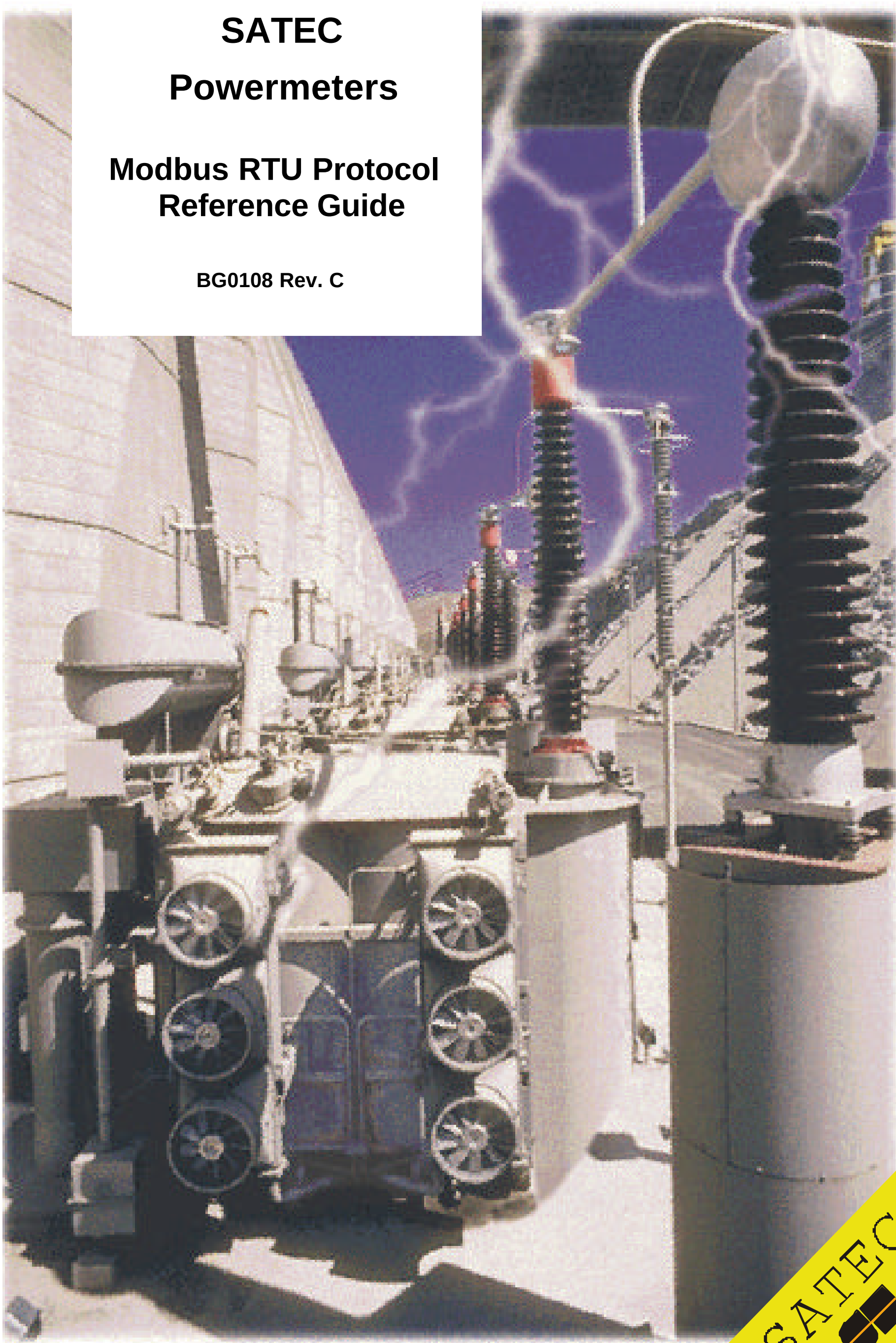
SATEC

Powermeters

Modbus RTU Protocol Reference Guide

BG0108 Rev. C



SATEC POWERMETERS

Modbus RTU Communications Protocol

REFERENCE GUIDE

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If further information is desired by the purchaser regarding his particular installation, operation or maintenance of his equipment, the manufacturer or local representative or local distributor should be contacted.

BG0108 Rev.C

Table of Contents

1 GENERAL

This document specifies a subset of the Modicon Modbus serial communications protocol implemented in the SATEC powermeters. The document describes the implementation of Modbus and provides the memory map information necessary to access the powermeter data registers.

Information in this document covers the models RPM090, PM170/170E, PM270, PM290, and PM290H/HD powermeters. In the model PM295 powermeter, the setup access registers, relays setpoints setup, pulsing relays setup and analog outputs setup registers are nonexistent or mapped to different memory addresses. If necessary, refer to the PM295 Modbus User's Guide for the PM295 memory map.

Additional information concerning communications operation, configuring the communications parameters and communications connections is found in your powermeter User's Guide.

NOTE

Some of the parameters described in this document might not be relevant to your instrument and thus, may not be accessed via communications. Refer to your powermeter User's Guide to check parameters supported by your instrument.

IMPORTANT

- The voltage parameters throughout the protocol can represent line-to-neutral or line-to-line voltages depending on the wiring mode selected in the powermeter. When a 4L-N wiring mode is selected, they will be line-to-neutral voltages, and when another mode is selected, they will be line-to-line voltages. In 4-wire connections using either 4L-N or 4L-L wiring mode, voltage harmonics and captured waveforms will represent line-to-neutral voltages. In a 3-wire direct connection, voltage harmonics and captured waveforms will represent line-to-neutral voltages that arise on the powermeter's input transformers. In a 3-wire open delta connection, voltage harmonics and captured waveforms will comprise L12 and L23 line-to-line voltages.
- In 3-wire connection schemes, the individual phase values for power factor, active power, apparent power and reactive power will be zeros, because they have no meaning. The only total three-phase power values can be used.

2 MODBUS FRAMING

2.1 Transmission Mode

The powermeter Modbus protocol implementation uses the 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 powermeter communications.

2.2 RTU Frame Format

Frame synchronization is maintained in RTU transmission mode by simulating a synchronization message. The receiving device monitors the elapsed time between reception 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.

Table 2.1 RTU Message Frame Format

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

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

2.3 Address Field

The address field contains a user assigned address (1-247) of the powermeter that is to receive message. Address 0 can be used in the master's message to broadcast to all powermeters (broadcast mode is available only with write functions 06 and 16). In this case all powermeters receive message and take action on the request, but don't issue a response.

2.4 Function Field

The function field contains function code that tells the powermeter what action to perform. Function codes used in the protocol are shown below in Table 2-1.

Table 2-1 Modbus function codes

Code (decimal)	*Meaning in Modbus*	*Action in the powermeter*
03	Read holding registers	Read multiple contiguous registers
04	Read input registers	Read multiple contiguous registers
06	Preset single register	Write single register
08	Loopback test	Communications test
16	Preset multiple registers	Write multiple contiguous registers
20	Read general reference	Read multiple non-contiguous registers
21	Write general reference	Write multiple non-contiguous registers

2.5 Data Field

Data field contains information for the powermeter to perform specific function or data collected by the powermeter 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 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), 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 then, and since there are no carries used in 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.

2.7 Data Conversion

In the powermeter implementation of Modbus, the following data conversion methods are used to convert the raw data received from the powermeter into engineering units.

NONE

The data will be presented exactly as retrieved by the communication program from the powermeter. No conversion will take place.

LIN3 (Linear)

This conversion maps the raw data received by the communication 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:

$$Y = (X / 9999) \times (HI - LO) + LO$$

where:

Y - the true value in engineering units
X - 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.

EXAMPLE

Suppose, you have read a value of 5000 from register 256 that contains a voltage reading (see *Table 5-1*). If you have the instrument with the 144V input option, and use potential transformers with the ratings of 22,000V : 110V = 200, then the voltage high scale is HI = 144×200 = 28,800, and in accordance with the above formula, the voltage reading in engineering units will be as follows:

$$5000 \times (28800 - 0)/9999 + 0 = 14401V$$

When a value is written to the powermeter, the conversion is carried out in reverse to produce the written value in the range of 0 - 9999:

$$X = 9999 \times (Y - LO) / (HI - LO)$$

Transmitting fractional numbers

When a value is a fractional number, it can be transmitted by using a LIN3 conversion method with fractional limits, or being multiplied by a scale factor (modulus) of 10 or 100 depending on the number of digits in the fractional part.

When using a modulus method, to process a value received from the powermeter in this format, the value must be multiplied by the modulus. To write such a number into the powermeter register, the number should be divided by the modulus.

Transmitting long numbers

The energy values are kept in the powermeter in unsigned long integer format. They are accessed in two contiguous registers.

To transmit such numbers, the powermeter splits the value into two words with the range of 0 to 9999. The number is divided by 10,000 and represented in the next manner: the low word contains a fractional part of the value up to 9999 in unit-hours (for instance, in kWh), and the high word contains the integer part of the value in units of 10,000 unit-hours. To process this type of numbers, the value in the high word must be multiplied by 10,000 and added to the value in the low word.

EXAMPLE

Suppose, the kWh import value being read in two contiguous registers 40288 and 40289 is represented as follows:

40256 = 5100
40257 = 2

The actual energy value in kWh units is 2 × 10,000 + 5,100 = 25,100 kWh

2.8 Data Addressing Modes

Modicon Addressing Scheme

In the Modicon applications, the powermeter registers can be accessed by simulating input or holding registers of the Modicon 584, 884, or 984 Programmable Controller. To map a powermeter actual register address to the range of the Modicon PLC input or holding registers, you should add a value of 30001 or 40001 to the register *absolute* address, respectively. Throughout this document, the powermeter registers are represented being mapped to Modbus holding registers using the 5-digit "4XXXX" addressing scheme (although you can use both types of registers in your applications).

The Modicon addressing scheme can be used with Modbus functions 03, 04, 06 and 16. In some powermeters, the extended Modbus functions 20 and 21 are utilized, allowing the user to access multiple non-contiguous registers. These functions may not address the powermeter registers using the Modicon addressing scheme because they are not based on the register absolute addresses. Instead, they require the relative addressing mode to be used (see below). Conventional Modicon drivers do not support these functions, so you cannot use this mode with them, but you do can use it if your own driver supports Modbus functions 20 and 21.

Powermeter Addressing Modes

In the User's Guide shipped with your instrument, the Modbus registers can be referred to by using the *absolute* or *relative* addressing modes. In the absolute addressing mode, the data registers are specified by their absolute addresses in the powermeter memory map. When using the relative addressing mode, the data registers are organized into tables (files), and an actual register address is specified by the table (file) number and the register offset (relative address) within the table. The table length is always 256 registers. The register absolute address is build in the following manner:

High byte	*Low byte*
Modbus data table No	Register offset (relative address) within the table

When a conversion from one addressing mode to another is needed, use the following:

When register addresses are defined for your instrument in a relative form, you can calculate the register absolute address as *table number ´ 256 + register offset*. To get the register relative address from the absolute address, calculate the table (file) number as *register absolute address/256*, and the register offset in the table as *register absolute address mod 256*.

2.9 Modbus Messages

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:

Powermeter 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:

Powermeter 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.

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:

Powermeter 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:

Powermeter 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.

Function 20 - Read Multiple Registers

This command allows the user to obtain contents of *non-contiguous* data registers from different data tables. Several sub-requests can be included in one message. The maximum number of registers to be read is dependent upon the maximum message length. The maximum query and response message length is 256 bytes including the error check bytes. This request requires the relative addressing mode to be used (see *Section 2.8*).

Request:

Powermeter Address	Function (20)	Byte Count	Sub-request 1	...	Sub-request N	Error Check
1 byte	1 byte	1 byte	7 bytes	...	7 bytes	2 bytes

Sub-request Format

Reference Type (06)	Table No	Starting Address	Word Count
1 byte	2 bytes	2 bytes	2 bytes

Byte Count Total number of binary bytes in the message, excluding the powermeter address, function code, byte count, and error check fields
Reference type Fixed field. Must be 06
Table No The powermeter's Modbus table number
Starting Address Relative address of the first register to be read in the table (file)
Word Count The number of contiguous words to be read

Response

Powermeter Address	Function (20)	Byte Count	Sub-Response	...	Sub-Response	Error Check
1 byte	1 byte	1 byte	...	...	...	2 bytes

Sub - response

Sub-response byte count	Reference Type (06)	Data Word 1	...	Data Word N
1 byte	1 byte	2 bytes	...	2 bytes

The sub-response byte count contains the number of binary bytes in each separate sub-response. Data Word 1 ... Data Word N - the data from contiguous registers being read.

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:

Powermeter 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.

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:

Powermeter 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:

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

Function 21 - Write Multiple Registers

This request allows the user to write the contents of multiple *non-contiguous* registers into different data tables where registers can be written. Several sub-requests can be included in one message. The maximum number of registers to be written is dependent upon the maximum message length. The maximum query and response message length is 256 bytes including the error check bytes. This request requires the relative addressing mode to be used (see S*ection 2.8*).

Request:

Powermeter Address	Function (21)	Byte Count	Sub-request 1	...	Sub-request N	Error Check
1 byte	1 byte	1 byte	...	...	...	2 bytes

Sub - Request

Reference Type (06)	Table No	Starting Address	Word Count	Data Word 1	...	Data Word N
1 byte	2 bytes	2 bytes	2 bytes	2 bytes	...	2 bytes

Byte Count Total number of binary bytes in the message, excluding the powermeter address, function code, byte count, and error check fields
Reference type Fixed field. Must be 06
Table No The powermeter's Modbus table number
Starting Address Relative address of the first register to be written in the table (file)
Word Count The number of contiguous words to be written
Data Word 1 ... N Data to be written

Response

The normal response to a write request is the retransmission of the request.

Function 08 - Loopback Communications Test

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

Request:

Powermeter 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 Loopback 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 powermeter. The entire message returned will be identical to the message transmitted by the master, field-per-field.

Response:

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

The normal response is the retransmission of a test message.

2.10 Exception Responses

Powermeter sends 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:

Powermeter 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 error, but the powermeter is being programmed from the front panel (for requests accessing setup registers)

NOTE

When the character framing, parity, or redundancy check error is detected, processing of the master's request stops. The powermeter will not act on or respond to the message.

3 POWERMETER DATA MAP

This chapter specifies the powermeter registers using three addressing modes: by the register offset (relative address) within a powermeter's Modbus data table, by the register absolute address in the powermeter memory map, and in terms of the Modbus data identification convention using the "4XXXX" (5 digits) addressing scheme.

3.1 Basic Data Registers

These registers are used to retrieve a predefined set of the data measured by the Powermeter.

Table 3-1 Basic data registers (Modbus Table #1)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale ①*	*High scale ①*	*Con-version*
Voltage L1/L12	0	256	40257	R	V	0	Vmax	LIN3
Voltage L2/L23	1	257	40258	R	V	0	Vmax	LIN3
Voltage L3/L31	2	258	40259	R	V	0	Vmax	LIN3
Current L1	3	259	40260	R	A	0	Imax	LIN3
Current L2	4	260	40261	R	A	0	Imax	LIN3
Current L3	5	261	40262	R	A	0	Imax	LIN3
kW L1	6	262	40263	R	kW	-Pmax	Pmax	LIN3
kW L2	7	263	40264	R	kW	-Pmax	Pmax	LIN3
kW L3	8	264	40265	R	kW	-Pmax	Pmax	LIN3
kvar L1	9	265	40266	R	kvar	-Pmax	Pmax	LIN3
kvar L2	10	266	40267	R	kvar	-Pmax	Pmax	LIN3
kvar L3	11	267	40268	R	kvar	-Pmax	Pmax	LIN3
kVA L1	12	268	40269	R	kVA	-Pmax	Pmax	LIN3
kVA L2	13	269	40270	R	kVA	-Pmax	Pmax	LIN3
kVA L3	14	270	40271	R	kVA	-Pmax	Pmax	LIN3
Power factor L1	15	271	40272	R		-1.00	1.00	LIN3
Power factor L2	16	272	40273	R		-1.00	1.00	LIN3
Power factor L3	17	273	40274	R		-1.00	1.00	LIN3
Total power factor	18	274	40275	R		-1.00	1.00	LIN3
Total kW	19	275	40276	R	kW	-Pmax	Pmax	LIN3
Total kvar	20	276	40277	R	kvar	-Pmax	Pmax	LIN3
Total kVA	21	277	40278	R	kVA	-Pmax	Pmax	LIN3
Unbalanced (neutral) current (Ground leakage ④)	22	278	40279	R	A (mA)	0	Imax (Iaux max)	LIN3
Frequency	23	279	40280	R	Hz	45.0	65.0	LIN3
Maximum kW demand	24	280	40281	R/W	kW	-Pmax	Pmax	LIN3
Accumulated kW demand	25	281	40282	R/W	kW	-Pmax	Pmax	LIN3
Maximum kVA demand	26	282	40283	R/W	kW	-Pmax	Pmax	LIN3
Accumulated kVA demand	27	283	40284	R/W	kVA	-Pmax	Pmax	LIN3
Maximum ampere demand L1	28	284	40285	R/W	kVA	0	Imax	LIN3
Maximum ampere demand L2	29	285	40286	R/W	A	0	Imax	LIN3
Maximum ampere demand L3	30	286	40287	R/W	A	0	Imax	LIN3
kWh import (low)	31	287	40288	R/W	kWh	0	9999	NONE
kWh import (high)	32	288	40289	R/W	kWh	0	999	x10^4
kWh export (low)	33	289	40290	R/W	kWh	0	9999	NONE
kWh export (high)	34	290	40291	R/W	kWh	0	999	x10^4
+kvarh net (low) ②	35	291	40292	R/W	kvarh	0	9999	NONE
+kvarh net (high) ②	36	292	40293	R/W	kvarh	0	999	x10^4

Table 3-1 Basic data registers (Modbus Table #1) (continued)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale ①*	*High scale ①*	*Con-version*
-kvarh net (low) ③	37	293	40294	R/W	kvarh	0	9999	NONE
-kvarh net (high) ③	38	294	40295	R/W	kvarh	0	999	$x10^4$
Voltage THD L1/L12	39	295	40296	R	%	0	100.0	LIN3
Voltage THD L2/L23	40	296	40297	R	%	0	100.0	LIN3
Voltage THD L3	41	297	40298	R	%	0	100.0	LIN3
Current THD L1	42	298	40299	R	%	0	100.0	LIN3
Current THD L2	43	299	40300	R	%	0	100.0	LIN3
Current THD L3	44	300	40301	R	%	0	100.0	LIN3

① The parameters' limits are as follows:

Vmax (660 V input option) = 660 [V] @ PT Ratio = 1.0
Vmax (660 V input option) = 144 ∗ PT Ratio [V] @ PT ratio > 1.0
Vmax (120 V input option) = 144 ∗ PT Ratio [V]
Imax = 1.2 ∗ CT primary current [A] @ current overrange = 20%
Imax = 2 ∗ CT primary current [A] @ current overrange = 100%
Iaux max = 1.2 ∗ Auxiliary CT primary current [mA]
Pmax = (Imax ∗ Vmax ∗ 3)/1000 [kW] @ wiring mode 4L-N
Pmax = (Imax ∗ Vmax ∗ 2)/1000 [kW] @ wiring mode 4L-L, 3-OP, or 3DIR

② Positive readings of kvarh net

③ Negative readings of kvarh net

④ For instruments with the "L" option

NOTES

1. To reset maximum demands, write zero into one of registers 40281 through 40287. To reset accumulated energies, write zero into one of the energy keeping registers as follows:

   kW import - register 40288 or 40289
   kW export - register 40290 or 40291
   kvarh net - registers 40292 through 40295

2. For instruments that provide measuring kWh qualified as net, i.e., energy measurements represent the difference between energy imported and exported, registers 40288/40289 will show positive energy readings, and registers 40290/40291 will show negative energy readings.

3. All electrical parameters are averaged values over the specified number of the real-time measurements (see the *averaging buffer size* in *Table 3-13*).

3.2 Setup Access Registers

These registers show which setups are available in the instrument. Each register contains a bit string where available setups are designated by a '1', and those that are not available are designated by a '0' bit. Available setups may vary from instrument to instrument.

Table 3-2 Setup access registers (Modbus Table #2)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Range*
Relay #1 setpoints	0	512	40513	R	See Table 3-3
Relay #2 setpoints	1	513	40514	R	See Table 3-3
Relay #3 setpoints	2	514	40515	R	See Table 3-3
Relay #4 setpoints	3	515	40516	R	See Table 3-3
Pulsing relays setup	4	516	40517	R	See Table 3-4
Analog outputs setup	5	517	40518	R	See Table 3-5
Basic setup	6	518	40519	R	See Table 3-6

Table 3-3 Relays setpoints' setup access register

Setpoint trigger parameter	*Setup access bit*
High voltage	0
Low voltage	1
High current	2
High unbalanced (neutral) current	3
High accumulated kW demand	4
High kvar	5
High kVA	6
Low power factor (lag)	7
High THD	8

Table 3-4 Pulsing relays' setup access register

Setup parameter	*Setup access bit*
kWh imported - relay #1	0
kWh exported - relay #4	1
kvarh total - relay #2 (except the PM270M)	2
kVAh - relay #2 (for the PM270M)	3

Table 3-5 Analog outputs' setup access register

Setup parameter	*Setup access bit*
Voltage L1/L12	0
Voltage L2/L23	1
Voltage L3/L31	2
Current L1	3
Current L2	4
Current L3	5
Reserved	6
Unbalanced (neutral) current	7
kW	8
kvar	9
kVA	10
Accumulated kW demand	11
Accumulated kVA demand	12
Power factor	13
Frequency	14

Table 3-6 Basic setup access register

Setup parameter	*Setup access bit*
Wiring mode	0
PT ratio	1
CT primary current	2
Power demand period	3
Ampere demand period	4
Averaging buffer size	5
Reset enable/disable	6
Auxiliary (ground leakage) CT primary current	7

3.3 Relays Setpoints Setup Registers

These registers allow the user to obtain or change the setup for the relays setpoints.

Table 3-7 Relay #1 setpoints registers (Modbus Table #3)

Relay setpoint	*Setpoint parameter*	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale* ①	*High scale* ①	*Con-version*
High voltage	Operate limit	0	768	40769	R/W	V	0	Vmax	LIN3
	Operate delay	1	769	40770	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	2	770	40771	R/W	V	0	Vmax	LIN3
	Release delay	3	771	40772	R/W	s	0	999 ②	NONE
Low voltage	Operate limit	4	772	40773	R/W	V	0	Vmax	LIN3
	Operate delay	5	773	40774	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	6	774	40775	R/W	V	0	Vmax	LIN3
	Release delay	7	775	40776	R/W	s	0	999 ②	NONE
High current	Operate limit	8	776	40777	R/W	A	0	Imax	LIN3
	Operate delay	9	777	40778	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	10	778	40779	R/W	A	0	Imax	LIN3
	Release delay	11	779	40780	R/W	s	0	999 ②	NONE
High unbalanced (or auxiliary ③) current	Operate limit	12	780	40781	R/W	A	0	Imax ③	LIN3
	Operate delay	13	781	40782	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	14	782	40783	R/W	A	0	Imax ③	LIN3
	Release delay	15	783	40784	R/W	s	0	999 ②	NONE
High accumulated kW demand	Operate limit	16	784	40785	R/W	kW	0	Pmax	LIN3
	Operate delay	17	785	40786	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	18	786	40787	R/W	kW	0	Pmax	LIN3
	Release delay	19	787	40788	R/W	s	0	999 ②	NONE
High kvar (positive)	Operate limit	20	788	40789	R/W	kvar	0	Pmax	LIN3
	Operate delay	21	789	40790	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	22	790	40791	R/W	kvar	0	Pmax	LIN3
	Release delay	23	791	40792	R/W	s	0	999 ②	NONE
High kVA	Operate limit	24	792	40793	R/W	kVA	0	Pmax	LIN3
	Operate delay	25	793	40794	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	26	794	40795	R/W	kVA	0	Pmax	LIN3
	Release delay	27	795	40796	R/W	s	0	999 ②	NONE
Low power factor (lag)	Operate limit	28	796	40797	R/W		0	1.00	LIN3
	Operate delay	29	797	40798	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	30	798	40799	R/W		0	1.00	LIN3
	Release delay	31	799	40800	R/W	s	0	999 ②	NONE
High THD	Operate limit	32	800	40801	R/W	%	0	100	LIN3
	Operate delay	33	801	40802	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	34	802	40803	R/W	%	0	100	LIN3
	Release delay	35	803	40804	R/W	s	0	999 ②	NONE

Table 3-8 Relay #2 setpoints registers (Modbus Table #4)

Relay setpoint	*Setpoint parameter*	*Register offset*	*Register address*	*Modbus address*	*Direc- tion*	*Unit*	*Low scale ①*	*High scale ①*	*Con- version*
High voltage	Operate limit	0	1024	41025	R/W	V	0	Vmax	LIN3
	Operate delay	1	1025	41026	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	2	1026	41027	R/W	V	0	Vmax	LIN3
	Release delay	3	1027	41028	R/W	s	0	999 ②	NONE
Low voltage	Operate limit	4	1028	41029	R/W	V	0	Vmax	LIN3
	Operate delay	5	1029	41030	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	6	1030	41031	R/W	V	0	Vmax	LIN3
	Release delay	7	1031	41032	R/W	s	0	999 ②	NONE
High current	Operate limit	8	1032	41033	R/W	A	0	Imax	LIN3
	Operate delay	9	1033	41034	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	10	1034	41035	R/W	A	0	Imax	LIN3
	Release delay	11	1035	41036	R/W	s	0	999 ②	NONE
High unbalanced (or auxiliary ③) current	Operate limit	12	1036	41037	R/W	A	0	Imax ③	LIN3
	Operate delay	13	1037	41038	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	14	1038	41039	R/W	A	0	Imax ③	LIN3
	Release delay	15	1039	41040	R/W	s	0	999 ②	NONE
High accumulated kW demand	Operate limit	16	1040	41041	R/W	kW	0	Pmax	LIN3
	Operate delay	17	1041	41042	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	18	1042	41043	R/W	kW	0	Pmax	LIN3
	Release delay	19	1043	41044	R/W	s	0	999 ②	NONE
High kvar (positive)	Operate limit	20	1044	41045	R/W	kvar	0	Pmax	LIN3
	Operate delay	21	1045	41046	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	22	1046	41047	R/W	kvar	0	Pmax	LIN3
	Release delay	23	1047	41048	R/W	s	0	999 ②	NONE
High kVA	Operate limit	24	1048	41049	R/W	kVA	0	Pmax	LIN3
	Operate delay	25	1049	41050	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	26	1050	41051	R/W	kVA	0	Pmax	LIN3
	Release delay	27	1051	41052	R/W	s	0	999 ②	NONE
Low power factor (lag)	Operate limit	28	1052	41053	R/W		0	1.00	LIN3
	Operate delay	29	1053	41054	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	30	1054	41055	R/W		0	1.00	LIN3
	Release delay	31	1055	41056	R/W	s	0	999 ②	NONE
High THD	Operate limit	32	1056	41057	R/W	%	0	100	LIN3
	Operate delay	33	1057	41058	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	34	1058	41059	R/W	%	0	100	LIN3
	Release delay	35	1059	41060	R/W	s	0	999 ②	NONE

Table 3-9 Relay #3 setpoints registers (Modbus Table #5)

Relay setpoint	*Setpoint parameter*	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale* ①	*High scale* ①	*Con-version*
High voltage	Operate limit	0	1280	41281	R/W	V	0	Vmax	LIN3
	Operate delay	1	1281	41282	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	2	1282	41283	R/W	V	0	Vmax	LIN3
	Release delay	3	1283	41284	R/W	s	0	999 ②	NONE
Low voltage	Operate limit	4	1284	41285	R/W	V	0	Vmax	LIN3
	Operate delay	5	1285	41286	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	6	1286	41287	R/W	V	0	Vmax	LIN3
	Release delay	7	1287	41288	R/W	s	0	999 ②	NONE
High current	Operate limit	8	1288	41289	R/W	A	0	Imax	LIN3
	Operate delay	9	1289	41290	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	10	1290	41291	R/W	A	0	Imax	LIN3
	Release delay	11	1291	41292	R/W	s	0	999 ②	NONE
High unbalanced (or auxiliary ③) current	Operate limit	12	1292	41293	R/W	A	0	Imax ③	LIN3
	Operate delay	13	1293	41294	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	14	1294	41295	R/W	A	0	Imax ③	LIN3
	Release delay	15	1295	41296	R/W	s	0	999 ②	NONE
High accumulated kW demand	Operate limit	16	1296	41297	R/W	kW	0	Pmax	LIN3
	Operate delay	17	1297	41298	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	18	1298	41299	R/W	kW	0	Pmax	LIN3
	Release delay	19	1299	41300	R/W	s	0	999 ②	NONE
High kvar (positive)	Operate limit	20	1300	41301	R/W	kvar	0	Pmax	LIN3
	Operate delay	21	1301	41302	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	22	1302	41303	R/W	kvar	0	Pmax	LIN3
	Release delay	23	1303	41304	R/W	s	0	999 ②	NONE
High kVA	Operate limit	24	1304	41305	R/W	kVA	0	Pmax	LIN3
	Operate delay	25	1305	41306	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	26	1306	41307	R/W	kVA	0	Pmax	LIN3
	Release delay	27	1307	41308	R/W	s	0	999 ②	NONE
Low power factor (lag)	Operate limit	28	1308	41309	R/W		0	1.00	LIN3
	Operate delay	29	1309	41310	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	30	1310	41311	R/W		0	1.00	LIN3
	Release delay	31	1311	41312	R/W	s	0	999 ②	NONE
High THD	Operate limit	32	1312	41313	R/W	%	0	100	LIN3
	Operate delay	33	1313	41314	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	34	1314	41315	R/W	%	0	100	LIN3
	Release delay	35	1315	41316	R/W	s	0	999 ②	NONE

Table 3-10 Relay #4 setpoints registers (Modbus Table #6)

Relay setpoint	*Setpoint parameter*	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale ①*	*High scale ①*	*Con-version*
High voltage	Operate limit	0	1536	41537	R/W	V	0	Vmax	LIN3
	Operate delay	1	1537	41538	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	2	1538	41539	R/W	V	0	Vmax	LIN3
	Release delay	3	1539	41540	R/W	s	0	999 ②	NONE
Low voltage	Operate limit	4	1540	41541	R/W	V	0	Vmax	LIN3
	Operate delay	5	1541	41542	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	6	1542	41543	R/W	V	0	Vmax	LIN3
	Release delay	7	1543	41544	R/W	s	0	999 ②	NONE
High current	Operate limit	8	1544	41545	R/W	A	0	Imax	LIN3
	Operate delay	9	1545	41546	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	10	1546	41547	R/W	A	0	Imax	LIN3
	Release delay	11	1547	41548	R/W	s	0	999 ②	NONE
High unbalanced (or auxiliary ③) current	Operate limit	12	1548	41549	R/W	A	0	Imax ③	LIN3
	Operate delay	13	1549	41550	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	14	1550	41551	R/W	A	0	Imax ③	LIN3
	Release delay	15	1551	41552	R/W	s	0	999 ②	NONE
High accumulated kW demand	Operate limit	16	1552	41553	R/W	kW	0	Pmax	LIN3
	Operate delay	17	1553	41554	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	18	1554	41555	R/W	kW	0	Pmax	LIN3
	Release delay	19	1555	41556	R/W	s	0	999 ②	NONE
High kvar (positive)	Operate limit	20	1556	41507	R/W	kvar	0	Pmax	LIN3
	Operate delay	21	1557	41558	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	22	1558	41559	R/W	kvar	0	Pmax	LIN3
	Release delay	23	1559	41560	R/W	s	0	999 ②	NONE
High kVA	Operate limit	24	1560	41561	R/W	kVA	0	Pmax	LIN3
	Operate delay	25	1561	41562	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	26	1562	41563	R/W	kVA	0	Pmax	LIN3
	Release delay	27	1563	41564	R/W	s	0	999 ②	NONE
Low power factor (lag)	Operate limit	28	1564	41565	R/W		0	1.00	LIN3
	Operate delay	29	1565	41566	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	30	1566	41567	R/W		0	1.00	LIN3
	Release delay	31	1567	41568	R/W	s	0	999 ②	NONE
High THD	Operate limit	32	1568	41569	R/W	%	0	100	LIN3
	Operate delay	33	1569	41570	R/W	0.1 s	0	999 ②	10^{-1}
	Release limit	34	1570	41571	R/W	%	0	100	LIN3
	Release delay	35	1571	41572	R/W	s	0	999 ②	NONE

① For the parameters' limits, see note ① to Table 3.1

② The operate delay is specified in 0.1 second units using modulus 10^{-1}. A value of 10 corresponds to a 1 sec delay, and a value of 999 corresponds to a 99.9 sec delay. The release delay is specified in 1 second units.

The delay value of 65535 designates that a setpoint is disabled. To disable a setpoint, write 65535 into the operate delay register.

③ In the instruments with the ‘L’ option that have an additional current input, this setpoint will refer to auxiliary (ground leakage) current. For the setpoint high scale, refer to **Iaux max** in note ① to Table 3.1.

NOTES

1. The setpoint operate limit and operate delay should be written before you set the setpoint release parameters.
2. If a relay has been allocated to output energy pulses, an attempt to re-allocate it for a setpoint will result in a negative response.

3.4 Pulsing Relays Setup Registers

These registers allow the user to obtain or change the setup for the energy pulsing relays.

Table 3-11 Pulsing relays registers (Modbus Table #7)

Pulsing parameter	*Output relay No*	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
kWh import	1	0	1792	41793	R/W	kWh	0	200 ①	NONE
kWh export	4	1	1793	41794	R/W	kWh	0	200 ①	NONE
kvarh total	2	2	1794	41795	R/W	kvarh	0	200 ①	NONE
kVAh	2	3	1795	41796	R/W	kVAh	0	200 ①	NONE

① The pulsing output setup value specifies the number of unit-hours between pulses. A value of 65535 designates that a pulsing output is disabled. To disable a pulsing output, write 65535 into the pulsing output register.

NOTE

Allocating a relay for pulsing will unconditionally disable all setpoints associated with this relay.

3.5 Analog Outputs Setup Registers

These registers allow the user to obtain or change the setup for the analog outputs.

Table 3-12 Analog outputs registers (Modbus Table #8)

Output parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Low scale*	*High scale*	*Con-version*
Voltage L1/L12	0	2048	42049	R/W	0	14 ①	NONE
Voltage L2/L23	1	2049	42050	R/W	0	14 ①	NONE
Voltage L3/L31	2	2050	42051	R/W	0	14 ①	NONE
Current L1	3	2051	42052	R/W	0	14 ①	NONE
Current L2	4	2052	42053	R/W	0	14 ①	NONE
Current L3	5	2053	42054	R/W	0	14 ①	NONE
Reserved	6	2054	42055	R/W	0	14 ①	NONE
Unbalanced (neutral) current	7	2055	42056	R/W	0	14 ①	NONE
kW	8	2056	42057	R/W	0	14 ①	NONE
kvar	9	2057	42058	R/W	0	14 ①	NONE
kVA	10	2058	42059	R/W	0	14 ①	NONE
Accumulated kW demand	11	2059	42060	R/W	0	14 ①	NONE
Accumulated kVA demand	12	2060	42061	R/W	0	14 ①	NONE
Power factor	13	2061	42062	R/W	0	14 ①	NONE
Frequency	14	2062	42063	R/W	0	14 ①	NONE

① The analog output setup value assigns the analog output for each output parameter as follows:

0 = the parameter is allocated to the internal analog output

1-14 = the parameter is allocated to the analog expander AX-7 analog channel (channels 1 to 7 correspond to the first analog expander, and channels 8 to 14 correspond to the second one).

65535 = output is disabled. To disable an analog output parameter, write 65535, except of the reserved location.

NOTES

1. Addressing of a reserved item will result in a negative response.
2. Allocating the same analog output for two or more output parameters will unconditionally disable all output parameters previously associated with this output.

3.6 Basic Setup Registers

These registers allow the user to obtain or change the setup for the analog outputs.

Table 3-13 Basic setup registers (Modbus Table #9)

Setup parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Range*	*Con-version*
WIRING MODE	0	2304	42305	R/W		0 = 3OP 1 = 4L-N 2 = 3DIR 3 = 4L-L	NONE
PT RATIO	1	2305	42050	R/W		1 to 65,000 ①	10^{-1}
CT PRIMARY CURRENT	2	2306	42051	R/W	A	1 to 50,000	NONE
Power demand period	3	2307	42052	R/W	min	1,2,5,10,15,20,30,60 255 = external synchronization	NONE
Ampere demand period	4	2308	42053	R/W	sec	0 to 1800 0 = measuring peak currents	NONE
Averaging buffer size	5	2309	42054	R/W		8, 32 entries	NONE
Reset enable/disable	6	2310	42055	R/W		0 = disable 1 = enable	NONE
Auxiliary CT PRIMARY CURRENT ('L' option)	7	2311	42056	R/W	mA	1 to 50,000	NONE

① PT RATIO is specified in 0.1 units using modulus 10^{-1}. A value of 10 corresponds to PT RATIO = 1.0, and a value of 65,000 corresponds to PT RATIO = 6500.0.

3.7 Powermeter Status Registers

These registers are used to retrieve the present powermeter status. Writing a value of 65535 into register 2560 will cause the powermeter to restart as if it were power up.

Table 3-14 Instrument status registers (Modbus Table #10)

Setup parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Range*	*Con-version*
Powermeter reset register	0	2560	42561	R/W	0 (when read) 65535 (when written) = reset instrument	NONE
Keypad status	1	2561	42562	R	See Table 3-15	NONE
Relay status	2	2562	42563	R	See Table 3-16	NONE
DIP switch status	3	2563	42564	R	See Table 3-17	NONE
Status inputs	4	2564	42565	R	See Table 3-18	NONE
Firmware version number	5	2565	42566	R	100-999	NONE

Table 3-15 Keypad status

Bit number	*Description*
0	Up key status
1	Enter key status
2	Select key status
3	Down key status

Bit meaning: 0 = key released, 1 = key pressed

Table 3-16 Relay status

Bit number	*Description*
4	Relay #4 status
5	Relay #3 status
6	Relay #2 status
7	Relay #1 status

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

Table 3-17 DIP switch status

Bit number	*Description*
6	Switch #10 status (Switch #4 in the PM290H/HD)
7	Switch #9 status (Switch #3 in the PM290H/HD)

Bit meaning: 0 = switch OFF, 1 = switch ON

Table 3-18 Status inputs

Bit number	*Description*
0	Status input #1
1	Status input #2
2	Status input #3
3	Status input #4
4	Status input #5
5	Status input #6
6	Status input #7
7	Status input #8
8-15	Not used (permanently set to 0)

Bit meaning: 0 = contact open, 1 = contact closed

3.8 Phase Harmonics Registers

These registers are used to obtain the phase harmonics table for any of the voltage or current inputs. Harmonic magnitudes are read in percentage of the fundamental harmonic.

Table 3-19 L1/L12 voltage harmonics (Modbus Table #11)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Phase voltage (RMS) ①	0	2816	42817	R	V	0	Vmax (see note ① to Table 3.1)	LIN3
Fundamental frequency	1	2817	42818	R	Hz	0	100.0	LIN3
%THD	2	2818	42819	R	%	0	100.0	LIN3
Harmonic H01(reference)	3	2819	42820	R	%	0	100.00	LIN3
Harmonic H02	4	2820	42821	R	%	0	100.00	LIN3
Harmonic H03	5	2821	42822	R	%	0	100.00	LIN3
. . .								
Harmonic H31	33	2849	42850	R	%	0	100.00	LIN3

① Phase voltage will be line-to-line voltage in a 3-wire open delta connection, and line-to-neutral voltage in other configurations.

Table 3-20 L2/L23 voltage harmonics (Modbus Table #12)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Phase voltage (RMS) ①	0	3072	43073	R	V	0	Vmax (see note ① to Table 3.1)	LIN3
Fundamental frequency	1	3072	43074	R	Hz	0	100.0	LIN3
%THD	2	3073	43075	R	%	0	100.0	LIN3
Harmonic H01(reference)	3	3074	43076	R	%	0	100.00	LIN3
Harmonic H02	4	3075	43077	R	%	0	100.00	LIN3
Harmonic H03	5	3076	43078	R	%	0	100.00	LIN3
. . .								
Harmonic H31	33	3105	43106	R	%	0	100.00	LIN3

① Phase voltage will be line-to-line voltage in a 3-wire open delta connection, and line-to-neutral voltage in other configurations.

Table 3-21 L3 voltage harmonics (Modbus Table #13)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Phase voltage (RMS)	0	3328	43329	R	V	0	Vmax (see note ① to Table 3.1)	LIN3
Fundamental frequency	1	3329	43330	R	Hz	0	100.0	LIN3
%THD	2	3330	43331	R	%	0	100.0	LIN3
Harmonic H01(reference)	3	3331	43332	R	%	0	100.00	LIN3
Harmonic H02	4	3332	43333	R	%	0	100.00	LIN3
Harmonic H03	5	3333	43334	R	%	0	100.00	LIN3
. . .								
Harmonic H31	33	3361	43362	R	%	0	100.00	LIN3

Table 3-22 L1 current harmonics (Modbus Table #14)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Phase current (RMS)	0	3584	43585	R	V	0	Imax (see note ① to Table 3.1)	LIN3
Fundamental frequency	1	3585	43586	R	Hz	0	100.0	LIN3
%THD	2	3586	43587	R	%	0	100.0	LIN3
Harmonic H01(reference)	3	3587	43588	R	%	0	100.00	LIN3
Harmonic H02	4	3588	43589	R	%	0	100.00	LIN3
Harmonic H03	5	3589	43590	R	%	0	100.00	LIN3
. . .								
Harmonic H31	33	3617	43618	R	%	0	100.00	LIN3

Table 3-23 L2 current harmonics (Modbus Table #15)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Phase current (RMS)	0	3840	43841	R	V	0	Imax (see note ① to Table 3.1)	LIN3
Fundamental frequency	1	3841	43842	R	Hz	0	100.0	LIN3
%THD	2	3842	43843	R	%	0	100.0	LIN3
Harmonic H01(reference)	3	3843	43844	R	%	0	100.00	LIN3
Harmonic H02	4	3844	43845	R	%	0	100.00	LIN3
Harmonic H03	5	3845	43846	R	%	0	100.00	LIN3
. . .								
Harmonic H31	33	3873	43874	R	%	0	100.00	LIN3

Table 3-24 L3 current harmonics (Modbus Table #16)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Phase current (RMS)	0	4096	44097	R	V	0	Imax (see note ① to Table 3.1)	LIN3
Fundamental frequency	1	4097	44098	R	Hz	0	100.0	LIN3
%THD	2	4098	44099	R	%	0	100.0	LIN3
Harmonic H01(reference)	3	4099	44100	R	%	0	100.00	LIN3
Harmonic H02	4	4100	44101	R	%	0	100.00	LIN3
Harmonic H03	5	4101	44102	R	%	0	100.00	LIN3
. . .								
Harmonic H31	33	4129	44130	R	%	0	100.00	LIN3

3.9 Real-Time Clock Registers

These registers allow the user to obtain the present RTC indication, or to setup the powermeter's RTC.

Table 3-25 RTC registers (Modbus Table #17)

Parameter	*Register address*	*Register address*	*Modbus address*	*Direc-tion*	*Range*	*Con-version*
Second	0	4352	44353	R/W	0-59	NONE
Minute	1	4353	44354	R/W	0-59	NONE
Hour	2	4354	44355	R/W	0-23	NONE
Day of month	3	4355	44356	R/W	1-31	NONE
Month	4	4356	44357	R/W	1-12	NONE
Year	5	4357	44358	R/W	0-99	NONE
Day of week ①	6	4358	44359	R/W	1-7 (1=Sunday)	NONE

① available only in the PM295

3.10 Real-Time Waveform Registers

Waveform registers allow the user to obtain the real-time waveforms (4 cycles x 128 samples per cycle) sampled by the powermeter.

Each waveform consists of 512 samples. A waveform record contains six waveforms: 2 inputs (voltage and current) x 3 phases. Both the voltage and current waveforms on any phase are always sampled and recorded simultaneously.

To access the real-time waveforms, a particular order of requests is needed. The waveform data is transmitted to a master via the special large scale communications buffer. Before reading the waveform samples, the waveform record containing two waveforms for the selected phase should be locked in the communications buffer. It is made by reading the corresponding header record for the voltage input (see Tables 3-26 - 3-31). Before accessing the current waveform samples, the current waveform header record must be accessed to prepare waveform for reading. The capture code register should be always read first.

Once waveform is locked in the communications buffer, the user can read the waveform samples by accessing the samples' registers (see Tables 3-32, 3-33). Data in the communications buffer doesn't change until a header record for the voltage channel is accessed.

Each waveform sample is represented by a value in the range of 0 to 1023. A value of 0 corresponds to the highest negative amplitude of the measured signal, and a value of 1023 corresponds to the highest positive amplitude.

Table 3-26 L1/L12 voltage waveform header (Modbus Table #18)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Capture code	0	4608	44609	R		0	0	NONE
Second	1	4609	44610	R		0	59	NONE
Minute	2	4610	44611	R		0	59	NONE
Hour	3	4611	44612	R		0	23	NONE
Day of month	4	4612	44613	R		1	31	NONE
Month	5	4613	44614	R		1	12	NONE
Year	6	4614	44615	R		0	99	NONE
Phase voltage (RMS) ➀	7	4615	44616	R	V	0	Vmax (see note ➀ to Table 3.1)	LIN3
Fundamental frequency	8	4616	44617	R	Hz	0	100.0	LIN3
%THD	9	4617	44618	R	%	0	100.0	LIN3

➀ Phase voltage will be line-to-line voltage in a 3-wire open delta connection, and line-to-neutral voltage in other configurations.

Table 3-27 L2/L23 voltage waveform header (Modbus Table #19)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Capture code	0	4864	44865	R		0	0	NONE
Second	1	4865	44866	R		0	59	NONE
Minute	2	4866	44867	R		0	59	NONE
Hour	3	4867	44868	R		0	23	NONE
Day of month	4	4868	44869	R		1	31	NONE
Month	5	4869	44870	R		1	12	NONE
Year	6	4870	44871	R		0	99	NONE
Phase voltage (RMS) ➀	7	4871	44872	R	V	0	Vmax (see note ➀ to Table 3.1)	LIN3
Fundamental frequency	8	4872	44873	R	Hz	0	100.0	LIN3
%THD	9	4873	44674	R	%	0	100.0	LIN3

➀ Phase voltage will be line-to-line voltage in a 3-wire open delta connection, and line-to-neutral voltage in other configurations.

Table 3-28 L3 voltage waveform header (Modbus Table #20)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Capture code	0	5120	45121	R		0	0	NONE
Second	1	5121	45122	R		0	59	NONE
Minute	2	5122	45123	R		0	59	NONE
Hour	3	5123	45124	R		0	23	NONE
Day of month	4	5124	45125	R		1	31	NONE
Month	5	5125	45126	R		1	12	NONE
Year	6	5126	45127	R		0	99	NONE
Phase voltage (RMS)	7	5127	45128	R	V	0	Vmax (see note ➀ to Table 3.1)	LIN3
Fundamental frequency	8	5128	45129	R	Hz	0	100.0	LIN3
%THD	9	5129	45130	R	%	0	100.0	LIN3

Table 3-29 L1 current waveform header (Modbus Table #21)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Capture code	0	5376	45377	R		0	0	NONE
Second	1	5377	45378	R		0	59	NONE
Minute	2	5378	45379	R		0	59	NONE
Hour	3	5379	45380	R		0	23	NONE
Day of month	4	5380	45381	R		1	31	NONE
Month	5	5381	45382	R		1	12	NONE
Year	6	5382	45383	R		0	99	NONE
Phase current (RMS)	7	5383	45384	R	A	0	Imax (see note ① to Table 3.1)	LIN3
Fundamental frequency	8	5384	45385	R	Hz	0	100.0	LIN3
%THD	9	5385	45386	R	%	0	100.0	LIN3

Table 3-30 L2 current waveform header (Modbus Table #22)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Capture code	0	5632	45633	R		0	0	NONE
Second	1	5633	45634	R		0	59	NONE
Minute	2	5634	45635	R		0	59	NONE
Hour	3	5635	45636	R		0	23	NONE
Day of month	4	5636	45637	R		1	31	NONE
Month	5	5637	45638	R		1	12	NONE
Year	6	5638	45639	R		0	99	NONE
Phase current (RMS)	7	5639	45640	R	A	0	Imax (see note ① to Table 3.1)	LIN3
Fundamental frequency	8	5640	45641	R	Hz	0	100.0	LIN3
%THD	9	5641	45642	R	%	0	100.0	LIN3

Table 3-31 L3 current waveform header (Modbus Table #23)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Capture code	0	5888	45889	R		0	0	NONE
Second	1	5889	45890	R		0	59	NONE
Minute	2	5890	45891	R		0	59	NONE
Hour	3	5891	45892	R		0	23	NONE
Day of month	4	5892	45893	R		1	31	NONE
Month	5	5893	45894	R		1	12	NONE
Year	6	5894	45895	R		0	99	NONE
Phase current (RMS)	7	5895	45896	R	A	0	Imax (see note ① to Table 3.1)	LIN3
Fundamental frequency	8	5896	45897	R	Hz	0	100.0	LIN3
%THD	9	5897	45898	R	%	0	100.0	LIN3

Table 3-32 Real-time waveform samples (Modbus Table #24)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Waveform point #1	0	6144	46145	R		0	1023	NONE
Waveform point #2	1	6145	46146	R		0	1023	NONE
Waveform point #3	2	6146	46147	R		0	1023	NONE
...								
Waveform point #256	255	6399	46400	R		0	1023	NONE

Table 3-33 Real-time waveform samples (Modbus Table #25)

Parameter	*Register offset*	*Register address*	*Modbus address*	*Direc-tion*	*Unit*	*Low scale*	*High scale*	*Con-version*
Waveform point #257	0	6400	46401	R		0	1023	NONE
Waveform point #258	1	6401	46402	R		0	1023	NONE
Waveform point #259	2	6402	46403	R		0	1023	NONE
...								
Waveform point #512	255	6655	46656	R		0	1023	NONE

NOTES