Description of

Interface for

IS1 field stations

EtherNet/IP interface description

Content:

EtherNet/IP interface description

The historical development of field bus technology at R. STAHL

In the year 1986 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 the input and output of signals in a potentially explosive atmosphere (Zone 1).
This bus system consists of a master station installed in the control room as the interface 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 a potentially explosive atmosphere but that 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 traffic 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 interface options for the VOS 200 were expanded again in 1997 and supplemented to include a PROFIBUS DP connection.

A further step in optimising this field bus technology was realised in 1999 with the development of the IS1 Remote I/O 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.

IS1 has been extended in further steps by adding new modules, functions and communication protocols.

The IS1 system was extended in 2008 by SIL2 SAIMH modules which are communicating via PROFIsafe protocol. IS1 is the first zone 1 RIO with PROFIsafe I/O modules worldwide.

In July 2009 the IS1 System was extended with a new Ethernet CPU 9141 using MODBUS TCP protocol as a first step.

The following section describes the system characteristics of the IS1 system when interfaced to an automation system via EtherNet/IP.

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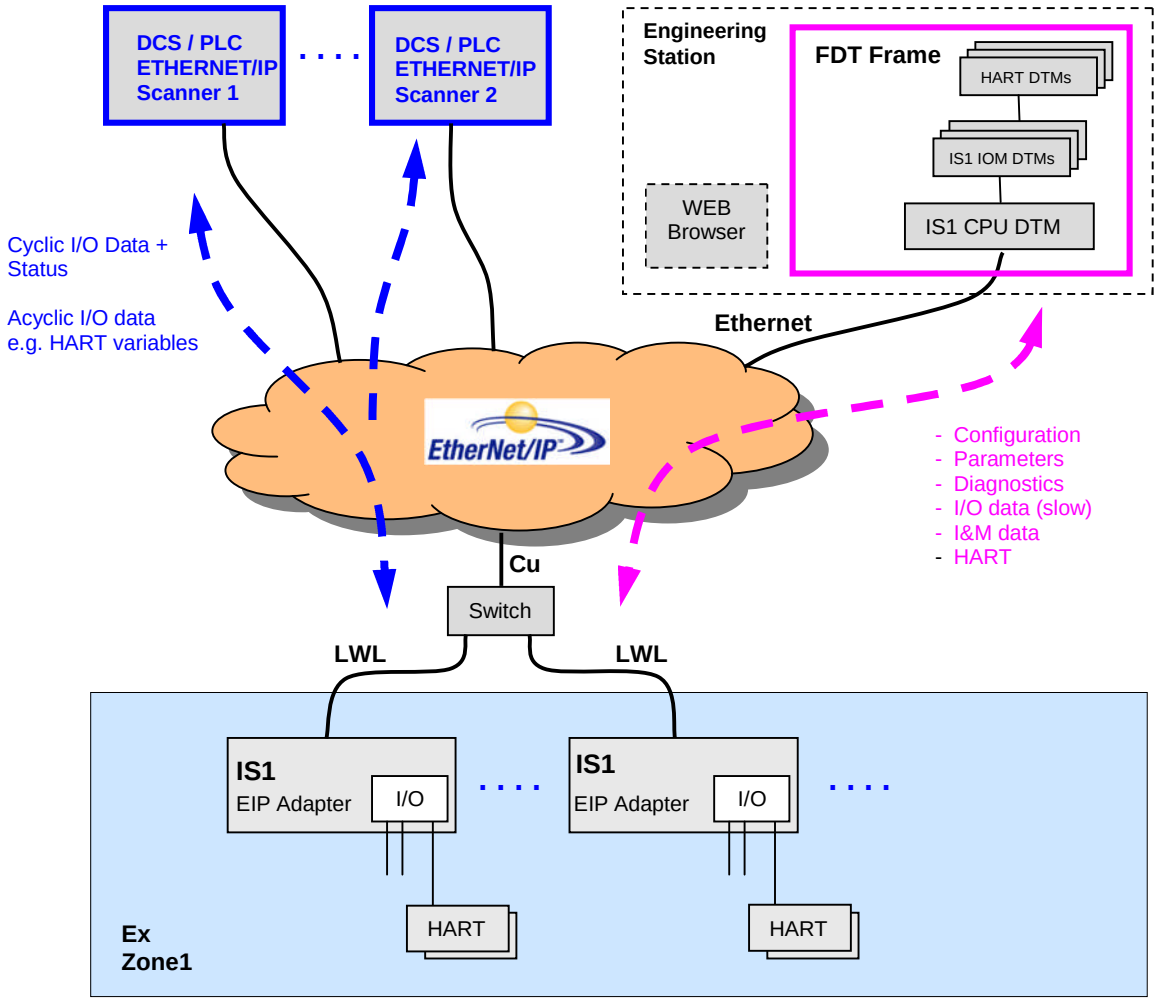
1 System overview



As an off-the-shelf explosion protected unit, the IS1 field station can be installed directly in the potentially explosive atmosphere (Zone 1 or Zone 2). It can also be installed in the safe area. The diagram above shows a Zone 1 solution.

The IS1 field station comes with an Ethernet fibre optic connection and operates as a EtherNet/IP adapter.

Configuration, parameter setting, diagnostics and HART communication for the IS1 field station and its I/O modules are carried out via IS1 DTMs interfaced using FDT technology.

A webserver is integrated in the IS1 CPUs which offers additional diagnostic functions for OEM service support.

2 Commissioning

2.1 Overview

Planning of the complete EtherNet/IP network:

- Which masters (EtherNet/IP Scanner) are in the network
- Which slaves (EtherNet/IP Adapter) are in the network
- Selection of network topology and network physics (switches, repeaters, glass fibre links ...)
- Unique allocation of the IP addresses.

Perform the commissioning:

- Mechanical installation of the IS1 field stations.
- Mechanical installation of the Ethernet switches
- Mechanical installation of all other bus users.

- Set up the bus connections.

- Set up the voltage supply of the IS1 field station.
- Set up the voltage supply of the switches and other network components

- Set up the IP addresses, Subnet Mask, Gateway…. on the IS1 Fieldstations.
- Set up the addresses of all other users.

- Install a FDT Frame and the IS1 DTMs on the PC.
- Configure the IS1 field stations with its I/O modules using the FDT software.

- Configuration of EtherNet/IP Scanner.
  Import EDS file (Electronic Data Sheet) in configuration software of EtherNet/IP Scanner and configure communication to IS1.

- Put the EtherNet/IP Scanner into operation. This results in the automatic start-up of the cyclic communication.

- Check Ethernet connection using:
  - LED´s on Ethernet Switches
  - Link LED´s of CPU on IS1 Fieldstation
  - „Ping“ command. Ping is responding in any IS1 CPU state.

- Check communication on the EtherNet/IP using the following tools:
  - Diagnostics information from the EtherNet/IP scanner or from the diagnostic tools for the scanner.
  - LEDs and text display on the CPU of the IS1 field station
  - Webserver in IS1 CPU

- Check I/O signals using the following tools:
  - Information from the EtherNet/IP scanner or its diagnostic tool.
  - Use of diagnostics functions for the IS1 DTMs.

2.2 System requirements

Hardware requirements:

- IS1 field station with CPU 9441/12-00-00
- single socket 9492/12-11-11 or redundant socket 9492/12-11-12

Software requirements:

- CPU firmware EtherNet/IP from revision V30-00
- I/O module firmware from revision 2.00 (support for the extended parameter set)
- IS1 DTMs from revision 3.0.1.0

2.3 Engineering limits

The general regulations according to the IS1 operating instructions apply to the engineering of an IS1 field station.

Possible limitations due to EtherNet/IP scanner:

- memory for I/O data in scanner and with this a limitation of the number of I/O modules and a maximum number of signals.
- maximum number of adapters in a network

Thus, the limits on the EtherNet/IP scanner used must also be taken into account during the engineering.

2.4 Addressing the IS1 field station

The following information is required to address an IS1 field station:

- IP address
- SubNet mask
- optional: Gateway (only necessary for communication via routers)

The addresses for an IS1 field station can be set via:

- Buttons and display on IS1 CPU.
- IS1 webserver
- BootP server (optional)

Attention! The IP addresses must be unique in the network (see ACD).

2.4.1 BOOTP (Bootstrap Protocol)

IS1 supports the setting of IP Address via BOOTP Protocol according RFC951.
The IS1 Fieldstation must be configured in a BOOTP server which must be present on the Ethernet network.
The IP-Address for the IS1 CPU must be allocated to its MAC-Address.

After power on the IS1 CPU checks the availability of a BOOTP server on the network and receives its IP address from this BOOTP server. The IP address is stored non volatile in the socket of the IS1 CPU.

If no BOOTP server is detected or the IS1 CPU is not configured in the BOOTP server then the IS1 CPU use the previous non volatile stored IP address.

2.4.2 Address Conflict Detection (ACD)

Double IP addresses in one Ethernet Network can lead to unforeseeable behavior. To detect and to handle such situations ACD according RFC5227 was defined. IS1 is supporting this feature.
Additionally the specification ´IPv4 Address Conflict Detection for EtherNet/IPDevices´ was considered.

Address conflict during startup:
After power on start up the IS1 CPU checks for other devices with the same IP address on the network.
In case of conflict the IS1 CPU stopps further standard communication on Ethernet and checks in the background if the conflict is still present.

Address conflict during operation:
Depending on the behavior of the conflict partner the IS1 CPU or the conflict partner can withdraw from communication on Ethernet network.

Behavior of IS1 CPU in case of own withdraw from communicastion

- Error LED(red) at IS1 CPU = On
- LCD Display: IP conflict stop
- Error Message in event memory of IS1 CPU
- PLC, IS1 Webserver and IS1 DTM: no connection to IS1 CPU

About 1 minute after removal of the IP address conflict through changes on the conflict partner the IS1 CPU will restart its own communication.

Behavior of IS1 CPU in case of withdraw from communicastion of the communication partner

- No error on Error LED and LCD Display
- IS1 CPU Web-Server: Error message on page ´Protocol´:
  Two messages toggle in a slow cycle (1 minute):
  - Address Conflict: IP address conflict, defending IP address!
  - Address Conflict: No adress conflict

  On each new detection of the address conflict the counter ´ Address Conflict detection count´ is incremented.

2.5 Configuration of EtherNet/IP Scanner

- Import IS1 EDS File (Electronic Data Sheet) to EtherNet/IP Scanner configuration tool.
- Select EtherNet/IP cyclic connection size according the highest slot number of used IS1 I/O module.
- Set EtherNet/IP scanner into cyclic operation.

Cyclic input- and output data of one IS1 fieldstation are grouped to one assembly each and allocated to connections with different size:

2.5.1 Cyclic I/O Data connections

Number IOM slots	Connections		Connection parameter						
			Input Instance	Input Size (T->O) [Byte]	Output Instance	Output Size (O->T) [Byte]	Config Instance	Config Size [Byte]	Connection Path
4	**Exclusive Owner *1)**	EO 4 IOM	141	**70**	131	**70**	107	0	20 04 24 6B 2C 83 2C 8D
8		EO 8 IOM	142	**134**	132	**134**	107	0	20 04 24 6B 2C 84 2C 8E
12		EO 12 IOM	143	**198**	133	**198**	107	0	20 04 24 6B 2C 85 2C 8F
16		EO 16 IOM	144	**262**	134	**262**	107	0	20 04 24 6B 2C 86 2C 90
4	**Input Only**	IO 4 IOM	141	70	108	0	107	0	20 04 24 6B 2C 6C 2C 8D
8		IO 8 IOM	142	134	108	0	107	0	20 04 24 6B 2C 6C 2C 8E
12		IO 12 IOM	143	198	108	0	107	0	20 04 24 6B 2C 6C 2C 8F
16		IO 16 IOM	144	262	108	0	107	0	20 04 24 6B 2C 6C 2C 90
4	**Listen Only**	LO 4 IOM	141	70	109	0	107	0	20 04 24 6B 2C 6D 2C 8D
8		LO 8 IOM	142	134	109	0	107	0	20 04 24 6B 2C 6D 2C 8E
12		LO 12 IOM	143	198	109	0	107	0	20 04 24 6B 2C 6D 2C 8F
16		LO 16 IOM	144	262	109	0	107	0	20 04 24 6B 2C 6D 2C 90

Online configuration change of IS1 I/O modules within the the limits of the selected assembly is possible.

Requirements for online configuration changes:
Changes of the assembly size and with this the size of the cyclic data can not be changed online.
Changes must be done offline by choosing a different assembly.
To allow online extensions of I/O modules of a IS1 fieldstation, the assemblies have to be choosen big enough through project planning phase. Spare for future extensions should be considered.

Attention!
1) Only one of the four possible exclusive owner connections (EO) is allowed at the same time because output signals of a IS1 fieldstation must come unique from one EIP scanner.
If a second EO connection is established while a first EO connection is active then the output data of the second connection are rejected and folowwing messages are generated:

Web Server: Message ´The output data will not be forwarded!´ on page ´Protocol´ in Extended CIP Status
Identity Objekt: Status = 0x0A ´Multiple EO connections!´

Max 8 IOM are allowed using Zone 1 CPU 9441/… and PS 9444/12-11!

2.6 System start-up behaviour

Configuration data and parameter data for CPU and all I/O modules are generated using the IS1 DTMs, transferred to the IS1 field station by 'download' and are stored in non-volatile memory in the socket for the IS1 CPU.

After power on the entire data range of the output register is initialised with the value 0x8000. All output signals therefore remain in the safe setting. The remaining data areas are initialised with 0x0000.

After power on the CPU checks that valid configuration data and parameter data are available.

Without valid data the CPU enters ´Config or parameter error´ state.
If valid data is available the CPU remains in the state ´No data exchange´ until as a scanner starts up cyclic communication.

The output signals remain in safe setting until valid output data is written by the AS or by the IS1 DTMs.

Possible CPU states:

Configuration data and parameter data	**Message on the display**	**CPU state after checking and booting**
Data valid and cyclic data exchange with EtherNet/IP scanner	Data Exchange	Data Exchange with Scanner (2) Config + Param. from DTM
No data available	No Data Exchange	No data exchange (3)
Data invalid (e.g. CRC error)	Config Error	Config or parameter error (4)
Data valid	Quit Data Exchange	Data exchange with AS quit (5)

IOM exchange and restart

Changing I/O modules during operation is possible. After plugging in a new module, parameters are automatically transferred from CPU to the I/O module, followed by a restart of the I/O module. -> Hot swap I/O module.

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

3 Data traffic

3.1 Data mapping

- For each I/O-module slot 16 byte Input- and 16 byte Output Data are reserved independent from I/O module type and configuration. -> Thus there is not shift of data in memory for the unchanged I/O modules in case of online configuration changes.
- I/O modules are allocated to the different slots of a IS1 fieldstation using FDT and the IS1 DTMs.
- Module data is mapped to the allocated areas acording the selected I/O module types. Not allocated areas remain empty but are cyclically exchanged by the EIP scanner.
- Differnt Assemblies with differnt size of cyclic data and with this the number of exchanged I/O module slots can be configured in EtherNet/IP scanner.

Example:

Slot	IOM Type
-	-
0-0 (CPU)	-
1	**AIM**
2	**DIM**
3	**AOM**
……	
Max. 16 (8)	**DOM**

Cyclic Data (Implicid Message)			
Byte No.		**Input Assembly**	**Output Assembly**
0	1	Module Status Slot 0 to 15	-
2	3	Module Status Slot 16	-
4	5	CPU Status	CPU Control Register
6	7	AI 0	-
8	9	AI 1	-
10	11	AI 2	-
12	13	AI 3	-
14	15	AI 4	-
16	17	AI 5	-
18	19	AI 6	-
20	21	AI 7	-
22	23	DI 0 – 15	Control Cmd
24	25	Signal Status 0 – 15	-
26	27	CF 14	-
28	29	CF 15	-
30	31	-	-
32	33	-	-
34	35	-	-
36	37	-	-
38	39	Signal Status 0 - 7	AO 0
40	41	-	AO 1
42	43	-	AO 2
44	45	-	AO 3
46	47	-	AO 4
48	49	-	AO 5
50	51	-	AO 6
52	53	-	AO 7
……	……	……	……
246	247	Signal Status 0 - 7	DO 0 – 7
248	249	-	-
250	251	-	-
252	253	-	-
254	255	-	-
256	257	-	-
258	259	-	-
260 (132)	261 (133)	-	-

3.2 Classes

The following classes are supported by the IS1 EtherNet/IP firmware:

3.2.1 CIP Common Classes

Klasse	Name
0x01	Identity
0x02	Message Router
0x04	Assembly
0x06	Connection Manager
0xF5	TCP/IP Interface Objekt
0xF6	Ethernet Link Objekt

3.2.2 Identity Object, Class 0x01

Class Attributes

Attribute ID	Access	Name	Data type	Description	Default
1	Get	Revision	UINT	Revision dieses Objektes	0x001
2		Max Instance	UINT	Maximale Instanz	0x001

Number of Instances: 1

Instance Attributes

Attribute ID	Access	Name	Data type	Description	Default
1	Get	VENDOR_ID	UINT	885 = „R. Stahl“ (defined by ODVA)	885
2		DEVICE_TYPE	UINT	12 = Communication Adapter	0x0c (12)
3		PRODUCT_CODE	UINT	Vendor specific	0x01
4		REVISION	Struct of USINT USINT	IS1 CPU Firmware Revision e.g. 31-02	
5		STATUS		Actual status of the device, see „Bit Definitions for Status Instance Attribute of Identity Object“ in CIP Object Library Extended Device Status - Vendor specific: Bit 4-7 = 0x0A => Multiple EO Connections with different output size in the O->T path. Only the data from the first established connection are processed internally. Which connection is active is shown by the web server.	-
6		SERIAL_NUMBER	UDINT	Serial number of IS1 CPU	-
7		PRODUCT_NAME	String 32	Product name	„IS1 RIO EtherNet/IP“

Class/Instance Services

Servicecode	Service supported		Service Name
	Class	Instance	
0x01	Yes	Yes	Get_Attribute_All
0x05	No	Yes	Reset
0x0E	Yes	Yes	Get_Attribute_Single

3.2.3 Message Router Object , Klasse 0x02

No external access to this object.

3.2.4 Assembly / Parameter Class 0x04

Class Attributes

Attribute ID	Name
1	Revision

Instance Attributes

Attribute ID	Name
3	Data

Class/Instance Services

Servicecode	Service supported		Service Name
	Class	Instance	
0x01	No	No	Get_Attribute_All
0x0E	No	Yes	Get_Attribute_Single
0x10	No	Yes	Set_Attribute_Single

Acyclic data, readable as assembly:

Instance	Access	Name	Description	ConnectionPath	Size [Byte]
101 *1)	Get	CpuStatus	See CPU status register	20 04 24 65 30 03	2
102 *1)		ModulStatus	1 Bit Status per module	20 04 24 66 30 03	4
103		SignalStatus	1 Bit Status per signal	20 04 24 67 30 03	32
110		HART LiveList	1 Bit Livelist per HART channel	20 04 24 6E 30 03	16
111		HV_IOM1	Max. 8 HART Variables per IOM	20 04 24 6F 30 03	32
112		HV_IOM2		20 04 24 70 30 03	32
113		HV_IOM3		20 04 24 71 30 03	32
114		HV_IOM4		20 04 24 72 30 03	32
115		HV_IOM5		20 04 24 73 30 03	32
116		HV_IOM6		20 04 24 74 30 03	32
117		HV_IOM7		20 04 24 75 30 03	32
118		HV_IOM8		20 04 24 76 30 03	32
119		HV_IOM9		20 04 24 77 30 03	32
120		HV_IOM10		20 04 24 78 30 03	32
121		HV_IOM11		20 04 24 79 30 03	32
122		HV_IOM12		20 04 24 7A 30 03	32
123		HV_IOM13		20 04 24 7B 30 03	32
124		HV_IOM14		20 04 24 7C 30 03	32
125		HV_IOM15		20 04 24 7D 30 03	32
126		HV_IOM16		20 04 24 7E 30 03	32

*1) In EDS based tools, acces to the instances 101 and 102 as parameter is aditionally supported.

Acyclic readable Assemblies:

Instance	Access	Name	Description	ConnectionPath	Size [Byte]
141	Get	Inputs 4IOM (T->O)	Read Input Data Same data structure as cyclic data.	20 04 24 8D 30 03	70
142		Inputs 8IOM (T->O)		20 04 24 8E 30 03	134
143		Inputs 12IOM (T->O)		20 04 24 8F 30 03	198
144		Inputs 16IOM (T->O)		20 04 24 90 30 03	262

3.2.5 Connection Manager Object, Class 0x06

Class Attributes

Attribute ID	Access	Name	Data type	Description	Default
1	Get	Revision	UINT	Revision of this Object	0x001
2		Max Instance	UINT	Maximum Instance	0x001

Number of Instances: 1

Instance Attributes

Attribute ID	Access	Name	Data type	Description	Default
1	Get	Open Requests	UINT	Number of Forward Open service requests received.	-
2		Open Format Rejects	UINT	Number of Forward Open service requests which were rejected due to bad format	-
3		Open Resource Rejects	UINT	Number of Forward Open service requests which were rejected due to lack of resources.	-
4		Open Other Rejects	UINT	Number of Forward Open service requests which were rejected for reasons other than bad format or lack of resources	-
5		Close Requests	UINT	Number of Forward Close service requests received.	-
6		Close Format Requests	UINT	Number of Forward Close service requests which were rejected due to bad format.	-
7		Close Other Requests	UINT	Number of Forward Close service requests which were rejected for reasons other than bad format.	-
8		Connection Timeouts	UINT	Total number of connection timeouts that have occurred in connections controlled by this Connection Manager	-
9		Connection Entry List NumConnEntries ConnOpenBits	See „Connection Manager Object Instance Attributes“ in Vol. 1: Common Industrial Protocol Specification		-
10	Reserved				
11	Get	CPU_Utilization	UINT	CPU Utilization in tenths of a percent.	-
12		MaxBuffSize	UDINT	Amount of buffer space originally available.	-
13		BufSize Remaining	UDINT	Amount of buffer space available at this time.	-

Class/Instance Services

Servicecode	Service supported		Service Name	Description
	Class	Instance		
0x01	Yes	Yes	Get_Attribute_All	
0x0E	Yes	Yes	Get_Attribute_Single	
0x4E	No	Yes	Forward_Close	
0x52	No	Yes	Unconnected_Send	
0x54	No	Yes	Forward_Open	

3.2.6 TCP/IP Interface Object / Instance, Class 0xF5

See Chapter 5 of Volume 2, EtherNet/IP Adaptation of CIP

Class Attributes

Attribute ID	Access	Name	Data type	Description	Default
1	Get	Revision	UINT	Revision of this object	0x001
2	Get	Max Instance	UINT	Maximum Instance	0x001

Number of Instances: 1

Instance Attributes

Attribute ID	Access	Name	Data type	Description	Default
1	Get	Status	DWORD	Interface status	-
2	Get	Configuration Capability	DWORD	Interface capability flags	-
3	Get / Set	Configuration Control	DWORD	Interface control flags	-
4	Get	Physical Link	STRUCT	Path to physical link object	-
5	Get / Set	Interface Configuration	STRUCT	TCP/IP network interface configuration.	-
6	Get / Set	Host Name	STRING	Host Name	-

Class/Instance Services

Servicecode	Service supported		Service Name
	Class	Instance	
0x01	Yes	Yes	Get_Attribute_All
0x0E	Yes	Yes	Get_Attribute_Single
0x10	No	Yes	Set_Attribute_Single

3.2.7 Ethernet Link Object / Instance , Class 0xF6

See Chapter 5 of Volume 2, EtherNet/IP Adaptation of CIP

Class Attributes

Attribute ID	Access	Name	Data type	Description	Default
1	Get	Revision	UINT	Revision of this object	0x001
2	Get	Max Instance	UINT	Maximum Instance	0x001
3	Get	Number of In-stances	UINT	Number of object instances current-ly created at this class level of the device	0x001

Number of Instances: 1

Instance Attributes

Attribute ID	Access	Name	Data type	Description	Default
1	Get	Interface Speed	UDINT	Interface speed currently in use	-
2	Get	Interface Flags	DWORD	Interface status flags	-
3	Get	Physical Address	ARRAY of 6 USINTs	MAC layer address	-
4	Get	Interface Counters	STRUCT	Interface Counters	-
5	Get	Media Counters	STRUCT	Media Counters	-
6	Get/Set	InterfaceControl	STRUCT	Media-specific counters	-
7	Get	InterfaceType	USINT	Type of interface: twisted pair, fiber, internal, etc	-
8	Get	InterfaceState	USINT	Current state of the interface: operational, disabled, etc	-
9	Get/Set	AdminState	USINT	Administrative state: enable, disable	-
10	Get	InterfaceLabel	SHORT_STRING	Human readable identification	-

Class/Instance Services

Servicecode	Service supported		Service Name
	Class	Instance	
0x01	Yes	Yes	Get_Attribute_All
0x0E	No	Yes	Get_Attribute_Single
0x10	No	Yes	Set_Attribute_Single
0x4C	No	Yes	Get_and_Clear

3.3 Data Formats

3.3.1 I/O Assembly Data Attribute Format

General rule for the posion of IOM data inside the communicated data block:

Address of first byte [Byte] = IOM Slot * 16 + Byte Offset – 10

3.3.1.1 Digital Input Module - DIM

Input Data:

Function	Byte Offset	Signal								Data Type
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Input Signals	0	Discrete Input 7	Discrete Input 6	Discrete Input 5	Discrete Input 4	Discrete Input 3	Discrete Input 2	Discrete Input 1	Discrete Input 0	Bit
	1	Discrete Input 15	Discrete Input 14	Discrete Input 13	Discrete Input 12	Discrete Input 11	Discrete Input 10	Discrete Input 9	Discrete Input 8	
Signal Status	2	Status I 7	Status I 6	Status I 5	Status I 4	Status I 3	Status I 2	Status I 1	Status I 0	
	3	Status I 15	Status I 14	Status I 13	Status I 12	Status I 11	Status I 10	Status I 9	Status I 8	
Counter Frequency:	4 – 5	Counter Frequency Eingang 14								UINT16 (C7)
	6 – 7	Counter Frequency Eingang 15								
Reserved	8 - 15	-								-

Output Data:

Function	Byte Offset	Signal								Data Type
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Steuer-register	0	-	-	-	-	Start/Stop (Eing. 15)	Start/Stop (Eing. 14)	Reset (Eing.15)	Reset (Eing.14)	Bit
Reserved	1 - 15	-								-

3.3.1.2 Digital Output Module - DOM

Input Data:

Function	Byte Offset	Signal								Data Type
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Signal Status	0	Discrete Output Status 7	Discrete Output Status 6	Discrete Output Status 5	Discrete Output Status 4	Discrete Output Status 3	Discrete Output Status 2	Discrete Output Status 1	Discrete Output Status 0	Bit
Reserved	1 - 15	-								-

Output Data:

Function	Byte Offset	Signal								Data Type
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Output Signale	0	Discrete Output 7	Discrete Output 6	Discrete Output 5	Discrete Output 4	Discrete Output 3	Discrete Output 2	Discrete Output 1	Discrete Output 0	Bit
Reserved	1 - 15	-								-

3.3.1.3 Analog Input Module - AIM

Input Data:

Function	Byte Offset	Signal	Data Type
Analog Input Signals	0 - 1	AI 0	INT16 (C3)
	2 - 3	AI 1	
	4 - 5	AI 2	
	6 – 7	AI 3	
	8 – 9	AI 4	
	10 – 11	AI 5	
	12 – 13	AI 6	
	14 – 15	AI 7	

Signal Status Information is available as Alarm Code within the Integer values and as seperate signal status bit (see Analog input modules)

Output Data:

Function	Byte Offset	Signal	Data Type
Reserved	0 - 15	-	-

3.3.1.4 Analog Output Module - AOM

Input Data:

Function	Byte Offset	Signal								Data Type
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Signal Status	0	Analog Output Status 7	Analog Output Status 6	Analog Output Status 5	Analog Output Status 4	Analog Output Status 3	Analog Output Status 2	Analog Output Status 1	Analog Output Status 0	Bit
Reserved	1 - 15	-								-

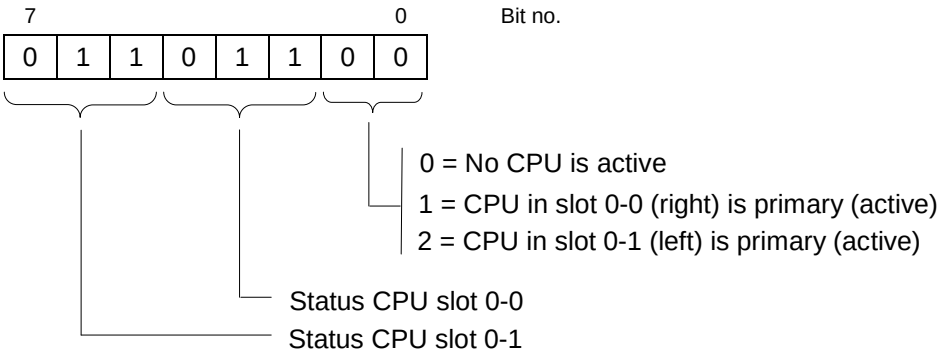
Output Data:

Function	Byte Offset	Signal	Data Type
Analog Output Signals	0 - 1	AO 0	INT16 (C3)
	2 - 3	AO 1	
	4 - 5	AO 2	
	6 – 7	AO 3	
	8 – 9	AO 4	
	10 – 11	AO 5	
	12 – 13	AO 6	
	14 – 15	AO 7	

3.3.2 CPU Status

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

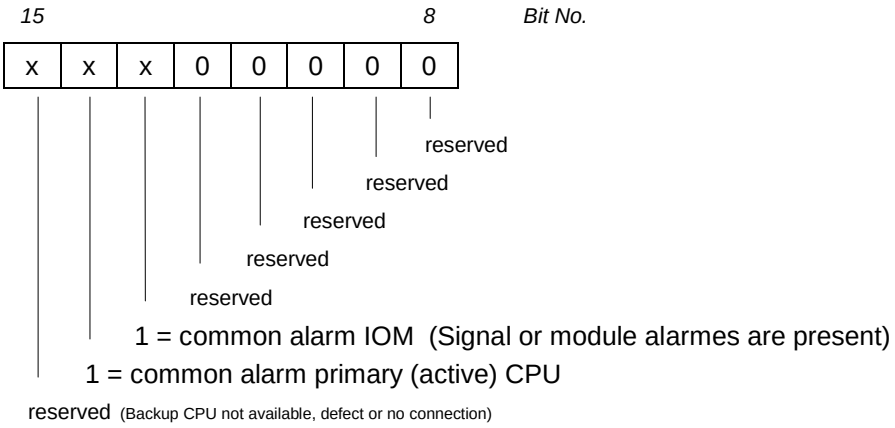
Low Byte (Byte 4):



Status CPU:

value 1 (000)	Reserved
value 1 (001)	Hardware error CPU
value 2 (010)	**Data exchange with AS (config + parameters from IS1 DTM)**
value 3 (011)	No data exchange (after power on without config- and parameter data)
value 4 (100)	Configuration- or parameter failure
value 5 (101)	Data exchange with AS quit (as well after PowerOn, if config- and parameter data are valid)
value 6 (110)	Reserved
value 7 (111)	Reserved (red. CPU not available)

High Byte (Byte 5) :



The CPU Status is also shown on the CPU display.

3.3.3 Control register

reserved

3.3.4 Module Status

In the bytes 0 to 3 module status information can be read. These registers contain one bit per I/O module with the following allocation:

Status bit = 0 -> At least one signal alarm (short circuit, open circuit....) or a module alarm is present.

Status bit = 1 -> No alarms in module. All inputs or outputs on the module are without errors.

Signal Diagnoses:

- Short circuit
- Line break
- .....

Module Diagnoses:

- IOM module not responding
- Wrong module
- Prim/Red. rail connection disturbed

With these status bits, alarm messages can be generated in the automation system. For input signals additional status information is available in the cyclic data area (see chapter Signal behaviour in case of errors). Details of the alarms can be displayed via the IS1 DTMs.

Function	Byte Offset	Signal								Data Type
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Modul Status IOM	0	Status Slot 7	Status Slot 6	Status Slot 5	Status Slot 4	Status Slot 3	Status Slot 2	Status Slot 1	Status Slot 0	Bit
	1	Status Slot 15	Status Slot 14	Status Slot 13	Status Slot 12	Status Slot 11	Status Slot 10	Status Slot 9	Status Slot 8	
	2	X	x	x	x	x	x	x	Status Slot 16	
	3	x	x	x	x	x	x	x	X	

x: Register = 1 (Reserviert)

3.3.5 Signal Status:

Function	Byte Offset	Signal								Data Type
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Signal status Slot 1	0	Status S 7	Status S 6	Status S 5	Status S 4	Status S 3	Status S 2	Status S 1	Status S 0	Bit
	1	Status S 15	Status S 14	Status S 13	Status S 12	Status S 11	Status S 10	Status S 9	Status S 8	
Signal status Slot …	…	.	.	.	.	.	.	.	.	
	…	.	.	.	.	.	.	.	.	
Signal status Slot 16	30	Status S 7	Status S 6	Status S 5	Status S 4	Status S 3	Status S 2	Status S 1	Status S 0	
	31	Status S 15	Status S 14	Status S 13	Status S 12	Status S 11	Status S 10	Status S 9	Status S 8	

One status bit is provided per signal with the following allocation:

Status bit = 0 -> Signal malfunction (short circuit, open circuit, module error....)

Status bit = 1 -> No signal malfunction or signal not available. No signal or module alarms present.

Details of the alarms can be displayed via the IS1 DTMs.

3.3.6 HART Livelist

Function	Byte Offset	Signal								Data Type
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
HLL Slot 1	0	LL Channel 7	LL Channel 6	LL Channel 5	LL Channel 4	LL Channel 3	LL Channel 2	LL Channel 1	LL Channel 0	Bit
HLL Slot . . .	…	…	…	…	…	…	…	…	…	
HLL Slot 16	15	LL Channel 7	LL Channel 6	LL Channel 5	LL Channel 4	LL Channel 3	LL Channel 2	LL Channel 1	LL Channel 0	

LL: HART device is available on channel: 0= No, 1=Yes

Livelist Info is updated only if activated via Parameter ´Scan HART Livelist´ = On

3.3.7 HART Variables

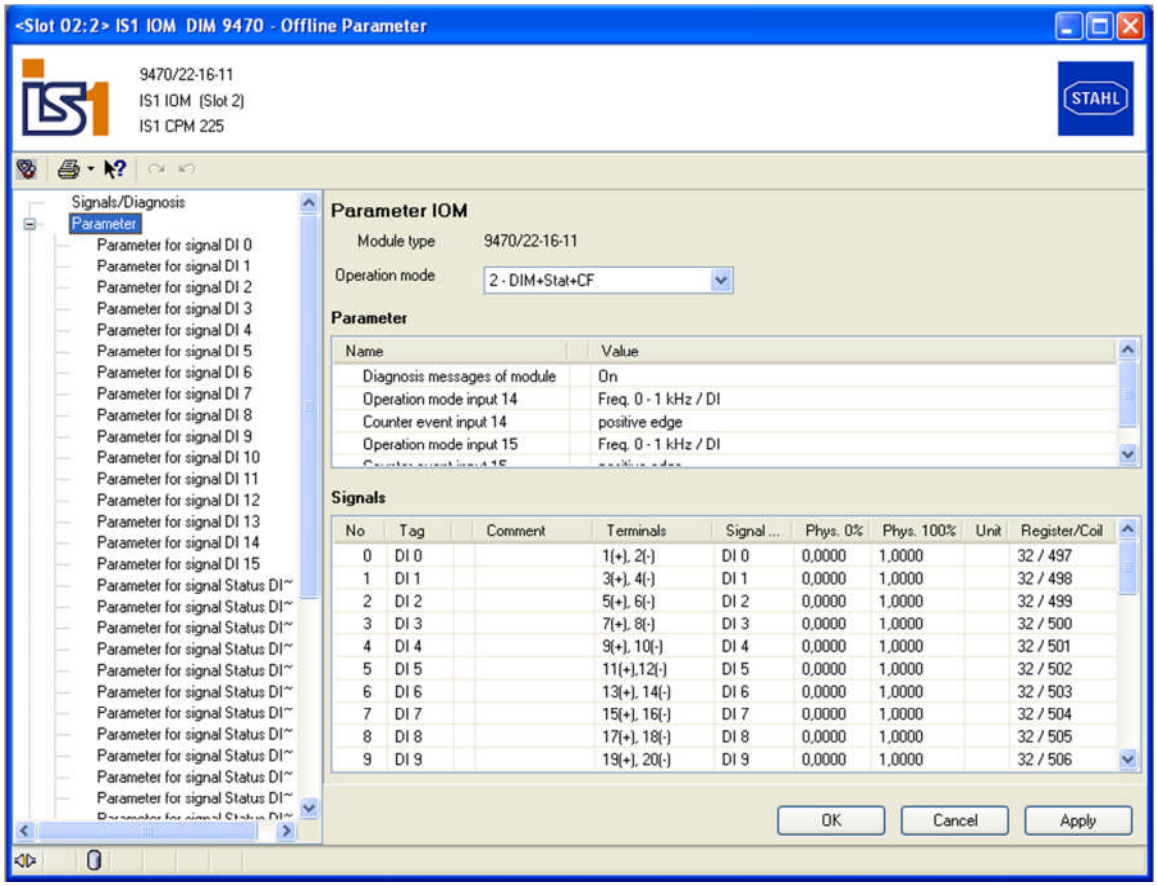
One assembly with 8 HART variables is available for each IOM slot. HART variables (HV) from HART devices connected to IS1 HART modules are seleceted via parameters and are transmitted on the positions 1 to 8 within the assembly.

Function	Byte Offset	Signal	Data Type
HART variables	0 – 3	HV Pos 1	Float
	4 – 7	HV Pos 2	
	8 – 11	HV Pos 3	
	12 – 15	HV Pos 4	
	16 – 19	HV Pos 5	
	20 – 23	HV Pos 6	
	24 – 27	HV Pos 7	
	28 – 31	HV Pos 8	

3.4 Setting parameters for the IS1 field station and the I/O modules

Configuration, parameter setting, diagnostics and HART communication for the IS1 field stations is handled via the IS1 DTMs using FDT technology.

Example:



For further information on the use of the IS1 DTMs see operating instructions ´DTM IS1´.

3.5 Extended parameter set for IS1

3.5.1 CPU parameters

Parameter name	Parameter value (bold = default)
Timeout for output modules T_{Mod} (x 100 ms)	Unsigned8 (1 - 255) **Default: 1**

3.5.2 I/O module parameters

3.5.2.1 AIM / AIMH

Parameter	Default value	Value range / selection
Diagnostic messages of the module	On	Off ***On***
Input filter	Medium	Small ***Medium*** Big (50 Hz) Big (60 Hz)
Signal in case of error I 0	Alarm code	-10 % (4 mA only) 0 % 100 % ***Alarm code*** Freeze (initial value 0%) Freeze (initial value 100%)
Signal in case of error I 1	Alarm code	
Signal in case of error I 2	Alarm code	
Signal in case of error I 3	Alarm code	
Signal in case of error I 4	Alarm code	
Signal in case of error I 5	Alarm code	
Signal in case of error I 6	Alarm code	
Signal in case of error I 7	Alarm code	
Error detection I 0	On	Off ***On***
Error detection I 1	On	
Error detection I 2	On	
Error detection I 3	On	
Error detection I 4	On	
Error detection I 5	On	
Error detection I 6	On	
Error detection I 7	On	
Input range I 0	4…20 mA	0…20 mA ***4…20 mA***
Input range I 1	4…20 mA	
Input range I 2	4…20 mA	
Input range I 3	4…20 mA	
Input range I 4	4…20 mA	
Input range I 5	4…20 mA	
Input range I 6	4…20 mA	
Input range I 7	4…20 mA	
Measurem. range ac. NAMUR I 0	No	***No*** Yes
Measurem. range ac. NAMUR I 1	No	
Measurem. range ac. NAMUR I 2	No	
Measurem. range ac. NAMUR I 3	No	
Measurem. range ac. NAMUR I 4	No	
Measurem. range ac. NAMUR I 5	No	
Measurem. range ac. NAMUR I 6	No	
Measurem. range ac. NAMUR I 7	No	
Scan HART livelist	On	Off ***On***
Input No. HART device for pos. 1	Not used	0…7 ***´Not used´***
Input No. HART device for pos. 2	Not used	
Input No. HART device for pos. 3	Not used	
Input No. HART device for pos. 4	Not used	
Input No. HART device for pos. 5	Not used	
Input No. HART device for pos. 6	Not used	
Input No. HART device for pos. 7	Not used	
Input No. HART device for pos. 8	Not used	
No. HART variable for pos. 1	HART variable No. 2	HART variable No. 1 ***HART variable No. 2*** HART variable No. 3 HART variable No. 4
No. HART variable for pos. 2	HART variable No. 2	
No. HART variable for pos. 3	HART variable No. 2	
No. HART variable for pos. 4	HART variable No. 2	
No. HART variable for pos. 5	HART variable No. 2	
No. HART variable for pos. 6	HART variable No. 2	
No. HART variable for pos. 7	HART variable No. 2	
No. HART variable for pos. 8	HART variable No. 2	

Default values in ***´bold´***

Available only on HART modules (AIMH) !

3.5.2.2 TIMR

Parameter	Default value	Value range / selection
Diagnostic messages of the module	On	Off ***On***
Input filter	50 Hz	***50 Hz*** 60 Hz Off (not recommended)
Operation mode	8 inputs	***8 inputs*** 2 inputs
Signal in case of error I 0	Alarm code	***Alarm code*** Freeze (initialisation value 0%)
Signal in case of error I 1	Alarm code	
Signal in case of error I 2	Alarm code	
Signal in case of error I 3	Alarm code	
Signal in case of error I 4	Alarm code	
Signal in case of error I 5	Alarm code	
Signal in case of error I 6	Alarm code	
Signal in case of error I 7	Alarm code	
Error detection I 0	On	Off ***On***
Error detection I 1	On	
Error detection I 2	On	
Error detection I 3	On	
Error detection I 4	On	
Error detection I 5	On	
Error detection I 6	On	
Error detection I 7	On	
Type I 0	Pt 100	***Pt100*** Pt500 Pt1000 Ni100 Ni500 Ni1000 Resistance 10k Resistance 5k Resistance 2k5 Resistance 500R Pt100 GOST M50 GOST } from Fw. V02-04 M100 GOST Cu53 GOST Pt46 GOST } from Fw. V02-05 Pt50 GOST
Type I 1	Pt 100	
Type I 2	Pt 100	
Type I 3	Pt 100	
Type I 4	Pt 100	
Type I 5	Pt 100	
Type I 6	Pt 100	
Type I 7	Pt 100	
Connection I 0	4 wire	2 wire 3 wire ***4 wire***
Connection I 1	4 wire	
Connection I 2	4 wire	
Connection I 3	4 wire	
Connection I 4	4 wire	
Connection I 5	4 wire	
Connection I 6	4 wire	
Connection I 7	4 wire	

3.5.2.3 TIM mV

Parameter	Default value	Value range / selection
Diagnostic messages of the module	On	Off ***On***
Input filter	50 Hz	***50 Hz*** 60 Hz
Signal in case of error I 0	Alarm code	***Alarm code*** Freeze (initialisation value 0%)
Signal in case of error I 1	Alarm code	
Signal in case of error I 2	Alarm code	
Signal in case of error I 3	Alarm code	
Signal in case of error I 4	Alarm code	
Signal in case of error I 5	Alarm code	
Signal in case of error I 6	Alarm code	
Signal in case of error I 7	Alarm code	
Error detection I 0	On	Off ***On***
Error detection I 1	On	
Error detection I 2	On	
Error detection I 3	On	
Error detection I 4	On	
Error detection I 5	On	
Error detection I 6	On	
Error detection I 7	On	
Type I 0	THC Type K	0…100 mV THC Type B THC Type E THC Type J ***THC Type K*** THC Type N THC Type R THC Type S THC Type T THC Type L THC Type U THC Type XK (L)
Type I 1	THC Type K	
Type I 2	THC Type K	
Type I 3	THC Type K	
Type I 4	THC Type K	
Type I 5	THC Type K	
Type I 6	THC Type K	
Type I 7	THC Type K	
Input signal I 0	Balanced	***Balanced*** Unbalanced
Input signal I 1	Balanced	
Input signal I 2	Balanced	
Input signal I 3	Balanced	
Input signal I 4	Balanced	
Input signal I 5	Balanced	
Input signal I 6	Balanced	
Input signal I 7	Balanced	

3.5.2.4 DIM

Parameter	Default value	Value range / selection
Diagnostic messages of the module	On	Off ***On***
Signal in case of error I 0	0	***0*** 1 Freeze (initial value 0) Freeze (initial value 1)
Signal in case of error I 1	0	
Signal in case of error I 2	0	
Signal in case of error I 3	0	
Signal in case of error I 4	0	
Signal in case of error I 5	0	
Signal in case of error I 6	0	
Signal in case of error I 7	0	
Signal in case of error I 8	0	
Signal in case of error I 9	0	
Signal in case of error I 10	0	
Signal in case of error I 11	0	
Signal in case of error I 12	0	
Signal in case of error I 13	0	
Signal in case of error I 14	0	
Signal in case of error I 15	0	
Error detection I 0	On	Off ***On***
Error detection I 1	On	
Error detection I 2	On	
Error detection I 3	On	
Error detection I 4	On	
Error detection I 5	On	
Error detection I 6	On	
Error detection I 7	On	
Error detection I 8	On	
Error detection I 9	On	
Error detection I 10	On	
Error detection I 11	On	
Error detection I 12	On	
Error detection I 13	On	
Error detection I 14	On	
Error detection I 15	On	
Invert I 0	No	***No*** Yes
Invert I 1	No	
Invert I 2	No	
Invert I 3	No	
Invert I 4	No	
Invert I 5	No	
Invert I 6	No	
Invert I 7	No	
Invert I 8	No	
Invert I 9	No	
Invert I 10	No	
Invert I 11	No	
Invert I 12	No	
Invert I 13	No	
Invert I 14	No	
Invert I 15	No	

Parameters not present on DIM 24 V ! (9471/...)

Pulse extension I 0	0 Sec.	
Pulse extension I 1	0 Sec.	
Pulse extension I 2	0 Sec.	
Pulse extension I 3	0 Sec.	
Pulse extension I 4	0 Sec.	
Pulse extension I 5	0 Sec.	
Pulse extension I 6	0 Sec.	***0 s***
Pulse extension I 7	0 Sec.	0.6 s
Pulse extension I 8	0 Sec.	1.2 s
Pulse extension I 9	0 Sec.	2.4 s
Pulse extension I 10	0 Sec.	
Pulse extension I 11	0 Sec.	
Pulse extension I 12	0 Sec.	
Pulse extension I 13	0 Sec.	
Pulse extension I 14	0 Sec.	
Pulse extension II 15	0 Sec.	
Operation mode I 14	Freq. 0-1 kHz / DI	Counter ***Freq. 0-1 kHz / DI*** Freq. 0-20 kHz gate 50 ms / DI Freq. 0-20 kHz gate 200 ms / DI Freq. 0-20 kHz gate 1 s / DI
Counter event I 14	Positive edge	***Positive edge*** Negative edge
Operation mode I 15	Freq. 0-1 kHz / DI	s. a.
Counter event I 15	Positive edge	s. a.

Parameters available only in the case of operating mode DIM16 + CF!

3.5.2.5 AOM / AOMH

Parameter	Default value	Value range / selection	
Diagnostic messages of the module	On	Off ***On***	
Signal in case of error O 0	0 %	-10 % (4 mA only) ***0 %*** 100 % 110 % Freeze	
Signal in case of error O 1	0 %		
Signal in case of error O 2	0 %		
Signal in case of error O 3	0 %		
Signal in case of error O 4	0 %		
Signal in case of error O 5	0 %		
Signal in case of error O 6	0 %		
Signal in case of error O 7	0 %		
Error detection O 0	On	Off ***On***	
Error detection O 1	On		
Error detection O 2	On		
Error detection O 3	On		
Error detection O 4	On		
Error detection O 5	On		
Error detection O 6	On		
Error detection O 7	On		
Output range O 0	4…20 mA	0…20 mA ***4…20 mA***	
Output range O 1	4…20 mA		
Output range O 2	4…20 mA		
Output range O 3	4…20 mA		
Output range O 4	4…20 mA		
Output range O 5	4…20 mA		
Output range O 6	4…20 mA		
Output range O 7	4…20 mA		
Scan HART livelist	On	Off ***On***	Available only on HART modules (AOMH) !
Output No. HART device for pos. 1	Not used	0…7 ***Not used***	
Output No. HART device for pos. 2	Not used		
Output No. HART device for pos. 3	Not used		
Output No. HART device for pos. 4	Not used		
Output No. HART device for pos. 5	Not used		
Output No. HART device for pos. 6	Not used		
Output No. HART device for pos. 7	Not used		
Output No. HART device for pos. 8	Not used		
No. HART variable for pos. 1	HART variable No. 2	HART variable No. 1 ***HART variable No. 2*** HART variable No. 3 HART variable No. 4	
No. HART variable for pos. 2	HART variable No. 2		
No. HART variable for pos. 3	HART variable No. 2		
No. HART variable for pos. 4	HART variable No. 2		
No. HART variable for pos. 5	HART variable No. 2		
No. HART variable for pos. 6	HART variable No. 2		
No. HART variable for pos. 7	HART variable No. 2		
No. HART variable for pos. 8	HART variable No. 2		

3.5.2.6 DOM

Parameter	Default value	Value range / selection	Parameter available		
			DOM	DOMR	DOMV
Diagnostic messages of the module	On	Off ***On***	✓	✓	✓
Signal in case of error O 0	0	***0*** 1 Freeze	✓	✓	✓
Signal in case of error O 1	0				
Signal in case of error O 2	0				
Signal in case of error O 3	0				
Signal in case of error O 4	0				
Signal in case of error O 5	0				
Signal in case of error O 6	0				
Signal in case of error O 7	0				
Error detection O 0	On	Off On without test current ***On***	✓	-	-
Error detection O 1	On				
Error detection O 2	On				
Error detection O 3	On				
Error detection O 4	On				
Error detection O 5	On				
Error detection O 6	On				
Error detection O 7	On				
Output 0 and 1 parallel	Outputs separate	***Outputs separate*** Outputs parallel	✓	✓	-
Output 2 and 3 parallel	Outputs separate				
Output 4 and 5 parallel	Outputs separate				
Output 6 and 7 parallel	Outputs separate				

3.6 Data word structure of the I/O modules

3.6.1 Analog input modules

Analogue signals are exchanged between the IS1 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 / Diagnostics
	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 / Diagnostics
	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 behaviour set in the parameters if an error occurs:**

Behaviour set in the parameters if an error occurs	Type of error	Value transmitted if an error occurs	
Freeze	All I/O module errors	Last valid value	
-10%	All I/O module errors	-2765	F533
0%	All I/O module errors	0	0
100%	All I/O module errors	27648	6C00
Alarm code General rule to generate status information in AS for all AI signals: Signal has malfunction if value >= 32512 or value<= -32512 see 3.10.1 Behaviour of the input signals in case of errors	Short circuit	32767	7FFF
	Open circuit	-32762	8006
	I/O module does not respond	-32736	8020
	Config. unequal from module	-32735	8021
	Data not available	-32734	8022

EtherNet/IP interface description

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

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

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

*2) The limits of the measurement range depend on the input type set in the parameters (see Operating instructions IS1)

2 wire and 4 wire resistance measurement 500 R .... 10K (module 9480 / ....)

Range				Units		%	Range	Alarms / Diagnostics
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 (module 9480/..)

Range				Units		%	Range	Alarms / Diagnostics
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 / Diagnostics
>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 cannot be detected during resistance and voltage measurement !

***1) Transmitted value depends on behaviour set in parameters if an error occurs:**

Behaviour set in parameters if an error occurs	Type of error	Value transmitted if an error occurs	
freeze	All I/O module errors	Last valid value	
Alarm code General rule to generate status information in AS for all AI signals: Signal has a malfunction if value >= 32512 or value<= -32512 see 3.10.1 Behaviour of the input signals in case of errors	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
	I/O module does not respond	-32736	8020
	Config. unequal from module	-32735	8021
	Data not available	-32734	8022
	I/O module hardware error	-32733	8023

*1) Depending on the direction of signal change, for the respective error type a positive or negative alarm-code 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 load resistance, the maximum output voltage of the AOM may be reached, as a result the current can no longer be increased.

Safe setting after power on:
After CPU power on the data area for the outputs is initialised with the value -32768 (0x8000) as the code for the safe setting.
The outputs remain in the safe setting until the allocated data area is overwritten with a valid output value (<> -32768 (0x8000)) by AS or by the IS1 DTMs.

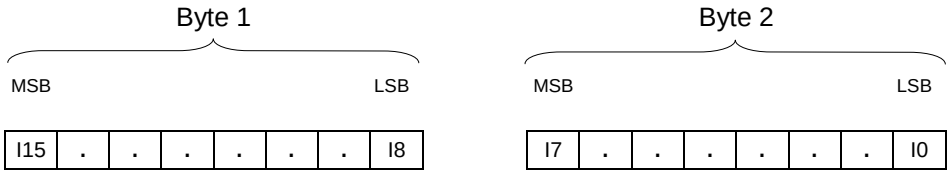
3.6.2 DIM, DIM+CF (9470/.. 9471/..)

On the modules 9470 und 9471 the inputs 14 und 15 can optionally be used as a digital input (DI), counter input (C) or frequency input (F).
The operating mode for the DIM can be selected in the IS1 DTMs.

Operating mode selection	**Input data**	**Output data**	**Available signal types for inputs 14 and 15**
DIM 16 (9470/.. , 9471/..)	2 bytes (16 bit DI)	-	Only DI (without status)
9470 /. . -16-1. **DIM 16** ..... 9471 /. . -16-1. **DIM 16**	4 bytes (16 bit DI + 16 bit status)	-	Only DI (with status)
9470 /. . -16-1. **DIM 16+CF** ..... 9471 /. . -16-1. **DIM 16+CF**	8 bytes (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 and 15 are updated in the DI data area and can therefore also be used as DI signals in this operating mode.

Data word structure DI (inputs I0 to I15)



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

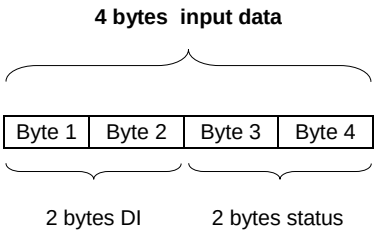
Module	Open circuit alarm	Signal = 0	Signal = 1	Short circuit alarm
9470/ ...	I < 0,05 mA	I < 1,2 mA	I > 2,1 mA	R_L < 100 Ohm
9471/ ...	-	U < 5 V	U > 13 V	-

Data word structure status (status bits S0 to S15)

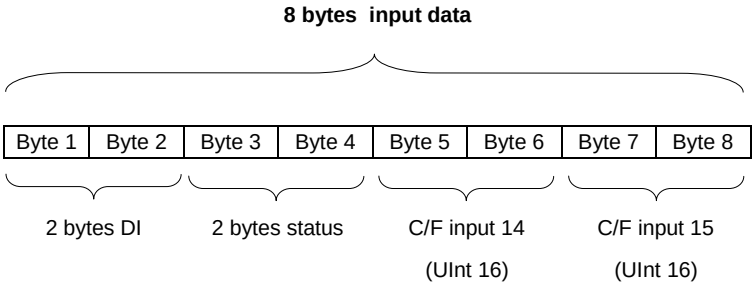
Status bit = 1: Signal OK
Status bit = 0: Signal malfunction

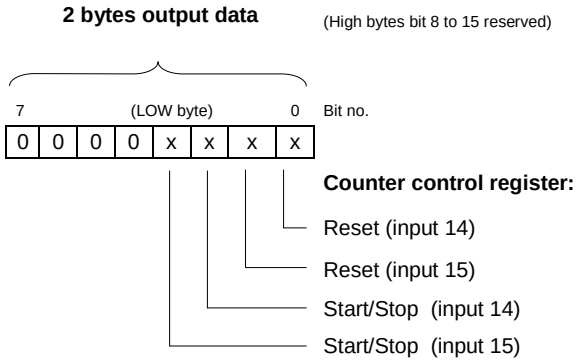
Signal and status are transmitted synchronously and consistently!

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

Operating 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)

Status in operating mode ´counter´:

The status is initialised with ´0´ = signal malfunction.
Using the Reset bit in the control register, the counter register is set to ´0´ and the status is set to ´1´= signal OK.
In case of errors (short circuit, open circuit) the status is set to ´0´ and will be held at ´0´ until the next reset. Therefore malfunctions during the count procedure are recognisable via the status.

Operating mode ´Frequency´

Selection operation mode:	Measurement method	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

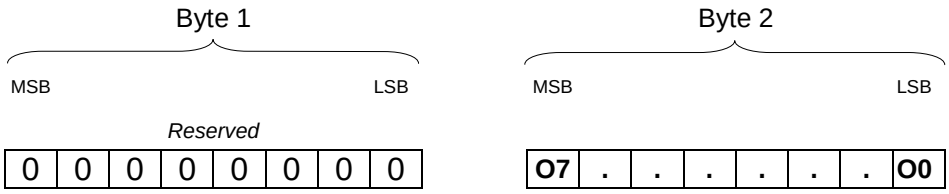
Behaviour in case of excessively high frequencies:

If the input frequency is higher than the maximum over-range value allowed, input pulses can no longer be detected. Pulses are lost during the evaluation and as a result the measured value is smaller than the frequency actually present at the input. No alarm is generated.

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

Data word structure DO (Outputs O0 to O7)

DOM 8 channels:



All DO data are in the low byte of the register. The high byte is reserved.

DOM 4:

The bits 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	Type
output high impedance (actuator = Off)	output is powered according type specification (actuator = On)	DOM
relay contact = open	relay contact = closed	DOMR
Valve closed	Valve open	DOMV

3.7 Signal behaviour in case of errors

3.7.1 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 subassembly...), an item of diagnostics information is created which can be read via the IS1 DTMs. Despite the outstanding malfunction, data continues to be transmitted to the AS.

The behaviour of the signal values transmitted if a malfunction has occurred can be selected separately for every module by setting parameters (see I/O module parameters).

Application hint:

If the behaviour of input signals in case of errors is realised through the IS1 system, this behaviour seen from the application software in the automation system can only be guaranteed with correct communication on EtherNet/IP.

In the event of the failure of the EtherNet/IP comunication additional project specific reactions must be realised in the application software.

To guarantee the same behaviour of all input signals in the event of an error, we recommend the following procedure:

Generate a status bit for each input signal in the automation system:

- for DI signals the status bits available optionally from IS1 are used in the input data area.
- for AI signals the ´Alarm code´ behaviour parameter are set in the IS1. In the application software the following function must be used:

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

The signal behaviour in case of an error (freeze, substitute value ...) can now be realised in the automation system controlled by the related status bit.

In this case the event ´communication failure on EtherNet/IP´ of the EIP adapter can be logical linked to the signal status whereby the signal behaviour in case of an error is always the same under all error conditions.

To generate alarm messages for output modules, in the automation system one bit per module (module status) or one bit per signal (signal status) can be polled by the CPU to generate messages or system reactions. The details on the diagnostics information should be read and displayed via the IS1 DTMs.

3.7.2 Behaviour of the output signals in case of errors

Communication error between the master and IS1 field station:
The cyclic data traffic between the EtherNet/IP scanner and IS1 (EtherNet/IP adapter) is checked in the IS1 CPU.
In case of a lost exclusive owner connection all output registers are set to 0x8000H and the outputs adopt the safe state.

Via the Run/Idle Bit in the EIP Status Header (32Bit) the output modules adopt safe state after entering the ´Idle Mode´ and after expiration of $T_{Mod.}$

Communication error between the CPU and output module:
There are watchdog circuits on the output modules that monitor the data transmission between the CPU and the output modules. If an output module does not receive any valid data for more than T_{Mod}, the subassembly adopts the safe setting.
T_{Mod} (timeout for output modules) parameter can be set in the range 100 ms to 25.5 sec. (default value: 100 ms).

The safe setting parameter for the output signals can be set separately for each module (see IOM Parameter).

3.8 HART variables

In addition to the analogue process value, HART field devices offer the option of digitally reading up to four process variables (HART variables HV: PV, SV, TV, QV) from the transmitter.

IS1 offers the option of an acyclic read of such HART variables to the EtherNet/IP scanner.

HART Variablen are cyclicaly read by the IS1 CPU via the IS1 HART modules (slow -> 1 Sec. and up) from the connected HART devices.

8 HVs per IS1 module can be read from the EtherNet/IP scanner via explicit messages.

Transmission of HART Livelist und HART Data see ´Assembly, class 0x04´.

3.8.1 Selection of transmitted HART Variables

Up to 8 HART field devices can be connected to one HART module of IS1. Since each HART field device may have up to 4 variables, this means that a maximum of 32 HART variables are possible per module.

4 or 8 of these 32 HV´s to the positions in the HART data Assembly of the respective IS1 module can be selected by parameter assignment:

Parameter name	Value range	Function
Input No. HART device for pos. 1	0 ... 7, Not used	Selection of the channel no. (input / output no.) of the HART module to which the HART field device is connected which is to be transmitted at pos. 1. If ´Not Used´ is selected, value ´Not a Number´ (7F A0 00 00) is transmitted.
Input No. HART device for pos. 2	0 ... 7, Not used	Selection for pos. 2
. . . . .		
Input No. HART device for pos. 4 (8)	0 ... 7, Not used	Selection for pos. 4 (8)
No. HART variable for pos. 1	1 … 4	Selection of the variables of the HART field device which is to be transmitted at pos. 1.
No. HART variable for pos. 2	1 … 4	Selection for pos. 2
. . . . .		
No. HART variable for pos. 4 (8)	1 … 4	Selection for pos. 4 (8)

3.8.2 Data format HART variables

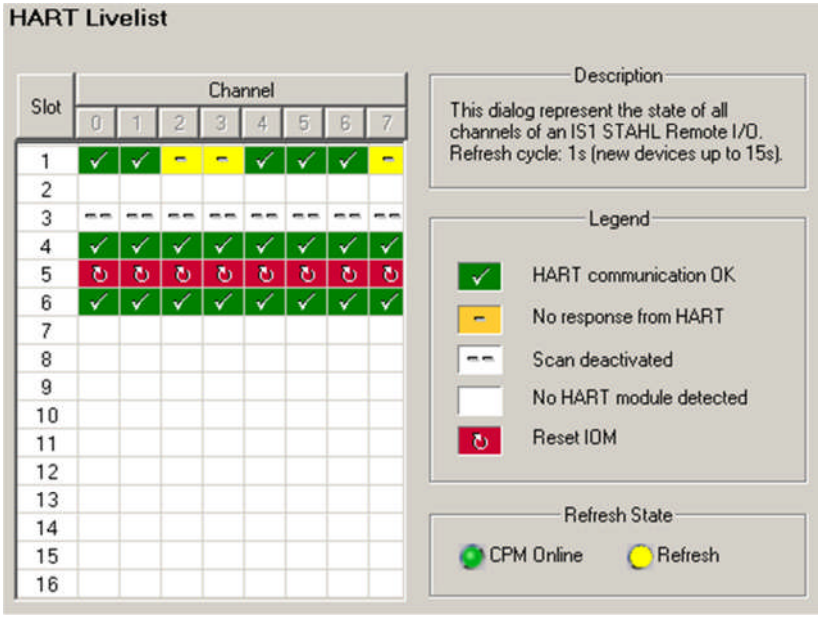
HART variables are transmitted as IEEE floating-point numbers (4 bytes).
If a HART variable cannot be read (e.g. HART device undergoing startup, not connected, defective or HART variable not found, ...), value 7F A0 00 00 (Not a Number) is transmitted. This may be evaluated in the AS for generation of a signal status of the HART variables. Detailed status and diagnostic information on the HART field devices can be evaluated via FDT HART Management Systems.

3.8.3 Module selection in IS1 DTM

The number of the transmitted HART variables depends on the module configuration in the IS1 DTM:

Module selection text	Number of HART variables (HVs) transmitted
9461/12-08-11 **AIMH**8 2w Exi	None
9461/12-08-11 **AIMH**8+4HV 2w Exi	4 HV
9461/12-08-11 **AIMH**8+8HV 2w Exi	8 HV
9461/12-08-21 **AIMH**8 Exi	None
9461/12-08-21 **AIMH**8+4HV Exi	4 HV
9461/12-08-21 **AIMH**8+8HV Exi	8 HV
9466/12-08-11 **AOMH**8 Exi	None
9466/12-08-11 **AOMH**8+4HV Exi	4 HV
9466/12-08-11 **AOMH**8+8HV Exi	8 HV

3.8.4 HART Livelist



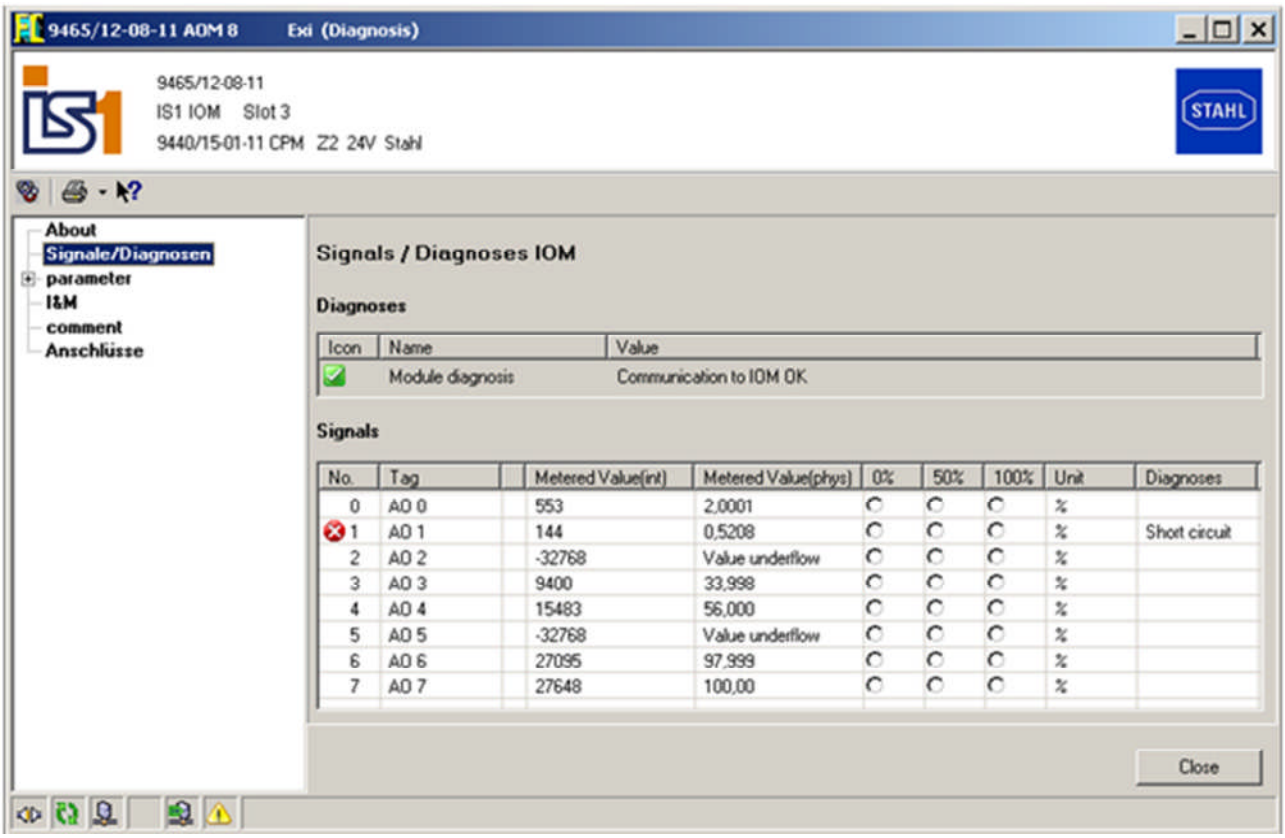
Overview of the status of all HART field devices connected to one IS1 field station for simplified commissioning and maintenance.

For further information for use of the IS1 DTMs see operating instructions ´DTM IS1 Mod´.

3.9 IS1 DTMs

Configuration, parameter setting, diagnostics and HART communication for the IS1 field stations is handled via the IS1 DTMs using FDT technology.

Example: Signals / Diagnostics

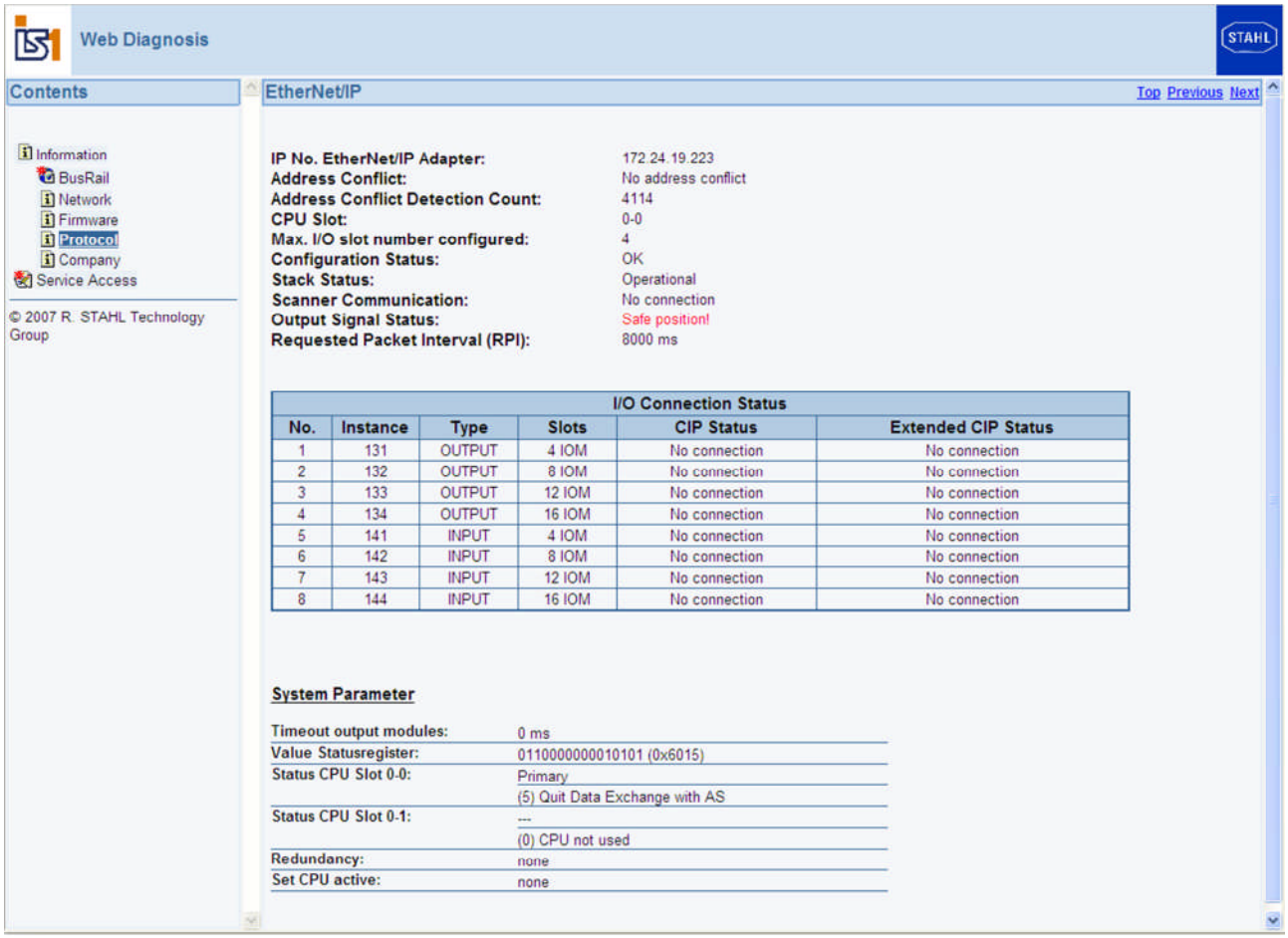


For further information on the use of the IS1 DTMs see operating instructions ´DTM IS1´.

3.10 Webserver in IS1 CPU

A webserver is integrated in the IS1 CPUs which offers additional diagnostic functions for commissioning, maintenance and OEM service support.
For access standard WEB browsers (e.g. Microsoft Internet Explorer) can be used.

Example:



3.11 LED and LCD displays of the CPU

The operational state and the communication on the EtherNet/IP can be assessed on site using the LEDs and the LCD display on the CPU of an IS1 field station.
Additionally the signal values, the signal and module alarms can be displayed on the LCD display.

For details, see the IS1 operating instructions.

3.12 Online behaviour of the IS1 field station.

3.12.1 Parameter changes.

If an IS1 field station is in cyclic data exchange with a EtherNet/IP Scanner (exclusive owner connection), parameters can be modified online via the IS1 DTMs.

3.12.2 Configuration changes.

Module configuration of IS1 field stations can be changed or extended online during operation.
Configuration data can be downloaded from the IS1 DTMs to the IS1 CPU while the CPU is in cyclic exchange on EtherNet/IP.

Precondition for online module extension:

- Spare must already be panned during project planning of an IS1 field station.
- Spare slots on the IS1 rail must be available.
- The data areas of the spare slots must already be communicated cyclically with the EtherNet/IP scanner.

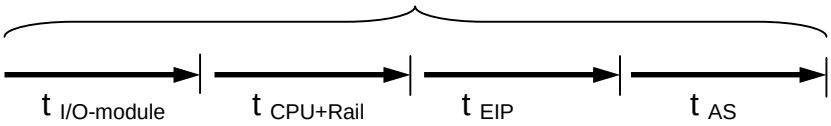
After a download, the IS1 CPU checks the real existing modules (actual state) against the configuration data (target state). All modules of the field station where the configured modules agree with the existing module type in the field station are updated cyclically after restart.
For modules, which do not agree with the configuration data, alarms are generated. The signals for these modules are not updated and react according the behaviour set in the parameters in case of error.
The signals of not changed modules remain bumpless in data exchange.

Process for online expansion:

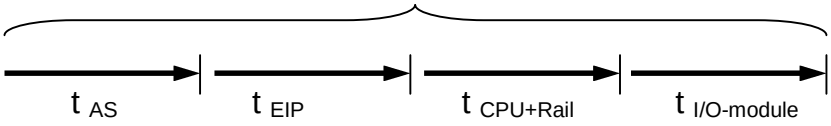
- Add new modules (expansions to an existing field station) in free slots on the rail.
- Add new modules to configuration offline in FDT frame.
- Online download of the configuration to the IS1 CPU while EtherNet/IP is in online operation.
- Expansion of the PLC software for use of the signals of the newly added modules.

3.13 Transmission time:

Total delay of input signals (worst case):



Total delay of output signals (worst case):



$t_{I/O\text{-}module}$ max. signal delay see operation manual of the different IS1 I/O modules.

$t_{CPU+Rail}$ ca. 4ms + Number IOM * 1 ms

t_{EIP} RPI (Requested Packet Interval) configured from EIP Scanner

t_{AS} AS cycle + further delays in automation system (AS)

3.14 Techn. Data

RPI Requested Packet Interval (RPI) is configured at the EIP Scanner.

Connection	CIP Connection size (TxRx) [Byte]	Max. Packets per second	Anzahl EIP Scanner je IS1 Feldstation		
			1 Scanner	2 Scanner	3 Scanner
			min. RPI [ms]		
4 – 8 IOM	70 – 134	125	8	16	24
12 - 16 IOM	198 - 262	100	10	20	30

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
SAIMH	**S**afety **A**nalogue **I**nput **M**odule + **H**ART (PROFIsafe)
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
DOMR	**D**igital **O**utput **M**odule **R**elays
DOMV	**D**igital **O**utput **M**odule **V**alves
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
SIL	**S**afety **I**ntegrity **L**evel
TIM	**T**emperature **I**nput **M**odule

CIP™	Common Industrial Protocol
ODVA	Open DeviceNet Vendor Association siehe www.odva.org
RPI	Requested Packet Interval
EtherNet/IP	EtherNet/IP stands for Ethernet Industrial Protocol. Products compliant with this specification as well as the CIP Common specification are known as EtherNet/IP products. [Source: RFC1392]

5 Release notes:

Version Interface description EtherNet/IP	Extensions / Changes
V 1.00	First Release
V1.02	From FW V31-02: Signal- and Modul Status inverted. Status = 1 = OK.

6 Further reading

Find more details about CIP protocols and EtherNet/IP on: http://www.odva.org/

7 Support address

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