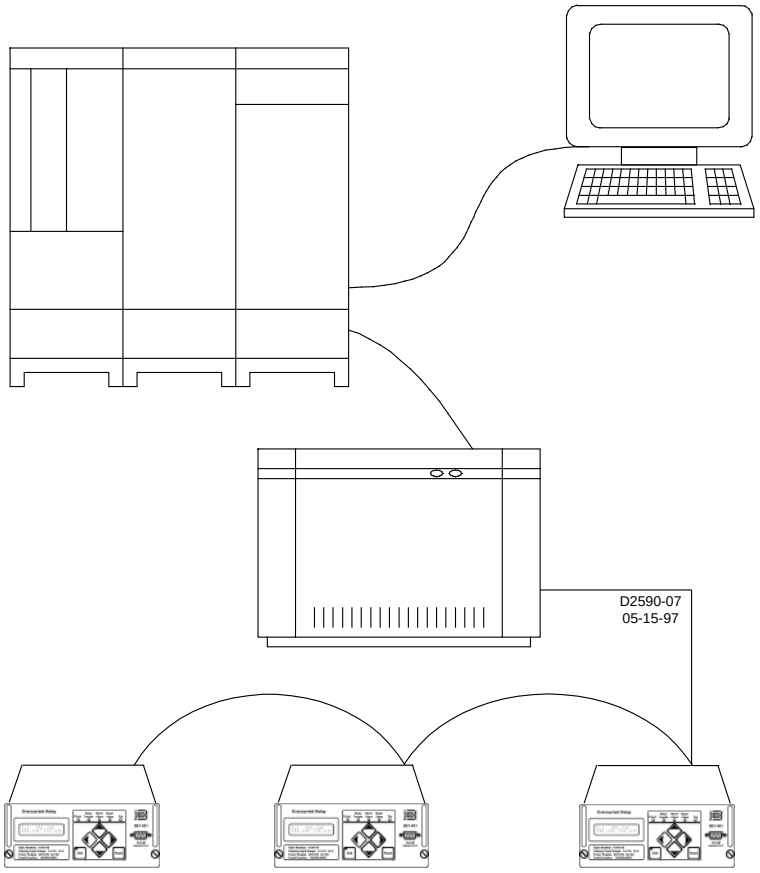
INSTRUCTION MANUAL
FOR
BE1-MMS100
MULTIFUNCTION METER SYSTEM
MODBUS® PROTOCOL



Basler Electric®

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INTRODUCTION

This manual provides detailed communications protocol information for the BE1-MMS, Multifunction Meter System with the Modbus® Protocol.

WARNING

TO AVOID PERSONAL INJURY OR EQUIPMENT DAMAGE, ONLY QUALIFIED PERSONNEL SHOULD PERFORM THE PROCEDURES PRESENTED IN THIS MANUAL.

CAUTION

MEGGERS AND HIGH POTENTIAL TEST EQUIPMENT SHOULD BE USED WITH EXTREME CARE. INCORRECT USE OF SUCH EQUIPMENT COULD DAMAGE COMPONENTS CONTAINED IN THE DEVICE.

CAUTION

THIS PRODUCT CONTAINS ONE OR MORE NONVOLATILE MEMORY DEVICES. NONVOLATILE MEMORY IS USED TO STORE INFORMATION (SUCH AS SETTINGS) THAT NEEDS TO BE PRESERVED WHEN THE PRODUCT IS POWER-CYCLED OR OTHERWISE RESTARTED. ESTABLISHED NONVOLATILE MEMORY TECHNOLOGIES HAVE A PHYSICAL LIMIT ON THE NUMBER OF TIMES THEY CAN BE ERASED AND WRITTEN. IN THIS PRODUCT, THE LIMIT IS 100,000 ERASE/WRITE CYCLES. DURING PRODUCT APPLICATION, CONSIDERATION SHOULD BE GIVEN TO COMMUNICATIONS, LOGIC, AND OTHER FACTORS THAT MAY CAUSE FREQUENT/REPEATED WRITES OF SETTINGS OR OTHER INFORMATION THAT IS RETAINED BY THE PRODUCT. APPLICATIONS THAT RESULT IN SUCH FREQUENT/REPEATED WRITES MAY REDUCE THE USEABLE PRODUCT LIFE AND RESULT IN LOSS OF INFORMATION AND/OR PRODUCT INOPERABILITY.

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PRODUCT REVISION HISTORY

The following information provides a historical summary of the changes made to the embedded software (firmware) of this device. The corresponding revisions made to this instruction manual are also summarized. This revision history is separated into two categories: Software Changes and Manual Revisions. All revisions are listed in chronological order.

Modbus® Program Firmware Version	Change
07.01.00 – 04/01	Initial release

The following information provides a historical summary of the changes made to this manual. All revisions are listed in chronological order.

Revision - Date	Change
None – 04/01	Initial release
A – 11/02	In Table 4, parameter descriptions were modified for holding registers 40040, 40046, and 40052.
B – 09/17	Added caution box about nonvolatile memory overwrite.

TABLE OF CONTENTS

GENERAL INFORMATION

This document describes the Modbus® communications protocol employed by BE1-MMS relays, and how to exchange information with BE1-MMS relays over a Modbus® network. The BE1-MMS communicates by emulating a subset of the Modicon 984 Programmable Controller.

FUNCTIONAL DESCRIPTION

Modbus® communications use a master-slave technique in which only the master can initiate a transaction. This transaction is called a query. When appropriate, a slave (BE1-MMS) responds to the query. When a Modbus® master communicates with a slave, information is provided or requested by the master. Information residing in the BE1-MPS100 is grouped categorically as follows:

Category

Session Parameters
Global Parameters
Control Parameters (Select Before Operate)
Setting Parameters
Report Parameters
Metering Parameters

All supported data can be read as specified in the register table. Abbreviations are used in the *Register Table* to indicate the register type. Register types are:

Read/Write = RW
Read Only = R -

Select Before Operate (SBO) functions are used to change active settings groups and control outputs. There are two settings groups in the BE1-MMS, one of which may be selected as active using SBO commands.

When a slave receives a query, the slave responds by either supplying the requested data to the master or performing the requested action. A slave device never initiates communications on the Modbus®, and will always generate a response to the query unless certain error conditions occur. The BE1-MMS is designed to communicate on the Modbus® only as a slave device.

Message Structure

Master initiated queries and BE1-MMS responses share the same message structure. Each message is comprised of four message fields. They are:

- Device Address (1 byte)
- Function Code (1 byte)
- Data Block (n bytes)
- Error Check field (2 bytes)

Device Address Field

NOTE
To set the device address from the front panel, use the COM SETTINGS screen in the GENERAL SETTINGS branch and set the **ADR** parameter on screen COM1 or COM2.

The device address field contains the unique Modbus® address of the slave being queried. The addressed slave repeats the address in the device address field of the response message. This field is 1 byte.

Although Modbus® protocol limits a device address from 1 - 247, a BE1-MMS can be assigned a device address in the range of 1 - 65534. The address is user-selectable at installation, and can be altered during real-time operation.

Function Code Field

The function code field in the query message defines the action to be taken by the addressed slave. This field is echoed in the response message, and is altered by setting the most significant bit (MSB) of the field to 1 if the response is an error response. This field is 1 byte.

The BE1-MMS maps all available data into the Modicon 984 holding register address space (4XXXX) and supports the following function codes.

- Function 03 (03 hex) - read holding registers
- Function 06 (06 hex) – preset single register (write single holding register)
- Function 16 (10 hex) - preset multiple registers, non-broadcast and broadcast

Data Block Field

The query data block contains additional information needed by the slave to perform the requested function. The response data block contains data collected by the slave for the queried function. An error response will substitute an exception response code for the data block. The length of this field varies with each query. See the paragraphs on *Register Definitions* in this manual for interpretation of data.

Error Check Field

The error check field provides a method for the slave to validate the integrity of the query message contents and allows the master to confirm the validity of response message contents. This field is 2 bytes.

Serial Transmission Details

A standard Modbus® network offers two transmission modes for communication: ASCII or remote terminal unit (RTU). The BE1-MMS supports only the RTU mode.

Each 8-bit byte in a message contains two 4-bit hexadecimal characters. The message is transmitted in a continuous stream with the LSB of each byte of data transmitted first. Transmission of each 8-bit data byte occurs with one start bit and either one or two stop bits. Parity checking is performed, when enabled, and can be either odd or even. The transmission baud rate is user-selectable, and can be set at installation and altered during real-time operation. The BE1-MMS Modbus® supported baud rates are 2400, 4800, 9600, and 19200. The factory default baud rate is 9600.

NOTE
To set the baud rate from the front panel, use the COM SETTINGS screen in the GENERAL SETTINGS branch and set the **BAUD** parameter on screen COM1 or COM2.

BE1-MMS supports both RS-232 and RS-485 compatible serial interfaces. Both interfaces are accessible from the rear panel of the BE1-MMS. The RS-232 interfaces (front and rear) are configured for ASCII command mode while the RS-485 interface is configured for Modbus™ communication, when this option is installed. The sixth character of the relay style number must be '1' for the relay to be configured for Modbus®.

Message Framing And Timing Considerations

When receiving a message, the BE1-MMS requires an inter-byte latency of 3.5 character times before considering the message complete.

Once a valid query is received, the BE1-MMS waits a specified amount of time before responding. This time delay is set in the remote delay time parameter with the SG-COM ASCII command. This parameter contains a value from 10 - 200 milliseconds. The default value is 10 milliseconds.

Table 1 provides the response message transmission time (in seconds) and 3.5 character times (in milliseconds) for various message lengths and baud rates.

Table 1. Timing Considerations

Baud Rate	3.5 Character Time (ms)	Message Tx Time (sec)	
		128 Bytes	256 Bytes
2400	16.04	0.59	1.17
4800	8.021	0.29	0.59
9600	4.0104	0.15	0.29
19200	2.0052	0.07	0.15

Error Handling And Exception Responses

Any query received that contains a non-existent device address, a framing error, or CRC error is ignored. No response is transmitted. Queries addressed to a BE1-MMS with an unsupported function or illegal values in the data block result in an error response message with an exception response code. The exception response codes supported by the BE1-MMS are provided in Table 2.

Table 2. Supported Exception Response Codes

Code	Name	Meaning
01	Illegal Function	The query Function/Subfunction Code is unsupported; query read of more than 125 registers; query preset of more than 100 registers
02	Illegal Data Address	A register referenced in the data block does not support queried read/write; query preset of a subset of a numerical register group.
03	Illegal Data Value	A preset register data block contains an incorrect number of bytes or one or more data values out of range.

COMMUNICATIONS HARDWARE REQUIREMENTS

The BE1-MMS RS-485 physical interface is three positions of a terminal strip with locations for Send/Receive A (A), Send/Receive B (B) and Signal Ground (C). Refer to the BE1-MMS Instruction Manual (9 3267 00 991) for further details.

DETAILED MESSAGE QUERY AND RESPONSE

A detailed description of BE1-MMS supported message queries and responses is provided in the following paragraphs.

Read Holding Registers

Query

This query message requests a register or block of registers to be read. The data block contains the starting register address and the quantity of registers to be read. A register address of N will read holding register N+1. If the query is a broadcast (device address = 0), no response message is returned.

Device Address
Function Code = 03 (hex)
Starting Address Hi
Starting Address Lo
No. of Registers Hi
No. of Registers Lo
CRC Hi error check
CRC Lo error check

The number of registers cannot exceed 125 without causing an error response with the exception code for an illegal function.

Response

The response message contains the data queried. The data block contains the block length in bytes followed by the data (one Data Hi byte and one Data Lo byte) for each requested register.

Reading an unassigned holding register returns a value of zero.

Device Address
Function Code = 03 (hex)
Byte Count
Data Hi (For each requested register, there is one Data Hi and one Data Lo.)
Data Lo
.
.
Data Hi
Data Lo
CRC Hi error check
CRC Lo error check

Preset Multiple Registers

A preset multiple registers query could address multiple registers in one slave or multiple slaves. If the query is a broadcast (device address = 0), no response message is returned.

Query

A Preset Multiple Register query message requests a register or block of registers to be written. The data block contains the starting address and the quantity of registers to be written, followed by the Data Block byte count and data. The BE1-MMS will perform the write when the device address is the same as the BE1-MMS remote address or when the device address is 0. A device address is 0 for a broadcast query.

A register address of N will write Holding Register N+1.

Data will cease to be written if any of the following exceptions occur.

- Queries to write to Read Only registers result in an error response with Exception Code of “Illegal Data Address”.
- Queries attempting to write more than 100 registers cause an error response with Exception Code “Illegal Function”.
- An incorrect Byte Count will result in an error response with Exception Code of “Illegal Data Value”.
- There are several instances of registers that are grouped together to collectively represent a single numerical BE1-MMS data value (i.e. - floating point data and 32-bit integer data). A query to write a subset of such a register group will result in an error response with Exception Code “Illegal Data Address”.
- A query to write a not allowed value (out of range) to a register results in an error response with Exception Code of “Illegal Data Value”.

Device Address
Function Code = 10 (hex)
Starting Address Hi
Starting Address Lo
No. of Registers Hi
No. of Registers Lo
Byte Count
Data Hi
Data Lo
.
.
Data Hi
Data Lo
CRC Hi error check
CRC Lo error check

Response

The response message echoes the starting address and the number of registers. There is no response message when the query is a broadcast (device address = 0).

Device Address
Function Code = 10 (hex)
Starting Address Hi
Starting Address Lo
No. of Registers Hi
No. of Registers Lo
CRC Hi Error Check
CRC Lo Error Check

DATA FORMATS

BE1-MMS data varies from one to four bytes in length. Single byte data resides in the holding register least-significant byte with the most-significant byte set to zero. Floating point data and long integer data (each 32-bits in length) place the two most-significant bytes in the higher holding register address of the associated register pair.

Floating Point Data Format (FP)

The Modbus™ floating point data format uses two consecutive holding registers to represent a data value. The first register contains the low-order 16 bits of the following 32 bit format:

- MSB is the sign bit for the floating point value (0 = positive).
- The next 8 bits are the exponent biased by 127 decimal.
- The 23 LSBs comprise the normalized mantissa. The most-significant bit of the mantissa is always assumed to be 1 and is not explicitly stored, yielding an effective precision of 24 bits.

The value of the floating point number is obtained by multiplying the binary mantissa times two raised to the power of the unbiased exponent. The assumed bit of the binary mantissa has the value of 1.0, with the remaining 23 bits providing a fractional value. Table 3 shows the floating point format.

Table 3. Floating Point Format

Sign	Exponent + 127	Mantissa
1 Bit	8 Bits	23 Bits

The floating point format allows for values ranging from approximately $8.43X10^{-37}$ to $3.38X10^{38}$. A floating point value of all zeroes is the value zero. A floating point value of all ones (not a number) signifies a value currently not applicable or disabled.

Example: The value 95,800 represented in floating point format is hexadecimal 47BB1C00. This number will read from two consecutive holding registers as follows:

Holding Register	Value
K (Hi Byte)	hex 1C
K (Lo Byte)	hex 00
K+1 (Hi Byte)	hex 47
K+1 (Lo Byte)	hex BB

The same byte alignments are required to write.

Sixteen-Bit Data Format

All Modbus® 16-bit data is in hexadecimal. The 16-bit data format range is 0h to ffffh which is equal to 0 to 65535 in decimal.

CRC Error Check

This field contains a two-byte CRC value for transmission error detection. The master first calculates the CRC and appends it to the query message. The BE1-MMS recalculates the CRC value for the received query and performs a comparison to the query CRC value to determine if a transmission error has occurred. If so, no response message is generated. If no transmission error has occurred, the slave calculates a new CRC value for the response message and appends it to the message for transmission.

The CRC calculation is performed using all bytes of the device address, function code and data block fields. A 16-bit CRC-register is initialized to all 1's. Then each eight-bit byte of the message is used in the following algorithm:

First, exclusive-OR the message byte with the low-order byte of the CRC-register. The result, stored in the CRC-register, will then be right-shifted eight times. The CRC-register MSB is zero-filled with each shift. After each shift, the CRC-register LSB is examined. If the LSB IS a 1, the CRC-register is then exclusive-ORed with the fixed polynomial value A001 (hex) prior to the next shift. Once all bytes of the message have undergone the above algorithm, the CRC-register will contain the message CRC value to be placed in the error check field.

Select Before Operate Registers

Select before operate is a special function that requires a preset multiple register query to enable the write (operate) command. The preset multiple register query (write command) to CONTROL SELECT register 4311x (with appropriate data) opens a 30 second enabling window. The preset multiple register query to CONTROL OPERATE register 4312x (write command) must be received during the time that the window is enabled. Once the operate command is executed, the enabling window automatically closes. Subsequent operate commands are ignored and the ILLEGAL FUNCTION response is returned by the slave.

Preset Single Register (Write Single Holding Register)

A Preset Single Register query message requests a single register to be written. The BE1-951 will perform the write when the device address is the same as the BE1-951's remote address.

Query

Data will cease to be written if any of the following exceptions occur.

- Queries to write to Read Only registers result in an error response with Exception Code of "Illegal Data Address".
- A query to write an unallowed value (out of range) to a register results in an error response with Exception Code of "Illegal Data Value".

Device Address
Function Code = 06 (hex)
Address Hi
Address Lo
Data Hi
Data Lo
CRC Hi error check
CRC Lo error check

Response

The response message echoes the Query message after the register has been altered.

MODBUS® REGISTERS

BE1-MMS registers are arranged so that the most efficient operation occurs when Modbus® requests are structured to correspond with the TNP polls. This structure also ensures that the data is time-consistent.

Registers 40XXX

Registers 40xxx are read-only, floating point data format. Each data item (parameter) uses two registers: an even-odd pair. Users must specify only even-numbered registers and an even register count. Requests for odd-numbered registers or odd-numbered register counts receive the exception code for ILLEGAL DATA ADDRESS.

Table 4. Read-Only Registers 40xxx (Equivalent to TNP "A" Poll Response)

Holding Register	Parameter
40002	Volts A phase
40004	Volts B phase
40006	Volts C phase
40008	Current A phase
40010	Current B phase
40012	Current C phase
40014	Current N phase
40016	Watts A phase
40018	Watts B phase
40020	Watts C phase
40022	Total Watts (sum of phases)
40024	VARs A phase
40026	VARs B phase
40028	VARs C phase

Holding Register	Parameter
40030	Total VARs (sum of phases)
40032	Power Factor
40034	Frequency
40036	Kilowatt-hours positive
40038	Kilowatt-hours negative
40040	Kilowatt-hours total
40042	Kilovar-hours positive
40044	Kilovar-hours negative
40046	Kilovar-hours total
40048	Kilo-volt-ampere-hours positive
40050	Kilo-volt-ampere-hours negative
40052	Kilo-volt-ampere-hours total
40054	Pulse 1 accumulated
40056	Pulse 2 accumulated
40058	Pulse 3 accumulated
40060	Pulse 4 accumulated
40062	Accumulated total
40064	Minutes (since last reset)
40066	Maximum volts A phase
40068	Maximum volts B phase
40070	Maximum volts C phase
40072	Minimum volts A phase
40074	Minimum volts B phase
40076	Minimum volts C phase
40078	Maximum current A phase
40080	Maximum current B phase
40082	Maximum current C phase
40084	Maximum current N phase
40086	Minimum current A phase
40088	Minimum current B phase
40090	Minimum current C phase
40092	Minimum current N phase
40094	Maximum watts A phase
40096	Maximum watts B phase
40098	Maximum watts C phase
40100	Minimum watts A phase
40102	Minimum watts B phase
40104	Minimum watts C phase
40106	Total watts maximum
40108	Total watts minimum
40110	Maximum vars A phase
40112	Maximum vars B phase
40114	Maximum vars C phase
40116	Minimum vars A phase
40118	Minimum vars B phase
40120	Minimum vars C phase

Holding Register	Parameter
40122	Total vars maximum
40124	Total vars minimum

Table 5. Read-Only Registers 40202 to 40208 Equivalent to TNP "P" Poll Response

Holding Register	Parameter
40202	Pulse Counter 1
40204	Pulse Counter 2
40206	Pulse Counter 3
40208	Pulse Counter 4

Table 6. Read-Only Registers 40302 to 40306

Holding Register	Parameter
40302	Total harmonic distortion phase A
40304	Total harmonic distortion phase B
40306	Total harmonic distortion phase C

Table 7. Read-Only Registers 40402 TO 40462

Holding Register	Parameter
40402	Harmonics A 1
40404	Harmonics A 2
40406	Harmonics A 3
40408	Harmonics A 4
40410	Harmonics A 5
40412	Harmonics A 6
40414	Harmonics A 7
40416	Harmonics A 8
40418	Harmonics A 9
40420	Harmonics A 10
40422	Harmonics A 11
40424	Harmonics A 12
40426	Harmonics A 13
40428	Harmonics A 14
40430	Harmonics A 15
40432	Harmonics A 16
40434	Harmonics A 17
40436	Harmonics A 18
40438	Harmonics A 19
40440	Harmonics A 20
40442	Harmonics A 21
40444	Harmonics A 22
40446	Harmonics A 23
40448	Harmonics A 24
40450	Harmonics A 25

Holding Register	Parameter
40452	Harmonics A 26
40454	Harmonics A 27
40456	Harmonics A 28
40458	Harmonics A 29
40460	Harmonics A 30
40462	Harmonics A 31

Table 8. Read-Only Registers 40502 TO 40562

Holding Register	Parameter
40502	Harmonics B 1
40504	Harmonics B 2
40506	Harmonics B 3
40508	Harmonics B 4
40510	Harmonics B 5
40512	Harmonics B 6
40514	Harmonics B 7
40516	Harmonics B 8
40518	Harmonics B 9
40520	Harmonics B 10
40522	Harmonics B 11
40524	Harmonics B 12
40526	Harmonics B 13
40528	Harmonics B 14
40530	Harmonics B 15
40532	Harmonics B 16
40534	Harmonics B 17
40536	Harmonics B 18
40538	Harmonics B 19
40540	Harmonics B 20
40542	Harmonics B 21
40544	Harmonics B 22
40546	Harmonics B 23
40548	Harmonics B 24
40550	Harmonics B 25
40552	Harmonics B 26
40554	Harmonics B 27
40556	Harmonics B 28
40558	Harmonics B 29
40560	Harmonics B 30
40562	Harmonics B 31

Table 9. Read-Only Registers 40602 TO 40662

Holding Register	Parameter
40602	Harmonics C 1
40604	Harmonics C 2
40606	Harmonics C 3
40608	Harmonics C 4
40610	Harmonics C 5
40612	Harmonics C 6
40614	Harmonics C 7
40616	Harmonics C 8
40618	Harmonics C 9
40620	Harmonics C 10
40622	Harmonics C 11
40624	Harmonics C 12
40626	Harmonics C 13
40628	Harmonics C 14
40630	Harmonics C 15
40632	Harmonics C 16
40634	Harmonics C 17
40636	Harmonics C 18
40638	Harmonics C 19
40640	Harmonics C 20
40642	Harmonics C 21
40644	Harmonics C 22
40646	Harmonics C 23
40648	Harmonics C 24
40650	Harmonics C 25
40652	Harmonics C 26
40654	Harmonics C 27
40656	Harmonics C 28
40658	Harmonics C 29
40660	Harmonics C 30
40662	Harmonics C 31

Registers 41XXX

Registers 41xxx are 16-bit, read-only registers.

Table 10. Read-Only Registers 41xxx

Holding Register	Parameter
41001	Digital input status
41101	Digital output status

Registers 42XXX

Registers 40xxx are read/write, floating point registers. Each data item (parameter) uses two registers: an even-odd pair. Users must specify only even-numbered registers and an even register count. Requests for odd-numbered registers or odd-numbered register counts receive the exception code for ILLEGAL DATA ADDRESS.

*Table 11. R*ead/Write *Registers 42002 TO 42018*

Holding Register	Parameter
42002	Phase CT
42004	Neutral CT
42006	PT
42008	Pulse input multiplier 1
42010	Pulse input multiplier 2
42012	Pulse input multiplier 3
42014	Pulse input multiplier 4
42016	Pulse out multiplier 1
42018	Pulse out multiplier 2

Registers 430XX

Registers 430xx are 16-bit integer, write-only registers.

Table 12. Write-Only Registers 430xx

Holding Register	Parameter
43001	Pulse out source 1
43002	Pulse out source 2
43003	Accumulated total source

Select Before Operate Registers 4311X (Select)

Registers 4311x are 16-bit integer, write-only registers. Registers 43110 through 43115 are formatted as follows:

- If the high-order bit is zero, it is a momentary operation and the low-order fifteen bits is the pulse time in milliseconds.
- If the high-order bit is one, it is a latched operation and the low-order bit indicates ON or OFF. If the low-order bit is a one, the latched operation is ON. If the low-order bit is a zero, the latched operation is OFF.

Table 13. Write-Only Registers 4311x

Holding Register	Parameter
43101 to 43109	Reserved (Unused)
43110	Select output 1
43111	Select output 2
43112	Select output 3
43113	Select output 4
43114	Select output 5
43115	Select output 6
43116 to 43119	Reserved (Unused)

Select Before Operate Registers 4312X (Operate)

Registers 4312x are 16-bit integer, write-only registers. Registers 43120 through 43125 are formatted as follows:

- If the high-order bit is zero, it is a momentary operation and the low-order fifteen bits is the pulse time in milliseconds.
- If the high-order bit is one, it is a latched operation and the low-order bit indicates ON or OFF. If the low-order bit is a one, the latched operation is ON. If the low-order bit is a zero, the latched operation is OFF.

Table 14. Write-Only Registers 4312x

Holding Register	Parameter
43120	Operate output 1
43121	Operate output 2
43122	Operate output 3
43123	Operate output 4
43124	Operate output 5
43125	Operate output 6

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