SERIES PM130P/E/EH POWERMETERS

COMMUNICATIONS

Modbus Communications Protocol

REFERENCE GUIDE

REVISION HISTORY

Rev.A2 (F/W Version 3.54 or later).

Rev.A3 (F/W Version 3.58.1 or later):

1. Added the firmware build number (Table 5-6).
2. Added three-phase average voltage and current registers.

BG0373 Rev.A3

Table of Contents

1 GENERAL

This document specifies a subset of the Modbus serial communications protocol used to transfer data between a master computer station and the PM130. The document provides the complete information necessary to develop a third-party communications software capable of communication with the Series PM130 Powermeters. Additional information concerning communications operation, configuring the communications parameters, and communications connections is found in "Series PM130 Powermeters, Installation and Operation Manual".

IMPORTANT

In 3-wire connection schemes, the unbalanced current and phase readings for power factor, active power, and reactive power will be zeros, because they have no meaning. Only the total three-phase power values can be used.

Most of the instrument advanced features are configured using multiple setup parameters that can be accessed in some contiguous registers. When writing the setup registers, it is recommended to write all the registers at once using a single request, or to clear (zero) the setup before writing into separate registers.

Designations used in the guide:

E - available in the meters with the E and EH suffixes
EH - available in the meters with the EH suffix

2 MODBUS FRAMING

2.1 Transmission Mode

The protocol uses the Modbus Remote Terminal Unit (RTU) transmission mode. In RTU mode, data is sent in 8-bit binary characters. The 8 bit even parity or 8 bit no parity data format must be selected when configuring the instrument communications. The data format is shown in the following table.

Table 2-1 RTU Data Format

Field	No. of bits
Start bit	1
Data bits ①	8
Parity (optional)	1
Stop bit	1

① Least significant bit first

2.2 The RTU Frame Format

Frame synchronization is maintained in RTU transmission mode by simulating a synchronization message. The receiving device monitors the elapsed time between receptions of characters. If three and one-half character times elapse without a new character or completion of the frame, then the device flushes the frame and assumes that the next byte received will be an address. The frame format is defined below.

The maximum query and response message length is 256 bytes including check characters.

RTU Message Frame Format

T1 T2 T3	Address	Function	Data	CRC Check	T1 T2 T3
	8 bits	8 bits	N * 8 bits	16 bits	

2.3 Address Field

The address field contains a user assigned address (1-247) of the instrument that is to receive a message. Address 0 is used in broadcast mode to transmit to all instruments (broadcast mode is available only for functions 06 and 16). In this case all instruments receive the message and take action on the request, but do not issue a response. In the PM130, the broadcast mode is supported only for register addresses 287-294 and 301-302 (reset energies and maximum demands), 3404-3415 (reset/clear registers), and 4352-4358 (real-time clock registers).

2.4 Function Field

The function field contains a function code that tells the instrument what action to perform. Function codes used in the protocol are shown below in Table 2-2.

Table 2-2 Modbus Function Codes

Code (decimal)	Meaning in Modbus	Action
03	Read holding registers	Read multiple registers
04	Read input registers	Read multiple registers
06	Preset single register	Write single register
16	Preset multiple registers	Write multiple registers
08	Loop-back test	Communications test

NOTE Broadcast mode available only for functions code 06 and 16.

2.5 Data Field

The data field contains information needed by the instrument to perform a specific function, or data collected by the instrument in response to a query.

IMPORTANT Fields composed of two bytes are sent in the order high byte first, low byte second.

2.6 Error Check Field

The error check field contains the Cyclical Redundancy Check (CRC) word. The start of the message is ignored in calculating the CRC. The CRC-16 error check sequence is implemented as described in the following paragraphs.

The message (data bits only, disregarding start/stop and optional parity bits) is considered one continuous binary number whose most significant bit (MSB) is transmitted first. The message is pre-multiplied by x^{16} (shifted left 16 bits), and then divided by $x^{16} + x^{15} + x^2 + 1$ expressed as a binary number (11000000000000101). The integer quotient digits are ignored and the 16-bit remainder (initialized to all ones at the start to avoid the case of all zeros being an accepted message) is appended to the message (MSB first) as the two CRC check bytes. The resulting message including CRC, when divided by the same polynomial ($x^{16} + x^{15} + x^2 + 1$) at the receiver will give a zero remainder if no errors have occurred. (The receiving unit recalculates the CRC and compares it to the transmitted CRC). All arithmetic is performed modulo two (no carries).

The device used to serialize the data for transmission will send the conventional LSB or right-most bit of each character first. In generating the CRC, the first bit transmitted is defined as the MSB of the dividend. For convenience, and since there are no carries used in the arithmetic, let's assume while computing the CRC that the MSB is on the right. To be consistent, the bit order of the generating polynomial must be reversed. The MSB of the polynomial is dropped since it affects only the quotient and not the remainder. This yields 1010 0000 0000 0001 (Hex A001). Note that this reversal of the bit order will have no effect whatever on the interpretation or bit order of characters external to the CRC calculations.

The step by step procedure to form the CRC-16 check bytes is as follows:

1. Load a 16-bit register with all 1's.
2. Exclusive OR the first 8-bit byte with the low order byte of the 16-bit register, putting the result in the 16-bit register.
3. Shift the 16-bit register one bit to the right.

4a. If the bit shifted out to the right (flag) is one, exclusive OR the generating polynomial 1010 000 000 0001 with the 16-bit register.

4b. If the bit shifted out to the right is zero, return to step 3.

5. Repeat steps 3 and 4 until 8 shifts have been performed.
6. Exclusive OR the next 8-bit byte with the 16-bit register.
7. Repeat step 3 through 6 until all bytes of the message have been exclusive ORed with the 16-bit register and shifted 8 times.
8. When the 16-bit CRC is transmitted in the message, the low order byte will be transmitted first, followed by the high order byte.

For detailed information about CRC calculation, refer to the Modbus Protocol Reference Guide.

3 MODBUS MESSAGE FORMATS

3.1 Function 03 - Read Multiple Registers

This command allows the user to obtain contents of up to 125 contiguous registers from a single data table.

Request

Instrument Address	Function (03)	Starting Address	Word Count	Error Check
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Starting Address Address of the first register to be read
Word Count The number of contiguous words to be read

Response

Instrument Address	Function (03)	Byte Count	Data Word 1	...	Data Word N	Error Check
1 byte	1 byte	1 byte	2 bytes	...	2 bytes	2 bytes

The byte count field contains quantity of bytes to be returned.

3.2 Function 04 - Read Multiple Registers

This command allows the user to obtain contents of up to 125 contiguous registers from a single data table. It can be used instead of function 03.

Request

Instrument Address	Function (04)	Starting Address	Word Count	Error Check
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Starting Address Address of the first register to be read
Word Count The number of contiguous words to be read

Response

Instrument Address	Function (04)	Byte Count	Data Word 1	...	Data Word N	Error Check
1 byte	1 byte	1 byte	2 bytes	...	2 bytes	2 bytes

The byte count field contains quantity of bytes to be returned.

3.3 Function 06 - Write Single Register

This command allows the user to write the contents of a data register in any data table where a register can be written.

Request

Instrument Address	Function (06)	Starting Address	Data Word	Error check
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Starting Address Address of the register to be written
Data Value Data to be written to the register

Response

The normal response is the retransmission of the write request.

3.4 Function 16 - Write Multiple Registers

This request allows the user to write the contents of multiple contiguous registers to a single data table where registers can be written.

Request

Instrument Address	Function (16)	Starting Address	Word Count	Byte Count
1 byte	1 byte	2 bytes	2 bytes	1 byte

Data Word 1	...	...	...	Data Word N	Error Check
2 bytes	...	...	...	2 bytes	2 bytes

Starting Address Address of the first register to be written
Word Count The number of contiguous words to be written
Byte Count The number of bytes to be written

Response

Instrument Address	Function (16)	Starting Address	Word Count	Error Check
1 byte	1 byte	2 bytes	1 word	2 bytes

3.5 Function 08 - Loop-back Communications Test

The purpose of this request is to check the communications link between the specified instrument and PC.

Request

Instrument Address	Function (08)	Diagnostic Code (0)	Data	Error Check
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Diagnostic Code Designates action to be taken in Loop-back test. The protocol supports only Diagnostic Code 0 - return query data.

Data Query data. The data passed in this field will be returned to the master through the instrument. The entire message returned will be identical to the message transmitted by the master, field-per-field.

Response

Instrument Address	Function (08)	Diagnostic Code (0)	Data	Error Check
1 byte	1 byte	2 bytes	2 bytes	2 bytes

The normal response is the re-transmission of a test message.

3.6 Exception Responses

The instrument sends an exception response when errors are detected in the received message. To indicate that the response is notification of an error, the high order bit of the function code is set to 1.

Exception Response

Instrument Address	Function (high order bit is set to 1)	Exception Code	Error Check
1 byte	1 byte	1 byte	2 byte

Exception response codes:
01 - Illegal function
02 - Illegal data address
03 - Illegal data value
06 - Busy, rejected message. The message was received without errors, but the instrument is being programmed from the keypad (only for requests accessing setup registers).

NOTE When the character framing, parity, or redundancy check detects a communication error, processing of the master's request stops. The instrument will not act on or respond to the message.

4 PROTOCOL IMPLEMENTATION

4.1 Modbus Register Addresses

The PM130 Modbus registers are referred to by using addresses in the range of 0 to 65535. From within the Modbus applications, the PM130 Modbus registers can be accessed by simulating holding registers of the Modicon 584, 884 or 984 Programmable Controller, using a 5-digit “4XXXX” or 6-digit “4XXXXX” addressing scheme. To map the PM130 register address to the range of the Modbus holding registers, add a value of 40001 to the PM130 register address. When a register address exceeds 9999, use a 6-digit addressing scheme by adding 400001 to the PM130 register address.

4.2 Data Formats

The PM130 uses three data formats to pass data between a master application and the instrument: a 16-bit integer format, a 32-bit modulo 10000 format, and a 32-bit long integer format.

4.2.1 16-bit Integer Format

A 16-bit data is transmitted in a single 16-bit Modbus register as unsigned (UINT16) or signed (INT16) integer (whole) numbers without conversion or using pre-scaling to accommodate large-scale and fractional numbers to a 16-bit register format. Scaling can be made using either the LIN3 linear conversion, or decimal pre-scaling to pass fractional numbers in integer format.

Non-scaled data

The data will be presented exactly as retrieved by the communications program from the instrument. The value range for unsigned data is 0 to 65535; for signed data the range is -32768 to 32767.

LIN3 (Linear) Scaling

This conversion maps the raw data received by the communications program in the range of 0-9999 onto the user-defined LO scale/HI scale range. The conversion is carried out according to the formula:

$$Engineering\_Units\_Value = \frac{Raw\_Data \times (HI - LO)}{9999} + LO$$

where:

Engineering_Units_Value	-	the true value in engineering units
Raw_Data	-	the raw input data in the range of 0 - 9999
LO, HI	-	the data low and high scales in engineering units

When data conversion is necessary, the HI and LO scales, and data conversion method are indicated for the corresponding registers.

Conversion Examples

1. Voltage readings

a) Assume device settings (690V input, direct wiring): PT ratio = 1.

Voltage engineering scales (see Note 1 to Table 5-1):

HI = Vmax = 828V
LO = 0V

If the raw data reading is 1449 then the voltage reading in engineering units will be as follows:

Volts reading = 1449 × (828 - 0)/9999 + 0 = 120V

b) Assume device settings (wiring via PT): PT ratio = 14,400V : 120V = 120.

Voltage engineering scales:

HI = Vmax = 144 × PT ratio = 144 × 120 = 17,280V

LO = 0V

If the raw data reading is 8314 then the voltage reading in engineering units will be as follows:

Volts reading = 8314 × (17,280 - 0)/9999 + 0 = 14,368V

2. Current readings

Assume device settings: CT primary current = 200A; current input overload = 150% (7.5A).

Current engineering scales:

HI = Imax = CT primary current × 1.5 = 200 × 1.5 = 300A
LO = 0A

If the raw data reading is 250 then the current reading in engineering units will be as follows:

Amps reading = 250 × (300 - 0)/9999 + 0 = 7.5A

3. Power readings

a) Assume device settings (690V input, direct wiring): wiring configuration 4LN3; PT = 1; CT primary current = 200A.

Active Power engineering scales:

HI = Pmax = Vmax × Imax × 3 = 828 × (200 × 1.5) × 3 = 745,200W = 745.2kW
LO = -Pmax = -745.2kW

If the raw data reading is 5500 then the power reading in engineering units will be as follows:

Watts reading = 5500 × (745.2 - (-745.2))/9999 + (-745.2) = 74.6kW

If the raw data reading is 500 then the power reading in engineering units will be as follows:

Watts reading = 500 × (745.2 - (-745.2))/9999 + (-745.2) = -670.67kW

b) Assume device settings (wiring via PT): wiring configuration 4LL3; PT = 120; CT primary current = 200A.

Active Power engineering scales:

HI = Pmax = Vmax × Imax × 2 = (144 × 120) × (200.00 × 1.5) × 2/1000 = 10368kW
LO = -Pmax = -10368kW

If the raw data reading is 5500 then the power reading in engineering units will be as follows:

Watts reading = 5500 × (10368 - (-10368))/9999 + (-10368) = 1037.9kW

If the raw data reading is 500 then the power reading in engineering units will be as follows:

Watts reading = 500 × (10368 - (-10368))/9999 + (-10368) = -9331.1kW

4. Power Factor readings

Power factor engineering scales:

HI = 1.000.
LO = -1.000.

If the raw data reading is 8900 then the power factor in engineering units will be as follows:

Power factor reading = 8900 × (1.000 - (-1.000))/9999 + (-1.000) = 0.78

Decimal Scaling

Decimal pre-scaling can be used to accommodate fractional numbers to an integer register format. Fractional numbers pre-multiplied by 10 in power N, where N is the number of digits in the fractional part. For example, the frequency reading of 50.01 Hz is transmitted as 5001, having been pre-multiplied by 100. Whenever a data register contains a fractional number, the register measurement unit is given with a multiplier ×0.1, ×0.01 or ×0.001, showing an actual register resolution (the weight of the least significant decimal digit). To get an actual fractional number with specified precision, scale the register value with the given multiplier. To write a fractional number into the register, divide the number by the given multiplier.

4.2.2 32-bit Modulo 10000 Format

The short energy registers 287-294, and 301-302 are transmitted in two contiguous 16-bit registers in modulo 10000 format. The first (low order) register contains the value mod 10000, and the second (high order) register contains the value/10000. To get the true energy reading, the high order register value should be multiplied by 10,000 and added to the low order register.

4.2.3 32-bit Long Integer Format

In a 32-bit long integer format, data is transmitted in two adjacent 16-bit Modbus registers as unsigned (UINT32) or signed (INT32) long integer (whole) numbers. The first register contains the low-order word (lower 16 bits) and the second register contains the high order word (higher 16 bits) of the 32-bit long number. The low-order word always starts at an even Modbus address. The value range for unsigned data is 0 to 4,294,967,295; for signed data the range is -2,147,483,648 to 2,147,483,647.

Negative values are transmitted in a two's complement code. This means that a negative value is added to 4,294,967,296, that is 2 to power 32.

Fractional numbers are premultiplied by 10 to power N, where N is the number of decimal places, and are transmitted as whole numbers.

If your Modbus driver does not support a 32-bit long integer format, you can read the two 16-bit registers separately, and then convert them into a 32-bit value as follows (using C notation):

32-bit value = (signed short)high_order_register × 65536L + (unsigned short)low_order_register

Examples

1. Unsigned 32-bit Values

If you read unsigned Voltage V1 of 69,000V from registers 13952-13953, then the register readings will be as follows:

(13952) = 3464
(13953) = 1

The 32-bit value is (1 x 65536 + 3464) = 69000V.

2. Signed 32-bit Values

If you read signed kW of -789kW from registers 14336-14337, then the register readings will be:

(14336) = 64747 (unsigned)
(14337) = 65535 (unsigned) or -1(signed value).

To take the high order register as a signed value, compare it with 32767. If the value is less or equal to 32767, use it as is. If it is greater than 32767, then this is a negative number in a two's complement code (like in our example) - just subtract it from 65536 to get the original negative value.

The 32-bit reading is (-1 x 65536 + 64747) = -789kW.

4.3 User Assignable Registers

The PM130 contains the 120 user assignable registers in the address range of 0 to 119 (see Table 4-1), any of which you can map to either register address accessible in the instrument. Registers that reside in different locations may be accessed by a single request by re-mapping them to adjacent addresses in the user assignable registers area.

The actual addresses of the assignable registers which are accessed via addresses 0 to 119 are specified in the user assignable register map (see Table 4-2). This map occupies addresses from 120 to 239, where map register 120 should contain the actual address of the register accessed via assignable register 0, register 121 should contain the actual address of the register accessed via assignable register 1, and so on. Note that the assignable register addresses and the map register addresses may not be re-mapped.

To build your own register map, write to map registers (120 to 239) the actual addresses you want to read from or write to via the assignable area (0 to 119). Note that long word registers should always be aligned at even addresses. For example, if you want to read registers 7136 (real-time voltage of phase A, word) and 7576/7577 (kWh import, long word) via registers 0-2, then do the following:

- write 7576 to register 120
- write 7577 to register 121
- write 7136 to register 122

Reading from registers 0-2 will return the kWh reading in registers 0 (low word) and 1 (high word), and the voltage reading in register 2.

Table 4-1 User Assignable Registers

Address	Register contents	Type
0	Assigned register #0	INT16
1	Assigned register #1	INT16
2	Assigned register #2	INT16
…	…	…
119	Assigned register #119	INT16

Table 4-2 User Assignable Register Map

Address	Register contents	Type	R/W	Range
120	Mapped address for register #0	UINT16	R/W	256 to 65535
121	Mapped address for register #1	UINT16	R/W	256 to 65535
122	Mapped address for register #2	UINT16	R/W	256 to 65535
…	…	…	…	…
239	Mapped address for register #119	UINT16	R/W	256 to 65535

5 POWERMETER REGISTERS DESCRIPTION

5.1 Basic Data Registers Set

Table 5-1 Basic Data Registers

Address	Parameter	Type	R/W	Unit	Scale [1]		Con-version
					Low	High	
256	Voltage L1/L12 [5]	UINT16	R	V	0	Vmax	LIN3
257	Voltage L2/L23 [5]	UINT16	R	V	0	Vmax	LIN3
258	Voltage L3/L31 [5]	UINT16	R	V	0	Vmax	LIN3
259	Current L1	UINT16	R	A	0	Imax	LIN3
260	Current L2	UINT16	R	A	0	Imax	LIN3
261	Current L3	UINT16	R	A	0	Imax	LIN3
262	kW L1	UINT16	R	kW	-Pmax	Pmax	LIN3
263	kW L2	UINT16	R	kW	-Pmax	Pmax	LIN3
264	kW L3	UINT16	R	kW	-Pmax	Pmax	LIN3
265	kvar L1	UINT16	R	kvar	-Pmax	Pmax	LIN3
266	kvar L2	UINT16	R	kvar	-Pmax	Pmax	LIN3
267	kvar L3	UINT16	R	kvar	-Pmax	Pmax	LIN3
268	kVA L1	UINT16	R	kVA	-Pmax	Pmax	LIN3
269	kVA L2	UINT16	R	kVA	-Pmax	Pmax	LIN3
270	kVA L3	UINT16	R	kVA	-Pmax	Pmax	LIN3
271	Power factor L1	UINT16	R	0.001	-1.000	1.000	LIN3
272	Power factor L2	UINT16	R	0.001	-1.000	1.000	LIN3
273	Power factor L3	UINT16	R	0.001	-1.000	1.000	LIN3
274	Total power factor	UINT16	R	0.001	-1.000	1.000	LIN3
275	Total kW	UINT16	R	kW	-Pmax	Pmax	LIN3
276	Total kvar	UINT16	R	kvar	-Pmax	Pmax	LIN3
277	Total kVA	UINT16	R	kVA	-Pmax	Pmax	LIN3
278	Neutral current	UINT16	R	A	0	Imax	LIN3
279	Frequency	UINT16	R	0.01Hz	45.00	65.00	LIN3
280	Maximum sliding window kW demand [4 E]	UINT16	R/W	kW	-Pmax	Pmax	LIN3
281	Accumulated kW demand [E]	UINT16	R/W	kW	-Pmax	Pmax	LIN3
282	Maximum sliding window kVA demand [4 E]	UINT16	R/W	kVA	-Pmax	Pmax	LIN3
283	Accumulated kVA demand [E]	UINT16	R/W	kVA	-Pmax	Pmax	LIN3
284	Max. ampere demand L1	UINT16	R/W	A	0	Imax	LIN3
285	Max. ampere demand L2	UINT16	R/W	A	0	Imax	LIN3
286	Max. ampere demand L3	UINT16	R/W	A	0	Imax	LIN3
287	kWh import (low) [E]	UINT16	R/W	kWh	0	9999	NONE
288	kWh import (high) [E]	UINT16	R/W	10,000 kWh	0	9999	x10^4
289	kWh export (low) [E]	UINT16	R/W	kWh	0	9999	NONE
290	kWh export (high) [E]	UINT16	R/W	10,000 kWh	0	9999	x10^4
291	+kvarh net (low) [2 E]	UINT16	R/W	kvarh	0	9999	NONE
292	+kvarh net (high) [2 E]	UINT16	R/W	10,000 kvarh	0	9999	x10^4
293	-kvarh net (low) [3 E]	UINT16	R/W	kvarh	0	9999	NONE
294	-kvarh net (high) [3 E]	UINT16	R/W	10,000 kvarh	0	999	x10^4
295	Voltage THD L1/L12 [6 EH]	UINT16	R	0.1%	0	999.9	LIN3
296	Voltage THD L2/L23 [6 EH]	UINT16	R	0.1%	0	999.9	LIN3
297	Voltage THD L3 [6 EH]	UINT16	R	0.1%	0	999.9	LIN3
298	Current THD L1 [EH]	UINT16	R	0.1%	0	999.9	LIN3
299	Current THD L2 [EH]	UINT16	R	0.1%	0	999.9	LIN3
300	Current THD L3 [EH]	UINT16	R	0.1%	0	999.9	LIN3
301	kVAh (low) [E]	UINT16	R/W	kVAh	0	9999	NONE
302	kVAh (high) [E]	UINT16	R/W	10,000 kVAh	0	9999	x10^4
303	Present sliding window kW demand [4 E]	UINT16	R	kW	-Pmax	Pmax	LIN3
304	Present sliding window kVA demand [4 E]	UINT16	R	kVA	-Pmax	Pmax	LIN3
305	PF at maximum siding window kVA demand	UINT16	R	0.001	-1.000	1.000	LIN3
306	Current TDD L1 [EH]	UINT16	R	0.1%	0	100.0	LIN3
307	Current TDD L2 [EH]	UINT16	R	0.1%	0	100.0	LIN3
308	Current TDD L3 [EH]	UINT16	R	0.1%	0	100.0	LIN3

[1] The parameter limits are as follows:

Imax (x150% over-range) = 1.5 × CT primary current [A]

Direct wiring (PT Ratio = 1):

Vmax (690 V input option) = 828 V
Vmax (120 V input option) = 144 V

Wiring via PTs (PT Ratio > 1):

Vmax (690 V input option) = 144 × PT Ratio [V]
Vmax (120 V input option) = 144 × PT Ratio [V]

Pmax = (Imax × Vmax × 3)/1000 [kW] if wiring mode is 4LN3 or 3LN3
Pmax = (Imax × Vmax × 2)/1000 [kW] if wiring mode is 4LL3, 3OP2, 3DIR2, 3OP3 or 3LL3

[2] Positive readings of kvarh net

[3] Negative readings of kvarh net

[4] To get block interval demand readings, specify the number of demand periods equal to 1 (see Table 5-2)

[5] When the 4LN3 or 3LN3 wiring mode is selected, the voltages will be line-to-neutral; for any other wiring mode, they will be line-to-line voltages.

[6] In the 4LN3, 4LL3, 3LN3, 3LL3 and 3DIR2 wiring modes, the harmonic voltages will represent line-to-neutral voltages; in the 3OP2 and 3OP3 wiring modes, they will comprise L12 and L23 line-to-line voltages.

NOTE Writing a zero to one of registers 280-286 causes reset of all maximum demands. Writing a zero to one of registers 287-294 and 301-302 causes reset of all accumulated energies.

5.2 Basic Setup

Table 5-2 Basic Setup Registers

Parameter	Address	Type	R/W	Range
Wiring mode [1]	2304	UINT16	R/W	0 = 3OP2, 1 = 4LN3, 2 = 3DIR2, 3 = 4LL3, 4 = 3OP3, 5 = 3LN3, 6 = 3LL3
PT ratio	2305	UINT16	R/W	10 to 65000 × 0.1
CT primary current	2306	UINT16	R/W	1 to 10000 A
Power demand period [E]	2307	UINT16	R/W	1,2,5,10,15,20,30,60 min, 255 = external synchronization [2]
Volt/ampere demand period	2308	UINT16	R/W	0 to 1800 sec
Averaging buffer size	2309	UINT16	R/W	8, 16, 32
Reset enable/disable	2310	UINT16	R/W	0 = disable, 1 = enable
Reserved	2311	UINT16	R	Read as 65535
The number of demand periods [E]	2312	UINT16	R/W	1 to 15
Reserved	2313	UINT16	R	Read as 65535
Reserved	2314	UINT16	R	Read as 65535
Nominal frequency	2315	UINT16	R/W	50, 60 Hz
Maximum demand load current	2316	UINT16	R/W	0 to 10000 A (0 = CT primary current)

[1] The wiring mode options are as follows:

3OP2 - 3-wire open delta using 2 CTs (2 element)
4LN3 - 4-wire WYE using 3 PTs (3 element), line to neutral voltage readings
3DIR2 - 3-wire direct connection using 2 CTs (2 element)
4LL3 - 4-wire WYE using 3 PTs (3 element), line to line voltage readings
3OP3 - 3-wire open delta using 3 CTs (2 1/2 element)
3LN3 - 4-wire WYE using 2 PTs (2 1/2 element), line to neutral voltage readings
3LL3 - 4-wire WYE using 2 PTs (2 1/2 element), line to line voltage readings

[2] Synchronization of power demand interval can be made through communications using the synchronize power demand interval command (see Table 5-5)

5.3 User Selectable Options Setup

Table 5-3 User Selectable Options Registers

Parameter	Address	Type	R/W	Range
Power calculation mode	2376	UINT16	R/W	0 = using reactive power, 1 = using non-active power
Energy roll value [1] [E]	2377	UINT16	R/W	0 = 1×10^4 1 = 1×10^5 2 = 1×10^6 3 = 1×10^7 4 = 1×10^8
Phase energy calculation mode [E]	2378	UINT16	R/W	0 = disable, 1 = enable

[1] For short energy registers (see Table 5-1), the maximum roll value will be 1×10^8 for positive readings and 1×10^7 for negative readings.

5.4 Communications Setup

Table 5-4 Communications Setup Registers

Parameter	Address	Type	R/W	Range
Reserved	2344	UINT16	R	Read as 65535
Interface	2345	UINT16	R/W	2 = RS-485 (not changeable)
Address	2346	UINT16	R/W	1 to 247
Baud rate	2347	UINT16	R/W	0 = 110 bps 1 = 300 bps 2 = 600 bps 3 = 1200 bps 4 = 2400 bps 5 = 4800 bps 6 = 9600 bps 7 = 19200 bps
Data format	2348	UINT16	R/W	1 = 8 bits/no parity 2 = 8 bits/even parity

When changing the instrument address, baud rate or data format, the new communications parameters will take effect 100 ms after the instrument responds to the master's request.

5.5 Reset/Synchronization Registers

Table 5-5 Reset/Synchronization Registers

Register function	Address	Type	R/W	Reset value
Clear total energy registers [E]	3404	UINT16	W	0
Clear total maximum demand registers	3405	UINT16	W	0 = all maximum demands 1 = power demands [E] 2 = volt/ampere demands
Reserved	3406-3407	UINT16		
Clear event/time counters	3408	UINT16	W	0 = all counters 1-4 = counter #1 - #4
Clear Min/Max log	3409	UINT16	W	0
Reserved	3410-3419	UINT16		
Synchronize power demand interval [1] [E]	3420	UINT16	W	0

[1] 1) If the power demand period is set to External Synchronization (see Table 5-2), writing a zero to this location will simulate an external synchronization pulse denoting the start of the next demand interval. The synchronization requests should not follow in intervals of less than 30 seconds, or the request will be rejected.

2) If the power demand period is specified in minutes, writing a zero to this location provides synchronization of the instrument's internal timer with the time of reception of the master's request. If the time expired from the beginning of the current demand interval is more than 30 seconds, the new demand interval starts immediately, otherwise synchronization is delayed until the next demand interval.

5.6 Instrument Status

Table 5-6 Instrument Status Registers

Parameter	Address	Type	R/W	Range
Instrument reset register [1]	2560	UINT16	R/W	0 (when read) 65535 (when written) = reset the instrument
Reserved	2561	UINT16	R	Read as 0
Relay status	2562	UINT16	R	see Table 5-7
Firmware build number	2563	UINT16	R	0-99
Reserved	2564	UINT16	R	
Firmware version number	2565	UINT16	R	0-65535
Instrument options 1	2566	UINT16	R	See Table 5-8
Instrument options 2	2567	UINT16	R	See Table 5-8

[1] Writing a value of 65535 into register 2560 will cause the instrument to perform a warm restart.

Table 5-7 Relay Status

Bit number	Description
0-6	Not used (permanently set to 1)
7	Relay status
8-15	Not used (permanently set to 0)

Bit meaning: 0 = relay operated, 1 = relay released

Table 5-8 Instrument Options

Options register	Bit	Description
Options1	0	120V option
	1	690V option
	2-4	Reserved
	5	150% current over-range
	6-8	Reserved
	9	Relays option
	10-15	Reserved
Options 2	0-2	Number of relays - 1
	3-15	Reserved

5.7 Extended Status

Table 5-9 Extended Status Registers

Register description	Address	Type	R/W	Value range
Relay status	3452	UINT16	R	See Table 5-10
Reserved	3453-	UINT16	R	Read as 0
	3454	UINT16		
Setpoints status	3455	UINT16	R	See Table 5-11
Log status	3456	UINT16	R	See Table 5-12
Reserved	3457-3473	UINT16	R	Read as 0
Setpoint alarm status	3474	UINT16	R/W	See Table 5-13
Self-check alarm status	3475	UINT16	R/W	See Table 5-14

Table 5-10 Relay Status

Bit	Description
0	Relay status
1-15	Not used (permanently set to 0)

Bit meaning: 0 = relay released, 1 = relay operated

Table 5-11 Setpoints Status

Bit	Description
0	Setpoint # 1 status
1	Setpoint # 2 status
2	Setpoint # 3 status
3	Setpoint # 4 status
4	Setpoint # 5 status
5	Setpoint # 6 status
6	Setpoint # 7 status
7	Setpoint # 8 status
8	Setpoint # 9 status
9	Setpoint # 10 status
10	Setpoint # 11 status
11	Setpoint # 12 status
12	Setpoint # 13 status
13	Setpoint # 14 status
14	Setpoint # 15 status
15	Setpoint # 16 status

Bit meaning: 0 = setpoint is released, 1 = setpoint is operated

Table 5-12 Log Status

Bit	Description
0	Reserved
1	New Min/Max Log
2-15	Not used (permanently set to 0)

Bit meaning: 0 = no new logs, 1 = new log recorded (the new log flag is reset when the user reads the first log record after the flag has been set)

Table 5-13 Setpoint Alarm Status

Bit	Description
0	Alarm #1
1	Alarm #2
2	Alarm #3
3	Alarm #4
4	Alarm #5
5	Alarm #6
6	Alarm #7
7	Alarm #8
8	Alarm #9
9	Alarm #10
10	Alarm #11
11	Alarm #12
12	Alarm #13
13	Alarm #14
14	Alarm #15
15	Alarm #16

Bit meaning: 1 = setpoint has been operated

The setpoint alarm register stores the status of the operated setpoints by setting the appropriate bits to 1. The alarm status bits can be reset all together by writing zero to the setpoint alarm register. It is possible to reset each alarm status bit separately by writing back the contents of the alarm register with a corresponding alarm bit set to 0.

Table 5-14 Self-check Alarm Status

Bit	Description
0	Reserved
1	ROM error
2	RAM error

Bit	Description
3	Watchdog timer reset
4	Sampling failure
5	Out of control trap
6	Reserved
7	Timing failure
8	Loss of power (power up)
9	External reset (warm restart)
10	Configuration corrupted
11-15	Reserved

The self-check alarm register indicates possible problems with the instrument hardware or setup configuration. The hardware problems are indicated by the appropriate bits which are set whenever the instrument fails self-test diagnostics or in the event of loss of power. The setup configuration problems are indicated by the dedicated bit which is set when either configuration register is corrupted. In this event, the instrument will use the default configuration. The configuration corrupt bit may also be set as a result of the legal changes in the setup configuration since the instrument might implicitly change or clear other setups if they are affected by the changes made.

Hardware fault bits can be reset by writing zero to the self-check alarm register. The configuration corrupt status bit is also reset automatically when you change setup either via the front panel or through communications.

5.8 Extended Data Registers

The following table lists all registers containing the data measured by the instrument. Notice that these registers are arranged into groups which are not located at adjacent addresses. You can re-map these registers into adjacent addresses to access multiple data from different data groups by using a single request. Refer to Section 2.9 for information on the user assignable registers.

Along with the register address, the table shows for each data item its point identifier (ID). This is a one word containing a data group ID in the high byte and the parameter offset in a group in the low byte. Point IDs are used to specify input or output parameters whenever a data parameter specification is needed, for example, when selecting analog output parameters or reading Min/Max log records.

Table 5-15 Extended Data Registers

Parameter	16-bit Register		32-bit Register	Point ID	R/W	Unit	Range/Scale [1]	
	Reg.	Cnv.					Low	High
None								
None	6656		11776-11777	0x0000	R		0	0
Relays								
Relay status (see Table 5-10)	6976		12800-12801	0x0800	R		0	3
Event/time counters								
Counter #1	7056-7057		13056-13057	0x0A00	R/W		0	99999
Counter #2	7058-7059		13058-13059	0x0A01	R/W		0	99999
Counter #3	7060-7061		13060-13061	0x0A02	R/W		0	99999
Counter #4	7062-7063		13062-13063	0x0A03	R/W		0	99999
Real-time values per phase								
Voltage L1/L12 [5]	7136	LIN3	13312-13313	0x0C00	R	V	0	Vmax
Voltage L2/L23 [5]	7137	LIN3	13314-13315	0x0C01	R	V	0	Vmax
Voltage L3/L31 [5]	7138	LIN3	13316-13317	0x0C02	R	V	0	Vmax
Current L1	7139	LIN3	13318-13319	0x0C03	R	A	0	Imax
Current L2	7140	LIN3	13320-13321	0x0C04	R	A	0	Imax
Current L3	7141	LIN3	13322-13323	0x0C05	R	A	0	Imax
kW L1	7142	LIN3	13324-13325	0x0C06	R	kW	-Pmax	Pmax
kW L2	7143	LIN3	13326-13327	0x0C07	R	kW	-Pmax	Pmax
kW L3	7144	LIN3	13328-13329	0x0C08	R	kW	-Pmax	Pmax

Parameter	16-bit Register		32-bit Register	Point ID	R/W	Unit	Range/Scale [1]	
	Reg.	Cnv.					Low	High
kvar L1	7145	LIN3	13330-13331	0x0C09	R	kvar	-Pmax	Pmax
kvar L2	7146	LIN3	13332-13333	0x0C0A	R	kvar	-Pmax	Pmax
kvar L3	7147	LIN3	13334-13335	0x0C0B	R	kvar	-Pmax	Pmax
kVA L1	7148	LIN3	13336-13337	0x0C0C	R	kVA	0	Pmax
kVA L2	7149	LIN3	13338-13339	0x0C0D	R	kVA	0	Pmax
kVA L3	7150	LIN3	13340-13341	0x0C0E	R	kVA	0	Pmax
Power factor L1	7151	LIN3	13342-13343	0x0C0F	R	0.001	-1.000	1.000
Power factor L2	7152	LIN3	13344-13345	0x0C10	R	0.001	-1.000	1.000
Power factor L3	7153	LIN3	13346-13347	0x0C11	R	0.001	-1.000	1.000
Voltage THD L1/L12 [6 EH]	7154	LIN3	13348-13349	0x0C12	R	0.1%	0	999.9
Voltage THD L2/L23 [6 EH]	7155	LIN3	13350-13351	0x0C13	R	0.1%	0	999.9
Voltage THD L3 [6 EH]	7156	LIN3	13352-13353	0x0C14	R	0.1%	0	999.9
Current THD L1 [EH]	7157	LIN3	13354-13355	0x0C15	R	0.1%	0	999.9
Current THD L2 [EH]	7158	LIN3	13356-13357	0x0C16	R	0.1%	0	999.9
Current THD L3 [EH]	7159	LIN3	13358-13359	0x0C17	R	0.1%	0	999.9
K-Factor L1 [EH]	7160	LIN3	13360-13361	0x0C18	R	0.1	1.0	999.9
K-Factor L2 [EH]	7161	LIN3	13362-13363	0x0C19	R	0.1	1.0	999.9
K-Factor L3 [EH]	7162	LIN3	13364-13365	0x0C1A	R	0.1	1.0	999.9
Current TDD L1 [EH]	7163	LIN3	13366-13367	0x0C1B	R	0.1%	0	100.0
Current TDD L2 [EH]	7164	LIN3	13368-13369	0x0C1C	R	0.1%	0	100.0
Current TDD L3 [EH]	7165	LIN3	13370-13371	0x0C1D	R	0.1%	0	100.0
Voltage L12	7166	LIN3	13372-13373	0x0C1E	R	V	0	Vmax
Voltage L23	7167	LIN3	13374-13375	0x0C1F	R	V	0	Vmax
Voltage L31	7168	LIN3	13376-13377	0x0C20	R	V	0	Vmax
Real-time total values								
Total kW	7256	LIN3	13696-13697	0x0F00	R	kW	-Pmax	Pmax
Total kvar	7257	LIN3	13698-13699	0x0F01	R	kvar	-Pmax	Pmax
Total kVA	7258	LIN3	13700-13701	0x0F02	R	kVA	0	Pmax
Total PF	7259	LIN3	13702-13703	0x0F03	R	0.001	-1.000	1.000
Total PF lag [8]	7260	LIN3	13704-13705	0x0F04	R	0.001	0	1.000
Total PF lead [8]	7261	LIN3	13706-13707	0x0F05	R	0.001	0	1.000
Total kW import [8]	7262	LIN3	13708-13709	0x0F06	R	kW	0	Pmax
Total kW export [8]	7263	LIN3	13710-13711	0x0F07	R	kW	0	Pmax
Total kvar import [8]	7264	LIN3	13712-13713	0x0F08	R	kvar	0	Pmax
Total kvar export [8]	7265	LIN3	13714-13715	0x0F09	R	kvar	0	Pmax
3-phase average voltage [5, 8]	7266	LIN3	13716-13717	0x0F0A	R	V	0	Vmax
3-phase average L-L voltage [8]	7267	LIN3	13718-13719	0x0F0B	R	V	0	Vmax
3-phase average current [8]	7268	LIN3	13720-13721	0x0F0C	R	A	0	Imax
Real-time auxiliary values								
Reserved	7296		13824-13825	0x1000	R		0	0
Neutral current	7297	LIN3	13826-13827	0x1001	R	A	0	Imax
Frequency	7298	LIN3	13828-13829	0x1002	R	0.01Hz	0	100.00 [2]
Voltage unbalance	7299	LIN3	13830-13831	0x1003	R	1%	0	300
Current unbalance	7300	LIN3	13832-13833	0x1004	R	1%	0	300
Phasors [7]								
Voltage L1/L12	7316	LIN3	13864-13865	0x1080	R	V	0	Vmax
Voltage L2/L23	7317	LIN3	13866-13867	0x1081	R	V	0	Vmax
Voltage L3/L31	7318	LIN3	13868-13869	0x1082	R	V	0	Vmax
Reserved	7319	LIN3	13870-13871	0x1083	R	V	0	Vmax
Current L1	7320	LIN3	13872-13873	0x1084	R	A	0	Imax
Current L2	7321	LIN3	13874-13875	0x1085	R	A	0	Imax
Current L3	7322	LIN3	13876-13877	0x1086	R	A	0	Imax
Reserved	7323	LIN3	13878-13879	0x1087	R	A	0	Imax
V1/V12 Voltage angle	7324	LIN3	13880-13881	0x1088	R	0.1º	-180.0	180.0
V2/V23 Voltage angle	7325	LIN3	13882-13883	0x1089	R	0.1º	-180.0	180.0
V3/V31 Voltage angle	7326	LIN3	13884-13885	0x108A	R	0.1º	-180.0	180.0
Reserved	7327	LIN3	13886-13887	0x108B	R		-180.0	180.0
I1 Current angle	7328	LIN3	13888-13889	0x108C	R	0.1º	-180.0	180.0
I2 Current angle	7329	LIN3	13890-13891	0x108D	R	0.1º	-180.0	180.0
I3 Current angle	7330	LIN3	13892-13893	0x108E	R	0.1º	-180.0	180.0

Parameter	16-bit Register		32-bit Register	Point ID	R/W	Unit	Range/Scale [1]	
	Reg.	Cnv.					Low	High
Reserved	7331	LIN3	13894-13895	0x108F	R		-180.0	180.0
Average values per phase								
Voltage L1/L12 [5]	7336	LIN3	13952-13953	0x1100	R	V	0	Vmax
Voltage L2/L23 [5]	7337	LIN3	13954-13955	0x1101	R	V	0	Vmax
Voltage L3/L31 [5]	7338	LIN3	13956-13957	0x1102	R	V	0	Vmax
Current L1	7339	LIN3	13958-13959	0x1103	R	A	0	Imax
Current L2	7340	LIN3	13960-13961	0x1104	R	A	0	Imax
Current L3	7341	LIN3	13962-13963	0x1105	R	A	0	Imax
kW L1	7342	LIN3	13964-13965	0x1106	R	kW	-Pmax	Pmax
kW L2	7343	LIN3	13966-13967	0x1107	R	kW	-Pmax	Pmax
kW L3	7344	LIN3	13968-13969	0x1108	R	kW	-Pmax	Pmax
kvar L1	7345	LIN3	13970-13971	0x1109	R	kvar	-Pmax	Pmax
kvar L2	7346	LIN3	13972-13973	0x110A	R	kvar	-Pmax	Pmax
kvar L3	7347	LIN3	13974-13975	0x110B	R	kvar	-Pmax	Pmax
kVA L1	7348	LIN3	13976-13977	0x110C	R	kVA	0	Pmax
kVA L2	7349	LIN3	13978-13979	0x110D	R	kVA	0	Pmax
kVA L3	7350	LIN3	13980-13981	0x110E	R	kVA	0	Pmax
Power factor L1	7351	LIN3	13982-13983	0x110F	R	0.001	-1.000	1.000
Power factor L2	7352	LIN3	13984-13985	0x1110	R	0.001	-1.000	1.000
Power factor L3	7353	LIN3	13986-13987	0x1111	R	0.001	-1.000	1.000
Voltage THD L1/L12 [6 EH]	7354	LIN3	13988-13989	0x1112	R	0.1%	0	999.9
Voltage THD L2/L23 [6 EH]	7355	LIN3	13990-13991	0x1113	R	0.1%	0	999.9
Voltage THD L3 [6 EH]	7356	LIN3	13992-13993	0x1114	R	0.1%	0	999.9
Current THD L1 [EH]	7357	LIN3	13994-13995	0x1115	R	0.1%	0	999.9
Current THD L2 [EH]	7358	LIN3	13996-13997	0x1116	R	0.1%	0	999.9
Current THD L3 [EH]	7359	LIN3	13998-13999	0x1117	R	0.1%	0	999.9
K-Factor L1 [EH]	7360	LIN3	14000-14001	0x1118	R	0.1	1.0	999.9
K-Factor L2 [EH]	7361	LIN3	14002-14003	0x1119	R	0.1	1.0	999.9
K-Factor L3 [EH]	7362	LIN3	14004-14005	0x111A	R	0.1	1.0	999.9
Current TDD L1 [EH]	7363	LIN3	14006-14007	0x111B	R	0.1%	0	100.0
Current TDD L2 [EH]	7364	LIN3	14008-14009	0x111C	R	0.1%	0	100.0
Current TDD L3 [EH]	7365	LIN3	14010-14011	0x111D	R	0.1%	0	100.0
Voltage L12	7366	LIN3	14012-14013	0x111E	R	V	0	Vmax
Voltage L23	7367	LIN3	14014-14015	0x111F	R	V	0	Vmax
Voltage L31	7368	LIN3	14016-14017	0x1120	R	V	0	Vmax
Average total values								
Total kW	7456	LIN3	14336-14337	0x1400	R	kW	-Pmax	Pmax
Total kvar	7457	LIN3	14338-14339	0x1401	R	kvar	-Pmax	Pmax
Total kVA	7458	LIN3	14340-14341	0x1402	R	kVA	0	Pmax
Total PF	7459	LIN3	14342-14343	0x1403	R	0.001	-1.000	1.000
Total PF lag [8]	7460	LIN3	14344-14345	0x1404	R	0.001	0	1.000
Total PF lead [8]	7461	LIN3	14346-14347	0x1405	R	0.001	0	1.000
Total kW import [8]	7462	LIN3	14348-14349	0x1406	R	kW	0	Pmax
Total kW export [8]	7463	LIN3	14350-14351	0x1407	R	kW	0	Pmax
Total kvar import [8]	7464	LIN3	14352-14353	0x1408	R	kvar	0	Pmax
Total kvar export [8]	7465	LIN3	14354-14355	0x1409	R	kvar	0	Pmax
3-phase average voltage [5, 8]	7466	LIN3	14356-14357	0x140A	R	V	0	Vmax
3-phase average L-L voltage [8]	7467	LIN3	14358-14359	0x140B	R	V	0	Vmax
3-phase average current [8]	7468	LIN3	14360-14361	0x140C	R	A	0	Imax
Average auxiliary values								
Reserved	7496		14464-14465	0x1500	R		0	0
Neutral current	7497	LIN3	14466-14467	0x1501	R	A	0	Imax
Frequency	7498	LIN3	14468-14469	0x1502	R	0.01Hz	0	100.00 [2]
Voltage unbalance	7499	LIN3	14470-14471	0x1503	R	1%	0	300
Current unbalance	7500	LIN3	14472-14473	0x1504	R	1%	0	300
Present demands								
Volt demand L1/L12 [5]	7536	LIN3	14592-14593	0x1600	R	V	0	Vmax
Volt demand L2/L23 [5]	7537	LIN3	14594-14595	0x1601	R	V	0	Vmax
Volt demand L3/L31 [5]	7538	LIN3	14596-14597	0x1602	R	V	0	Vmax
Ampere demand L1	7539	LIN3	14598-14599	0x1603	R	A	0	Imax

Parameter	16-bit Register		32-bit Register	Point ID	R/W	Unit	Range/Scale [1]	
	Reg.	Cnv.					Low	High
Ampere demand L2	7540	LIN3	14600-14601	0x1604	R	A	0	Imax
Ampere demand L3	7541	LIN3	14602-14603	0x1605	R	A	0	Imax
Block kW demand [E]	7542	LIN3	14604-14605	0x1606	R	kW	0	Pmax
Reserved	7543		14606-14607	0x1607	R		0	0
Block kVA demand [E]	7544	LIN3	14608-14609	0x1608	R	kVA	0	Pmax
Sliding window kW demand [E]	7545	LIN3	14610-14611	0x1609	R	kW	0	Pmax
Reserved	7546		14612-14613	0x160A	R		0	0
Sliding window kVA demand [E]	7547	LIN3	14614-14615	0x160B	R	kVA	0	Pmax
Reserved	7548		14616-14617	0x160C	R		0	0
Reserved	7549		14618-14619	0x160D	R		0	0
Reserved	7550		14620-14621	0x160E	R		0	0
Accumulated kW demand (import) [E]	7551	LIN3	14622-14623	0x160F	R	kW	0	Pmax
Reserved	7552		14624-14625	0x1610	R		0	0
Accumulated kVA demand [E]	7553	LIN3	14626-14627	0x1611	R	kVA	0	Pmax
Predicted sliding window kW demand [E]	7554	LIN3	14628-14629	0x1612	R	kW	0	Pmax
Reserved	7555		14630-14631	0x1613	R		0	0
Predicted sliding window kVA demand [E]	7556	LIN3	14632-14633	0x1614	R	kVA	0	Pmax
PF at maximum sliding window kVA demand [E]	7557	LIN3	14634-14635	0x1615	R	0.001	-1.000	1.000
Total energies [E]								
kWh import	7576 7577		14720-14721	0x1700	R	kWh	0	10^8-1
kWh export [4]	7578 7579		14722-14723	0x1701	R	kWh	0	10^8-1
Reserved	7580 7581		14724-14725	0x1702	R		0	0
Reserved	7582 7583		14726-14727	0x1703	R		0	0
kvarh import	7584 7585		14728-14729	0x1704	R	kvarh	0	10^8-1
kvarh export [4]	7586 7587		14730-14731	0x1705	R	kvarh	0	10^8-1
Reserved	7588 7589		14732-14733	0x1706	R		0	0
Reserved	7590 7591		14734-14735	0x1707	R		0	0
kVAh total	7592 7593		14736-14737	0x1708	R	kVAh	0	10^8-1
Phase energies [E]								
kWh import L1	7616 7617		14848-14849	0x1800	R	kWh	0	10^8-1
kWh import L2	7618 7619		14850-14851	0x1801	R	kWh	0	10^8-1
kWh import L3	7620 7621		14852-14853	0x1802	R	kWh	0	10^8-1
kvarh import L1	7622 7623		14854-14855	0x1803	R	kvarh	0	10^8-1
kvarh import L2	7624 7625		14856-14857	0x1804	R	kvarh	0	10^8-1
kvarh import L3	7626 7627		14858-14859	0x1805	R	kvarh	0	10^8-1
kVAh total L1	7628 7629		14860-14861	0x1806	R	kVAh	0	10^8-1
kVAh total L2	7630 7631		14862-14863	0x1807	R	kVAh	0	10^8-1
kVAh total L3	7632 7633		14864-14865	0x1808	R	kVAh	0	10^8-1
Fundamental's (H01) real-time values per phase [EH]								
Voltage L1/L12 [6]	8296	LIN3	17024-17025	0x2900	R	V	0	Vmax

Parameter	16-bit Register		32-bit Register	Point ID	R/W	Unit	Range/Scale [1]	
	Reg.	Cnv.					Low	High
Voltage L2/L23 [6]	8297	LIN3	17026-17027	0x2901	R	V	0	Vmax
Voltage L3 [6]	8298	LIN3	17028-17029	0x2902	R	V	0	Vmax
Current L1	8299	LIN3	17030-17031	0x2903	R	A	0	Imax
Current L2	8300	LIN3	17032-17033	0x2904	R	A	0	Imax
Current L3	8301	LIN3	17034-17035	0x2905	R	A	0	Imax
kW L1	8302	LIN3	17036-17037	0x2906	R	kW	-Pmax	Pmax
kW L2	8303	LIN3	17038-17039	0x2907	R	kW	-Pmax	Pmax
kW L3	8304	LIN3	17040-17041	0x2908	R	kW	-Pmax	Pmax
kvar L1	8305	LIN3	17042-17043	0x2909	R	kvar	-Pmax	Pmax
kvar L2	8306	LIN3	17044-17045	0x290A	R	kvar	-Pmax	Pmax
kvar L3	8307	LIN3	17046-17047	0x290B	R	kvar	-Pmax	Pmax
kVA L1	8308	LIN3	17048-17049	0x290C	R	kVA	0	Pmax
kVA L2	8309	LIN3	17050-17051	0x290D	R	kVA	0	Pmax
kVA L3	8310	LIN3	17052-17053	0x290E	R	kVA	0	Pmax
Power factor L1	8311	LIN3	17054-17055	0x290F	R	0.001	-1.000	1.000
Power factor L2	8312	LIN3	17056-17055	0x2910	R	0.001	-1.000	1.000
Power factor L3	8313	LIN3	17058-17059	0x2911	R	0.001	-1.000	1.000
Fundamental's (H01) real-time total values [EH]								
Total fundamental kW	8336	LIN3	17152-17153	0x2A00	R	kW	-Pmax	Pmax
Total fundamental kvar	8337	LIN3	17154-17155	0x2A01	R	kvar	-Pmax	Pmax
Total fundamental kVA	8338	LIN3	17156-17157	0x2A02	R	kVA	0	Pmax
Total fundamental PF	8339	LIN3	17158-17159	0x2A03	R	0.001	-1.000	1.000
Minimum real-time values per phase (M)								
Voltage L1/L12 [5]	8416	LIN3	17408-17409	0x2C00	R	V	0	Vmax
Voltage L2/L23 [5]	8417	LIN3	17410-17411	0x2C01	R	V	0	Vmax
Voltage L3/L31 [5]	8418	LIN3	17412-17413	0x2C02	R	V	0	Vmax
Current L1	8419	LIN3	17414-17415	0x2C03	R	A	0	Imax
Current L2	8420	LIN3	17416-17417	0x2C04	R	A	0	Imax
Current L3	8421	LIN3	17418-17419	0x2C05	R	A	0	Imax
Minimum real-time total values (M)								
Total kW	8456	LIN3	17536-17537	0x2D00	R	kW	-Pmax	Pmax
Total kvar	8457	LIN3	17538-17539	0x2D01	R	kvar	-Pmax	Pmax
Total kVA	8458	LIN3	17540-17541	0x2D02	R	kVA	0	Pmax
Total PF [3]	8459	LIN3	17542-17543	0x2D03	R	0.001	0	1.000
Minimum real-time auxiliary values (M)								
Reserved	8496		17664-17665	0x2E00	R		0	0
Neutral current	8497	LIN3	17666-17667	0x2E01	R	A	0	Imax
Frequency	8498	LIN3	17668-17669	0x2E02	R	0.01Hz	0	100.00 [2]
Maximum real-time values per phase (M)								
Voltage L1/L12 [5]	8736	LIN3	18432-18433	0x3400	R	V	0	Vmax
Voltage L2/L23 [5]	8737	LIN3	18434-18435	0x3401	R	V	0	Vmax
Voltage L3/L31 [5]	8738	LIN3	18436-18437	0x3402	R	V	0	Vmax
Current L1	8739	LIN3	18438-18439	0x3403	R	A	0	Imax
Current L2	8740	LIN3	18440-18441	0x3404	R	A	0	Imax
Current L3	8741	LIN3	18442-18443	0x3405	R	A	0	Imax
Maximum real-time total values (M)								
Total kW	8776	LIN3	18560-18561	0x3500	R	kW	-Pmax	Pmax
Total kvar	8777	LIN3	18562-18563	0x3501	R	kvar	-Pmax	Pmax
Total kVA	8778	LIN3	18564-18565	0x3502	R	kVA	0	Pmax
Total PF [3]	8779	LIN3	18566-18567	0x3503	R	0.001	0	1.000
Maximum real-time auxiliary values (M)								
Reserved	8816		18688-18689	0x3600	R		0	
Neutral current	8817	LIN3	18680-18681	0x3601	R	A	0	Imax
Frequency	8818	LIN3	18682-18683	0x3602	R	0.01Hz	0	100.00 [2]
Maximum demands (M)								
Max. volt demand L1/L12 [5]	8856	LIN3	18816-18817	0x3700	R	V	0	Vmax
Max. volt demand L2/L23 [5]	8857	LIN3	18818-18819	0x3701	R	V	0	Vmax
Max. volt demand L3/L31 [5]	8858	LIN3	18820-18821	0x3702	R	V	0	Vmax
Max. ampere demand L1	8859	LIN3	18822-18823	0x3703	R	A	0	Imax
Max. ampere demand L2	8860	LIN3	18824-18825	0x3704	R	A	0	Imax

Parameter	16-bit Register		32-bit Register	Point ID	R/W	Unit	Range/Scale [1]	
	Reg.	Cnv.					Low	High
Max. ampere demand L3	8861	LIN3	18826-18827	0x3705	R	A	0	Imax
Reserved	8862		18828-18829	0x3706	R		0	0
Reserved	8863		18830-18831	0x3707	R		0	0
Reserved	8864		18832-18833	0x3708	R		0	0
Max. sliding window kW demand[E]	8865	LIN3	18834-18835	0x3709	R	kW	0	Pmax
Reserved	8866		18836-18837	0x370A	R		0	0
Max. sliding window kVA demand [E]	8867	LIN3	18838-18839	0x370B	R	kVA	0	Pmax

1 For the parameter limits, see Note[1] to Table 5-1

2 The actual frequency range is 45.00 - 65.00 Hz

3 Absolute min/max value (lag or lead)

4 The exported energy registers are read as positive unsigned long (32-bit) integers

5 When the 4LN3 or 3LN3 wiring mode is selected, the voltages will be line-to-neutral; for any other wiring mode, they will be line-to-line voltages.

6 In the 4LN3, 4LL3, 3LN3, 3LL3 and 3DIR2 wiring modes, the harmonic voltages will represent line-to-neutral voltages; in the 3OP2 and 3OP3 wiring modes, they will comprise L12 and L23 line-to-line voltages.

7 Available in Version 3.55 and later. Phase angles are referenced to Voltage V1 in 4-wire (4LN3, 4LL3, 3LN3 and 3LL3 wiring modes), and to Voltage V12 in 3-wire connections (3DIR2, 3OP2 and 3OP3 wiring modes).

8 Available in Version 3.58.01 and later.

(M) These parameters are recorded to the Min/Max log

5.9 Alarm/Event Setpoints

Table 5-16 Setpoint Registers

Setpoint	Setup registers (see Table 5-17)
Setpoint #1	2576-2583
Setpoint #2	2584-2591
Setpoint #3	2592-2599
Setpoint #4	2600-2607
Setpoint #5	2608-2615
Setpoint #6	2616-2623
Setpoint #7	2624-2631
Setpoint #8	2632-2639
Setpoint #9	2640-2647
Setpoint #10	2648-2655
Setpoint #11	2656-2663
Setpoint #12	2664-2671
Setpoint #13	2672-2679
Setpoint #14	2680-2687
Setpoint #15	2688-2695
Setpoint #16	2696-2703

Table 5-17 Setpoint Setup Registers

Parameter	Offset	Type	Direction	Range
Trigger parameter ID	+0	UINT16	R/W	See Table 5-18
Action	+1	UINT16	R/W	See Table 5-19
Operate delay	+2	UINT16	R/W	0-9999 (× 0.1 sec)
Release delay	+3	UINT16	R/W	0-9999 (× 0.1 sec)
Operate limit	+4, 5	INT32	R/W	See Table 5-18
Release limit	+6, 7	INT32	R/W	See Table 5-18

The setpoint is disabled when its trigger parameter is set to NONE. To disable the setpoint, write zero into this register.

When writing the setpoint registers (except the event when the setpoint is to be disabled), it is recommended to write all the setpoint registers using a single request, or disable the setpoint before writing into separate registers. Each value being written is checked for compatibility with the other setpoint parameters; if the new value does not conform to these, the request will be rejected.

Operate and release limits for the trigger parameters and their conversion scales are indicated in Table 5-18. Each limit value occupies two contiguous registers, the first of which (low word) contains the limit value, and the second (high word) is reserved for long parameters. This register is always read as zero. When written, its value is ignored.

Limits indicated in Table 5-18 by a N/A mark are read as zeros. When writing, they can be omitted or should be written as zeros.

When a setpoint action is directed to a relay allocated to output energy pulses, an attempt to re-allocate it for a setpoint will result in a negative response.

Table 5-18 Setpoint Trigger Parameters

Trigger parameter	Trigger ID	Type	Unit	Limit/scale [1]		Con-version
				Low	High	
None						
None	0x0000	UINT16		N/A	N/A	NONE
Phase reversal						
Positive phase rotation reversal [2]	0x8901	UINT16		N/A	N/A	NONE
Negative phase rotation reversal [2]	0x8902	UINT16		N/A	N/A	NONE
High/low real-time values on any phase						
High voltage [4]	0x0E00	UINT16	V	0	Vmax	LIN3
Low voltage [4]	0x8D00	UINT16	V	0	Vmax	LIN3
High current	0x0E01	UINT16	A	0	Imax	LIN3
Low current	0x8D01	UINT16	A	0	Imax	LIN3
High voltage THD [5] [EH]	0x0E07	UINT16	0.1%	0	999.9	LIN3
High current THD [EH]	0x0E08	UINT16	0.1%	0	999.9	LIN3
High K-Factor [EH]	0x0E09	UINT16	0.1	1.0	999.9	LIN3
High current TDD [EH]	0x0E0A	UINT16	0.1%	0	100.0	LIN3
High/low real-time auxiliary values						
High frequency	0x1002	UINT16	0.01Hz	0	100.00 [3]	LIN3
Low frequency	0x9002	UINT16	0.01Hz	0	100.00 [3]	LIN3
High/low average values per phase						
High current L1	0x1103	UINT16	A	0	Imax	LIN3
High current L2	0x1104	UINT16	A	0	Imax	LIN3
High current L3	0x1105	UINT16	A	0	Imax	LIN3
Low current L1	0x9103	UINT16	A	0	Imax	LIN3
Low current L2	0x9104	UINT16	A	0	Imax	LIN3
Low current L3	0x9105	UINT16	A	0	Imax	LIN3
High/low average values on any phase						
High voltage [4]	0x1300	UINT16	V	0	Vmax	LIN3
Low voltage [4]	0x9200	UINT16	V	0	Vmax	LIN3
High current	0x0301	UINT16	A	0	Vmax	LIN3
Low current	0x8201	UINT16	A	0	Vmax	LIN3
High/low average total values						
High total kW import	0x1406	UINT16	kW	-Pmax	Pmax	LIN3
High total kW export	0x1407	UINT16	kW	-Pmax	Pmax	LIN3
High total kvar import	0x1408	UINT16	kvar	-Pmax	Pmax	LIN3
High total kvar export	0x1409	UINT16	kvar	-Pmax	Pmax	LIN3
High total kVA	0x1402	UINT16	kVA	0	Pmax	LIN3
Low total PF Lag	0x9404	UINT16	0.001	0	1.000	LIN3
Low total PF Lead	0x9405	UINT16	0.001	0	1.000	LIN3
High/low average auxiliary values						
High neutral current	0x1501	UINT16	A	0	Imax	LIN3
High frequency	0x1502	UINT16	0.01Hz	0	100.00 [3]	LIN3
Low frequency	0x9502	UINT16	0.01Hz	0	100.00 [3]	LIN3

Trigger parameter	Trigger ID	Type	Unit	Limit/scale [1]		Con- version
				Low	High	
High present demands						
High volt demand L1/L12 [4]	0x1600	UINT16	V	0	Vmax	LIN3
High volt demand L2/L23 [4]	0x1601	UINT16	V	0	Vmax	LIN3
High volt demand L3/L31 [4]	0x1602	UINT16	V	0	Vmax	LIN3
High ampere demand L1	0x1603	UINT16	A	0	Imax	LIN3
High ampere demand L2	0x1604	UINT16	A	0	Imax	LIN3
High ampere demand L3	0x1605	UINT16	A	0	Imax	LIN3
High block kW demand [E]	0x1606	UINT16	kW	0	Pmax	LIN3
High block kVA demand [E]	0x1608	UINT16	kVA	0	Pmax	LIN3
High sliding window kW demand [E]	0x1609	UINT16	kW	0	Pmax	LIN3
High sliding window kVA demand [E]	0x160B	UINT16	kVA	0	Pmax	LIN3
High accumulated kW demand [E]	0x160F	UINT16	kW	0	Pmax	LIN3
High accumulated kVA demand [E]	0x1611	UINT16	kVA	0	Pmax	LIN3
High predicted kW demand [E]	0x1612	UINT16	kW	0	Pmax	LIN3
High predicted kVA demand [E]	0x1614	UINT16	kVA	0	Pmax	LIN3

1 For parameter limits, see Note[1] to Table 5-1

2 The setpoint is operated when the actual phase sequence does not match the indicated phase rotation

3 The actual frequency range is 45.00 - 65.00 Hz

4 When the 4LN3 or 3LN3 wiring mode is selected, the voltages will be line-to-neutral; for any other wiring mode, they will be line-to-line voltages.

5 In the 4LN3, 4LL3, 3LN3, 3LL3 and 3DIR2 wiring modes, the harmonic voltages will represent line-to-neutral voltages; in the 3OP2 and 3OP3 wiring modes, they will comprise L12 and L23 line-to-line voltages.

Table 5-19 Setpoint Actions

Action	Action ID
No action	0x0000
Operate relay	0x3000
Increment counter #1	0x4000
Increment counter #2	0x4001
Increment counter #3	0x4002
Increment counter #4	0x4003
Count operating time using counter #1 [1]	0x4400
Count operating time using counter #2 [1]	0x4401
Count operating time using counter #3 [1]	0x4402
Count operating time using counter #4 [1]	0x4403

1 This action converts a common event counter to the time counter which measures time at 0.1 hour resolution while the setpoint is in the operated state. Each time counter has a non-volatile shadow counter which counts time at 1 second resolution before the corresponding time counter is incremented.

5.10 Pulsing Setpoints

Table 5-20 Pulsing Registers

Setup registers (see Table 5-21)
2892-2893

Table 5-21 Pulsing Setup Registers

Parameter	Offset	Type	R/W	Range
Output parameter ID	+0	UINT16	R/W	See Table 5-22
Number of unit-hours per pulse	+1	UINT16	R/W	1-9999

Table 5-22 Pulsing Output Parameters

Pulsing parameter	ID
None	0
kWh import	1
kWh export	2
kvarh import	4
kvarh export	5
kvarh total (absolute)	6
kVAh total	7

5.11 Relay Operation Control

These registers allow the user to manually override a relay operation that is normally operated via alarm setpoints.

A relay allocated as a pulsing relay may not be manually operated or released. When a relay is allocated for pulsing, it automatically reverts to normal operation.

Table 5-23 Relay Operation Control Registers

Parameter	Address	Type	R/W	Range
Relay control status	3244	UINT16	R/W	See Table 5-24

Table 5-24 Relay Operation Status

Operation status	Value
Normal operation	0
Force operate	1
Force release	2

5.12 Min/Max Log

The Min/Max log registers are supported only for compatibility with other models of instruments. Because the Min/Max log is not time stamped in the PM130, reading these registers returns you only values of the Min/Max log parameters which you can read directly via extended data registers (see Table 5-15).

Table 5-25 Min/Max Log Windows Registers

Min/Max log window	Registers (see Table 5-26)
Min/Max log window #1	4174-4181
Min/Max log window #2	4182-4189
Min/Max log window #3	4190-4197
Min/Max log window #4	4198-4205
Min/Max log window #5	4206-4213
Min/Max log window #6	4214-4221
Min/Max log window #7	4222-4229
Min/Max log window #8	4230-4237
Min/Max log window #9	4238-4245
Min/Max log window #10	4246-4253
Min/Max log window #11	4254-4261
Min/Max log window #12	4262-4269

Table 5-26 Min/Max Log Window Registers

Parameter	Offset	Type	R/W	Range
Second	+0	UINT16	R	0
Minute	+1	UINT16	R	0
Hour	+2	UINT16	R	0
Day	+3	UINT16	R	0
Month	+4	UINT16	R	0
Year	+5	UINT16	R	0
Parameter value [1]	+6	UINT16	R	See Table 5-15

Parameter	Offset	Type	R/W	Range
Reserved	+7	UINT16	R	0

[1] The Min/Max parameter value is read as a 16-bit scaled value using LIN3 conversion. For the conversion scales, refer to Table 5-15. The time stamp is not available in the PM130 and is read as zeros.

Table 5-27 Min/Max Log Mapping Register

Parameter	Address	Type	R/W	Range
Min/Max log start parameter ID for window #1	4172	UINT16	R/W	See Table 5-15

From 1 to 12 adjacent Min/Max log records can be read at a time via the Min/Max log windows. The starting window #1 can be mapped to any Min/Max log parameter listed in Table 5-15 by writing the parameter ID to the Min/Max log mapping register. This must be written before reading the Min/Max log windows. Note that through Min/Max log windows, you can read only adjacent parameters within the same Min/Max log data group. Reading parameters outside of the selected Min/Max log data group will return zero.