Description of

Modbus RTU Interface

for

I.S. 1 field stations

MODBUS RTU interface for I.S. 1

Content:

The historical developement of field bus technology at R. STAHL

More than 12 years ago, R. STAHL SCHALTGERÄTE GMBH brought the ICS MUX field bus system onto the market as the first manufacturer to introduce an I.S. bus system world-wide for input and output of signals within the hazardous area (Zone 1).
This bus system consists of a master station installed in the control room as the coupling partner for automation units together with several completely explosion protected on-site stations or field stations (VOS) installed directly in the field (Zone 1). The connection between the master station and field stations is made via a single coaxial cable.

One of the many highlights of this I.S. bus system is that all the subassemblies of the system - even the power packs – can be plugged or unplugged during operation without affecting the explosion protection. This bus system enabled R. STAHL to present users from the chemical, petrochemical or pharmaceutical industries with an apparatus that can be installed in the hazardous area but can be operated like an apparatus installed in the control room.
This provided the ideal combination of the technical advantages of field bus technology (simple cabling structures, powerful diagnostic options) with the resulting economical advantages (lower investment costs).

The VOS 200 system variant based on this bus system was introduced in 1993 as a supplement that includes all the recognised advantages of the field bus system and was developed under two fundamental aspects:

- Field bus solution for low signal volumes or decentralised automation units that do not require a master station.
- Standard solution to enable the simple implementation of future standardised bus systems.

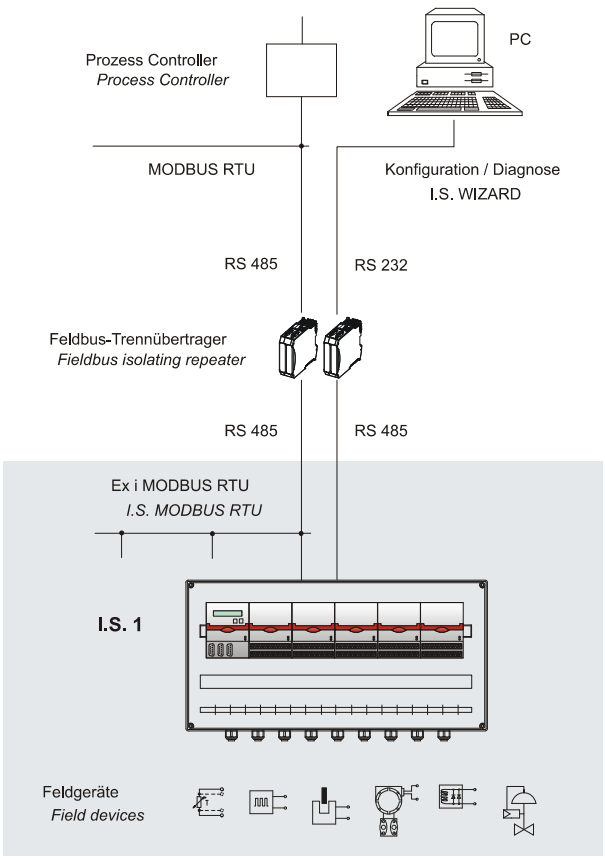
The VOS 200 can be coupled to the most varied automation devices in either a redundant or non-redundant configuration as a point-to-point connection or (multi-drop) bus connection.
The principle element of the VOS 200 system variant is the 9503 central unit (CU). This multi-processor subassembly with dual port RAM takes over both the data traffic from and to the connected I/O subassemblies as well as the upwards communication to distributed control systems or programmable logic controllers.
The various coupling options of the VOS 200 were expanded again in 1997 and supplemented to include a PROFIBUS DP connection.

A further step for optimising this field bus technology was realised with the development of the I.S.1 system. Experience gained from previous systems was used to implement a new, more flexible and more powerful product for the user as well as to provide a solution to all types of automation tasks.

The following section describes the system characteristics of the I.S. 1 system when coupled to an automation system via MODBUS RTU.

1 System overview

1.1 Connection principle of I.S. 1 field stations to MODBUS RTU



As an off-the-shelf explosion protected mounted unit, the I.S. 1 field station can be installed directly in the hazardous area (Zone 1 or Zone 2). It can also be installed in the safe area. The adjacent diagram shows a Zone 1 solution.

The I.S. 1 field station has two serial interfaces. One of them is used to connect to an automation system and the second serial interface can be used as a bus-capable maintenance interface for the configuration, error diagnosis and communication with HART field devices.

Several I.S. 1 field stations can be used in the hazardous area to form a MODBUS network that is connected directly - both hierarchically and topologically - with the MODBUS network in the non-hazardous area.

The following applies to Zone 1 installations:
From a safety-engineering aspect relating to explosion protection, the field bus isolating repeater for the MODBUS takes on the function of a “barrier” between the ex area and non-hazardous area. The field bus isolating repeater operates as a repeater.

In such a MODBUS network, the I.S.1 field station behaves hierarchically as a MODBUS slave where the configuration of the field station with its I/O modules is performed via the service Bus with the software I.S. Wizard.

2 Commissioning

2.1 Overview

Planning of the complete MODBUS network:

- Which masters are in the network
- Which slaves are in the network
- Selection of network topology and network physics (repeaters, glass fibre links ...)
- Selection of the baud rate depending on lengths of cable, volumes of data and time requirements
- Unique allocation of the MODBUS slave addresses.

Perform the commissioning:

- Mechanical mounting of the I.S. 1 field station.
- Mechanical mounting of the field bus isolating repeater.
- Mechanical mounting of all other bus users.

- Set up the bus connections. Ensure the correct bus termination of all segments!

- Set up the baud rate on the field bus isolating repeaters (9372. or 9185.).

- Set up the voltage supply of the I.S. 1 field station.
- Set up the voltage supply of the isolating repeaters.

- Set up the slave addresses on the I.S. 1 field stations.
- Set up the addresses of all other users.

- Optional use of the service bus:

- Mechanical mounting of the service bus and the associated field bus isolating repeater.
- Install the I.S. Wizard software on the PC.
- selection of the I.S.1 parameter set (standard or extended) which shell be used.
- Configure the I.S.1 field stations with ist I/O-modules with the software I.S. Wizard.

- Parameterise the Modbus master:
  Konfiguration of Modbus telegrams in MODBUS master according the I/O-modules in the fieldstations.

- Put the master into operation. This results in the automatic start-up of the cyclic master <-> slave communication.

- Check communication on the MODBUS using the following tools:

  - Diagnosis information of the master or of the diagnostic tools belonging to the master.
  - LEDs on the 9372 or 9185 field bus isolating repeaters
  - LEDs and text display on the CPM of the I.S. 1 field station

- Check I/O signals using the following tools:

  - Information of the master or of the diagnostic tool belonging to the master.
  - use of Diagnosis software I.S. WIZARD on a PC connected via the service bus.

2.2 Engineering limits

The general regulations according to the I.S.1operating instructions apply to the engineering of an I.S.1 field station.

Moreover, further limitations of the number of IOMs, the maximum number of signals and the maximum number of slaves in a network ... depend on the performance of the MODBUS master used. Thus, the limits of the MODBUS master used must also be taken into account during the engineering.

2.3 Bus segments

A MODBUS network is based on RS485 bus physics with a twisted pair cable as the transmission medium. A network can consist of several **line-type** segments that are connected by repeaters or optical transmission routes.
The 9185 field bus isolating repeater can be seen as a repeater that connects a non-hazardous bus segment with an I.S. bus segment (RS485IS).

2.4 Bus termination

Every RS485 bus segment must be terminated at the first and last device of a segment with a bus termination resistor.

End of line resistor in Ex i segment see operating instructions:

Project Planning, Installation and Commissioning of the RS 485 Fieldbus System from R. STAHL for Non-Hazardous and Hazardous Areas.

2.5 Address of the I.S. 1 field station

The setting of the address (Modbus slave address) of an I.S. 1 field station is performed by means of operating keys on the CPM module.
An address within the range 0 to 127 can be given here. Please note that addresses may only be allocated once in a MODBUS network.
The address that is set on the CPM is also valid for addressing the I. S. 1 field station on the service bus. (see also the CPM operating manual)

2.6 Baud rate

The setting of Baudrate, Parity .... for the MODBUS interface on terminal X1 of the CPM can be done via the I.S. Wizard software over the service bus.

Attention ! The selected baud rate for the 9372 or 9185 field bus isolating repeaters must be set on DIP switches.

2.7 Pin allocation of 9-pole D-type connectors:

The CPM and the 9372/21 and 9185 field bus isolating repeaters have 9-pole D-type sockets with the following allocation for connecting the MODBUS:

Pin no.	Signal name	Description
1	-	-
2	-	-
3	RxD / TxD (+)	B data (+)
4	-	-
5	GND	Reference potential for interface (from device) *1)
6	+5V	Supply voltage (from device) *1)
7	-	-
8	RxD / TxD (-)	A data (-)
9	-	-

*1): Not connected on Zone 1 CPM 9440/12-01-11

End of line resistors in non Ex segment:

220 R between data lines (Pin 3 to 8)
390 R between data B (+) and +5V (Pin 3 to 6)
390 R between data A (-) and GND (Pin 8 to 5)

End of line resistor in Ex i segment see operating instructions:

Project Planning, Installation and Commissioning of the RS 485 Fieldbus System from R. STAHL for Non-Hazardous and Hazardous Areas.

2.8 Start-up behaviour

Configuration and Parameter data of CPM and all IOM are generated with I.S. Wizard and are stored in the CPM. After power On the CPM checks, that valid konfiguration and parameter data is available in the EEPROM.
If valid data is available, the I/O-modules are initialised and the input signals are read cyclic from the CPM. Input signals can now be read from the automation system (AS).
The output signals remain in save position as long as new output data is written from the AS or from I.S. Wizard.
Changing I/O-modules during operation is possible. After pluging in a new module, parameters are automaticaly transfered from CPM to the I/O-module, followed by a restart of the I/O-module. -> Hot swap IOM.

Exception: Modul TIM R 9480/.. : The calibration value for wire resistance compensation in 2 wire operation is stored in the I/O-module.
After changing of I/O-modules a new calibration is required.

2.9 Overview MODBUS Functions

MODBUS Functions		Telegram length [Byte] without CRC-Byte	
		Request	**Response**
01	READ COIL STATUS	6	3 + Bytecount
02	READ INPUT STATUS	6	3 + Bytecount
03	READ HOLDING REGISTERS	6	3 + Bytecount
04	READ INPUT REGISTERS	6	3 + Bytecount
06	PRESET SINGLE REGISTER	6	6
08	Loopback Diagnostic Test	6	6
15 (0FH)	FORCE MULTIPLE COILS	7 + Bytecount	6
16 (10H)	PRESET MULTIBLE REGISTERS	7 + Bytecount	6

In case of a communication error, or an incorrect Modbus function is used, the slave will give no reply to the master. This will cause a timeout error in the master.

(Further rules for telegram execution see chapter 3.1.3)

Modbus function 5 (PRESET SINGLE Coil) is not supported because the mechanism for the safety position of outputs in case of error is a module global function. This requires that all signals of a module has to be communicated consistent (in one telegram). This is not fulfilled by Modbus function 5. Please use the MODBUS function 06, 15 or 16 to write to DO-modules.

2.10 Telegram structure

2.10.1 MODBUS FUNCTION 01, 02, 03 and 04 (Read Register / Coil)

Request:

SLAVE-Adresse	Function	DATA START Register HIGH	DATA START Register LOW	DATA Account Reg. HIGH	DATA Account Reg. LOW	CRC	CRC
xxH	01	..	..	xx *1)	xx	CRC.1	CRC.2
xxH	02	..	..	xx *1)	xx	CRC.1	CRC.2
xxH	03	..	..	xx *2)	xx	CRC.1	CRC.2
xxH	04	..	..	xx *2)	xx	CRC.1	CRC.2

*1) DATA Account Reg. = Account of databits in telegram
*2) DATA Account Reg. = Account of datawords (registers) in telegram

Response:

SLAVE-Address	Function	BYTE COUNT	DATA DW 1 HIGH	DATA DW 1 LOW	*3)	DATA DW max HIGH	DATA DW max LOW	CRC	CRC
xxH	01	ACCOUNT DW*2	HIGH	LOW	.....	HIGH	LOW	CRC.1	CRC.2
xxH	02	ACCOUNT DW*2	HIGH	LOW	.....	HIGH	LOW	CRC.1	CRC.2
xxH	03	ACCOUNT DW*2	HIGH	LOW	.....	HIGH	LOW	CRC.1	CRC.2
xxH	04	ACCOUNT DW*2	HIGH	LOW	.....	HIGH	LOW	CRC.1	CRC.2

*3) Contents of the data words (DW) see chapter 3.5

2.10.2 MODBUS-FUNCTION 6, 15 (0FH) and 16 (10H) (write Register / Coil)

Request:

SLAVE-ADDR	Function	DATA START HIGH	DATA START LOW	DATA HIGH	DATA LOW	CRC	CRC
xxH	06H	..	..	XX	XX	CRC.1	CRC.2

SLAVE-ADDR	Function	DATA START REG. HIGH	DATA START REG. LOW	ACCOUNT HIGH *1)	ACCOUNT LOW *1)	BYTE COUNT	DATA DW.1 HIGH	DATA DW.1 LOW	..*3.)..	DATA DW.max HIGH	DATA DW.max LOW	CRC	CRC
xxH	0FH	..	..	XX	XX	ACC DW*2	XX	XX	.....	XX	XX	CRC.1	CRC.2
xxH	10H	..	..	XX *2)	XX	ACC DW*2	XX	XX	.....	XX	XX	CRC.1	CRC.2

Response:

SLAVE-ADDR	Function	DATA START HIGH	DATA START LOW	DATA HIGH	DATA LOW	CRC	CRC
xxH	06H	..	..	XX	XX	CRC.1	CRC.2

SLAVE-ADDR	FUNC	DATA START REG. HIGH	DATA START REG. LOW	DATA ACCOUNT HIGH *1)	DATA ACCOUNT LOW *1)	CRC	CRC
xxH	0FH	.. *4)	..	ACC Bit	ACC Bit	CRC.1	CRC.2
xxH	10H	.. *4)	..	00 *2)	ACC DW	CRC.1	CRC.2

*1) ACCOUNT = Account of Databits (DW * 16)
*2) ACCOUNT = Account of Dateaword (Registers)
*3) Contents of the data words see chapter 5
*4) Echo of request telegram.

XX = dont care
ACC Bit = Account of databits = ACC DW * 16
ACC **DW** = Account of **d**ata**w**ords

2.10.3 MODBUS-FUNCTION 08 - LOOPBACK TEST

This function can be used to check the physical connection between Master and Slave.

Request:

SLAVE-Address	Function	DATA	DATA	DATA*	DATA*	CRC	CRC
xxH	08	00	00	XX	XX	CRC.1	CRC.2

Response:

SLAVE-Address	Function	DATA	DATA	DATA*	DATA*	CRC	CRC
xxH	08	00	00	XX	XX	CRC.1	CRC.2

.) DATA is echoed back in the reply.

3 Data traffic

3.1 Signal marshalling

The assignment of the signals of a fieldstation to the MODBUS registers results through a automatic block function for all input and output data. Seperately for the input and the output area the signals of the IO modules are put to data blocks, starting with the slot 1 on a defined MODBUS Startaddress, according the row of the I/O modules. This process has the advantage, that all data can be read and/or written in one telegram, where the result is a efficient data transmission with a minimum of protocol overhead.

The following table shows the data length of the individual I/O module types.

Modul selection in I.S. Wizard	Data length [Registers] Input	Output
9460/12-08-11 **AIM** 4/8 Exi	8	-
9461/12-08-11 **AIMH**8 2w Exi	8	-
*9461/12-08-11 **AIMH**8+4HV 2w Exi *1)*	16	-
*9461/12-08-11 **AIMH**8+8HV 2w Exi *1)*	24	-
9461/12-08-21 **AIMH** 8 Exi	8	-
*9461/12-08-21 **AIMH** 8 +4HV Exi *1)*	16	-
*9461/12-08-21 **AIMH** 8 +8HV Exi *1)*	24	-
9461/15-08-12 **AIMH**8 2w Exn	8	-
9461/15-08-12 **AIMH**8+4HV 2w Exn	16	-
9461/15-08-12 **AIMH**8+8HV 2w Exn	24	-
9465/12-08-11 **AOM** 8 Exi	-	8
9466/12-08-11 **AOMH** 8 Exi	-	8
*9466/12-08-11 **AOMH** 8 +4HV Exi *1)*	8	8
*9466/12-08-11 **AOMH** 8 +8HV Exi *1)*	16	8
9466/15-08-12 **AOMH** 8 Exn	-	8
9466/15-08-12 **AOMH** 8+4HV Exn *1)*	8	8
9466/15-08-12 **AOMH** 8+8HV Exn *1)*	16	8
9470/22-16-11 **DIM** 16 NamExi	2	-
9470/22-16-11 **DIM** 16+CF NamExi	4	1
9470/25-16-12 **DIM**16 Nam Exn	2	-
9470/25-16-12 **DIM**16+CF Nam Exn	4	1
9471/10-16-11 **DIM** 16 24V	2	-
9471/10-16-11 **DIM** 16+CF 24V	4	1
9471/15-16-12 **DIM** 16 24V Exn	2	-
9471/15-16-12 **DIM** 16+CF24V Exn	4	1
9475/12-04-11 **DOM** 4 Exi1	-	1
9475/12-04-21 **DOM** 4 Exi2	-	1
9475/12-04-31 **DOM** 4 Exi3	-	1
9475/12-08-41 **DOM** 8 Exi1	-	1
9475/12-08-51 **DOM** 8 Exi2	-	1
9475/12-08-61 **DOM** 8 Exi3	-	1
9475/12-07-71 **DOM** 7 Exi4	-	1
9475/22-04-21 **DOM** 4 OD Exi2	-	1
9475/22-08-51 **DOM** 8 OD Exi2	-	1
9475/22-08-61 **DOM** 8 OD Exi3	-	1
9477/10-08-12 **DOM** 8 Rel	-	1
9477/12-08-12 **DOM** 8 60V Rel Z1	-	1
9477/12-06-12 **DOM** 6 250VRel Z1	-	1
9477/15-08-12 **DOM** 8 Rel Z2	-	1
9480/12-08-11 **TIM** 8 R Exi	8	-
9481/12-08-11 **TIM** 8 mV Exi	8	-
AIM 4/8 (9460/.., 9461/..)	8	-
AOM 8 (9465/.., 9466/..)	-	8
DIM 16 (9470/.., 9471/..)	1	-
DOM 4/8 (9475/..)	-	1
Empty module	-	-

1) Attention!
The modules with HART variables (+4HV or +8HV) must only be used with the extended parameter set of I.S.1!

3.1.1 Register allocation to I/O signals:

Input Signals (DI / AI):

Modbus Address on serial interface		**Modbus Address in AS *2)**		**content**	**allowed Modbus Functions**
Register Address	Coil Address *1)	Register Address	Coil Address *1)		
0x001c (28)	0x01c0 (448)	0x001d (29)	0x01c1 (449)	Modul alarms Modul 0 to 15	read: 02 (coil) and 04 (register)
0x001d (29)	0x01d0 (464)	0x001e (30)	0x01d1 (465)	Modul alarms Modul 16	
0x001e (30)	0x01e0 (480)	0x001f (31)	0x01e1 (481)	status register CPM	
from 0x001f (31) ↓	0x01f0 (496) ↓	from 0x0020 (32) ↓	0x01f1 (497) ↓	**Data block Input Modules**	

Output Signals (DO / AO):

Modbus Address on serial interface		**Modbus Addess in AS *2)**		**content**	**allowed Modbus Functions**
Register Address	Coil Address *1)	Register Address	Coil Address *1)		
0x001e (30)	0x01e0 (480)	0x001f (31)	0x01e1 (481)	control register CPM	read: 01 (coil) 03 (register) write: 15 (coil) 06, 16 (register)
from 0x001f (31) ↓	0x01f0 (496) ↓	from 0x0020 (32) ↓	0x01f1 (497) ↓	**Data block Output Modules**	

*1): The MODBUS Functions 01, 02 and 15 are using Coil Address.
The MODBUS Functions 03, 04, 06 and 16 are using Register Address.

Coil Address = Register Address * 16

*2): Most automation systems display a incremented (+1) address.
(related to the address on the serial interface) !

Example:

A I.S.1 fieldstation is used with the following modules:

Module Type:	CPM	DIM16	DIM 16 + CF	DOM 8	AIM 8	AOM 8
Slot:	0	1	2	3	4	5

With this the following address allocation emerge to the signals:

Input Signals			**MODBUS Address Input Registers / Coils** (read with Modbus Functions 2 or 4)			
Slot	**Module Type**	**Signals**	**Address in AS**		**Address on ser. interface**	
			Register	**Coil**	**Register**	**Coil**
1	DIM 16	DI 0 ... DI 15 Status 0 ... 15	32 33	497 – 512 513 – 528	31 32	496 – 511 512 – 527
2	DIM 16 +CF	DI 0 ... DI 15 Status 0 ... 15 Counter / Freq. Input 14 Counter / Freq. Input 15	34 35 36 37	529 – 544 545 – 560 561 – 576 577 – 592	33 34 35 36	528 – 543 544 – 559 560 – 575 576 – 591
4	AIM	AI 0 AI 1 AI 2 AI 3 AI 4 AI 5 AI 6 AI 7	38 39 40 41 42 43 44 45		37 38 39 40 41 42 43 44	

Output Signals			**MODBUS Address Output Registers / Coils** (read with Modbus Functions 1 or 3, write with Modbus Functions 6, 15 or 16)			
Slot	**Module Type**	**Signals**	**Address in AS**		**Address on ser. interface**	
			Register	**Coil**	**Register**	**Coil**
2	DIM16 +CF	control register for counter	32	497 – 512	31	496 – 511
3	DOM 8	DO 0 ... DO 7	33	513 – 528	32	512 – 527
5	AOM	AO 0 AO 1 AO 2 AO 3 AO 4 AO 5 AO 6 AO 7	34 35 36 37 38 39 40 41		33 34 35 36 37 38 39 40	

3.1.2 Allocation tabelle

No.	Address on ser. interface		Address in AS	
	Register	Coil	Register	Coil
1	31	496 - 511	32	497 - 512
2	32	512 - 527	33	513 - 528
3	33	528 - 543	34	529 - 544
4	34	544 - 559	35	545 - 560
5	35	560 - 575	36	561 - 576
6	36	576 - 591	37	577 - 592
7	37	592 - 607	38	593 - 608
8	38	608 - 623	39	609 - 624
9	39	624 - 639	40	625 - 640
10	40	640 - 655	41	641 - 656
11	41	656 - 671	42	657 - 672
12	42	672 - 687	43	673 - 688
13	43	688 - 703	44	689 - 704
14	44	704 - 719	45	705 - 720
15	45	720 - 735	46	721 - 736
16	46	736 - 751	47	737 - 752
17	47	752 - 767	48	753 - 768
18	48	768 - 783	49	769 - 784
19	49	784 - 799	50	785 - 800
20	50	800 - 815	51	801 - 816
21	51	816 - 831	52	817 - 832
22	52	832 - 847	53	833 - 848
23	53	848 - 863	54	849 - 864
24	54	864 - 879	55	865 - 880
25	55	880 - 895	56	881 - 896
26	56	896 - 911	57	897 - 912
27	57	912 - 927	58	913 - 928
28	58	928 - 943	59	929 - 944
29	59	944 - 959	60	945 - 960
30	60	960 - 975	61	961 - 976
31	61	976 - 991	62	977 - 992
32	62	992 - 1007	63	993 - 1008
33	63	1008 - 1023	64	1009 - 1024
34	64	1024 - 1039	65	1025 - 1040
35	65	1040 - 1055	66	1041 - 1056
36	66	1056 - 1071	67	1057 - 1072
37	67	1072 - 1087	68	1073 - 1088
38	68	1088 - 1103	69	1089 - 1104
39	69	1104 - 1119	70	1105 - 1120
40	70	1120 - 1135	71	1121 - 1136
41	71	1136 - 1151	72	1137 - 1152
42	72	1152 - 1167	73	1153 - 1168
43	73	1168 - 1183	74	1169 - 1184
44	74	1184 - 1199	75	1185 - 1200
45	75	1200 - 1215	76	1201 - 1216
46	76	1216 - 1231	77	1217 - 1232
47	77	1232 - 1247	78	1233 - 1248
48	78	1248 - 1263	79	1249 - 1264
49	79	1264 - 1279	80	1265 - 1280
50	80	1280 - 1295	81	1281 - 1296
51	81	1296 - 1311	82	1297 - 1312
52	82	1312 - 1327	83	1313 - 1328
53	83	1328 - 1343	84	1329 - 1344
54	84	1344 - 1359	85	1345 - 1360
55	85	1360 - 1375	86	1361 - 1376
56	86	1376 - 1391	87	1377 - 1392
57	87	1392 - 1407	88	1393 - 1408
58	88	1408 - 1423	89	1409 - 1424
59	89	1424 - 1439	90	1425 - 1440
60	90	1440 - 1455	91	1441 - 1456
61	91	1456 - 1471	92	1457 - 1472
62	92	1472 - 1487	93	1473 - 1488
63	93	1488 - 1503	94	1489 - 1504
64	94	1504 - 1519	95	1505 - 1520

No.	Address on ser. interface		Address in AS	
	Register	Coil	Register	Coil
65	95	1520 - 1535	96	1521 - 1536
66	96	1536 - 1551	97	1537 - 1552
67	97	1552 - 1567	98	1553 - 1568
68	98	1568 - 1583	99	1569 - 1584
69	99	1584 - 1599	100	1585 - 1600
70	100	1600 - 1615	101	1601 - 1616
71	101	1616 - 1631	102	1617 - 1632
72	102	1632 - 1647	103	1633 - 1648
73	103	1648 - 1663	104	1649 - 1664
74	104	1664 - 1679	105	1665 - 1680
75	105	1680 - 1695	106	1681 - 1696
76	106	1696 - 1711	107	1697 - 1712
77	107	1712 - 1727	108	1713 - 1728
78	108	1728 - 1743	109	1729 - 1744
79	109	1744 - 1759	110	1745 - 1760
80	110	1760 - 1775	111	1761 - 1776
81	111	1776 - 1791	112	1777 - 1792
82	112	1792 - 1807	113	1793 - 1808
83	113	1808 - 1823	114	1809 - 1824
84	114	1824 - 1839	115	1825 - 1840
85	115	1840 - 1855	116	1841 - 1856
86	116	1856 - 1871	117	1857 - 1872
87	117	1872 - 1887	118	1873 - 1888
88	118	1888 - 1903	119	1889 - 1904
89	119	1904 - 1919	120	1905 - 1920
90	120	1920 - 1935	121	1921 - 1936
91	121	1936 - 1951	122	1937 - 1952
92	122	1952 - 1967	123	1953 - 1968
93	123	1968 - 1983	124	1969 - 1984
94	124	1984 - 1999	125	1985 - 2000
95	125	2000 - 2015	126	2001 - 2016
96	126	2016 - 2031	127	2017 - 2032
97	127	2032 - 2047	128	2033 - 2048
98	128	2048 - 2063	129	2049 - 2064
99	129	2064 - 2079	130	2065 - 2080
100	130	2080 - 2095	131	2081 - 2096
101	131	2096 - 2111	132	2097 - 2112
102	132	2112 - 2127	133	2113 - 2128
103	133	2128 - 2143	134	2129 - 2144
104	134	2144 - 2159	135	2145 - 2160
105	135	2160 - 2175	136	2161 - 2176
106	136	2176 - 2191	137	2177 - 2192
107	137	2192 - 2207	138	2193 - 2208
108	138	2208 - 2223	139	2209 - 2224
109	139	2224 - 2239	140	2225 - 2240
110	140	2240 - 2255	141	2241 - 2256
111	141	2256 - 2271	142	2257 - 2272
112	142	2272 - 2287	143	2273 - 2288
113	143	2288 - 2303	144	2289 - 2304
114	144	2304 - 2319	145	2305 - 2320
115	145	2320 - 2335	146	2321 - 2336
116	146	2336 - 2351	147	2337 - 2352
117	147	2352 - 2367	148	2353 - 2368
118	148	2368 - 2383	149	2369 - 2384
119	149	2384 - 2399	150	2385 - 2400
120	150	2400 - 2415	151	2401 - 2416
121	151	2416 - 2431	152	2417 - 2432
122	152	2432 - 2447	153	2433 - 2448
123	153	2448 - 2463	154	2449 - 2464
124	154	2464 - 2479	155	2465 - 2480
125	155	2480 - 2495	156	2481 - 2496
126	156	2496 - 2511	157	2497 - 2512
127	157	2512 - 2527	158	2513 - 2528
128	158	2528 - 2543	159	2529 - 2544

3.1.3 Rules for telegram execution:

- on serial interface:
  - Coil Address of least significant Bit (LSB) in Register = Register Address * 16
  - The Startaddress of Coil Telegrams must start on the LSB of a Register (496, 512, 528, ...)
  - Registers over Regiserter Adress 158 (Coil Address 2543) can not be accessed
    -> timeout in master

- Address in AS = Address on serial interface + 1 (vaild for Coil and Register addresses).

- The telegram length (Number of Bits) of Coil Telegrams must be a multible of 16
  (only complete Registers are transmitted). No response in case of error -> timeout in master.

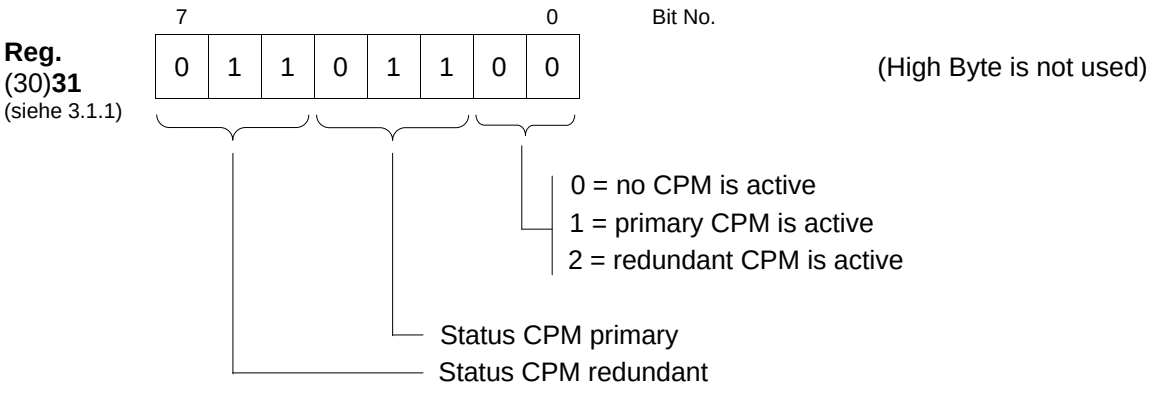
- Maximum telegram length 128 Registers (2048 Coils).

- The data area of the output registers (reg. 0 – 158) will be initialized for configured modules after power on with the value 0x8000. The remaining data area (not configured with output modules) will be initialized with 0x0000.
A Write telegram on a not configured area is accepted but, the written value is rejected. A Read telegram on not configured output areas therefore delivers always values with 0x0000. The start of a redundant CPM using start condition 'Write telegram' can be made by a Write telegram also on a not configured output area.

3.2 Status register

Through the Status register the actual status of the CPM (both CPM in redundant operation) can be read:

Status register CPM:



Status CPM:

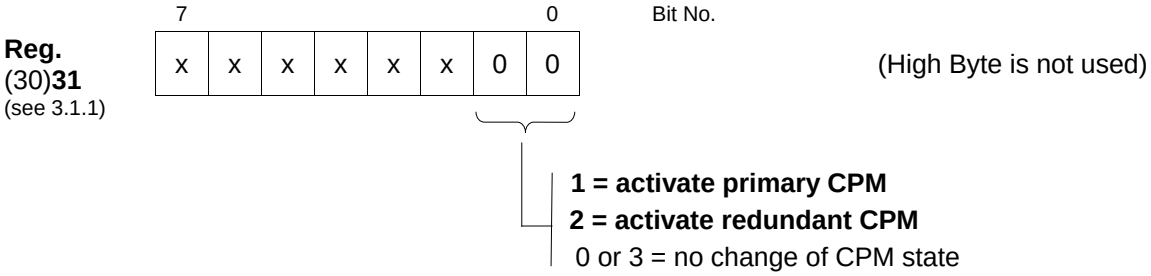
value 1 (001)	Hardware error CPM
value 2 (010)	Data Exchange with AS (Config + Parameter from I.S. Wizard)
value 3 (011)	no Data Exchange (after Power On)
value 4 (100)	Configuration- or Parameter failure
value 5 (101)	Quit Data Exchange with AS
value 6 (110)	Reserved

3.3 Control register

One of two redundant CPMs can be started via writing from the automation system to the control registers in the CPMs.

Write of the control registers is possible with the Modbus functions 06, 15 and 16.

Control register CPM:



The following parameters must be set if the control register shall be used:

Parameter Name	**Parameter Value**
I.S.1 CPM Redundant	- Yes (notice ´start condition´)
CPM start condition via control register	- Yes (Start only via control register)

The control register for starting one of two redundant CPMs must be written with identical content to both CPM (prim. and red.).

The from the automation system selected active CPM must permanently be controlled with the respective control code (value 1 or 2). This facilitates automatic restart after malfunctions.

The function ´Start via control register ´ is supported from CPM firmware as of V11-08.
Older firmware (without support of the control register) does not respond to write telegrams to the control register.

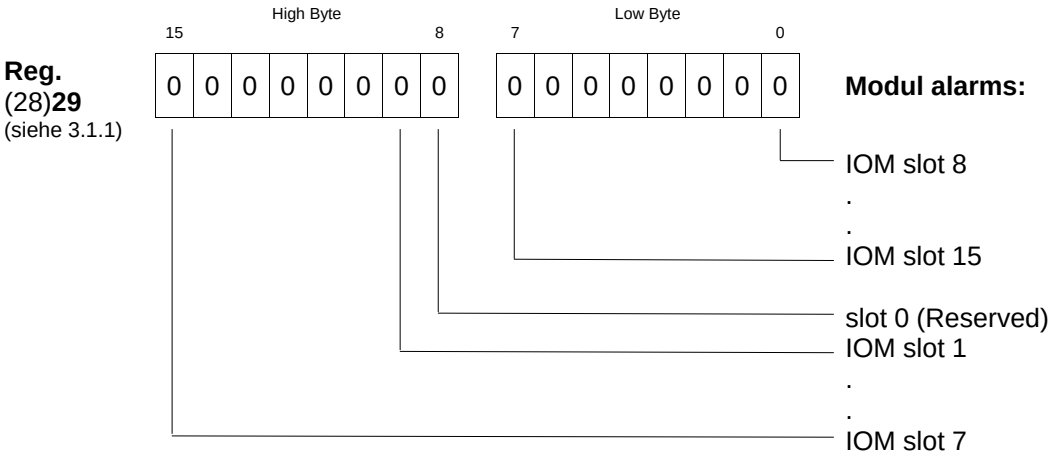
3.4 Modul alarms

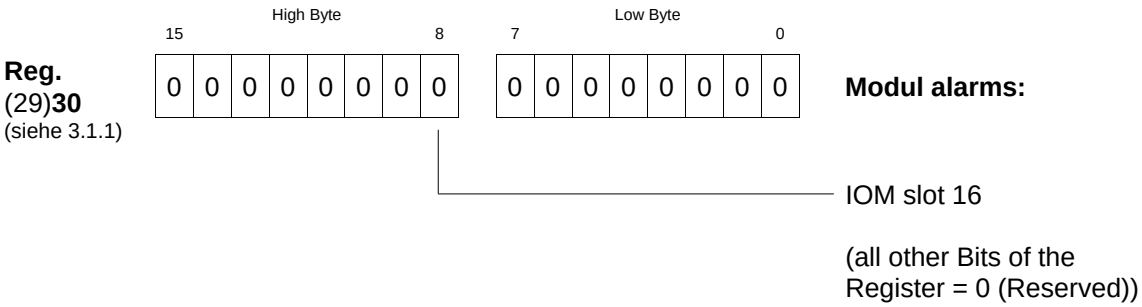
With the Modbus functions 02 and 04 2 Registers (Register address 29 and 30 in AS) with modul alarms can be read from the CPM. This registers contain one bit per IOM with the following allocation:

module alarmbit = 0 -> no alarms in modul. All In- or Outputs of the module are without failures.
module alarmbit = 1 -> at least one signal alarm (Short, Open Circuit....) or a module alarm is present.

With this module alarmbits messages can be generated in the automation system. For Input signals additional statusinformation is available in the cyclic data area (see capter 3.7 Signalverhalten im Fehlerfall). Details of the alarms can be displayed with I.S.Wizard.

Allocation of the module alarmbits to the Registers:





3.5 CPM Redundancy

Redundant operation of two CPM in one fieldstation is supported from Firmware Revision **V11-03**.

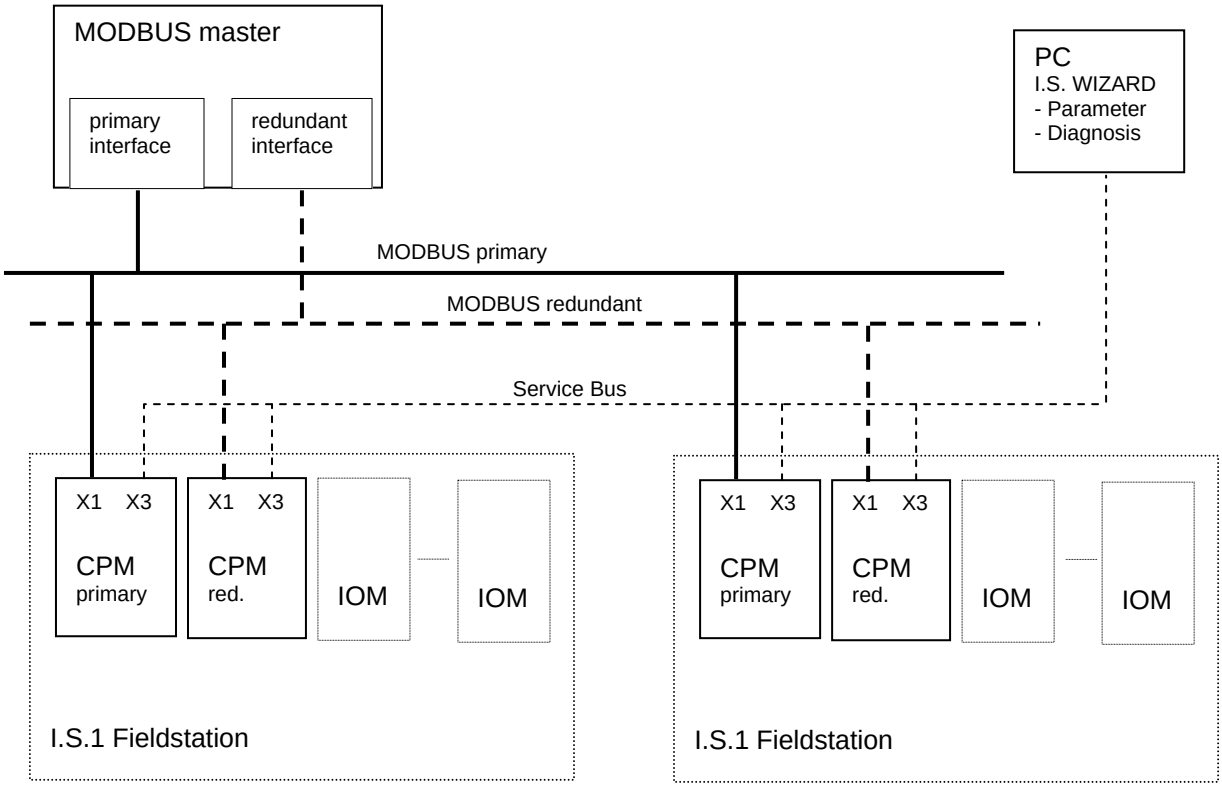
3.5.1 Prepared redundancy

To prepare a later easy extension with redundant CPM´s (prepared Redundancy) please follow the following rule:
The first, left slot on the rail remains empty for later extension with the redundant CPM. The next slot on the rail is used for the existing CPM. The right slot beside this CPM is the slot 1 for IOM modules.

Alternatively it is also possible to use two CPM in one fieldstation but only one of the two CPM is connected to the MODBUS. The MODBUS interface of the other CPM should be not connected. MODBUS communication to both CPM at the same time is not allowed. Via changing the Bus connection from one CPM to the other it can be choosen, which of the two CPM shell communicate.

3.5.2 Redundant system structure

System structure using a modbus master with redundant interfaces:



Address setting:

Primary und redundant CPM of one fieldstation are set to the **same slave address**. This address is valid for the Modbus- and for the service bus interface of both CPM. The allocation of ´primary´ and ´redundant´ CPM is made via slot coding.

Parameter Settings:
For redundant operation of two CPM, use the parameter ´**I.S.1 CPM redundant = Yes**´.
In this case the Parameter ´ CPM start condition´ is effective.
If the parameter ´I.S.1 CPM redundant = No´ has been choosen, the CPM is starting on all read or write telegrams except MODBUS Funktion 8 (Loopback).

For a bumpless switch over in case of disturbance on the active interface, the parameter ´**timeout for output modules T_{MOD}**´ has to be choosen bigger than the switch over time of the MODBUS master.
This switch over time depends on the parameters of the MODBUS master (Baudrate, Message timeout, Number of retries).
If the parameter ´timeout for output modules T_{MOD}´ has to be choosen too small, the output signals will go to save position for a short time during switch over of the redundant MODBUS interfaces.

3.5.3 Selection of ´CPM start condition´

Using the start condition ´Read telegramm or Write telegramm´ the ´CPM start condition´ must only be fulfilled on the active interface of the MODBUS Masters.
Depending on the behaviour of the MODBUS Master on the inactive interface and the data telegrams on the active interface the parameter ´CPM start condition´ has to be selected:

Data trafic on the active interface	**Data trafic on the inactive interface (standby interface)**	**Select parameter ´CPM start condition´**
R/W	Loopback	Read telegramm or Write telegramm
R	Loopback	Read telegramm
W	Loopback	Write telegramm
R/W	R	Write telegramm
W	R	Write telegramm
R	*R*	*Control register*
R/W	*R/W*	*Control register*

R = **R**ead (Modbus functions 1, 2, 3 or 4) W = **W**rite (Modbus functions 6, 15 or 16)

Attention! If the CPM start condition is fulfilled on both CPM at the same time, so both CPM try to start. Both CPM must not be avtive at the same time. Via interacted interlocking a already started CPM will be stopped (Power On reset) by a new started CPM. In such a case both CPM toggle after app. 10 Sec. with Reset.

Startup:
Without data trafic on MODBUS both CPM of a fieldstation are inactive after power on. The display indicates ´FB off´. All output signals are in save position.

Signals in Read responses have the following content:
- DI according parameter ´Signal in case of error ´
- AI with Alarm Code –32734 (0x8022) ´Data not available´

On the first receieve of a telegram, which fulfills the ´CPM start condition´ the CPM will change to the active state and starts with the cyclic exchange of I/O data.

3.5.4 Transmit of Configuration and Parameter data to redundant CPM

The service bus has to be connected to both CPM of a redundant field station.
The configuration and parameter data generated with I.S.Wizard are transmitted via the service bus with the function ´transmit configuration data to I.S.1´ to both CPM of a redundant fieldstation and are stored non-volatile in EEPROM (from I.S.Wizard Rev. 2.2.5)

If parameters are changed online with I.S.Wizard, the changed data are also stored in both CPM.

During operation the active CPM checks whether the inactive CPM has the same configuration and parameter data. In case of inequality this is reported by I.S.Wizard in the CPM diagnosis. This can happen, if two CPM with different data are plugged into one field station. In this case the configuration and parameter data have to be transmitted to the CPM again using I.S.Wizard.

3.5.5 Process data of CPMs during redundancy switch over

During standard operation of two redundant CPMs the Input signals in the memory of the inactive CPM are cyclicaly updated by the active CPM.
If this cyclic update is not possible, the inactive CPM will delete the I/O data in the memory after 20 seconds (5 seconds with CPM firmware V11-06 or older) to avoid usage of old process data.

Bumpless redundancy switch over therefore must be performed in less than 20 (5) seconds.

3.5.6 State of redundant CPM

LCD display CPM	CPM state	state of the other CPM	function / actions
FB off or **FB baud**	**config / parameter error** LED red = ON LED green = flashing	any	No valid configuration and parameter data are stored in CPM. A new download of this data from I.S. Wizard to the CPM is required.

FB off	No data traffic on fieldbus	any	After Power On or after ´Watchdog time AS interface´ expired.
			Please check:
			- Fieldbus hardware
			- DIP-switches on Fieldbus isolation repeater
			- MODBUS Master active ?
			- Parameters of master and fieldstation:
			  - Slave Address
			  - Baudrate
			  - Parity

FB baud	no CPM started. Connection to AS OK	not active	CPM is communicating all telegrams (Read, Write or Loopback) but is not started. No update of I/O data. Please check the parameter ´CPM start condition´
FB OK- I	CPM **I**nactive	active	CPM is communicating telegrams (Read or Loopback) only for connection check. Input data are updated from the active CPM in the inactive CPM too. The cyclic connection to the master is checked: - For Read telegrams according parameter ´Watchdogtime AS interface´. - For ´Loopback´ telegrams with Watchdog = 20 Seconds. If watchdog expired -> Power On RESET -> FB off
FB OK- A	CPM **A**ctive	Any	CPM is cyclicaly updating I/O-data with I/O-modules and the fieldbus. The cyclic exchange with the MODBUS master is monitored according the parameter´Watchdogtime AS interface´. If watchdog expired -> Power On RESET -> FB off (see also 3.7.2 ´ Behaviour of the output signals in case of errors ´).

3.6 Parameterisation of the I.S. 1 field station and the IOM

The information about the location of the parameter bytes in the following chapter is only for internal purposes and is not needed by the user. For configuration and parametrisation of the I.S.1 fieldstation as well as the selection of the parameter set (standard or extended) the software I.S. Wizard is used and the parameters can be handeled in easy screen masks.
For the communication between the PC with I.S. Wizard and the fieldstation the servicebus is used.

3.6.1 New features with the extended parameter set

The functionality of the I.S.1 Remote I/O-System has been extended with the extended parameter set in following points:

- Signal parameter
  - predominant separate parameters for each single signal of IOM (previous partially module global).

- HART Variables
  - HART variables can be mapped to MODBUS registers and transmitted to the MODBUS master (PLC/DCS)

3.6.2 System requirements

Requirements for use of the **Extended Parameter Set** of the I.S. 1 Remote I/O System:

Hardware requirements:

- CPM 9440/12-01-11 (24V Z1 Stahl) as of Revision F
- CPM 9440/15-01-11 (24V Z2 Stahl) as of Revision F
- CPM 9440/22-01-11 (24V Z1 PNO) all Revisions
- CPM 9440/22-01-21 (230V Z1 PNO) all Revisions

Software requirements:

- IOM Firmware as of Revision 2.00
- CPM Firmware DPV0 as of Revision V11-06
- I.S.Wizard as of Revision 3.0.0

I M P O R T A N T

Using older hard- and software releases, the Standard Parameter Set has to be selected.

3.6.3 Documentation of the I.S.1 Parameter Sets

I.S.1 Parameter Set	Documentation of the parameters
Standard	Following in this document
Extended	In seperate document: ´Operating instructions Extended Parameter Set for I.S.1 Remote I/O-System´

3.7 Standard Parameter Set for I.S.1

3.7.1 CPM Parameter

The CPM Parameter are identical using Standard or Extended Parameter Set !

Parameter Name	**Parameter Value (bold = default)**
Baudrate AS interface X1 on CPM:	- 9600 Baud **- 19,2 kBaud** - 38,4 kBaud
Parity:	**- Odd** - Even
Watchdogtime AS Interface T_{WD} (x 100 ms)	Unsigned8 (0 - 255) **Default: 20** (0 = Watchdog Off)
timeout for output modules T_{Mod} (x 100 ms)	Unsigned8 (1 - 255) **Default: 1**
I.S.1 CPM Redundant	**- No (Parameter ´Start condition´ not used.)** - Yes (notice ´start condition´)
CPM start condition via Read- or Write telegram ***1)**	**- Modbus Readtelegram (01, 02, 03, 04)** - Modbus Writetelegram (06, 15, 16)
CPM start condition via control register ***1)**	**- No (Start via Read- or Write telegram)** - Yes (Start only via control register)
IOM 9 -16 on rail X4	**- No** - Yes

*1) This parameter is active only in redundant operation with 2 CPM´s in one fieldstation.
In non redundant operation (only one CPM in one fieldstation) the CPM is starting with every MODBUS read or write telegram except MODBUS function 8 (loopback).

3.7.2 I/O module parameters

3.7.2.1 AIM parameters (9460/.., 9461/..)

Byte 0

7							0	Bit no.
0	0	0	0	0	0	1	1	**Input signal in case of error:**

Initialisation value for
´ Input signal in case of error´**:**

If no valid old value for the "freeze" function is present in the system (e.g. after return of voltage to the FS or after start-up of the Master–Slave communication), the selected initialisation value is used.

0= -10% (only if live zero)
1 = 0%
2 = 100%
3 = Alarm code
6 = freeze (initialisation value 0%)
7 = freeze (initialisation value 100%)

Byte 1

7							0	Bit no.
0	0	0	0	0	0	0	0	Reserved

Byte 2

7							0	Bit no.
1	0	0	0	0	0	0	1	

Input Filter:
0=small **1=medium** 2=large (50Hz) 3= large (60Hz)
measurement range according NAMUR: **0 = No** 1 = Yes
(see 3.3.1 data word structure AIM)
Scan HART Livelist: 0 = OFF **1 = On**

Byte 3

7							0	Bit no.
1	1	1	1	1	1	1	1	**Input ranges:** 0 = 0 – 20 mA **1 = 4 – 20 mA**

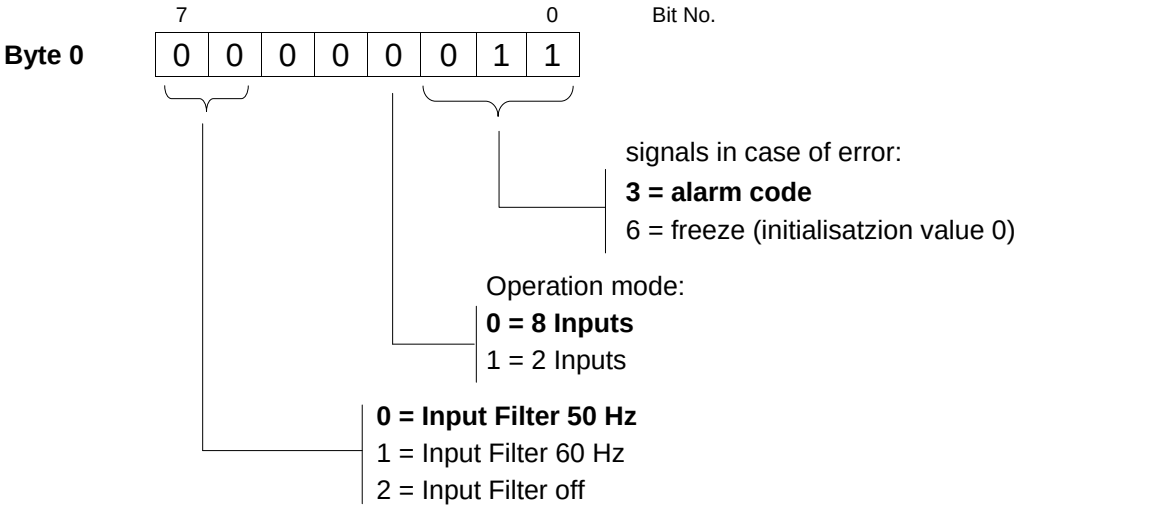
Input 0
Input 1
Input 2
Input 3
Input 4
Input 5
Input 6
Input 7

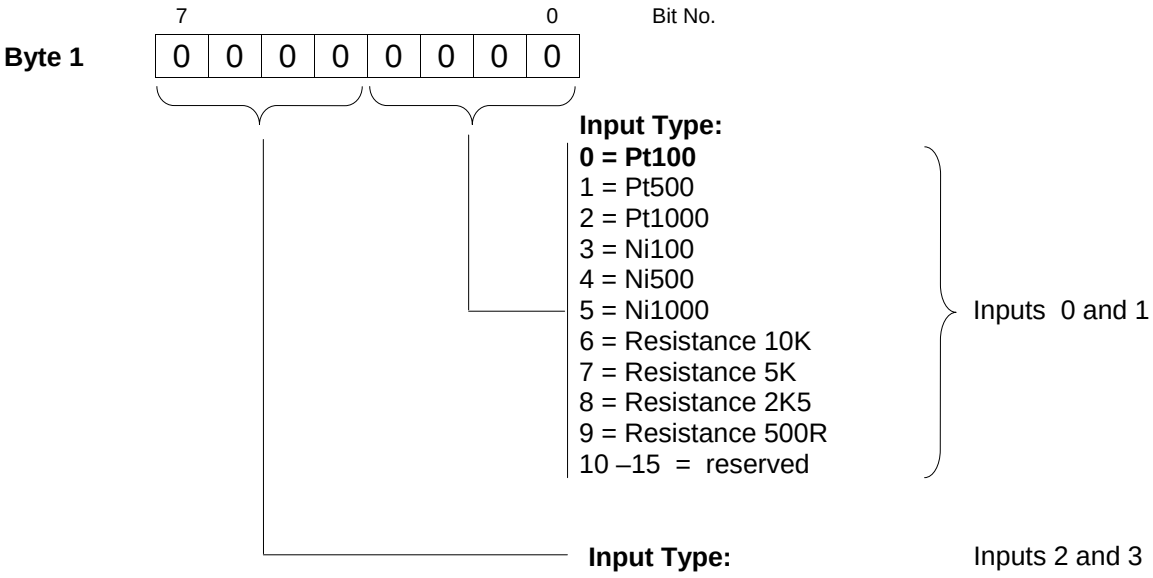
Byte 4

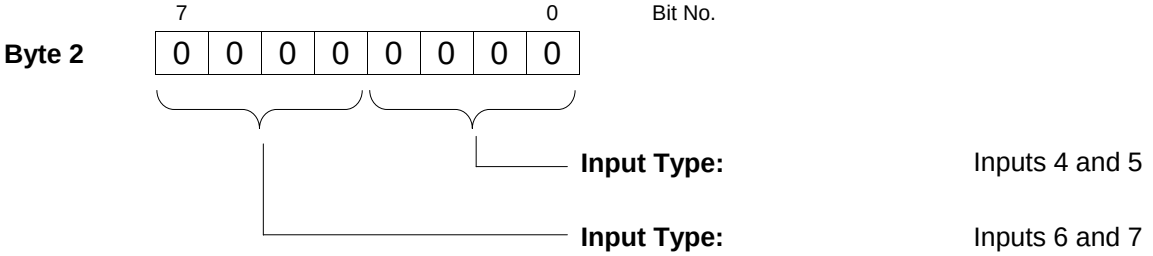
7							0	Bit no.
1	1	1	1	1	1	1	1	**Error detection inputs:** 0 = No **1 = Yes**

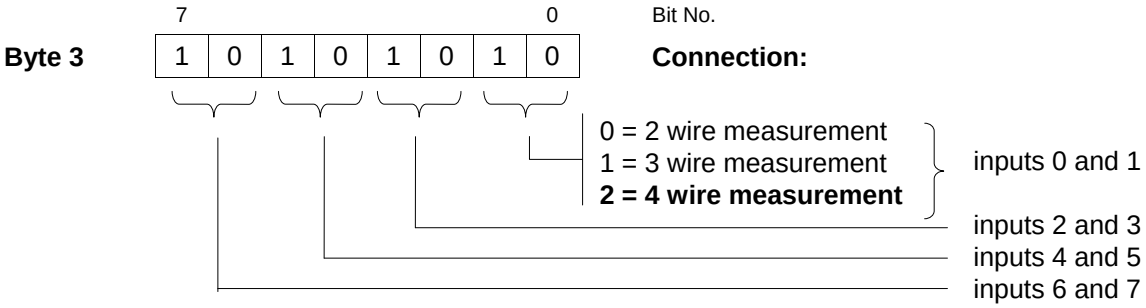
Input 0
Input 1
Input 2
Input 3
Input 4
Input 5
Input 6
Input 7

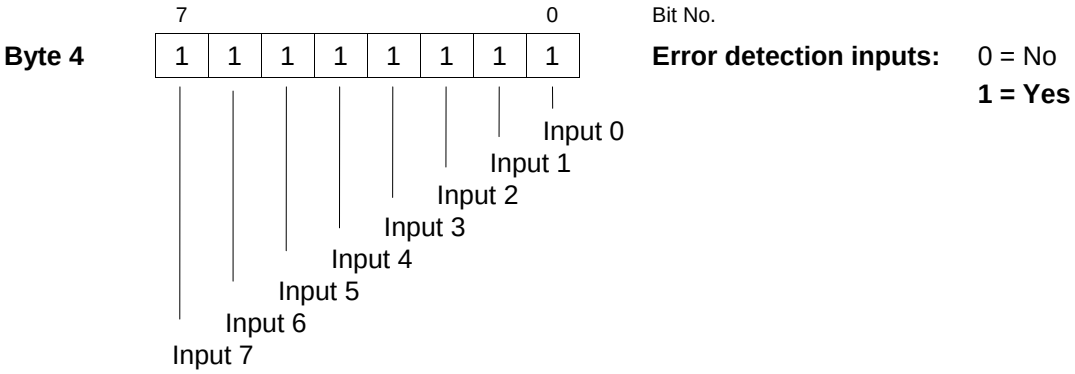
3.7.2.2 TIM 8 R parameters (9480/...)





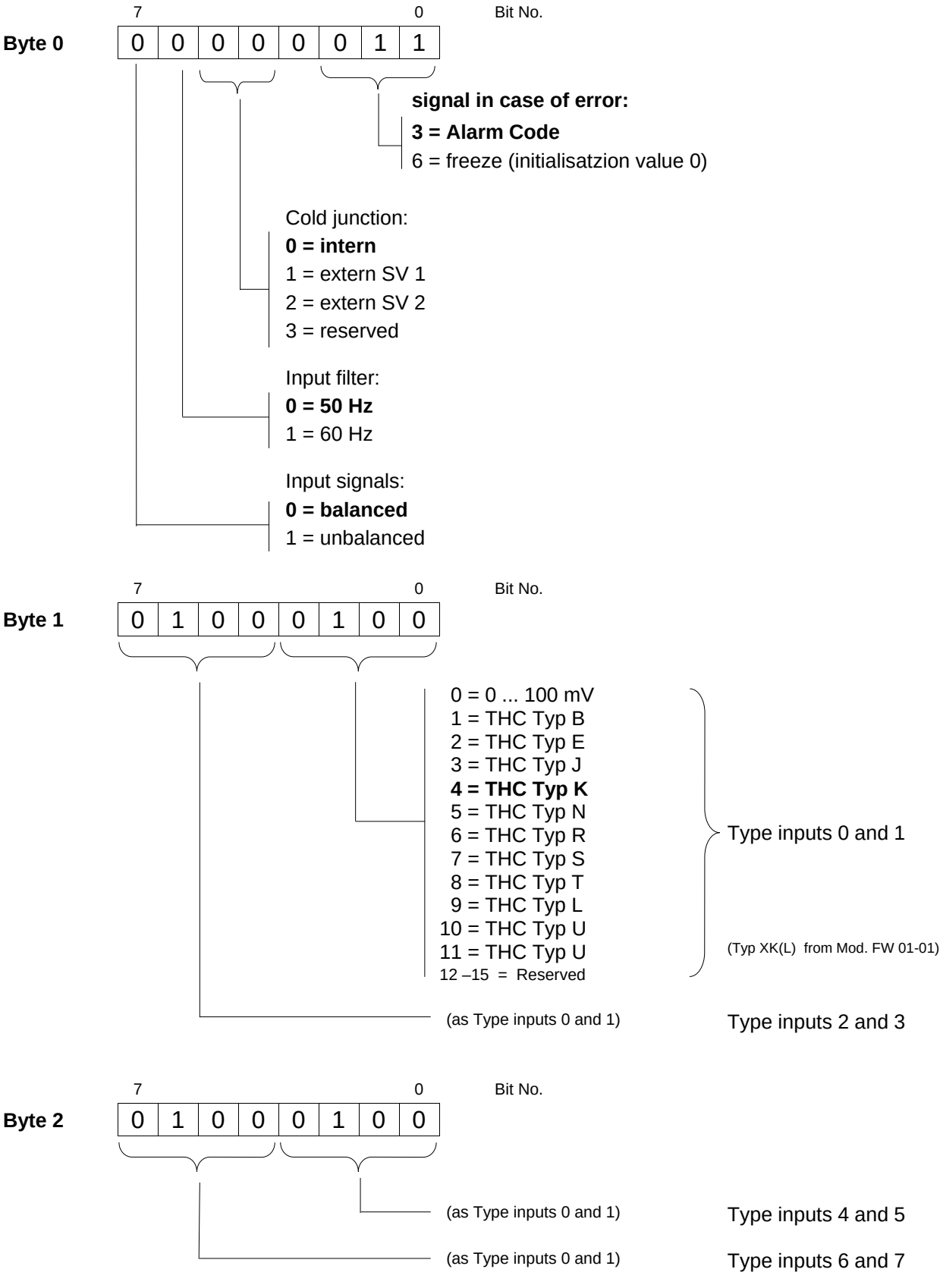






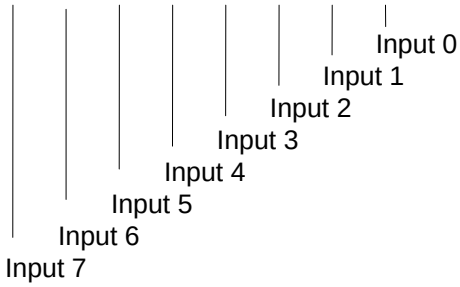
The update time for the input signals is influenced by the parameters ´Operation mode´, ´Input Filter´ and ´Error detection Inputs´ (see data sheet 9480/..).

3.7.2.3 TIM 8 mV parameters (9481/...)



	7							0	Bit Nr.
Byte 3	0	0	0	0	0	0	0	0	**Reserved**

	7							0	Bit No.	
Byte 4	1	1	1	1	1	1	1	1	**Error detection inputs:**	0 = No **1 = Yes**



3.7.2.4 DIM / CIM+CF parameters (9470/.., 9471/..)

Byte 0

7							0
0	0	0	0	0	0	0	0

Bit no.

DI signals in case of error:

0= ´0´
1= ´1´
2= freeze (initial value 0)
3= freeze (initial value 1)

Initial value for ´freeze´:

If no valid old value for the “freeze” function is present in the system (e.g. after return of voltage to the FS or after start-up of the Master–Slave communication), the selected initialisation value is used.

Byte 1

7							0
0	0	0	0	1	0	0	1

Bit no.

Operation mode input 14:
0 = Counter
1 = freq. 0-1 kHz / DI
2 = freq. 0-20 kHz gate time. 50 ms / DI
3 = freq. 0-20 kHz gate time 200 ms / DI
4 = freq. 0-20 kHz gate time 1 s / DI

Operation mode input 15:
(allocation as input 14)

Parameters only used if DIM 16 + CF is selected

Counter event: **0 = positive** / 1 = negative edge

Byte 2

7							0
0	0	0	0	0	0	0	0

Bit no.

DIM parameters

Pulse extension inputs 0 – 3 :
0=0 sec. 1=0.6 sec. 2=1.2 sec. 3=2.4 sec.

Pulse extension inputs 4 – 15 :
0=0 sec. 1=0.6 sec. 2=1.2 sec. 3=2.4 sec.

1 = Invert all inputs of the module

Byte 3

7							0
1	1	1	1	1	1	1	1

Bit no.

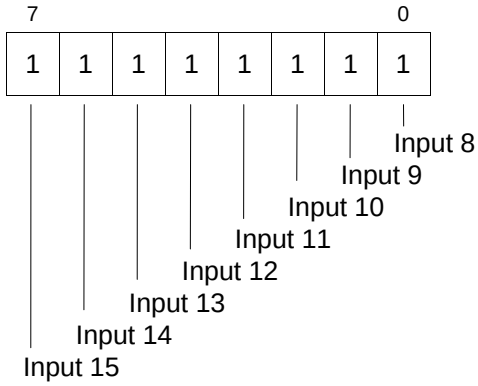
Error detection inputs: 0 = No
1 = Yes

Input 0
Input 1
Input 2
Input 3
Input 4
Input 5
Input 6
Input 7

Parameter ´Error detection inputs´ only available for 9470/..

Byte 3 + 4 = 0 for 9471/...

Byte 4



Bit no.

Error detection inputs: 0 = No

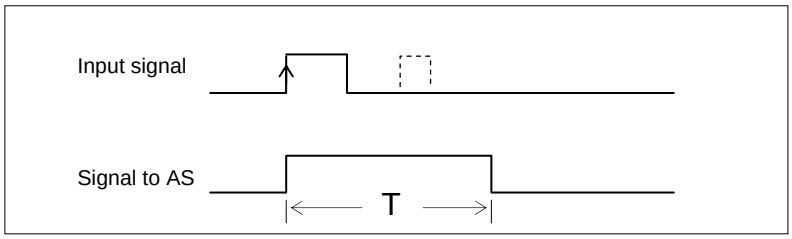
1 = Yes

Pulse extension:

This function can be used to increase the length of short pulses. With this e.g. a short activity of a manual sensor (term approx. 10 .. 50 ms) can be extended to a time selectable by parameterisation (T = 0,6 sec., 1.2 sec., 2.4 sec.).
Short pulses can be recognized surely from the AS also with slower cycle times of the application software

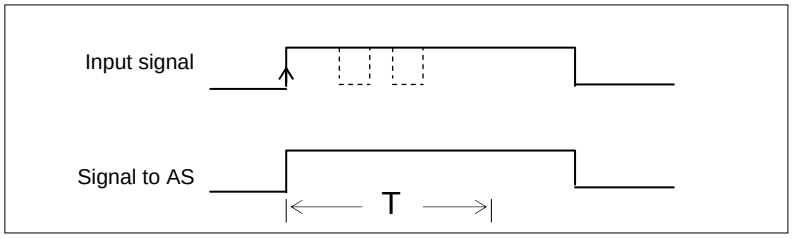
Pulse extension with not inverted operation:

(Parameter ´Invert all inputs of the module´ = No)



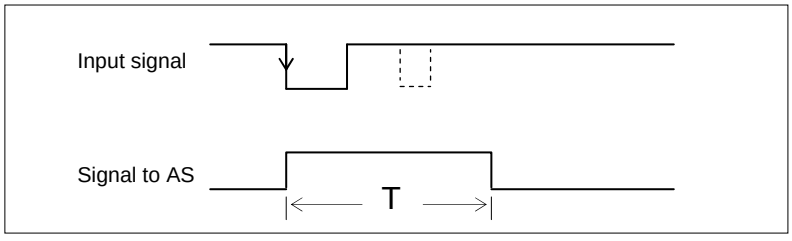
T = 0,6 sec., 1,2 sec., 2,4 sec.
(parametrisable)

Pulses which are longer than the parametrised time T, are not extended.
Short pulses during time T are suppressed.



Pulse extension with inverted operation:

(Parameter ´Invert all inputs of the module´ = Yes)



3.7.2.5 AOM parameters (9465/.., 9466/..)

Byte 0

7							0	Bit no.
0	0	0	0	0	0	0	0	Reserved

Byte 1

7							0	Bit no.
0	0	0	0	0	0	0	1	**Output signals in case of error:**

Initial value for ´freeze´:

If no valid old value for the "freeze" function is present in the system (e.g. after return of voltage to the FS or after start-up of the Master–Slave communication), the outputs are switched off (no voltage, no current) .

0 = -10% (only for live zero)
1 = 0%
2 = 100%
3 = 110%
7 = freeze

Byte 2

7							0	Bit no.
1	0	0	0	0	0	0	0	Reserved

Scan HART Livelist: 0 = OFF **1 = On**

Byte 3

7							0	Bit no.
1	1	1	1	1	1	1	1	**Output ranges:** 0 = 0 – 20 mA **1 = 4 – 20 mA**

Output 0
Output 1
Output 2
Output 3
Output 4
Output 5
Output 6
Output 7

Byte 4

7							0	Bit no.
1	1	1	1	1	1	1	1	**Error detection outputs:** 0 = No **1 = Yes**

Output 0
Output 1
Output 2
Output 3
Output 4
Output 5
Output 6
Output 7

3.7.2.6 DOM parameters (9475/.., 9476/.., 9477/..)

Byte 0

7							0	Bit no.
0	0	0	0	0	0	0	0	Reserved

Byte 1

7							0	Bit no.
0	0	0	0	0	0	0	0	**Output signals in case of error:**

0= ´0´
1= ´1´
2= freeze

Initial value for ´freeze´:
If no valid old value for the “freeze” function is present in the system (e.g. after return of voltage to the FS or after start-up of the Master–Slave communication), the outputs are switched off (no voltage, no current) .

Byte 2

7							0	Bit no.
0	0	0	0	0	0	0	0	Reserved

Byte 3

7							0	Bit no.
0	0	0	0	0	0	0	0	**If Output x = Off:** **0 = Test current On**
								1 = Test current Off

Output 0
Output 1
Output 2
Output 3
Output 4
Output 5
Output 6
Output 7

Parameter ´**Test current On / Off**´ (Line break detection while output is switched off) is only effective for all DOM Type No. 9475/.. with Revision F or higher.
For all other DOM this parameter is not effective.

Byte 4

7							0	Bit no.
1	1	1	1	1	1	1	1	**Error detection outputs:** 0 = No
								1 = Yes

Output 0
Output 1
Output 2
Output 3
Output 4
Output 5
Output 6
Output 7

For the modules 9475/.2-04-.. (DOM 4) the error detection can only be parametrised for the outputs 0 to 3. The outputs 4 to 7 are set to ´ 0 = No ´.

For the modules 9477/.. (DOM Relais) error detection of the outputs is not possible.
Byte 3 and 4 are set to ´0´.

For the modules 9475/12-07-71 (DOM 7) the error detection can only be parametrised for the outputs 0 to 6. The output 7 is set to ´ 0 = No ´.

3.8 Data word structure of the I/O modules

3.8.1 Analog modules

Analogue signals are exchanged between the I.S. 1 field station and an automation system in 16-bit two's complement format (signed integer). Converting to and from floating point variables (physical values) must be performed in the automation system if required.

AIM, AIMH (9460/..., 9461/...)
0 – 20 mA

Measuring range 0 – 20 mA	Units		%	Parameter: Measurement range limits according NAMUR	Range	Alarms / Diagnoses
	Decimal	Hex				
>23.518 mA >21 mA	*1)	*1)		No Yes		Short circuit
23.518 mA 21 mA .	32511 29030 .	7EFF 7166 .	117.6% 105 %	No Yes	Over range	-
20 mA . 10 mA . 0 mA	27648 . 13824 . 0	6C00 . 3600 . 0	100% . 50% . 0%		Nominal range	-
< 0 mA	0	0	0%			

AIM 4 – 20 mA

Measuring range 4 – 20 mA	Units		%	Parameter: Measurement range limits according NAMUR	Range	Alarms / Diagnoses
	Decimal	Hex				
>22.814 mA >21 mA	*1)	*1)		No Yes		Short circuit
22.814 mA 21 mA	32511 29376	7EFF 72C0	117.6% 106,25 %	No Yes	Over range	-
20 mA . 12 mA . 4 mA	27648 . 13824 . 0	6C00 . 3600 . 0	100% . 50% . 0%		Nominal range	-
3.999 mA 3,6 mA 2.4 mA	-1 -691 -2765	FFFF FD4D F533	 -2,5% -10%	 Yes No	Under range	-
< 3,6 mA < 2.4 mA	*1)	*1)		Yes No		Line break

***1) Transmitted value depends on parameterised behaviour if an error occurs:**

Parameterised behaviour if an error occurs	Type of error	Value transmitted if an error occurs	
freeze	All IOM errors	Last valid value	
-10%	All IOM errors	-2765	F533
0%	All IOM errors	0	0
100%	All IOM errors	27648	6C00
Alarm code General rule to generate status information in AS for all AI signals: Signal is disturbed if Value >= 32512 or Value<= -32512 see 3.4.1 Behaviour of input signals in case of error	Short circuit	32767	7FFF
	Open circuit	-32762	8006
	IOM does not respond	-32736	8020
	Config. unequal from module	-32735	8021
	Data not available	-32734	8022
	IOM hardware error	-32733	8023

Measurement range limits according NAMUR:

The limits of the measurement range to the short circuit and open circuit area can be modified by the parameter ´Measurement range limits according NAMUR´ according the above table.

This parameter is available with firmware Revision V01-02 of all AIM and AIMH modules (9460/.. und 9461/..).
Modules with older firmware revisions do not support this parameter. This modules use the fix setting ´Measurement range limits according NAMUR = No´.

TIM (9480/... , 9481/...)

Temperature measurement (1 Digit = 0,1 °C)

Temperature	Units		Range	Alarms / Diagnoses
	Decimal	hexadezimal		
	*1)	*1)		Upper limit exceeded
*2) . 1000 °C . 1 °C . 0 °C	*2) . 10000 . 10 . 0	*2) . 2710 . 000A . 0	Temperature measurement range	
-1 °C . -100 °C . *2)	-1 . -1000 . *2)	FFFF . FC18 . *2)		
	*1)	*1)		Lower limit exceeded

*2) The limits of the measurement range are pending on the parametrised input type (see Operating instructions I.S.1)

2 wire and 4 wire Resistance Measurement 500 R .... 10K (modul 9480 / ....)

Range				Units		%	Range	Alarms / Diagnoses
500 R	2 K 5	5 K	10 K	decimal	hexadecimal			
>588 R	>2,94 K	> 5,88K	>11,76 K	*1)	*1)			Line break
588 R	2,94 K	5,88 K	11,76 K	32511 .	7EFF .	117,6%	Over range	-
500 R . 250 R . 0 K	2 K 5 . 1K250 . 0 K	5 K . 2K5 . 0 K	10 K . 5 K . 0 K	27648 . 13824 . 0	6C00 . 3600 . 0	100% . 50% . 0%	Nominal range	-

3 wire Resistance / Position Measurement 500 R .... 10K (modul 9480/..)

Range				Units		%	Range	Alarms / Diagnoses
500R	2K5	5 K	10 K	decimal	hexadecimal			
>588 R	>2,94 K	>5,88 K	>11,76K	*1)	*1)			Line break
position 100 % . position 50 % . position 0 %				27648 . 13824 . 0	6C00 . 3600 . 0	100% 50% 0%	Nominal range	-
< 50 R	< 250 R	< 500 R	< 1 K	*1)	*1)			short circuit

0,02 R	0,1 R	0,2 R	0,4 R	Resolution per Digit

0 ... 100 mV measurement (9481/..)

Range 0 ... 100 mV	Units decimal	Units hexadecimal	%	Range	Alarms / Diagnoses
>117,6 mV	*1)	*1)			Upper limit exceeded
117,6 mV	32511	7EFF	117,6 %	Over range	-
100 mV . 50 mV . 0 mV	27648 . 13824 . 0	6C00 . 3600 . 0	100 % 50 % 0 %	Nominal range	-
-0,0036 mV -10 mV	-1 -2765	FFFF F533	 -10 %	Under range	-
< -10 mV	*1)	*1)			Lower limit exceeded

Short circuit alarm can not be detected at Resistance and Voltage measurement !

***1) Transmitted value depends on parameterised behaviour if an error occurs:**

Parameterised behaviour if an error occurs	Type of error	Value transmitted if an error occurs	
freeze	All IOM errors	Last valid value	
Alarm code General rule to generate status information in AS for all AI signals: Signal is disturbed if Value >= 32512 or Value<= -32512 see 3.4.1 Behaviour of input signals in case of error	Short circuit	+ / - 32767	7FFF / 8001
	Open circuit	+ / - 32762	7FFA / 8006
	Upper limit exceeded	32761	7FF9
	Lower limit exceeded	-32760	8008
	Cold Junction error	-32752	8010
	IOM does not respond	-32736	8020
	Config. unequal from module	-32735	8021
	Data not available	-32734	8022
	IOM hardware error	-32733	8023

*1) depending of the direction of signal change at the respective error type a positve or negative alarmcode is used:

error type	TIM R 9480 / ...	TIM mV 9481 / ...
short circuit	-32767 (8001)	not detectable
open circuit	+32762 (7FFA)	-32762 (8006)

AOM 0 – 20 mA

Measuring range 0 – 20 mA	Units		%	Range
	Decimal	Hexadecimal		
*1)	>30137	>75B9		
21,8 mA .	30137 .	75B9 .	109%	Over range
20 mA . 10 mA . 0 mA	27648 . 13824 . 0	6C00 . 3600 . 0	100% 50% 0%	Nominal range
0 mA	< 0	< 0		

AOM 4 – 20 mA

Measuring range 4 – 20 mA	Units		%	Range
	Decimal	Hexadecimal		
*1)	>30759	>7827		
21,8 mA .	30759 .	7827 .	111,25%	Over range
20 mA . 12 mA . 4 mA	27648 . 13824 . 0	6C00 . 3600 . 0	100% 50% 0%	Nominal range
3,999 mA 0 mA	-1 -6912	FFFF E500	 -25%	Under range
0 mA	< -6912	< E500		

*1) : The AOM attempts to increase the current further according to the control value. However, depending on the burden effective resistance, the maximum output voltage of the AOM may be reached whereby the current can no longer be increased.

Safety position after Power On:
After Power On of the CPM the data area of the outputs is initialized with the value -32768 (0x8000) als signal for the safety position.
The outputs remain in the save position as long as the allocated register is overwritten with a valid output value (<> -32768 (0x8000)) from AS or from I.S. Wizard.

(see also chapter 3.7.2)

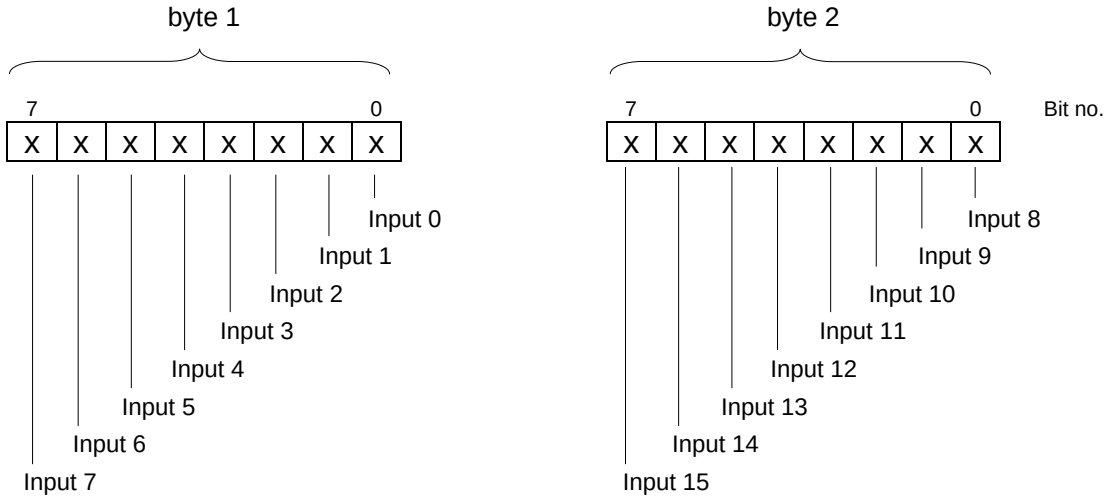
3.8.2 DIM, DIM+CF (9470/.. 9471/..)

On the modules 9470 und 9471 the inputs 14 und 15 can optionaly be used as digital- (DI), counter- (C) or frequency input (F).
Through selection of different module descriptions in I.S. Wizard the transmitted data area can be coosen.

module selection text in I.S. Wizard	**input data**	**output data**	**available signal types for inputs 14 and 15**
DIM 16 (9470/.. , 9471/..)	2 Byte (16 Bit DI)	-	only DI (without status)
9470 /. . -16-1. **DIM 16** ..... 9471 /. . -16-1. **DIM 16**	4 Byte (16 Bit DI + 16 Bit status)	-	only DI (with status)
9470 /. . -16-1. **DIM 16+CF** ..... 9471 /. . -16-1. **DIM 16+CF**	8 Byte (16 Bit DI + 16 Bit status + 2 words CF)	1 Byte (control register for counter)	DI or Counter or Frequency (with status)

Even if DIM 16+CF (with counter / frequency) is selected the inputs 14 und 15 are mapped to the standard DI data area (byte 2) and therefore can be used as standard DI inputs.

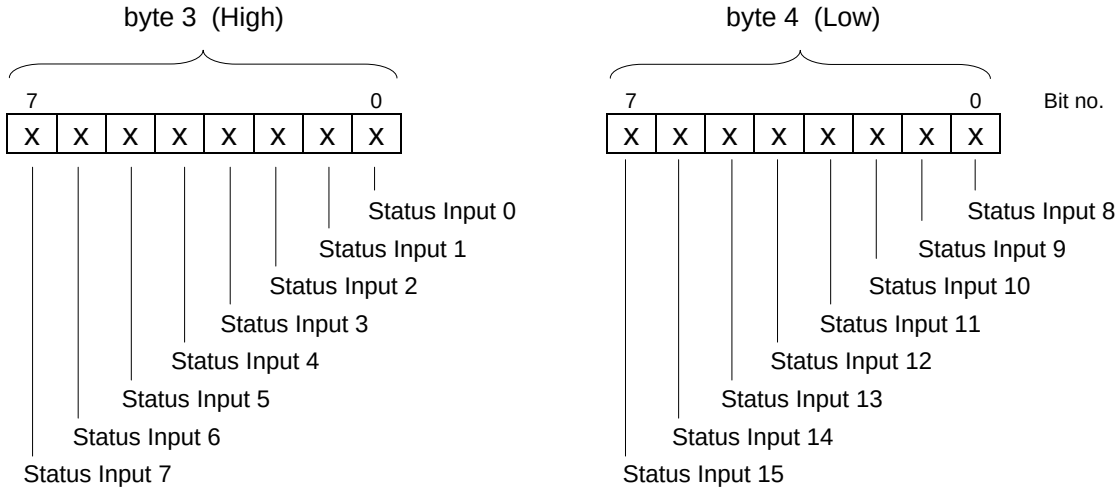
Data word structure DI



Signal definition with Parameter ´Invert all inputs of the module = No´:

Module	open circuit alarm	signal = 0	signal = 1	short circuit alarm
9470/ ...	I < 0,05 mA	I < 1,2 mA	I > 2,1 mA	R_L < 100 Ohm
9471/ ...	-	U < 5 V	U > 13 V	-

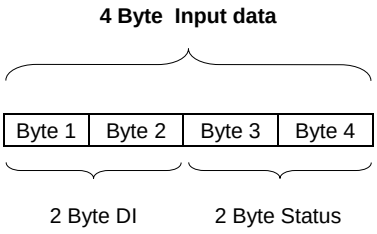
Data word structure status



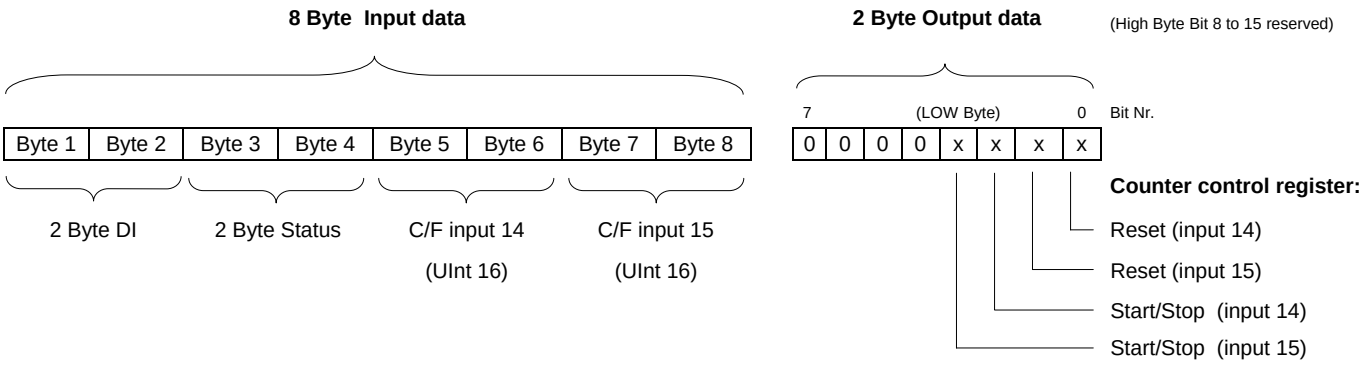
status bit = 1: Signal OK
status bit = 0: Signal disturbed

Signal and status are transmitted synchronized and consistent !

Data word structure (DIM 16 with status)



Data word structure (DIM 16+CF)



Reset = "0": counter running	Start/Stop = 0 : counter running
Reset = "1": counter = 0	Start/Stop = 1 : counter stopped

Operation mode ´counter´

Incremental operation with overflow (after 65535 register changes to 0)

Count range:	0 – 65535 (Unsigned Integer UInt16)
Count event:	Positive / Negative edge selectable.
Signal in case of error:	freeze last value (Initial value 0)
Alarming:	Status and channel diagnosis
Reset:	Reset counter register to ´0´
Start/Stop:	in ´Stop´ mode input pulses are ignored (not counted)

Signal status in operation mode ´counter´:

The status bit is initialized with ´0´ = signal disturbed.
With the Reset bit in the control register the counter register is set to ´0´ and the status bit is set to ´1´= signal OK.
In case of errors (short circuit, open circuit, bus failure ...) the status bit is set to ´0´ and will be held at ´0´ until the next Reset. Therefore disturbances during the count procedure are recognizable via the status bit.

Operation mode ´Frequency´

Selection operation mode:	Measurement methode	Scaling	Resolution
Frequency 1 Hz -1 kHz	Pulse time measurement	0,05 Hz / Bit	+/- 0,05 Hz
Frequency 0-20 kHz gate time 50 ms	Gate time measurement	1 Hz / Bit	+/- 20 Hz
Frequency 0-20 kHz gate time 200 ms	Gate time measurement	1 Hz / Bit	+/- 5 Hz
Frequency 0-20 kHz gate time 1 s	Gate time measurement	1 Hz / Bit	+/- 1 Hz

Measuring range 1 Hz – 1 kHz	Measuring range 0 – 20 kHz	Units		%	Range
		decimal	hex		
1,3 kHz 1,1 kHz	- 22 kHz	26000 22000	6590 55F0	130 % 110 %	Over range
1 kHz . 500 Hz . 0 Hz	20 kHz . 10 kHz . 0 kHz	20000 . 10000 . 0	4E20 . 2710 . 0	100 % 50 % 0 %	Nominal range

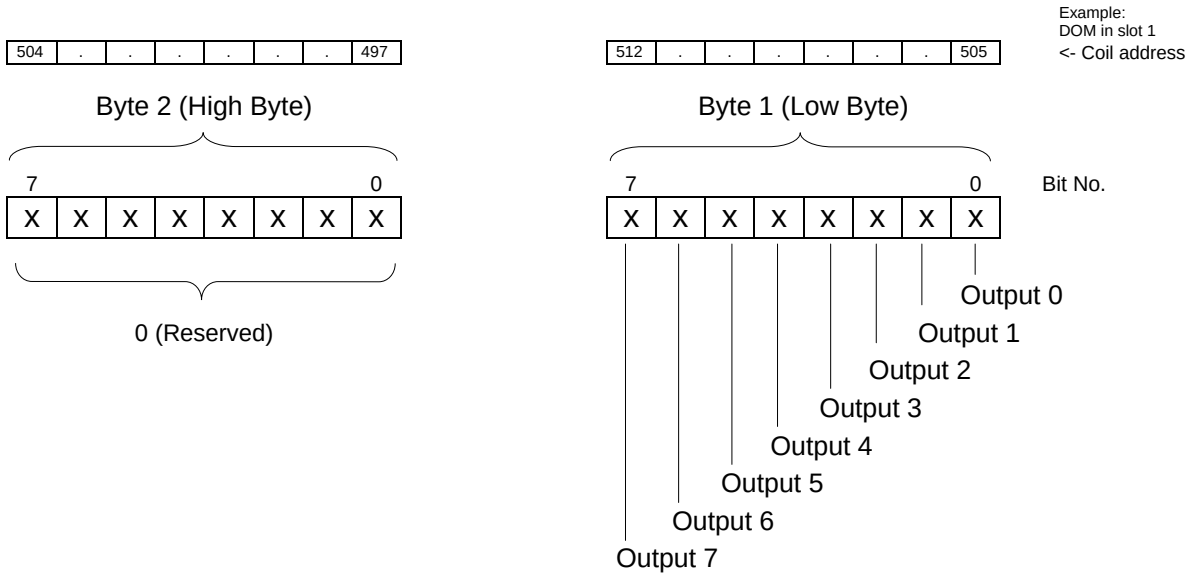
Signal in case of error: freeze (Initial value 0)
Alarming: status und channel diagnosis

Behaviour in case of too high input frequencies:

If the input frequency is higher as the maximum allowed over range value input pulses can be lost. In this case the measured value is smaller as the existing frequency at the input. No alarm is generated.

3.8.3 DOM (9475/.., 9476/.., 9477/..)

DOM 8 channels:



Register format: **High byte first**
The DO–data is in the Low Byte of the Register. The High Byte is reserved.

DOM 7: The module 9475/12-07-71 is not using the output 7. All other outputs are allocated as shown above.

DOM 4:

The Bits No. 4 to 7 for the outputs for 4 to 7 are not used (= 0).
All other outputs are allocated as shown above.

Signal definition:

signal bit = 0	signal bit = 1
output high impedance (actuator = Off) or relais contact = open	output is powered according typespecification (actuator = On) or relais contact = closed

3.9 LED and LCD displays of the CPM

The operational state and the communication on the MODBUS can be assessed on site using the LEDs and the LCD display on the CPM of an I.S. 1 field station.
Additionaly the signal values, the signal- and module alarms can be displayed on the LCD display of the CPM using CPM firmware rev. 11-01 or higher.

For details, see the I.S.1 operating instructions.

3.10 Signal behaviour in case of errors

3.10.1 Behaviour of the input signals in case of errors

If no valid signal value can be formed as a result of a malfunction (short circuit, open circuit, defective sub-assembly...), a diagnosis information is created which can be read from I.S. Wizard. Despite the outstanding malfunction, data continues to be transmitted to the master.

The behaviour of the signal values transmitted if a malfunction has occurred can be selected separately for every module using parameterisation (see 3.2.2 IOM parameters).

Application hint:

If the behaviour of input signals in case of error is realized through the I.S.1 system, this behaviour seen from the application software in the automation system can only be guaranteed with undisturbed communication on MODBUS.

At loss of cyclic communication on MODBUS additional project specific reactions have to be realized in the application software in the automation system.

To guarantee the same behaviour of all input signals in any case of error (even in case of bus failure), we recommend the following procedure:

Generate a Status Bit for each input signal in the automaton system:

- for DI signals the optional available statusbits of I.S.1 in the cyclic data of MODBUS can be used.
- for AI signals the ´behaviour in case of error = Alarmcode´ has to be choosen in the parameters of all AI signals (default). In the application software of the automation system the following function has to be used for each AI signal:

```
If SignalValue >= 32512  Or  SignalValue <= -32512 then
      SignalStatusBit = disturbed
Else
      SignalStatusBit = OK
End IF
```

The signal behaviour in case of error (freeze, substitute value ...) should now be realized in the automation system.

In this case the event ´loss of cyclic communication on MODBUS´ can be logical wired with the signal status bit whereby the signal behaviour in case of error is always the same under all error conditions.

To generate alarmmessages for output modules in the automation system two registers with module alarm bits (1 bit per module) can be read from the CPM. The Details of the diagnosis information should be read and displayed via I.S. Wizard.

3.10.2 Behaviour of the output signals in case of errors

Communication error between the master and I.S.1 field station:
The cyclic data traffic between the MODBUS master and the CPM is checked in the CPM using response monitoring.
Response monitoring in the CPM makes sure that if the master suffers a failure or there is some other communication loss to the master after expiry of the time (T_{WD}), the outputs adopt the safe state.
The T_{WD} time can be parameterised within the range 100 ms to 25,5 Seconds (using I.S. Wizard, CPM Parameter: Watchdogtime AS interface, Default = 2 Sec.). After expiry of T_{WD}, the cyclic updating of the output modules is stopped by the CPM of the I.S. 1 field station.
The response monitoring of the slaves can also be deactivated (T_{WD}=0). In this case, the slave cannot recognise a loss of communication to the master. The output signals of the slaves are frozen if updating from the master cannot be performed.

Communication error between the CPM and output module:
There are Watchdog circuits on the output modules that monitor the data transmission between the CPM and the output modules. If an output module does not receive any valid data for more than T_{Mod}, the subassembly adopts the safety position.
T_{MOD} (timeout für output modules) can be parameterised in I.S. Wizard (CPM parameter: timeout for output modules) within the range 100 ms to 25.5 sec. (default value: 100 ms).

Consequently, the safety position of the output modules follows at a delay of T_S after failure of the communication to the master where:

$$T_S = T_{WD} + T_{Mod}$$

The safety position of the output signals can be parameterised separately for every module (see 3.2.2 IOM parameters).

3.11 Online behaviour of the I.S.1 fieldstation.

3.11.1 Parameter change.

If a I.S.1 Fieldstation is in Data Exchange with the Modbus master, IOM parameters can be modified during operation (online) via I.S. Wizard.

3.11.2 Configuration change.

If a I.S.1 Fieldstation is in Data Exchange with the Modbus master, new or modified konfiguration data can be loaded to the CPM from I.S. Wizard.
During the download the CPM shortly stopps the communication on the MODBUS interface which can cause one telegram failure on the MODBUS. This will generate one retry of the MODBUS master.
After finishing the download, the CPM continues communicating on MODBUS according the new konfiguration data.

The marshalling of the I/O-signals to the MODBUS Registers is according the new konfiguration data.
It is to be examined, whether through the konfiguration changes adjustments in the signal marshalling in the automation system are necessary.

After restart of the CPM with the new configuration data the CPM checks the real existing modules on the rail against the configuration data.
All modules of the fieldstation where the konfigured module type agree with the existing module type in the fieldstation are updated cyclically after start-up.
For modules, which do not agree with the configuration data, alarms are generated. The signals of this modules are not updated and react according the parametrized behaviour in case of error.

Through the before described conduct online expansions of a fieldstation can be realized by adding new modules after the up to now existing modules. In this case the assignment of the signals of the modules located up to now in the fieldstation to the MODBUS registers is not changed.
Newly added modules are appended behind the previous used register area.

Execution of online expansion:

- add new modules in free slots on the rail **after** (higher slot numbers) the up to now used IO-modules.
- Add new modules offline in I.S. Wizard configuration software.
- Online download of the modified configuration data from I.S. Wizard to the CPM while MODBUS is running.
- Expansion of the current telegrams in the MODBUS master to transmit the signals of the newly added modules.

Attention!

An **online change is not possible**, if existing modules are changed against other module types and herewith the amount of input - and output registers of the module change at the modified slot.
In this case the allocation of the signals to registers in the automation system has to be modified which is usually not possible without consequences on the running process.

3.12 Interface parameters

Parameter	Selection	Selection by:
Baudrate	9600, 19200, 38400 Baud	I.S.Wizard (see CPM Parameter)
Parity	Odd, Even	
Startbit	1	fix
Stopbit	1	fix
Zeichenverzugszeit	2 ms	fix
Quittungsverzugszeit	> 2ms	fix

3.13 Transmission time on MODBUS:

Transmission time for read telegrams (Functions 01, 02, 03, 04):

t [s] = (16 + account DW * 2) * 11 / Baudrate *1)

Transmission time for write telegrams (Functions 15, 16):

t [s] = (20 + account DW * 2) * 11 / Baudrate *1)

*1) The above formulas consider the response delay times of the CPM, but not the telegram delay times of the automation system. They are used for calculating the attainable minimum transmission time. Dependent on the telegram delay times of the automation system the actually attainable values are subject to increase.

DW = data words (Registers)

easy rule of thumb:

Baudrate [Baud]	Transmission capacity on MODBUS
9600	250 Registers / Second
19200	500 Registers / Second
38400	1000 Registers / Second

4 List of abbreviations:

AS	**A**utomation **S**ystem
AIM	**A**nalogue **I**nput **m**odule
AIMH	**A**nalogue **I**nput **m**odule + **H**ART
AOM	**A**nalogue **O**utput **module**
AOMH	Analogue output module +HART
CPM	**C**PU + **PM** = CPM Central unit consisting of communication processor with power pack
DIM	**D**igital **I**nput **M**odule
DOM	**D**igital **O**utput **M**odule
HW	Hardware
IOP	**I/O P**rocessor of the central unit
IOM	General description of **I/O M**odule
PM	**P**ower **M**odule (power pack)
SW	Software
TIM	**T**emperature **I**nput **M**odule

5 Release Notes:

Version Interface description Modbus	**Extensions / Changes**
00/09.03	First Revision
00/11.06	- Coil Addressing added for Modbus Functions 01, 02 and 15. **- CPM Firmware Revision V10-00** (Firmware File for CPM: IS1_CPM_MB_10_00.fdl) This CPM Revision accepts no CPM parameters from I.S. Wizard. The Parameters are fix in the firmware of the CPM with the following values: Baudrate: 9600 Baud Parity: odd Watchdog time AS: 4 Sek. Holdtime Output modules: 100 ms All Parameters of the I/O modules can be modified by I.S. Wizard.
00/11.08	- CPM parameters (Baudrate, Parity, Watchdog, Holdtime...) can be modified from I.S. Wizard (offline and online). - Online extension of fieldstations possible. - new Baudrate 38,4 kBaud on MODBUS is supported now. - max. telegram length 128 registers. Therefore optimal use of the transmission capacity of MODBUS (low protocol overhead) **- CPM Firmware Revision V11-00** (Firmware File for CPM: IS1_CPM_MB_11_00.fdl)
01/02.09	Extensions for module TIM R 9480/..: (9480 firmware rev. V 01-00). - 3 wire resistance / position measurement - 2 wire calibration supported - Alarmcodes of module changed **- CPM Firmware Revision V11-01:** (Firmware file for CPM: IS1_CPM_MB_11_01.fdl) - CPM display: Display of signal- and diagnosis information supported.
01/12.10	New I/O-moduls added: 9475/22-08-51 **DOM** 8 OD Exi2 9475/22-08-61 **DOM** 8 OD Exi3 9477/12-08-12 **DOM** 8 60V Rel Z1 9477/12-06-12 **DOM** 6 250VRel Z1 New Parameter ´Test current On / Off ´ for DOM 9475/.. Rev. E . CPM Parameter added: - IOM 9 -16 on Rail X4 - Line redundancy AS bus **CPM Firmware Revision V11-03:** (Firmware file for CPM: IS1_CPM_MB_11_03.fdl) Support of redundant CPM in one fieldstation
02/05.11	- Details in description of redundancy added. - New parameter for TIM 8 mV 9481/.. : Thermocouple Typ XK(L) from 9481 modul FW-Revision 01-01)
02/06.12	Parameter ´Test current On / Off ´ for DOM 9475/.. Rev. F

Version Interface description Modbus	Extensions / Changes
02/08.13	- New I/O-module added: 9475/22-04-21 **DOM** 4 OD Exi2
04/05.14	- Description of Dataformat DOM (3.6.3) extended
04/06.15	- Extended Parameter set for I.S.1 - HART variables in cyclic data exchange with MODBUS Master
04/07.16	- Parameter ´Scan HART Livelist On / Off´ added for all HART modules
06/04.17	- Documentation of registers improved - Parameter ´Start via control register´ added. - New Exn - modules added: 9461/15-08-12 AIMH8 2w Exn 9461/15-08-12 AIMH8+4HV 2w Exn 9461/15-08-12 AIMH8+8HV 2w Exn 9466/15-08-12 AOMH 8 Exn 9466/15-08-12 AOMH 8+4HV Exn 9466/15-08-12 AOMH 8+8HV Exn 9470/25-16-12 DIM16 Nam Exn 9470/25-16-12 DIM16+CF Nam Exn 9471/15-16-12 DIM16 24V Exn 9471/15-16-12 DIM16+CF 24V Exn

6 Support address

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