

Modbus[®] over TCP/IP

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Introduction

Using '**Modbus over TCP/IP**' the following data may be read from a DME407- resp. DME408-Ethernet:

- Present measurands of the monitored multi phase system
- Up to 4 meter contents
- Up to 10 average values with trend and remaining interval time
- Statistic of the average values
- Time and date of the built-in Real time clock (RTC)

The time synchronization may be performed via power frequency or by means of minute pulses. The usage of minute pulses assumes, that the time is set with an accuracy of $\pm 30s$ at the beginning of the synchronization process. Therefore, setting of time and date is the only control implemented via Modbus protocol.

The present manual describes the device specific parts of the Modbus protocol, especially the used register addresses for data acquisition. For further information please refer to the following documents:

- Modbus Messaging on TCP/IP Implementation Guide Rev 1.0
- Modbus Application Protocol Specification V1.1
- Modbus Protocol Reference Guide Rev J

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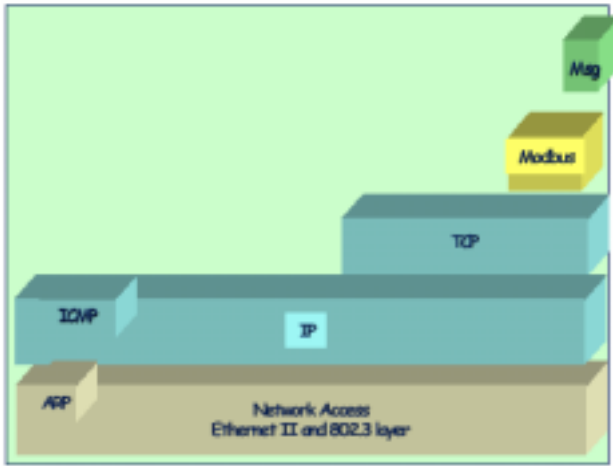
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Änderung	Datum Vis.:	Typ: DME407/408-Ethernet	Nr.: 1 / 9	gez.: 06.04.04 RR
		Bezeichnung: MODBUS[®] over TCP/IP interface	Zeichnr.:	W2415e

1. Interface realization



1.1 Generic telegram types

The ADU (Application Data Unit) of the Modbus over TCP/IP protocol is composed of the following parts

MBAP Header	Function code	Data
7 Bytes	1 Byte	n Bytes

MBAP Header (Modbus Application Protocol Header)

Byte 0,1: transaction identifier - Identification number if multiple requests are pending.

Byte 2,3: protocol identifier - always set to 0 (=Modbus protocol)

Byte 4: Number of data bytes following (high byte) - always 0 (because all messages are shorter than 256 bytes)

Byte 5: Number of data bytes following (high byte)

Byte 6: unit identifier (previous 'device address'). The device is accessed directly via IP address, therefore this parameter has no function and may be set to 0xFF.

Function code

Byte 7: Function code of the standard MODBUS protocol. The following codes are supported:

Code	MODBUS [®] Function	Used for ...
03 _H	READ HOLDING REGISTERS	- Reading present measurands - Reading meter contents - Reading average values and their trends - Reading average value historics and their time stamps - Reading time and date - Reading some configuration parameters
08 _H	DIAGNOSTIC	- Via Sub-Function 0 the connection may be tested
10 _H	PRESET MULTIPLE REGISTERS	- Setting time and date

Data

Byte 8..n: The data area corresponds to the standard MODBUS protocol. Data is transferred using 16-bit-registers. For higher resolution float numbers are used as well (multiple registers). The CRC checksum is not needed, because this part is implemented on TCP/IP protocol level.

1.2 Communications-Management

The Modbus communication requires to establish a TCP connection between a client (e.g. PC) and a server (DME407 resp. DME408). Normally the reserved **TCP-Port 502** is used. However, the user is free to set another port number. At the same time 2 connections via port 502 and 3 connections via the configured port number may be active.

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1.3 Error handling

If a transmission error occurs or if a non-existing (or switched-off) device is accessed, the server will send no reply. A timeout results.

Other errors are reported to the master using corresponding error messages:

Device answer:

MBAP Header	Function code	Data
A copy of the request	Code+80 _H	error code

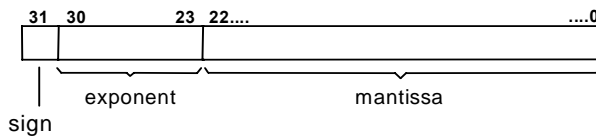
To report an error the received code is copied and the most significant bit (MSB) is set. Error codes show an operating or programming malfunction. The following error codes are supported:

Error code	Meaning
01 _H	Function code of the request is not supported by the device
02 _H	An invalid register address has been used for read or write operations.
03 _H	Invalid data values has been used, i.e. an invalid number of registers.
06 _H	Server busy: The maximum of concurrent transactions is reached.

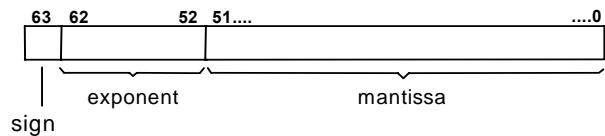
1.4 Special data types

The MODBUS[®] protocol defines only 16-bit registers for data transfer. However, float data types or 32-bit-integers are also commonly used to achieve higher resolution. These data types are built of multiple registers. The standard IEEE format of these numbers is used, which is also used by PCs. The format is as follows:

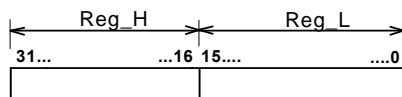
32-Bit-Float



64-Bit-Float



32-Bit-Integer (unsigned)



The values are transmitted as consecutive 16-bit registers. The sequence is as follows:

>>>	<i>Reg_L (15..0)</i>		<i>Reg_H (31..16)</i>		<i>Reg_L (47..32)</i>		<i>Reg_H (63..48)</i>	
	HByte	LByte	HByte	LByte	HByte	LByte	HByte	LByte
			(if used)		(if used)		(if used)	

When transferring **Byte information** (half registers), in contrary to the above shown, the sequence of the data bytes is not modified.

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1.5 Telegram examples

Function 03 (Hex), reading data

Request Client->Server	Transact. identifier		Protocol identifier		Number of data bytes		unit identifier	Function	Data			
	0x00	<i>tno</i>	0x00	0x00	0x00	0x06	0xFF	03 _H	Start address		# register	
	0x00	<i>tno</i>	0x00	0x00	0x00	0x06	0xFF	03 _H	High-Byte	Low-Byte	High-Byte	Low-Byte

Response Server->Client	Transact. identifier		Protocol identifier		Number of data bytes		unit identifier	Function	Data			
	0x00	<i>tno</i>	0x00	0x00	0x00	n+3	0xFF	03 _H	# data bytes		Information	
	0x00	<i>tno</i>	0x00	0x00	0x00	n+3	0xFF	03 _H	n		n/2 Register	

Example: Reading U12 (register 108/109)

(Hex) >>> 00 00 00 00 00 06 FF 03 00 6B 00 02
 <<< 00 00 00 00 00 07 FF 03 04 **CC CD 42 8D**

Note: Register address 108 is accessed as register 107 in accordance with the MODBUS specification.

Function 08 (Hex), Subfunction 00: Diagnostic (connection test)

Request Client->Server	Transact. identifier		Protocol identifier		Number of data bytes		unit identifier	Function	Data			
	0x00	<i>tno</i>	0x00	0x00	0x00	0x06	0xFF	08 _H	Sub-Function		Data	
	0x00	<i>tno</i>	0x00	0x00	0x00	0x06	0xFF	08 _H	0x00	0x00	High-Byte	Low-Byte

Response Server->Client	Transact. identifier		Protocol identifier		Number of data bytes		unit identifier	Function	Data			
	0x00	<i>tno</i>	0x00	0x00	0x00	0x06	0xFF	03 _H	Sub-Function		Data	
	0x00	<i>tno</i>	0x00	0x00	0x00	0x06	0xFF	03 _H	n		High-Byte	Low-Byte

Example

(Hex) >>> 00 00 00 00 00 06 FF 08 00 00 AA 55
 <<< 00 00 00 00 00 06 FF 08 00 00 AA 55

Note: The telegram is sent back 1:1

Function 10 (Hex): Storing data in the device

Request Client->Server	Transact. identifier		Protocol identifier		Number of data bytes		unit identifier	Function	Daten					
	0x00	<i>tno</i>	0x00	0x00	0x00	n+7	0xFF	10 _H	Start addr		# reg.	# bytes	Info	
	0x00	<i>tno</i>	0x00	0x00	0x00	n+7	0xFF	10 _H	High	Low	High	Low	n	n Bytes

Antwort Server->Client	Transact. identifier		Protocol identifier		Number of data bytes		unit identifier	Function	Data			
	0x00	<i>tno</i>	0x00	0x00	0x00	0x06	0xFF	10 _H	Start address		# register	
	0x00	<i>tno</i>	0x00	0x00	0x00	0x06	0xFF	10 _H	High-Byte	Low-Byte	High-Byte	Low-Byte

Example: Setting time and date (Register 400/401)

(Hex): >>> 00 00 00 00 00 0B FF 10 01 8F 00 02 04 **t2 t1 t4 t3**
 <<< 00 00 00 00 00 06 FF 10 01 8F 00 02

(t1..t4: Coded information time + date, Format see chapter 3)

Note: Register address 400 is accessed as register 399 in accordance with the MODBUS specification.

tno = Identification-No., useful (but uncommon) if more then one request is active at the same time

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2 Measurands acquisition

2.1 Present measurands

Register (read only)	Measurand	single-phase / 3 or 4-wire balanced load systems	3-wire unb. system	4-wire unb. system
100	U	☉	-	-
102	U1N	-	-	☉
104	U2N	-	-	☉
106	U3N	-	-	☉
108	U12	-	☉	☉
110	U23	-	☉	☉
112	U31	-	☉	☉
114	I	☉	-	-
116	I1	-	☉	☉
118	I2	-	☉	☉
120	I3	-	☉	☉
122	P	☉	☉	☉
124	P1	-	-	☉
126	P2	-	-	☉
128	P3	-	-	☉
130	Q	☉	☉	☉
132	Q1	-	-	☉
134	Q2	-	-	☉
136	Q3	-	-	☉
138	PF	☉	☉	☉
140	PF1	-	-	☉
142	PF2	-	-	☉
144	PF3	-	-	☉
146	QF	☉	☉	☉
148	QF1	-	-	☉
150	QF2	-	-	☉
152	QF3	-	-	☉
154	F	☉	☉	☉
156	S	☉	☉	☉
158	S1	-	-	☉
160	S2	-	-	☉
162	S3	-	-	☉
164	IM	-	☉	☉
166	IMS	-	☉	☉
168	LF	☉	☉	☉
170	LF1	-	-	☉
172	LF2	-	-	☉
174	LF3	-	-	☉
176	IB 15min	☉	-	-
178	IB1 15min	-	☉	☉
180	IB2 15min	-	☉	☉
182	IB3 15min	-	☉	☉
184	BS 15min	☉	-	-
186	BS1 15min	-	☉	☉
188	BS2 15min	-	☉	☉
190	BS3 15min	-	☉	☉
192	UM	-	☉	☉

☉ = Valid measurand - = unusable (value 0.00)

All present measurands are 32-Bit float numbers (2 registers per value), scaled to primary values.

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2.2 Meter contents

Up to 4 internal meters may be configured.

In the device meter contents are stored as 32-bit integers, scaled on secondary values. For the MODBUS interface these values are converted to **primary values in floating-point format**. During conversion to 32-bit float some resolution is lost. The higher the meter content the higher this lost will be. It can be minimized e.g. by frequent meter reset. However, if this is not acceptable, you can use the 64-bit-double meter contents, which are provided as well.

32-Bit-Float meter contents [Wh, Varh, VAh, Ah]

Register (read-only)	Measurand
200..201	Meter content 1
202..203	Meter content 2
204..205	Meter content 3
206..207	Meter content 4

64-Bit-Double meter contents [Wh, Varh, VAh, Ah]

Register (read-only)	Measurand
210..213	Meter content 1
214..217	Meter content 2
218..221	Meter content 3
222..225	Meter content 4

Because the measurands of the meters are configurable, the associated unit has to be determined via the used measurand. This can be done:

- during normal operation by requesting the measurands
- by fixed assignment due to a previous configuration request

Meter measurands

Register (read only)	Data	
230	Meter measurand [0..1]	0: LSB, 1 :MSB
231	Meter measurand [2..3]	2: LSB, 3: MSB

The following measurands may be used for meters:

Value	Measurand	single-phase / 3 or 4-wire balanced load	3-wire unb. system	4-wire unb. system	Value	Measurand	single-phase / 3 or 4-wire balanced load	3-wire unb. system	4-wire unb. system
0	not used				16	Q (inductive)	☺	☺	☺
8	I	☺	-	-	17	Q1 (inductive)	-	-	☺
9	I1	-	☺	☺	18	Q2 (inductive)	-	-	☺
10	I2	-	☺	☺	19	Q3 (inductive)	-	-	☺
11	I3	-	☺	☺	48	P (outg.)	☺	☺	☺
29	S	☺	☺	☺	49	P1 (outg.)	-	-	☺
30	S1	-	-	☺	50	P2 (outg.)	-	-	☺
31	S2	-	-	☺	51	P3 (outg.)	-	-	☺
32	S3	-	-	☺	52	Q (capac.)	☺	☺	☺
12	P (inc.)	☺	☺	☺	53	Q1 (capac.)	-	-	☺
13	P1 (inc.)	-	-	☺	54	Q2 (capac.)	-	-	☺
14	P2 (inc.)	-	-	☺	55	Q3 (capac.)	-	-	☺
15	P3 (inc.)	-	-	☺					

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2.3 Free configurable average values

Up to 10 measurands for average values may be configured. The following measurands may be requested for each average value:

- Last interval value
- Trend of the not expired present interval
- remaining interval time in [s] (same for all average values)

Register (read only)	Measurand	
300	Average value 1	(Trend)
302	Average value 2	(Trend)
304	Average value 3	(Trend)
306	Average value 4	(Trend)
308	Average value 5	(Trend)
310	Average value 6	(Trend)
312	Average value 7	(Trend)
314	Average value 8	(Trend)
316	Average value 9	(Trend)
318	Average value 10	(Trend)
320	Average value 1	(Last value)
322	Average value 2	(Last value)
324	Average value 3	(Last value)
326	Average value 4	(Last value)
328	Average value 5	(Last value)
330	Average value 6	(Last value)
332	Average value 7	(Last value)
334	Average value 8	(Last value)
336	Average value 9	(Last value)
338	Average value 10	(Last value)
340	Remaining time	[s]

All values are 32-bit float numbers (2 registers per value). Average values are scaled to primary values.

Because the measurands of the average values are configurable, the associated unit has to be determined via the used measurand. This can be done:

- during normal operation by requesting the measurands
- by fixed assignment due to a previous configuration request

Measurands of average values

Register (read only)	data	
350	Average measurand [0..1]	0: LSB, 1:MSB
351	Average measurand [2..3]	2: LSB, 3: MSB
352	Average measurand [4..5]	4: LSB, 5:MSB
353	Average measurand [6..7]	6: LSB, 7: MSB
354	Average measurand [8..9]	8: LSB, 9: MSB

Unused average values are always arranged at the end of the table. There are no gaps with unconfigured values. If e.g. 5 average values are configured, the appropriate measurands are stored in variables [0]..[4], the variables [5]..[9] are set to 0 (unused). The assignment of read values to the measurands is given in the following table.

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The following measurands may be used for average values:

Value	Measurand	single-phase / 3 or 4-wire balanced load	3-wire unb. system	4-wire unb. system	Value	Measurand	single-phase / 3 or 4-wire balanced load	3-wire unb. system	4-wire unb. system
0	not used				24	QF	☺	☺	☺
1	U	☺	-	-	25	QF1	-	-	☺
2	U1N	-	-	☺	26	QF2	-	-	☺
3	U2N	-	-	☺	27	QF3	-	-	☺
4	U3N	-	-	☺	28	F	☺	☺	☺
5	U12	-	☺	☺	29	S	☺	☺	☺
6	U23	-	☺	☺	30	S1	-	-	☺
7	U31	-	☺	☺	31	S2	-	-	☺
8	I	☺	-	-	32	S3	-	-	☺
9	I1	-	☺	☺	33	IM	-	☺	☺
10	I2	-	☺	☺	34	IMS	-	☺	☺
11	I3	-	☺	☺	35	LF	☺	☺	☺
12	P (inc.)	☺	☺	☺	36	LF1	-	-	☺
13	P1 (inc.)	-	-	☺	37	LF2	-	-	☺
14	P2 (inc.)	-	-	☺	38	LF3	-	-	☺
15	P3 (inc.)	-	-	☺	47	UM	-	-	☺
16	Q (inc.)	☺	☺	☺	48	P (outg.)	☺	☺	☺
17	Q1 (ind.)	-	-	☺	49	P1 (outg.)	-	-	☺
18	Q2 (ind.)	-	-	☺	50	P2 (outg.)	-	-	☺
19	Q3 (ind.)	-	-	☺	51	P3 (outg.)	-	-	☺
20	PF	☺	☺	☺	52	Q (cap.)	☺	☺	☺
21	PF1	-	-	☺	53	Q1 (cap.)	-	-	☺
22	PF2	-	-	☺	54	Q2 (cap.)	-	-	☺
23	PF3	-	-	☺	55	Q3 (cap.)	-	-	☺

2.4 Mean values progression (Logger)

If average values are configured, also their progression is stored for a specific time period. The number of stored values per average value depends on the number of configured average values and the selected storage time. The recording is done in the endless mode. Therefore the oldest values are overwritten if the maximum storage capacity is reached.

Data storage is performed by means of data sets. A **data set** contains the average values and their dedicated storage time (end of measuring interval). The structure is as follows:

Register offset	Content	Format
0	Time and date	32-bit integer (see chapter 3)
2	Average value 1 (if used)	Primary value, 32-bit float
4	Average value 2 (if used)	Primary value, 32-bit float
6	Average value 3 (if used)	Primary value, 32-bit float
8	Average value 4 (if used)	Primary value, 32-bit float
10	Average value 5 (if used)	Primary value, 32-bit float
12	Average value 6 (if used)	Primary value, 32-bit float
14	Average value 7 (if used)	Primary value, 32-bit float
16	Average value 8 (if used)	Primary value, 32-bit float
18	Average value 9 (if used)	Primary value, 32-bit float
20	Average value 10 (if used)	Primary value, 32-bit float

The storage size **DATASET** (number of registers) depends on the number of configured average values.

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Status information

Register (read only)	Content	Note
360	Number of stored data sets	This parameter will not change during runtime. It is always set to the maximum of storable data sets. To find data sets which are not yet acquired or invalid (e.g. due to power failure) one has to check the time stamps. If a time stamp is out of the normal sequence or invalid, the appropriate data set may not be used for analysis.
361	Number of selected measurands	By means of this values the constant DATASET can be determined: DATASET =(Number of measurands+1) * 2

Reading of data sets

To read the full statistic of the average values, the acquisition procedure has to be divided. A maximum of 120 registers may be read at the same time.

Register (read only)	Content	Hint
500...	most up to date data set	If the time stamp of the data set is out of sequence or invalid, the data set hasn't be acquired yet or it is invalid.
500+ DATASET	most up to date data set -1	
500+ n*DATASET	most up to date data set - n	

Attention: During a reading of larger portions of data sets, a **register offset** may occur. This happens if a new data set is stored between two readings. Therefore you always have to check the time stamp to see if a data set has been read already.

Example: 5 average values selected, 10 days storage time, averaging time 15 min.

-> Number of stored data sets 960

-> DATASET=(5+1)*2=12

Register	Content
500...511	most up to date data set
512...523	most up to date data set -1
524...535	most up to date data set -2
....	most up to date data set -n
12008	Last (oldest) data set

3. Time and date

The built-in real time clock (RTC) serves as the time base for calculating average values and may be read to time stamp other measurands.

The clock may be synchronized via system frequency or by using minute pulses. If minute pulses are used, the time has to be set with an accuracy of +/-30s to allow proper synchronization. Setting of time and date is therefore the only control facility implemented via Modbus.

Register (read + write)	Meaning	Format
400..401	Time and date	32-Bit unsigned int

Coding of time / date information

Bit 31-27: Day	1..31	Bit 16-12: Hours	0..23
Bit 26-23: Month	1..12	Bit 11-6: Minutes	0..59
Bit 22-17: Year	(20)00..63	Bit 5-0: Seconds	0..59

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