8. Modbus Register Map

This chapter provides a complete description of the Modbus register map (protocol version 6.0) for the PEM330/PEM333 series, to facilitate accessing information. In general, the registers are implemented as Modbus Read Only Registers (RO = read only) with the exception of the DO control registers, which are implemented as Write Only Registers (WO = write only).
PEM330/PEM333 supports die 6-digit addressing scheme and the following Modbus functions:

1. Holding Register to read out values
   (Read Holding Register; function code 0x03)
2. Register for setting the DO status
   (Force Single Coil; function code 0x05)
3. Register for device programming
   (Preset Multiple Registers; function code 0x10)

The register addresses are listed without the Modbus Address prefix (4 for Holding Register; 0 for Coil Register). For a complete Modbus protocol specification, please visit http://www.modbus.org.

8.1 Basic measuring values

Register	Property	Description	Format	Scale/ unit
40000	RO	U_{L1} 1)	UINT32	×100, V (2
40002	RO	U_{L2} 1)	UINT32	×100, V
40004	RO	U_{L3} 1)	UINT32	×100, V
40006	RO	Ø U_{LN}	UINT32	×100, V

Register	Property	Description	Format	Scale/ unit
40008	RO	U_{L1L2}	UINT32	×100, V
40010	RO	U_{L2L3}	UINT32	×100, V
40012	RO	U_{L3L1}	UINT32	×100, V
40014	RO	Ø U_{LL}	UINT32	×100, V
40016	RO	I_1 1)	UINT32	×1000, A
40018	RO	I_2 1)	UINT32	×1000, A
40020	RO	I_3 1)	UINT32	×1000, A
40022	RO	Ø I	UINT32	×1000, A
40024	RO	P_{L1} 1)	INT32	×1000, kW
40026	RO	P_{L2} 1)	INT32	×1000, kW
40028	RO	P_{L3} 1)	INT32	×1000, kW
40030	RO	P_{ges}	INT32	×1000, kW
40032	RO	Q_{L1} 1)	INT32	×1000, kvar
40034	RO	Q_{L2} 1)	INT32	×1000, kvar
40036	RO	Q_{L3} 1)	INT32	×1000, kvar

Register	Property	Description	Format	Scale/ unit
40038	RO	Q_{ges}	INT32	×1000, kvar
40040	RO	S_{L1} [1)]	INT32	×1000, kVA
40042	RO	S_{L2} [1)]	INT32	×1000, kVA
40044	RO	S_{L3} [1)]	INT32	×1000, kVA
40046	RO	S_{ges}	INT32	×1000, kVA
40048	RO	λ_{L1} [1)]	INT16	×1000, -
40049	RO	λ_{L2} [1)]	INT16	×1000, -
40050	RO	λ_{L3} [1)]	INT16	×1000, -
40051	RO	λ_{ges}	INT16	×1000, -
40052	RO	*F*	UINT16	×100, Hz
40053	RO	*I4*	UINT32	x1000, A
40055	RO	Voltage unbalance	UINT16	x1000
40056	RO	Current unbalance	UINT16	x1000
40057	RO	Displacement factor L1	INT16	x1000

Register	Property	Description	Format	Scale/ unit
40058	RO	Displacement factor L2	INT16	x1000
40059	RO	Displacement factor L3	INT16	x1000
40060	RO	Demand *P*	INT32	x1000, kW
40062	RO	Demand *Q*	INT32	x1000, kvar
40064	RO	Demand *S*	INT32	x1000, kVA
40066	RO	Demand I_1	UINT32	x1000, A
40068	RO	Demand I_2	UINT32	x1000, A
40070	RO	Demand I_3	UINT32	x1000, A
40072	RO	Phase angle U_1	UINT16	x 100, °
40073	RO	Phase angle U_2	UINT16	x 100, °
40074	RO	Phase angle U_3	UINT16	x 100, °
40075	RO	Phase angle I_1	UINT16	x 100, °
40076	RO	Phase angle I_2	UINT16	x 100, °
40077	RO	Phase angle I_3	UINT16	x 100, °
40078… 40094	Reserved			

Register	Property	Description	Format	Scale/ unit
40095	RO	Alarm [3]	Bitmap	
40096	RO	Status digital outputs [4]	Bitmap	
40097	RO	Status digital inputs [5]	Bitmap	
40098	RO	SOE pointer [6]	UNIT32	

Tab. 8.1: Basic measuring values

Notes:

1) Only in the case of wye connection.

2) "x 100, V" means that the voltage value in the register is 100 times the actual measured value (therefore, the value of the register must be divided by 100 to obtain the measuring value).

3) The alarm register 40095 shows various alarm states (1 = active, 0 = inactive). Tab. 8.2: Bit sequence alarm register (40095) illustrates details of the alarm register.

Bit in register 40095	Alarm by event
B0…B2	Reserved
B3	Setpoint 1
B4	Setpoint 2
B5	Setpoint 3
B6	Setpoint 4
B7	Setpoint 5
B8	Setpoint 6
all other bits	Reserved

Tab. 8.2: Bit sequence alarm register (40095)

4) **Status register 40096:**
Represents the **status of the two digital outputs**
B0 for DO1 (1 = active/closed; 0 = inactive/open)
B1 for DO2 (1 = active/closed; 0 = inactive/open)

5) **Status register 44097**:
Represents the **status of the two digital inputs**
B0 for DI1 (1 = active/closed; 0 = inactive/open)
B1 for DI2 (1 = active/closed; 0 = inactive/open)

6) The event log can store up to 32 events.
It works like a ring buffer according to the FIFO principle: the 33rd value overwrites the first value, the 34th the second and so on. The event log can be reset in the setup parameter menu (see page 43).

8.2 Energy measurement

Register	Characteristics	Description	Format	Unit
40100	RW	Active energy import	UINT32	x 0.1 kWh
40102	RW	Active energy export	UINT32	x 0.1 kWh
40104	Reserved			
40106	RW	Reactive energy import	UINT32	x 0.1 kvarh
40108	RW	Reactive energy export	UINT32	x 0.1 kvarh
40110	Reserved			
40112	RW	Apparent energy	UINT32	x 0.1 kVAh

Tab. 8.3: Energy measurement

Note: When the maximum value of 99,999,999 kWh/kvarh/kVAh is reached, the measurement will restart with 0.

8.3 Peak demand

The value of the peak demand register is 1000 times the actual value, that means, that the value of the register has to be divided by 1000 to obtain the value in kW, kVA or kvar.

Register	Characteristics	Description	Format
40500	RO	Peak demand *P*	see Tab. 8.5: Data structure peak demand
40504	RO	Peak demand *Q*	
40508	RO	Peak demand *S*	
40512	RO	Peak demand I_1	
40516	RO	Peak demand I_2	
40520	RO	Peak demand I_3	

Tab. 8.4: Peak demand

Structure of registers 40500…40520	Description
Register 1	Peak demand HiWord
Register 2	Peak demand LoWord
Register 3	UNIX time HiWord
Register 4	UNIX time LoWord

Tab. 8.5: Data structure peak demand

8.4 Total harmonic distortion (THD) and k-factor

Total harmonic distortion (THD): The value of the THD returned is 10,000 times the actual value.
Example: If the register contains a value of 1031, it means 1031/10.000 = 0.1031 or 10.31 %

k-factor: The value of the k-factor returned is ten times the actual measured value.

Register	Property	Description	Format	Factor
40703	RO	k-factor I_1	UINT16	×10
40704	RO	k-factor I_2	UINT16	×10
40705	RO	k-factor I_3	UINT16	×10
40706…40717	Reserved			
40718	RO	THD U_{L1}	UINT16	×10000
40719	RO	THD U_{L2}	UINT16	×10000
40720	RO	THD U_{L3}	UINT16	×10000
40721	RO	THD I_1	UINT16	×10000
40722	RO	THD I_2	UINT16	×10000
40723	RO	THD I_3	UINT16	×10000

Tab. 8.6: Harmonic and k-factor measurements

8.5 Setup parameters

Register	Property	Description	Format	Range/unit
41000…41009	Reserved			
41010	RW	Transformer ratio voltage trans-former	UINT16	1…2200 (100*)
41011	RW	Transformer ratio measuring current transformer	UINT16	1…6000 (current input 5 A) 1…30000 (current input 1 A) (1000 *)
41012	RW	Connection mode	UINT16	0 = WYE* 1 = DELTA 2 = DEMO
41013	RW	Device address	UINT16	1…247 (100*)
41014	RW	Baud rate	UINT16	1 = 1200 2 = 2400 3 = 4800 4 = 9600* 5 = 19200
41015	RO	Parity	UINT16	0 = 8N2; 1 = 8O1 2 = 8E1* ; 3 = 8N1 4 = 8O2 ; 5 = 8E2
41016… 41018	Reserved			

* factory setting

Register	Property	Description	Format	Range/unit
41019	WO	clear all energy value registers	UINT16	Writing 0xFF00 to the register clears the values for *P*, *Q* and *S*
41020	WO	Resets the event log	UINT16	Writing 0xFF00 to the register resets the SOE pointer of the event log to 0
41021… 41024	Reserved			
41025	RW	Setpoint 1	Data structure setpoint 1)	
41029	RW	Setpoint 2		
41033	RW	Setpoint 3		
41037	RW	Setpoint 4		
41041	RW	Setpoint 5		
41045	RW	Setpoint 6		
41049	RW	DI1 setpoint trigger	UINT16	0* = disabled 1 = DO1; 2 = DO2
41050	RW	DI2 setpoint trigger	UINT16	0* = disabled 1 = DO1; 2 = DO2
41051… 41052	Reserved			
41053	RW	Power factor convention	UINT16	B1B0: 00* = IEC 01= IEEE 10 = -IEEE

* factory setting

Register	Property	Description	Format	Range/unit
41054	RW	Calculation method *S*	UINT16	B1B0: 00* = vector 01 = scalar
41055	Reserved			
41056	RW	Polarity measuring current trans-former L1	UINT16	0* = normal 1 = reversed
41057	RW	Polarity measuring current trans-former L2	UINT16	0* = normal 1=reversed
41058	RW	Polarity measuring current trans-former L3	UINT16	0=normal 1=reversed
41059…41222		Reserved	UINT16	
41223	RW	Specified time for demand measure-ment	UINT16	1, 2, 3, 5, 10, 15*, 30, 60 minutes
41224…41225	Reserved			
41226	WO	Clear peak demand value	UINT16	Writing „0xFF00“ to the register resets the peak demand value to 0

Tab. 8.7: Setup parameters

* factory setting

Notes:

1) Data structure setpoint

Structure of the registers 41025…41045	**Format**	**Description**	
Register 1 (LoByte)	UINT16	>-Setpoint Setpoint exceeded: 1 = U_{LN}, 2 = U_{LL}, 3 = I 4 = P_{ges} 5 = Q_{ges}	<-Setpoint Value below setpoint: 6 = U_{LN} 7 = U_{LL} 8 = λ_{ges}
Register 1 (HiByte)		Setpoint trigger: 0 = No Trigger, 1 = Trigger DO1, 2 = Trigger DO2	
Register 2	UINT32	Setpoint limits	
Register 3			
Register 4	UINT16	Setpoint delay: 0…9999 (seconds)	

Tab. 8.8: Setpoint data structure

The value of the power factor λ displayed is 1000 times the measured value. Example: desired setpoint is 0.866; value to be set: 0.866 x 1000 = 866.

8.6 Event log (SOE log)

Each SOE event occupies 7 registers, as shown in the following table. The internal data structure of the event log is listed in Tab. 8.10: Event data structure.

Register	Characteristics	Description	Format
42000…42006	RO	Event 1	see Tab. 8.10: Event data structure
42007…42013	RO	Event 2	
42014…42020	RO	Event 3	
42021…42027	RO	Event 4	
42028…42034	RO	Event 5	
42035…42041	RO	Event 6	
42042…42048	RO	Event 7	
42049…42055	RO	Event 8	
42056…42062	RO	Event 9	
42063…42069	RO	Event 10	
42070…42076	RO	Event 11	
42077…42083	RO	Event 12	
42084…42090	RO	Event 13	
42091…42097	RO	Event 14	
42098…42104	RO	Event 15	
42105…42111	RO	Event 16	
……			
42217…42223	RO	Event 32	

Tab. 8.9: Event log (SOE log)

Event data structure

The internal data structure of the 7 registers belonging to each event in the SOE log is described in the table below.

Register	Characteristics	Description
Register 1	RO	Reserved
Register 2	RO	Event classification (seeTab. 8.11: Event classification (2. Event log register)ff.)
Register 3	RO	Event value HiWord
Register 4	RO	Event value LoWord
Register 5	RO	Event time (milliseconds) 0…999
Register 6	RO	Event timestamp HiWord (UNIX time in seconds)
Register 7	RO	Event timestamp LoWord (UNIX time in seconds)

Tab. 8.10: Event data structure

Event classification

Event classification	Meaning
1	Digital input 1 closed
2	Digital input 1 open
3	Digital input 2 closed
4	Digital input 2 open
11	Digital output 1 closed
12	Digital output 1 open
13	Digital output 2 closed
14	Digital output 2 open
22	Failure supply voltage
31	Setup changed via device buttons
32	Setup changed via communications
33…40	Reserved
41	DO1 triggered by DI1
42	DO2 triggered by DI1
43	DO1 triggered by DI2
44	DO2 triggered by DI2
51…59	Reserved
60	Setpoint active: phase voltage exceeded
61	Setpoint active: line-to-line voltage exceeded

Event classification	Meaning
62	Setpoint active: *I* exceeded
63	Setpoint active: P_{ges} exceeded
64	Setpoint active: Q_{ges} exceeded
65	Setpoint active: phase voltage exceeded
66	Setpoint active: line-to-line voltage below setpoint
67	Setpoint active: power factor below setpoint
68	Setpoint inactive: phase voltage exceeded
69	Setpoint inactive: line-to-line voltage exceeded
70	Setpoint inactive: *I* exceeded
71	Setpoint inactive: P_{ges} exceeded
72	Setpoint inactive: Q_{ges} exceeded
73	Setpoint inactive: phase voltage exceeded
74	Setpoint inactive: line-to-line voltage below setpoint
75	Setpoint inactive: power factor below setpoint

Tab. 8.11: Event classification (2. Event log register)

8.7 Time setting

The PEM333 provides two time display formats:

1. Year/Month/Day/Hour/Minute/Second register 60000…60002
2. UNIX time register 60004…60005

When sending the time via Modbus communications, make sure to use only one time display format of the two time register sets. All registers within a time register set must be written in a single transaction.
If all the registers **60000…60005** are set, both timestamp registers will display the time as UNIX time. Time specified in the first display format will be ignored.
Optionally, the register **60003** displays milliseconds. For transmitting the timestamp, the function code has to be set to 0x10 (Preset Multiple Register). Invalid date or time values will be rejected by the measuring device.

Register	Proper ty	Description	Format	Note
60000	RW	Year and month	UINT16	HiWord: year 2000 + (1…69) LoWord: month (1…12)
60001	RW	Day and hour	UINT16	HiWord: day (1…28/29/30/31) LoWord: hour (0…23)
60002	RW	Minute and second	UINT16	HiWord: minute (0…59) LoWord: second (0…59)
60003	RW	Millisecond	UINT16	0…999
60004…60005	RW	UINX Time	UINT32	Time in seconds elapsed since January 1, 1970 (00:00:00 h) (0…3155759999)

Tab. 8.12: Timestamp register

8.8 DOx control

The DI control register are implemented as "Write-Only" registers (WO) and are set with the function code 0x05. In order to query the current DO status, the register **40066** has to read out.
PEM executes commands to the outputs in two steps (**ARM before EXECUTING**): Before sending an open or close command to one of the outputs, it must be activated first. This is achieved by writing 0xFF00 to the appropriate DO register. If an "Execute" command is not received within 15 seconds, the output will be deactivated again.
Each command to be executed sent to an output not being activated before, will be ignored by the PEM333 and returned as an exception code 0x04.

Register	Property	Format	Description
60064	WO	UINT16	Activate close DO1
60065	WO	UINT16	Execute close DO1
60066	WO	UINT16	Activate open DO1
60067	WO	UINT16	Execute open DO1
60068	WO	UINT16	Activate close DO2
60069	WO	UINT16	Execute close DO2
60070	WO	UINT16	Activate open DO2
60071	WO	UINT16	Execute open DO2
60072…60127	Reserved		
60128	WO	UINT16	Activate reset alarm LED and buzzer
60129	WO	UINT16	Execute reset alarm LED and buzzer

Tab. 8.13: Digital output control register

8.9 Universal measuring device information

Register	Property	Description	Format	Note
60200… 60219	RO	Model*	UINT16	see Tab. 8.15: ASCII coding of "PEM333"
60220	RO	Software version	UINT16	e.g.: 10000 = V1.00.00
60221	RO	Protocol version	UINT16	e.g.: 40 = V4.0
60222	RO	Software update date (year + 2000)	UINT16	e.g.: 080709 = July 9, 2008
60223	RO	Software updateDate: month	UINT16	
60224	RO	Software updateDate: day	UINT16	
60225…60229	Reserved			
60230	RO	Measuring current input	UINT16	1 / 5 (A)
60231	RO	U_S	UINT16	100 / 400 (V)

Tab. 8.14: Measuring device information

* The model of the universal measuring device appears in the registers 60200…60219. A coding example is given in the table below using the "PEM333" by way of example.

Register	Value (Hex)	ASCII
60200	0x50	P
60201	0x45	E
60202	0x4D	M
60203	0x33	3
60204	0x33	3
60205	0x33	3
60206…60219	0x20	Null

Tab. 8.15: ASCII coding of "PEM333"