500.0)
4:0316 – 4:0318	Flow Stable Time	Elapsed Time format: 0 – 7199