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Configuration of Redundant I/O Modules in PCS 7

SIMATIC PCS 7

http://support.automation.siemens.com/WW/view/en/28430682

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Foreword

Purpose of this document

Using PCS 7 applications, this document describes:

- Redundant I/O modules especially with channel granular functionality
- Setup, wiring and configuration of redundant ET 200M stations
- Using Marshalled Termination Assemblies (MTA) as an interface between the distributed I/O modules and the acutators or sensors
- Diagnostics options on a fault-tolerant system with redundant I/Os in case of an error

Required basic knowledge

This documentation addresses people working in the field of configuration, commissioning and service with basic knowledge of PCS 7.

Classification within the informational landscape

Further information on the topic of redundancy in PCS 7 and on direct handling of the individual fault-tolerant components is given in the following documents. They are part of the software package Process Control System PCS 7 Toolset V7.0 SP1.

Table 0-1

Document	Content
Process Control System PCS 7 V7.0 SP1 Fault-tolerant process control systems	• Solutions for the I/Os • Configuration of fault-tolerant components
Automation system S7-400H Fault-tolerant sytems	• Setup of a CPU 41x-H • Connection of redundant I/O
Distributed I/O ET 200M	• Setup of ET 200M
Automation system S7-300 module data	• Technical data on signal modules.
Marshalled Termination Assemblies ET 200M Remote I/O Modules	• Commissioning of MTA Boards
Function Manual PCS 7 Library V70	• Description of the PCS 7 channel blocks
Process Control System PCS 7 V7.0 SP1 Released Modules	• List of the system-tested SIMATIC modules released in the PCS 7 environment
Process control system PCS 7 V7.0 Asset Management	• Passivation/depassivation of redundant modules
Distributed I/O ET 200M HART analog modules	• Connecting of actuators / sensors in redundant operation

Validity

Valid from PCS 7 V7.0 SP1

Table of contents

1 Introduction

1.1 Redundant I/O

The high-availability in PCS 7 can be principally applied on all levels. In this documentation the emphasis is placed on the application of redundant distributed I/O using ET 200M modules. Thereby, particularly the wiring options of the input/output modules as well as the individual configuration steps are explained.

The term redundant I/O refers to input/output modules (I/O) which exist twice with redundant configuration and operation in pairs. The application of redundant I/Os offers the highest availability as it enables buffering the failure of a CPU as well as of a signal module.

Marshalled Termination Assemblies (MTA) as interface modules offer the possibility of connecting field devices, sensors and actuators in a simple, quick and secure manner to an I/O module of the ET 200M. This document displays how such MTA are structured, which important features and advantages they have, and that they can be implemented without extensive wiring and configuration works.

Note The “Automation System S7-400H, fault-tolerant systems” manual contains extensive information on the redundancy mechanisms in the AS level.

1.2 Channel granularity

Since PCS 7 V7.0 the “channel granular redundancy” using the “Redundant I/O CGP” has been added to the function type “module granular redundancy” with library “RED_LIB V1”.

If for module granular redundancy an error occurs on one of the channels of the first redundant module, for example, the entire module is passivated including all channels. If an error then occurs on a different channel of the second module, then this second error cannot be controlled unless the first error is repaired and the first module has been depassivated.

The advantage of the channel granular redundancy is the higher availability at equal hardware setup, and a more precise error search for several channel errors on a module. Therefore the channel granular redundancy is stressed in this documentation.

Channel errors either due to discrepancy or due to diagnostic alarm (OB82), do not lead to passivation of the entire module. Instead, only the affected channel is passivated. A depassivation activates the affected channel as well as the module passivated due to module failure. Due to channel granular passivation, the availability is clearly increased in the following cases:

- Relatively frequent encoder failures
- Long repair duration
- Several channel errors on one module

When changing from “module granular redundancy” to “channel granular redundany” you must notice the following points:

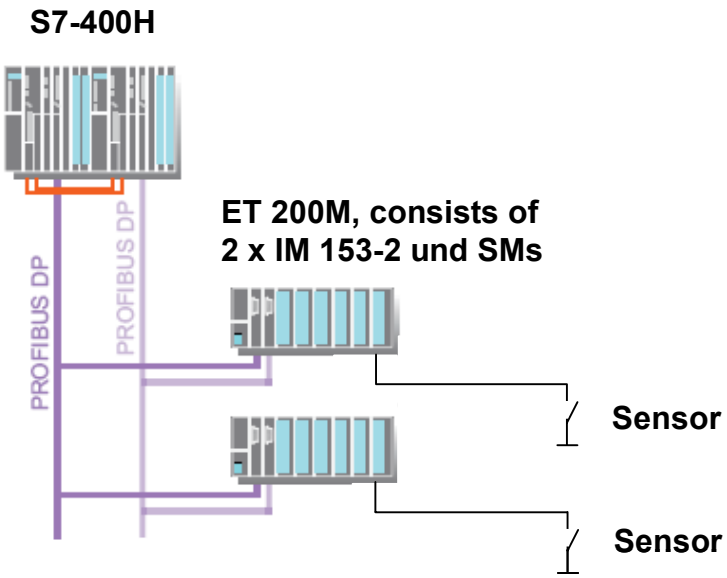
- For activating the channel granular passivation you must stop the automation system (general reset and reload of user program in STOP mode).
- Expand the existing projects either with blocks of the “RED_LIB (V1)” library or switch entirely to “Redundant IO CGP”. The FB452 RED_DIAG now calls the SFB 54. For this reason error information is supplemented for this FB. Therefore you check the calling blocks.
- Ensure during conversion of a project that all blocks named FB450-453 and FC450-451 have been deleted from the block folder. Perform this step in each relevant program. Compile and load your project.

Note Mixing of blocks from libraries “RED_LIB (V1)” and “Redundant IO CGP” in one CPU is not permitted and may cause unpredictable behavior.

1.3 Hardware components

Principally, the availability can be increased in two ways. On the one hand via an I/O interconnected as single-channel as illustrated in the example in Figure 1-1. The discussions in this documentation are mainly restricted to the usage of redundant I/O with two ET 200M station**s.**

Figure 1-1



A redundant I/O is exists if the input/output modules for a process signal are available twice and can be addressed by the AS (S7-400H).

In PCS 7 a redundant I/O can be established with selected S7-300 I/O modules of the ET 200M series.

The distributed I/O device ET 200M is connected to a fault-tolerant automation system (DP master) as a DP slave via PROFIBUS DP. A redundant setup is reached by an additional ET 200M and an additional PROFIBUS DP connection.

The individual hardware components for setting up a fault-tolerant system with redundant distributed I/O are further described in the following sections.

1.3.1 Fault-tolerant automation system (AS)

The aim for using fault-tolerant automation systems is reducing the risk of production outage.

For the S7-400H to remain available in any case, it has a redundant structure. This means that all main components exist twice: the central processing unit CPU, the power supply and the hardware for coupling both central processing units.

Table 1-1 shows the CPU types which can be used with PCS 7.

Table 1-1

Designation	MLFB	FW Version
CPU 414-4H	6ES7 414-4HJ00-0AB0	V3.1
CPU 414-4H	6ES7 414-4HJ04-0AB0	V4.0
CPU 417-4H	6ES7 417-4HL01-0AB0	V3.1
CPU 417-4H	6ES7 417-4HL04-0AB0	V4.0
CPU from PCS 7 V7.0 SP1		
CPU 412-3H	6ES7 412-3HJ14-0AB0	V4.5
CPU 414-4H	6ES7 414-4HM14-0AB0	V4.5
CPU 417-4H	6ES7 417-4HT14-0AB0	V4.5

1.3.2 Interface modules (IM)

Interface modules, also referred to as interface module (IM), serve as a PROFIBUS DP interface in the distributed I/O ET 200M. For redundant I/O it must be ensured, that per ET 200M station two interface modules (IMs) are used and the same bus address (via DIP switch) has been set for both.

If the active interface module fails during runtime, there will be a bumpless take-over of the function by the passive interface module. The active interface is displayed by the LED ACT light on the respective interface module.

Table 1-2 shows IM modules for redundant applications.

Table 1-2

Designation	MLFB	FW Version
ET200M-IM153-2	6ES7 153-2BA00-0XB0	V3.x
ET200M-IM153-2	6ES7 153-2BA01-0XB0	V4.x
ET200M-IM153-2	6ES7 153-2BA81-0XB0	V4.x
ET200M-IM153-2	6ES7 153-2BA02-0XB0	V5.x
ET200M-IM153-2	6ES7 153-2BA82-0XB0	V5.x
ET200M-IM 153-2 FO	6ES7 153-2BB00-0XB0	V3.x

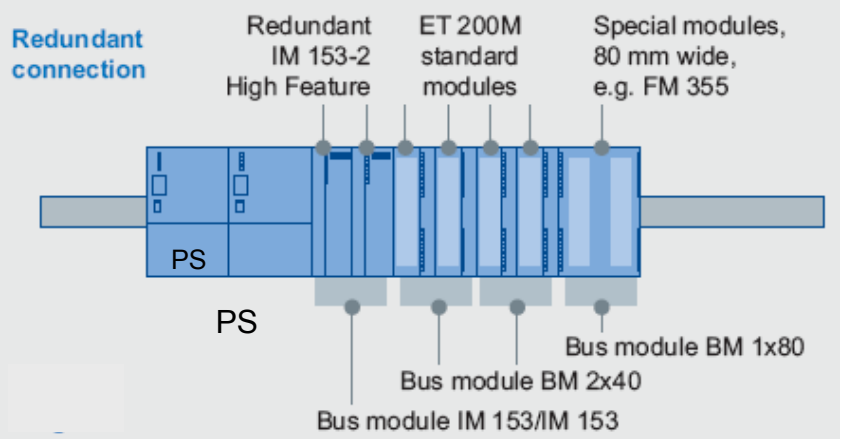
1.3.3 Bus modules

As already mentioned above, for PCS 7 only active bus modules are used for redundant applications with ET 200M. This enables plugging and pulling the modules during runtime. For redundant operation two IM 153-2 High Feature are mounted to the active bus module for an ET 200M.

Further modules are used for the ET 200M standard modules (e.g. DI, DO, AI, AO).

Figure 1-2 shows a possible setup of an ET 200M station. It must be noted, that using the redundant power supply module (PS) is optional here.

Figure 1-2



Note Permitted combinations between connections and bus modules, as well as available functionalities are available in the manual “SIMATIC distributed I/O device ET 200M”.

For the setup of a redundant ET 200M station an IM 153 redundancy bundle is often ordered in practice. It consists of two IM 153-2 High Feature and an active bu8s module IM 153/IM 153.

1.3.4 I/O modules

I/O modules with channel granular functionality

From PCS 7 V7.0 on you can define how redundant input/output modules behave during a channel failure (e.g. wire-break, short-circuit on the signal line). During a channel failure, the following reactions must be expected depending on the used module and the configuration:

- When an error occurs only the faulty channel is passivated (recommended channel granular passivation method)
- The entire module is passivated when an error occurs (module granular passivation behavior)

The following Table 1-3 shows input and output modules suitable for the redundant setup with ET200M and equipped with channel granular functionality. It must be noted here, that modules with channel granular properties can always also be used for module granular applications, however, not vice versa.

Table 1-3

Designation	MLFB
Digital input module	
SM321 DI 16xDC24V, Alarm	6ES7 321-7BH01-0AB0
Digital output module	
SM322 DO 16xDC24V/0,5A	6ES7 322-8BH01-0AB0
Analog input module	
SM331 AI 8x16Bit	6ES7 331-7NF00-0AB0
SM331 AI 8x0/4…20mA HART	6ES7 331-7TF01-0AB0
Analog output module	
SM332 AO 8x12Bit	6ES7 332-5HF00-0AB0
SM332 AO 8x0/4…20mA HART	6ES7 332-8TF01-0AB0

Note The application of HART modules requires PCS 7 V7.0 SP1. Furthermore, certain interface modules (6ES7 153-2BA02-0XB0 or 6ES7 153-2BA82-0XB0) must be used.

Particularities for HART modules

Note When using redundant HART analog modules, only one measuring transmitter (encoder) can be connected.

Redundant HART signal modules work as "Primary Master" and "Secondary Master", in order to enable simultaneous HART communication via both modules with one field device.

The module with the lowest address is declared by the system as the "Primary Master". If it fails, the communication occurs via the "Secondary Master".

Note In order to not affect this system behavior, no further HART masters, such as handheld, must be connected.

1.3.5 Marshalled Termination Assemblies (MTA)

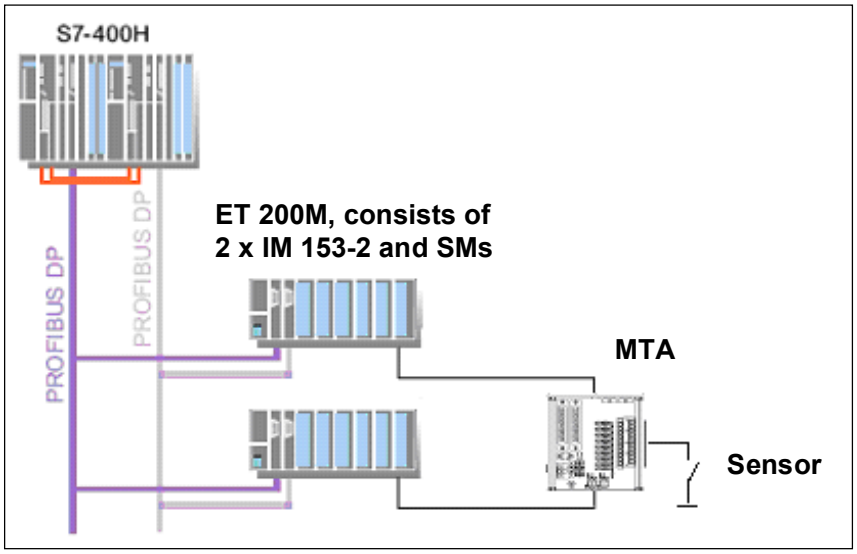
SIMATIC PCS 7 MTA offers the possibility of connecting field devices, sensors and actuators in a simple and quick manner to an I/O module of the distributed I/O ET 200M.

The MTA are tailored to specific I/O modules from the ET 200M range. MTA versions for standard I/O modules are equally available as for redundant and safety-directed I/O modules.

Using them expenses and costs for cabling and commissioning can be reduced significantly and wiring errors can be avoided.

The following figure shows an option for implementing an MTA to two ET 200M stations (with one encoder).

Figure 1-3



The SIMATIC PCS 7 MTA are connected via 3m or 8m long, prefabricated cable assemblies to an I/O module.

Product characteristics

MTA are characterized by the following properties:

- Redundant voltage supply DC 24 V with LED display
- Screw-type terminals for the direct (1:1) connection of the field devices, sensors and actuators
- Securing with LED display for each I/O channel
- Preconfigured cable for connecting the MTA with the I/O module
  - with SUB D connector, 50/25 pole, socket version, for MTA
  - with Siemens front connector 40/20 pole, socket version, for ET 200M module
- Simulation options on board for IBS purposes (wire-break, connect/disconnect channel)
- Tested as SIMATIC PCS 7 system component and approved with respective certification (FM, UL, CE, ATEX, TÜV)

Advantages

- MTA enables quick and simple cabling with field devices
- Direct connection of the field devices
- SUB D connector for connecting preassembled cables
- One fuse for each channel with LED display
- Redundant voltage supply DC 24 V
- Simulation options on board, e.g. for IBS purposes
- Support for redundant ET 200M modules
- Channel granular protection
- Accessibility
- Internal potential distribution
- Simple maintenance due to plug-type connectors
- Faster IBS
- Connection options for HART modem at MTA

Note Further detailed information is available in the manual “Marshalled Termination Assemblies ET 200M Remote I/O Modules”.

For the MTA it must be noted that an MTA module can only be switched with certain input/output modules. Table 1-4 shows possible connection options.

Table 1-4

Product imprint	MLFB
MTA 16 channels DI standard	6ES7650-1AC10-3XX0
MTA 8 channels AI standard	6ES7650-1AA50-2XX0
MTA 8 channels AO standard	6ES7650-1AB50-2XX0
MTA 8 channels TC standard	6ES7650-1AF50-2XX0
MTA 8 channels RTD standard	6ES7650-1AG50-2XX0
MTA 24 channels F-DI (failsafe)	6ES7650-1AK10-7XX0
MTA 10 channels F-DI (failsafe)	6ES7650-1AL10-6XX0
MTA 8 channels F-AI (failsafe)	6ES7650-1AH50-5XX0
MTA 10 channels Relais DO	6ES7650-1AM30-6XX0

Note Detailed information on the individual MTA types is available in the delivery approval: http://support.automation.siemens.com/DE/view/en/22538324

2 Setup and Wiring

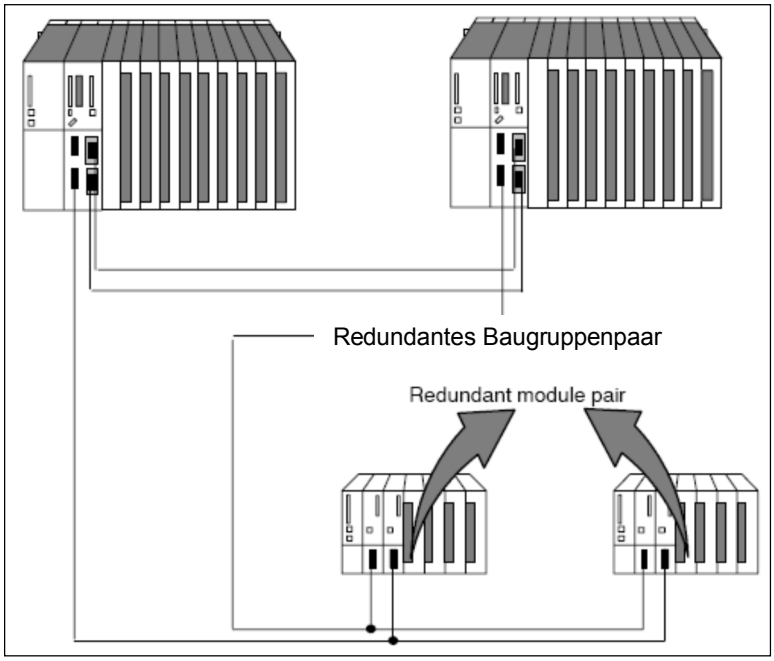
2.1 Redundant PROFIBUS-DP connection

The transition from automation system to PROFIBUS DP occurs via a CP 443-5 Extended or via one of both internal PROFIBUS DP interfaces of the CPU.

2.2 Redundant connections of the distributed I/O

Figure 2-1 gives an example of the connection of the redundant I/O in the connected DP slave mode. As opposed to the redundant I/O in one-sided DP slave mode, the signal modules are employed here in the distributed I/O devices ET 200M.

Figure 2-1



The following chapter describes the connection of the encoders to the signal modules.

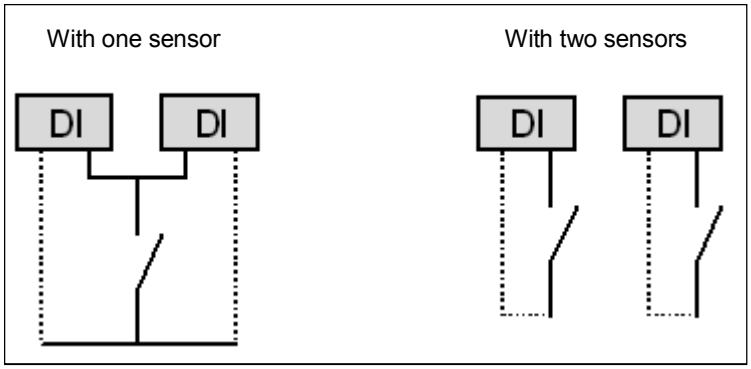
Note Detailed circuit diagrams and module details are available in the manuals “Automation System S7-300 – Module Data” and “Automation System S7-400H fault-tolerant systems”.

2.2.1 Digital input:

Encoder connection

One or two encoders are connected to two redundant SM 321; DI 16 x DC 24 V (2oo2 structure).

Figure 2-2



In order to reach a maximum availability it is recommended to use two encoders.

Note When connecting an encoder to several digital input modules, the redundant modules must have the same reference potential.

Connection and principle circuit diagram of SM 321; DI 16 x DC 24 V

The following figure shows the principle circuit diagram of the digital input module with channel granular functionality (6ES7 321-7BH01-0AB0).

Figure 2-3

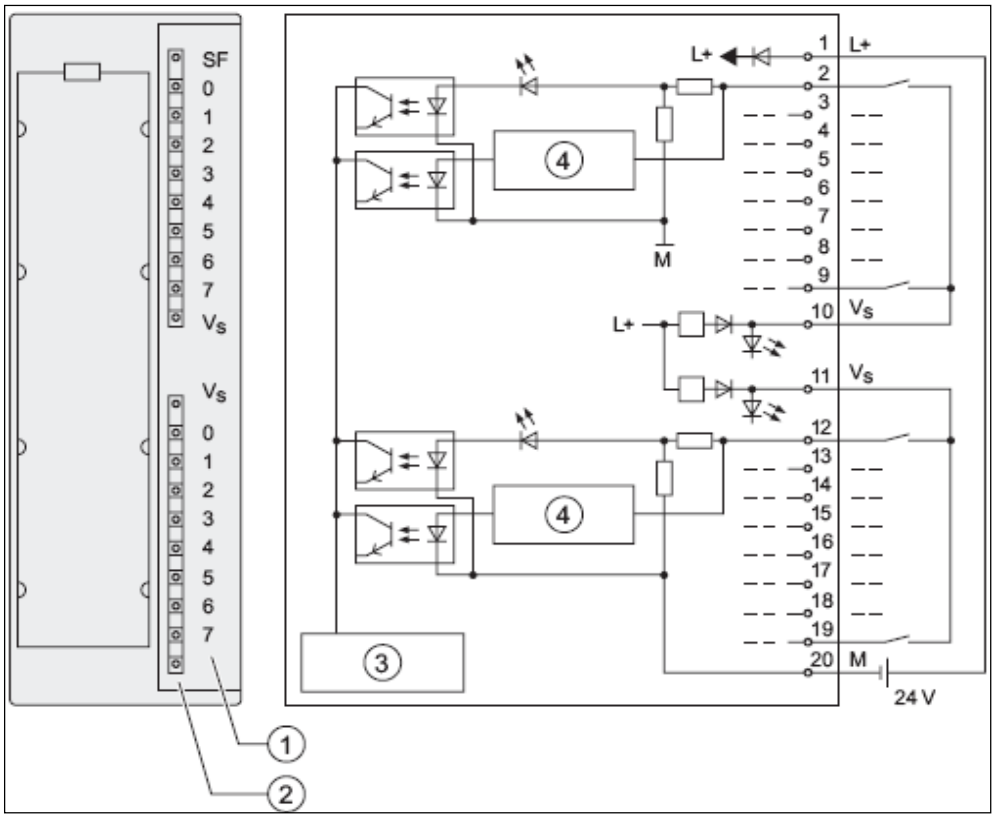


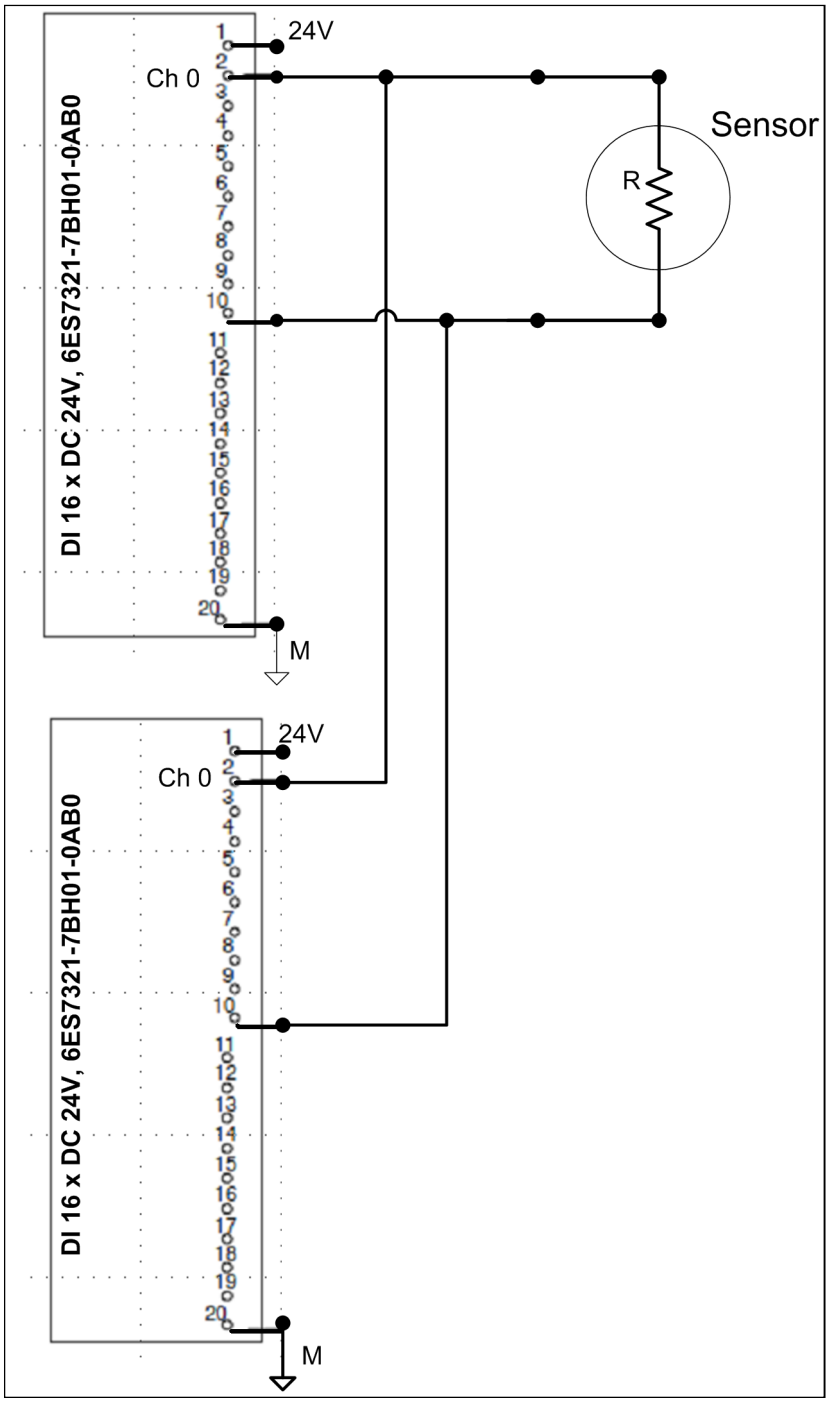
Table 2-1

Number	Description
1	Channel number
2	Status display (green) Error display (red) Encoder supply VS (green)
3	Backplane bus connection
4	Wire-break detection

Example

One encoder is connected to two SM 321; DI 16 x DC 24 V at channel 0 respectively.

Figure 2-4



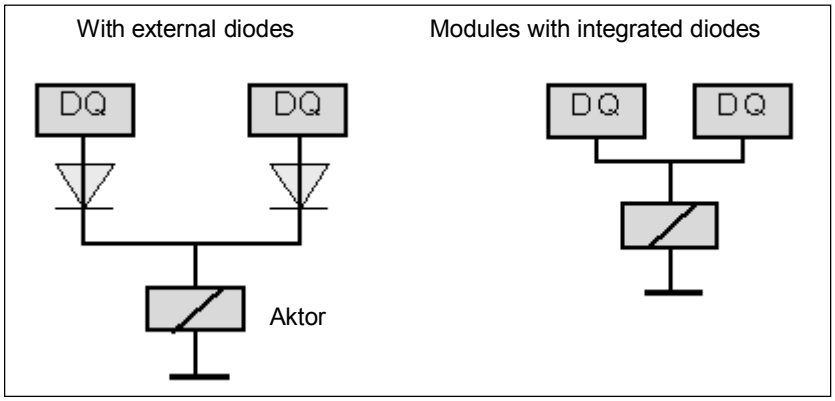
2.2.2 Digital output

Controlling the final control element

The actuator is connected to two redundant SM 322; DO 16 x DC 24 V / 0.5 A (2oo2 structure). Depending on the type of digital output modules, additional diodes must be used in redundant operation.

Note The overview of which digital output modules can be wired via external diodes, are available in the manual “Automation systems S7-400H fault-tolerant systems” in table 8-4.

Figure 2-4



The digital output module with channel granular functionality (6ES7 322-8BH01-0AB0) is switched without external diodes.

Note The digital output modules must have a joint load voltage supply.

Connection and principle circuit diagram of SM 322; DO 16 x DC 24 V / 0.5 A

The following figure shows the principle circuit diagram of the digital output module with channel granular functionality (6ES7 322-8BH01-0AB0).

Figure 2-4

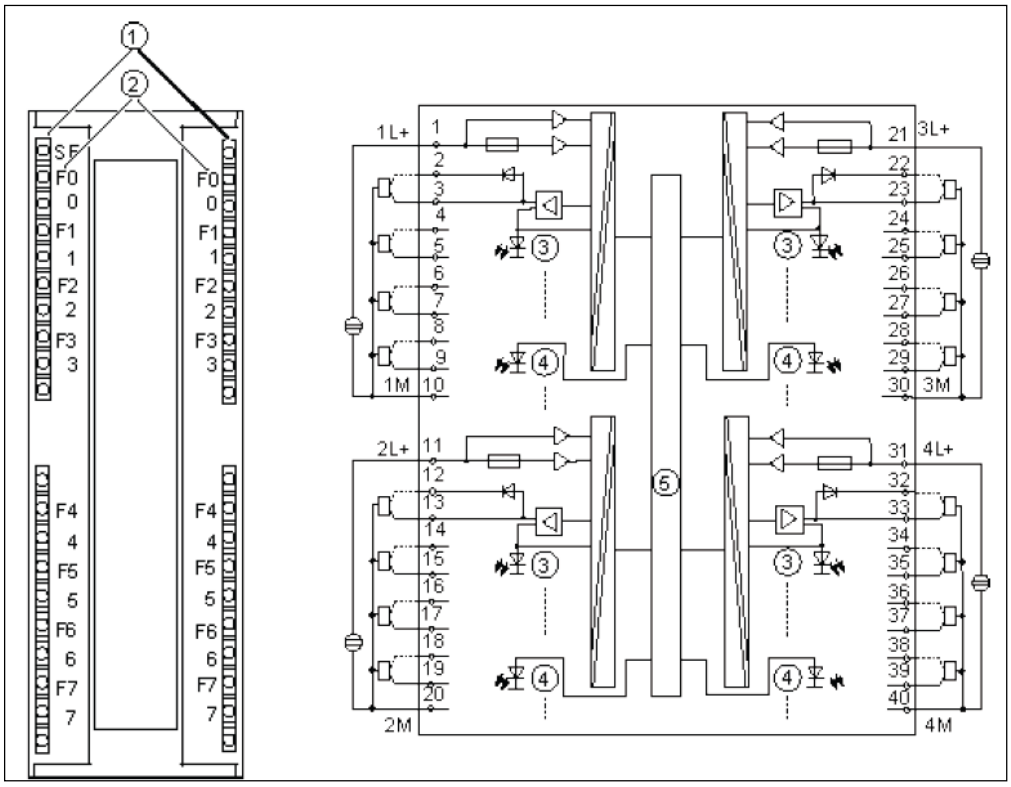


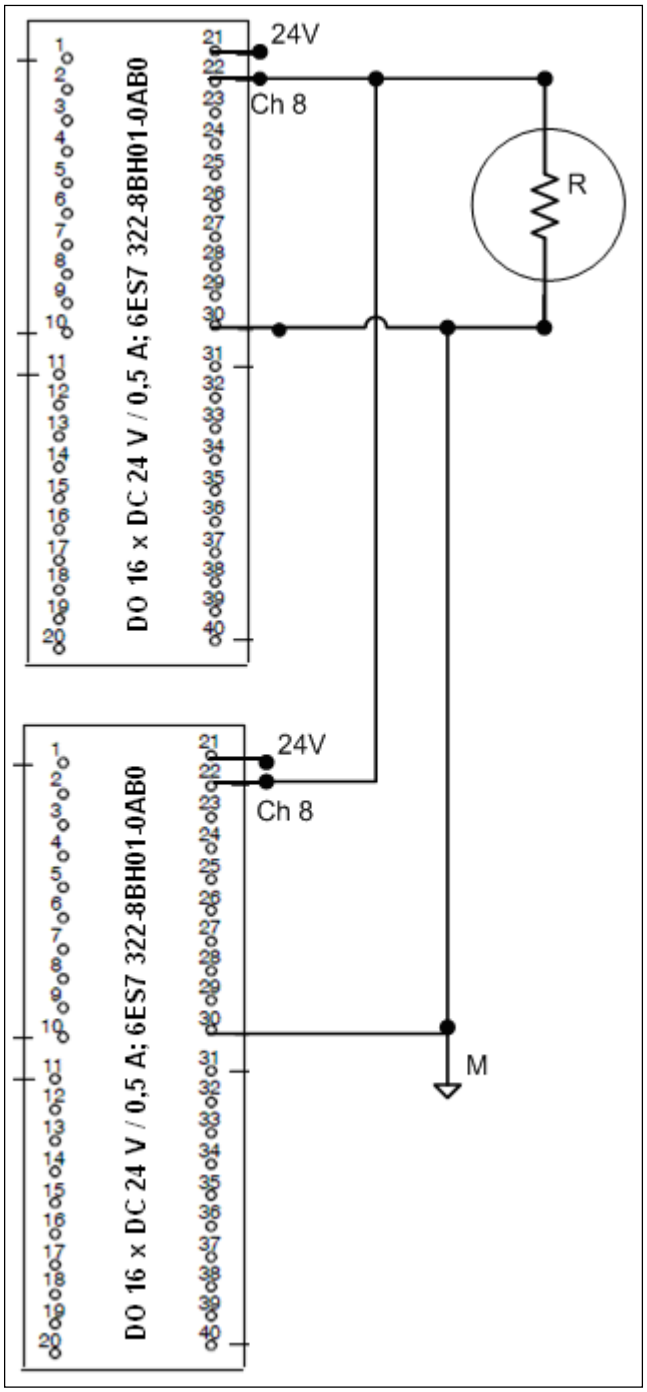
Table 2-2

Number	Description
1	Status display (green) Error display (red)
2	Channel number Numbers 0 to 7 on the right side correspond to channel numbers 8 to 15
3	Channel status (green)
4	Channel error (red)

Example

An actuator is connected to two SM 322; DO 16xDC 24V/0.5A at channel 8 respectively:

Figure 2-5

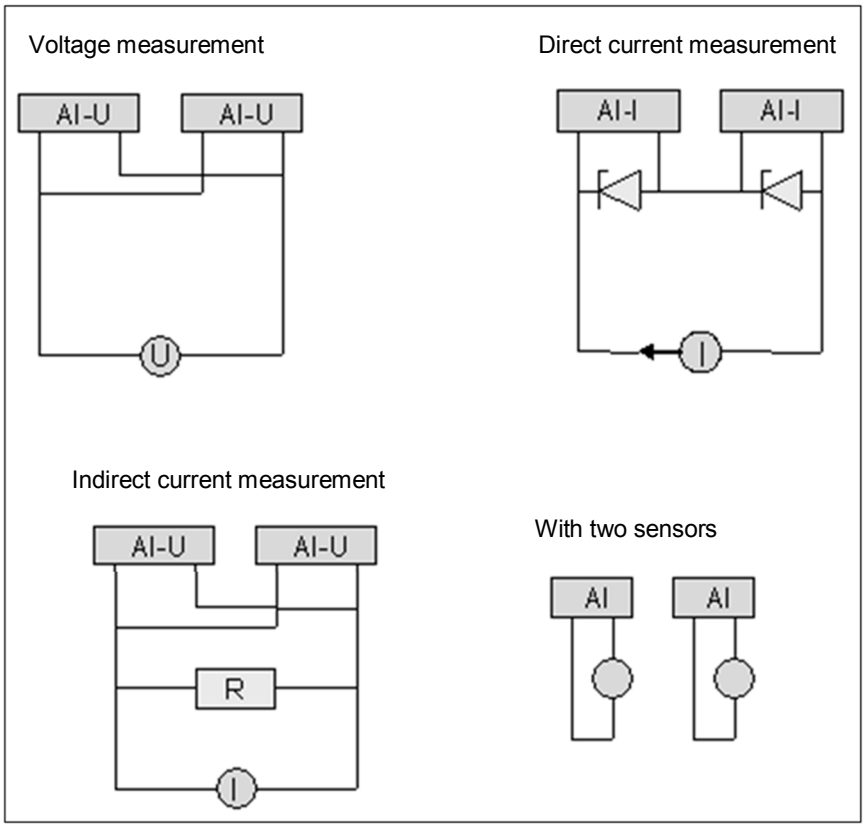


2.2.3 Analog input

Encoder connection

The analog input module SM331; AI 8x16 bit can be used in redundant operation with one or two encoders (2oo2 structure).

Figure 2-6



In order to reach a maximum availability it is recommended to use redundant encoders.

Note When using redundant HART analog modules, only one measuring transmitter (encoder) can be connected.

Connection and principle circuit diagram of SM 331; AI 8 x 16 bit (voltage measurement)

The following two figures respectively show the principle circuit diagram of the analog input module SM331 AI 8x16Bit (6ES7 331-7NF00-0AB0) with channel granular functionality for voltage and current measurement.

Figure 2-7

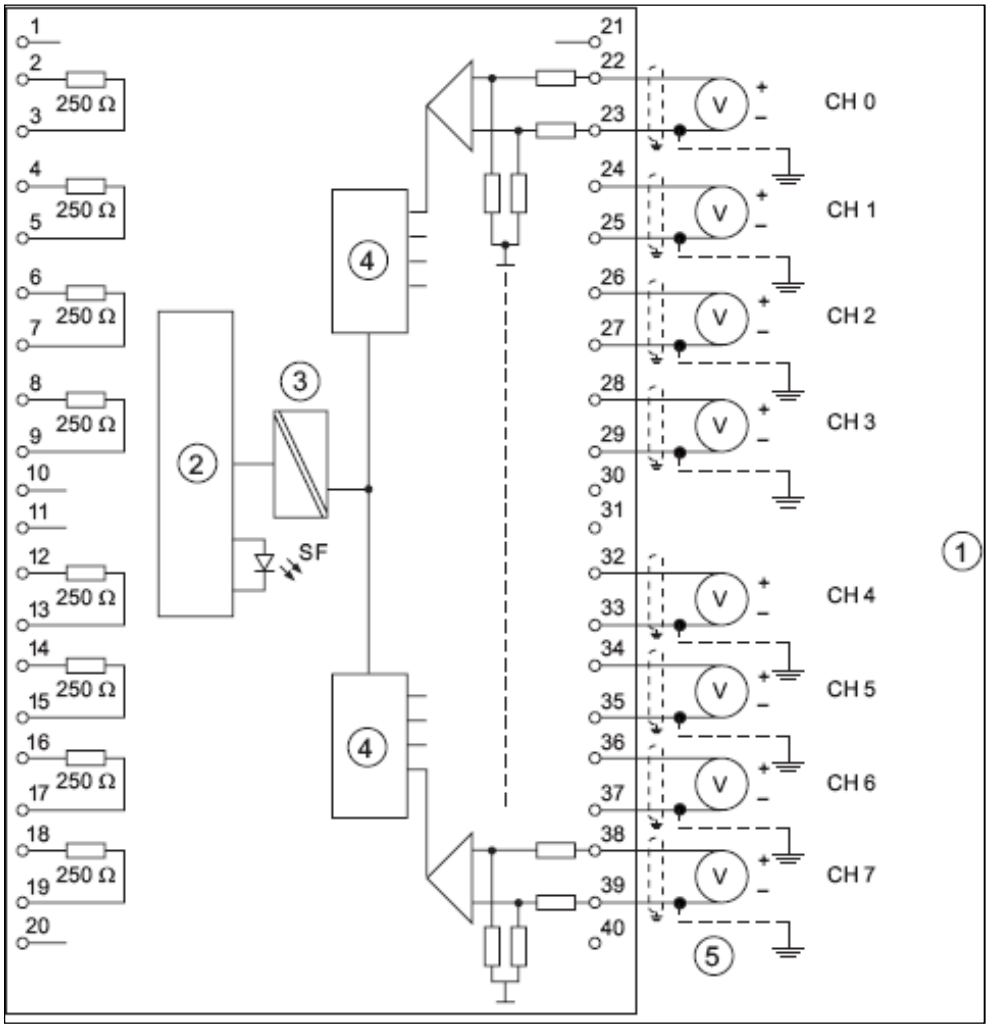


Table 2-3

Number	Description
1	Voltage measurement
2	Backplane bus connection
3	Electrical isolation
4	Analog-digital converter (ADU)
5	Equipotential bonding

Connection and principle circuit diagram SM 331; AI 8 x 16 bit (current measurement)

For measuring currents the DC terminals of a channel are switched parallel with the respective current resistor. This occurs by bridging the channel input terminals with the neighboring terminals of the connection socket.

For example, to configure channel 0 for the current measurement, you bridge terminals 22 and 2 and terminals 23 and 3 respectively.

In the channel configured for current measurement the current resistance must be connected to the neighboring channel terminals in order to reach the specified precision.

4-wire measuring transformer (channel 0) or
2-wire measuring transformer with external supply (channel 7)

Figure 2-8

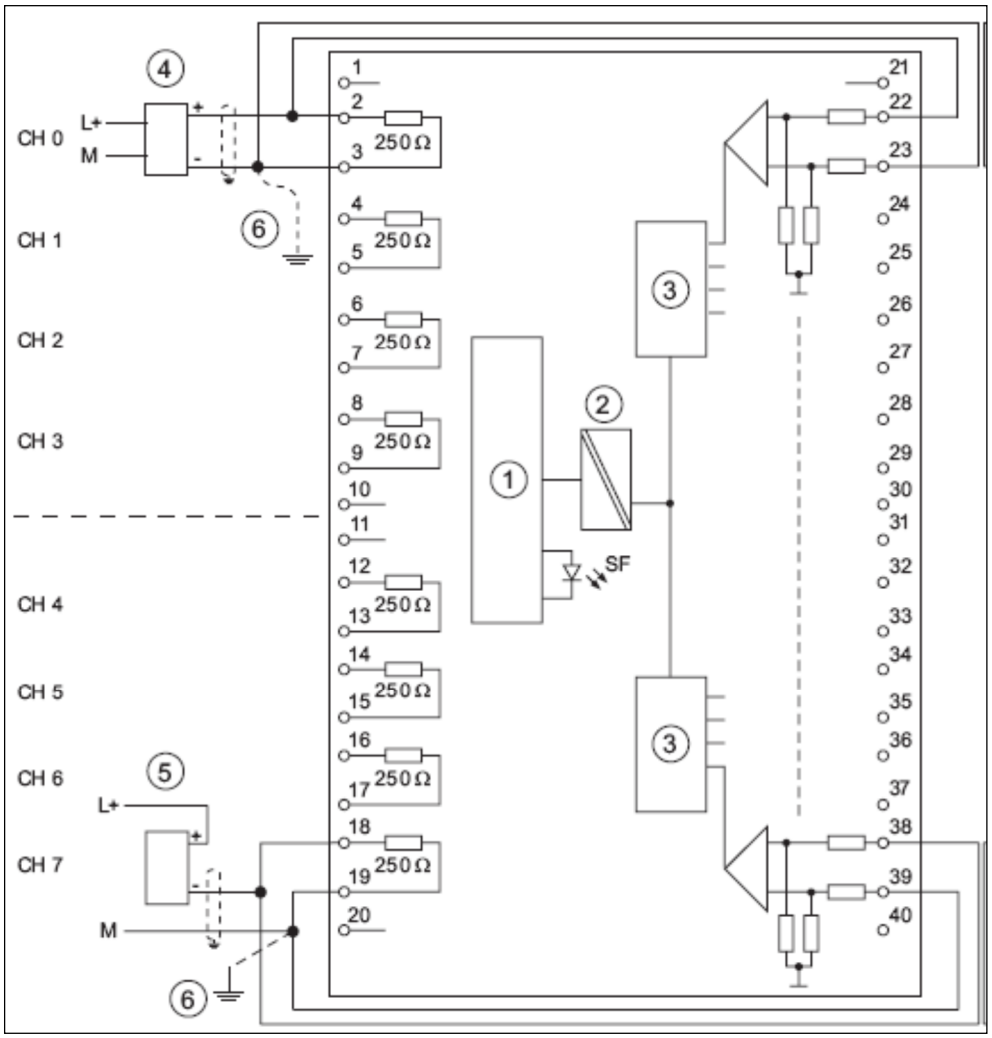


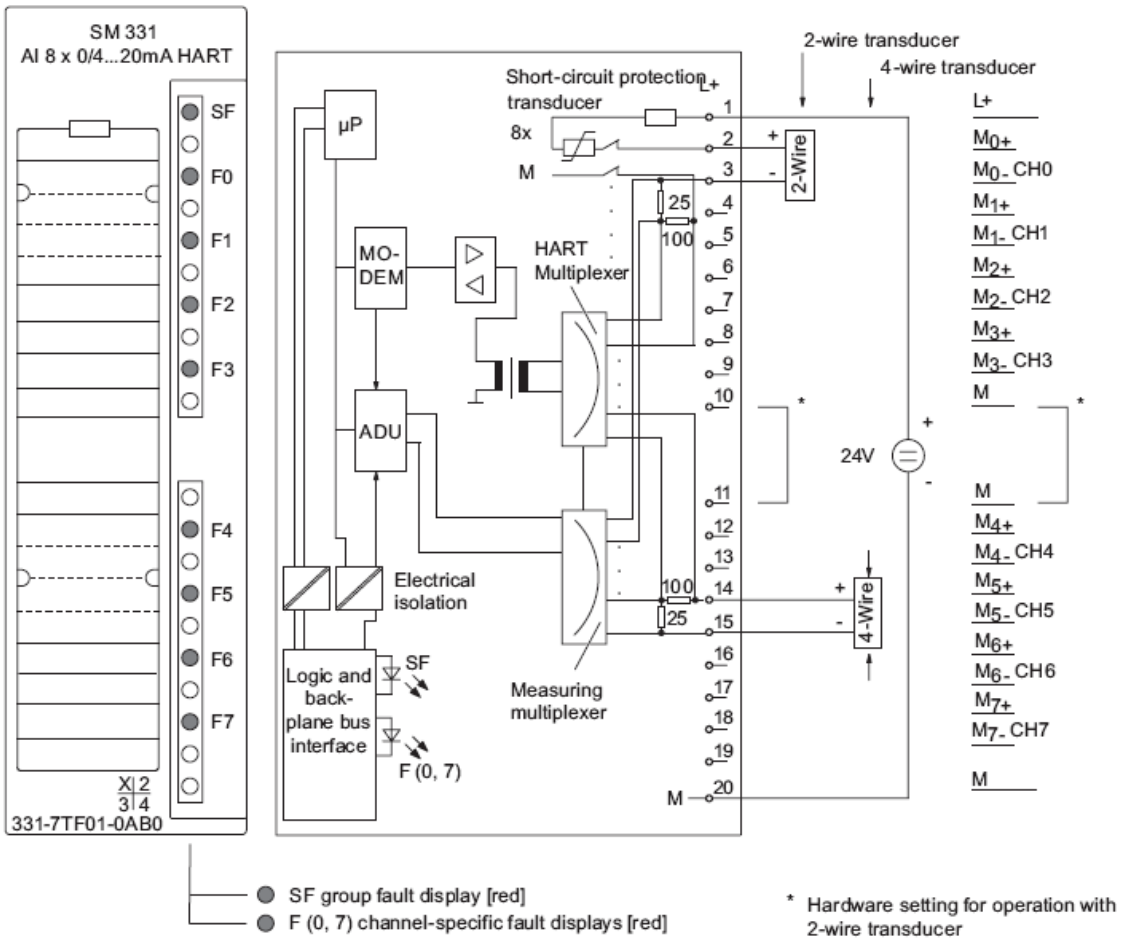
Table 2-4

Number	Description
1	Backplane bus connection
2	Electrical isolation
3	Analog-digital converter (ADU)
4	CH 0 for 4-wire measuring transformer
5	CH 7 for 2-wire measuring transformer (with external supply)
6	Equipotential bonding

Connection and principle circuit diagram SM 331; AI 8 x 0/4…20 mA HART

The following figure shows the principle circuit diagram of the analog HART input module SM331 AI 8x0/4…20 mA (6ES7 331-7TF01-0AB0) with channel granular functionality .

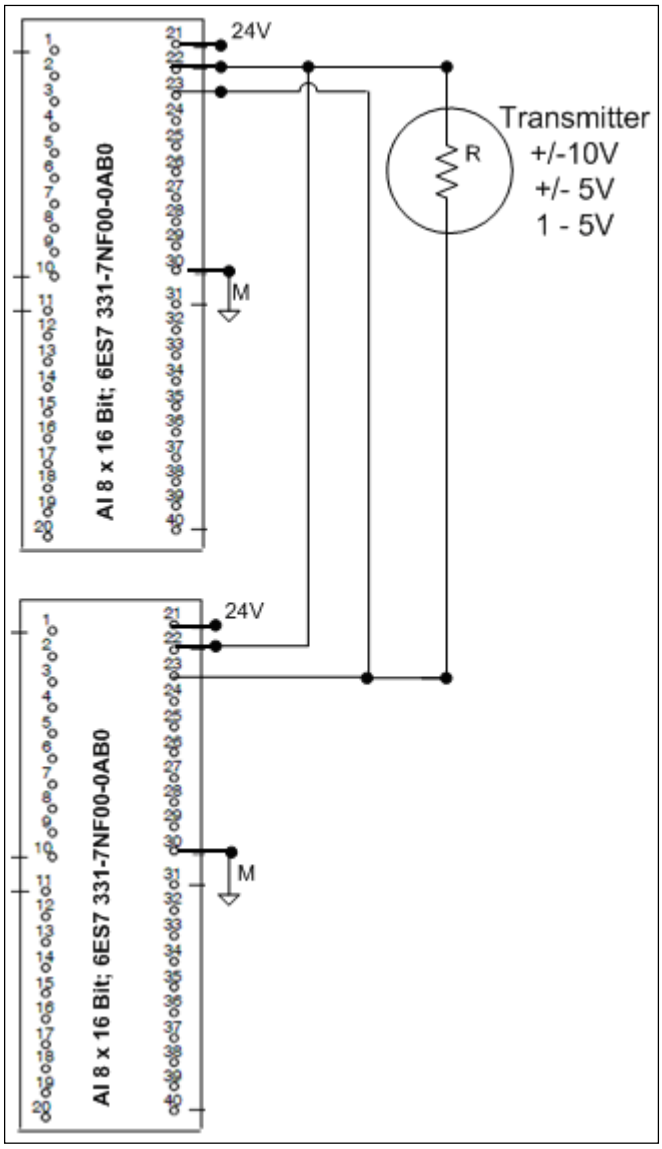
Figure 2-9



Example of an SM 331; AI 8 x 16 Bit

For voltage supply the following figure shows the connection of a transmitter to two AI 8 x 16 bit modules.

Figure 2-10



Example of an SM 331; AI 8x0/4…20 mA HART (2-wire measuring transformer)

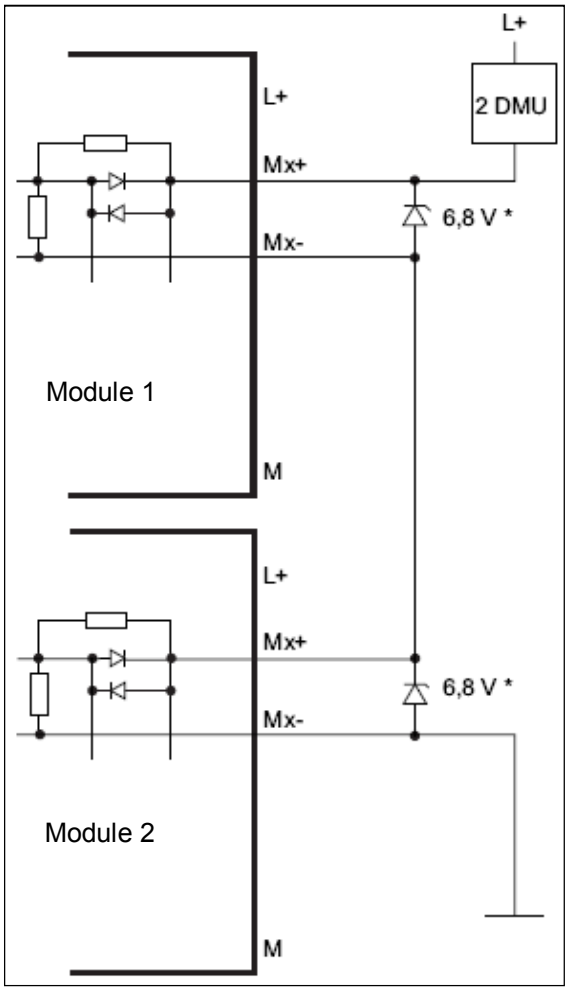
Note

A 2-wire measuring transformer must be connected to two redundant HART analog modules as 4-wire measuring transducer and be configured.

Further detailed information is available in the manual “Distributed I/O device ET 200M HART analog modules”.

At the front connecter the connections 10 and 11 must not be connected (see Figure 2-9).

Figure 2-11

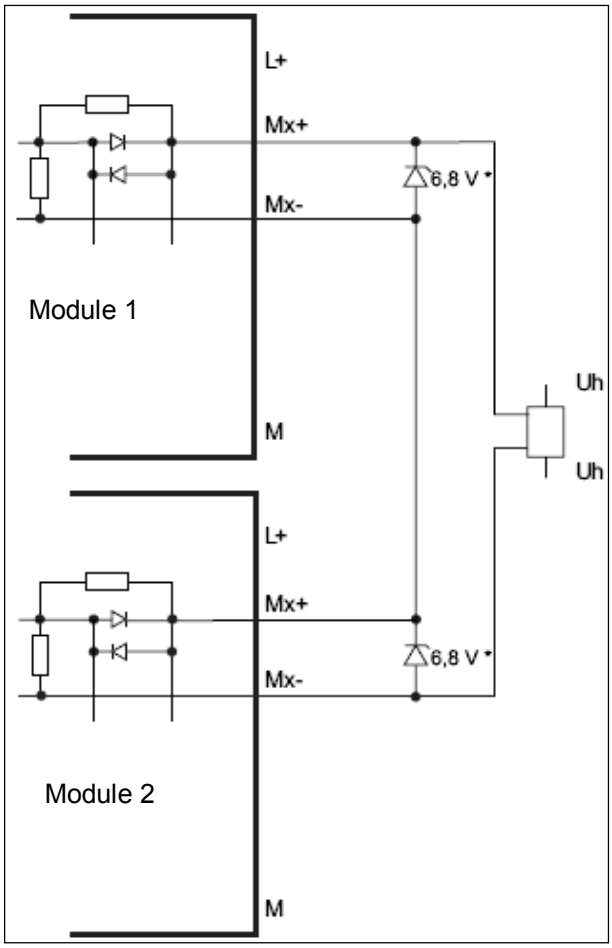


The wired Z-diodes are necessary if after pulling a module the system shall continue to run.

Example of an SM 331; AI 8x0/4…20 mA HART (4-wire measuring transformer)

A 4-wire measuring transducer is connected to two redundant HART analog input modules:

Figure 2-12



The wired Z-diodes are necessary if after pulling a module the system shall continue to run.

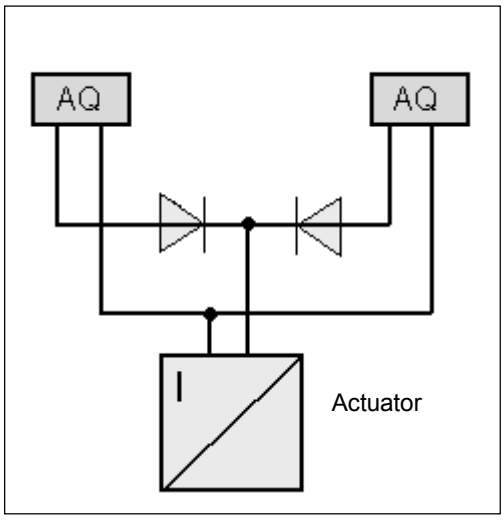
2.2.4 Analog output

Controlling the final control element

For the fault-tolerant controls of a final control element two outputs are switched parallel (2oo2 structure) by two SM 332; AO 8x12 bit via diodes.

Only analog output modules with current outputs can be operated redundantly (0 to 20 mA or 4 to 20 mA).

Figure 2-13



Both outputs output half of the value. If one of the modules fails, the still inactive output delivers the complete value.

Connection and principle circuit diagram of SM 332; AO 8 x 12 bit (voltage output)

The following image shows the principle circuit diagram of the analog output module SM331 AO 8x16Bit (6ES7 332-5HF00-0AB0) with channel granular functionality in 2 and 4 line connection for voltage output.

- 2 line connection without compensation of line resistors
- 4 line connection with compensation of line resistors

Figure 2-14

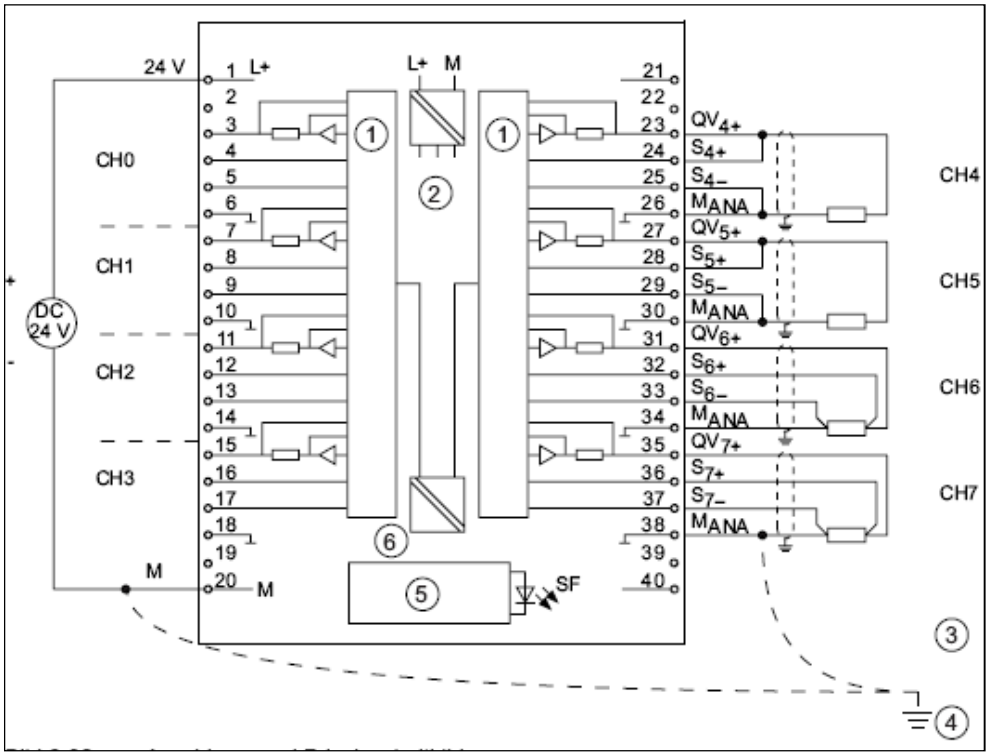


Table 2-5

Number	Description
1	DAU
2	Internal supply
3	Equipotential bonding
4	Functional earth
5	Backplane connection
6	Electrical isolation

Connection and principle circuit diagram of SM 332; AO 8 x 12 bit (current output)

The following image shows the principle circuit diagram of the analog output module SM331 AO 8x16Bit (6ES7 332-5HF00-0AB0) with channel granular functionality as current output.

Figure 2-15

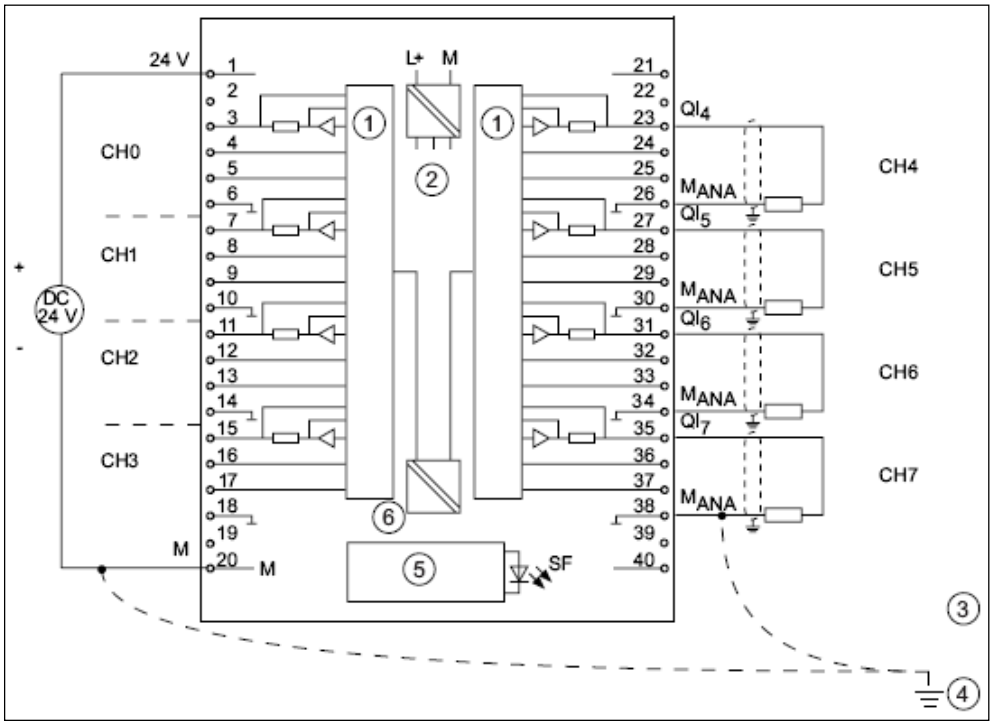


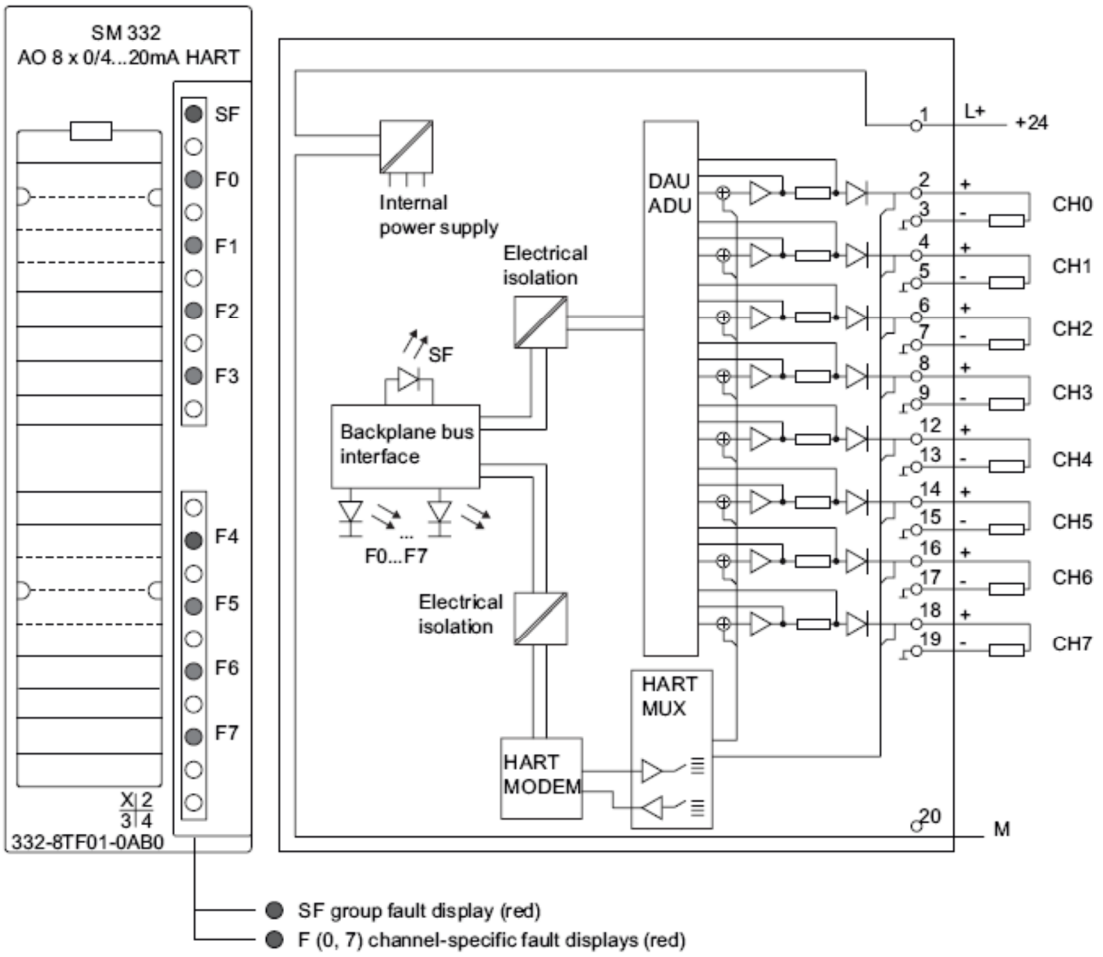
Table 2-6

Number	Description
1	DAU
2	Internal supply
3	Equipotential bonding
4	Functional earth
5	Backplane connection
6	Electrical isolation

Connection and principle circuit diagram SM 332; AO 8 x 16Bit, 0/4…20mA HART

The following figure shows the principle circuit diagram of the analog HART output module SM331 AI 8x16 bit, 0/4…20 mA (6ES7 332-8TF01-0AB0) with channel granular functionality.

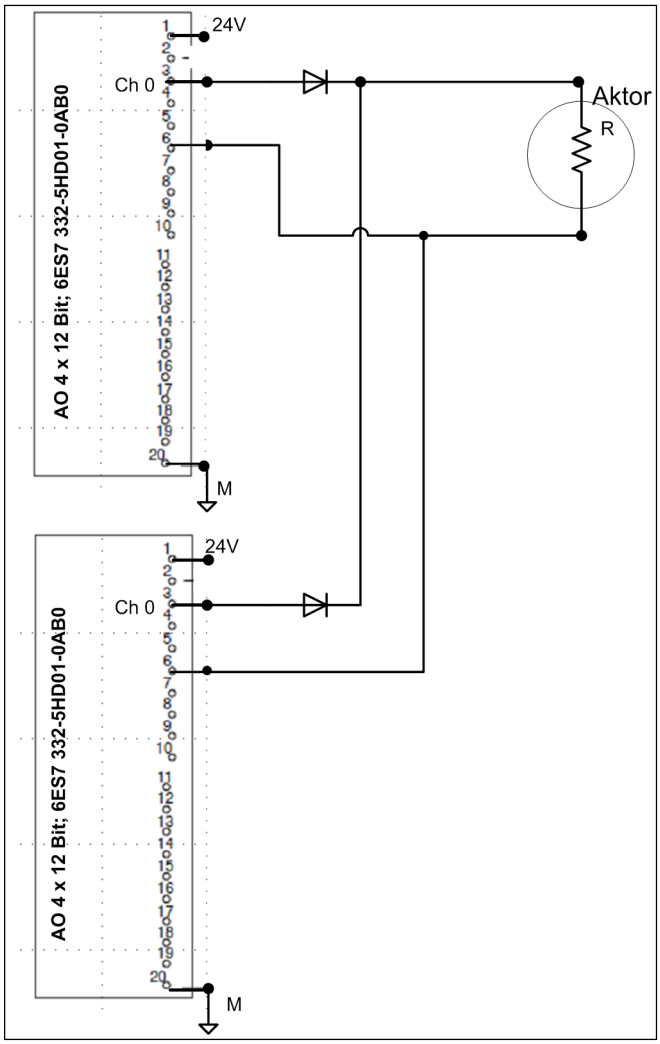
Figure 2-16



Example of an SM 332; AO 8 x 12 Bit

The actuator is connected to two redundant SM 332; AO 8 x 12 bit at channel 0 respectively.

Figure 2-17



Note

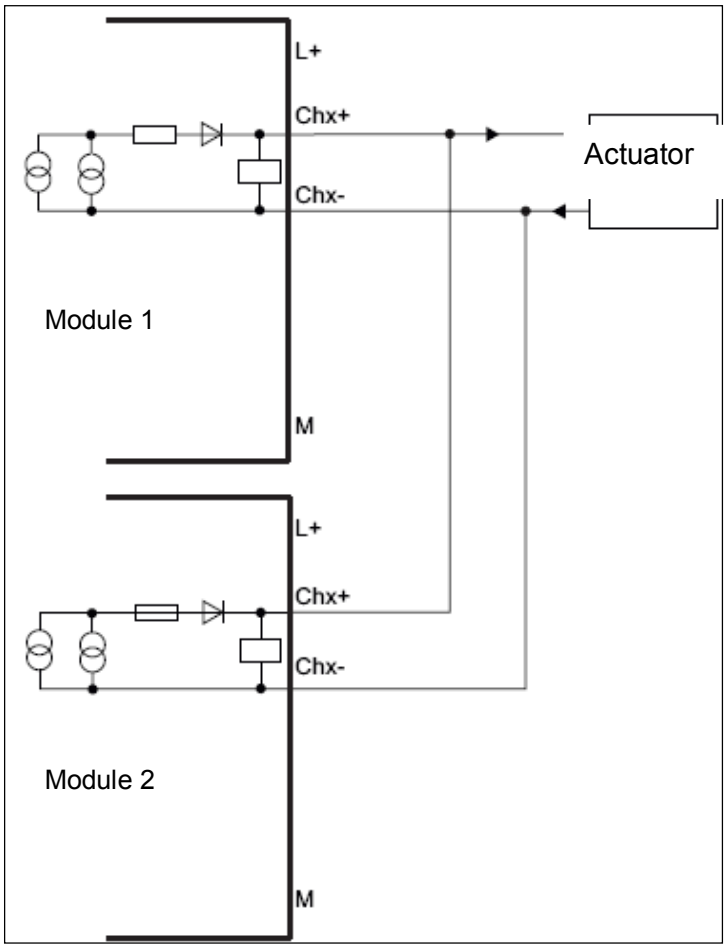
Suitable as diodes are, for example, types from the 1N4003 ... 1N4007 series or any other diode with U_r >=200 V and I_F >= 1 A.

It is sensible to separate module earth and load earth. Equipotential must exist between both

Example of an SM 332; AO 8 x 16Bit, 0/4…20mA HART

The actuator is connected to two redundant HART analog output modules.

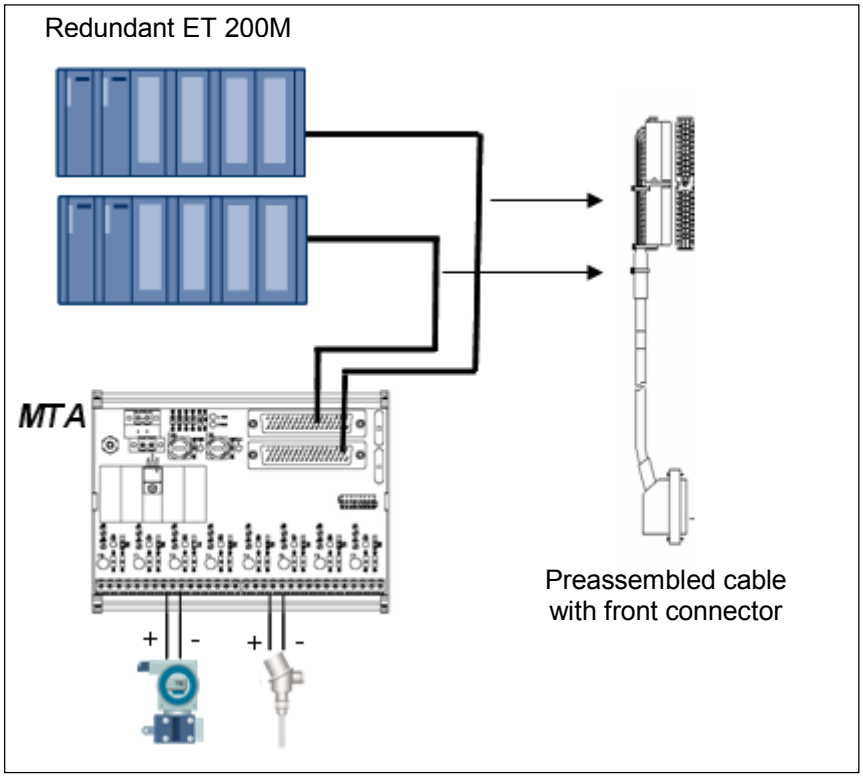
Figure 2-18



2.3 Connection of Marshalled Termination Assemblies

MTA offers the fast and simple connection of the field level to the ET 200M I/O modules. They reduce wiring expenses and prevent errors.

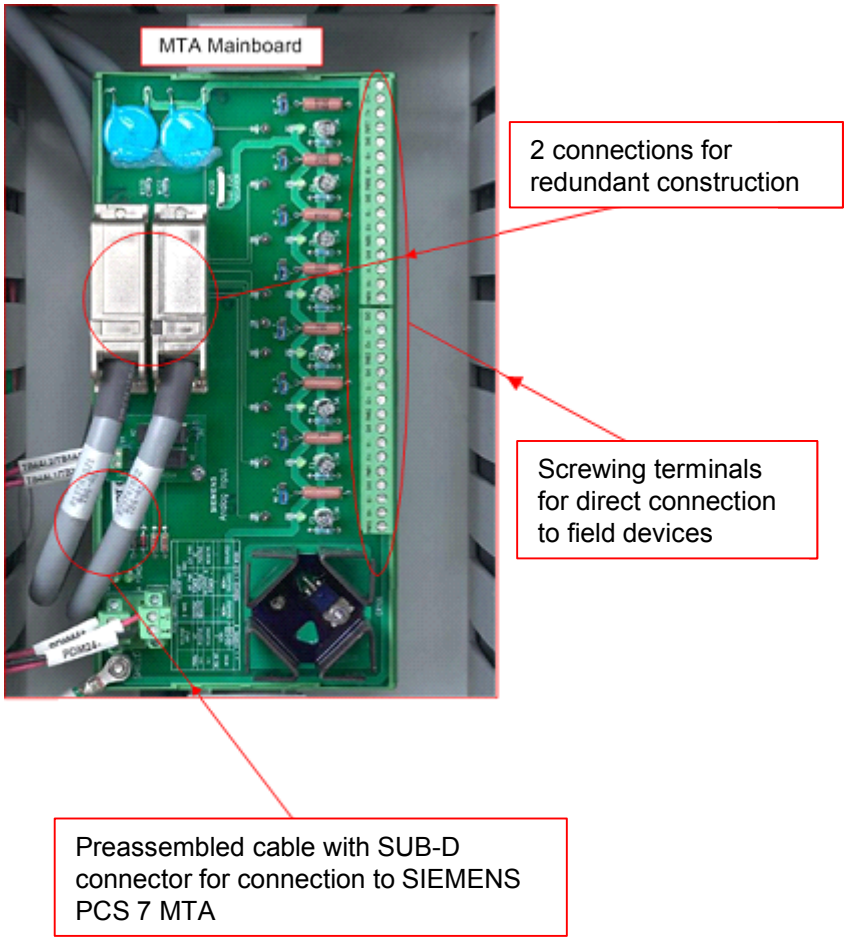
Figure 2-19



Note For a maximum availability with redundant encoders two MTA are required which are switched between the input modules and the encoders respectively.

The connection from ET 200M modules to MTA occurs via the connection cable corresponding to the type, as illustrated in the following figure.

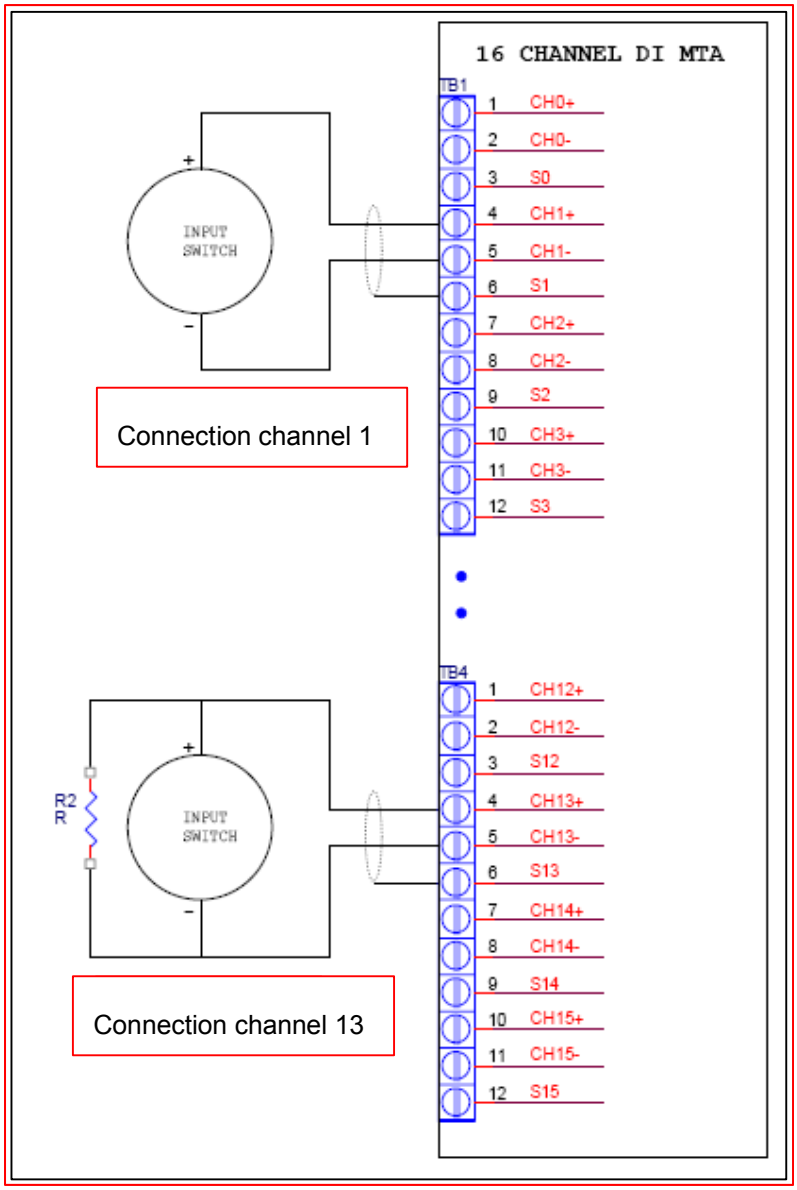
Figure 2-20



Connection example of sensors at the screw-type terminals of the MTA

The following figure shows the encoder connection at the example of digital inputs.

Figure 2-21



Note Further detailed information is available in the manual “Marshalled Termination Assemblies ET 200M Remote I/O Modules”.

3 Configuring the Redundant I/O

The following sections describe the configuration of individual components of the distributed I/O with PCS 7. It is assumed, that a PCS 7 project has been created with an H-station using the project wizard.

The following configuration steps are described:

- Setting the CPU (H parameters)
- Configuring the first ET 200M (interface module IM 153-2)
- Configuration of the individual signal module IOs
- Configuring the second ET 200M by copying
- Redundancy settings at the signal modules
- Symbolic name assignment
- CFC configuration

3.1 Settings at the CPU

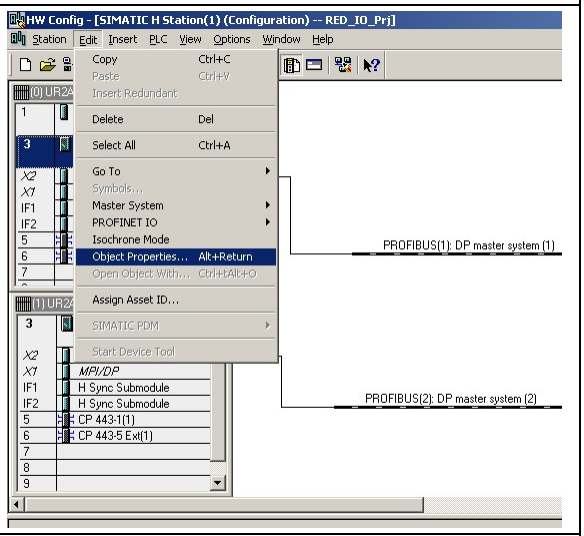
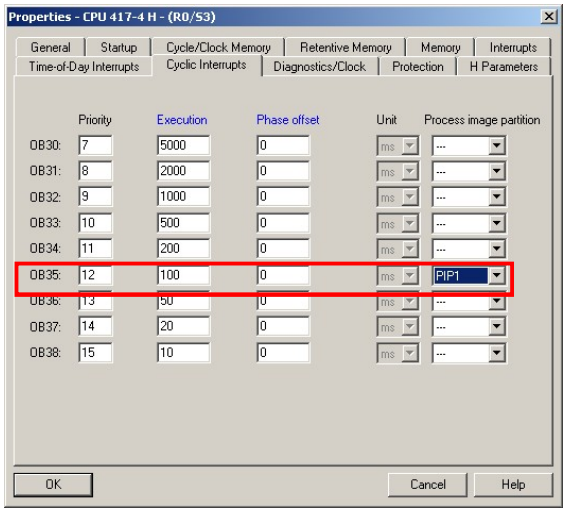
In order to enable the redundant functioning between the AS and the distributed I/O, certain settings need to be made at the CPU.

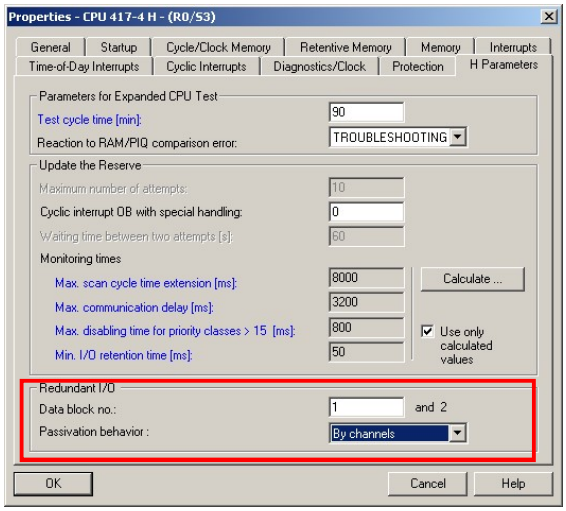
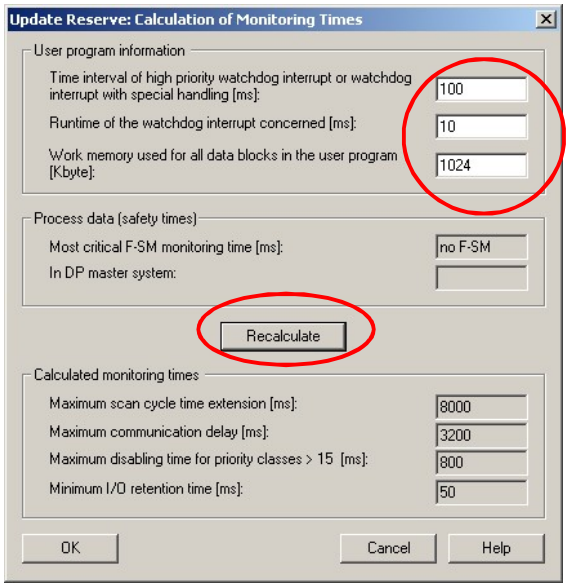
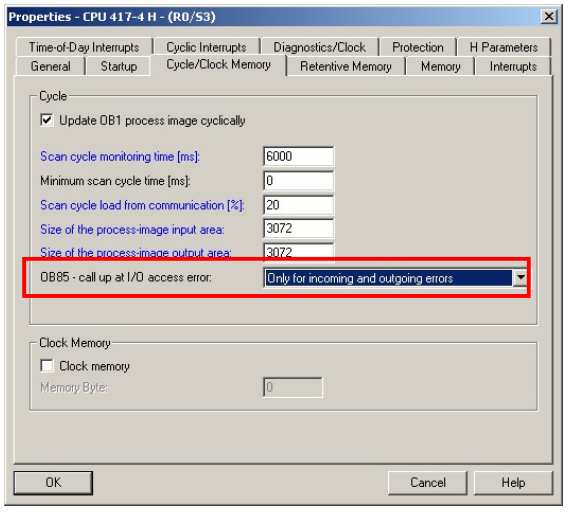
Precondition

- The PCS 7 project with a SIMATIC H station is opened in the SIMATIC Manager.
- If the channel granuar passivation behavior is required, respective signal modules must be used for configuring the ET 200M (see chapter 1.3).

Procedure

Table 3-1

	Activity	Screenshot
1.	Open the SIMATIC H Station in HW Config	
2.	Select the first used CPU on slot 3 of the rack (0) and select the menu item "Edit > Object Properties".	
3.	Switch to the "Cyclic Interrupts" tab. Via the drop-down list you select the desired process image partition for the respective cyclic interrupt OB into which the channel blocks are integrated later on.	

	Activity	Screenshot
4.	Switch to the "H Parameters". Note the used data blocks in the "Data block no." field, which are given as a standard encoder so they cannot be used otherwise in your configuration. From the "Passivation bahavior" drop-down list you select the desired setting (channel granular or module granular). In the field "Update the Reserve" you click the "Calculate..." button. These settings are performed for calculating the monitoring times. Note: Here you set how the redundant input/output modules behave during channel errors (see chapter 1.4). This setting applies to all redundantly configured signal modules connected at the CPU.	
5.	In the dialog field which appears you make all entries in the User program information field and then click the "Recalculate" button. Click OK to close the dialog box. In the properties dialog field of the CPU in the "H Parameters" the new calculated values are now added in "Calculated monitoring times" (see step 4).	
6.	Switch to the "Cycle/Clock Memory" tab. At "OB 85 call for I/O error" you select "Only for incoming and outgoing errors" from the drop-down list. Close the Properties dialog with "OK".	

Note Further information on the settings at the CPU is available in the manual “PCS 7 Fault-tolerant Process Control Systems”.

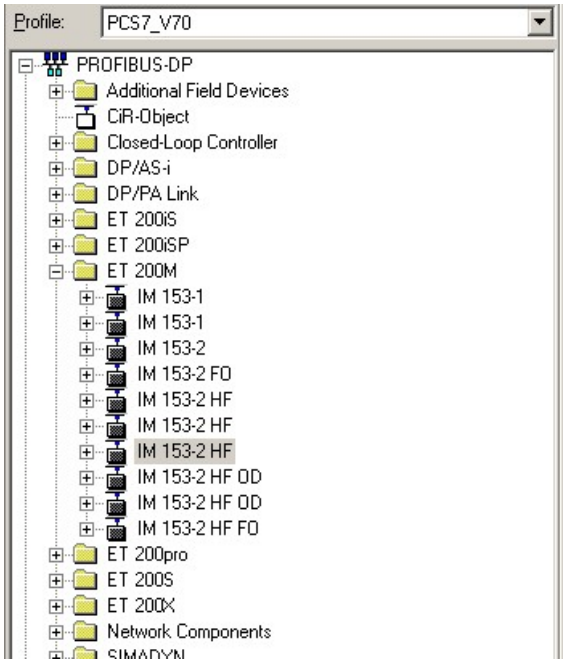
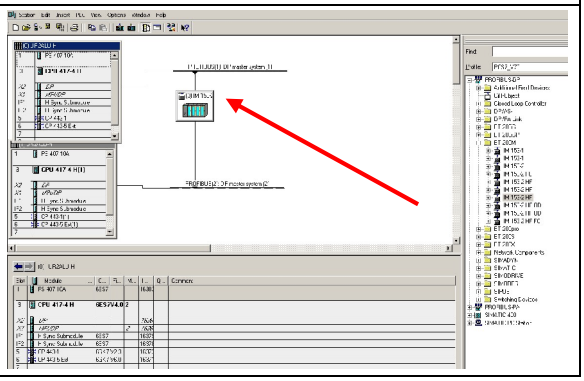
3.2 Configuring the first ET 200M (Interface Module IM 153-2)

Precondition

- The PCS 7 project with a SIMATIC H station is opened in the SIMATIC Manager.
- In HW Config a redundant PROFIBUS DP master system has been configured at the SIMATIC H station.
- The HW Config of the SIMATIC H Station is opened. If the hardware catalog does not appear, please select the menu item "View > Catalog".

Procedure

Table 3-2

	Activity	Screenshot
1.	In the drop-down menu of the hardware catalog you select the current PCS 7 profile in the "Profile" field. In the catalog you double-click "PROFIBUS DP". In "PROFIBUS-DP > ET 200M" of the catalog you select the suitable redundancy capable connection module IM 153-2 and draw it to one of both PROFIBUS DP segments via drag & drop.	
2.	In the "Properties PROFIBUS Interface IM 153-2" you enter the address and click "OK". The connection with the redundant PROFIBUS DP segment is generated automatically.	

3.3 Configuring the signal modules

The procedure for configuring the standard and HART signal modules is explained below.

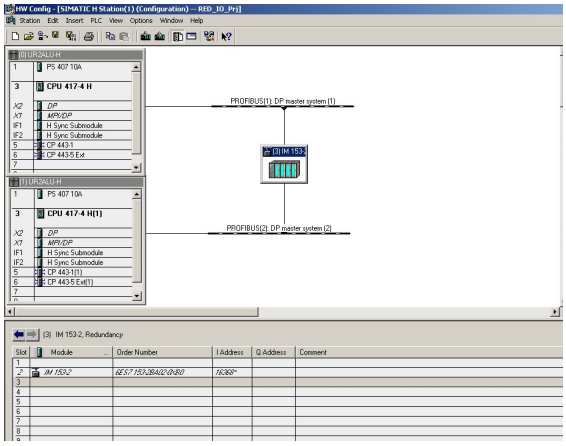
Note Do not add any HART signal modules to the HART field devices as yet. This work step follows in chapter 0.

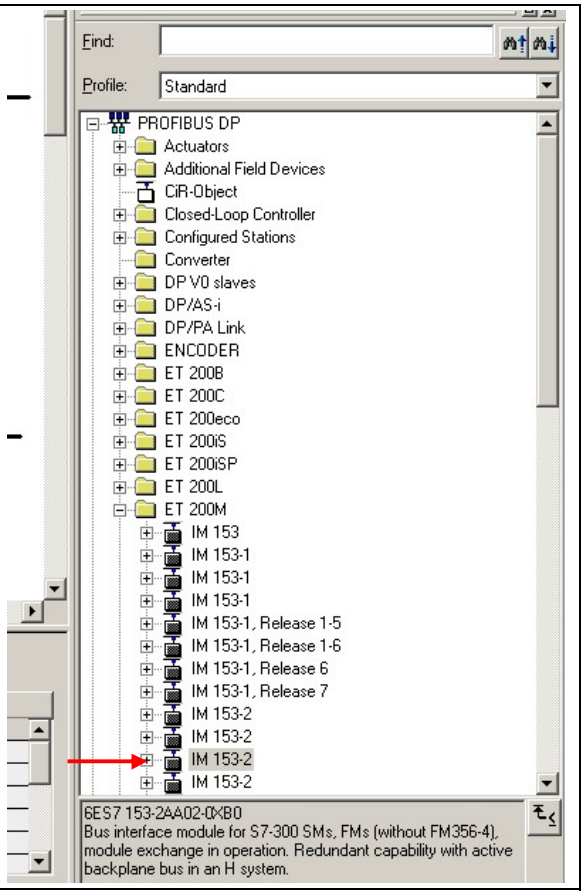
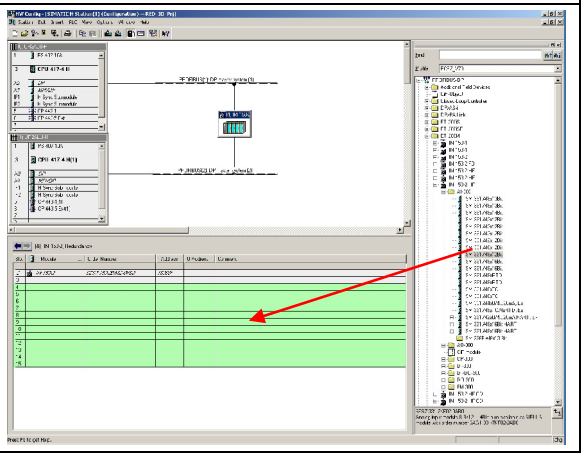
Precondition

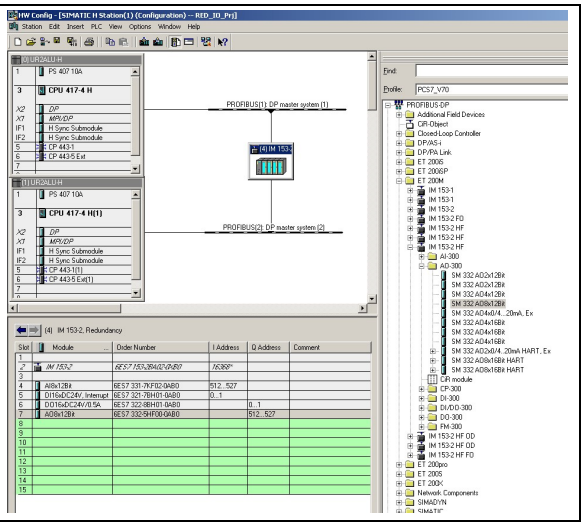
- The PCS 7 project with a H-CPU is created and opened in the SIMATIC Manager.
- In HW Config a redundant PROFIBUS DP master system has been configured at the SIMATIC H Station.
- In HW Config the interface module IM 153-2 has been configured for the ET 200M at the redundant PROFIBUS DP.

Procedure

Table 3-3

	Activity	Screenshot
3.	Select the configured IM 153-2. In the bottom window the module overview is displayed.	

4.	In the hardware catalog at “PROFIBUS-DP > ET 200M” you select the interface module which you have already moved to the PROFIBUS DP master system via drag & drop.	
5.	In the sub-directories you select a redundancy capable signal module and move it to a free slot of the IM 153-2 (module overview) via drag & drop.	

6.	Repeat steps 1-3 for further signal modules.	

3.4 Configuring the second ET 200M

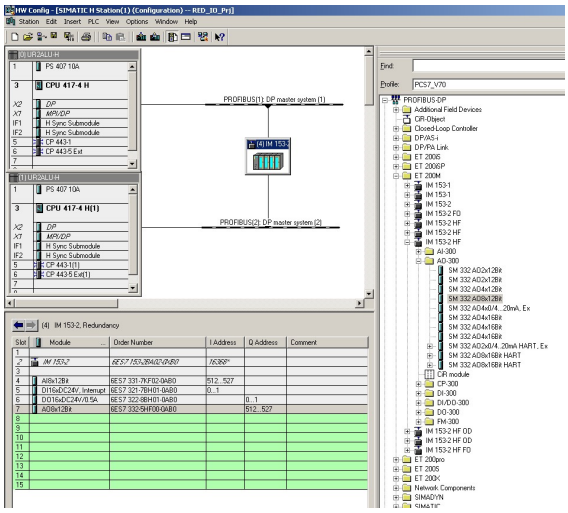
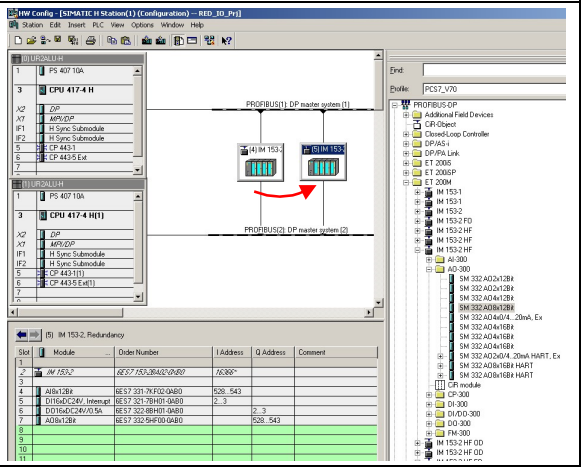
After configuring the first ET 200M including all required components (interface module IM 153-2, signal modules), you must now configure the second redundant ET 200M. It must be noticed here, that a redundant operation is only possible with modules of equal MLFB. To avoid configuration errors, it makes sense to copy the first ET 200M and reinsert it into the same master system.

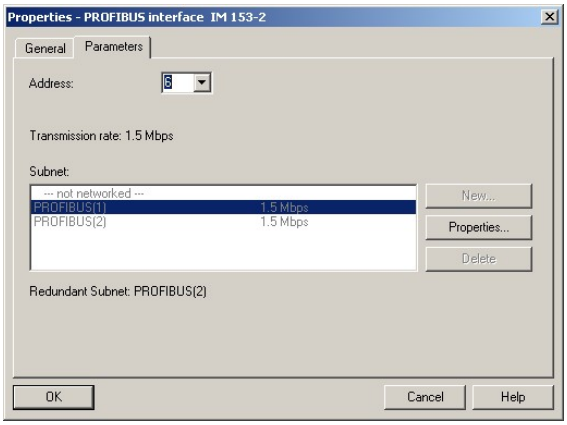
Precondition

- The PCS 7 project with a H-CPU is created and opened in the SIMATIC Manager.
- In HW Config a redundant PROFIBUS DP master system has been configured at the SIMATIC H Station.
- In HW Config the interface module IM 153-2 has been configured for the ET 200M at the redundant PROFIBUS DP.
- All required signal modules have been configured.

Procedure

Table 3-4

	Activity	Screenshot
1.	HW Config is opened. Select the already configured ET 200M and copy it into the clipboard.	
2.	Select on of the PROFIBUS DP segments and add the copied ET 200M.	

	Activity	Screenshot
3.	In the “PROFIBUS Interface IM 153-2” Properties dialog you assign the address of the redundant slave and click “OK”. Ensure that this address differs from the address of the first ET 200M.	

3.5 Settings at the signal modules

After both ET 200M stations have been configured, various settings need to be made at the standard and HART signal modules next.

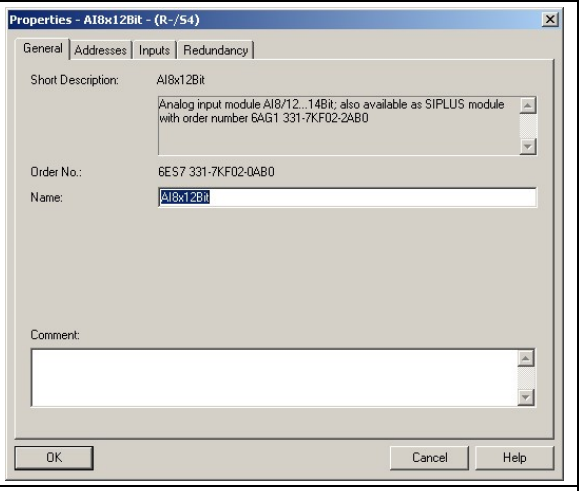
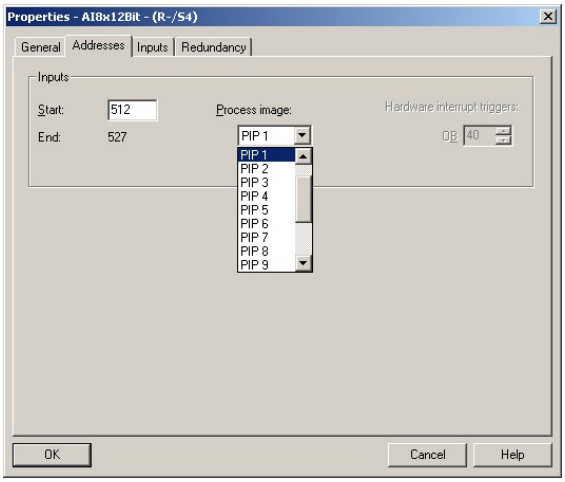
Redundant modules must lie in the process image of the inputs or the outputs. Redundant modules must only be accessed via the process image.

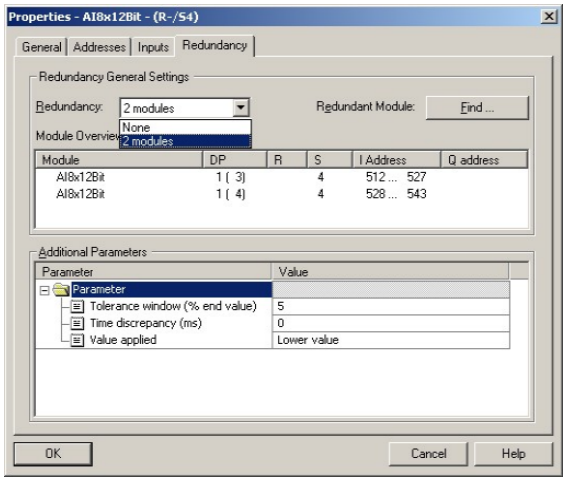
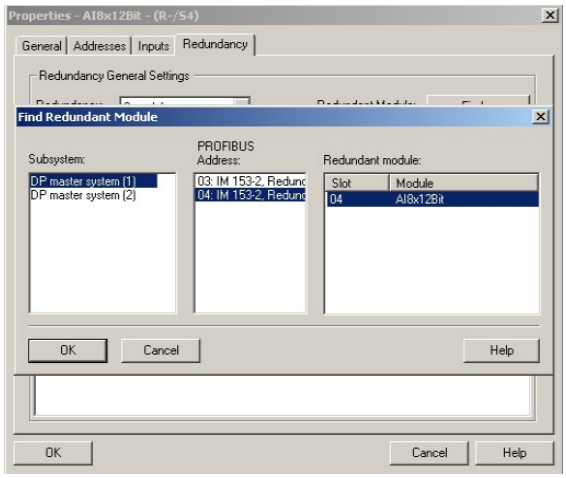
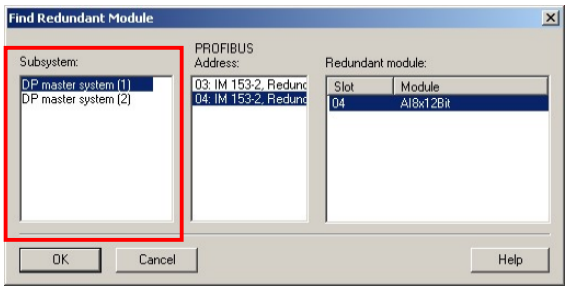
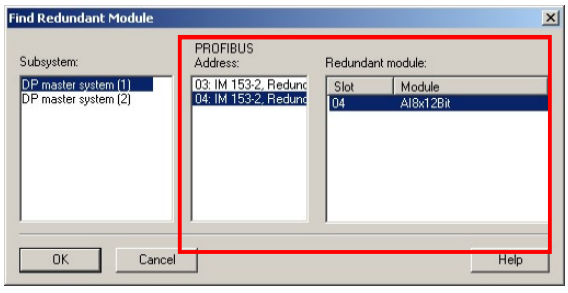
Precondition

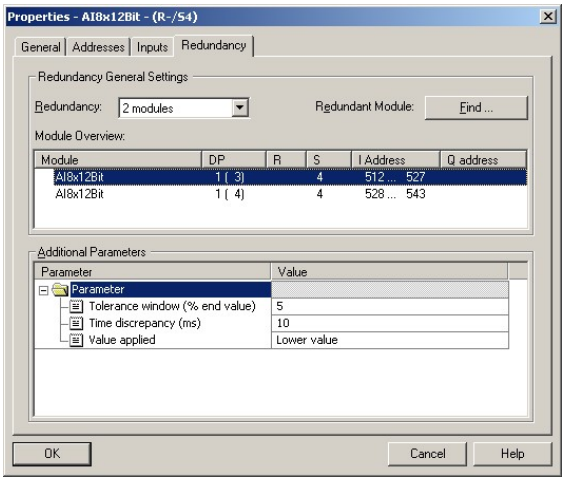
- The PCS 7 project with a H-CPU is created and opened in the SIMATIC Manager.
- In HW Config a redundant PROFIBUS DP master system has been configured at the SIMATIC H Station.
- In HW Config the interface module IM 153-2 has been configured for the ET 200M at the redundant PROFIBUS DP.
- All required signal modules have been configured.
- The redundant ET 200M was configured.

Procedure

Table 3-5

	Activity	Screenshot
1.	HW Config is opened. Select the first IM 153-2 again. Double-click on a signal module in the module view. The dialog “Properties” of this module is opened.	
2.	Switch to the “Addresses” tab. In the “Process image” drop-down list you select the desired process image partition.	

	Activity	Screenshot
3.	Then you select the “Redundancy” tab. In the “Redundancy” drop-down list you select the entry “2 modules”.	
4.	Click the “Find...” button. The dialog “Find Redundant Module” opens.	
5.	In the “Subsystem” box you select the DP master system in which the redundant signal module is configured. In the “PROFIBUS address” field, all PROFIBUS addresses available at this DP master system are displayed.	
6.	In the “PROFIBUS Address” box you select the IM 153-2 in which the redundant signal module is configured. In the “Redundant module” field the redundancy capable signal modules available in this IM 153-2 are displayed, for which no redundancy has yet been configured. In the “Redundant module” field you select the signal module which is to be used as redundant signal module and click the “OK” button.	

	Activity	Screenshot
7.	In the “Module Overview” box, the redundant signal modules are now listed. You can now set additional parameters (see chapter 3.6 “Additional parameter settings for configuration of redundant AI modules”). These additional parameters are only set for the input modules DI and AI. Click the “OK“ button to accept the settings. Use the button “Help”.for information regarding the additional parameters.	
8.	For redundant switching of all desired signal modules repeat steps 1 to 7.	

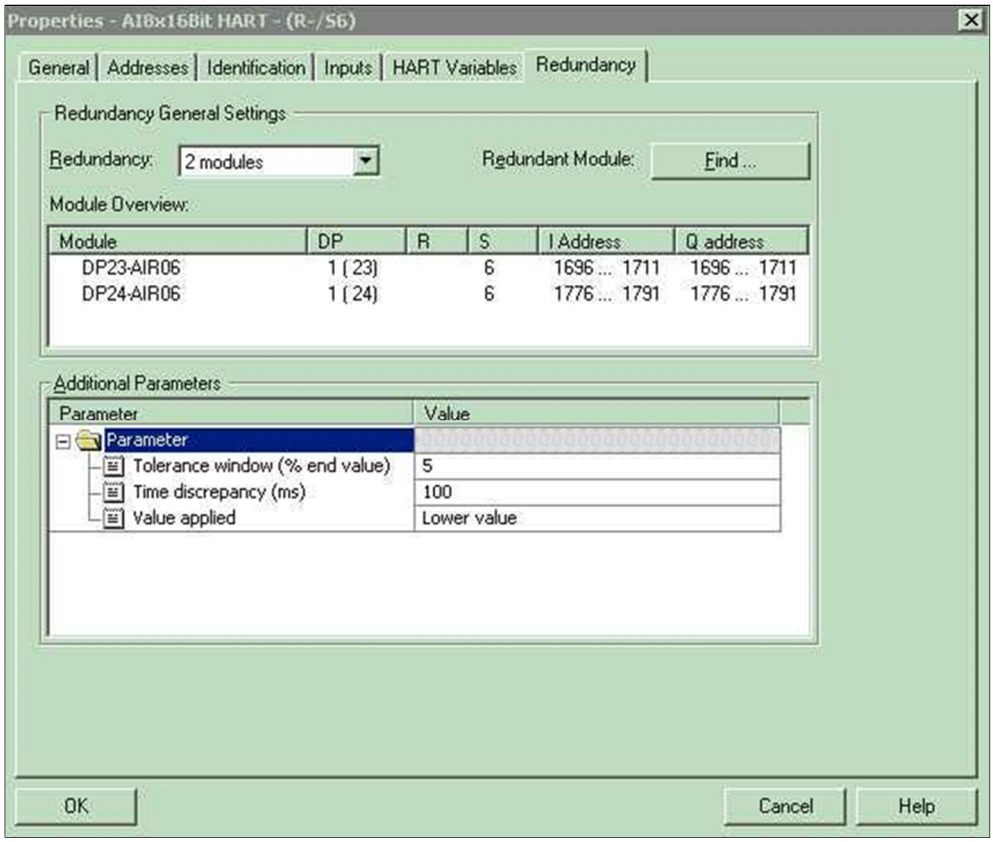
3.6 Additional parameter settings for configuration of redundant AI modules

The purpose of this chapter is to give some support on the various parameters that have to be set when configuring redundant AI modules.

There are two main parts to consider:

- Special redundancy related parameters in HW Config
- Time or cycle considerations

Figure 3-1



Help of “Redundancy” Tab of AI Module

- Tolerance window
  Configured as a percent of the end value of the measuring range.
  Two analog values are regarded as the same when they within the tolerance window.
- Discrepancy time
  Maximum allowed time in which the redundant input signal can be outside the tolerance window. The set discrepancy time must be a multiple of the update time of the process image and therefore also the basic conversion time of the channels. If there is an input value discrepancy after expiration of the configured discrepancy time, there is an error.
- Applied value
  The applied value is the value from the two analog input values that is entered into the user program.

Discrepancy time / Time discrepancy

As described in the help of the AI module, the discrepancy time should be a multiple of the update time. In order to calculate the update time the following parameters have to be considered:

- Update time of the AI module
- Cycle time of the PROFIBUS (can be ignored if the Baud rate is set to 1.5 MBps or higher)
- Update time of the PIP

The update time of an analogue value from an analogue input card like 6ES7 331-7TF01-0AB0 can be taken from Table 3-6: “Analog value parameters”. First the parameter “Integration time/ interference frequency suppression” has to be selected. Secondly the number of used channels needs to be considered.

Table 3-6: Analog value parameters

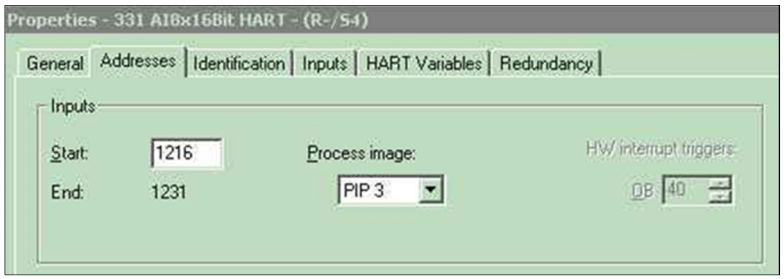
Analog value generation			
Measurement principle	**SIGMA DELTA**		
Integration time/ interference frequency suppression (per channel)	60 Hz	50 Hz	10 Hz
Integration time error	± 0.05%	± 0.04%	± 0.02%
Integration time in ms	16,6	20	100
Basic conversion time including integration time in ms (per channel)	55	65	305
Basic execution time of the module, in ms (all channels enabled)	440	520	2440
Smoothing of the measured values	**Step:** None Weak Medium Strong	**Time constant:** 1 x cycle time *** 4 x cycle time *** 32 x cycle time *** 64 x cycle time ***	**Max. Module cycle:** 2.44 s 9.76 s 78.08 s 156.16 s

Table 3-7: Update Time Calculation Examples

Integration time/ interference frequency suppression	Number of used channels	Update time module
50 Hz	1	65 ms
50 Hz	4	260 ms
50 Hz	8	520 ms
10 Hz	1	305 ms
10 Hz	4	1220 ms
10 Hz	8	2440 ms

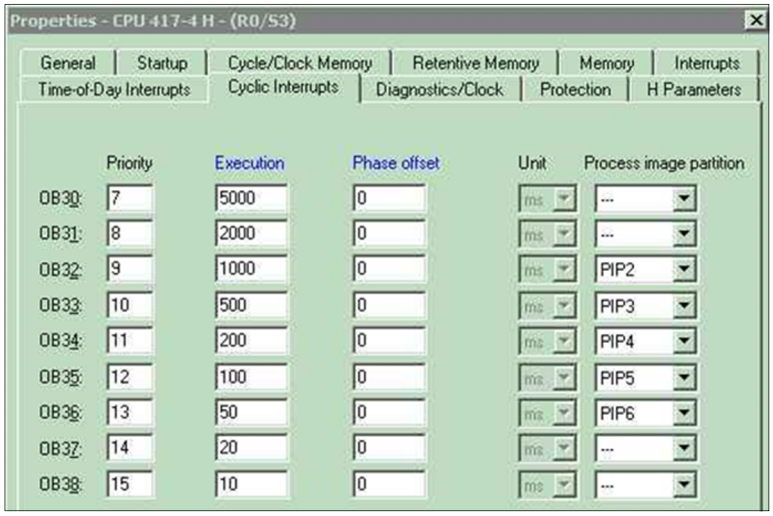
In order to get the update time of the PIP in the first step the assigned PIP for the relevant AI module has to be found from the settings in HW Config like shown in the following picture:

Figure 3-2



In a second step the cycle time can be found in the properties of the CPU. In this example the PIP update time is 500 ms for the used PIP 3.

Figure 3-3



Calculation of the total discrepancy time:

Time $_{Discrepancy}$ = 2 * (Time $_{module}$ + Time $_{PIP}$)

The factor 2 is the minimum factor to be used. If process conditions allow for a higher value a factor of 3 or 4 could be used.

Table 3-8. Discrepancy Time Calculation Examples

Parameters	Discrepancy time to be set
50 Hz, 1 channel, PIP = 500 ms	1130 ms
50 Hz, 4 channels, PIP = 500 ms	1520 ms
50 Hz, 8 channels, PIP = 500 ms	2040 ms
10 Hz, 8 channels, PIP = 500 ms	5880 ms

Special consideration, if the channels of one module are assigned to two different integration times (50 Hz and 10 Hz):

In this case the worst case has to be calculated. I. e. the calculation has to be done with 10 Hz.

Tolerance Window

Depending on the quality of the field signals the tolerance window should be set to 5% to 20%.

General time or cycle considerations

Redundant modules must only be accessed via the process image.

Details, how to configure the I/O modules can be found in Chapter 3.5 “Settings at the signal modules”.

Attention must be paid that both modules of a redundant pair are assigned to the same process image partition.

The relevant channel driver should either be placed in the same cycle as the process image partition or in a slower cycle. Faster than process image partition does not make sense.

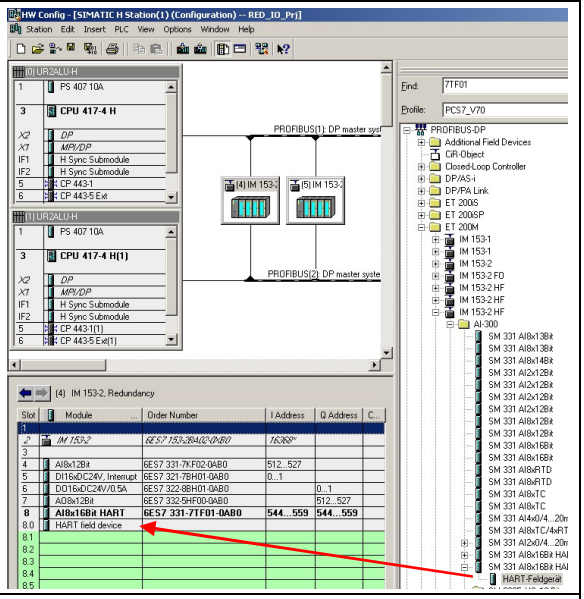
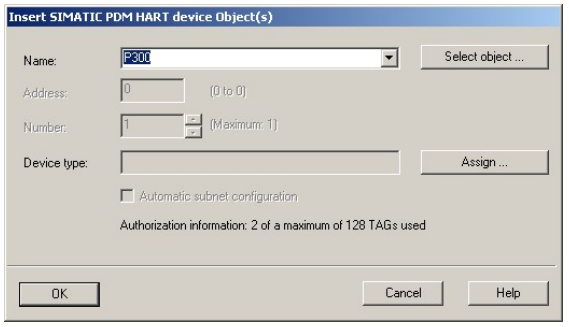
3.7 Configuring the HART field devices

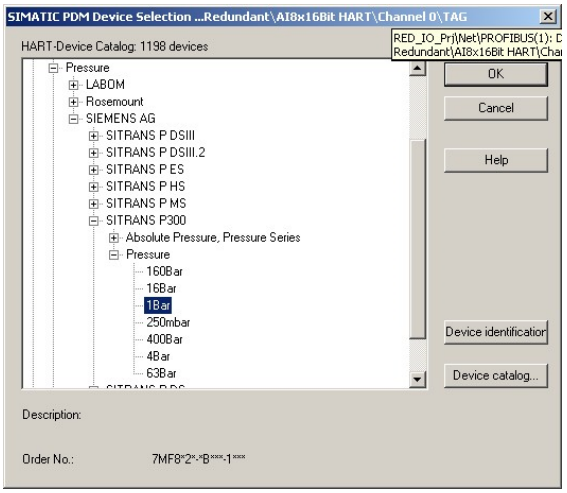
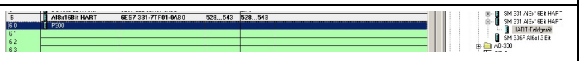
Precondition

- The PCS 7 project with a H-CPU is created and opened in the SIMATIC Manager.
- In HW Config a redundant PROFIBUS DP master system has been configured at the SIMATIC H Station.
- In HW Config the interface module IM 153-2 has been configured for the ET 200M at the redundant PROFIBUS DP.
- All required signal modules have been configured.
- The redundant ET 200M was configured.
- Settings at the signal modules have been made

Procedure

Table 3-9

	Activity	Screenshot
1.	HW Config is opened. In the hardware catalog you select the HART field device and drag it to a free slot of the HART module in the Module Overview via drag & drop.	
2.	Double-click the HART field device. In the dialog field which appears you assign a name and click on "Assign..".	

	Activity	Screenshot
3.	In the “Device Selection” dialog which appears you select the respective device and click “OK”.	
4.	Again you select the HART field device in the Hardware catalog and drag it to a free slot of the redundancy partner (HART module of the second ET 200M) via drag & drop. After brief loading, the configured field device of the first ET 200M is automatically assigned.	

3.8 Symbolic name assignment

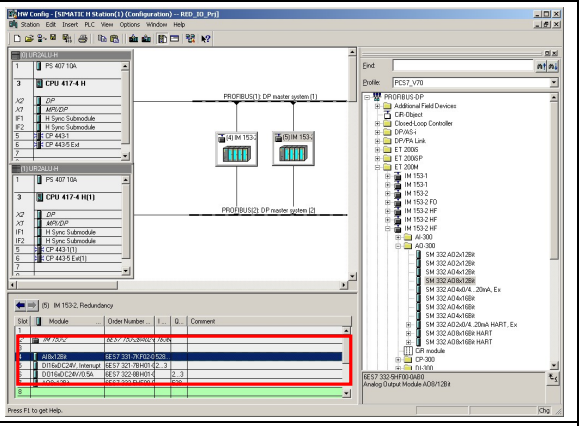
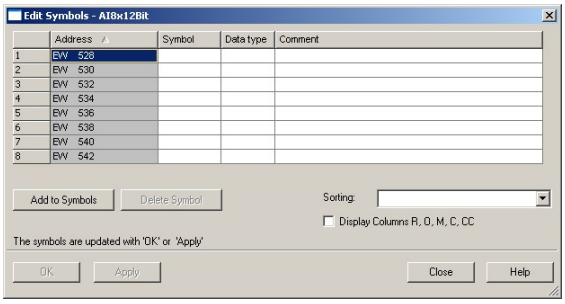
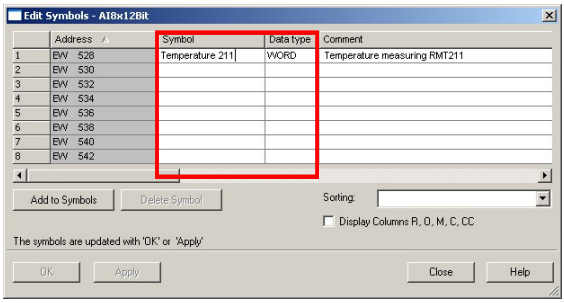
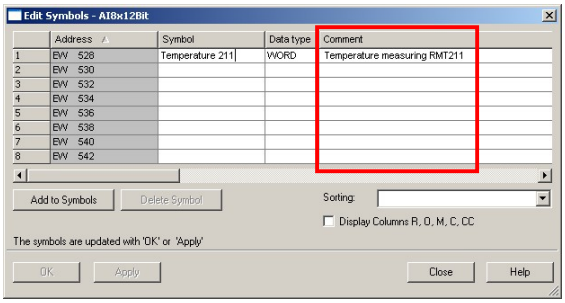
Symbolic name assignment requires that the input/output modules in HW Config have been added. If this has happened, you can assign self-explanatory symbolic names to the inputs and outputs of these modules. You use these names for connecting CFC plans with the input and output modules.

Precondition

- The PCS 7 project with a H-CPU is created and opened in the SIMATIC Manager.
- In HW Config a redundant PROFIBUS DP master system has been configured at the SIMATIC H Station.
- In HW Config the interface module IM 153-2 has been configured for the ET 200M at the redundant PROFIBUS DP.
- All required signal modules have been configured.
- The redundant ET 200M was configured.
- Settings at the signal modules have been made

Procedure

Table 3-10

	Activity	Screenshot
1.	HW Config is opened. In the work space you select one of both IM 153-2 interface modules. In the Module Overview all input/output modules are displayed which you have added during the hardware configuration.	
2.	In the Module Overview you select the first signal module e.g. "AI8x16Bit".	
3.	Select the menu command "Edit > Symbols". The dialog "Edit Symbols" opens. All absolute addresses of the inputs of this module are given to you in the list.	
4.	Place the cursor into the "Symbol" column next to address "EW 512", for example. Enter "Temperatur211", for example, and press the "TAB" button. The entered value will be accepted and the system automatically enters the data type "WORD".	
5.	Change to the "Comment" column. Here you can enter a suitable comment, or position the cursor in the "Symbol" column in the next line by pressing the "TAB" button again.	
6.	If necessary you edit further symbols and save your input by clicking the "OK" button. The "Edit Symbols" dialog is closed.	

	Activity	Screenshot
7.	In the Module Overview you successively select the individual signal modules and assign the symbolic names. To do this, please follow steps 2 to 6.	

3.9 CFC configuration

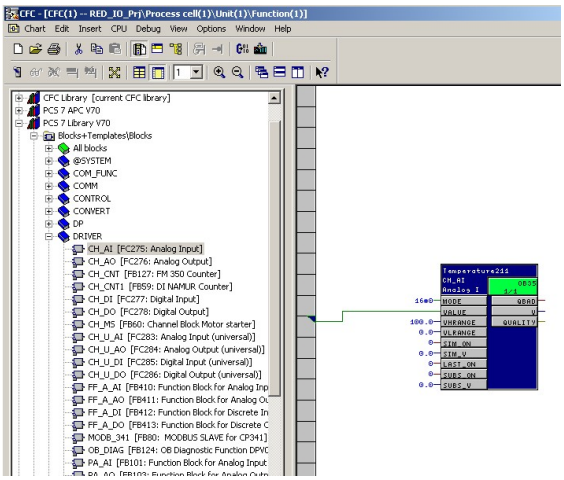
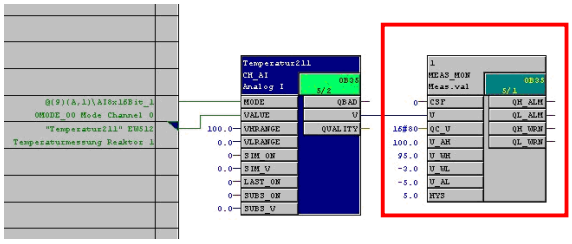
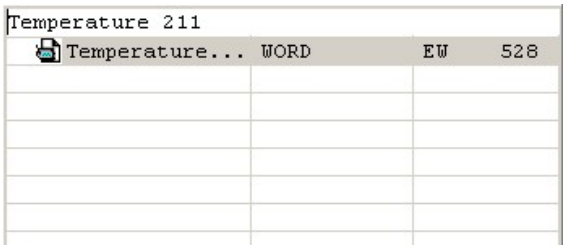
After you performed all necessary configurations, it is now necessary to create CFC plans. Hereby the input/output modules are interconnected with the respective channel blocks.

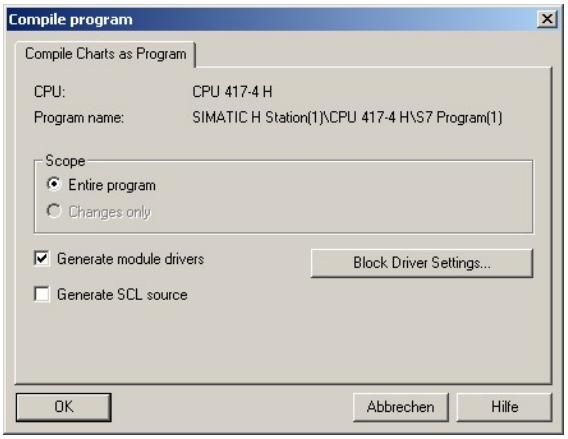
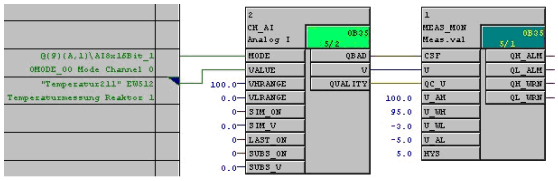
Precondition

- All necessary input/output modules were configured in HW Config and the respective symbols were assigned.
- CFC plan was created and is opened.

Procedure

Table 3-11

	Activity	Screenshot
1.	In the bottom left window pane you select the "Libraries" tab. Here you select the path "*PCS 7 Library V70 > Blocks+Templates\Blocks > Driver*". Depending on input/output module you now draw the driver block CH_AI, CH_AO, CH_DI or CH_DO into your plan via drag & drop.	
2.	If necessary you draw further blocks into your plan to interconnect them. For temperature measurement, for example, you can interconnect the channel block with a MEAS_MON, in order to have the temperature displayed during runtime later on.	
3.	For interconnecting the channel block with your configured input/output module you select the block and click the "`Value`" button of the channel block and open the menu command "`Insert > Interconnection to Address`". A symbol table opens.	
4.	Click the respective symbol you wish to connect the block with. Here you can select the symbols you have assigned in HW Config during symbol assignment (see chapter 3.8).	

	Activity	Screenshot
5.	During final compilation the module drivers for the respective modules are generated automatically. It must be ensured that “Generate module drivers” is check-marked in the appearing “Compile program” dialog window.	
6.	As a result, the MODE input of the channel block is interconnected with the @-plans automatically generated by the system.	

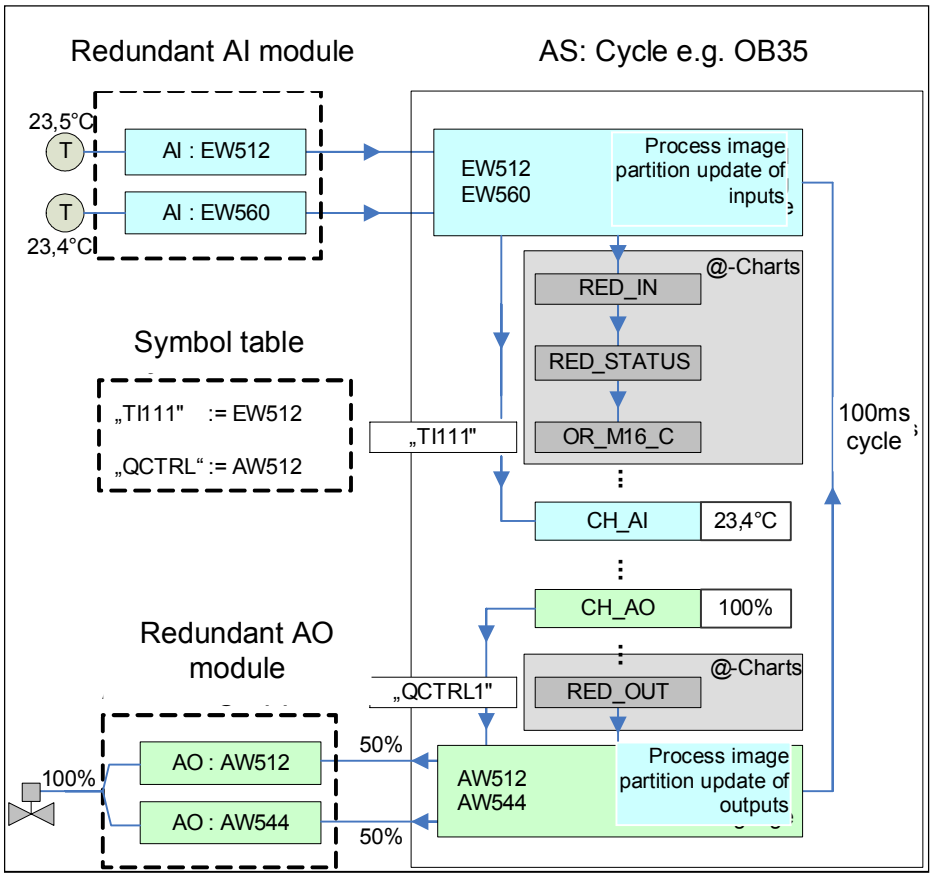
4 Function Mechanisms

4.1 Example of a process sequence

The following figure gives an example of a process sequence for redundant input/output modules and the signal processing in the AS.

NOTE The example shows the use of two sensors. In the process industry the wiring of a sensor to a redundant module pair is also typical (see chapter 2.2 "Redundant connections of the distributed I/O").

Figure 4-1



Description of the upper part of the process sequence

In the upper part, two temperature measuring values are recorded by two encoders via redundant AI modules and are written into the process image partition of the inputs via two addresses (EW512, EW560).

Depending on the setting of the accepted value (see additional parameter Table 3-5 point 7) the smaller or larger value is written to the channel block CH_AI via the respective symbol “TI111” in the user program.

The diagnosis and redundancy evaluation is performed via the @-charts, in which also the blocks of the redundant IO CGP (RED_IN, RED_STATUS, etc.) and from the PCS 7 Library (OR_M16_C) are located. The block OR_M16_C forwards the respective diagnosis or redundancy status to the channel block CH_AI.

Depending on the status the respective redundancy message characteristics (OR_M16_C, see below) will result automatically.

Description of the bottom part of the process sequence

In the bottom part of the process sequence a control valve is controlled by two redundant analog output modules.

Note Redundant operation is only possible for output modules with current outputs (0…20mA, 4…20mA). See chapter 2.2.4 “Analog output”.

From channel block CH_AO a value is written to the previously configured symbol “QCTRL1” into the process image partition of the outputs. Information is evaluated and respective values are output by the system via the @-charts and especially via the RED_OUT. This is handled by the process image partition of the outputs (addresses AW512 and AW544).

The output value is halved and half of the value each is output by both channels. If a channel or a module fails, this will be detected and the still remaining channel or module will output the complete value.

The output value will for a short time drop down to half, however, after the reaction in the program (milliseconds) it will be raised to the proper value. Due to the inertia of the final control element this has no effect on the process.

This process sequence is repeated cyclically depending on the call and the cycle time of the managed OB (in this case OB35→every 100 ms).

4.2 Library functions

The bocks/functions used from PCS 7 Library and Redundant IO CGP are described below.

4.2.1 PCS 7 Library

OR_M_16C

Block OR_M_16C is used to form a value status, channel granular, of two redundant signal modules.

MOD-D1

Block MOD_1 monitors the non-diagnosis capable, maximal 16-channel S7-300/400 SM module (no mixed groups).

For H systems, only modules in switched module racks are supported.

4.2.2 Redundant IO CGP

RED_IN

The FB 450 handles the reading of signals of the redundant input I/O (DI, AI), which is assigned to the process image partition of the priority class of the calling OB.

The FB 450 performs a discrepancy analysis of the redundant input I/O and saves the valid value to the lower address in the process image of the inputs (PAE). The user must only access this one in his application. The PAE of the high module is irrelevant.

RED_STATUS

The FB 453 “RED_STATUS” provides an interface block and contains information regarding the passivation of blocks.

RED_OUT

The FB 451 outputs those redundant I/O signals which are assigned to the process image partition of the priority class of the calling OB.

RED_DIAG

The FB 452 RED_DIAG evaluates the start information of individual error and diagnosis OBs to point to a respective processing sequence.

It is called in acyclic OBs (e.g. OB 82, OB 85).

RED_DEPA

With this function a depassivation is triggered by the user program.

The FC checks whether a redundant module or a channel is passivated. If a module or a channel is passivated, an overall depassivation is triggered in FB 450 “RED_IN”. In a different case (there is no passivation of a module or a channel) processing of FC 451 is terminated immediately.

The function is called in acyclic OBs (e.g. OB 82, OB 85).

RED_INIT

The I/O redundancy is initialized during the startup of an H system using the FC 450 “RED_INIT”.

When called up, the FC 450 creates administration data blocks for the functional I/O redundancy and assigns them with default values or it updates already existing administration DBs. The function triggers an overall depassivation which is then executed in FB 450 “RED_IN”.

The function is called in acyclic OBs (e.g. OB 82, OB 85).

4.3 OS messages of the modules

The following module elements are created in the OS by means of OS compilation.

Redundancy message characteristics (OR_M_16C)

- BG x/y/z: failure of module redundancy pair
- BG x/y/z: modules redundancy loss
- BG x/y/z: module status cannot be determined
- BG x/y/z: discrepancy time has elapsed
- BG x/y/z: failure of redundancy pair channel xx

Table 4-1

Letter	Description
X	DP master system no.
Y	Y - DP slave address
Z	Z – slot no
XX	Channel no

Message characteristics of a diagnosis capable module (MOD_D1)

- Possible module errors (output parameter QMODF = TRUE):
  - External auxiliary voltage missing
  - Front connector missing
  - Module not configured
  - wrong parameters in module
  - Module missing/wrong
  - Communication failure CPU module
  - Time monitoring responded (watch-dog)
  - BG internal supply voltage failed
  - Module rack failure
  - Processor failure
  - EPROM error
  - RAM error
  - ADU/DAU error
  - Fuse tripped
  - Power supply 1: error
  - Power supply 2: error
- Possible channel failure (value status "invalid value", OMODE_xx = 16#00xxxx):
  - Configuration/parameterization error
  - Common mode error, only analog input/output
  - P short-circuit
  - M short-circuit
  - Output transistor interrupted
  - Wire break
  - Reference channel error (only analog input)
  - Below measuring range (only analog input)
  - Above measuring range (only analog input)
  - Load voltage missing (only analog and digital output)
  - Encoder voltage missing (only digital output)
  - Fuse tripped (only digital output)
  - Mass error (only digital input/output)
  - Overtemperature (only digital output)

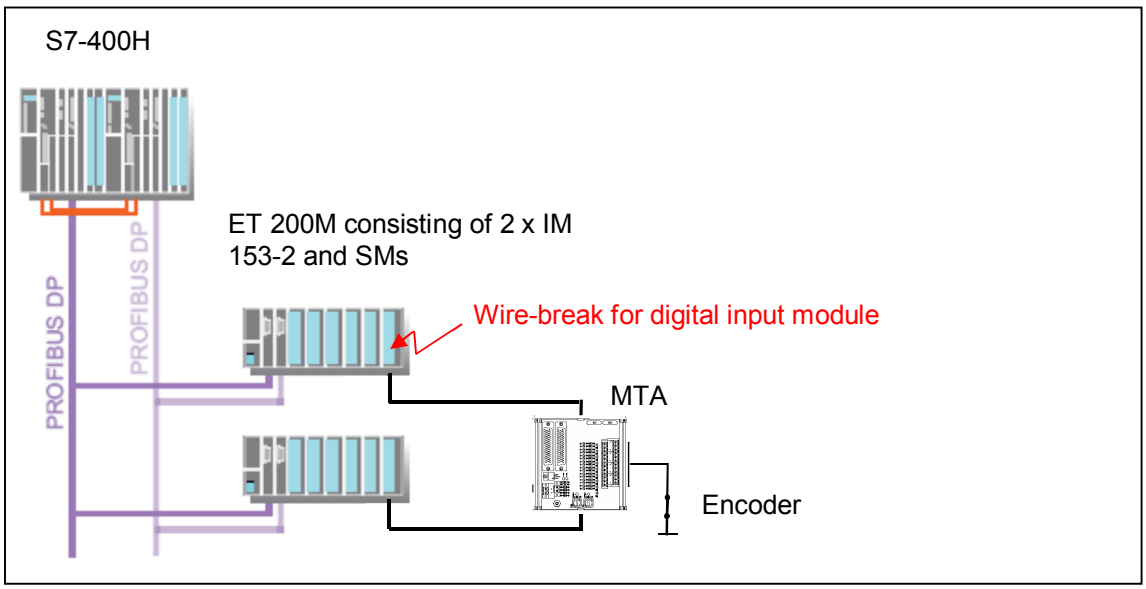
5 Diagnosis

In this chapter an example for the diagnostic possibilities with PCS 7 is illustrated with regards to redundant I/O.

5.1 Error scenario

Within the running system a channel error due to wire break at a digital input module is simulated.

Figure 5-1



It must be noted, that in this example channel granular components are used. The wire-break at a connection of the digital input module does therefore not passivate the entire module, but only the faulty channel (or channel group). The following diagnosis options exist for the error:

- OS messages
- Asset management
- HW Config
- CFC test mode

In the practical environment the error first becomes visible for the operator in the control center on the OS. There, the maintenance engineer will first have the respective message list displayed to him.

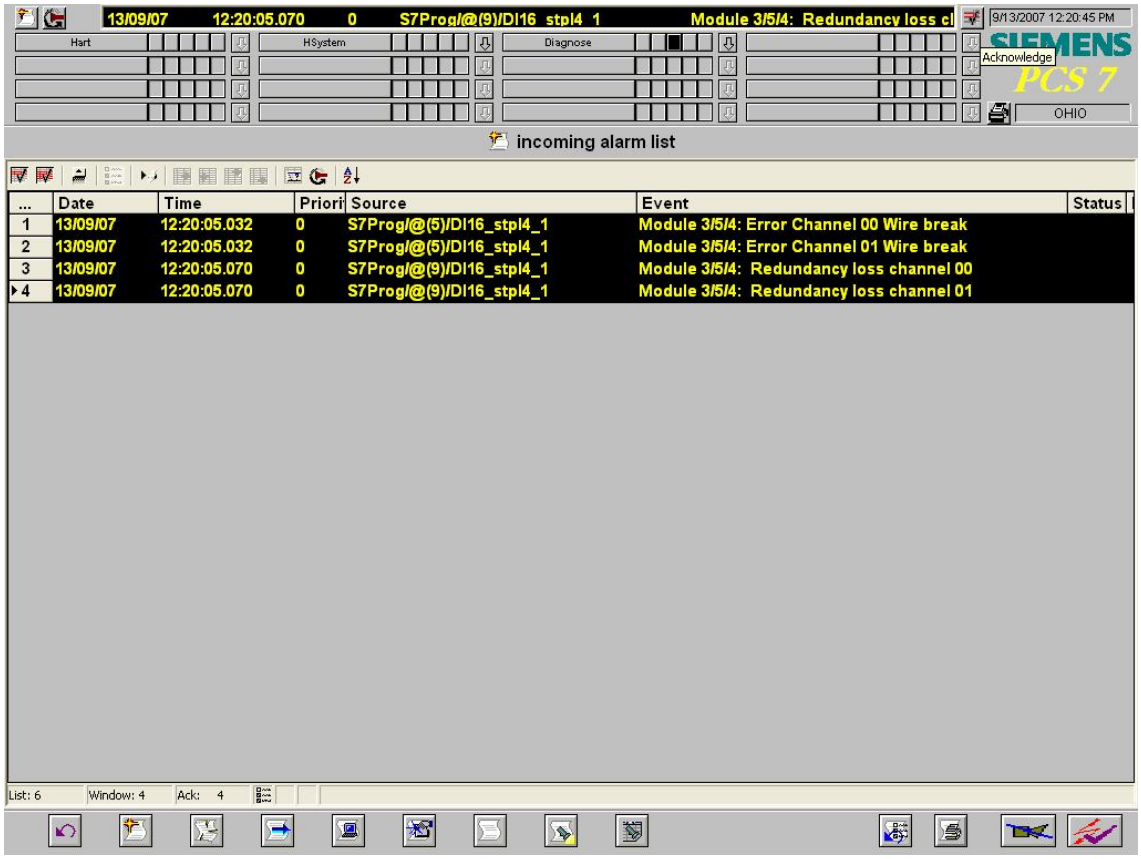
Parallel he receives further information on the status of the signal module via the asset management. From the asset management there is the option to switch to HW Config via a button in order to receive further diagnostic entries in the module status of H-CPU and signal module.

Parallel, further status values of the signal module are available in the CFC test mode.

5.2 OS messages

In the OS you will receive respective error messages via the Incoming alarm list button.

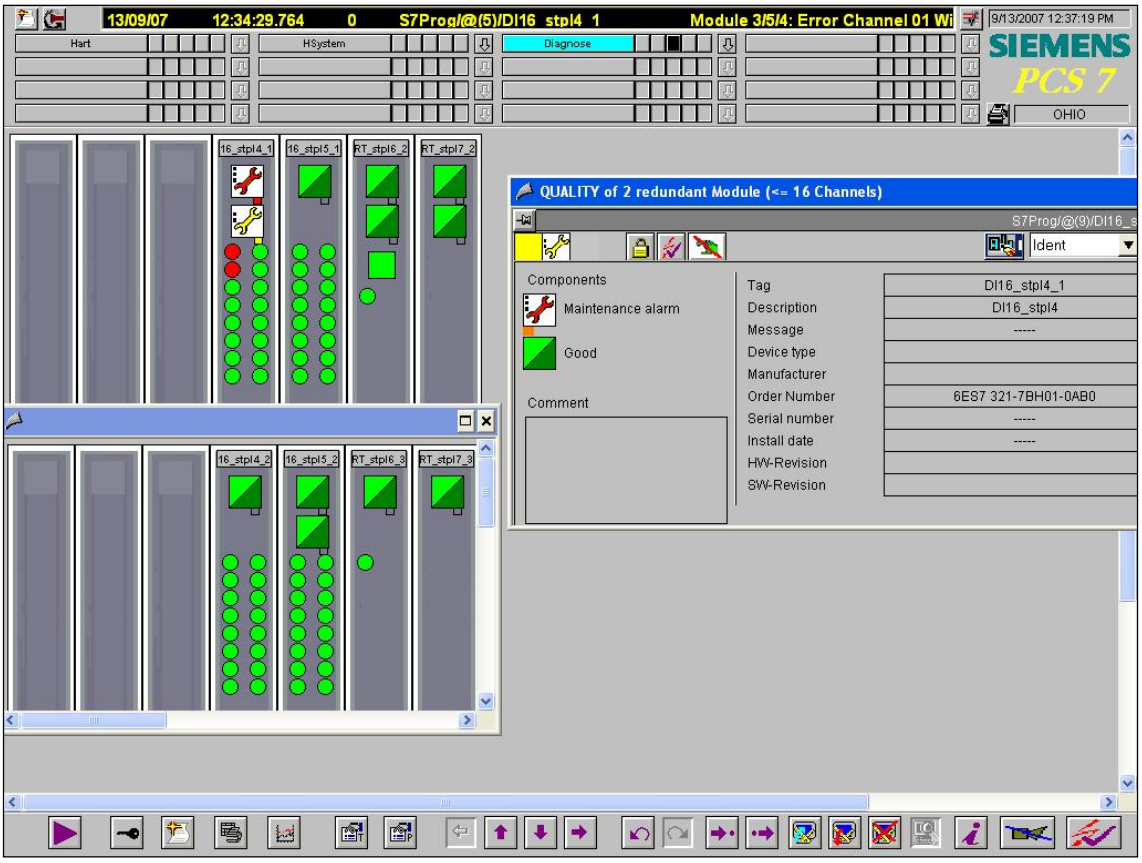
Figure 5-2



5.3 Asset Management

If Asset Management has been implemented in your PCS 7 project, then you also receive information on errors of the redundant I/O.

Figure 5-3



Note Further information is available in the manual “Process Control System PCS 7 V7.0 Asset Management” in the chapter “Passivation/depassivation of redundant modules”.

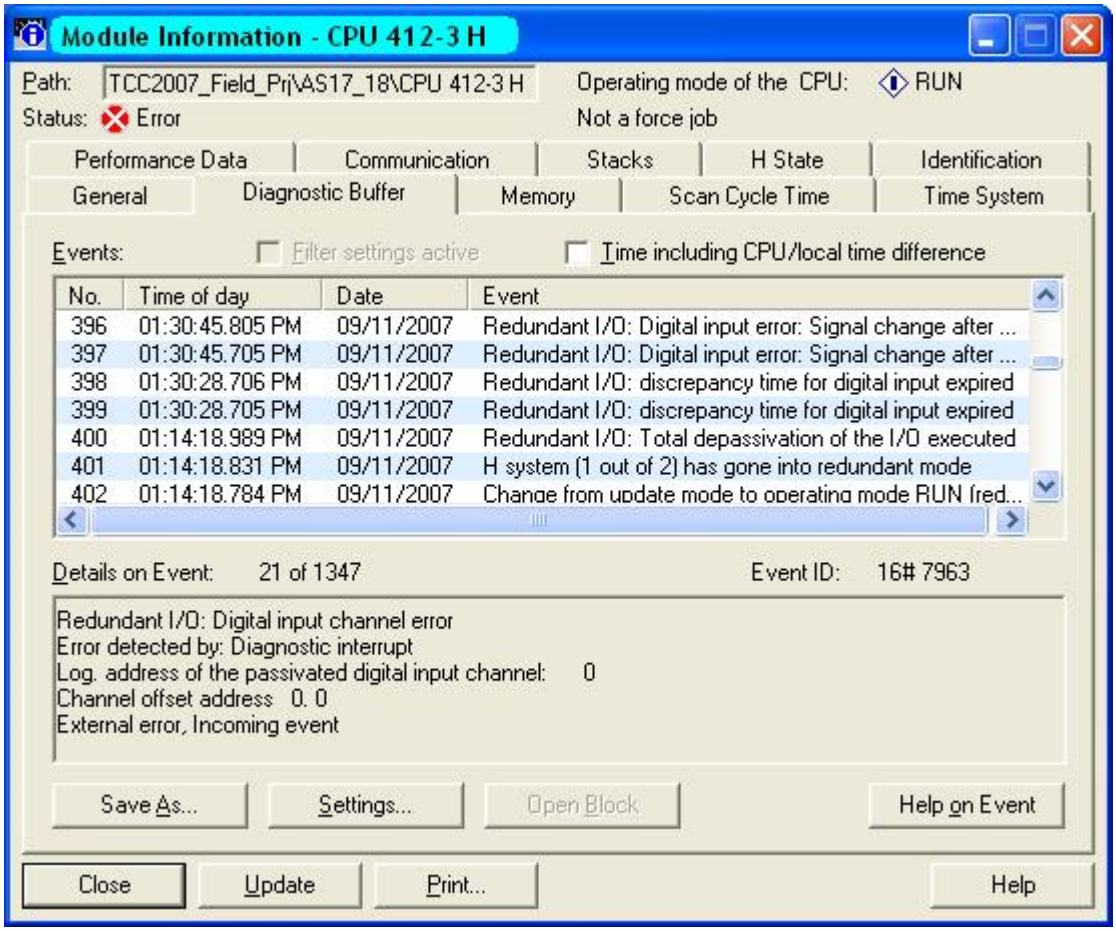
5.4 HW Config online

Diagnostic buffer

In the online mode in HW Config you can see the displayed events messages, which are displayed in Figure 5-4, in the “Module Information” of the H-CPU in the “Diagnostic Buffer” tab. Apart from the error messages information on the behavior of the modules are also listed here.

The wire break is listed here in the “Events” field by no. 20 to no. 23. By marking the respective message further information is displayed in the “Details on Event” field.

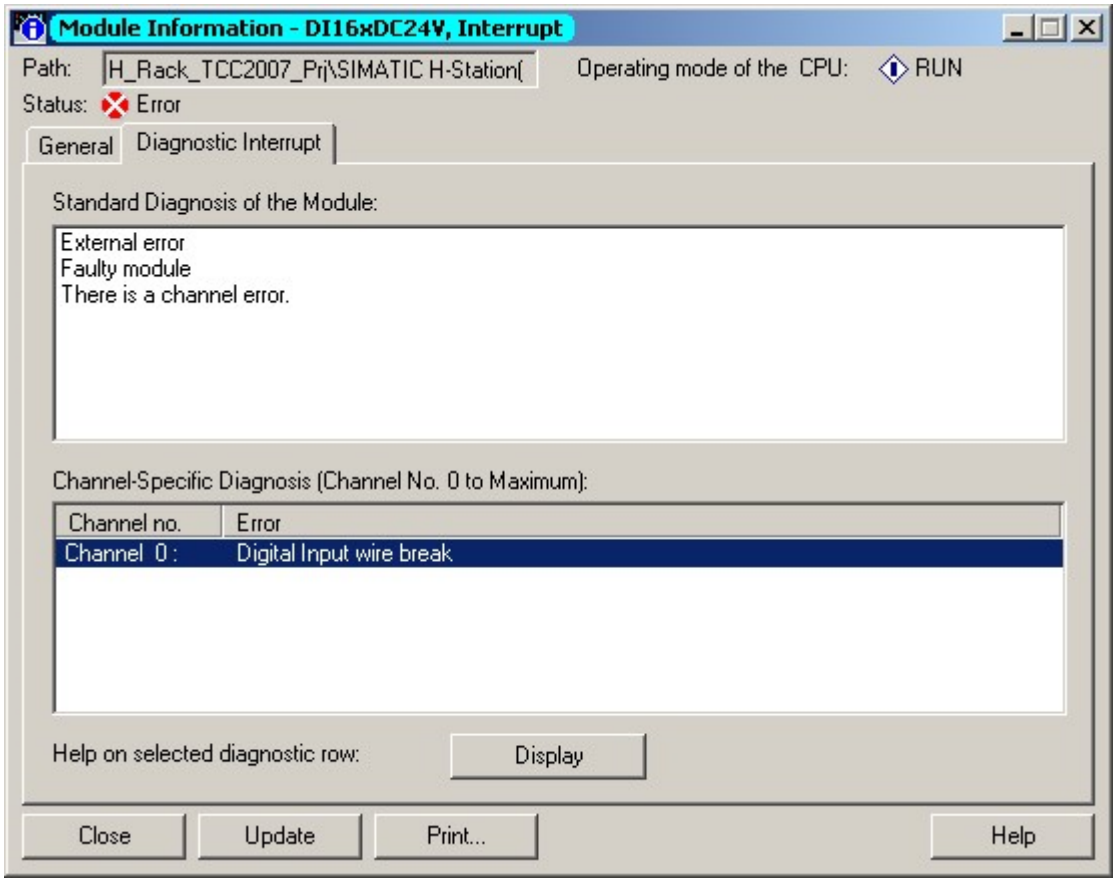
Figure 5-4



Diagnostic alarm

A further diagnostic option in HW Config is the “Module status” of the signal module (Figure 5-5). Here you find a “Standard Diagnosis of the Module” and the “Channel-Specific Diagnosis” in the “Diagnostic Interrupt” tab.

Figure 5-5



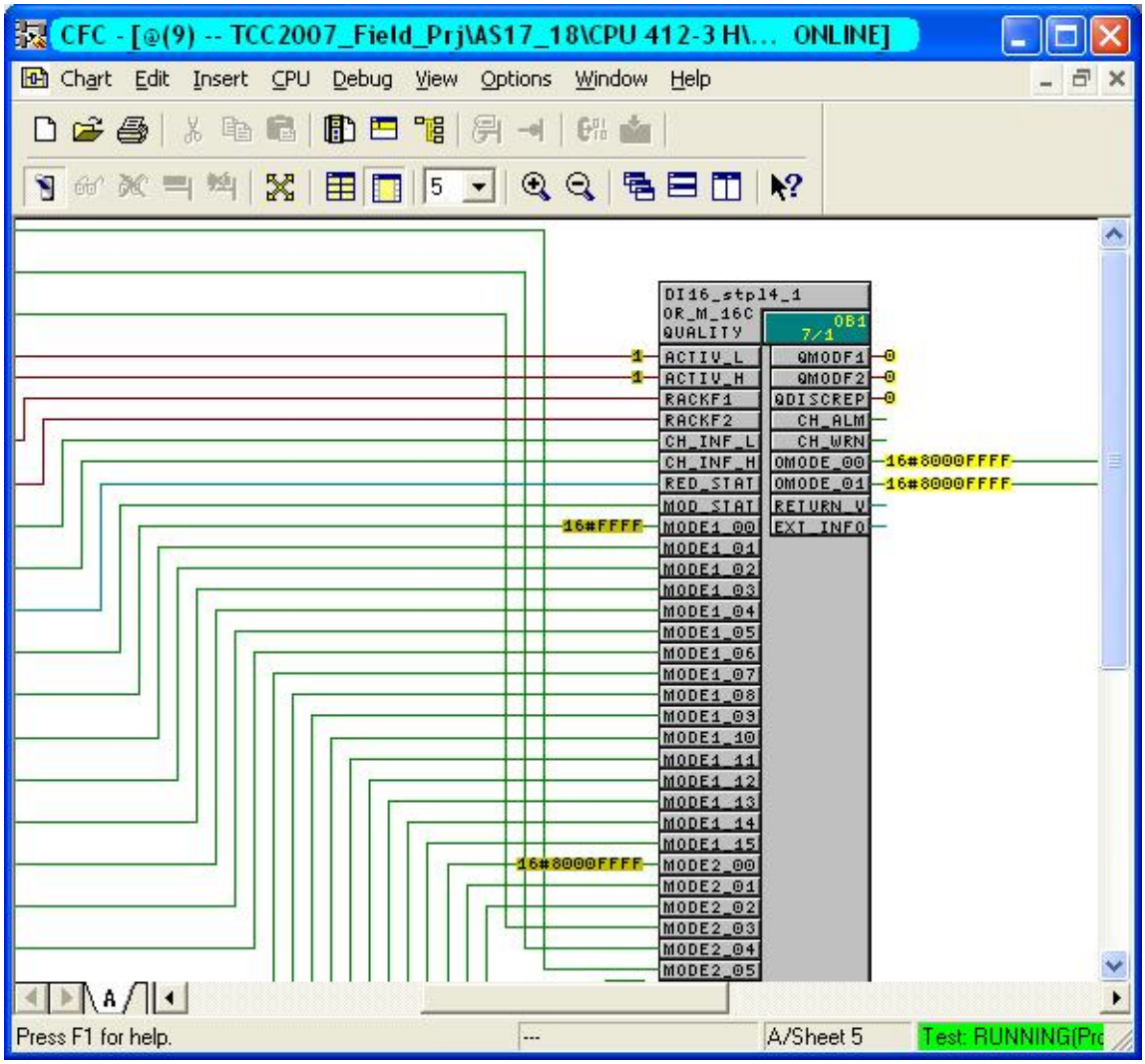
A mouse-click on the “Display” button yields further information on the selected diagnostic line.

5.5 CFC test mode

The value status of the redundant signal modules is diagnosed in the CFC plan using OR_M_16C (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

The various connections of the block can be logged on here.

Figure 5-6



Due to the wire-break status, 16#FFFF is an invalid value at connection MODE1_00.

Connection MODE1_00 displays the status for channel 0 of the primary digital input module.

The connection MODE2_00 displays the status for channel 0 of the second redundant digital input module. With 16#8000FFFF there is a valid value at connection MODE2_00.

The following table shows further connection properties of OR_M_16C:

Table 5-1

Connection	Meaning	Data Type	Default setting	Type
MODE1_xx	Operating mode channel (xx = 00 – 07 / 00 – 15) of the primary module	DWORD	0	I
MODE2_xx	Operating mode channel (xx = 00 – 07 / 00 – 15) of the redundant module	DWORD	0	I
OMODE_xx	Operating mode channel (xx = 00 – 07 / 00 – 15)	DWORD	0	O
QDISCREP	1 = discrepancy time elapsed	BOOL	0	O
QMODF1	1 = error module 1	BOOL	0	O
QMODF2	1 = error module 2	BOOL	0	O

Note Further information regarding the connections of OR_M_16 as well as its error messages are available in the manual “PCS 7 Library V70”.

Examples for the value status

- Byte 3:
  - 16#80: value status "valid value"
  - 16#00: value status "invalid value" (channel error)
  - 16#40: value status "invalid value" (higher-level error)
- Byte 2:
  - 16#01: OB 100 restarted
  - 16#02: measuring range exceeded (diagnostic channel error)
  - 16#04: measuring range fallen short of (diagnostic channel error)

6 Related literature

Table 6-1

	Topic	Title / Link
\1\	Siemens Industry Online Support	http://support.automation.siemens.com
\2\	Download page of this entry	http://support.automation.siemens.com/WW/view/en/28430682

7 History

Table 7-1

Version	Date	Modifications
V1.0	02/2008	First version
V1.1	04/2010	Figure 2-6 has been corrected
V1.2	10/2013	Additional chapter 3.6 “Additional parameter settings for configuration of redundant AI modules”