Modbus/RTU interface SINEAX AM2000 / AM3000

Content

The basics of the **MODBUS®** communication are summarized in the document **"Modbus Basics. PDF"** (see documentation CD or on our website http://www.camillebauer.com)

GMC INSTRUMENTS

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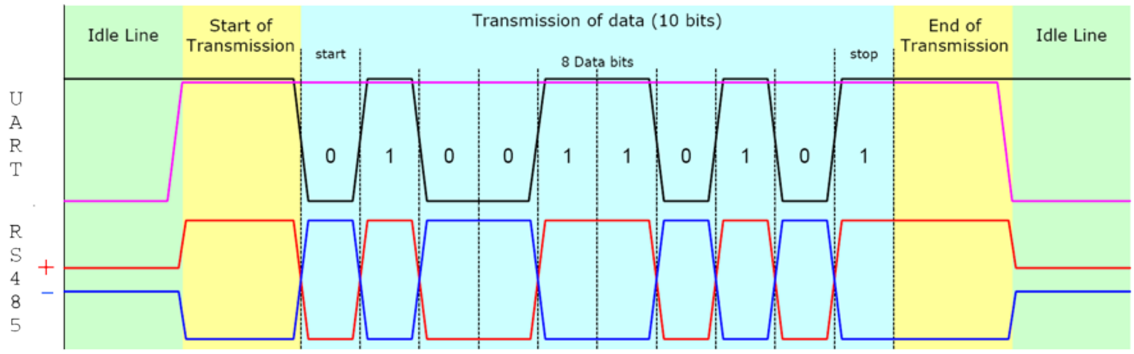
1 EIA-RS-485 Standard

The EIA-RS 485 standard defines the physical layer of the Modbus interface.

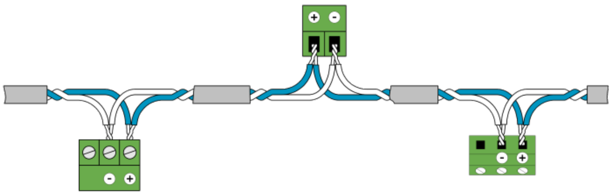
1.1 Coding

The data will be transferred serially via the 2-wire bus. The information is coded in NRZ code as a differential signal. The positive polarity signals a logical 1, the negative polarity signals a logical 0.

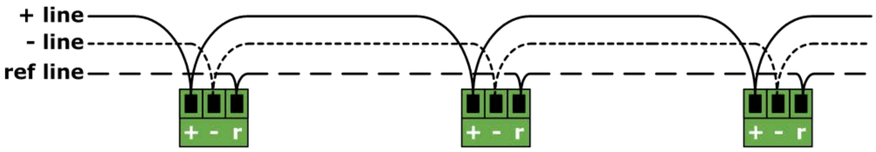


1.2 Connections

We recommend using a shielded and twisted two-wire bus cable. Shielding improves the electromagnetic compatibility (EMC). The notation of the wires A resp. B is contradictory depending on the information source.

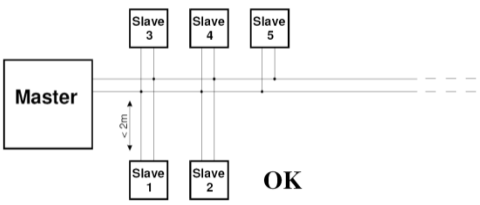


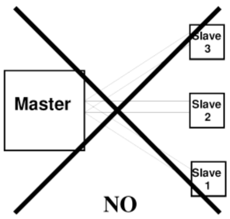
The potential difference of all bus members must not exceed ± 7V. Therefore the use of a shield or of a third wire (ref line) for potential equalization is recommended.

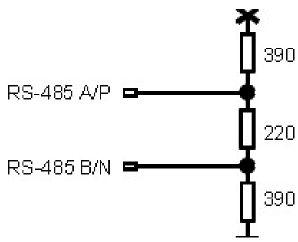


1.3 Topology

On both ends of the bus cable a termination resistor must be provided. In addition to the bus termination resistors a resistor R_U (Pull-up) must be connected to the supply voltage and a resistor R_D (Pull down) to the reference potential. By means of these two resistors a defined idle state of the line is ensured if no bus member is sending data.







1.4 System requirements

Cable	: twisted 2-wire line, characteristic impedance 100 up to 130 Ω, min. 0.22mm^2 (24AWG)
Cable length	: maximum of 1'200m, depending on the transfer rate
Members	: maximum of 32 per segment
Baud rate	: 2'400, 4'800, 9'600, 19'200, 38'400, 57'600, 115'200 Baud
Mode	: 11 Bit format - 2 stop bits, no parity or 1 stop bit with odd/even parity
	10 Bit format - 1 stop bit, no parity (possible, but not in accordance with Modbus standard)

2 Coding and addressing

Addressing

Modbus groups different data types as references. The telegram functions 03H (Read Holding Register) and 10H (Preset Multiple Registers) e.g. use register addresses starting at 40001. The reference 4xxxx is implicit, i.e. is given by the used telegram function. Therefore for addressing the leading 4 is omitted. Another specialty in Modbus telegrams: The register numeration starts at 1, but the addressing starts at 0.

Example: Measurement U1N on register address 40102

- Address declaration (see chapter 5.1): 40102
- Real address: 102 (offset 1)
- Address used in telegram: 101 (offset 0)

Serializing

The Modbus specification defines the telegrams to be sequences of data bytes. For the correct serializing of the bytes (MSB or LSB First), the appropriate physical layer (RS485, Ethernet) is responsible. The RS485 (UART, COM) transmits the „Least Significant Bit“ first (LSB First) and adds the synchronization and parity bits (start bit, parity bit and stop bit).

Start	1	2	3	4	5	6	7	8	Par	Stop

Reading bit information: Function 0x01, Read Coil Status

Bits are represented within a byte in a conventional way, MSB (Bit 7) on the most left and LSB (Bit 0) most right (0101’1010 = 0x5A = 90).

Example: Reading coils 100 up to 111 of device 17

Byte	Request		Answer	
1	Slave address	0x11	Slave address	0x11
2	Function code	0x01	Function code	0x01
3	Start address 99 = Coil 100	0x00	Byte count	0x02
4		0x63	Byte 1	**0x53**
5	Number of registers: 100…111 => 12	0x00	Byte 2	**0x03**
6		0x0C	Checksum CRC16	crc_l
7	Checksum CRC16	crc_l		crc_h
8		crc_h		

The start address of the request plus the bit position in the answer bytes corresponds to the coil address. Started bytes are filled with zeros.

	Hex	**Binary**	**Coil 8**	**Coil 7**	**Coil 6**	**Coil 5**	**Coil 4**	**Coil 3**	**Coil 2**	**Coil 1**
Byte 1	0x53	01010011b	OFF	ON	OFF	ON	OFF	OFF	ON	ON

	Hex	**Binary**	**-**	**-**	**-**	**-**	**Coil 12**	**Coil 11**	**Coil 10**	**Coil 9**
Byte 2	0x03	00000011b	-	-	-	-	OFF	OFF	ON	ON

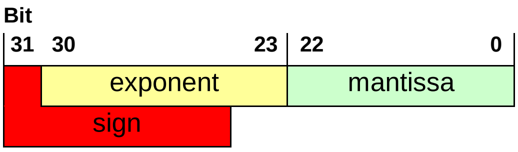
Reading float numbers (REAL): Function 0x03, Read Holding Register

There is no representation for floating point numbers in the Modbus specification. But as a matter of principle any desired data structure can be casted to a sequence of 16Bit registers.

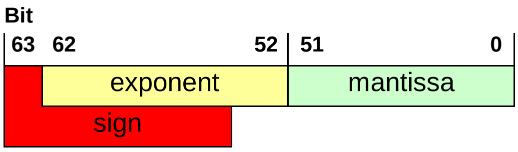
The IEEE 754 standard as the most often used standard for the representation of floating numbers is applied. 32 and 64 Bit numbers are used:

- The first register contains the bits 0 – 15
- The second register contains the bits 16 – 31
- The third register contains the bits 32 – 47
- The fourth register contains the bits 48 – 63

32-Bit Float (REAL32)



64-Bit Float (REAL64)



Example: Reading voltage U1N on register address 40102 of device 17.

Byte	Request		Answer	
1	Slave address	0x11	Slave address	0x11
2	Function code	0x03	Function code	0x03
3	Start address	0x00	Byte Count	0x04
4	(102-1)	0x65	Byte 1	**0xE8**
5	Number of registers:	0x00	Byte 2	**0x78**
6	2	0x02	Byte 3	**0x43**
7	Checksum	crc_l	Byte 4	**0x6B**
8	CRC16	crc_h	Checksum	crc_l
9			CRC16	crc_h

0x436B																**0xE878**															
0	1	0	0	0	0	1	1	0	1	1	0	1	0	1	1	1	1	1	0	1	0	0	0	0	1	1	1	1	0	0	0
+	Exponent: 134-127=**7**								Mantissa=1.1101011110100001111000b=**1,84303188323974609375d**																						

➢ **U1N** = +1,84303188323974609375 * 2^7 **= 234,908V**

3 Mapping

3.1 Address space

The address space may be divided in 4 address spaces in accordance with the 4 data types.

Space	Access	Address range	Function code	
Coil	readable / writable	00001 – 09999	0x01 0x05 0x0F	Read Coil Status Force Single Coil Force Multiple Coils
Discrete input	read only	10001 – 19999	0x02	Read Input Status 1)
Input register	read only	30001 – 39999	0x04	Read Input Register 1)
Holding register	readable / writable	40001 – 49999	0x03 0x06 0x10	Read Holding Register Force Single Register 1) Preset Multiple Register

1) not implemented

To reduce the number of commands the device image has been mapped using „Holding register“ if possible. Quantities normally addressed as a single bit information are implemented as „Coil“ or „Discrete input“.

3.2 Used addresses

Address	# Reg.	Description	Access
40100 – 40193	114	Instantaneous values general	R
40230 – 40247	18	Instantaneous values of harmonic analysis	R
40250 – 40837	588	Instantaneous values of harmonics	R
40850 – 40885	36	Instantaneous values of imbalance analysis acc. Fortescue	R
40900 – 40955	56	Instantaneous values of extended power analysis	R
41000 – 41081	82	Timestamps of minimum/maximum of instantaneous values	R
41100 – 41181	82	Minimum/maximum of instantaneous values	R
41200 – 41811	612	Maximum values of harmonic analysis	R
41850 – 41865	16	Maximum values of imbalance analysis acc. Fortescue	R
41870 – 41909	40	Timestamps of maximum values of extended power analysis	R
41920 – 41959	40	Maximum values of extended power analysis	R
42000 – 42139	140	Power mean-values: Trend, last value, minimum / maximum value	R
42150 – 42293	144	Free selectable mean-values: Trend, last value, minimum / maximum	R
42300 – 42323	24	Bimetal current: Present value, timestamp and slave-pointer	R
42600 – 42631	32	Reading meter contents of standard quantities	R
42640 – 42735	48	Reading meter contents of free selectable quantities	R
42750 – 42781	32	Setting meter contents of standard quantities	W
42790 – 42885	48	Setting meter contents of free selectable quantities	W
42900 – 42931	32	Setting analog outputs (remote control)	W
43000 – 43039	43	Device description texts	R
43100 – 43567	468	Harmonics voltage/current (50.-89.)	R
43600 – 44067	468	Maximum values of harmonics voltage/current (50.-89.)	R
1 – 5		Reset of min/max values group 1…5	W
20		Reset of summary alarm	W
50 – 59		Remote I/O	W
100 – 111		State of limit values 1-12	R
140 – 147		State of monitoring functions 1…8	R
170 – 171		State of summary alarm	R

Access: R = readable, W = writable

3.3 Used Syntax

Address	Start address of described data block (Register, Coil or Input Status)
Time	Register address of a timestamp, typically of a minimum / maximum value
Value	Register address of a measured value, typically for minimum / maximum values
Reset	Coil register address to reset a corresponding measured quantity
Name	Unique name of a variable or structure
Type	**Data type of variable** UINT32: 32-bit integer without sign REAL32 (32-bit float) REAL64 (64-bit float) CHAR[..]:String with/without termination (NULL) TIME: seconds since 1970/1/1 (UINT32) COIL: Bit information
Default	Value when delivering, after a hardware reset or if quantity is not available
Description	Description of the quantity
14 | 2L | 3G | 3P | 3U | 3A | 4U | 4O	Availability of the measured quantities, depending on the connected system **14** = single phase system or 4-wire balanced load **2L** = two phase system (split phase) **3G** = 3-wire balanced load **3P** = 3-wire balanced load, phase shift (2U,1I) **available for AM3000 only** **3U** = 3-wire unbalanced load **3A** = 3-wire balanced load, Aron connection **4U** = 4-wire unbalanced load **4O** = 4-wire unbalanced load, Open-Y connection

4 Device information

4.1 Device identification

The type of the connected device may be identified using the function ***Report Slave ID*** (0x11).

Device address	Function	CRC	
ADDR	0x11	Low-Byte	High-Byte

Device answer:

Device address	Function	#Bytes	Device ID	Data1	Data2	CRC	
ADDR	0x11	3	<sid>			Low-Byte	High-Byte

0x01	0x00	VR660	Temperature controller
0x02	0x00	A200R	Display unit temperature controller
0x03	0x01	CAM	Measurement unit power quantities
0x04	0xFF	A*PLUS*	Multifunctional display unit
0x05	0x00	V604s	Universal transmitter
0x05	0x01	VB604s	Universal transmitter
0x05	0x02	VC604s	Universal transmitter
0x05	0x03	VQ604s	Universal transmitter
0x07	0x00	VS30	Temperature transmitter
0x08	0x00	DM5S	Multi-transducer DM5S
0x08	0x01	DM5F	Multi-transducer DM5F
0x0A	0xFF	HW730	Angular transmitter
0x0B	0xFF	AM1000	Multifunctional display unit
0x0C	0xFF	AM2000	Multifunctional display unit
0x0D	0xFF	AM3000	Multifunctional display unit
0x0E	0xFF	PQ3000	Power quality display unit

The value for Data2 is reserved for future extensions.

5 Measurements

5.1 General instantaneous values

Address	Name	14	2L	3G	3P	3U	3A	4U	4O	Type	Description
40100	U	●	●	-	-	●	-	-	-	REAL32	System voltage [V]
40102	U1N	-	●	-	-	-	-	●	●		Voltage phase L1 to N [V]
40104	U2N	-	●	-	-	-	-	●	●		Voltage phase L2 to N [V]
40106	U3N	-	-	-	-	-	-	●	●		Voltage phase L3 to N [V]
40108	U12	-	-	●	●	-	●	●	●		Voltage phase L1 to L2 [V]
40110	U23	-	-	●	●	-	●	●	●		Voltage phase L2 to L3 [V]
40112	U31	-	-	●	●	-	●	●	●		Voltage phase L3 to L1 [V]
40114	UNE	-	-	-	-	-	-	●	●		Zero displacement voltage in 4-wire systems [V]
40116	I	●	-	●	●	●	-	-	-	REAL32	System current [A]
40118	I1	-	●	-	-	-	●	●	●		Current in phase L1 [A]
40120	I2	-	●	-	-	-	●	●	●		Current in phase L2 [A]
40122	I3	-	-	-	-	-	●	●	●		Current in phase L3 [A]
40124	I4 / IN	-	●	-	-	-	-	●	●		Neutral current [A]
40126	P	●	●	●	●	●	●	●	●	REAL32	Active power system [W]
40128	P1	-	●	-	-	-	-	●	●		Active power phase 1 (L1 – N) [W]
40130	P2	-	●	-	-	-	-	●	●		Active power phase 2 (L2 – N) [W]
40132	P3	-	-	-	-	-	-	●	●		Active power phase 3 (L3 – N) [W]
40134	Q	●	●	●	●	●	●	●	●	REAL32	Reactive power system [var]
40136	Q1	-	●	-	-	-	-	●	●		Reactive power phase 1 (L1 – N) [var]
40138	Q2	-	●	-	-	-	-	●	●		Reactive power phase 2 (L2 – N) [var]
40140	Q3	-	-	-	-	-	-	●	●		Reactive power phase 3 (L3 – N) [var]
40142	S	●	●	●	●	●	●	●	●	REAL32	Apparent power system S [VA]
40144	S1	-	●	-	-	-	-	●	●		Reactive power phase 1 (L1 – N) [VA]
40146	S2	-	●	-	-	-	-	●	●		Reactive power phase 2 (L2 – N) [VA]
40148	S3	-	-	-	-	-	-	●	●		Reactive power phase 3 (L3 – N) [VA]
40150	F	●	●	●	●	●	●	●	●	REAL32	System frequency [Hz]
40152	PF	●	●	●	●	●	●	●	●	REAL32	PF = P / S, Power factor system
40154	PF1	-	●	-	-	-	-	●	●		Power factor phase 1 (L1 – N)
40156	PF2	-	●	-	-	-	-	●	●		Power factor phase 2 (L2 – N)
40158	PF3	-	-	-	-	-	-	●	●		Power factor phase 3 (L3 – N)
40160	QF	●	●	●	●	●	●	●	●	REAL32	QF = Q / S, Reactive power factor system
40162	QF1	-	●	-	-	-	-	●	●		Reactive power factor phase 1 (L1 – N)
40164	QF2	-	●	-	-	-	-	●	●		Reactive power factor phase 2 (L2 – N)
40166	QF3	-	-	-	-	-	-	●	●		Reactive power factor phase 3 (L3 – N)
40168	LF	●	●	●	●	●	●	●	●	REAL32	sign(Q)·(1 – abs(PF)), Load factor system
40170	LF1	-	●	-	-	-	-	●	●		Load factor phase 1 (L1 – N)
40172	LF2	-	●	-	-	-	-	●	●		Load factor phase 2 (L2 – N)
40174	LF3	-	-	-	-	-	-	●	●		Load factor phase 3 (L3 – N)
40176	U_MEAN	-	●	●	●	-	●	●	-	REAL32	Average value of voltages (U1x+U2x+U3x)/3 [V]
40178	I_MEAN	-	●	-	-	-	-	●	●		Average value of currents (I1+I2+I3)/3 [A]
40180	UF12	-	-	●	●	-	●	●	●	REAL32	Phase angle voltage U1-U2 [°]
40182	UF23	-	-	●	●	-	●	●	●		Phase angle voltage U2-U3 [°]
40184	UF31	-	-	●	●	-	●	●	●		Phase angle voltage U3-U1 [°]
40186	DEV_UMAX	-	●	●	●	-	●	●	●	REAL32	Max. deviation from the average value of voltages [V]
40188	DEV_IMAX	-	●	-	-	-	●	●	●	REAL32	Max. deviation from the average value of currents [A]
40190	IMS	●	●	●	●	●	●	●	●	REAL32	Average value of currents with sign of P [A]
40192	IPE [1)]	-	-	-	-	-	-	●	●	REAL32	Earth current [A]

1) Available for AM3000 only

5.2 System analysis

5.2.1 Instantaneous values of harmonic analysis

Address	Name	14	2L	3G	3P	3U	3A	4U	4O	Type	Description
40230	THD_U1x	U	U1N	U12	U	U12	U12	U1N	U1N	REAL32	Total Harmonic Distortion [%]
40232	THD_U2x	-	U2N	U23	-	U23	U23	U2N	U2N	REAL32	Total Harmonic Distortion [%]
40234	THD_U3x	-	-	U31	-	U31	U31	U3N	U3N	REAL32	Total Harmonic Distortion [%]
40236	TDD_I1	I	I1	I	I	I1	I1	I1	I1	REAL32	Total Demand Distortion [%]
40238	TDD_I2	-	I2	-	-	I2	I2	I2	I2	REAL32	Total Demand Distortion [%]
40240	TDD_I3	-	-	-	-	I3	I3	I3	I3	REAL32	Total Demand Distortion [%]
40242	THD_I1	I	I1	I	I	I1	I1	I1	I1	REAL32	Total Harmonic Distortion [%]
40244	THD_I2	-	I2	-	-	I2	I2	I2	I2	REAL32	Total Harmonic Distortion [%]
40246	THD_I3	-	-	-	-	I3	I3	I3	I3	REAL32	Total Harmonic Distortion [%]

►THD_U: Harmonic content related to the fundamental of the RMS value of the voltage

►TDD_I: Harmonic content related to the **rated value** of the current

►THD_I: Harmonic content related to the fundamental of the RMS value of the current

Address	Name	14	2L	3G	3G	3U	3A	4U	4O	Type	Description
40250	H2_U1X ..... H50_U1X	U	U1N	U12	U	U12	U12	U1N	U1N	REAL32	Content of 2nd harmonic [%] ..... Content of 50th harmonic [%]
40348	H2_U2X ..... H50_U2X	-	U2N	U23	-	U23	U23	U2N	U2N	REAL32	Content of 2nd harmonic [%] ..... Content of 50th harmonic [%]
40446	H2_U3X ..... H50_U3X	-	-	U31	-	U31	U31	U3N	U3N	REAL32	Content of 2nd harmonic [%] ..... Content of 50th harmonic [%]
40544	H2_I1X ..... H50_I1X	I	I1	I	I	I1	I1	I1	I1	REAL32	Content of 2nd harmonic [%] ..... Content of 50th harmonic [%]
40642	H2_I2X ..... H50_I2X	-	I2	-	-	I2	I2	I2	I2	REAL32	Content of 2nd harmonic [%] ..... Content of 50th harmonic [%]
40740	H2_I3X ..... H50_I3X	-	-	-	-	I3	I3	I3	I3	REAL32	Content of 2nd harmonic [%] ..... Content of 50th harmonic [%]

Address	Name	14	2L	3G	3P	3U	3A	4U	4O	Type	Description
43100	H51_U1X ..... H89_U1X	U	U1N	U12	U	U12	U12	U1N	U1N	REAL32	Content of 51st harmonic [%] ..... Content of 89th harmonic [%]
43178	H51_U2X ..... H89_U2X	-	U2N	U23	-	U23	U23	U2N	U2N	REAL32	Content of 51st harmonic [%] ..... Content of 89th harmonic [%]
43256	H51_U3X ..... H89_U3X	-	-	U31	-	U31	U31	U3N	U3N	REAL32	Content of 51st harmonic [%] ..... Content of 89th harmonic [%]
43334	H51_I1X ..... H89_I1X	I	I1	I	I	I1	I1	I1	I1	REAL32	Content of 51st harmonic [%] ..... Content of 89th harmonic [%]
43412	H51_I2X ..... H89_I2X	-	I2	-	-	I2	I2	I2	I2	REAL32	Content of 51st harmonic [%] ..... Content of 89th harmonic [%]
43490	H51_I3X ..... H89_I3X	-	-	-	-	I3	I3	I3	I3	REAL32	Content of 51st harmonic [%] ..... Content of 89th harmonic [%]

►Hi_Uxy: Harmonic content of the voltage related to the fundamental 100 %

►Hi_Ixy: Harmonic content of the current related to the **rated** current

►At rated frequency 60Hz harmonics are available up to the 75th only, the other values are 0.0

5.2.2 Instantaneous values of imbalance analysis acc. Fortescue

Address	Name	14	2L	3G	3P	3U	3A	4U	4O	Type	Description
40850	UR1	-	-	●	-	●	●	●	-	REAL32	Voltage [V]: Positive sequence
40852	UR2	-	-	●	-	●	●	●	-		Voltage [V]: Negative sequence
40854	U0	-	-	-	-	-	-	●	-		Voltage [V]: Zero sequence
40856	IR1	-	-	-	-	●	-	●	●	REAL32	Current [A]: Positive sequence
40858	IR2	-	-	-	-	●	-	●	●		Current [A]: Negative sequence
40860	I0	-	-	-	-	-	-	●	●		Current [A]: Zero sequence
40862	UNB_UR2_UR1	-	-	●	-	●	●	●	-	REAL32	Imbalance factor voltage: UR2/UR1 [%]
40864	UNB_IR2_IR1	-	-	-	-	●	-	●	●		Imbalance factor current: IR2/IR1 [%]
40866	UNB_U0_UR1	-	-	-	-	-	-	●	-	REAL32	Imbalance factor voltage: U0/UR1 [%]
40868	UNB_I0_IR1	-	-	-	-	-	-	●	●		Imbalance factor current: I0/IR1 [%]

5.2.3 Instantaneous values of extended power analysis

Address	Name	14	2L	3G	3G	3U	3A	4U	4O	Type	Description
40908	Q_H1	●	●	●	●	●	●	●	●	REAL32	Reactive power of fundamental, system [var]
40910	Q1_H1	-	●	-	-	-	-	●	●		Reactive power of fundamental, phase L1 [var]
40912	Q2_H1	-	●	-	-	-	-	●	●		Reactive power of fundamental, phase L2 [var]
40914	Q3_H1	-	-	-	-	-	-	●	●		Reactive power of fundamental, phase L3 [var]
40924	D	●	●	●	●	●	●	●	●	REAL32	Distortion reactive power, system [var]
40926	D1	-	●	-	-	-	-	●	●		Distortion reactive power, phase L1 [var]
40928	D2	-	●	-	-	-	-	●	●		Distortion reactive power, phase L2 [var]
40930	D3	-	-	-	-	-	-	●	●		Distortion reactive power, phase L3 [var]
40932	CPHI	●	●	●	●	●	●	●	●	REAL32	cos(φ) of fundamental, system
40934	CPHI1	-	●	-	-	-	-	●	●		cos(φ) of fundamental, phase L1
40936	CPHI2	-	●	-	-	-	-	●	●		cos(φ) of fundamental, phase L2
40938	CPHI3	-	-	-	-	-	-	●	●		cos(φ) of fundamental, phase L3
40940	TPHI	●	●	●	●	●	●	●	●	REAL32	tan(φ) of fundamental, system
40942	TPHI1	-	●	-	-	-	-	●	●		tan(φ) of fundamental, phase L1
40944	TPHI2	-	●	-	-	-	-	●	●		tan(φ) of fundamental, phase L2
40946	TPHI3	-	-	-	-	-	-	●	●		tan(φ) of fundamental, phase L3

5.3 Minimum / maximum values of system quantities

Time [TIME]	Value [REAL32]	Name	14	2L	3G	3P	3U	3A	4U	4O	Description
41000	41100	U_MAX	●	●	-	●	-	-	-	-	Maximum value of U [V]
41002	41102	U1N_MAX	-	●	-	-	-	-	●	●	Maximum value of U1N [V]
41004	41104	U2N_MAX	-	●	-	-	-	-	●	●	Maximum value of U2N [V]
41006	41106	U3N_MAX	-	-	-	-	-	-	●	●	Maximum value of U3N [V]
41008	41108	U12_MAX	-	-	●	-	●	●	●	●	Maximum value of U12 [V]
41010	41110	U23_MAX	-	-	●	-	●	●	●	●	Maximum value of U23 [V]
41012	41112	U31_MAX	-	-	●	-	●	●	●	●	Maximum value of U31 [V]
41014	41114	UNE_MAX	-	-	-	-	-	-	●	●	Maximum value of UNE [V]
41016	41116	I_MAX	●	-	●	●	-	-	-	-	Maximum value of I [A]
41018	41118	I1_MAX	-	●	-	-	●	●	●	●	Maximum value of I1 [A]
41020	41120	I2_MAX	-	-	-	-	●	●	●	●	Maximum value of I2 [A]
41022	41122	I3_MAX	-	-	-	-	●	●	●	●	Maximum value of I3 [A]
41024	41124	IN_MAX	-	●	-	-	-	-	●	●	Maximum value of IN [A]
41026	41126	P_MAX	●	●	●	●	●	●	●	●	Maximum value of P [W]
41028	41128	P1_MAX	-	●	-	-	-	-	●	●	Maximum value of P1 [W]
41030	41130	P2_MAX	-	●	-	-	-	-	●	●	Maximum value of P2 [W]
41032	41132	P3_MAX	-	-	-	-	-	-	●	●	Maximum value of P3 [W]
41034	41134	Q_MAX	●	●	●	●	●	●	●	●	Maximum value of Q [var]
41036	41136	Q1_MAX	-	●	-	-	-	-	●	●	Maximum value of Q1 [var]
41038	41138	Q2_MAX	-	●	-	-	-	-	●	●	Maximum value of Q2 [var]
41040	41140	Q3_MAX	-	-	-	-	-	-	●	●	Maximum value of Q3 [var]
41042	41142	S_MAX	●	●	●	●	●	●	●	●	Maximum value of S [VA]
41044	41144	S1_MAX	-	●	-	-	-	-	●	●	Maximum value of S1 [VA]
41046	41146	S2_MAX	-	●	-	-	-	-	●	●	Maximum value of S2 [VA]
41048	41148	S3_MAX	-	-	-	-	-	-	●	●	Maximum value of S3 [VA]
41050	41150	F_MAX	●	●	●	●	●	●	●	●	Maximum value of F [Hz]
41052	41152	DEV_UMAX_MAX	-	-	●	-	●	●	●	●	Maximum value of DEV_UMAX [V]
41054	41154	DEV_IMAX_MAX	-	-	-	-	●	●	●	●	Maximum value of DEV_IMAX [A]
41056	41156	U_MIN	●	●	-	●	-	-	-	-	Minimum value of U [V]
41058	41158	U1N_MIN	-	●	-	-	-	-	●	●	Minimum value of U1N [V]
41060	41160	U2N_MIN	-	●	-	-	-	-	●	●	Minimum value of U2N [V]
41062	41162	U3N_MIN	-	-	-	-	-	-	●	●	Minimum value of U3N [V]
41064	41164	U12_MIN	-	-	●	-	●	●	●	●	Minimum value of U12 [V]
41066	41166	U23_MIN	-	-	●	-	●	●	●	●	Minimum value of U23 [V]
41068	41168	U31_MIN	-	-	●	-	●	●	●	●	Minimum value of U31 [V]
41070	41170	PF_MIN_QI	●	●	●	●	●	●	●	●	min. power factor quadrant I
41072	41172	PF_MIN_QIV	●	●	●	●	●	●	●	●	min. power factor quadrant IV
41074	41174	PF_MIN_QIII	●	●	●	●	●	●	●	●	min. power factor quadrant III
41076	41176	PF_MIN_QII	●	●	●	●	●	●	●	●	min. power factor quadrant II
41078	41178	F_MIN	●	●	●	●	●	●	●	●	Minimum value of F [Hz]
41080	41180	IPE_MAX 1)	-	-	-	-	-	-	●	●	Maximum value of IPE [A]

► Resetting of min/max values in groups, see Resetting of min/max values

► A timestamp "1.1.1970" indicates that the associated measurement is invalid.

1) Available for AM3000 only

5.4 Minimum / maximum values of system analysis

5.4.1 Maximum values of harmonic analysis

Time [TIME]	Value [REAL32]	Name	14	2L	3G	3P	3U	3A	4U	4O	Description
41200	41212	THD_U1X_MAX	U	U1N	U12	U	U12	U12	U1N	U1N	Max. THD value phase 1 [%]
41202	41214	THD_U2X_MAX	-	U2N	U23	-	U23	U23	U2N	U2N	Max. THD value phase 2 [%]
41204	41216	THD_U3X_MAX	-	-	U31	-	U31	U31	U3N	U3N	Max. THD value phase 3 [%]
41206	41218	TDD_I1X_MAX	I	I1	I	I	I1	I1	I1	I1	Max. TDD value phase 1 [%]
41208	41220	TDD_I2X_MAX	-	I2	-	-	I2	I2	I2	I2	Max. TDD value phase 2 [%]
41210	41222	TDD_I3X_MAX	-	-	-	-	I3	I3	I3	I3	Max. TDD value phase 3 [%]

Time [TIME]	Value [REAL32]	Name	14	2L	3G	3G	3U	3A	4U	4O	Description
41200	41224	H2_U1X_MAX	U	U1N	U12	U	U12	U12	U1N	U1N	Max. content of 2^{nd} harmonic [%]
	…..	…..									…..
	41320	H50_U1X_MAX									Max. content of 50^{th} harmonic [%]
41202	41322	H2_U2X_MAX	-	U2N	U23	-	U23	U23	U2N	U2N	Max. content of 2^{nd} harmonic [%]
	…..	…..									…..
	41418	H50_U2X_MAX									Max. content of 50^{th} harmonic [%]
41204	41420	H2_U3X_MAX	-	-	U31	-	U31	U31	U3N	U3N	Max. content of 2^{nd} harmonic [%]
	…..	…..									…..
	41516	H50_U3X_MAX									Max. content of 50^{th} harmonic [%]
41206	41518	H2_I1X_MAX	I	I1	I	I	I1	I1	I1	I1	Max. content of 2^{nd} harmonic [%]
	…..	…..									…..
	41614	H50_I1X_MAX									Max. content of 50^{th} harmonic [%]
41208	41616	H2_I2X_MAX	-	I2	-	-	I2	I2	I2	I2	Max. content of 2^{nd} harmonic [%]
	…..	…..									…..
	41712	H50_I2X_MAX									Max. content of 50^{th} harmonic [%]
41210	41714	H2_I3X_MAX	-	-	-	-	I3	I3	I3	I3	Max. content of 2^{nd} harmonic [%]
	…..	…..									…..
	41810	H50_I3X_MAX									Max. content of 50^{th} harmonic [%]

Time [TIME]	Value [REAL32]	Name	14	2L	3G	3P	3U	3A	4U	4O	Description
41200	43600	H51_U1X_MAX	U	U1N	U12	U	U12	U12	U1N	U1N	Max. content of 51^{st} harmonic [%]
	…..	…..									…..
	43676	H89_U1X_MAX									Max. content of 89^{th} harmonic [%]
41202	43678	H51_U2X_MAX	-	U2N	U23	-	U23	U23	U2N	U2N	Max. content of 51^{st} harmonic [%]
	…..	…..									…..
	43754	H89_U2X_MAX									Max. content of 89^{th} harmonic [%]
41204	43756	H51_U3X_MAX	-	-	U31	-	U31	U31	U3N	U3N	Max. content of 51^{st} harmonic [%]
	…..	…..									…..
	43832	H89_U3X_MAX									Max. content of 89^{th} harmonic [%]
41206	43834	H51_I1X_MAX	I	I1	I	I	I1	I1	I1	I1	Max. content of 51^{st} harmonic [%]
	…..	…..									…..
	43910	H89_I1X_MAX									Max. content of 89^{th} harmonic [%]
41208	43912	H51_I2X_MAX	-	I2	-	-	I2	I2	I2	I2	Max. content of 51^{st} harmonic [%]
	…..	…..									…..
	43988	H89_I2X_MAX									Max. content of 89^{th} harmonic [%]
41210	43990	H51_I3X_MAX	-	-	-	-	I3	I3	I3	I3	Max. content of 51^{st} harmonic [%]
	…..	…..									…..
	44066	H89_I3X_MAX									Max. content of 89^{th} harmonic [%]

- ► The maximum values of the harmonic analysis arise from monitoring the maximum values of THD resp. TDD. The maximum values of the individual harmonics are not monitored separately, but stored when a maximum value of THD or TDD is recognized. The image of the maximum harmonics therefore always corresponds to the associated THD resp. TDD.
- ► At rated frequency 60Hz only harmonics up to the 75^{th} are available, the other values are 0.0
- ► Resetting of min/max values in groups, see Resetting of min/max values
- ► A timestamp "1.1.1970" indicates that the associated measurement is invalid.

The individual harmonics are implemented as 32-bit float numbers (2 registers per value).

5.4.2 Maximum values of imbalance analysis acc. Fortescue

Time [TIME]	**Value** [REAL32]	**Name**	**14**	**2L**	**3G**	**3P**	**3U**	**3A**	**4U**	**4O**	**Description**	
41850	41858	UNB_UR2_UR1_MAX	-	-	●	-	●	●	●	-	max. imbalance UR2/UR1	[%]
41852	41860	UNB_IR2_IR1_MAX	-	-	-	-	-	-	●	●	max. imbalance IR2/IR1	[%]
41854	41862	UNB_U0_UR1_MAX	-	-	-	-	●	-	●	-	max. imbalance U0/UR1	[%]
41856	41864	UNB_I0_IR1_MAX	-	-	-	-	-	-	●	●	max. imbalance I0/IR1	[%]

► Resetting of min/max values in groups, see Resetting of min/max values

► A timestamp "1.1.1970" indicates that the associated measurement is invalid.

The imbalance maximum values are implemented as 32-bit float numbers (2 registers per value).

5.4.3 Maximum values of extended power analysis

Time [TIME]	Value [REAL32]	Name	14	2L	3G	3P	3U	3A	4U	4O	Description
41870	41920	P_MAX_H1	●	●	●	●	●	●	●	-	Max. active power of fundamental, system [W]
41872	41922	P1_MAX_H1	-	●	-	-	-	-	●	●	Max. active power of fundamental, phase L1 [W]
41874	41924	P2_MAX_H1	-	●	-	-	●	-	●	-	Max. active power of fundamental, phase L2 [W]
41876	41926	P3_MAX_H1	-	-	-	-	-	-	●	●	Max. active power of fundamental, phase L3 [W]
41878	41928	Q_MAX_H1	●	●	●	●	●	●	●	-	Max. reactive power fundamental, system [var]
41880	41930	Q1_MAX_H1	-	●	-	-	-	-	●	●	Max. reactive power fundamental, phase L1 [var]
41882	41932	Q2_MAX_H1	-	●	-	-	●	-	●	-	Max. reactive power fundamental, phase L2 [var]
41884	41934	Q3_MAX_H1	-	-	-	-	-	-	●	●	Max. reactive power fundamental, phase L3 [var]
41886	41936	Q_MAX_H1	●	●	●	●	●	●	●	-	Max. apparent power of fundamental, system [VA]
41888	41938	Q1_MAX_H1	-	●	-	-	-	-	●	●	Max. apparent power fundamental, phase L1 [VA]
41890	41940	Q2_MAX_H1	-	●	-	-	●	-	●	-	Max. apparent power fundamental, phase L2 [VA]
41892	41942	Q3_MAX_H1	-	-	-	-	-	-	●	●	Max. apparent power fundamental, phase L3 [VA]
41894	41944	D_MAX	●	●	●	●	●	●	●	-	Max. distortion reactive power, system [var]
41896	41946	D1_MAX	-	●	-	-	-	-	●	●	Max. distortion reactive power, phase L1 [var]
41898	41948	D2_MAX	-	●	-	-	●	-	●	-	Max. distortion reactive power, phase L2 [var]
41900	41950	D3_MAX	-	-	-	-	-	-	●	●	Max. distortion reactive power, phase L3 [var]
41902	41952	CPHI_MIN_QI	●	●	●	●	●	●	●	●	min. cos(φ) quadrant I (*)
41904	41954	CPHI _MIN_QIV	●	●	●	●	●	●	●	●	min. cos(φ) quadrant IV (*)
41906	41956	CPHI _MIN_QIII	●	●	●	●	●	●	●	●	min. cos(φ) quadrant III (*)
41908	41958	CPHI _MIN_OII	●	●	●	●	●	●	●	●	min. cos(φ) quadrant II (*)

(*) min. cos(φ) of the system fundamental in all 4 quadrants

All values are implemented as 32-bit float numbers (2 registers per value).

► Resetting of min/max values in groups, see Resetting of min/max values

► A timestamp "1.1.1970" indicates that the associated measurement is invalid.

5.5 Mean-values: Trend, Last values, minimum / maximum values

5.5.1 Mean values of power (standard quantities), averaging interval t1

	Trend	Mean-value	Maximum		Minimum		
Name	[REAL32]	Last ...... - 4 [REAL32]	**Time** [TIME]	**Value** [REAL32]	**Time** [TIME]	**Value** [REAL32]	**Description**
AVG_P_I_IV	42000	42010... 42018	42060	42080	42070	42090	Mean-value P, quadrant I+IV [W]
AVG_P_II_III	42002	42020... 42028	42062	42082	42072	42092	Mean-value P, quadrant II+III [W]
AVG_Q_I_II	42004	42030... 42038	42064	42084	42074	42094	Mean-value Q, quadrant I+II [var]
AVG_Q_III_IV	42006	42040... 42048	42066	42086	42076	42096	Mean-value Q, quadrant III+IV [var]
AVG_S	42008	42050... 42058	42068	42088	42078	42098	Mean-value S [VA]

► Resetting of min/max values in groups, see Resetting of min/max values

► A timestamp "1.1.1970" indicates that the associated measurement is invalid.

► For each of the standard quantities the mean-value for the last interval and the 4 previous values are provided.

5.5.2 Free configurable mean-value quantities, averaging interval t2

	Trend	Mean-value	Maximum		Minimum		
Name	[REAL32]	Last [REAL32]	**Time** [TIME]	**Value** [REAL32]	**Time** [TIME]	**Value** [REAL32]	**Description**
AVG_1	42150	42174	42198	42246	42222	42270	Config. mean-value 1
AVG_2	42152	42176	42200	42248	42224	42272	Config. mean-value 2
AVG_3	42154	42178	42202	42250	42226	42274	Config. mean-value 3
AVG_4	42156	42180	42204	42252	42228	42276	Config. mean-value 4
AVG_5	42158	42182	42206	42254	42230	42278	Config. mean-value 5
AVG_6	42160	42184	42208	42256	42232	42280	Config. mean-value 6
AVG_7	42162	42186	42210	42258	42234	42282	Config. mean-value 7
AVG_8	42164	42188	42212	42260	42236	42284	Config. mean-value 8
AVG_9	42166	42190	42214	42262	42238	42286	Config. mean-value 9
AVG_10	42168	42192	42216	42264	42240	42288	Config. mean-value 10
AVG_11	42170	42194	42218	42266	42242	42290	Config. mean-value 11
AVG_12	42172	42196	42220	42268	42244	42292	Config. mean-value 12

► Resetting of min/max values in groups, see Resetting of min/max values

► A timestamp "1.1.1970" indicates that the associated measurement is invalid.

5.5.3 Bimetal current, averaging interval t3

	Value	Maximum										
Name	[REAL32]	**Time** [TIME]	**Value** [REAL32]	**14**	**2L**	**3G**	**3P**	**3U**	**3A**	**4U**	**4O**	**Description**
IB	42300	42308	42316	●	-	●	●	-	-	-	-	Damped current in balanced systems [A]
IB1	42302	42310	42318	-	●	-	-	●	●	●	●	Damped current in phase L1 [A]
IB2	42304	42312	42320	-	●	-	-	●	●	●	●	Damped current in phase L2 [A]
IB3	42306	42314	42322	-	-	-	-	●	●	●	●	Damped current in phase L3 [A]

► Resetting of min/max values in groups, see Resetting of min/max values

► A timestamp "1.1.1970" indicates that the associated measurement is invalid.

5.6 Resetting of min/max values

Min/max values may be reset in groups via coils.

Address	Name	Type	Group to be reset
1	MM_RES1	COIL	- Min/max of voltages, currents, frequency
2	MM_RES2	COIL	- Min/max of active, reactive, apparent power - Min/max of fundamental and distortion reactive power - Minimum values of load factors, cosφ
3	MM_RES3	COIL	- Min/Max values of power mean-values / configurable mean-values - Bimetal slave pointers
4	MM_RES4	COIL	- Maximum of THD U/I, TDD I, individual harmonics
5	MM_RES5	COIL	- Maximum values of imbalance analysis

5.7 Present state of limit values

Address	Name	Type	Description
100	LIMIT_ST1	COIL	State of limit value 1 (0=OFF, 1=ON)
101	LIMIT_ST2		State of limit value 2 (0=OFF, 1=ON)
102	LIMIT_ST3		State of limit value 3 (0=OFF, 1=ON)
103	LIMIT_ST4		State of limit value 4 (0=OFF, 1=ON)
104	LIMIT_ST5		State of limit value 5 (0=OFF, 1=ON)
105	LIMIT_ST6		State of limit value 6 (0=OFF, 1=ON)
106	LIMIT_ST7		State of limit value 7 (0=OFF, 1=ON)
107	LIMIT_ST8		State of limit value 8 (0=OFF, 1=ON)
108	LIMIT_ST9		State of limit value 9 (0=OFF, 1=ON)
109	LIMIT_ST10		State of limit value 10 (0=OFF, 1=ON)
110	LIMIT_ST11		State of limit value 11 (0=OFF, 1=ON)
111	LIMIT_ST12		State of limit value 12 (0=OFF, 1=ON)

5.8 Present state of monitoring functions

Address	Name	Type	Description
140	MFUN_ST1	COIL	State of monitoring function 1 (0=inactive, 1=active)
141	MFUN_ST2		State of monitoring function 2 (0=inactive, 1=active)
142	MFUN_ST3		State of monitoring function 3 (0=inactive, 1=active)
143	MFUN_ST4		State of monitoring function 4 (0=inactive, 1=active)
144	MFUN_ST5		State of monitoring function 5 (0=inactive, 1=active)
145	MFUN_ST6		State of monitoring function 6 (0=inactive, 1=active)
146	MFUN_ST7		State of monitoring function 7 (0=inactive, 1=active)
147	MFUN_ST8		State of monitoring function 8 (0=inactive, 1=active)

5.9 Summary alarm

The summary alarm represents the over-all alarm state of the device. It is the AND combination of all defined monitoring functions enabled for the summary alarm and is active if at least one function is in the alarm state. The summary alarm is used for showing the alarm state on the display and can also activate a logic output (e.g. digital output or relay).

Via interface the summary alarm may be influenced as follows:

- **Resetting** the logic output of the summary alarm: The output will be reset even if there summary alarm is active.

Address	Name	Type	Description
170	SA_STATE	COIL	State of summary alarm (0=inactive, 1=active)
171	SA_RES_STATE	COIL	Logic output of summary alarm (0=inactive or reset, 1=active)
20	SA_RESET	COIL	For **Resetting** the logic output of the summary alarm

6 Energy meters

6.1 Meter contents of standard quantities

Reading [REAL64]	Writing [REAL64]	Name	14	2L	3G	3G	3U	3A	4U	4O	Description
42600	42750	P_I_IV_HT	●	●	●	●	●	●	●	●	Active energy QI+IV, high tariff [Wh]
42604	42754	P_II_III_HT	●	●	●	●	●	●	●	●	Active energy QII+III, high tariff [Wh]
42608	42758	Q_I_II_HT	●	●	●	●	●	●	●	●	Reactive energy QI+II, high tariff [varh]
42612	42762	Q_III_IV_HT	●	●	●	●	●	●	●	●	Reactive energy QIII+IV, high tariff [varh]
42616	42766	P_I_IV_LT	●	●	●	●	●	●	●	●	Active energy QI+IV, low tariff [Wh]
42620	42770	P_II_III_LT	●	●	●	●	●	●	●	●	Active energy QII+III, low tariff [Wh]
42624	42774	Q_I_II_LT	●	●	●	●	●	●	●	●	Reactive energy QI+II, low tariff [varh]
42628	42778	Q_III_IV_LT	●	●	●	●	●	●	●	●	Reactive energy QIII+IV, low tariff [varh]

- All values implemented as REAL64 numbers (4 registers per value).

6.2 Meter contents of free selectable quantities

Reading [REAL64]	Writing [REAL64]	Name	Description
42640	42790	METER1_HT	Free selectable meter 1, high tariff
42644	42794	METER2_HT	Free selectable meter 2, high tariff
42648	42798	METER3_HT	Free selectable meter 3, high tariff
42652	42802	METER4_HT	Free selectable meter 4, high tariff
42656	42806	METER5_HT	Free selectable meter 5, high tariff
42660	42810	METER6_HT	Free selectable meter 6, high tariff
42664	42814	METER7_HT	Free selectable meter 7, high tariff
42668	42818	METER8_HT	Free selectable meter 8, high tariff
42672	42822	METER9_HT	Free selectable meter 9, high tariff
42676	42826	METER10_HT	Free selectable meter 10, high tariff
42680	42830	METER11_HT	Free selectable meter 11, high tariff
42684	42834	METER12_HT	Free selectable meter 12, high tariff
42688	42838	METER1_NT	Free selectable meter 1, low tariff
42692	42842	METER2_NT	Free selectable meter 2, low tariff
42696	42846	METER3_NT	Free selectable meter 3, low tariff
42700	42850	METER4_NT	Free selectable meter 4, low tariff
42704	42854	METER5_NT	Free selectable meter 5, low tariff
42708	42858	METER6_NT	Free selectable meter 6, low tariff
42712	42862	METER7_NT	Free selectable meter 7, low tariff
42716	42866	METER8_NT	Free selectable meter 8, low tariff
42720	42870	METER9_NT	Free selectable meter 9, low tariff
42724	42874	METER10_NT	Free selectable meter 10, low tariff
42728	42878	METER11_NT	Free selectable meter 11, low tariff
42732	42882	METER12_NT	Free selectable meter 12, low tariff

- All meter contents are scaled in the basic unit of the appropriate base quantity (Ah, Wh, VAh, varh)
- All values implemented as REAL64 numbers (4 registers per value).

6.3 Present tariff of meters

The device supports two tariffs, high and low tariff. The same tariff is used for both, standard meters and free selectable meters. The tariff can be defined via digital input 0.1. The present state of this digital input therefore represents the active tariff.

Reading [COIL]	**Name**	**Description**
180	DIGIN0_1	**Tariff situation** 0: high tariff 1: low tariff

7 Remote interface

All relays or digital outputs **not used** for the normal device functionality may be used for other purposes. Driving is performed via the configuration interface, e.g. by means of a Modbus master software.

Address	Name	Type	Description
50	STAT_O1	COIL	State of digital output 0.1
51	STAT_O2	COIL	State of digital output 0.2
52	STAT_O3	COIL	State of relay 1.1
53	STAT_O4	COIL	State of relay 1.2
54	STAT_O5	COIL	State of relay 2.1
55	STAT_O6	COIL	State of relay 2.2
56	STAT_O7	COIL	State of relay 3.1
57	STAT_O8	COIL	State of relay 3.2
58	STAT_O9	COIL	State of relay 4.1
59	STAT_O10	COIL	State of relay 4.2

► The relay outputs are available for device versions with appropriate relay modules only

Analog outputs

Address	Name	Type	Description
42900	AOUT1_1	REAL32	Analog output 1.1 [mA]
42902	AOUT1_2	REAL32	Analog output 1.2 [mA]
42904	AOUT1_3	REAL32	Analog output 1.3 [mA]
42906	AOUT1_4	REAL32	Analog output 1.4 [mA]
42908	AOUT2_1	REAL32	Analog output 2.1 [mA]
42910	AOUT2_2	REAL32	Analog output 2.2 [mA]
42912	AOUT2_3	REAL32	Analog output 2.3 [mA]
42914	AOUT2_4	REAL32	Analog output 2.4 [mA]
42916	AOUT3_1	REAL32	Analog output 3.1 [mA]
42918	AOUT3_2	REAL32	Analog output 3.2 [mA]
42920	AOUT3_3	REAL32	Analog output 3.3 [mA]
42922	AOUT3_4	REAL32	Analog output 3.4 [mA]
42924	AOUT4_1	REAL32	Analog output 4.1 [mA]
42926	AOUT4_2	REAL32	Analog output 4.2 [mA]
42928	AOUT4_3	REAL32	Analog output 4.3 [mA]
42930	AOUT4_4	REAL32	Analog output 4.4 [mA]

► Analog outputs are available for device versions with appropriate analog output modules only