SIEMENS

SIMATIC

Automation System S7-400H Fault-tolerant Systems

Manual

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A5E00068197-07

Safety Guidelines

This manual contains notices intended to ensure personal safety, as well as to protect the products and connected equipment against damage. These notices are highlighted by the symbols shown below and graded according to severity by the following texts:

Danger

indicates that death, severe personal injury or substantial property damage will result if proper precautions are not taken.

Warning

indicates that death, severe personal injury or substantial property damage can result if proper precautions are not taken.

Caution

indicates that minor personal injury can result if proper precautions are not taken.

Caution

indicates that property damage can result if proper precautions are not taken.

Notice

draws your attention to particularly important information on the product, handling the product, or to a particular part of the documentation.

Qualified Personnel

Only **qualified personnel** should be allowed to install and work on this equipment. Qualified persons are defined as persons who are authorized to commission, to ground and to tag circuits, equipment, and systems in accordance with established safety practices and standards.

Correct Usage

Note the following:

Warning

This device and its components may only be used for the applications described in the catalog or the technical description, and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens.

This product can only function correctly and safely if it is transported, stored, set up, and installed correctly, and operated and maintained as recommended.

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Disclaim of Liability

We have checked the contents of this manual for agreement with the hardware and software described. Since deviations cannot be precluded entirely, we cannot guarantee full agreement. However, the data in this manual are reviewed regularly and any necessary corrections included in subsequent editions. Suggestions for improvement are welcomed.

Preface

Purpose of the manual

The present manual is intended for persons involved in the areas of configuration, commissioning and servicing of programmable logic control systems.

To help you get familiar with the product, we recommend that you start with the example in Chapter 3. It shows you an easy method of getting started on the subject of fault-tolerant systems.

Basic knowledge required

In order to understand the manual, you will need to be familiar with the general principles of automation technology.

Knowledge of S7 programs is also a prerequisite; you can read more about S7 programs in the *Programming with STEP 7* manual. As you need the STEP 7 standard software while you are configuring, you should also be familiar with running the standard software, as explained in the STEP 7 User Manual.

Target Group

This manual is aimed at people with the required qualifications to commission, operate and maintain the products described.

Validity of the manual

The manual is relevant to the following components:

- CPU 414-4H as of firmware version V3.1
- CPU 417-4H as of firmware version V3.1
- Optional package “S7 H Systems” beginning with Version 5.2

Changes compared to the previous version

The current version of the ”Redundant Systems” manual contains the following changes compared with the previous version:

- We have expanded the spectrum of redundant I/O modules.

Note: You can identify the previous version of the ”Redundant Systems” manual by the number on the footer: A5E00068197-06.

The current number is : A5E00068197-07.

Certification

The SIMATIC S7-400 product range has the following certificates:

- Underwriters Laboratories, Inc.: UL 508 (Industrial Control Equipment)
- Canadian Standards Association: CSA C22.2 Number 142 (Process Control Equipment)
- Factory Mutual Research: Approval Standard Class Number 3611.

Detailed information about the certifications and standards is available in the reference manual “Automation System S7-400, Module Specifications” in Chapter 1.1, Standards and Certifications.

CE Labeling

The SIMATIC S7-400 product range complies with the requirements and protection objectives of the following EU directives:

- EC low voltage directive 73/23/EEC
- EC electromagnetic compatibility directive 89/336/EEC

C-Tick Mark

The SIMATIC S7-400 product range complies with the requirements of the AS/NZS 2064 standard (Australia and New Zealand).

Standards

The SIMATIC S7-400 product range complies with the requirements and criteria of the IEC 61131-2.

Place of this documentation in the information environment

This manual can be order separately under the order number 6ES7988-8HA10-8BA0. It is also available in electronic version on the product CD “H Options Package”.

Online Help

In addition to the manual, detailed support on how to use the software is provided by the online Help system integrated in the software.

The Help system can be accessed using a number of interfaces:

- The **Help** menu contains a number of commands: **Contents** opens the Help index. You will find help on fault-tolerant systems at **Call Help on options packages, configuring fault-tolerant systems**.
- **How to Use Help** provides detailed instructions on how to use the online help system.
- Context-sensitive Help provides information on the current context - for example, on an open dialog box or an active window. It is accessed by means of the “Help” button or F1.
- Another form of context-sensitive Help is the status bar. A brief explanation of each menu command is displayed here when you place the mouse pointer on a command.
- A brief explanation of the toolbar buttons is also shown when the mouse pointer comes to rest for a short time on the buttons.

If you would like to read information from online Help in printed form, you can print individual topics, books or the entire Help.

Finding Your Way

To help you find special information quickly, the manual contains the following access aids:

- At the start of the manual you will find a complete table of contents and a list of the diagrams and tables that appear in the manual.
- An overview of the contents of each section is provided in the left column on each page of each chapter.
- You will find a glossary in the appendix at the end of the manual. The glossary contains definitions of the main technical terms used in the manual.
- At the end of the manual you will find a comprehensive index which gives you rapid access to the information you need.

Note

You require the following manuals and manual packages in order to program and commission an S7-400:

Manual/ Manual Package	Contents
Standard Software for S7 and M7 STEP 7 Basic Information	• Installing and starting up STEP 7 on a programming device / PC • Working with STEP 7 with the following contents: Managing projects and files Configuring and assigning parameters to the S7-400 configuration Assigning symbolic names for user programs Creating and testing a user program in STL/LAD Creating data blocks Configuring the communication between two or more CPUs Loading, storing and deleting user programs in the CPU / programming device Monitoring and controlling user programs Monitoring and controlling the CPU • Guide for efficiently implementing the programming task with the programming device / PC and STEP 7 • How the CPUs work (for example, memory concept, access to inputs and outputs, addressing, blocks, data management) • Description of STEP 7 data management • Using data types of STEP 7 • Using linear and structured programming • Using block call instructions • Using the debug and diagnostics functions of the CPUs in the user program (for example, error OBs, status word)
STEP 7 Reference Information *Statement List (STL) for S7-300 and S7-400* *Ladder Logic (LAD) for S7-300 and S7-400* *Function Block Diagram (FBD) for S7-300 and S7-400* *System and Standard Functions*	• Basic procedure for working with STL, LAD, or FBD (for example, structure of STL, LAD, or FBD, number formats, syntax) • Description of all instructions in STEP 7 (with program examples) • Description of the various addressing methods in STEP 7 (with examples) • Description of all functions integrated in the CPUs • Description of the internal registers in the CPU • Description of all system functions integrated in the CPUs • Description of all organization blocks integrated in the CPUs
Manual *PG 7xx*	• Description of the programming device hardware • Connecting a programming device to various devices • Starting up a programming device

Recycling and Disposal

The S7-400 H can be recycled due to the use of non-toxic materials in its construction. For environmentally compatible recycling and disposal of your old device in accordance with the current state of the art, please contact a certified recycling company for electronic component waste.

Further Support

If you have any technical questions, please get in touch with your Siemens representative or agent responsible.

`http://www.ad.siemens.com/automation/partner`

H/F Competence Center

The HF Competence Center in Nuremberg offers a special workshop on the subject redundant automation system SIMATIC S7. In addition, the H/F Competence Center offers you on-site assistance during configuration, commissioning or in the event of problems.

Phone: +49 (911) 895-4759
Fax: +49 (911) 895-4519

Training Centers

We offer a number of courses to help you become familiar with the SIMATIC S7 programmable logic controller. Please contact your regional training center or our central training center in D 90327 Nuremberg, Germany for details:

Phone: +49 (911) 895-3200.

Internet: `http://www.sitrain.com`

A&D Technical Support

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The languages of the SIMATIC Hotlines and the authorization hotline are generally German and English.		

Service & Support on the Internet

In addition to our documentation, we offer our Know-how online on the internet at:

`http://www.siemens.com/automation/service&support`

where you will find the following:

- The newsletter, which constantly provides you with up–to–date information on your products.
- The right documents via our Search function in Service & Support.
- A forum, where users and experts from all over the world exchange their experiences.
- Your local representative for Automation & Drives via our representatives database.
- Information on field service, repairs, spare parts and more under “Services”.

Contents

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Tables

Fault-Tolerant Programmable Logic Controllers 1

This chapter contains an introduction to redundant and fault-tolerant programmable logic controllers.

1.1 Redundant Programmable Logic Controllers in the SIMATIC Series

Economic, and thus resource-sparing and low-pollution production can be achieved nowadays in all branches of industry only by employing a high degree of automation. At the same time there is a demand for fail-safe programmable logic controllers with the greatest degree of distribution possible.

Redundant programmable logic controllers from Siemens have proved themselves in operation and thousands are in service.

Perhaps you are already familiar with one of the fault-tolerant systems such as the SIMATIC S5-115H and S5-155H, or the fail-safe S5-95F and S5-115F systems.

The S7-400H is the latest fault-tolerant PLC and we will be presenting it on the pages that follow. It is a member of the SIMATIC S7 system family, meaning that you can fully avail yourself of all the advantages of the SIMATIC S7.

Operating objectives of redundant PLCs

Redundant programmable logic controllers are used in practice with the aim of achieving a higher degree of availability or fault tolerance.

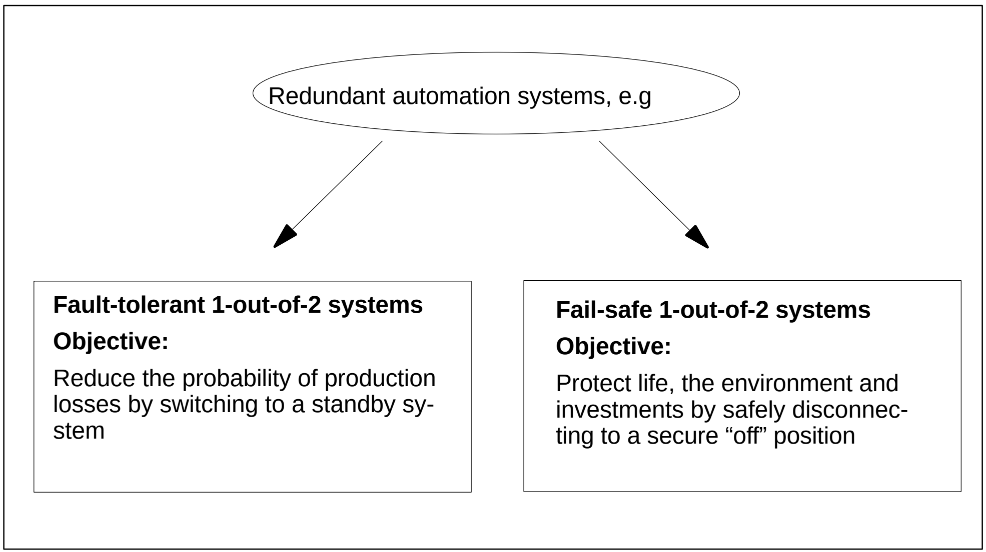


Figure 1-1 Operating objectives of redundant programmable logic controllers

Note the difference between fault-tolerant systems and fail-safe systems. The S7-400H is a fault-tolerant programmable logic controller that can be used only with additional means for controlling processes relevant to safety.

Why do we have fault-tolerant programmable logic controllers?

The objective of using high-availabilty programmable logic controllers is a reduction of production losses. It does not matter whether the losses are caused by an error or as a result of maintenance work.

The higher the costs of a stoppage, the more worthwhile it is to use a fault-tolerant system. The generally higher investment costs of fault-tolerant systems are quickly compensated by avoiding production losses.

Software redundancy

In a large number of applications, requirements for the quality of redundancy or the number of system sections that necessitate redundant PLCs are not high enough to warrant the use of a specific fault-tolerant system. Frequently, simple software mechanisms are sufficient to allow continuation of a failed control task on a substitute system in the event of an error.

The “SIMATIC S7 Software Redundancy” options software can run on S7-300 and S7-400 standard systems to control processes that tolerate transfer times to a substitute system within seconds, such as water works, water treatment systems or traffic flows.

1.2 Increasing System Availability

The S7-400H programmable logic controller meets these high requirements for availability, intelligence and distribution that are required of state-of-the-art programmable logic controllers. Further, it features all the functions for acquiring and preparing process data and for controlling, regulating and monitoring units and systems.

System-wide universality

The S7-400H programmable logic controller and all other SIMATIC components, such as the SIMATIC PCS7 control system, are harmonized. Total system universality, from the control console to the sensors and actuators, is a matter of course and guarantees maximum system performance.

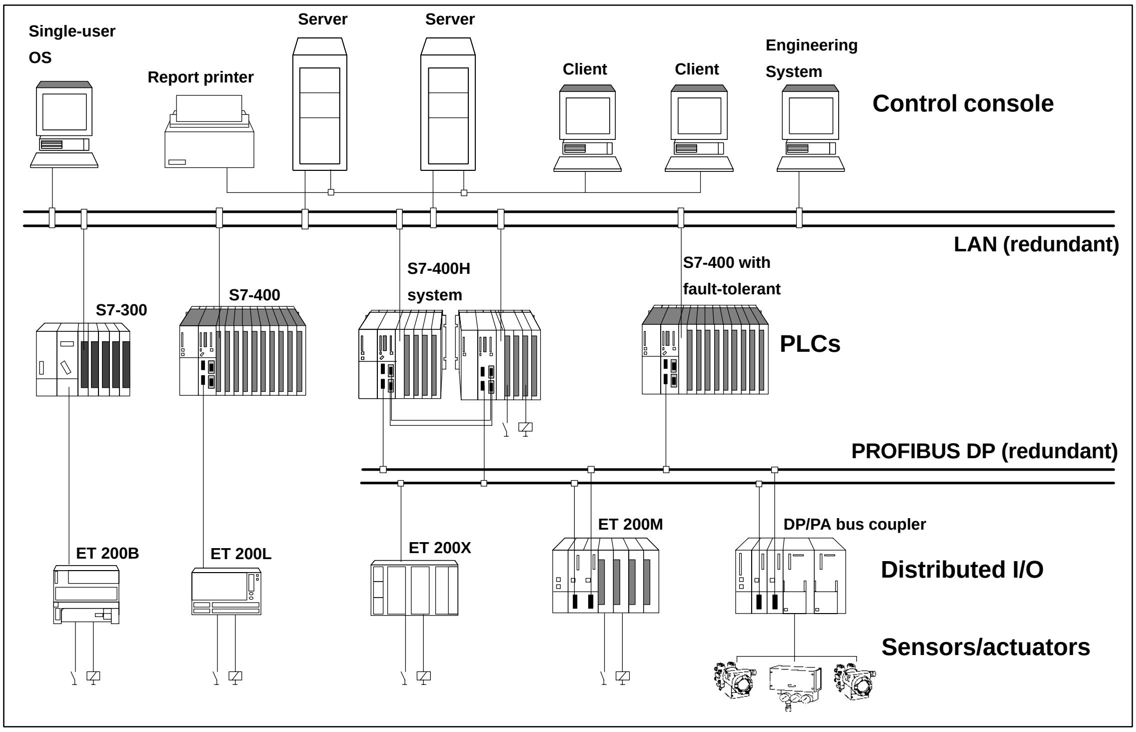


Figure 1-2 Universal automation solutions with SIMATIC

Graduated availability by duplicating components

The S7-400H is designed with redundancy so that it remains available at all events. This means that all major components are duplicated.

The components that are duplicated as a matter of policy are the central processing unit (CPU), the power supply and the hardware for interconnecting the two central processing units.

You can decide for yourself whether you wish to duplicate more components for the process you are going to automate and thus enhance their availability.

Redundant nodes

Redundant nodes represent the fault tolerance of systems with redundant components. The independence of a redundant node is given when the failure of a component within the node does not result in reliability constraints in other nodes or in the entire system.

The availability of the entire system can be illustrated in a simple manner by means of a block diagram. With a 2-out-of-2 system, **one** component of the redundant node may fail without impairing the operability of the overall system. The weakest link in the chain of redundant nodes determines the availability of the overall system.

Without malfunction (Figure 1-3).

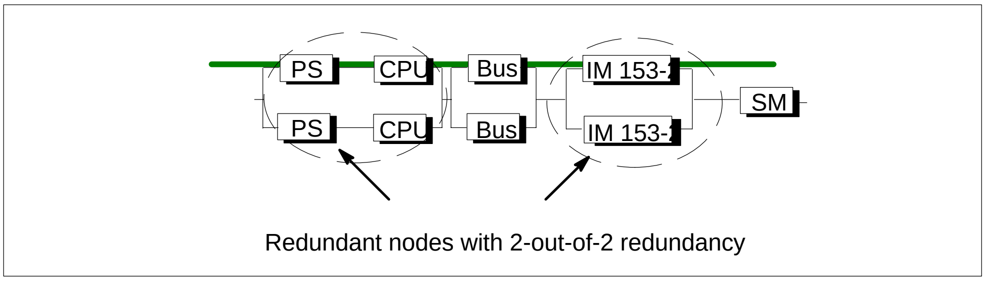


Figure 1-3 Example of redundancy in a network without malfunction

With malfunction

In Figure 1-4, one component may fail per redundant node without the functionality of the overall system being impaired.

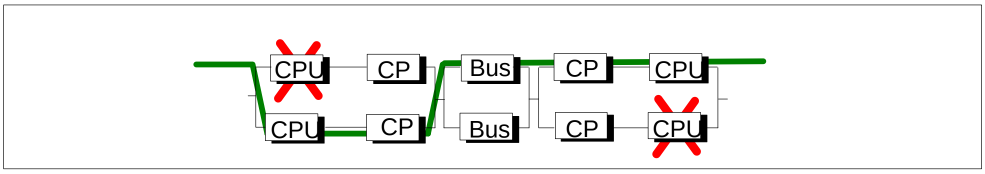


Figure 1-4 Example of redundancy in a 2-out-of-2 system with malfunction

Failure of a redundant node (total failure)

In Figure 1-5, the entire system is no longer operable since both subcomponents have failed in a 1-out-of-2 redundant node (total failure).

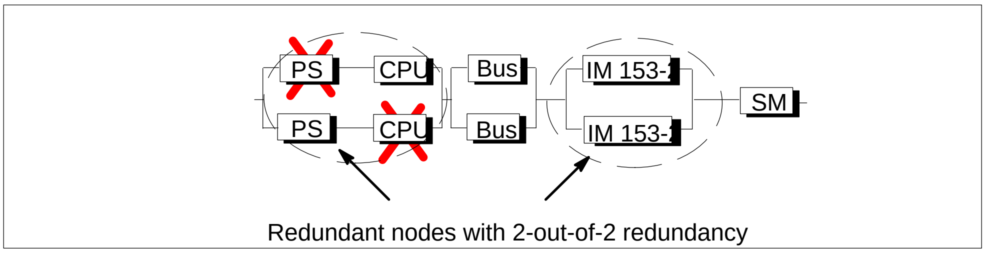


Figure 1-5 Example of redundancy in a 2-out-of-2 system with total failure

2 S7-400H Installation Options

The first part of the description starts with the basic configuration of the fault-tolerant S7-400H programmable controller and the components making up the S7-400H base system. We then describe the hardware components with which you can expand this base system.

The second part describes the software applications with which you can configure and program the S7-400H. In addition, a description is given of the additions and extensions, compared to the S7-400 standard system, that you will require for programming your user program in order to be able to react specifically to the properties of the S7-400H that enhance availability.

Figure 2-1 shows an example of the configuration of an S7-400H with common distributed I/O and a connection to a redundant system bus. On the next few pages we will describe step by step the hardware and software components necessary for configuring and operating the S7-400H.

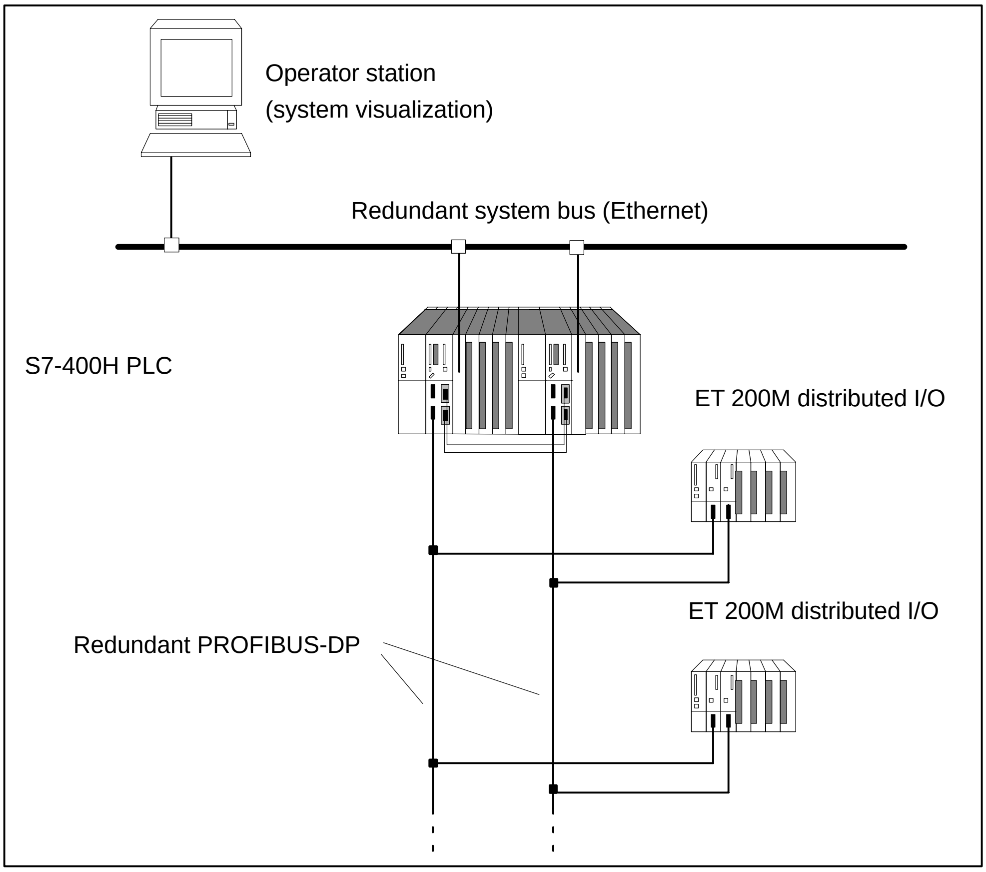


Figure 2-1 Overview

Further information

The components of the S7-400 standard system are also used in the fault-tolerant S7-400H programmable logic controller. A detailed description of all hardware components for S7-400 is available in the reference manual *Automation System S7-400, M7-400, Module Data*.

The same rules as for a standard S7-400 system apply to designing the user program and the usage of blocks for the fault-tolerant S7-400H programmable logic controller. Please take note of the descriptions in the *Programming with STEP 7* manual and in the *System Software for S7-300/400, System and Standard Functions* Reference Manual.

2.1 Base System of the S7-400H

Hardware of the base system

By base system of the S7-400H we mean the minimum configuration of the S7-400H. The base system consists of all the requisite hardware components that make up the fault-tolerant control system. Figure 2-2 shows the components in the installation.

You can upgrade the base system by means of standard modules from the S7-400. There are restrictions in the case of the function and communication processors (see Appendix E).

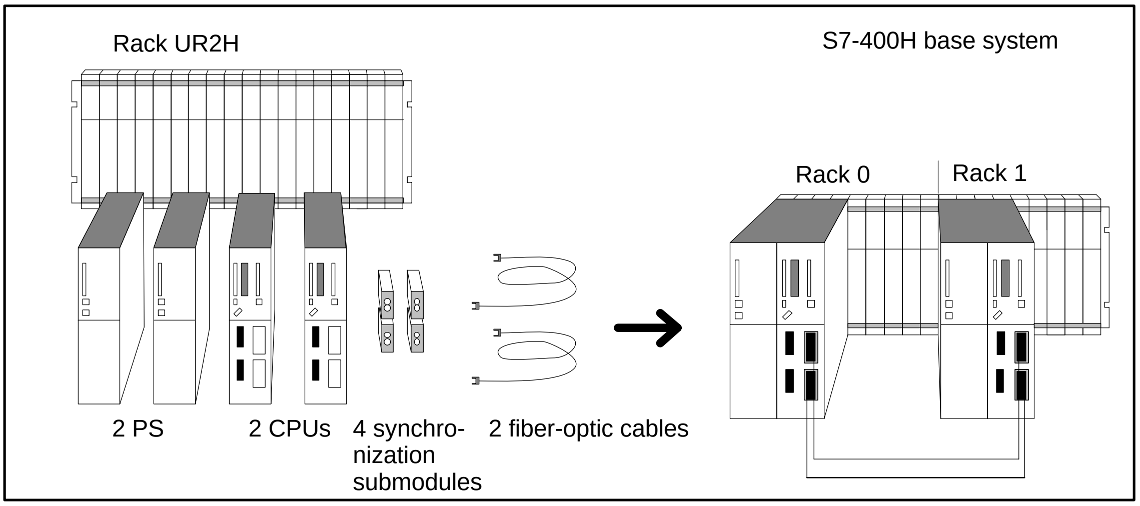


Figure 2-2 Hardware of the S7-400H base system

Central processing units

At the heart of the S7-400H are the two central processing units. Setting of the synchronization submodules, which have to be plugged into the CPU, defines the rack numbers. In the following we will refer to the CPU in rack 0 as CPU 0,and to the CPU in rack 1 as CPU 1.

Mounting rack for S7-400H

We recommend you the UR2-H mounting rack for the S7-400H. The mounting rack makes it possible to configure two separate subsystems, each containing nine slots, and is suitable for installation in 19” cabinets.

Alternatively, you can also configure the S7-400H on two separate mounting racks. Two mounting racks, the UR1 and UR2, are available for this purpose.

Power supply

As a power supply, you will require for each fault-tolerant CPU – or, to be more precise, for each of the two subsystems of the S7-400H – a power supply module from the standard range of the S7-400.

Power supply modules for rated input voltages of 24 VDC and 120/230 VAC are available with 10 and 20 A output current.

To enhance the availability of the power supply, you can also use two redundant power supplies in each subsystem. In this case you should use the PS 407 10 A R power supply module for rated voltages of 120/230 VAC with an output power of 10 A.

Synchronization submodules

The synchronization submodules are used to connect the two central processing units. They are installed in the central processing units and interconnected by means of fiber-optic cables.

Two synchronization submodules have to be inserted in each CPU.

Fiber-optic cables

The fiber-optic cables are inserted into the synchronization submodules and form the physical connection (redundant link) between the two central processing units.

2.2 I/O Modules for S7-400H

For the S7-400H you can use virtually any of the input/output modules featured in the SIMATIC S7 system range. The I/O can be used in

- central controllers
- expansion units
- distributed over PROFIBUS DP.

The function modules (FMs) and communication processors (CPs) that can be used in the S7-400H will be found in Appendix E.

I/O configuration versions

In addition to the power supplies and central processing units that are always used as redundant modules, there are the following configuration versions for the input/output modules:

- Single-channel, one-way configuration with normal availability

  With the single-channel, one-way configuration single input/output modules are present (single-channel). The input/output modules are located in just one of the subsystems and are only addressed by that subsystem.
- Single-channel, switched configuration with enhanced availability

  With the single-channel switched (distributed) configuration single input/output modules are present (single-channel) but can be addressed by either subsystem.
- Dual Channel Redundant Configuration with Fault Tolerance

  There are double the number of I/O modules in a dual–channel redundant configuration and these can be addresses by both subsystems.

Further information

You will find detailed information on the usage of I/O in Chapter 7.

2.3 Communication

For communication tasks on the S7-400H you can use almost any communications components offered in the SIMATIC system range.

This applies to communication components used either with central I/O or distributed I/O such as

- system busses (Industrial Ethernet)
- point-to-point connection

Communication availability

You can vary the availability of communications with the S7-400H. There are different solutions for the S7-400H in keeping with your communication requirements. They range from a simple linear network structure to a redundant optical two-fiber loop.

Fault-tolerant communication over PROFIBUS or Industrial Ethernet is supported entirely with S7 communication functions.

Programming and configuration

Apart from the use of additional hardware components, there are basically no differences with regard to configuration and programming compared to standard systems. Fault-tolerant connections have to be configured only; specific programming is not necessary.

All communication functions required for operating fault-tolerant communications have been integrated in the operating system of the fault-tolerant CPU and run automatically and in the background – for example, monitoring of the communication connection or automatic switching to a redundant connection in the event of a malfunction.

Further information

You will find detailed information on the subject of communications with the S7-400H in Chapter 8.

2.4 Tools for Configuration and Programming

Similar to the S7-400, the S7-400H is also configured and programmed with STEP 7.

After configuration with STEP 7, you treat the S7-400H as a normal S7-400 system.

For you this means that you can use your full knowledge of the SIMATIC S7 and, for example, only have to take minor constraints into account when writing your user program. However, there are also fault tolerant-specific additions to the configuration. Redundant components are monitored by the operating system, which independently performs switching in the event of a fault. You have already configured the information required for this in STEP 7 and it is known to the system.

You will find detailed information on this subject in online Help and in Chapter 9.

Required Software

The optional H package is required for configuration and programming.

Optional Software

All standard tools, engineering tools and runtime software that can be used on the S7-400 can, of course, also be used on the S7-400H.

2.5 The User Program

The rules applicable to the design and programming of the standard S7-400 system apply similarly to the S7-400H.

The user programs are stored in an identical form in the two central processing units and are executed simultaneously (event-synchronous).

From the viewpoint of user program execution, the S7-400H behaves in exactly the same manner as a standard system. The synchronization functions are integrated in the operating system and run automatically and totally in the background. There is no need to take these functions into account in the user program.

In order to be able to react to the lengthening of the cycle time due to updating, for example, a few specific blocks allow you to optimize your user program in this respect.

Specific Blocks for S7-400H

Apart from the blocks that can be used on both the S7-400 and the S7-400H, there are further additional blocks for the S7-400H with which you can influence the redundancy functions.

You can react to redundancy errors of the S7-400H with the following organization blocks:

- OB 70, I/O redundancy errors
- OB 72, CPU redundancy errors

Using the system function SFC 90 “H_CTRL” you can disable and re-enable link-up and updating of the fault-tolerant CPUs. You can also affect the scope and routine of the cyclic self–test.

Notice

With a fail-safe system, the periodic self-tests must not be inhibited and then enabled again.
For more details refer to the manual *S7-400F and S7-400FH Programmable Controllers.*

Further information

You will find detailed information on the programming of the above-mentioned blocks in the manual called *Programming with STEP 7* and in the Reference Manual called *System Software for S7-300/400, System and Standard Functions*.

2.6 Documentation

The following illustration provides an overview of the documentation for the various components and applications of the S7-400H automation system.

Subject	Documentation
Hardware: Redundancy–capable power supply Module rack UR2-H	*S7/M7-400 standard documentation* Installation Module Specifications Instruction List
IM 153-2	*ET 200M Distributed I/O*
Fault tolerant-specific programming: S7-400H-specific OBs, SFC S7-400H-specific expansion of the SSL, events and help on error	*STEP 7 documentation* Programming with STEP 7 V5.2 System and Standard Functions (manual and online Help)
Specifically for fault-tolerant systems: Fault-tolerant Systems Configuration Options for S7-400H Getting Started System Modes for S7-400H Link-up and Update I/O, Communications Configuration with the STEP 7 Option Pack Failure and Replacement, System Modification	*S7-400H PLC* Fault-Tolerant Systems (manual and online Help)

Figure 2-3 User documentation for fault-tolerant systems

Note

You will find the manuals listed in Figure 2-3 on the S7-400H product CD.

3 Getting Started

This guide walks you through the steps that have to be performed to commission the system by means of a specific example and results in a working application. You will learn how an S7-400H programmable logic controller operates and become familiar with its response to a fault.

It takes about one to two hours to work through this example, depending on your previous experience.

3.1 Requirements

The following requirements must be met:

A permitted version of the STEP 7 standard software and the “S7 Fault-Tolerant System” option pack are correctly installed on your programming device (refer to Section 9.1).

You must have the modules required for the hardware configuration:

- an S7-400H PLC consisting of:
  - 1 mounting rack, UR2-H
  - 2 power supplies, PS 407 10A
  - 2 fault-tolerant CPUs (CPU 414-4H and CPU 417-4H)
  - 4 synchronization submodules
  - 2 fiber-optic cables
- an ET 200M distributed I/O device with an active backplane bus and
  - 2 IM 153-2
  - 1 digital input module, SM321 DI 16 x DC24V
  - 1 digital output module, SM322 DO 16 x DC24V
- the necessary accessories such as PROFIBUS shielded cables, etc.

3.2 Configuring Hardware and Starting Up the S7-400H

Installing Hardware

To configure the S7-400H as illustrated in Figure 3-1, perform the following steps:

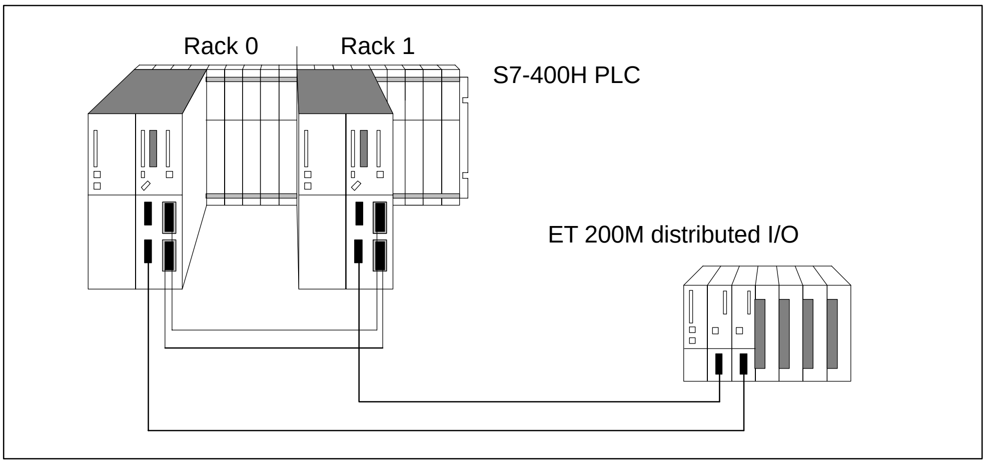


Figure 3-1 Hardware configuration

1. Configure the two subunits of the S7-400H PLC as described in the *S7-400, M7-400 Programmable Controllers, Hardware and Installation/Module Specifications* manuals. In addition, you must:
   - Set the mounting rack number by means of the switches on the synchronization submodules. The setting is applied by the CPU after POWER ON and a subsequent memory reset by means of the mode selector. If the mounting rack number is not set correctly you will not have online access and the CPU will not run in certain circumstances.
   - Insert the synchronization submodules into the CPUs. Then screw up the additional front bezels to activate them (refer to *S7-400, M7-400 Programmable Controllers, Hardware and Installation*).
   - Connect the fiber-optic cables (always connect the two upper synchronization submodules and the two lower synchronization submodules of the CPUs). Lay the fiber-optic cable so that it is protected from any damage.

     Make sure with the route wires in addition that the two fiber-optic cables are always laid so that they are isolated from each other. Laying them separately enhances their availability and protects then from potential dual faults in the event, say, of simultaneous interruption of the fiber-optic cables.

     In addition, make sure that the fiber-optic cables are plugged into the two CPUs before turning on the power supply or turning on the system. If they are not, the two CPUs might both process the user program as master CPUs.
2. Configure the distributed I/O as described in the *ET 200M Distributed I/O Device* manual.

3. Connect the programming device to the first fault-tolerant CPU (CPU0). This CPU should be the master CPU of the S7-400H.
4. A high-quality RAM test is performed after power on. It requires approximately 8 seconds per megabyte of RAM. During this time the CPU cannot be addressed via the multipoint interface and the STOP LED flashes. If there is a backup battery, the test will not be performed on further POWER ONs.
5. Perform a memory reset for both CPUs using the mode selector. This applies the set mounting rack numbers of the synchronization modules to the operating system of the CPU.
6. Perform commissioning individually for each CPU as described in the *S7-400, M7-400 Programmable Controllers, Hardware and Installation* manual. After loading the program carry out a warm restart: first for the CPU you want as the master CPU, and then for the standby CPU.
7. Switch the two CPUs of the S7-400H to STOP.

Starting up the S7-400H

To start up the S7-400H, perform the following steps:

1. Open the “H Project” in SIMATIC Manager. The configuration is the same as the hardware configuration described in “Requirements”.
2. Open the hardware configuration of the project by selecting the “Hardware” object and clicking the right mouse key and then selecting the context menu command **Object ▸ Open** . When you have an identical configuration, you can proceed with step 6.
3. If your hardware configuration is different from that of the project – for example, the module types, MPI addresses or DP address – you must adjust and save the project accordingly. You will find descriptions in the basic help for SIMATIC Manager.
4. Open the user program in the “S7 program” folder.

   The “S7 program” folder is assigned only to CPU0 in the offline view. The user program can run on the hardware configuration described. It makes the LEDs on the digital output module light up in the form of a running light.
5. If necessary, modify the user program – to adapt it to your hardware configuration, for example – and save it.
6. Load the user program into CPU0 with the command **PLC ▸ Download**.
7. Start the S7-400H PLC by switching the mode selector, first for CPU0 and then for CPU1, to RUN-P.

   Result: CPU0 starts up as the master CPU and CPU1 as the standby CPU. After the link-up and update of the standby CPU the S7-400H switches to redundant system mode and executes the user program (run light on digital output module).

Note

You can start and stop the S7-400H programmable logic controller using the programming device too. You will find more information on this in online Help of the S7-400H options package.

3.3 Examples of Fault-Tolerant System Response to Faults

Example 1: Failure of a central processing unit or power supply

Initial situation: The S7-400H is in redundant system mode.

1. Cause CPU0 to fail by turning off the power supply.

   Result: The LEDs REDF, IFM1F and IFM2F light on CPU1. CPU1 goes into solo mode, and the user program continues to run.

2. Turn the power supply back on.

   Result:

   – CPU0 performs an automatic LINK-UP and UPDATE.

   – CPU0 changes to RUN and now operates as the standby CPU.

   – The S7-400H is now in redundant system mode.

Example 2: Failure of a fiber-optic cable

Initial situation: The S7-400H is in redundant system mode. The mode selector of each CPU is at the RUN or RUN-P position.

1. Disconnect one of the fiber-optic cables.

   Result: The LEDs REDF and IFM1F or IFM2F (depending on which fiber-optic cable was disconnected) now light on the two CPUs. The original master CPU (CPU0) changes to single mode and the user program continues to run.

2. Reconnect the fiber-optic cable that you disconnected earlier.

3. Restart the original standby CPU (CPU1), which is now at STOP, by means of STEP7 “operating status”, for example.

   Result:

   – CPU1 performs an automatic LINK-UP and UPDATE.

   – The S7-400H reverts to redundant system mode.

Installation of a CPU 41x-H

4

Chapter Overview

4.1 Controls and Indicators of the CPUs

Operation and Display Elements of the CPU 414-4H/417-4H

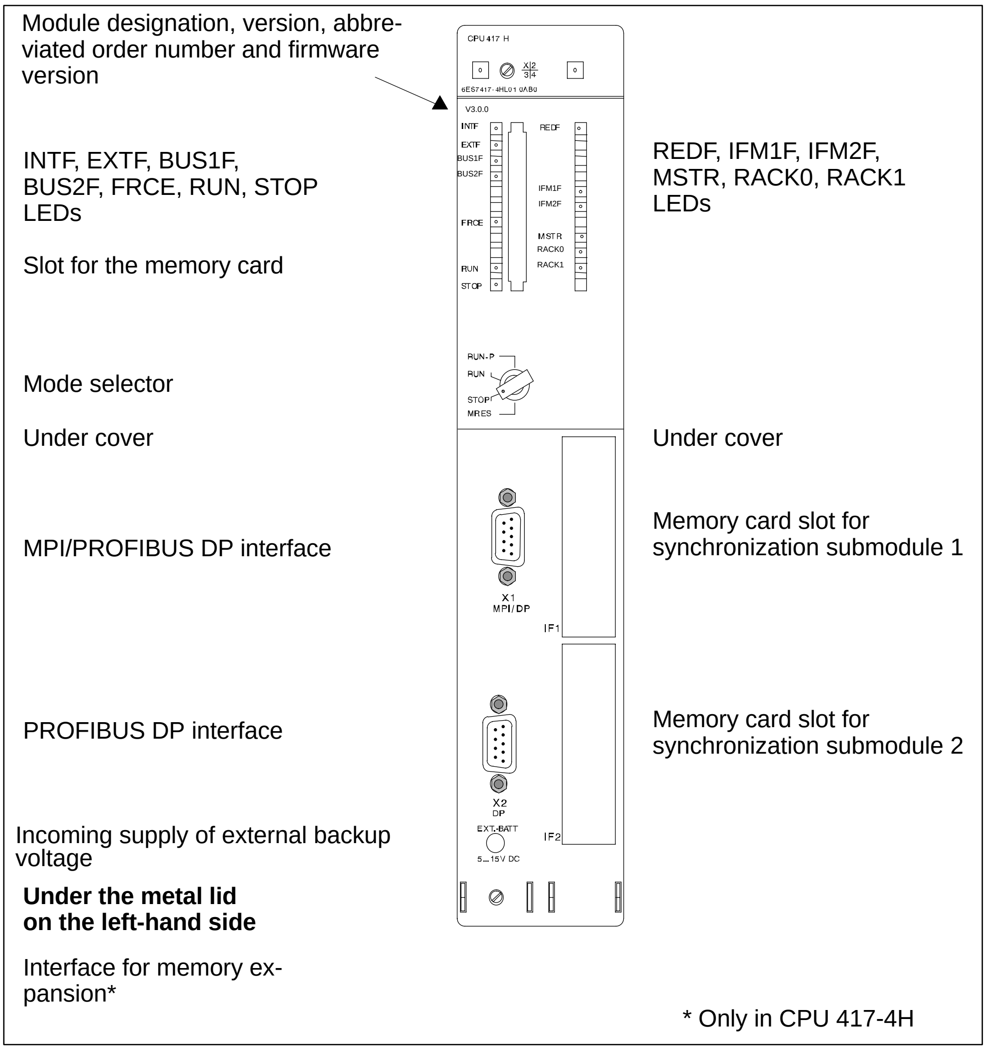


Figure 4-1 Layout of the controls and indicators of the CPU 414-4H/417-4H

LEDs

Table 4-1 gives you an overview of the LEDs on the individual CPUs.

Section 4.2 describes the statuses and errors indicated by these LEDs.

Table 4-1 LEDs of the CPUs

LED	Color	Meaning
INTF	red	Internal fault
EXTF	red	External fault
FRCE	yellow	Active force request
RUN	green	RUN mode
STOP	yellow	STOP mode
BUS1F	red	Bus fault at MPI/PROFIBUS DP interface 1
BUS2F	red	Bus fault at PROFIBUS DP interface 2
MSTR	yellow	CPU leads the process
REDF	red	Loss of redundancy/redundancy error
RACK0	yellow	CPU in rack 0
RACK1	yellow	CPU in rack 1
IFM1F	red	Error at interface submodule 1
IFM2F	red	Error at interface submodule 2

Operating Mode Selector

You can use the mode selector to select the current operating mode of the CPU. The mode selector is a key switch with four switching positions. You can use different protection levels and limit any program changes or startup options (STOP to RUN transition) to a certain group of people.

Section 4.4 describes the functions of the mode selector and the protection levels of the CPUs.

Slot for Memory Cards

You can insert a memory card in this slot.

There are two types of memory card:

- RAM cards

  You can expand the load memory of a CPU with the RAM card.

- FLASH cards

  You can use the FLASH card to store your user program and your data so that they are failproof (even without a backup battery). You can either program the FLASH card on the programming device or in the CPU. The FLASH card also expands the load memory of the CPU.

  A detailed description of memory cards is available in Chapter 4.5.1.

Interface for Expanded Memory

CPU 417-4H provides an additional interface for expanded memory. This make it possible to expand the working memory. (See Chapter 4.5)

Slot for Interface Modules

The H synchronization module can be inserted into this slot.

MPI/DP Interface

You can connect the following devices to the MPI of the CPU, for example:

- Programming devices
- Operation and monitoring devices
- Additional S7-400 or S7-300 controllers (see Section 4.6).

Use the bus connector with an angular outgoing cable (see the Installation manual, Chapter 7)

You can also configure the MPI interface as a DP master and use it as a PROFIBUS DP interface with up to 32 DP slaves.

Profibus-DP Interface

You can connect the distributed I/O, programming devices/OPs and additional DP master stations to the PROFIBUS DP interface.

Connecting External Backup Current to the “EXT. BATT.” Socket

You can use one or two backup batteries – depending on the module type – in the power supply modules of the S7-400 to do the following:

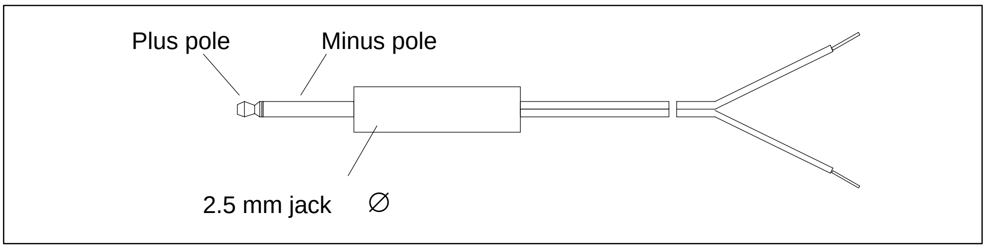
- Provide backup power for the user program you have stored in RAM.
- Ensure memory markers, timers, counters, system data and data in tag data blocks remain retentive.
- Provide backup power for the internal clock.

You can achieve the same backup if you apply DC voltage between 5 V and 15 V at the “EXT. BATT.” socket of the CPU.

The “EXT. BATT.” input has the following features:

- Reverse polarity protection
- A short-circuit current limit of 20 mA

To connect external power to the “EXT. BATT” socket, you need a cable with a 2.5 mm ∅ jack, as illustrated in the following figure. Note the polarity of the jack.



Note

You will require the external incoming supply at the “EXT. BATT.” socket if you replace a power supply module and want to provide a backup supply for the user program stored in RAM and the data mentioned above while the module is being replaced.

4.2 Monitoring Functions of the CPU

Monitoring and Error Messages

The CPU hardware and the operating system have monitoring functions that ensure that the system functions correctly and that there is a defined response to an error. A number of errors will also produce a response from the user program.

The following table gives you an overview of possible errors, their causes and the responses of the CPU.

There are also test and information functions available in each CPU that you can call up with STEP 7.

Type of Fault/Error	Cause of Error	Response of the Operating System	Error LED
Clock pulse failure	Monitoring of the failure of the processor clock pulse System standstill	Disabling of the digital outputs by issuing the “OD” (Output Disable) signal	–
Access error	Module failure (SM, FM, CP)	“EXTF” LED lights up until the fault is acknowledged. In SMs: • OB 122 call • Entry in the diagnostics buffer • In the case of input modules: Entry of null for the date in the accumulator or the process image In the case of other modules: • OB 122 call	EXTF
Timing error	• The runtime of the user program (OB1 and all the interrupts and error OBs) exceeds the specified maximum cycle time. • OB request error • Overrun of the start information buffer • Time error interrupt	“INTF” LED lights up until the fault is acknowledged. OB 80 call If the OB is not loaded: The CPU goes into STOP mode.	INTF
Power supply module error (not power failure)	In the central or distributed I/O rack: • At least one backup battery in the power supply module is empty. • The backup voltage is missing. • The 24 V supply to the power supply module has failed.	OB 81 call If the OB is not loaded: The CPU continues to run.	EXTF
Diagnostics Interrupt	An I/O module with interrupt capability reports a diagnostics interrupt.	OB 82 call If the OB is not loaded: The CPU goes into STOP mode.	EXTF
Remove/insert interrupt	Removal or insertion of an SM and insertion of an incorrect module type. If the only inserted SM is removed during STOP mode of the CPU with default parameter assignment, the EXTF LED will not light up. If the SM is inserted again, the LED lights up briefly.	OB 83 call If the OB is not loaded: The CPU goes into STOP mode.	EXTF

Type of Fault/Error	Cause of Error	Response of the Operating System	Error LED
Priority class error	• Priority class is called, but the corresponding OB is not available. • In the case of an SFB call: The instance DB is missing or defective.	OB 85 call If the OB is not loaded: The CPU goes into STOP mode.	INTF
	• Error during the updating of the process image		EXTF
Failure of a rack/station	• Power failure in an expansion rack • Failure of a DP line • Failure of a coupling line: missing or defective IM, interrupted line)	OB 86 call If the OB is not loaded: The CPU goes into STOP mode.	EXTF
Communication error	• Status information cannot be entered in DB • Incorrect frame identifier • Frame length error • Impermissible global identifier number • DB access error	OB 87 call If the OB is not loaded: The CPU goes into STOP mode.	INTF
Cancel processing	The processing of a program block is cancelled. Possible reasons for the cancellation are: • Too much nesting depth of a bracket level • Too much nesting depth of a master control relay • Too much nesting depth for synchronization errors • Too much nesting depth from block calls (i stack) • Too much nesting depth from block calls (b stack) • Error allocating local data • Unknown instruction • Branch instruction with destination outside of the block	OB 88 call If the OB is not loaded: The CPU goes into STOP mode.	INTF
Programming error	Error in the machine code or in the user program: • BCD conversion error • Range length error • Range error • Alignment error • Write error • Timer number error • Counter number error • Block number error • Block not loaded	OB 121 call If the OB is not loaded: The CPU goes into STOP mode.	INTF
MC7 code error	Error in the compiled user program (e.g. impermissible OP code or jump over the end of the block)	The CPU goes into STOP mode. Reboot or memory reset required.	INTF

4.3 Status and Error LEDs

LEDs RUN and STOP

The RUN and STOP LEDs provide information about the currently active CPU operating status.

LED		Meaning
RUN	STOP	
H	D	CPU is in RUN mode.
D	H	CPU is in STOP mode. The user program is not processed. Restart and warm restart/reboot is possible. If the STOP status was triggered by an error, the error indication (INTF or EXTF) is also set.
B 2 Hz	B 2 Hz	CPU has the status DEFECT. The INTF, EXTF and FRCE LEDs also flash.
B 0.5 Hz	H	HALT status has been triggered by a test function.
B 2 Hz	H	A warm restart/reboot/restart has been triggered. It can take a minute or longer to execute the warm restart/reboot/restart depending on the length of the OB called. If the CPU still does not go into RUN, there might be an error in the system configuration.
B 2 Hz	B 2 Hz	Self–test running for unbuffered POWER ON.
x	B 0.5 Hz	Memory reset is requested by the CPU.
x	B 2 Hz	Memory reset is running.

D = LED is dark; H = LED lights up; B = LED flashes with the specified frequency; x = LED status is irrelevant

LEDs MSTR, RACK0 and RACK1

The three LEDs, MSTR, RACK0 and RACK1, provide information about the mounting rack number configured in the synchronization module and which CPU has process control of the switched I/O modules.

LED			Meaning
MSTR	RACK0	RACK1	
H	x	x	CPU has the process control for the switched I/O
x	H	D	CPU on rack number 0
x	D	H	CPU on rack number 1

D = LED is dark; H = LED lights up; x = LED status is irrelevant

LEDs INTF, EXTF and FRCE

The three LEDs, INTF, EXTF and FRCE, provide information about the errors and special events during running of the user program.

LED			Meaning
INTF	EXTF	FRCE	
H	x	x	An internal error has been detected (programming or parameter assignment error).
x	H	x	An external error has been detected (in other words, the cause of the error cannot be traced back to the CPU module).
x	x	H	A force request is active.

H = LED lights up; x = LED status is irrelevant

LEDs BUSF1 and BUSF2

The LEDs BUSF1 and BUSF2 indicate errors in connection with the MPI/DP interface and the PROFIBUS DP interface.

LED		Meaning
BUS1F	BUS2F	
H	x	An error has been detected at the MPI/DP interface.
x	H	An error has been detected at the PROFIBUS DP interface.
B	x	DP master: One or more slaves at PROFIBUS DP interface 1 are not replying. DP slave: not addressed by the DP master
x	B	DP master: One or more slaves at PROFIBUS DP interface 2 are not replying. DP slave: not addressed by the DP master

H = LED lights up; B = LED flashes; x = LED status is irrelevant

LEDs IFM1F and IFM2F

The LEDs IFM1F and IFM2F indicate errors that occur in the first and second module interfaces.

LED		Meaning
IFM1F	IFM2F	
H	x	An error has been detected at module interface 1.
x	H	An error has been detected at module interface 2.

H = LED lights up; x = LED status is irrelevant

LED REDF

The LED REDF indicates specific system states and redundancy errors.

REDF LED	System Status	Boundary Conditions
Flashes at 0.5 Hz	Linking	–
Flashes at 2 Hz	Update	–
Off	Redundant (CPUs are redundant)	No redundancy error
Lights	Redundant (CPUs are redundant)	There is an I/O redundancy error: • Failure of a DP master or partial or complete failure of a DP master system • Loss of redundancy on the DP slave
	All the system states apart from redundant, linking, updating	–

Diagnostics Buffer

You can read out the exact cause of an error in STEP 7 (PLC –> Module Information) from the diagnostics buffer.

4.4 Mode Selector

Function of the Mode Selector

Using the mode selector, you can put the CPU in RUN/RUN-P or STOP mode or reset the memory of the CPU. STEP 7 offers further options for changing the mode.

Positions

The mode selector switch is designed as a keyswitch. Figure 4-2 illustrates the possible positions of the mode selector.

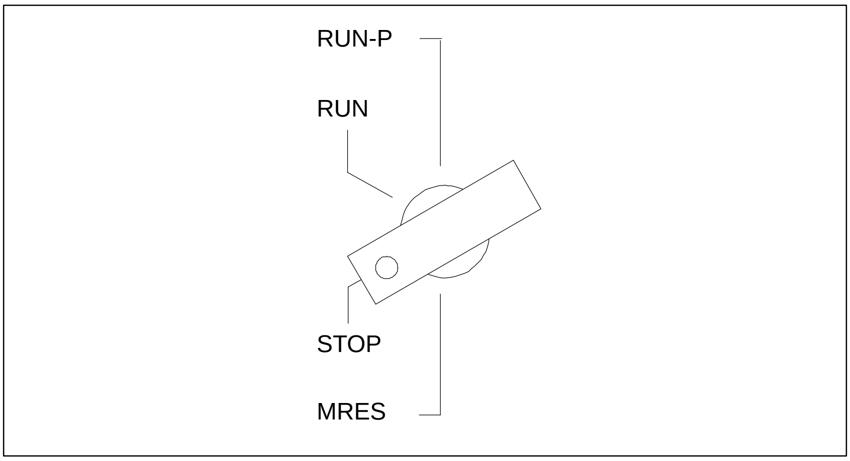


Figure 4-2 Positions of the mode selector

Table 4-2 explains the positions of the mode selector. In the event of a fault or if there are startup problems, the CPU will go into or remain in STOP mode irrespective of the position of the mode selector.

Table 4-2 Positions of the mode selector

Position	Explanation
RUN-P	If there are no startup problems or errors and the CPU was able to go into RUN, the CPU executes the user program or runs with no load. It is possible to access the I/O. The key **cannot** be removed in this position. Programs can: • Be read out with the programming device from the CPU (CPU programming device) • Be transferred to the CPU (programming device CPU).
RUN	If there are no startup problems or errors and the CPU was able to go into RUN, the CPU executes the user program or runs with no load. It is possible to access the I/O. The key can be removed in this position to ensure that the mode cannot be changed without authorization. Programs in the CPU can be read out with the programming device (CPU % programming device). **The program in the CPU cannot be changed when the switch is in the RUN position. (See STEP 7.) The protection level can be bypassed using a password set in STEP 7/HWCONFIG (STEP 7 V4.02 and above). In other words, if you use this password, the program can also be changed when the switch is in the RUN position.**
STOP	The CPU does not process the user program. The digital signal modules are disabled. The key can be removed in this position to ensure that the operating mode cannot be changed without authorization. Programs can: • Be read out with the programming device from the CPU (CPU programming device) • Be transferred to the CPU (programming device CPU).
MRES (Master Reset)	Momentary-contact position of the key switch for the master reset of the CPU and for cold restart (see the following pages).

Protection Levels

A protection level can be defined in the CPUs of the S7-400 that can be used to protect the programs in the CPU from unauthorized access. You can determine with the protection level which programming device functions a user can execute on the CPU in question without particular authorization (password). You can execute all the programming device function using a password.

Setting the Protection Levels

You can set the protection levels (1 to 3) for a CPU under STEP 7/Configuring Hardware.

You can remove the protection level set under STEP 7/Configuring Hardware using a manual reset with the mode selector.

You can also set protection levels 1 and 2 using the mode selector. Table 4-3 lists the protection levels of a CPU of the S7-400.

Table 4-3 Protection levels of a S7-400 CPU

Protection Level	Function	Switch Position
1	• All programming device functions are permitted (default setting).	RUN-P/STOP
2	• It is permissible to load objects from the CPU into programming device. In other words, only read programming device functions are permitted. • Functions for process control, process monitoring and process communication are permitted. • All information functions are permitted.	RUN
3	• Functions for process control, process monitoring and process communication are permitted. • All information functions are permitted.	–

If different protection levels are set with the mode selector and with STEP 7, the higher protection level applies (3 before 2, 2 before 1).

Operating Sequence for Memory Reset

Case A: You want to download a complete, new user program to the CPU.

1. Turn the switch to the STOP setting.

   Result: The STOP LED lights up.

2. Turn the switch to MRES, and keep it in this position.

   Result: The STOP LED is dark for a second, light for a second, dark for a second and then remains on.

3. Turn the switch back to STOP, and then within the next 3 seconds turn it back to MRES and then back to STOP.

   Result: The STOP LED flashes for at least 3 seconds at 2 Hz (memory reset is executed) and then lights up continuously

Case B: When the STOP LED flashes slowly at 0.5 Hz, the CPU is requesting a memory reset (system memory reset request, after a memory card has been removed or inserted, for example).

Turn the switch to MRES and back to the STOP position.

Result: The STOP LED flashes for at least 3 seconds at 2 Hz (a memory reset is executed) and then lights up continuously.

You can find the complete description of what happens during a memory reset in the: S7-400, M7-400 Programmable Controllers Installation Manual, Chapter 6.

Cold Restart

Following a cold restart, the user program starts from the beginning again. All the data, including the retentive data, are deleted.

Reboot (Warm Restart)

Following a reboot, the user program is restarted from the beginning. The retentive data and the contents of the data blocks are retained.

Operation Sequence for Reboot/Warm Start

1. Turn the switch to the STOP setting.

   Result: The STOP LED lights up.

2. Turn the switch to the RUN/RUNP position.

Operating Sequence at Cold Restart

1. Turn the switch to the STOP setting.

   Result: The STOP LED lights up.

2. Turn the switch to MRES, and keep it in this position.

   Result: The STOP LED is dark for a second, light for a second, dark for a second and then remains on.

3. Turn the switch to the RUN/RUNP position.

4.5 Expanded Memory

Determining Memory Requirements with the SIMATIC Manager

You can have the block length displayed offline in the dialog field “Properties - Block folder offline” (Blocks –> Object Properties –> Blocks tab).

The following lengths are shown in the offline view:

- Size (sum of all blocks without system data) in the load memory of the PLC
- Size (sum of all blocks without system data) in the working memory of the PLC

Block lengths from the programming device (PG/PC) are not shown in the properties of the block container.

Block lengths are shown in “byte” units.

The following values are shown in the properties of the block:

- Required number of local data: size of the local data in bytes
- MC7: size of the MC7 code in bytes, or size of the DB user data
- Size of the load memory in the programmable controller
- Size of the working memory in the programmable controller: only displayed if hardware assignment is recognized.)

For display purposes, it does not matter whether the block is located in the window of an online view or an offline view..

When a block container is opened and “View Details” is set, the RAM requirements are shown in the project window regardless whether the block container in the window is an online or offline view.

You can sum the block lengths by marking all of the relevant blocks. In this case the sum of the marked blocks will be shown in the status line of the SIMATIC Manager.

No lengths are shown for blocks (e.g. VATs) that cannot be loaded in the PLC.

Block lengths on the programming system (PG/PC) are not shown in the view details.

Generating block–specific messages

Memory requirements of SFBs for generating block–specific messages, in contrast to the specifications in the Online Help and electronic manual:

SFBs for generating block–specific messages generally require a communication buffer in the CPU work memory (code area), the size of which is also dependent on the length of the associated values. Please see the table below for corresponding information.

Block Type	CPU work memory requirements in [byte]
NOTIFY, NOTIFY_8P, ALARM, ALARM_8P	200 + 2 * the length of associated values specified to SD_1,...SD_10 during the initial call
ALARM_8	100
AR_SEND	54

4.5.1 Expanding Load Memory with Memory Cards

Order Numbers

The order numbers for memory cards are listed at the end of this chapter with the technical specifications.

Installation

The memory card is slightly larger than a credit card and protected by a strong metal casing. It is plugged into a receptacle at the front of the CPU; the end to be inserted is obvious from the design of the memory card.

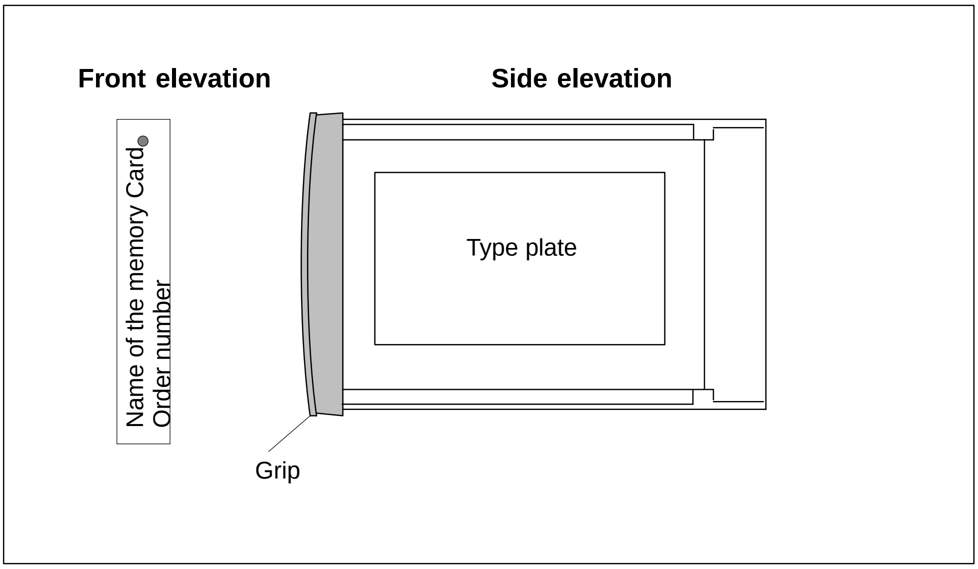


Figure 4-3 Design of the memory card

Function of the Memory Card

The memory card and an integrated memory area on the CPU together form the load memory of the CPU. In operation the load memory contains the complete user program including comments, symbols, special additional information that permits decompiling of the user program, and all the module parameters.

What the Memory Card Contains

The following data can be stored in the memory card:

- User program, i.e. blocks (OBs, FBs, FCs, DBs) and system data
- Parameters that determine the behavior of the CPU
- Parameters that determine the behavior of the I/O modules.
- As of STEP 7 V5.1 the complete project files on suitable memory cards.

Types of Memory Cards for the S7-400

Two types of memory card are used in the S7-400:

- RAM cards
- Flash cards (FEPROM cards)

Note

Third-party memory cards cannot be used in the S7-400.

Which Type of Memory Card to Use

Whether you use a RAM card or a Flash card depends on how you intend to use the memory card.

Table 4-4 Types of memory cards

If You ...	...Then
want to store the data in RAM and you want to modify your program during RUN or RUN-P mode,	use a **RAM card**
want to store your user program long-term on memory card also when the power is switched off (without backup or outside the CPU),	use a **Flash card**

RAM Card

When you use a RAM card, you have to plug this into the CPU to load the user program. The user program is loaded with the help of the programming device (PG).

You can load the entire user program or the individual parts such as FBs, FCs, OBs, DBs, or SDBs into the load memory in STOP mode or in RUN-P mode.

If you remove the RAM card from the CPU, the information stored on it is lost. The RAM card does not have a built-in backup battery.

When the power supply includes a functioning backup battery or when the CPU is supplied by an external backup current connected to the “EXT. BATT.” socket, the memory contents of the RAM Card are maintained when the power supply is switched off as long as the RAM card is inserted in the CPU and the CPU is inserted in the module rack.

FLASH Card

If you use a Flash card, there are two ways of loading the user program:

- Set the CPU to STOP with the mode selector, plug the Flash card into the CPU, and load the user program into the load memory with the help of the programming device (PG).
- Load the user program into the Flash card in offline mode at the programming device and then insert the Flash card into the CPU.

You can only load your complete user program with the Flash card. You can load smaller program sections into the integrated load memory on the CPU using the programming device. In the case of larger program changes, you must always reload the Flash card with the complete user program.

The FLASH card does not require power to store its contents, in other words, the data it contains is maintained when the FLASH card is removed from the CPU or your S7-400 is being operated without power backup (without a backup battery in the power supply module or without an external backup current connected to the “EXT. BATT.” socket of the CPU).

Which Memory Card Capacity to Use

The capacity of the memory card you use depends on the size of the user program and the additional memory requirement resulting from the use of function modules or communications modules. See the manuals of these modules for details of their memory requirements.

Changing Memory Cards

To change the memory card, follow the steps outlined below:

1. Set the CPU to STOP.

Note

If the memory card is not removed in the STOP mode, the CPU goes to the STOP state and the STOP indicator flashes every 3 seconds to prompt you to carry out a memory reset. This procedure cannot be influenced by error OBs.

---

2. Remove the plugged in memory card.
3. Insert a “new” memory card.
4. Perform a memory reset on the CPU.

Technical Specifications

Name	Order Number	Current Consumption at 5 V	BackupCurrents
MC 952 / 256 Kbytes / RAM	6ES7 952-1AH00-0AA0	typ. 35 mA max. 80 mA	typ. 1 μA max. 40 μA
MC 952 / 1 Mbyte / RAM	6ES7 952-1AK00-0AA0	typ. 40 mA Max. 90 mA	typ. 3 μA max. 50 μA
MC 952 / 2 Mbytes / RAM	6ES7 952-1AL00-0AA0	typ. 45 mA max. 100 mA	typ. 5 μA max. 60 μA
MC 952 / 4 MB / RAM	6ES7 952-1AM00-0AA0	typ. 45 mA max. 100 mA	typ. 5 μA max. 60 μA
MC 952 / 8 MB / RAM	6ES7 952-1AP00-0AA0	typ. 45 mA max. 100 mA	typ. 5 μA max. 60 μA
MC 952 / 16 MB / RAM	6ES7 952-1AS00-0AA0	typ. 45 mA max. 100 mA	typ. 5 μA max. 60 μA
MC 952 / 1 Mbyte / 5V Flash	6ES7 952-1KK00-0AA0	typ. 40 mA Max. 90 mA	–
MC 952 / 2 Mbytes / 5V Flash	6ES7 952-1KL00-0AA0	typ. 50 mA max. 100 mA	–
MC 952 / 4 Mbytes / 5V Flash	6ES7 952-1KM00-0AA0	typ. 40 mA Max. 90 mA	–
MC 952 / 8 Mbytes / 5V Flash	6ES7 952-1KP00-0AA0	typ. 50 mA max. 100 mA	–
MC 952 / 16 Mbytes / 5V Flash	6ES7 952-1KS00-0AA0	typ. 55 mA max. 110 mA	–
MC 952 / 32 Mbytes / 5V Flash	6ES7 952-1KT00-0AA0	typ. 55 mA max. 110 mA	–
MC 952 / 64 Mbytes / 5V Flash	6ES7 952-1KY00-0AA0	typ. 55 mA max. 110 mA	–
Dimensions W x H x D W×H×D (in mm)		7,5 × 57 × 87	
Weight		max. 35 g	
EMC protection		Provided by construction	

4.5.2 Expanding the Working Memory of the CPU 417-4 H with Memory Modules

Memory Expansion

The working memory of the CPU 417-4 H can be expanded with memory modules. The following points are important:

1. When only one module is used it has to be inserted in slot 1.
2. You may only insert a second submodule if a 4 Mbyte-submodule is inserted in slot 1.

The following combinations are then possible:

Combination	Slot 1	Slot 2
1	2 Mbytes	–
2	4 Mbytes	–
3	4 Mbytes	2 Mbytes
4	4 Mbytes	4 Mbytes

Note
Only use memory modules designed for the CPU.

Warning
The modules can be damaged.

Failure to observe ESD guidelines can result in damage to both the CPU and memory cards.

Observe the ESD guidelines when fitting memory cards.

Fitting Memory Cards in the CPU

Proceed as follows:

1. Remove the cover from the left side of the CPU by loosening the three screws.
2. Push the first memory card down through an angle of approximately 45^{o} into slot 1 (see Figure 4-4). Note the cutout at the front of the card (polarity reversal protection).
3. Push the memory card down until the tabs in the slot slide into the corresponding cutouts on the side of the card. Make sure that the metal flag at the end of the card lies on the metal edge of the module.
4. If necessary, insert the second memory card in slot 2 in the same way (see Figure 4-4).
5. Fit the cover on the upper left side of the CPU by securing it with three screws.

Note

The connectors to accept the memory cards are coded (see Figure 4-5). Do not apply force when fitting the memory cards.

Lightly press the guide supports out to remove the memory cards (see Figure 4-5).

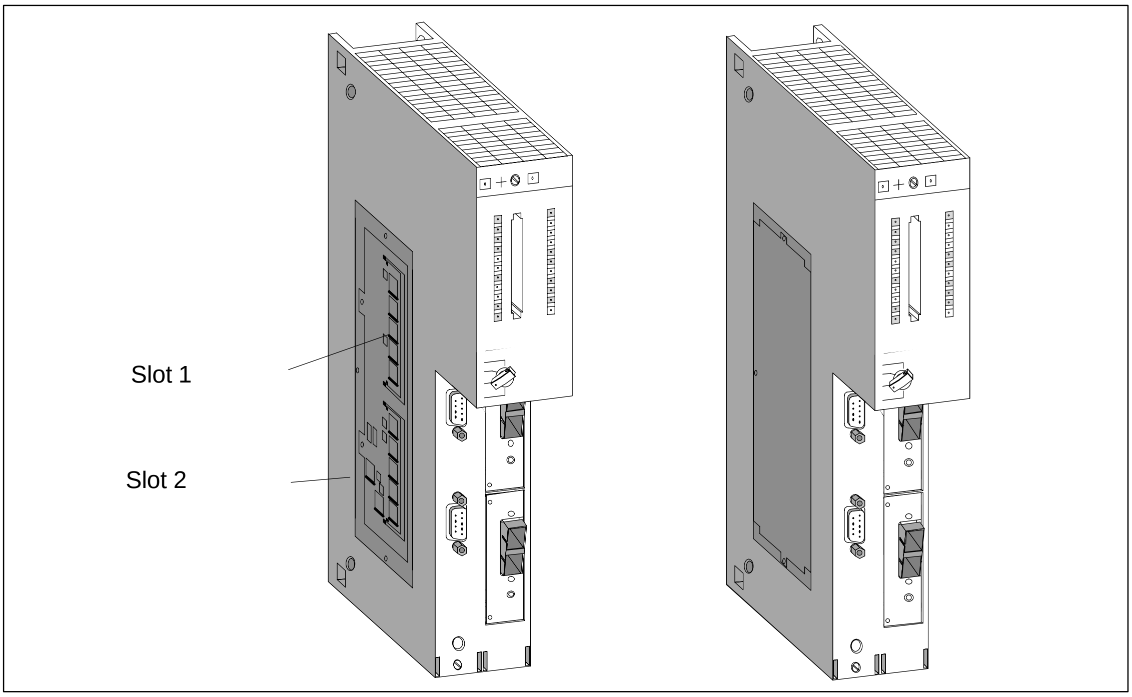


Figure 4-4 Fitting memory cards in the CPUs

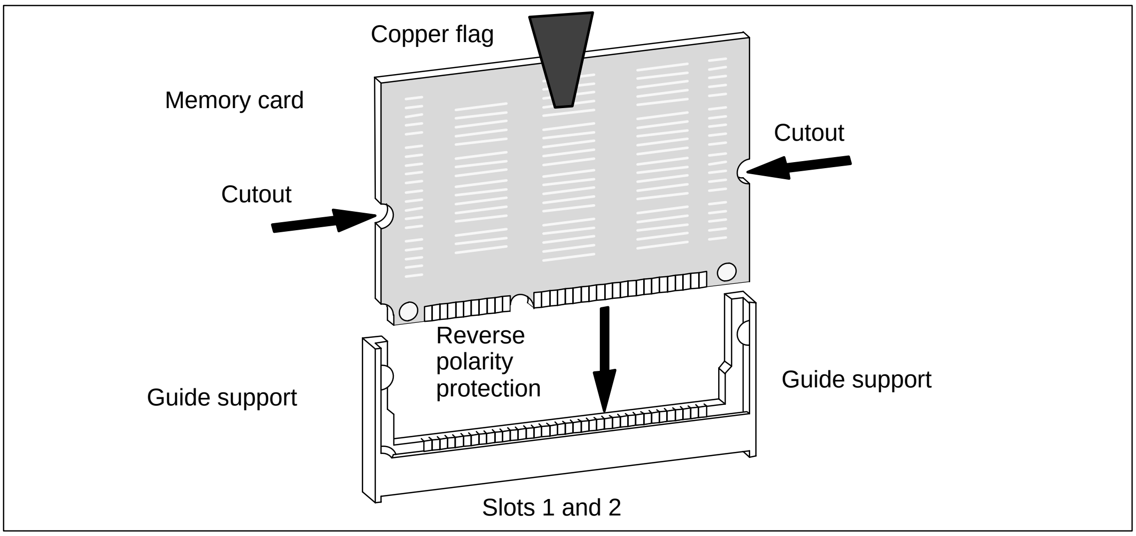


Figure 4-5 Memory card

4.6 Multipoint Interface (MPI)

Connectable Devices

You can, for example, connect the following nodes to the MPI:

- Programming devices (PG/PC)
- Operation and monitoring devices (OPs and TDs)
- Additional SIMATIC S7 programmable controllers

Some connectable devices take the 24 V supply from the interface. This voltage is available there in a non-isolated form.

PG/OP-CPU Communication

A CPU can maintain several simultaneous online connections during communication with programming devices/OPs. By default, one of these connections is for a programming device and one is for an OP/operation and monitoring unit.

Communication and Interrupt Response Times

Notice
The interrupt reaction times can be delayed by read and write jobs having a maximum aggregate (approx. 460 byte).

CPU-CPU Communication

The option “Data exchange via S7 communication” is provided for the CPU-CPU communication.

You can find additional information on this in the “Programming with STEP 7” manual.

Connectors

Only use bus connectors with an angular outgoing cable for PROFIBUS DP and programming device cables to connect devices to the MPI (see *Installation Manual*, Chapter 7).

Multipoint Interface as DP Interface

You can also configure the MPI interface as a DP interface. To do this, you can reconfigure the MPI interface under STEP 7 in SIMATIC Manager. You can use this to set up a DP line with a maximum of 32 slaves.

4.7 PROFIBUS DP Interface

Connectable Devices

All standard DP slaves can be connected to the Profibus DP interface.

The CPU is the DP master and is connected to the passive slave stations or other DP masters through the PROFIBUS-DP field bus.

Some connectable devices take the 24 V supply from the interface. This voltage is available there in a non-isolated form.

Connectors

Only use bus connectors for PROFIBUS DP and PROFIBUS cables to connect devices to the PROFIBUS DP interface (*see Installation Manual,* Chapter 5).

4.8 Overview of the Parameters for the S7-400 CPUs

Default Values

All the parameters have default settings at delivery. These defaults, which are suitable for a whole range of standard applications, mean that the S7-400 can be used immediately without the need for further settings.

You can find the CPU-specific default values using “Configuring Hardware” in STEP 7.

Parameter Blocks

The activity and properties of the CPU are defined by parameters. The CPUs have a defined default setting. You can change this default setting by modifying the parameters.

The following list gives you an overview of the system properties available in the CPUs that can be configured.

- General properties (e.g. MPI node no.)
- Startup (e.g. startup with POWER ON)
- Cycle/clock memory (e.g. cycle monitoring time)
- Retentivity (number of memory markers, timers and counters that are kept retentive)
- Memory (e.g. local data)

  Note: If, for example, you set greater or smaller values than the default values for the process image, the number of diagnostics buffer entries and the maximum number of ALARM-8 blocks **and** blocks for S7 communication, the working memory available for the program code and for data blocks will be reduced or increased by this amount.
- Assignment of interrupts (process interrupts, delay interrupts, asynchronous error interrupts) to the priority classes
- Time-of-day interrupts (e.g. start, interval duration, priority)
- Watchdog interrupts (e.g. priority, interval duration)
- Diagnostics/clock (e.g. time synchronization)
- Protection levels
- H-specific parameters

Note

16 memory bytes and 8 counters are kept retentive in the default setting. In other words, they are not deleted even when the CPU is rebooted.

Parameter Assignment Tool

You can set the individual CPU parameters using “Configuring Hardware” in STEP 7.

Note

If you make changes to the existing settings of the following parameters, the operating system carries out initializations like those during cold restart.

- Size of the process image of the inputs
- Size of the process image of the inputs
- Size of the local data
- Number of diagnostics buffer inputs
- Communication resources

These initializations are:

– Data blocks are initialized with the load values
– M, C, T, I, Q are deleted irrespective of the retentivity setting (0)
– DBs generated via SFC are deleted
– Hard-coded, dynamic connections are cleared down, as are the unconfigured connections of the X/I blocks from the active side of the connection
– All the priority classes start from the beginning again

Specially Saved Parameters

The following parameters are specially saved in an H CPU.

- The module rack number of an H CPU (0 or 1)
- The operating mode of an H CPU (single or redundant mode)

These parameters are not deleted when a memory reset is performed and you cannot change them in HW Config. The following describes how these parameters can be changed.

Changing the Rack Number of an H CPU

To change the rack number of an H CPU, carry out the following steps:

1. Change the rack number on the synchronization module
2. Perform a power on without backup.
3. Perform a manual memory reset.

Changing the Operating Mode of an H CPU

To change the operating mode of an H CPU, carry out one of following procedures depending on the operating mode you wish to change to and the module rack number of the CPU:

Changing from Redundant to Single Mode

1. Remove the interface module.
2. Perform a power on without backup e.g., by removing and inserting the CPU.
3. Load a project into the CPU in which it is configured for single mode.

Changing from Single to Redundant Mode, Module Rack Number 0

1. Connect the synchronization modules set for rack number 0.
2. Perform a power on without backup e.g., by removing and inserting the CPU.
3. Load a project into the CPU in which it is configured for redundant mode.

Changing from Single to Redundant Mode, Module Rack Number 1

1. Connect the synchronization modules set for rack number 1.
2. Perform a power on without backup e.g., by removing and inserting the CPU.
3. Load a project into the CPU in which it is configured for redundant mode.

4.9 CPU 41x-H as Profibus DP Master

Introduction

This chapter details the properties and technical specifications you need when you wish to use the CPU as a DP master and configure it for direct data communication.

Note

This description applies to CPUs as of V 3.0.0.

Chapter Overview

Further References

You can find descriptions of and information on configuration as a whole, the configuration of a PROFIBUS subnetwork and diagnostics in the PROFIBUS subnetwork in the *STEP 7* online help system.

Further information

You can find descriptions and information on changing from PROFIBUS DP to PROFIBUS DPV1 on the Internet at the following address:

http://www.ad.siemens.de/simatic-cs

Under the item number 7027576

4.9.1 DP Address Areas of the CPUs 41x

Address Areas of the CPUs 41x

Table 4-5 CPUs 41x (MPI/DP Interface as Profibus DP)

Address Area	414-4H	417-4H
MPI interface as PROFIBUS DP, inputs and outputs (bytes) in each case	2048	2048
DP interface as PROFIBUS DP, inputs and outputs (bytes) in each case	6144	8192
In the process image, inputs and outputs in each case Can be set up to x bytes	8192	16384

DP diagnostics addresses occupy at least one byte for the DP master and each DP slave in the address area. The DP standard diagnosis for each node can be called at these addresses, for example (LADDR parameter of SFC 13). You specify the DP diagnostics addresses at configuration. If you do not specify any DP diagnostics addresses, *STEP 7* assigns the addresses from the highest byte address downwards as DP diagnostics addresses.

In DPV1 mode of the master, the slaves generally have two diagnostics addresses.

4.9.2 CPU 41x as DP Master

Introduction

This chapter details the properties and technical specifications you need when you wish to operate the CPU as a Profibus DP master.

Prerequisite

Before commissioning, you must configure the CPU as a DP master. That means that you must do the following in *STEP 7*

- Configure the CPU as DP master
- Assign a PROFIBUS address
- Select an operating mode (S7-compatible or DPV1)
- Assign a diagnostics address
- Connect DP slaves to the DP master system

Note

Is one of the PROFIBUS DP slaves a CPU 31x or a CPU 41x?

If it is, you will find it in the PROFIBUS DP catalog as a preconfigured station. Assign this DP slave CPU a slave diagnostics address in the DP master. You must link the DP master to the DP slave CPU and specify the address areas for the transfer of data to the DP slave CPU.

Monitor/Modify, Programming via PROFIBUS

As an alternative to the MPI interface, you can use the PROFIBUS DP interface to program the CPU or execute the Monitor/Modify programming device functions via the PROFIBUS DP interface.

Note

The Programming and Monitor/Modify applications via the PROFIBUS DP interface extend the DP cycle.

Power-Up of the DP Master System

Use the following parameters to set power-up monitoring of the DP master:

- Transfer of the Parameters to Modules
- “Finished” Message by Means of Modules

In other words, the DP slaves must power up and be configured by the CPU (as DP master) in the set time.

PROFIBUS Address of the DP Master

All PROFIBUS addresses are permissible.

From EN 50170 to DPV1

The EN 50170 standard for distributed I/O has been further developed. The development results are included in IEC 61158 / IEC 61784-1:2002 Ed1 CP 3/1. In the SIMATIC documentation we refer to this as DPV1. The new version features a few additions and simplifications.

Some SIEMENS automation components already feature DPV1 functions. To be able to use these new features you first have to perform a few small modifications to your system. A detailed description of the conversion from EN 50170 to DPV1 is available as FAQ with the title “Changing from EN 50170 to DPV1”, FAQ contribution ID 7027576 at the Customer Support Internet site.

Components Supporting Profibus DPV1 Features

DPV1 Master

- The S7-400 CPUs with integrated DP interface beginning with firmware version 3.0.
- CP 443-5, order number 6GK7 443-5DX03-0XE0, if it to be used with one of the above–mentioned S7-400 CPUs.

DPV1 Slaves

- DP slaves from the hardware catalog of STEP 7 and listed under their family names can be recognized in the information text as DPV1 slaves.
- DP slaves integrated in STEP 7 through GSD files, beginning with GSD Revision 3.

STEP 7

Beginning with STEP 7 V5.1, Service Pack 2.

What are the Operating Modes for DPV1 Components?

- S7 Compatible Mode

  In this mode the components are compatible to EN 50170. However, you cannot fully use the DPV1 features.
- DPV1 Mode

  In this mode you have full access to the DPV1 features. The automation components in the station that do not support DPV1 can continued be used as before.

Compatibility between DPV1 and EN 50170?

You continue to use all the previous slaves after conversion to DPV1. However, your previous slaves do not support the additional functions of DPV1..

You can you use DPV1 slaves even without the conversion to DPV1. The DPV1 slaves then behave like conventional slaves.. DPV1 slaves from SIEMENS can be used in the S7–compatible mode. For DPV1 slaves from other manufacturers you need a GSD file to EN50170 earlier than Revision 3.

Determining the Bus Topology in a DP Master System with the SFC 103 “DP_TOPOL”

The diagnostics repeater is provided to improve the ability of locating disrupted modules or an interruption on the DP cables when failures occur in ongoing operation. This module is a slave that determines the topology of a DP strand and records any faults originating from it.

You can use SFC 103 “DP_TOPOL” to trigger the analysis of the bus topology of a DP master systems by the diagnostics repeater. SFC 103 is documented in the corresponding online help and in the manual “System and Standard Functions”. The diagnostics repeater is documented in the manual “Diagnostics Repeater for PROFIBUS DP”, order number 6ES7972-0AB00-8BA0.

System Modifications During Ongoing Operation

Some system configuration modifications can be made in the RUN state even when an H CPU is being operated in single mode. Processing is halted for a maximum of 2.5 seconds (configurable). The process outputs maintain their current value during this time. This has practically no effect on the process especially in processing engineering systems. See also the manual *“Modifications to the System During Operation Using CiR”*

System modification during ongoing operation can only be made for distributed I/O. It requires the type of configuration shown in the following illustration. To simplify the representation only one DP master system and only one PA master system are shown.

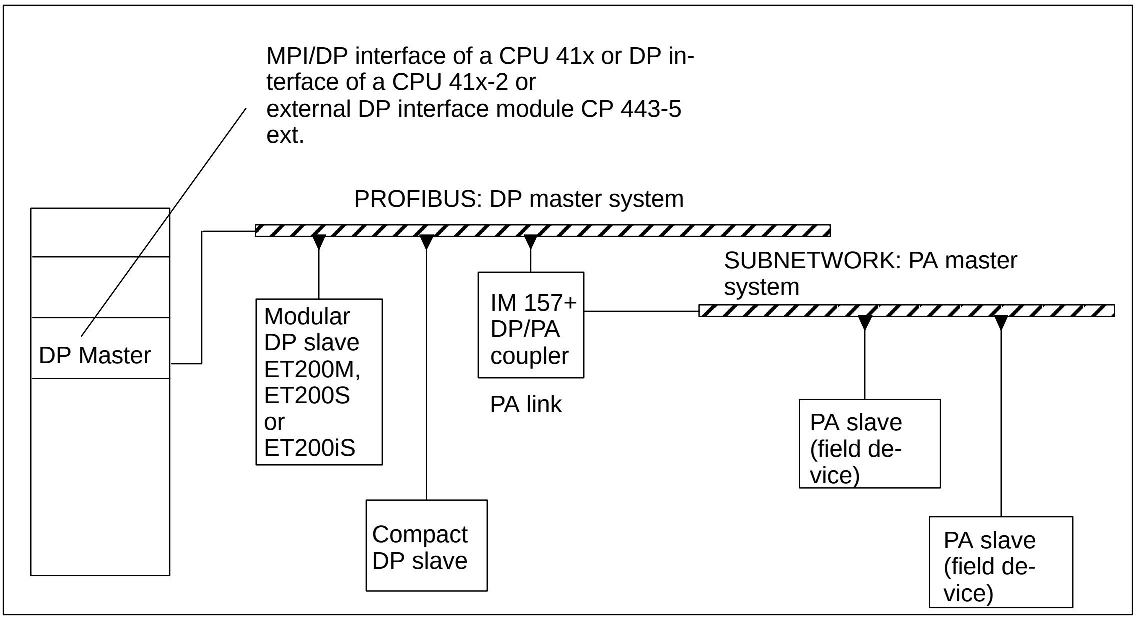


Figure 4-6 Overview: system configuration for modification of the system during operation

Hardware Requirements for System Modification During Operation

The following hardware requirements must be met in the commissioning phase to enable system modifications during ongoing operation:

- Use of an S7 400-CPU, firmware V3.1.0 or later
- S7 400 H-CPU only in single mode
- If you are using an extended CP 443-5, it has to be firmware V5.0 or later.
- If you want to add modules for the ET 200M: Use the IM153-2 as of MLFB 6ES7 153-2BA00-0XB0 or IM153-2FO as of version MLFB 6ES7 153-2BB00-0XB0. You will also need to install the ET 200M with an active backplane bus with enough free space for the planned expansion. The ET 200M has to be integrated in such a way that it conforms to IEC 61158.
- If you wish to add entire stations: be sure to include the required connectors, repeaters, etc.
- If you wish to add PA slaves (field devices): use IM157 version MLFB 6ES7 157-0AA82-0XA00 or later in the corresponding DP/PA Link.

Note

You can freely mix components that are cable of system modification during operation and those that are not. Depending on the chosen configuration, there may be restrictions to the components that can be modified during operation.

Software Requirements for System Modification During Operation

You require STEP7 V5.2. to be able to perform system modifications during ongoing operation the user program must be written in such a way that such events as station failures or module faults do not result in a CPU STOP.

Permitted System Modifications: Overview

The following modifications can be made to the system during operation:

- Addition of modules for modular DP slaves ET 200M, ET 200S, ET 200iS, if they respond in accordance with IEC 61158
- Use of a free channel on an existing module for the modular slaves ET 200M, ET 200S, ET 200iS
- Addition of DP slaves to an existing DP master system
- Addition of PA slaves (field devices) to an existing PA master system
- Addition of DP/PA couplers behind an IM157
- Addition of PA links (including PA master systems) to an existing DP master system
- Assignment of modules to a process image partition

- Reconfiguration of I/O modules, e.g. selection of other interrupt limits
- Reversal of modifications: added modules, DP slaves and PA slaves (field devices) can be removed.

4.9.3 Diagnostics of the CPU 41x as DP Master

Diagnostics Using LEDs

Table 4-6 explains the meaning of the BUSF LED.
The BUSF LED assigned to the interface configured as the PROFIBUS DP interface will always light up or flash.

Table 4-6 Meaning of the BUSF LEDs of the CPU 41x as DP master

BUSF	Meaning	What to Do
Off	Configuration correct All the configured slaves are addressable	–
Lights	• Bus fault (hardware fault) • DP interface fault • Different transmission rates in multi–DP master operation (only in single mode)	• Check the bus cable for a short circuit or interruption. • Evaluate the diagnosis. Reconfigure or correct the configuration.
Flashes	• Station failure • At least one of the assigned slaves is not addressable	• Check whether the bus cable is connected to the CPU 41x or whether the bus is interrupted. • Wait until the CPU 41x has powered up. If the LED does not stop flashing, check the DP slaves or evaluate the diagnosis of the DP slaves.

Reading Out the Diagnostics Information with STEP 7

Table 4-7 Reading out the diagnostics information with *STEP 7*

DP Master	Block or Tab in *STEP 7*	Application	Refer To...
CPU 41x	DP slave diagnostics tab	To display the slave diagnosis as plain text at the *STEP 7* user interface	See the section on hardware diagnostics in the *STEP 7* online help system and the *STEP 7* user guide STEP 7-STEP 7
	SFC 13 “DPNRM_DG”	To read out the slave diagnosis (store in the data area of the user program))	Configuration for CPU 41x, see CPU manual; SFC see Reference Manual *System and Standard Functions*, configuration for other slaves, see respective documentation.
	SFC 59 “RD_REC”	To read out data records of the S7 diagnosis (store in the data area of the user program))	See the *System and Standard Functions* Reference Manual
	SFC 51 “RDSYSST”	To read out SSL sublists. Call SFC 51 in the diagnostics interrupt using the SSL ID W#16#00B3 and read out the SSL of the slave CPU.	
	SFB 52 “RDREC”	For DPV1 slaves: To read out data records of the S7 diagnosis (store in the data area of the user program))	
	SFB 54 “RALRM”	For DPV1 slaves: To read out interrupt information within the associated interrupt OB	

Evaluating the Diagnosis in the User Program

The following figure shows you how to evaluate the diagnosis in the user program.

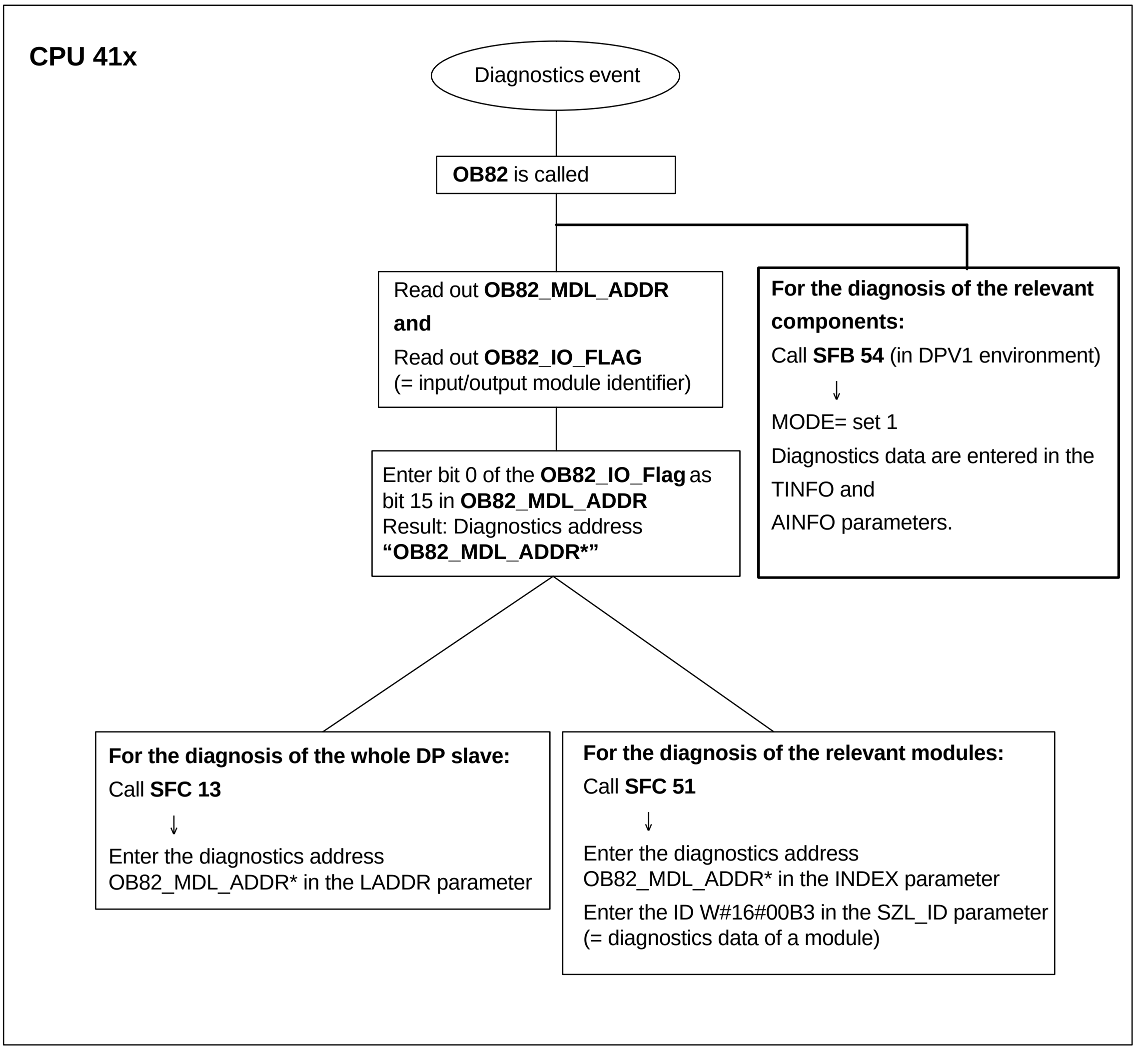


Figure 4-7 Diagnostics with CPU 41x

Diagnostics Addresses in Connection with DP Slave Functionality

You assign diagnostics addresses for the PROFIBUS DP in the CPU 41x. Ensure during configuration that DP diagnostics addresses are assigned once to the DP master and once to the DP slave.

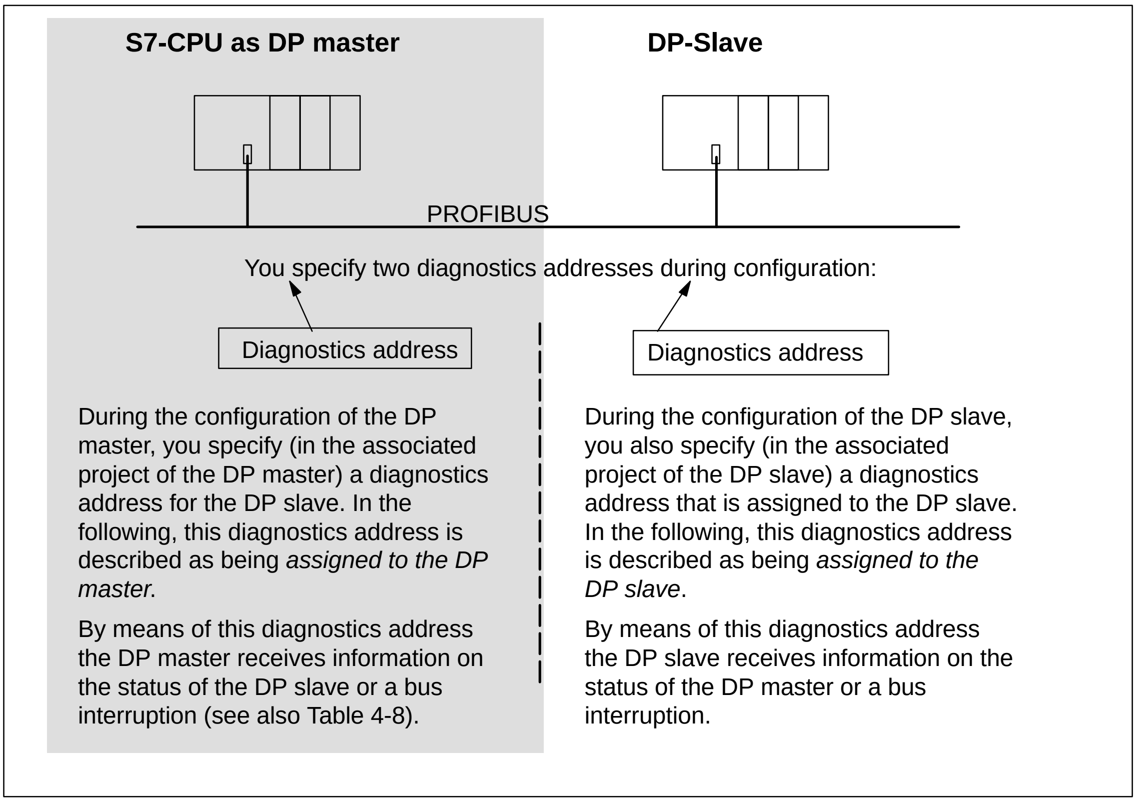


Figure 4-8 Diagnostics addresses for the DP master and DP slave

Event Detection

Table 4-8 shows how the CPU 41x acting as a DP master detects any changes in the operating mode of a CPU as DP slave or interruptions in data transfer.

Table 4-8 Event detection of the CPUs 41x as DP master

Event	What Happens in the DP Master
Bus interruption (short circuit, plug removed)	• OB 86 called with the message *Station failure* (incoming event; diagnostics address of the DP slave that is assigned to the DP master) • In the case of I/O access: Call of OB 122 (I/O access error)
DP slave: RUN → STOP	• OB 82 is called with the message *Faulty module* (incoming event; diagnostics address of the DP slave that is assigned to the DP master; tag OB82_MDL_STOP=1)
DP slave: STOP → RUN	• OB 82 is called with the message *Module ok.* (outgoing event; diagnostic address of the DP slave that is assigned to the DP master; Variable OB82_MDL_STOP=0)

Evaluation in the User Program

The following table shows you how, for example, you can evaluate RUN-STOP transitions of the DP slave in the DP master (see also Table 4-8).

In the DP Master	In the DP Slave (CPU 41x)
Diagnostics addresses: (example) Master diagnostics address=**1023** Slave diagnostics address in the master system=**1022**	Diagnostics addresses: (example) Slave diagnostics address=**422** Master diagnostics address=not relevant
The CPU calls OB 82 with the following information, amongst other things: • OB 82_MDL_ADDR:=**1022** • OB82_EV_CLASS:=B#16#39 (incoming event) • OB82_MDL_DEFECT:=module malfunction Tip: This information is also in the diagnostics buffer of the CPU You should also program the SFC 13 “DPNRM_DG” in the user program to read out the DP slave diagnostics data. We recommend you use SFB 54 in the DPV1 environment. It outputs the interrupt information in its entirety. ←	CPU: RUN → STOP CPU generates a DP slave diagnostics frame.

4.10 Consistent Data

Data that belongs together in terms of its content and a process state written at a specific point in time is known as consistent data.. To maintain consistency, the data should not be changed or updated during processing or transmission.

Example 1:

To ensure that the CPU has a consistent image of the process signals for the duration of cyclic program scanning, the process signals are read from the process image inputs prior to program scanning and written to the process image outputs after the program scanning. Subsequently, during program scanning when the address area "inputs" (I) and "outputs" (O) are addressed, the user program addresses the internal memory area of the CPU on which the image of the inputs and outputs is located instead of directly accessing the signal modules.

Example 2:

Inconsistency can arise if a communication block (e.g. SFB 14 "GET", SFB 15 "PUT") is interrupted by a process interrupt OB with a higher priority. If the user program in this process interrupt OB now changes the data which have already been processed in part by the communication block, the transferred data originate in part before and in part after the time the process interrupt was processed.

This means that these data are inconsistent (not coherent).

SFC 81 “UBLKMOV”

With SFC 81 “UBLKMOV” (uninterruptible block move), you can copy the contents of a memory area (= source area) consistently to a different memory area (= destination area). The copy operation cannot be interrupted by other operating system activities.

SFC 81 “UBLKMOV” enables you to copy the following memory areas:

- Memory markers
- DB contents
- Process image of the inputs
- Process image of outputs

The maximum amount of data you can copy is 512 bytes. Take into consideration the restrictions for the specific CPU, which are documented in the operations list, for example.

Since copying cannot be interrupted, the interrupt reaction times of your CPU may increase when using SFC 81 “UBLKMOV”.

The source and destination areas must not overlap. If the specified destination area is larger than the source area, the function only copies as much data to the destination area as that contained in the source area. If the specified destination area is smaller than the source area, the function only copies as much data as can be written to the destination area.

4.10.1 Consistency for Communication Blocks and Functions

Using S7–400 the communication data is not processed in the scan cycle checkpoint; instead, this data is processed in fixed time slices during the program cycle.

On the system side only the commands byte, word and double word can be processed in an intrinsically consistent way, in other words they cannot be interrupted by communication functions.

When communications blocks, which are only used in pairs (such as SFB 12 “BSEND” and SFB 13 “BRCV”), are invoked in the user program and access shared data, access to this data area can be coordinated by means of the “DONE” parameter, for example. Data consistency of the communication areas transmitted locally with a communication block can thus be ensured in the user program.

S7 communication functions such as SFB 14 “GET”, SFB 15 “PUT” react differently because no block is needed in the user program of the destination device. In this case the size of data consistency has to be taken into account beforehand during the programming phase.

4.10.2 Access to the Working Memory of the CPU

The communication functions of the operating system access the working memory of the CPU in fixed block lengths. The block length depends on the CPU; for S7-400 CPUs it is 32 bytes.

This ensures that the interrupt reaction time is not increased when communication functions are used. Since this access is perform asynchronous to the user program, you cannot transmit an unlimited number bytes of consistent data.

The following explains the rules that you should keep to guarantee data consistency.

4.10.3 Consistency Rules for SFB 14 “GET” and Reading Tags

Using SFB 14 “GET” data are transmitted consistently if you adhere to the following consistency rules:

- Active CPU (data receiver): Read the receive area in the OB by calling SFB 14 or – if this is not possible – read the receive area when the processing of SFB 14 is completed.
- Passive CPU (data sender): Write only as much data to the send area as the block size of the passive CPU (data sender) specifies.
- Passive CPU (data sender): Write the data to be sent to the send area using an interrupt block.

The following is an example of a situation in which consistent data transmission cannot be ensured because it violates the second consistency rule: 32 bytes are sent although the block size of the passive CPU (data sender) is only 8 bytes.

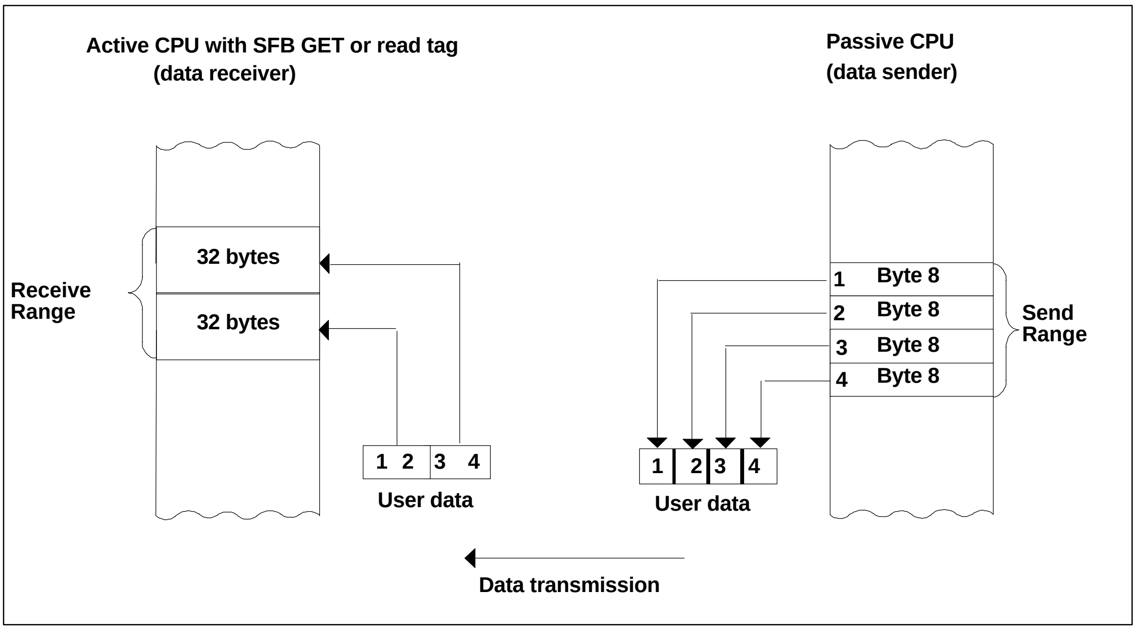


Figure 4-9 Data transmission without data consistency

Consistency Rules for SFB 15 “PUT” or Write Tag

Using SFB 15 “PUT” data are transmitted consistently if you adhere to the following consistency rules:

- Active CPU (data sender): Write the receive area in the OB by calling SFB 15 or – if this is not possible – write the send area when the processing of SFB 15 is completed.
- Active CPU (data sender): Write only as much data to the send area as the block size of the passive CPU (data receiver) specifies.
- Passive CPU (data receiver): Read the received data from the receive area using an interrupt block.

The following is an example of a situation in which consistent data transmission cannot be ensured because it violates the second consistency rule: 64 bytes are sent although the block size of the passive CPU (data receiver) is only 32 bytes.

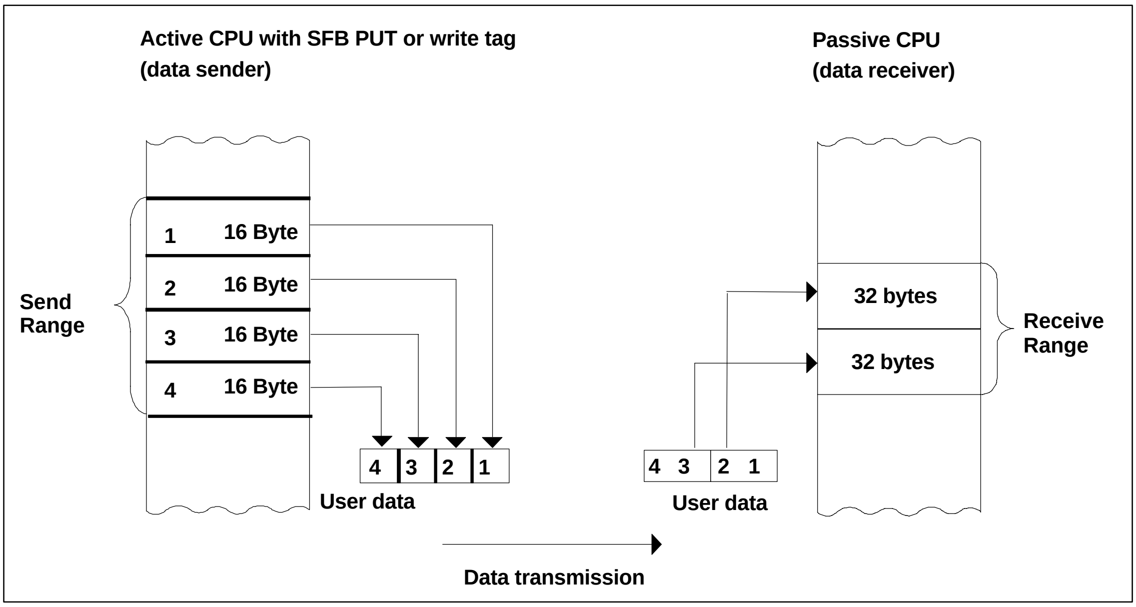


Figure 4-10 Data transmission without data consistency

Consistent transfer of larger data blocks spanning several tags can be ensured in the user program of the S7-400 using SFC 81 “UBLKMOV” (uninteruptable block move).

These data can be consistently accessed using SFB 14 “GET”, SFB 15 “PUT or reading/writing the tag, for example.

4.10.4 Reading Data consistently from a DP Standard Slave and Writing Consistently to a DP Standard Slave

Reading Data Consistently from a DP Standard Slave Using SFC 14 “DPRD_DAT”

Using SFC 14 “DPRD_DAT” (read consistent data of a DP standard slave) you can consistently read the data of a DP standard slave.

The data read is entered into the destination range defined by RECORD if no error occurs during the data transmission.

The destination range must have the same length as the one you have configured for the selected module with STEP 7.

By invoking SFC 14 you can only access the data of one module / DP ID at the configured start address.

Writing Data Consistently to a DP Standard Slave Using SFC 15 “DPWR_DAT”

Using SFC 15 “DPWR_DAT” (write consistent data to a DP standard slave) you can consistently write data to the DP standard slave addressed in the RECORD.

The source range must have the same length as the one you have configured for the selected module with STEP 7.

Note

The Profibus DP standard defines the upper limit for the transmission of consistent user data (see following section). Typical DP standard slaves adhere to this upper limit. In older CPUs (<1999) there are restrictions in the transmission of consistent user data depending on the CPU. For these CPUs you can determine the maximum length of the data which the CPU can consistently read and write to and from the DP standard in the respective technical specifications under the index entry “DP Master – User data per DP slave”. Newer CPUs are capable of exceeding the value for the amount of data that a DP standard slave can send and receive.

Upper Limit for the Transmission of Consistent User Data on a DP Slave

The Profibus DP standard defines the upper limit for the transmission of consistent user data to a DP slave.

For this reason a maximum of 64 words = 128 bytes of user data can be consistently transferred in a block to the DP slave.

During the configuration you can determine the size of the consistent area. You can set a maximum length of consistent data at 64 words = 128 bytes in the special identification format (SKF) (128 bytes for inputs and 128 bytes for outputs); the data block size cannot exceed this.

This upper limit only applies to pure user data. Diagnostics and parameter data are regrouped into full records and therefore always transferred consistently.

In the general identification format (AKF) the maximum length of consistent data can be set at 16 words = 32 bytes (32 bytes for inputs and 32 bytes for outputs); the data block size cannot exceed this.

Note in this context that a CPU 41x in a general environment acting as a DP slave on a third–party master (connection defined by GSD) has to be configured with the general identification format. The transfer memory of a CPU 41x acting as a DP slave to the PROFIBUS DP can therefore be a maximum of 16 words = 32 bytes.

4.10.5 Consistent Data Access without the Use of SFC 14 or SFC 15

Consistent data access of > 4 bytes without using SFC 14 or SFC 15 is possible for the CPUs listed below. The data area of a DP slave that should transfer consistently is transferred to a process image partition. The information in this area are therefore always consistent. You can subsequently access the process image partition using the load / transfer command (e.g. L EW 1). This is an especially convenient and efficient (low runtime load) way to access consistent data. It enables efficient connection and configuration of such devices as drives or other DP slaves.

This applies to CPUs 41x-H with firmware version 3.0 or later:

No I/O access errors occur with direct access (e.g. L PEW or T PAW).

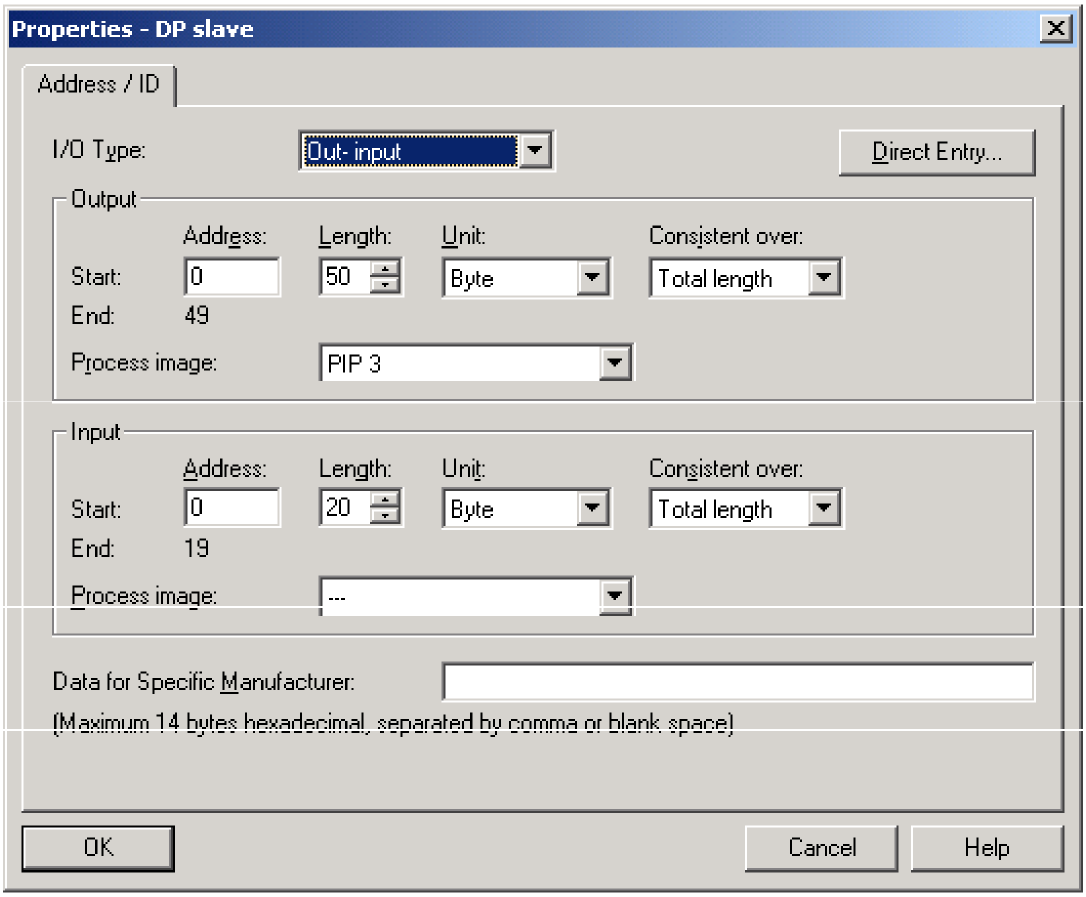
The following is important for converting from the SFC14/15 method to the process image method:

- When converting from the SFC14/15 method to the process image method, it is not recommended to use the system functions and the process image at the same time. Although the process image is updated when writing with the system function SFC15, this is not the case when reading. In other words, the consistency between the process image values and the values of the system function SFC14 is not ensured.
- SFC 50 “RD_LGADR” outputs another address area with the SFC 14/15 method as with the process image method.
- If you are using a CP 443-5 ext the simultaneous use of system functions and the process image results in the following errors: You cannot read/write into the process image and/or you can no longer read/write with SFC 14/15.

Example:

The following example (of the process image partition 3 “TPA 3”) shows such a configuration in HW Config:

- TPA 3 at output: These 50 bytes are stored consistent in the process image partition 3 (pull–down list “Consistent over –> entire length”) and can therefore be read through the normal “load input xy” commands.
- Selecting “Process Image Partition –> ––” under input in the pull–down menu means: do not store in a process image. Then the handling can only be performed using the system functions SFC14/15.


Properties - DP slave
Address / ID
I/O Type:
Out- input
Direct Entry...
Output
Address:
Length:
Unit:
Consistent over:
Start:
0
50
Byte
Total length
End:
49
Process image:
PIP 3
Input
Address:
Length:
Unit:
Consistent over:
Start:
0
20
Byte
Total length
End:
19
Process image:

Data for Specific Manufacturer:
(Maximum 14 bytes hexadecimal, separated by comma or blank space)
OK
Cancel
Help

System and Operating Modes of the S7-400H 5

This chapter features an introduction to the subject of S7-400H fault-tolerant systems.

You will learn the basic concepts that are used in describing how fault-tolerant systems operate.

Following that, you will receive information on fault-tolerant system modes. These modes depend on the operating modes of the different fault-tolerant CPUs, which will be described in the section that follows after that one.

In describing these operating modes, this section concentrates on the behavior that differs from a standard CPU. You will find a description of the normal behavior of a CPU in the corresponding operating mode in the *Programming with STEP 7 manual.*

The final section provides details on the modified time response of fault-tolerant CPUs.

5.1 Introduction

The S7-400H consists of two redundant configured subsystems that are synchronized via fiber-optic cables.

The two subsystems create a fault-tolerant programmable logic controller operating with a two-channel (1-out-of-2) structure on the “active redundancy” principle.

What does active redundancy mean?

Active redundancy, frequently referred to as functional redundancy too, means that all redundant resources are constantly in operation and are simultaneously involved in the execution of the control task.

This means for the S7-400H that the user program in the two CPUs is completely identical and is executed simultaneously (synchronously) by the two CPUs.

Declaration

To identify the two subsystems, we use the traditional expressions of “master” and “standby” for two-channel fault-tolerant systems in this description. The standby always operates so that it is synchronized with the events on the master, meaning that it does not wait for an error instance.

A distinction between the master CPU and the standby CPU is primarily important for ensuring reproducible error reactions. Thus, for example, the standby CPU switches to STOP mode in the event of the redundant link failing, whereas the master CPU remains in RUN mode.

Master/standby assignment

When the S7-400H is turned on for the first time, the first CPU to be stated up becomes the master CPU; the other CPU becomes the standby CPU.

Once the master/standby assignment has been established, it remains like that upon simultaneous POWER ON.

The master/standby assignment is modified by:

1. The standby CPU starting before the master CPU (interval of at least 3 s)
2. Failure or STOP of the master CPU in redundant system mode
3. No fault was found in TROUBLESHOOTING mode (refer also to Section 5.3.6)

Synchronizing the subsystems

The master and standby CPUs are linked by means of fiber-optic cables. The two CPUs maintain event-driven synchronous program scanning over this link.

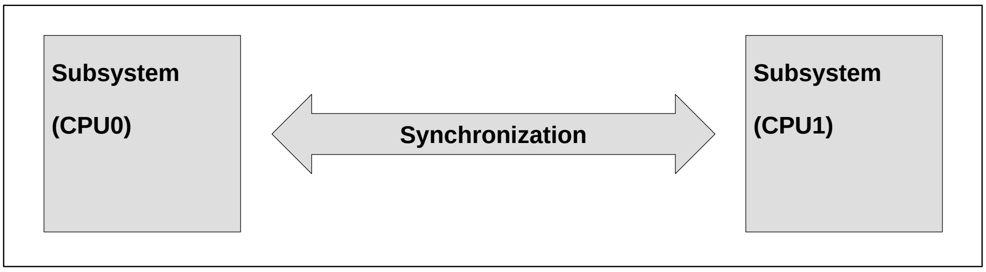


Figure 5-1 Synchronizing the subsystems

Synchronization is performed automatically by the operating system and has no effect on the user program. You create your program in the manner in which you are accustomed for standard CPUs on the S7-400.

Event-driven synchronization procedure

The “event-driven synchronization” procedure patented by Siemens has been used on the S7-400H. This procedure has proved itself in practice and has already been used for the S5-115H and S5-155H PLCs.

Event-driven synchronization means that data synchronization between the master and the standby is performed for any event which may result in a different internal mode of the subsystems.

The master and standby CPUs are synchronized upon:

- direct access to the I/O
- interrupts
- updating of user times – for example, S7 timers
- modification of data by communication functions

Continued operation – free from discontinuities – even in the event of loss of redundancy of a CPU

The event-driven synchronization procedure ensures continued operation at all times, and free from discontinuities, by the standby CPU even in the event of a master CPU failure.

Self-Test

Malfunctions have to be detected, isolated and reported as quickly as possible. Consequently, wide-ranging self-test functions have been implemented in the S7-400H that run automatically and entirely in the background.

The following components and functions are tested:

- interconnection of the central controllers
- processor
- Memory
- I/O bus

If the self-test detects an error, the fault-tolerant system tries to eliminate it or to suppress its effects.

5.2 System Modes of the S7-400H

The system modes of the S7-400H result from the operating modes of the two CPUs. The term “system mode” is used to obtain a simplified expression which identifies the concurrent operating modes of the two CPUs.

Example: Instead of “the master CPU is at RUN and the standby CPU is in the LINK-UP mode” we use “the S7-400H is in the Link-Up system mode”.

Overview of the system modes

The following table shows the system modes that are possible with the S7-400H.

Table 5-1 Overview of the S7-400H system modes

System Modes of the S7-400H	Operating Modes of the Two CPUs	
	Master	Standby
Stop	STOP	STOP, deenergized, DEFECTIVE
Startup	STARTUP	STOP, deenergized, DEFECTIVE, no synchronization
Single Mode	RUN	STOP, TROUBLESHOOTING, deenergized, DEFECTIVE, no synchronization
Linking	RUN	STARTUP, LINK-UP
Update	RUN	UPDATE
Redundant mode	RUN	RUN
Hold	HOLD	STOP, deenergized, DEFECTIVE

5.3 Operating Modes of the CPUs

Operating modes describe the behavior of the CPUs at any given point of time. Knowledge of the operating modes of the CPUs is useful for programming startup, the test and the error diagnostics.

Operating modes from POWER ON to redundant system mode

Generally speaking, the two CPUs enjoy equal rights so that either CPU can be the master or the standby CPU. For reasons of legibility, the illustration presupposes that the master CPU (CPU 0) is energized prior to the standby CPU (CPU 1) being energized.

Figure 5-2 deals with the operating modes of the two CPUs from POWER ON up to redundant system mode. HOLD mode (refer to Section 5.3.5) and ERROR-SEARCH (refer to Section 5.3.6) are not listed since they are a special case.

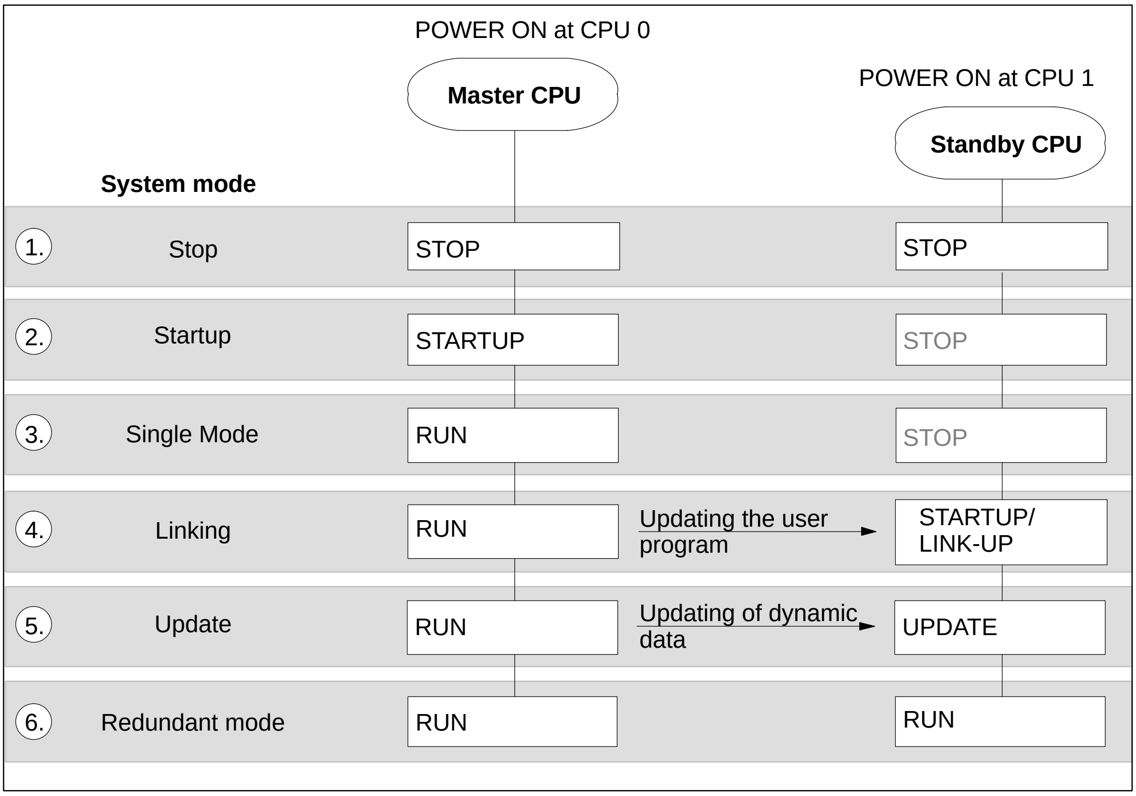


Figure 5-2 System and operating modes of the fault-tolerant system

Explanations relating to Figure 5-2

Table 5-2 Explanations relating to figure 5-2 System and Operating Modes of the Fault-Tolerant System

Item	Description
1.	Once the power supply has been turned on, the two CPUs (CPU 0 and CPU 1) are in the STOP mode.
2.	CPU 0 goes to STARTUP mode and processes OB 100 or OB 102, depending on the type of startup. (Refer to Section 5.3.2)
3.	If startup has been successful, the master CPU (CPU 0) changes to single mode (the master CPU processes the user program on its own).
4.	If the standby CPU (CPU 1) requests LINK-UP, the master and standby CPUs compare their user programs. If they establish differences, the master CPU updates the user program of the standby CPU. (Refer to Section 5.3.3)
5.	After a successful link-up the update starts (see Section 6.2.2). In this instance the master CPU updates the dynamic data of the standby CPU (dynamic data are inputs, outputs, timers, counters, memory markers and data blocks). The contents of the memories of both the CPUs are identical following updating. (Refer to Section 5.3.3)
6.	The master and standby CPUs are at RUN following updating. The two CPUs process the user program in synchronism. Exception: in the case of master/standby switch-over for configuration/program modifications. Redundant system mode is only possible if both CPUs are of the same release and the same firmware version.

5.3.1 STOP Operating Mode

Except for the additions described below, the CPUs of the S7-400H behave in exactly the same way in STOP mode as the standard CPUs on the S7-400 do.

When both CPUs are in STOP mode and you want to load a configuration, you must make sure you load it into the master CPU. Only then are the system data blocks transferred to the I/O modules.

Memory Reset

Memory Reset always affects only that CPU to whose function it is applied. If you want to reset both CPUs, you must do so first for one and then for the other.

5.3.2 STARTUP Operating Mode

Except for the additions described below, the CPUs of the S7-400H behave in exactly the same way in STARTUP mode as the standard CPUs on the S7-400 do.

Startup

The fault-tolerant CPUs distinguish between a cold restart and a reboot (warm restart).

The restart is not supported by fault-tolerant CPUs.

Startup processing by the master CPU

The startup system mode of an S7-400H is processed entirely by the master CPU; the standby CPU plays no part in startup.

At STARTUP the master CPU compares the existing I/O configuration with the hardware configuration that you created with STEP 7. If there are differences, the master CPU reacts in the same way a standard CPU would on the S7-400.

The master CPU checks and assigns parameters to the

1. switched I/O
2. one-way, single-channel I/O.

Further information

You will find detailed information on STARTUP mode in the *Programming with STEP 7* manual.

5.3.3 Operating States LINK–UP and UPDATE

Before the fault-tolerant system accepts redundant system mode the master CPU checks and updates the memory contents of the standby CPU. (Exception: in the case of link-up and update with subsequent switch-over to CPU with modified configuration).

Checking and updating of the memory contents are performed in two phases which run consecutively and will be referred to in the following as “link-up” and “update”.

During link-up and update the master CPU is always at RUN and the standby CPU is in LINK-UP or UPDATE mode.

When executing a link-up and update a distinction is made between whether redundant system mode or a master/standby switch-over is to be achieved (for master/standby switch-over for configuration modifications).
Detailed information on the link-up and update process can be found in Section 6.2

5.3.4 Operating State RUN

Except for the additions described below, the CPUs of the S7-400H behave in exactly the same way in the RUN mode as the standard CPUs on the S7-400 do.

The user program is executed by at least one of the two CPUs in the following system modes:

- Single Mode
- Link-up, Update
- Redundant mode

Single Mode, Link–up, Update

In the above-named system modes the master CPU is at RUN and executes the user program on its own.

Redundant System Mode

The master CPU and the standby CPU are at RUN in redundant system mode. The two CPUs execute the user program in synchronism and perform mutual checks.

In redundant system mode it is not possible to test the user program with breakpoints.

Redundant system mode is only possible if both CPUs are of the same release and the same firmware version. It is quit upon the causes of error listed in Table 5-3.

Table 5-3 Causes of Error Leading to the Termination of Redundant System Mode

Cause of Error	Reaction
Failure of one CPU	Refer to Section 10.1.1
Failure of the redundant link (synchronization submodule or fiber-optic cable)	Refer to Section 10.1.5
Error upon comparison of RAM (comparison error)	Refer to Section 5.3.6

Redundant modules

The following rule applies in Redundant system mode:

Redundantly used modules (for example, DP slave interface module IM 153-2) must be identical – in other words, they must have the same order number, the same version, and the same firmware version.

5.3.5 Operating States HOLD

Except for the additions described below, the S7-400H behaves in exactly the same way in HOLD mode as an S7-400 standard CPU.

HOLD mode is a special case. It is only used for test purposes.

When is HOLD mode possible?

HOLD mode can be reached only from STARTUP mode and from RUN submode of single mode.

Characteristics

- While the fault-tolerant CPU is in HOLD mode, link-up and update are not possible; the standby CPU remains in STOP mode with a diagnostics message.
- If the fault-tolerant system remains in redundant system mode, no hold positions can be set.

5.3.6 TROUBLESHOOTING Operating State

During the self-test, the master and standby CPUs are compared. If the test discovers a difference, an error is reported. Possible errors are hardware faults, checksum errors and RAM/PIQ comparison errors.

The following events will trigger TROUBLESHOOTING mode:

1. If, in redundant mode, there is a one-way call of OB 121 (only on one CPU), a hardware fault is assumed and this CPU goes into TROUBLESHOOTING mode. The other CPU becomes the master, if necessary, and continues in single mode.
2. If, in redundant mode, a checksum error occurs on only one CPU, this CPU goes into TROUBLESHOOTING mode. The other CPU becomes the master, if necessary, and continues in single mode.
3. If, in redundant mode, a RAM/PIQ comparison error occurs, the standby CPU goes into TROUBLESHOOTING mode (default reaction) and the master CPU continues in single mode.

   The response to a RAM/PIQ comparison error can be changed by means of configuration (e.g. the standby CPU goes into STOP).

The purpose of TROUBLESHOOTING mode is to detect and localize a faulty CPU. During the search for errors the standby CPU executes the entire self-test; the master CPU remains in RUN mode.

If an error is detected, the CPU goes into DEFECTIVE mode. If no error is detected, the CPU links up again. The fault-tolerant system goes into redundant system mode again. An automatic master-reserve swtichover then takes place. This ensures that when the next error is detected in TROUBLESHOOTING mode the hardware of the previous master CPU is tested.

No communication is possible in TROUBLESHOOTING mode.

For further information on the self-test, see Section 5.4.

5.4 Self-Test

Processing self-tests

Following unbuffered POWER ON (e.g. POWER ON after plugging in the CPU for the first time or POWER ON without a back-up battery) and in TROUBLESHOOTING mode, the CPU executes the complete self-test program. The processing time of the full self-test depends on the configuration of the S7-400H and lasts approximately 90 to 220 sec.

At RUN the operating system divides the self-test into small program sections (test slices) that are processed consecutively over a whole number of cycles. The cyclic self-test is organized so that it runs once to the end within a certain time. The default time is 90 minutes and can be changed in the configuration.

Response to errors during the self-test

If an error is detected as a result of the self-test, the following happens:

Table 5-4 Response to errors during the self-test

Type of Error	System Response
Hardware fault (without one-way OB 121 call)	Faulty CPU goes into DEFECTIVE mode. The fault-tolerant system goes into single mode. The cause of the error is entered in the diagnostics buffer.
Hardware fault with one-way OB 121 call	The CPU with the one-way OB 121 goes into TROUBLESHOOTING mode. The fault-tolerant system goes into single mode (see below).
RAM/PIQ comparison error	The cause of the error is entered in the diagnostics buffer. The configured system or operating mode is assumed (see below).
Checksum error	The response depends on the situation in which the error was detected (see below).

Hardware fault with one-way OB 121 call

If a hardware fault occurs with a one-way OB 121 call for the first time since the previous unbuffered POWER ON, the faulty CPU goes into TROUBLESHOOTING mode. The fault-tolerant system goes into single mode The cause of the error is entered in the diagnostics buffer.

If a hardware fault occurs with a one-way OB 121 call again within seven days, the faulty CPU goes into DEFECTIVE mode. The fault-tolerant system goes into single mode

RAM/PAA comparison error

If the self-test detects a RAM/PIQ comparison error, the fault-tolerant system quits redundant mode and the standby CPU goes into TROUBLESHOOTING mode (default configuration). The cause of the error is entered in the diagnostics buffer.

The response to a recurring RAM/PIQ comparison error depends on whether the error occurs in the subsequent self-test cycle or not until later.

Table 5-5 Response to a recurring comparison error

Comparison Error Occurs Again ...	Reaction
In the first self-test cycle subsequent to error search	The standby CPU goes into TROUBLESHOOTING mode and then into STOP mode. The fault-tolerant system goes into single mode.
After two or more self-test cycles subsequent to error search	Standby CPU goes into TROUBLESHOOTING. The fault-tolerant system goes into single mode.

Checksum errors

If a checksum error occurs for the first time since the last unbuffered POWER ON, the system responds as follows:

Table 5-6 Response to checksum errors

Detection Time	System Response
During the power-up test after POWER ON	Faulty CPU goes into DEFECTIVE mode. The fault-tolerant system goes into single mode.
In the cyclic self-test (STOP or single mode)	The error is corrected. The CPU remains in STOP or in single mode.
In the cyclic self-test (redundant system mode)	The error is corrected. Faulty CPU goes into TROUBLESHOOTING mode. The fault-tolerant system goes into single mode.
In TROUBLESHOOTING mode	Faulty CPU goes into DEFECTIVE mode. The fault-tolerant system goes into single mode.

The cause of the error is entered in the diagnostics buffer.

If a checksum error reoccurs within 7 days, the faulty CPU goes into DEFECTIVE mode and the fault-tolerant system goes into single mode.

In an F system, the F program is informed that the self-test has detected an error the first time a checksum error occurs in STOP or single mode. The reaction of the F program to this is described in the manual *Automation Systems S7-400F and S7-400FH*.

Influencing the cyclical self-test

With the SFC 90 H_CTRL you can also affect the scope and execution of the cyclical self-test. For example, you can remove and replace individual components of the test. In addition, certain test components can be explicitly called and started for execution.

You will find detailed information on the SFC 90 H_CTRL in the manual on *System Software for S7-300/400, System and Standard Functions*.

Notice

With a fail-safe system, the periodic self-tests must not be inhibited and then enabled again. For more details refer to the *S7-400F and S7-400FH Programmable Controllers* manual.

5.5 Time Response

Instruction run times

The run times of the STEP 7 instructions will be found in the instruction list for the S7-400 CPUs.

Processing I/O direct access

Please note that every I/O access necessitates synchronization of the two subsystems, thus resulting in a longer scan time.

You should therefore avoid I/O direct accesses in your user program and instead use access via process images (or process image sections – for example, for cyclic interrupts). This produces higher performance since a whole set of values have to be synchronized simultaneously in the case of process images.

Reaction time

Detailed information about calculating the response time is available in the reference manual *Automation System S7-400, CPU Data*.

Note that updating the standby CPU extends the interrupt reaction time (see also Section 6.3.1).

The interrupt reaction time depends on the priority class since a graduated delay of the interrupts is performed during updating.

5.6 Evaluation of Process Interrupts in the S7-400H System

When you use a module that creates process interrupts in the S7-400H system, it may be the case that the process values that can be read in the process interrupt OB by direct access do not correspond to the process values at the time of the interrupt. Evaluate instead the temporary variables (start information) in the process interrupt OB.

When you use the SM 321-7BH00 module, which creates process interrupts, it is therefore not advisable to have different responses to rising and falling edges on one and the same input, because this would require direct access to the I/O. If you want to respond differently to the two edge changes in your user program, apply the signal to two inputs from different channel groups and parameterize one input for a rising edge and the other input for a falling edge.

Linking and Synchronizing

6

6.1 Effects of Link-up and Update

Link-up and update are indicated by the REDF LEDs on the two CPUs. On link-up these LEDs flash with a frequency of 0.5 Hz, and on update with a frequency of 2 Hz.
Link-up and update have various effects on the execution of the user program and the communication functions.

Table 6-1 Properties of link-up and update

Process	Linking	Update
Execution of the user program	All priority classes (OBs) are executed.	Execution of the priority classes is delayed by sections. All the requirements are caught up with after the update. You will find the details in the sections which follow.
Deletion, loading, generation and compression of blocks	Blocks cannot be deleted, loaded, generated or compressed. If these actions are being executed, link-up and update will not be possible.	Blocks cannot be deleted, loaded, generated or compressed.
Execution of communication functions, PG operation	Communication functions are being executed.	Execution of the functions is restricted and delayed by sections. All the delayed functions are caught up with after the update. You will find the details in the chapters which follow.
CPU self-test	Will not be performed	Will not be performed
Test and commissioning functions, such as “Monitor and Control Tag”, “Monitor (On/Off)”	No test and commissioning functions are possible. If these actions are being executed, link-up and update will not be possible.	No test and commissioning functions are possible.
Processing of the connections to the master CPU	All the connections remain; no new connections can be made.	All the connections remain; no new connections can be made. Broken connections will only be re-made after the update
Processing of the connections to the standby CPU	All the connections are broken; no new connections can be made.	All the connections are already broken. They are aborted on link-up.

6.2 Functional Sequence of Link-up and Update

There are two types of link-up and update:

- In a “normal” link-up and update the fault-tolerant system should change from single mode to **redundant** system mode. The two CPUs then process the same program in synchronism.
- In the case of a link-up and update with **master/standby switch-over**, the second CPU with modified components may take over process control. Either the hardware configuration or the memory configuration or the operating system may be modified.

  In order to return to redundant system mode a “normal“ link-up and update must be performed subsequently.

How to start link-up and update

Initial situation: Single mode, i.e. only one of the CPUs of a fault-tolerant system connected via fiber-optic cables is in RUN mode.

Link-up and update to achieve redundant system mode can be initiated as follows:

- change the position of the mode selector on the standby from STOP to RUN or RUN-P
- POWER ON at the standby (mode selector position RUN or RUN-P), if prior to POWER DOWN the CPU was not in STOP mode
- operator control at the PG/ES.

You can only start link-up and update with master/standby switch-over through operator control at the PG/ES.

Notice

If link-up and update on the standby CPU is interrupted (for example, POWER DOWN, STOP) inconsistent data may result in a Reset request on this CPU. After the standby is reset link-up and update will be possible again.

Process diagram for link-up and update

The following illustration outlines the functional sequence of link-up and update in general terms. The starting point is with the master in single mode. In the illustration CPU 0 is assumed to be the master CPU.

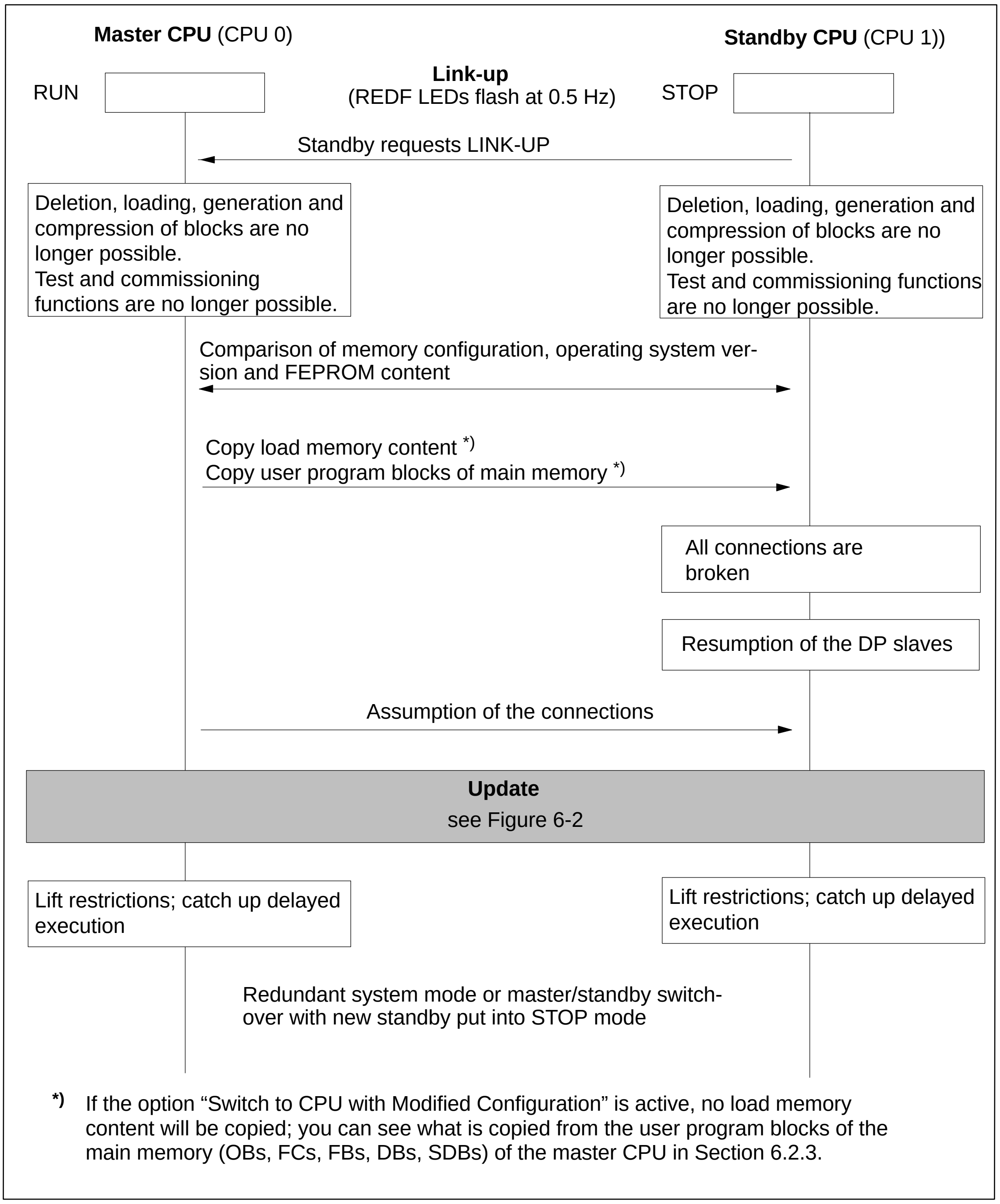


Figure 6-1 Functional sequence of link-up and update

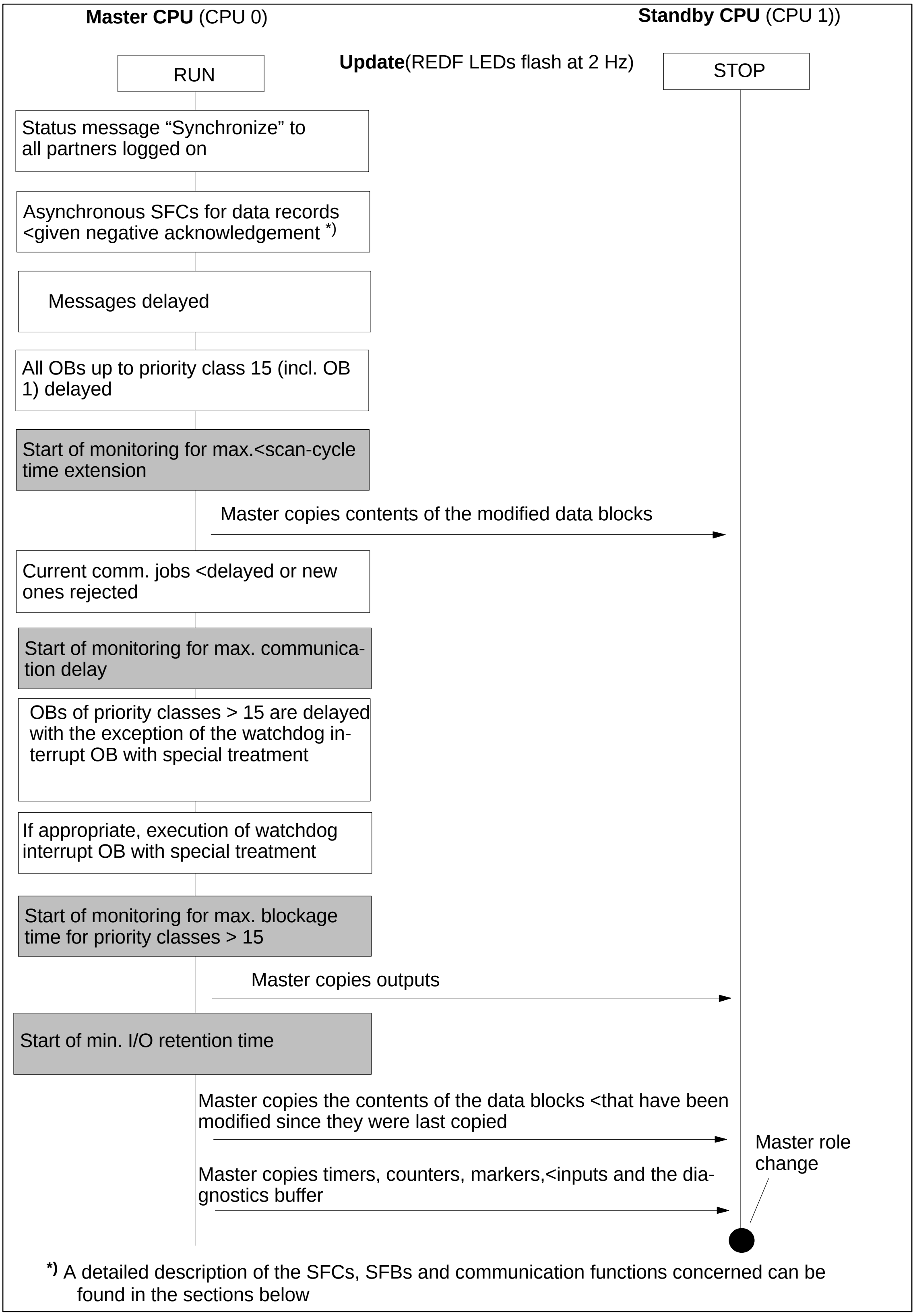


Figure 6-2 Process for update

Minimum signal duration of input signals during the update

During the update, program scanning is stopped for a certain time (we will discuss this subject in greater detail later). So that the change of an input signal can be reliably detected by the CPU even during the update, the following condition must be satisfied:

Min. signal duration > 2 ×× time required for I/O update (for DP only)
+ call interval of the priority class
+ processing time for the program of the priority class
+ time for the update
+ processing time for programs of high-priority priority classes

Example:

Minimum signal duration of an input signal that is evaluated in a priority class > 15 (for example, OB 40).

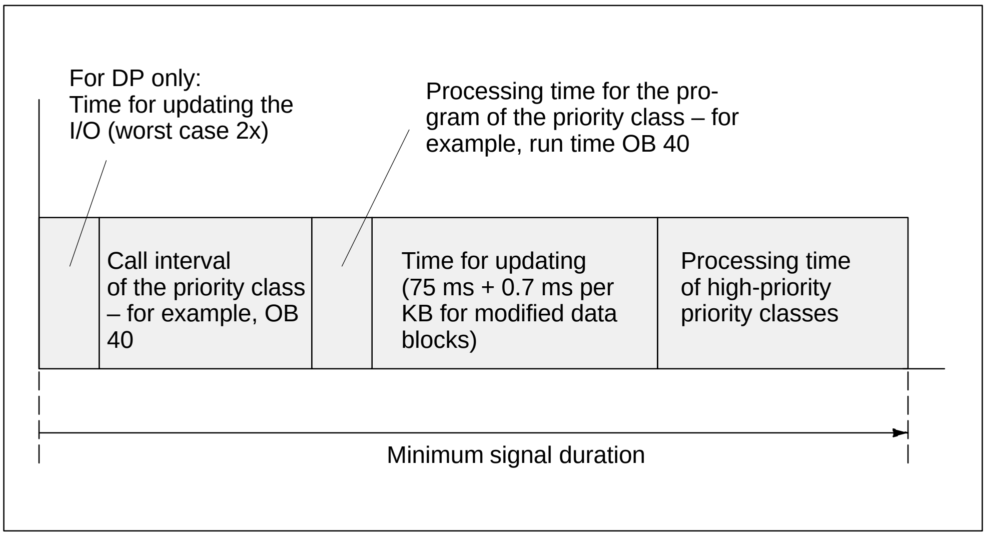


Figure 6-3 Example of minimum signal duration of an input signal during updating

6.2.1 Process of Link-up

In the link-up process a distinction is made between whether redundant system mode or a master/standby switch-over is to be achieved.

Link-up to achieve redundant system mode

In order to preclude differences in the two subsystems, the master CPU and the standby CPU perform the following comparisons.

The following are checked:

1. the identity of the memory configuration
2. the identity of the operating system version
3. the identity of the content of the load memory (FEPROM card)
4. the identity of the content of the load memory (integrated SRAM and RAM card)

If 1., 2. or 3. are not identical, the standby CPU switches to STOP mode with an error message.

In the case of non-identity of 4. the master CPU copies the user program in the load memory of its RAM to the standby CPU.

The user program in the load memory of the FEPROM is not copied.
It must be identical before link-up.

Link-up with master/standby switch-over

In STEP 7 you can choose one of the following options and thus release the following:

- ”Switch to CPU with modified configuration”
- ”Switch to CPU with expanded memory configuration”

The “Switch to CPU with modified operating system” option cannot be used with the present operating system versions.

Switch to CPU with modified configuration

You may have made the following memory modifications on the standby CPU:

- the hardware configuration
- the type of load memory (e.g. you have replaced a RAM card with a FLASH card); the new load memory may be larger or smaller than the old one.

On link-up no blocks are copied from the master to the standby (the exact circumstances are described in Section 6.2.3.).

The steps to be performed in the above-mentioned scenarios (modification of hardware configuration, change of type of load memory) are described in Chapter 11.

Note

If you have not changed either the hardware configuration or the type of load memory on the standby CPU a master/standby switch-over is still carried out and the previous master CPU switches to STOP mode.

Switch to CPU with expanded memory configuration

You may have made the following memory modifications on the standby CPU:

- expansion of the main memory and/or
- expansion of the load memory – in so doing you must have load memory module of the same type, i.e. either RAM cards or FLASH cards; in the case of FLASH cards the content must agree.

On link-up the user program blocks (OBs, FCs, FBs, DBs, SDBs) of the master are copied from the load memory and the main memory to the standby (exception: if the load memory modules are FLASH cards only the blocks from the main memory are copied).

The steps to be performed in the above-mentioned scenarios (expansion of the main memory, expansion of the load memory) are described in Chapter 11.

Notice

If you have changed the type of load memory or the operating system on the standby CPU this will not switch to RUN mode but instead will relapse into STOP mode with a corresponding diagnostics buffer entry.
If you have expanded neither the main memory nor the load memory on the standby CPU this will not switch to RUN mode but instead will relapse into STOP mode with a corresponding diagnostics buffer entry.
No master/standby switch-over will take place and the CPU that has been the master CPU up to that point will remain in RUN mode.

6.2.2 Updating Procedure

What happens during update?

On update the execution of the communication functions and of the OBs is restricted by section. Similarly, all the dynamic data (content of the data blocks, timers, counters and memory markers) are transferred to the standby CPU.

The update procedure is as follows:

1. All asynchronous SFCs that have recourse to data records of I/O modules (SFC 13, 51, 55 to 59) are given a “negative” acknowledgement until the end of the update:
   - A current job returns BUSY = TRUE. It will be fully executed after the update is complete.
   - A job interrupted during the update will return the value W#16#80C3 (SFCs 13, 55 to 59) or W#16#8085 (SFC 51) once the update is complete. With these return values the jobs should be repeated by the user program.
   - A job that you want to start during the update will be rejected with the return value W#16#80C3 (SFCs 13, 55 to 59) or W#16#8085 (SFC 51). With these return values the jobs should be repeated by the user program once the update is complete.
2. Notification functions are delayed until the end of the update (see list below).
3. The execution of the OB 1 and of all OBs up to and including priority class 15 is delayed.

   With watchdog interrupts, the generation of new OB requests is inhibited so that no new watchdog interrupts are stored and, consequently, no new request errors occur.

   Not until the end of the update is a maximum of one request generated and processed for each watchdog interrupt OB. The time stamp of the watchdog interrupts that are generated after a delay cannot be evaluated.
4. Transfer of all the data block contents that have been modified the since link-up.
5. Communication jobs from which the CPU itself derives jobs for other modules (e.g. I/O) are given a negative acknowledgement (see list below).
6. Initial calls (in other words, calls resulting in manipulation of the work memory, refer also to *System Software for S7-300/400 System and Standard Functions*) of communication functions receive a negative acknowledgement. All the remaining communication functions are delayed and caught up on once the update is complete.

7. The generation of new OB request for all OBs (in other words, also for those having a priority class > 15) is inhibited so that no new interrupts are stored and, consequently, no request errors occur.

   Not until the end of the update are the queued interrupts requested again and processed. The time stamp of the interrupts that are generated after a delay cannot be evaluated.

   The user program is not executed any more and there are no more I/O updates.

8. Generation of the start event for the watchdog interrupt OB with special handling if its priority class > 15 and execution of this OB, as necessary.

Note

The watchdog interrupt OB with special treatment is of particular significance if it must respond within a particular time to modules or program segments. This is typically the case for fail-safe systems. For more details see the manuals *S7-400F and S7-400FH Programmable Controllers* and *S7-300 Programmable Controllers; Fail-Safe Signal Modules*.

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9. Transfer the outputs and the entire data block contents that have been modified. Transfer the timers, counters, memory markers and inputs. Transfer the diagnostics buffer

   During this data synchronization, the clock pulse for watchdog interrupts, delay interrupts and S7 timers is stopped. This results in any synchronism that might have existed between watchdog interrupts and time-of-day interrupts being lost.

10. Lift all restrictions. Delayed interrupts and communication functions will be caught up. All OBs continue to be executed.

    Equidistance from the previous calls can no longer be guaranteed for delayed watchdog interrupt OBs.

Notice

Process interrupts and diagnostics interrupts are stored by the I/O. If such interrupts were set by modules of the remote input/output station they will be caught up when the block is lifted. If they were set by modules of the central I/O they can then only all be caught up if the particular interrupt request did not occur again during the block.

If the PG/ES requested a master/standby switch-over then on conclusion of the update the previous standby CPU becomes the master and the previous master CPU switches to STOP mode. Otherwise the two CPUs go to RUN (Redundant mode) and execute the user program in synchronism.

If a master/standby switch-over has been performed then in the next cycle after the update OB 1 has its own identifier (see Reference Manual *System Software for S7-300/400, System and Standard Functions*). For other peculiarities when the configuration is changed see Section 6.2.3.

Delayed notification functions

The SFCs, SFBs and operating system services listed trigger messages to all the parameters logged on in each case. These functions are delayed after the start of the update.

- SFC 17 “ALARM_SQ”, SFC 18 “ALARM_S”, SFC 107 “ALARM_DQ”, SFC 108 “ALARM_D”
- SFC 52 “WR_USMSG”
- SFB 31 “NOTIFY_8P”, SFB 33 “ALARM”, SFB 34 “ALARM_8”, SFB 35 “ALARM_8P”, SFB 36 “NOTIFY”, SFB 37 “AR_SEND”
- Statuses
- System diagnostics messages

From this time on instructions to block and release events via the SFC 9 “EN_MSG” and the SFC 10 “DIS_MSG” will be rejected with a negative return value.

Communication functions with derived jobs

If a CPU receives one of the jobs listed below it must in turn generate communication jobs from this and send these to other modules. This could be, for example, instructions to read or write parameter data records from/to modules of the remote input/output station. These jobs will be rejected until the update is complete.

- Read/write data records via O & M functions
- Read data records via SSL information
- Block and release messages
- Log on and off for messages
- Acknowledge messages

Note

The last 3 functions are recorded by a WinCC system and automatically repeated when the update is complete.

6.2.3 Switch to CPU with modified configuration

If link-up and update was triggered from STEP 7 using the option “Switch to CPU with modified configuration” the behavior will be different as regards processing of the memory content.

Load memory

The content of the load memory is not copied from the master CPU to the standby CPU.

Working memory

The following components are transferred from the main memory of the master CPU to the standby CPU:

- Contents of all the data blocks having the same interface time stamp in the two load memories and with the attributes “Read Only” and “unlinked” not set.
- Data blocks generated in the master CPU by SFC.

  The DBs generated in the standby CPU by SFC are reset.

  If a data block with the same number is also contained in the load memory of the standby CPU link-up will be interrupted with an entry in the diagnostics buffer.
- Process images, timers, counters and memory markers
- Diagnostics buffer

  If the diagnostics buffer in the standby CPU is configured smaller than in the master CPU only the number of entries for which the standby CPU is configured will be transferred. The most current entries will be selected from the master CPU.

If there is insufficient memory the link-up will be interrupted with an entry in the diagnostics buffer.

If data blocks that contain instances of SFBs of the S7 communication information have been modified then these instances will be returned to the state they were in before first being called.

Note

When switching to a CPU with a modified configuration the load memories of the master and standby may be of different sizes.

6.2.4 Block Link-up and Update

Link-up and update is associated with a scan-cycle time extension. Within this there is a margin of time in which no I/O updating is performed (see Section 6.3 “Time Monitoring”). This must be particularly observed if using distributed I/O and a master/standby switch-over takes place after the update (i.e. in the event of a configuration modification whilst in operation).

Caution

Only perform link-up and update in non-critical process states.

To specify the start time of the link-up and update yourself, the function SFC 90 “H_CTRL” is available. You will find a detailed description of this SFC in the manual on *System Software for S7-300/400, System and Standard Functions*).

Notice

If the process tolerates a longer scan-cycle time extension at any point of time, there is no need to call the 90 “H_CTRL” SFC.

The CPU self-test is not performed during link-up and updating. In the case of a fail-safe system, therefore, make sure that you do not delay the update over too long a period. For more details refer to the *S7-400F and S7-400FH Programmable Controllers* manual.

Example of a time-critical process

A slide block with a 50 mm long cam moves on an axis at a constant velocity v = 10 km/h = 2.78 m/s = 2.78 mm/ms. A push button is located on the axis. The push button is thus activated by the cam during a period of Δt = 18 ms.

In order for the activation of the push button to be recognized by the CPU the blocking time for priority classes > 15 (see below for definition) must be clearly below 18 ms.

Since in STEP 7 you are able to set the maximum blocking time for priority classes > 15 only to 0 ms or a value of between 100 and 60000 ms, you need to remedy the situation with one of the following measures:

- Move the start of link-up and update to a time at which the process state is not critical. To do this, use SFC 90 “H_CTRL” (see above).
- Use a substantially longer cam and / or clearly reduce the velocity of the slide block before it reaches the push button.

6.3 Time Monitoring

During the update program scanning is stopped for a particular duration. Section 6.3 will be relevant to you if this duration is critical for your process. If so, configure one or more of the monitoring times described below.

During the update the fault-tolerant system will monitor to check that the scan-cycle time extension, the communication delay and the blocking time for priority classes > 15 do not exceed the maximum values configured for them; at the same time it ensures that the minimal I/O retention time configured is maintained.

Notice

If you have not specified a value for any of the monitoring times then you must take the update into account in the cycle monitoring time. If the update is interrupted in this case, the fault-tolerant system will switch to single mode: The CPU that has been the master CPU up to that point will remain in RUN mode and the standby CPU will go to STOP mode.

You can either configure all the monitoring times or none.

You took the technological requirements into consideration in the monitoring times configured.

The monitoring times are explained in more detail below.

- Max. scan-cycle time extension
  - Scan-cycle time extension the time margin during the update in which there is no execution of OB 1 (and no execution of any other OBs up to priority class 15). During this margin of time the “normal” cycle time monitoring is ineffective.
  - Max. scan-cycle time extension the maximum permissible scan-cycle time extension that you have configured.
- Max. communication delay
  - Communication delay: the margin of time during the update during which no communication functions are executed. (Note: The existing communication links of the master CPU are maintained.)
  - Maximum communication delay: the maximum permissible communication delay that you have configured.
- Max. blocking time for priority classes > 15
  - Blocking time for priority classes > 15: the margin of time during the update during which no OB (and thus no user program) is executed and no more I/O updates are performed.
  - Max. blocking time for priority classes > 15: the max. permissible blocking time that you have configured for priority classes > 15.

- Minimum I/O retention time:

  This is the period of time between copying of the outputs from the master CPU to the standby CPU and the time of transition to redundant system mode or master/standby switch-over (time at which the former master CPU switches to STOP mode and the new master CPU switches to RUN mode). During this time the outputs of both CPUs are activated. This prevents ramping of the I/O even in the event of an update with master/standby switch-over.
  The minimum I/O retention time is especially important for updating with the master/standby switch–over. If you set a value of 0 for the minimum I/O retention time, the outputs may drop off when you make a system modification during ongoing operation.

The start times of the monitoring timers are shown in Figure 6-2 (underlaid boxes). In each case the times end when redundant system mode occurs or on master/standby switch-over (i.e. when the new master switches to RUN mode) at the end of the update.

The times relevant to the update are summarized in the figure below.

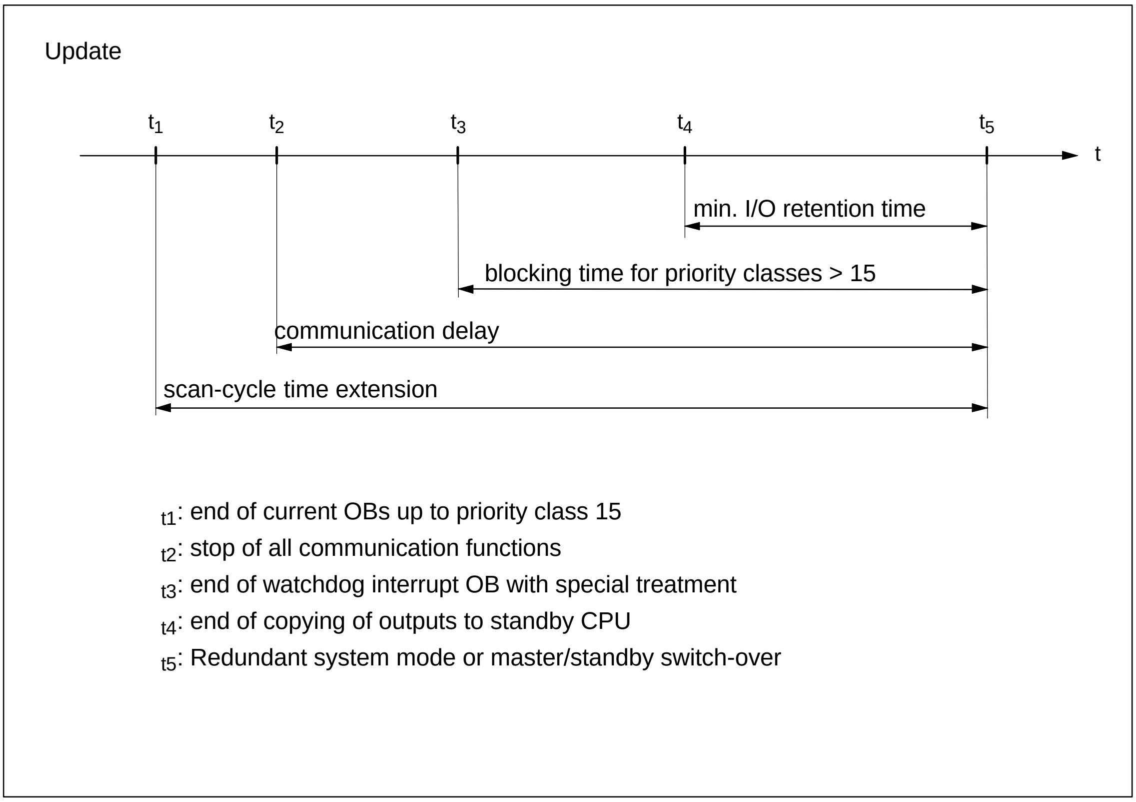

Figure 6-4 Significance of the times relevant during the update

Response to time-out

If one of the times monitored exceeds the maximum value configured then the following process is started:

1. Update aborted
2. Fault-tolerant system remains in single mode with existing master CPU in RUN mode
3. Reason for aborting entered in the diagnostics buffer
4. OB 72 called (with corresponding start information)

The standby CPU then re-evaluates its system data blocks.
Afterwards – but at least one minute later – there is a new attempt at link-up and update. If unsuccessful after 10 attempts no further attempts will be made. You must then initiate link-up and update again.

Reasons for expiration of the monitoring times may include:

- high interrupt load (i.e. of I/O modules)
- high communication load, so that execution of current functions takes longer
- in the final phase of the update large volumes of data have to be copied to the standby CPU.

6.3.1 Time Response

Time response during link-up

During link-up, the controller in your system should be influenced as little as possible. Therefore the duration of link-up increases with the rise in the current loading of your programmable logic controller. Link-up duration depends primarily on the

- communication load
- scan cycle time

The following applies to non-loaded programmable logic controllers:

Link–up run time = size of the load and working memories in MB $\times$ 1 s
\+ basic load

The basic load is a few seconds.

When your programmable logic controller is subjected to a high load, the memory-dependent share can rise to 1 minute per MB.

Time response during the update

The transfer time during updating depends on the number and overall length of the modified data blocks; it does not depend on the modified volume of data within a block. It is also dependent on the current process state and on the communication load.

In a simplified view, the max. blocking time to be configured for priority classes > 15 can be seen as a function of the volume of data in the main memory. The volume of code in the main memory is irrelevant.

6.3.2 Determination of the Monitoring Times

Determination with STEP7 or formulas

The monitoring times listed below are automatically calculation by STEP 7 in version 5.2 or later for each new configuration. You can also calculate them using the formulas and procedures described below. They are equivalent to the formulas used in STEP7.

- Maximum scan-cycle time extension
- Maximum communication delay
- Maximum retention time for priority classes
- minimum I/O retention time

You can also automatically calculate the monitoring times in HW Config in the dialog Properties CPU –> Trigger H Parameters.

Monitoring time accuracy

Note

The monitoring times determined by STEP7 or by using the formulas merely represent a recommendation.

They are based on a fault-tolerant system with two communication peers and an average communication load.

Since your system profile may vary sharply from this assumption, you must take note of the following rules.

- The rise in scan cycle time can increase sharply at a high communication load.
- If you perform changes to your system while it is operating, the rise in scan cycle time can increase appreciably as a result.
- The more program scanning (especially processing of communication blocks) you perform in priority classes > 15, the higher the communication delay and scan cycle time delay might grow.
- You can even undercut the calculated monitoring times in small systems with high performance requirements.

Use of redundant input and output modules

Notice

If you have redundant I/O modules and have taken this into account in your program accordingly, you might have to add a premium to the calculated monitoring times, so that surging does not occur at the output modules.

A premium is required only if you operate modules redundantly from the following table.

Table 6-2 Premium for the monitoring times of redundant I/O

Module type	Premium in ms
ET200M: standard output modules	2
ET200M: HART output modules	10
ET200M: fail-safe output modules	50
ET200L-SC with analog output modules	≤ 80
ET200S with analog output modules or technology modules	≤ 20

Perform the following steps:

- Determine the premium form the table. If several module types in the table are used in Redundant mode, take the highest premium.
- Add it to the monitoring times already determined.

Configuration of the monitoring times

When configuring the monitoring times you must note the following dependencies; conformity will be checked by STEP 7:

max. scan–cycle time extension
> max. communication delay
> (max. blocking time for priority classes > 15)
> min. I/O retention time

If, in the case of link-up and update with master/standby switch-over, the CPUs have been configured with different values for a monitoring function then the higher of the two values will be used.

Calculating the minimum I/O retention time (T_{PH})

The following applies to the calculation of the minimum I/O retention time:

- with central I/O: T_{PH} = 30 ms
- with distributed I/O: $T_{PH} = 3 \times T_{TRmax}$

  where T_{TRmax} = maximum target rotation time
  of all DP master systems of the fault-tolerant station

With the use of central and distributed I/O the resulting minimum I/O retention time is:

T_{PH} = MAX (30 ms, $3 \times T_{TRmax}$)

Figure 6-5 shows the relationship between the minimum I/O retention time and the maximum blocking time for priority classes > 15.

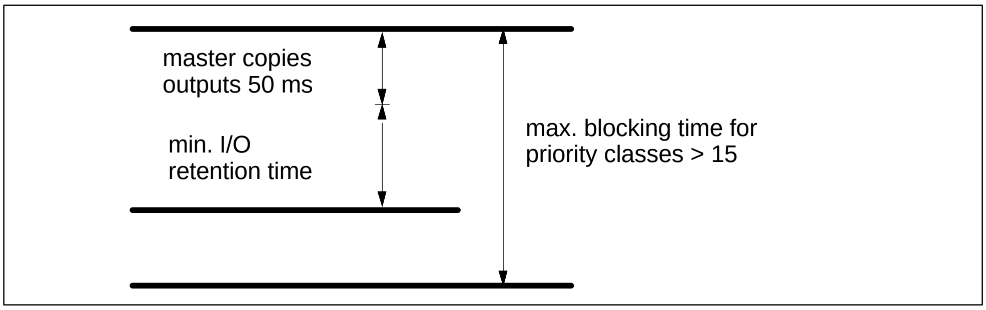

Figure 6-5 Relationship between the minimum I/O retention time and the maximum blocking time for priority classes > 15

Note that

50 ms + min. I/O retention time ≤
(max. blocking time for priority classes > 15)

must apply. As a result, a large minimum I/O retention time may determine the maximum blocking time for priority classes > 15.

Calculating the maximum blocking time for priority classes > 15 (T_{P15})

The maximum blocking time for priority classes > 15 is determined by 4 factors:

- As shown in Figure 6-2, at the end of the update all the contents of data blocks that have been modified since the last copy to the standby CPU are transferred to the standby CPU again. **The number and structure of the data blocks** that you describe in the high-priority classes determine the duration of this process and thus the maximum blocking time for priority classes > 15. A note is given for the remedies specified below.
- In the final phase of the update all the OBs are delayed or blocked. To avoid the max. blocking time for priority classes > 15 being unnecessarily extended as a result of unfavorable programming, modify the time-critical I/O components in a **selected watchdog interrupt**. This is particularly relevant in the case of fail-safe user programs. You can specify this watchdog interrupt in the configuration; it will then be executed immediately after the start of the maximum blocking time for priority classes > 15, but only if you have assigned it a priorityclass > 15.
- On link-up and update with master/standby switch-over (see Section 6.2.1) then on conclusion of the update the active communication channel in the switched DP slaves must be switched over. This extends the time for which no valid values can be read or output. The duration of this process is determined by your **hardware configuration**.
- The **process-related circumstances** give rise to requirements in respect of how long the I/O update can be deferred. This is particularly important in the case of time-monitored processes in fail-safe systems.

Note

Other factors to note when using fail-safe modules are described in the following manuals: *S7-400 F and S7-400 FH Programmable Controllers* and *S7-300 Programmable Controllers; Fail-Safe Signal Modules*. This applies in particular to module-internal run times in fail-safe modules.

1. For each DP master system determine from the bus parameters in STEP 7
   - T_{TR} for the DP master system
   - DP switch-over time (referred to below as T_{DP_UM})
2. For each DP master system determine from the Technical Data for the switched DP slaves
   - the maximum switch-over time for the active communication channel (referred to below as T_{SLAVE_UM}).
3. From the technological specifications for your system determine
   - the maximum permissible time period for which your I/O modules are not updated (referred to below as T_{PTO}).
4. From your user program determine
   - the scan time of the highest priority or selected (see above) watchdog interrupt (T_{WA})
   - the run time of your program in this watchdog interrupt (T_{PROG})
5. For each DP master system this gives rise to

   $$T_{P15}\text{ (DP master system)} = T_{PTO} - (2 \times T_{TR} + T_{WA} + T_{PROG} + T_{DP\_UM} + T_{SLAVE\_UM}) \quad [1]$$

Note

If T_{P15}(DP master system) < 0 the calculation is to be stopped here. Possible remedies are listed after the following example calculation. Make the appropriate modifications and start the calculation from 1 again.

6. Select the minimum of all the T_{P15} (DP master system) values. This time is then known as T_{P15_HW}.
7. Determine the share of the maximum blocking time for I/O classes > 15 determined by the minimum I/O retention time (T_{P15_OD}):

   $$T_{P15\_OD} = 50\text{ ms} + \text{min. I/O retention time} \quad [2]$$

Note

If $T_{P15\_OD} > T_{P15\_HW}$ the calculation is to be stopped here. Possible remedies are listed after the following example calculation. Make the appropriate modifications and start the calculation from 1 again.

8. From Section 6.3.4 determine the share of the maximum blocking time for priority classes > 15, which is dependent on the user program (T_{P15_AWP}).

Note

If $T_{P15\_AWP} > T_{P15\_HW}$ the calculation is to be stopped here. Possible remedies are listed after the following example calculation. Make the appropriate modifications and start the calculation from 1 again.

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9. The recommended value for the max. blocking time for priority classes > 15 now results from:

   $T_{P15} = MAX (T_{P15\_AWP}, T_{P15\_OD})$ [3]

Example of the Calculation of T_{P15}

In the following the maximum permissible period of time on update during which the operating system performs no program scanning and no I/O updates is determined for a given system configuration.

There are two DP master systems: DP master system_1 is “connected” to the CPU via the MPI/DP interface of the CPU and DP master system_2 via an external DP master interface module.

1. From the bus parameters in STEP 7:

   T_{TR_1} = 25 ms

   T_{TR_2} = 30 ms

   $T_{DP\_UM\_1}$ = 100 ms

   $T_{DP\_UM\_2}$ = 80 ms

2. From the Technical Data for the DP slaves used:

   $T_{SLAVE\_UM\_1}$ = 30 ms

   $T_{SLAVE\_UM\_2}$ = 50 ms

3. From the technological specifications for your system:

   T_{PTO_1} = 1250 ms

   T_{PTO_2} = 1200 ms

4. From the user program:

   T_{WA} = 300 ms

   T_{PROG} = 50 ms

5. From formula [1]:

   T_{P15} (DP master system_1)

   $= 1250\ ms - (2 \times 25\ ms + 300\ ms + 50\ ms + 100\ ms + 30\ ms) = 720\ ms$

   T_{P15} (DP master system_2)

   $= 1200\ ms - (2 \times 30\ ms + 300\ ms + 50\ ms + 80\ ms + 50\ ms) = 660\ ms$

   Check: if $T_{P15} > 0$, continue with

6. T_{P15_HW} = MIN (720 ms, 660 ms) = 660 ms

7. From formula [2]:

   $T_{P15\_OD} = 50\ ms + T_{PH} = 50\ ms + 90\ ms = 140\ ms$

   Check: if $T_{P15\_OD} = 140\ ms < T_{P15\_HW} = 660\ ms$, continue with

8. From Section 6.3.4 for 170 Kbytes user program data:

   $T_{P15\_AWP} = 194\ ms$

   Check: if $T_{P15\_AWP} = 194\ ms < T_{P15\_HW} = 660\ ms$, continue with

9. Formula [3] now provides the recomm. max. blocking time for priority classes > 15:

   T_{P15} = MAX (194 ms, 140 ms)

   $T_{P15} = 194\ ms$

Entering 194 ms for the maximum blocking time for priority class > 15 in STEP 7 ensures that a signal change during the update will always be recognized when the signal lasts 1250 ms or 1200 ms.

Remedies if it is not possible to calculate T_{P15}

If no recommendation results from the calculation of the maximum blocking time for priority classes > 15, you can remedy this by various measures:

- Reduce the watchdog interrupt cycle of the watchdog interrupt configured.
- For particularly high T_{TR} times, divide the slaves into several DP master systems.
- Increase the transmission rate on DP master systems affected.
- Configure the DP/PA links and Y links in separate DP master systems.
- If the DP slaves have very different switch-over times and thus (generally) great variations in T_{PTO}, distribute these slaves among a number of DP master systems.
- If only a small load due to interrupts or parameter assignment is to be expected in the individual DP master systems you can also reduce the T_{TR} times calculated by approx. 20–30%. This will increase the risk of a station failure occurring in the distributed I/O.

- The time T_{P15_AWP} indicates a guide value; this depends on your program structure. You can reduce it by using the following measures, for example:
  – Store data that is frequently modified in different DBs to data that is modified less often.
  – Specify a smaller amount of working memory for the DBs.

If you reduce the time T_{P15_AWP} without taking the measures stated, this increases the risk of the update being aborted due to expiration of the monitoring times.

Calculation of the max. communication delay

We recommend using the following formula:

Maximum communication delay =
4 × (maximum blocking time for priority classes > 15)

The final time is determined by the process state and the communication load on your system. This has to be taken to mean both the absolute load and also the load in relation to the size of your user program. You may have to correct the time if necessary.

Calculation of the max. scan-cycle time extension

We recommend using the following formula:

Maximum communication delay =
10 × (max. blocking time for priority classes > 15)

The final time is determined by the process state and the communication load on your system. This has to be taken to mean both the absolute load and also the load in relation to the size of your user program. You may have to correct the time if necessary.

6.3.3 Influences on the Time Response

The period during which no I/O updates take place is primarily determined by the following influencing factors:

- number and size of data blocks modified during the update
- number of instances of SFBs in the S7 communication information and SFBs for generating block-related messages
- Modifications to the System During Operation
- settings via dynamic volume frameworks
- expansion of distributed I/O (with falling transmission rate and increasing number of slaves the time required for I/O updates increases.)

In the least favorable cases this period is extended by the following amounts:

- maximum watchdog interrupt cycle used
- duration of all watchdog interrupt OBs
- duration of high-priority interrupt OBs running up until delay of the interrupts

Deliberate delaying of the update

Delay the update via SFC 90 “H_CTRL” and do not release it again until a state of lesser communication or interrupt load occurs.

Caution

Delaying the update will increase the time during which the fault-tolerant system is in single mode.

6.3.4 Performance Values for Link–up and Update

User program share T_{P15_AWP} of the max. blocking time for priority classes > 15

The user program share T_{P15_AWP} of the max. blocking time for priority classes > 15 can be calculated using the following formula:

T_{P15_AWP} in ms = 0,7 × size of the DBs in working memory in Kbyte + 75

The following table provides the resulting times for some typical values for the main memory data.

Table 6-3 Typical values for the user program share T_{P15_AWP} of the max. blocking time for priority classes > 15

Main memory data	T_{P15_AWP}
500 Kbyte	430 ms
1 Mbyte	800 ms
2 Mbyte	1.51 s

Table 6-3 Typical values for the user program share T_{P15_AWP} of the max. blocking time for priority classes > 15

Main memory data	T_{P15_AWP}
5 Mbyte	3.66 s
10 Mbyte	7.24 s

The following assumptions were made for this formula:

- 80% of the data blocks are modified prior to delaying the interrupts of priority classes > 15.
  This value must be determined more accurately for fail-safe systems in particular in order to avoid a time-out of the driver blocks (see Section 6.3.2).
- Approximately 100 ms of update time are allowed for each megabyte of working memory assigned by data blocks for currently running or held-back communication functions.
  Depending on the communication load of your programmable logic controller, you have to add to or deduct from the setting of T_{P15_AWP}.

6.4 Peculiarities during Link-up and Update

Requirement of input signals during the update

During the update the process signals read in previously are retained and are not updated. Modification of a process signal during the update will only be recognized by the CPU if the modified signal state remains at the end of the update.

Pulses (signal change "0 → 1 → 0" or "1 → 0 → 1") occurring during the update will not be recognized by the CPU.

Make sure, therefore, that the time between two signal changes (pulse duration) is always greater than the time required for the update.

Communication links and functions

In contrast to earlier firmware versions, links to the master CPU are no longer broken. However, associated communication jobs are not executed during the update. They are stored and caught up on when one of the following cases occurs:

- the update is complete and the system is in Redundant mode
- the update and master/standby switch-over are complete, the system is in single mode
- the update was aborted (e.g. due to a time-out) and the system is back in single mode.

It is not possible for the communication blocks to make an initial call during the update.

Reset instruction on aborting link-up

If the link-up is aborted whilst the contents of the load memory are being copied from the master CPU to the standby CPU then the standby CPU will given a Reset instruction. This is signaled by an entry in the diagnostics buffer with the event ID W#16#6523.

Using I/O on the S7-400H

7

This chapter provides an overview of the different I/O configurations on the S7-400H programmable logic controller and its availability. Further, it provides information on configuration and programming of the selected I/O installation.

For the S7-400H you can use virtually any of the input/output modules featured in the SIMATIC S7 system range. This applies to the input/output modules of the S7-400 standard system and to the PROFIBUS-DP components. The function modules (FMs) and communication processors (CPs) that can be used in the S7-400H will be found in Appendix E.

7.1 Introduction

I/O configuration types

In addition to the power supplies and central processing units, which are always redundant, there are the following configuration types for the I/O, which are supported by the operating system:

I/O Type	Configuration	Availability
Digital input	Single channel one-way Single channel switched Dual channel redundant	normal increased high
Digital output	Single channel one-way Single channel switched Dual channel redundant	normal increased high
Analog input	Single channel one-way Single channel switched Dual channel redundant	normal increased high
Analog output	Single channel one-way Single channel switched	normal increased

A two-channel redundant configuration on the user level is similarly possible. However, you have to implement the high degree of availability in the user program (refer to Section 7.4).

Addressing

No matter whether you are using a single-channel, one-way or switched I/O, you always specify the same address for the I/O.

Limits of I/O configuration

If there are insufficient slots in the central controllers, you can add up to 20 expansion units to the configuration of the S7-400H.

You can assign even-numbered mounting racks only to central controller 0, whereas odd-numbered mounting racks can be assigned only to central controller 1.

For using distributed I/O you can connect up to 12 DP master systems in each of the subsystems (2 DP master systems to the integrated interfaces of the CPU and 10 more via external DP master systems).

You can operate up to 32 slaves on the integrated MPI/DP interface. You can connect up to 125 distributed I/O devices to the integrated DP master interface and the external DP master systems.

7.2 Using Single-Channel, One-Sided I/O

What is single-channel, one-way I/O?

With the single-channel, one-way configuration single input/output modules are present (single-channel). The input/output modules are located in just one of the subsystems and are only addressed by that subsystem.

A single-channel, one-way I/O configuration is possible in

- central controllers and expansion units
- distributed I/Os

The single-channel, one-way I/O configuration is to be recommended for individual input/output channels for which normal availability of the I/O is sufficient.

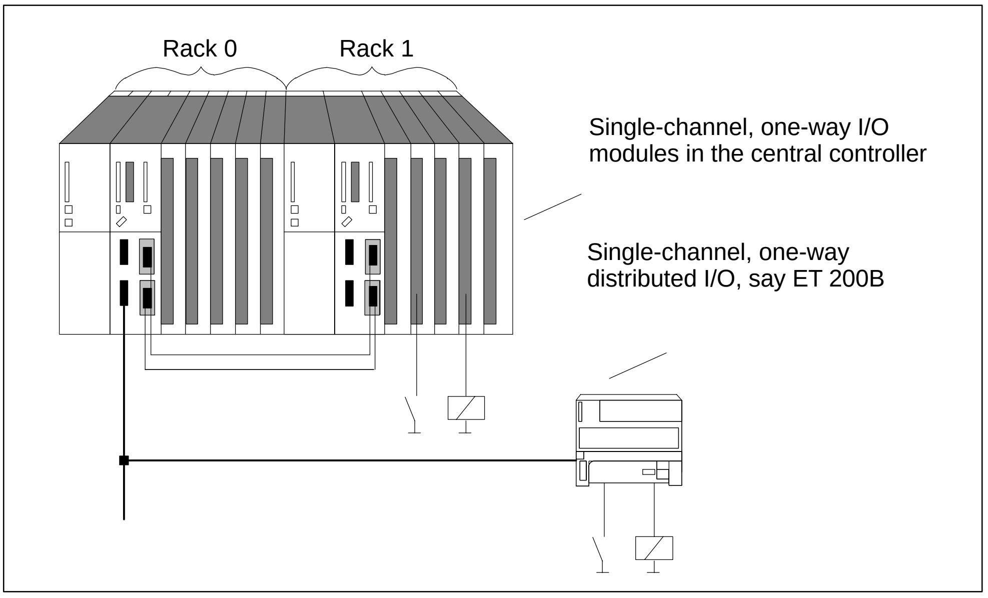


Figure 7-1 Single-channel, one-way I/O configuration

Single-channel, one-way I/Os and user program

Information read in on one side – for example, from digital inputs – is transferred automatically to the second subsystem via the synchronization link in redundant system mode.

After the information has been transferred, both subsystems have the data from the single-channel, one-way I/O and evaluate them in the two identical user programs that are present. It is therefore not decisive whether the I/O is connected to the master CPU or to the standby CPU as far as processing of the information in redundant system mode is concerned.

In single mode, the one-way I/O assigned to the cooperating subsystem cannot be accessed. This has to be taken into account in your programming as follows: you have to assign functions to the single-channel, one-way I/O that can only be performed conditionally. In this way you make sure that certain functions for I/O accesses are triggered only in redundant system mode and in single mode of the subsystem concerned.

Notice

The user program has to update the process image for single-channel, one-way output modules in single mode too (e.g. direct accesses). If subprocess images are used, the user program must update the subprocess images in OB 72 (redundancy return) accordingly (SFC 27 “UPDAT_PO”). If it did not, old values would initially be read out to the single-channel, one-way output modules of the standby CPU following transition to redundant system mode.

Failure of the single-channel, one-way I/O

In the event of a malfunction the S7-400H with a single-channel, one-way I/O behaves like a standard S7-400 system, in other words:

- When the I/O fails, the defective I/O is no longer available.
- When a subsystem fails, the entire process I/O of that subsystem is not available any more.

7.3 Using Single-Channel, Switched I/O

What is single-channel, switched I/O?

With the single-channel, switched configuration single input/output modules are present (single-channel).

In Redundant mode they may be addressed by both subsystems.

In single mode, the master subsystem can always address **all switched I/O** (as opposed to one-way I/O).

The single-channel, switched I/O configuration is possible with the ET 200M distributed I/O device equipped with an active backplane bus and a redundant PROFIBUS-DP slave interface module IM 153-2 or IM 153-2FO (permissible IM 153-2: 6ES7 153-2AA02-0XB0 version 7 or later; permissible IM 153-2FO: 6ES7 153-2AB01-0XB0 version 6 or later). Each subsystem of the S7-400H is connected to one of the two DP slave interfaces of the ET 200M (via a DP master interface).

PROFIBUS PA can be connected to a redundant system using DP/PA-Link (permissible IM 157: 6ES7 157-0AA82-0XA0).

A single-channel DP master system can be connected to a redundant system using a Y-coupler. The following combinations of IM 157 and Y-couplers are permissible:

IM 157	Y-coupler
6ES7 157-0AA82-0XA0	6ES7 197-1LB00-0XA0

The single-channel, switched I/O configuration is recommended for devices that tolerate the failure of individual modules within the ET 200M.

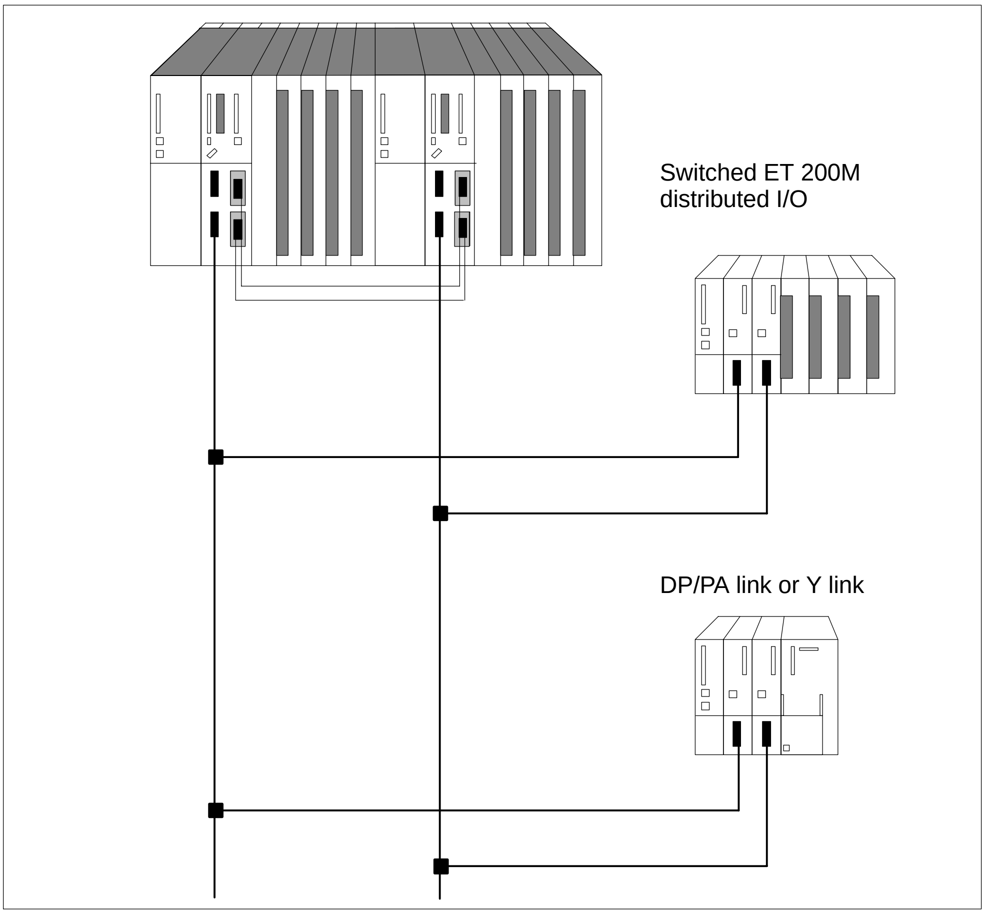


Figure 7-2 Single-channel, switched ET 200M distributed I/O

Rule

When you use a single-channel, switched I/O, the configuration must always be symmetrical, in other words:

- The fault-tolerant CPU and other DP masters must be located in identical slots n both subsystems (e.g. in slot 4 on both subsystems) or
- the DP masters must be connected on both subsystems to the same integrated interface (e.g. to the PROFIBUS-DP interfaces of the two fault-tolerant CPUs).

Single-channel, switched I/O and user program

In Redundant mode, in principle each subsystem may access single-channel switched I/O. The information is automatically transferred over the synchronization link and compared. An identical value is available to the two subsystems at all times owing to the synchronized access.

The S7-400H only ever uses one of the interfaces at any given time. The active interface is indicated by the ACT LED on the corresponding IM 153-2 or IM 157.

The path via the currently active interface (IM 153-2 or IM 157) is described as the **active channel** and the path via the other interface as the **passive channel**. The DP cycle always runs via both channels. However, only the input and output values of the active channel are processed in the user program or output to the I/O. The same applies to asynchronous activities such as interrupt processing and the exchange of data records.

Failure of the single-channel, switched I/O

In the event of a malfunction the S7-400H with a single-channel, switched I/O behaves as follows:

- When the I/O fails, the defective I/O is no longer available.
- In certain failure situations, e.g. failure of a subsystem, a DP master system or a DP slave IM153-2 or IM 157 interface module (refer to Chapter 8), the single-channel, switched I/O continues to be available to the process.
  This is achieved by switch-over between the active and slave channel. This switch-over takes place separately for each DP station. On a failure a distinction is made between
  - failures affecting one station only (failure of the DP slave interface module of the currently active channel)
  - failures affecting all the stations of a DP master system.
    These include unplugging the DP master interface module, shutdown of the DP master system (e.g. on RUN-STOP transition on a CP 443-5) and a short circuit in the cable loom of a DP master system.

The following applies to each station affected by a failure: if both DP slave interface modules are currently functional and the active channel fails, the previous slave channel automatically becomes the active channel. A redundancy loss is reported to the user program via the start of OB 70 (event W#16#73A3).

Once the fault has been remedied the redundancy is restored. This again results in the start of OB 70 (event W#16#72A3). In this instance there is no switch-over between the active and slave channel.

If one channel has already failed and the remaining (active) channel also fails, then there is a complete station failure. This results in the start of OB 86 (event W#16#39C4).

Note

If the DP master interface module can detect failure of the complete DP master system (e.g. in the case of a short-circuit), only this event is reported (“Master system failure coming” W#16#39C3). The operating system then no longer reports individual station failures. This allows the switch-over process between the active and slave channel to be accelerated.

Duration of switch-over of the active channel

The maximum switch-over time is

DP error detection time + DP switch-over time + switch-over time of DP slave interface module

You can determine the first two addends from the bus parameters of your DP master system in STEP 7. You define the last addend from the manuals of the DP slave interface modules concerned (*Distributed I/O ET 200M* and *DP/PA bus connection*).

Notice

If you are using F modules, you have to set the monitoring time of each F module larger than the failover time of the active channel in the H system. If you do not adhere to this, F modules may fail when a failover of the active channel occurs.

Notice

The above calculation also includes the processing time in OB 70 or OB 86. Note that the processing for a DP station must take **no more than 1 ms**. If more extensive processing is required, disconnect this from the direct processing of the OBs mentioned.

Note that a change of signal can only be detected by the CPU if the signal duration is greater than the specified switch-over time.
With a switch-over of the complete DP master system, the switch-over time of the slowest component applies to all DP components. A DP/PA link or Y link normally determines the transfer time and the associated minimum signal duration. We therefore recommend you to connect DP/PA and Y links to a separate DP master system.

If you are using F modules, you have to set the monitoring time of each F module larger than the failover time of the active channel in the H system. If you do not adhere to this, F modules may fail when a failover of the active channel occurs.

Switch-over of the active channel on link-up and update

On link-up and update with master/standby switch-over (see Section 6.2.1) the active and slave channels are switched over in all the stations of the switched I/O. OB 72 is invoked here.

No pulses during switch-over of the active channel

To prevent temporary failure of the I/O or output of substitute values during switch-over between the active and slave channel the DP stations of the switched I/O maintain their outputs until switch-over is complete and the new active channel has taken over processing.

To ensure that total failures of a DP station occurring during failover are also recognized, the failover process is monitored by both the individual DP stations and by the DP master system.

When the minimum I/O retention time is set correctly (see Section 6.3), no interrupts or records are lost during the failover. Automatic repetition takes place if necessary.

System configuration and design

You should sort switched I/O with different transfer times into separate looms. This simplifies calculation of the monitoring times, among other things.

7.4 Connecting Redundant I/O

Was is redundant I/O?

I/O modules are considered redundant when there are two of each and are configured and operated as redundant pairs. The use of redundant I/O provides the highest degree of availability since it means that failure of a CPU failure and failure of a signal module are both tolerated.

Configurations

The following configurations with redundant I/O are possible:

1. Redundant signal modules in the central and expansion devices
   The signal modules are installed in pairs in the subsystems of CPU 0 and CPU 1.

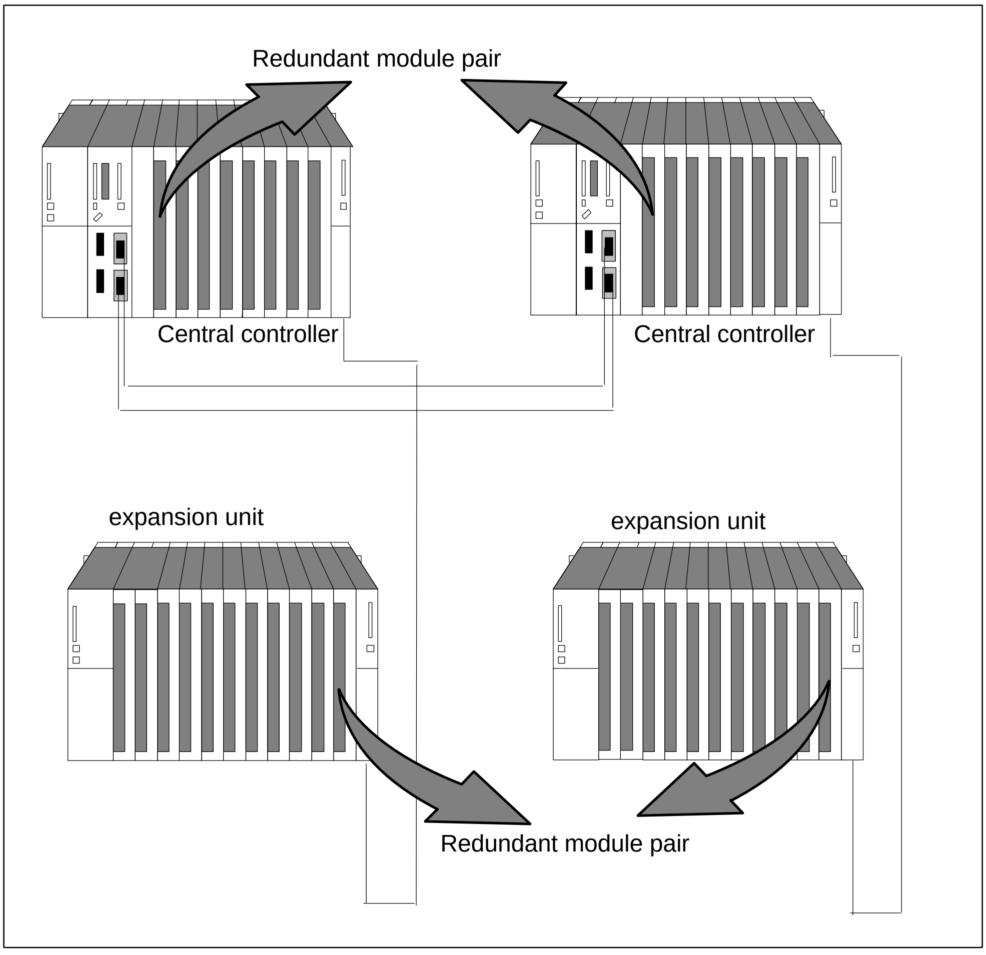


Figure 7-3 Redundant I/O in central- and expansion devices

2. Redundant I/O in the one-way DP slave

   The signal modules are installed in pairs in the distributed I/O device ET 200M with active backplane bus.

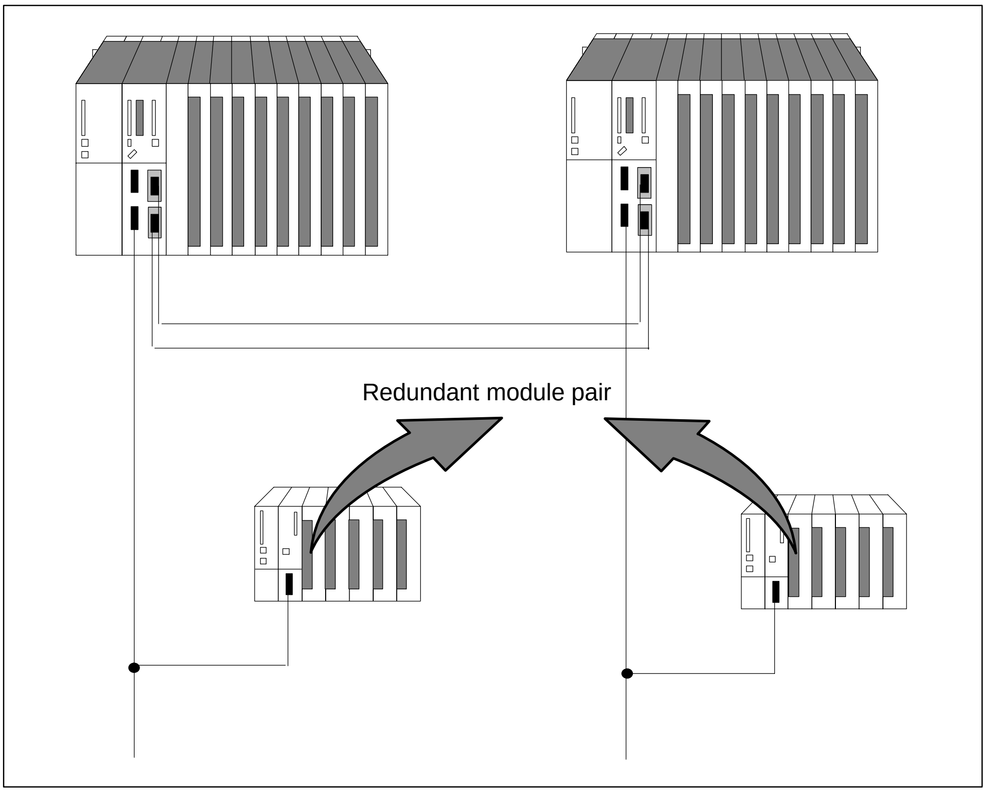


Figure 7-4 Redundant I/O in the one-way DP slave

3. Redundant I/O in the switched DP slave

   The signal modules are installed in pairs in the distributed I/O device ET 200M with active backplane bus.

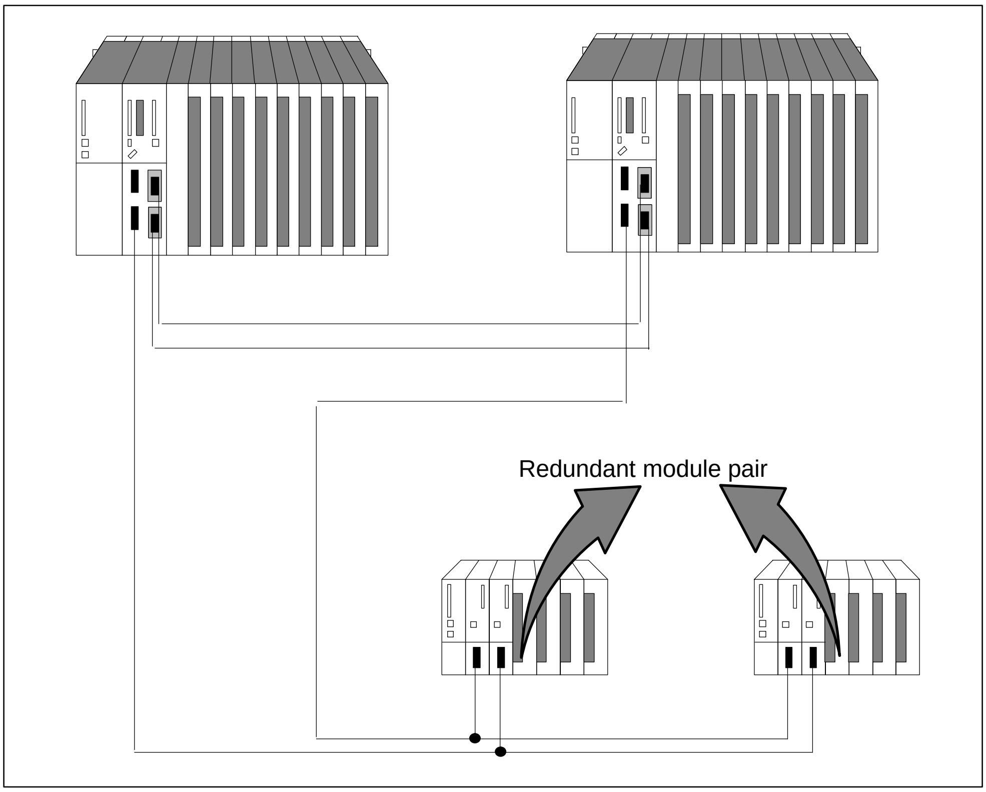


Figure 7-5 Redundant I/O in the switched DP slave

4. Redundant I/O on an H CPU in single mode

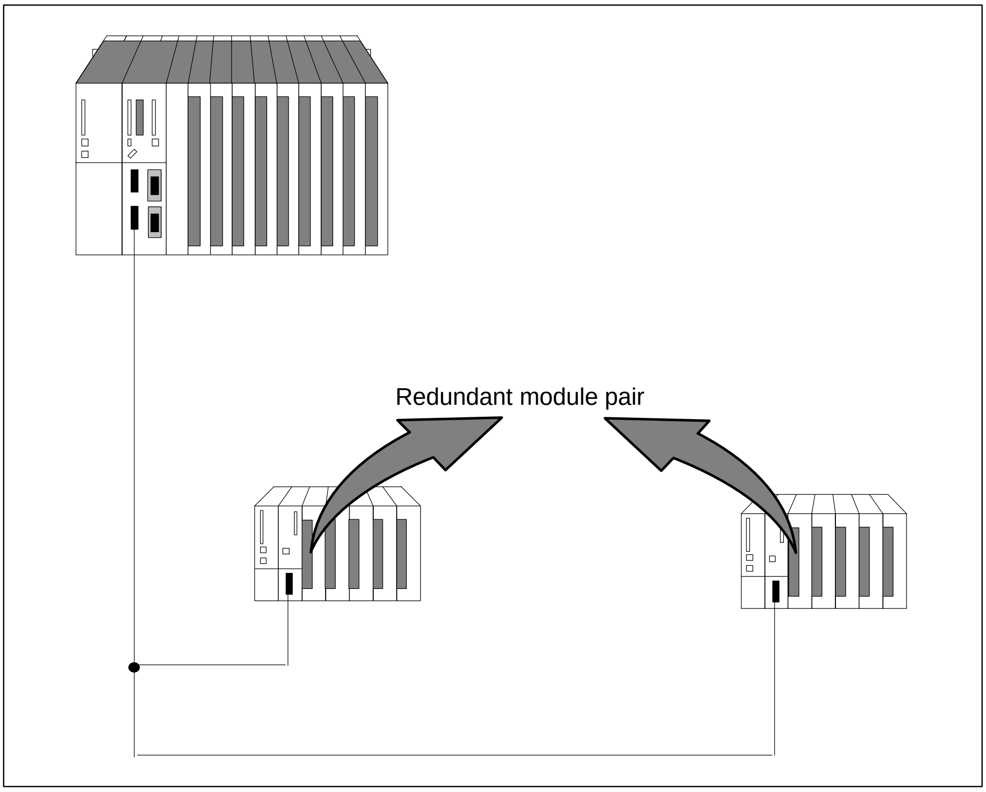


Figure 7-6 Redundant I/O in single mode

Block library “Functional I/O Redundancy”

The “Functional I/O Redundancy” block library, which is supplied with the optional H package and offers support for redundant I/O, contains the following blocks:

- FC 450 “RED_INIT”: Initialization function
- FC 451 “RED_DEPA”: Trigger depassivation
- FB 450 “RED_IN”: Function block for reading redundant inputs
- FB 451 “RED_OUT”: Function block for controlling redundant outputs
- FB 452 “RED_DIAG”: Function block for diagnostics of redundant I/O
- FB 453 “RED_STATUS”: Function block for redundancy status information

After installation of the H option package the block is located in the library “Redundant IO(V1)” under STEP 7\S7_LIBS\RED_IO. The functionality and use of the blocks are described in the corresponding online help.

Hardware installation and configuration of the redundant I/O

If you wish to use a redundant I/O, we would recommend you the following strategy:

1. Insert all of the modules that you wish to use redundantly. Pay attention to the following default rules for the configuration.
2. Configure the module redundancy using HW Config in the object properties for the respective module.
3. Either look for a partner module for each module or use the default settings

   In a centralized configuration: Insert the module in an even rack in slot X, the redundant module in the next odd rack is inserted in the same slot.
   If the module in the odd rack is inserted in slot X, the same slot in the preceding even rack is suggested for the module.

   Distributed in the one-way DP slave: If the module in the slave is inserted in slot X, provided that the DP master system is redundant, the same PROFIBUS address in the same DP subsystem is suggested for the module in the partner DP subsystem in the slave.

   Distributed in the switched DP slave, single mode: If the module in the slave is inserted with a DP address in slot X, the module in the slave with the next PROFIBUS address at slot X is suggested.
4. Enter the remaining redundancy parameters for the input modules.

Caution

Always switch off the station or the rack before you remove a module, otherwise you may disable the wrong module.

The valid value that can be processed by the user program are always at the lower address of both redundant modules. This way only the lower address can be used by the application; the values of the higher address are not relevant for the application.

Signal modules for redundancy

The signal modules listed below can be used as redundant I/O. Pay attention to the latest information about the use of modules available in the readme files and in the SIMATIC FAQs at
`http://www.siemens.com/automation/service&support` under the keyword “Redundant I/O”.

Table 7-1 Signal modules for redundancy

Modules	Order Number	Remark
Local: Redundant dual-channel DI		
DI 16 x 24 V DC Alarm	6ES7 421-7BH00-0AB0	
DI 32 x 24 V DC	6ES7 421-1BL0x-0AA0	
DI 32 x 120 V AC	6ES7 421-1EL00-0AA0	
Distributed: Redundant dual-channel DI		
DI 24 x 24 V DC	6ES7 326-1BK00-0AB0	F module in standard operating mode
DI 8 x NAMUR [EEx ib]	6ES7 326-1RF00-0AB0	F module in standard operating mode
DI 16 x 24 V DC, Alarm	6ES7 321-7BH00-0AB0	
DI 16 x 24 V DC	6ES7 321-1BH02-0AA0	
DI 32 x 24 V DC	6ES7 321-7BL00-0AA0	
DI 32 x 24 V DC	6ES7 321-7BH01-0AB0	
DI 8 x 230 V AC	6ES7 321-1FF01-0AA0	
DI 16 x Namur	6ES7 321-7TH00-0AB0	
DI 4 x Namur	6ES7 321-7RD00-0AB0	
Local: Redundant dual-channel AI		
AI 6x16Bit	6ES7 431-7QH00-0AB0	
Distributed: Redundant dual-channel AI		
AI 6 x 13 bits	6ES7 336-1HE00-0AB0	F module in standard operating mode
AI 8 x 12 bits	6ES7 331-7KF02-0AB0	
AI 8 x 16 bits	6ES7 331-7NF00-0AB0	
AI 4 x 15 bits	6ES7 331-7RD00-0AB0	
Local: Redundant dual-channel DO		
DO 32 x 24V DC / 0.5A	6ES7 422-7BL00-0AB0	
DO 16 x 120 / 230V AC / 2A	6ES7 422-1FH00-0AA0	

Table 7-1 Signal modules for redundancy, continued

Modules	Order Number	Remark
Distributed: Redundant dual-channel DO		
DO 10 x 24 V DC / 2 A	6ES7 326-2BF00-0AB0	F module in standard operating mode
DO 32 x 24 V DC / 0.5 A	6ES7 322-1BL00-0AA0	
DO 8 x 24 V DC / 2 A	6ES7 322-1BF01-0AA0	
DO 8 x 24 V DC / 0.5 A	6ES7 322-8BF00-0AB0	
DO 8 x 230 V AC / 2 A	6ES7 322-1FF01-0AA0	
DO 16 x 24 V DC / 0.5 A	6ES7 322-8BH00-0AB0	
DO 16 x 24 V / 10 nA (Ex)	6ES7 322-5SD00-0AB0	
Distributed: Redundant dual-channel AO		
AO 4 x 12 bits	6ES7 332-5HD01-0AB0	
AO 8 x 12 Bit	6ES7 332-5HF00-0AB0	
AO 4 x 15 Bit	6ES7 332-5RD00-0AB0	
AO 8 x 12bit	6ES7 332-5HF00-0AB0	

Notice

You need to install the F Configuration Pack V5.3 for F-modules. The F Configuration Pack can be downloaded free of charge from the Internet. You can find it at Customer Support under `http://www.siemens.com/automation/service&support`.

Which faults can be overcome using redundant I/O?

There are 3 quality levels for the reliable operation of a redundant configuration of signal modules:

- Highest quality with fail-safe signal modules (but without F functionality)
- Medium quality with signal modules capable of diagnostics
- Simple quality with signal modules without diagnostics

Using digital input modules as redundant I/O

The following parameters are set to configure digital input modules for redundant operation:

- Discrepancy time (maximum allowed time in which the redundant input signals can differ).
  When there is still a discrepancy in the input values after the configured discrepancy time has expired, a fault has occurred.
- Reaction of the H system to discrepancy in the input values

First, the input signals of the paired redundant modules are checked to see if they match. If the values match the uniform value is written to the lower data memory area of the input's process image. If there is a discrepancy and it is the first discrepancy, it is marked and the discrepancy time is started.

During the discrepancy time the most recent matching (non-discrepant) value is written to the process image of the module with the lower address. This procedure is repeated until the values once again match within the discrepancy time or until the discrepancy time of a bit has expired.

If the discrepancy continues past the expiration of the configured discrepancy time, a fault has occurred.

The localization of the defective page is performed according to the following strategy:

1. During the discrepancy time the most recent matching value is retained as a result.
2. Once the discrepancy time has expired the following error message is displayed:
   Error code 7960: "Redundant I/O: discrepancy time at digital input expired, error not yet localized". Passivation is not performed and no entry is made in the static error image. Until the next signal transition occurs, the configured reaction is performed after the discrepancy time expires.
3. If another signal transition occurs, the module in which the transition takes place is the intact module and the other module is passivated.

If both paired modules are completely passivated, "zeroes" are entered at the passivated memory location of the process image.

Notice

The time that the system actually needs to determine a discrepancy depends on several factors: bus operating times, cycle and call-up time of the user program, conversion time, etc. Redundant input signals may therefore be different longer than the discrepancy time.

Using digital input modules with non-redundant sensor

You install digital input modules with non-redundant sensors in a 1-out-of-2 configuration:

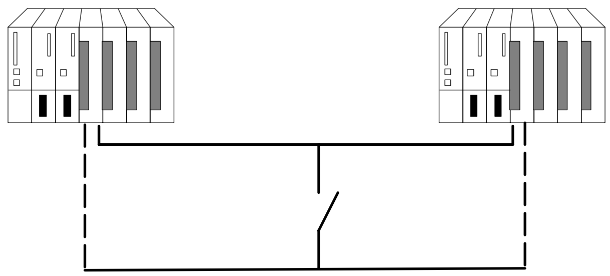


Figure 7-7 Fault-tolerant digital input module in a 1-out-of-2 configuration with one sensor

The use of redundant digital input modules increases their availability.

Discrepancy analysis detects “Continuous 1” and “Continuous 0” errors of the digital input modules. A continuous 1 error means the value 1 is continuous at the input, a continuous 0 error means that the input is continuously dead. This may be caused a short-circuit after L+ or after M, for example.

Potential flow across the connection between the encoder and chassis ground of the modules should be avoided as far as possible.

When connecting a sensor to several digital input modules, the redundant modules have to have the same reference potential.

Connection examples are available in Appendix F and in the SIMATIC FAQs at `http://www.siemens.com/automation/service&support` under the keyword “Redundant I/O”.

Note

Note that proximity switches (Beros) have to deliver double the current listed for single modules in the technical specifications.

Additional marginal conditions for various modules

DI 16 x 24 V DC Alarm 6ES7 321-7BH01-0AB0

DI 16 x 24 V DC Alarm 6ES7 421-7BH00-0AB0

DI 16 x 24 V DC Alarm 6ES7 421-7BH01-0AB0

- These modules are equipped with a “wire break” diagnostic function. In order to use this detection, you must ensure a cumulative quiescent current (= signal status “0”) between 2.4 mA und 4.9 mA at one or two inputs.

  To do so, switch a resistance by means of an encoder signal. The resistance depends on the switch used and lies between 6800 and 8200 Ohm for contacts.

  Formula for calculating the resistor for Beros:

  (30V / (4.9mA – I_R_Bero) < R < (20V / (2.4mA – I_R_Bero)

DI 16 x UC24/60V 6ES7 421-7DH00-0AB0

- This circuitry does not support the “wire break” diagnostic function.

DI 16 x NAMUR 6ES7 321-7TH00-0AB0

- Equipotential bonding of the encoder circuit should always be referenced to one point (usually encoder minus).
- Operate both redundant modules on a common load voltage supply.
- When you select an encoder, always compare its properties with specified input characteristics. Note that the function must be guaranteed both for one and for two inputs. This is for NAMUR encoders, for example, a “0” signal current > 0.7 mA and a “1” signal current > 4.2mA.

DI 4 x NAMUR Ex 6ES7 321-7RD00-0AB0

- Please note the relevant maximum current and voltage specifications for the operation of modules in Ex applications.
- You can use only the 2-wire NAMUR encoders or contact elements.
- Equipotential bonding of the encoder circuit should always be referenced to one point (usually encoder minus).
- When you select an encoder, always compare its properties with specified input characteristics. Note that the function must be guaranteed both for one and for two inputs. This is for NAMUR encoders, for example, a lo signal current > 0.2 mA and a hi signal current > 4.2mA.

Using redundant digital input modules with redundant sensors

You install digital input modules with redundant sensors in a 1-out-of-2 configuration:

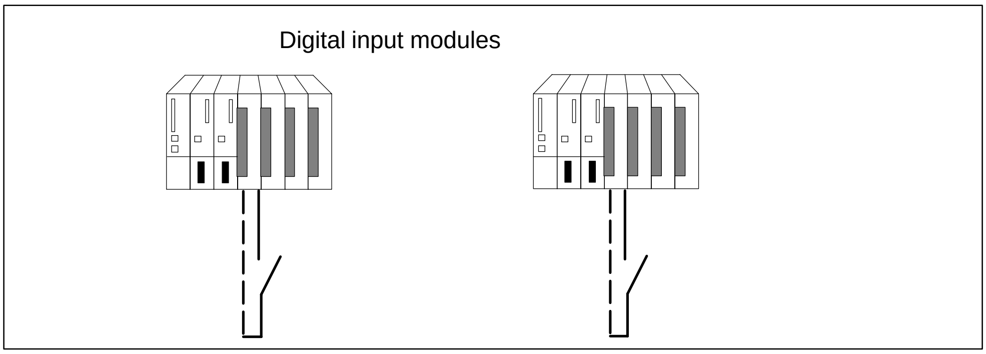


Figure 7-8 Fault-tolerant digital input modules in a 1-out-of-2 configuration with 2 sensors

The use of redundant sensors increases their availability. Discrepancy analysis detects all errors – except for the failure of a non-redundant on-load voltage supply. You can further increase the availability by installing redundant on-load voltage supplies.

When connecting a sensor to several digital input modules, the redundant modules have to have the same reference potential.

Connection examples are available in Appendix F and in the SIMATIC FAQs at `http://www.siemens.com/automation/service&support` under the keyword “Redundant I/O”.

Redundant digital output modules

The fault-tolerant control of an actuator can be achieved by connecting two outputs of two digital output modules or fail-safe digital output modules in parallel (1-out-of-2 configuration)

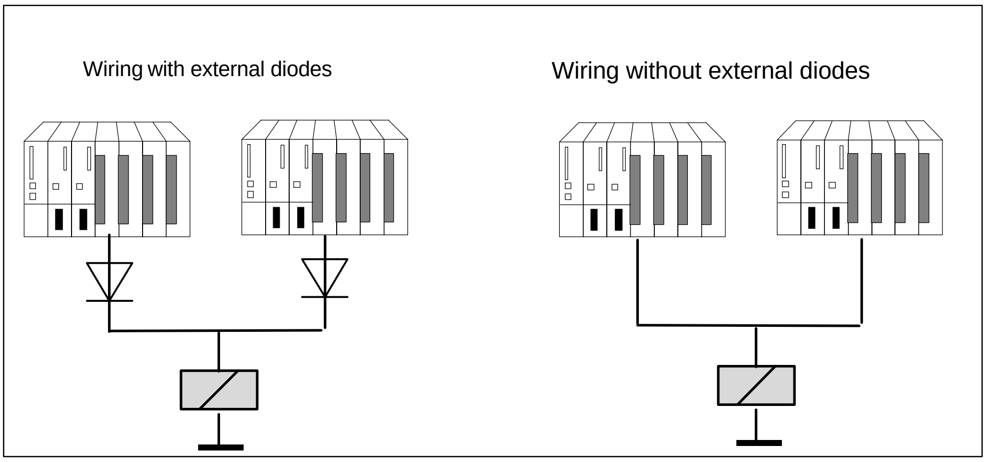


Figure 7-9 Fault-tolerant digital output module in a 1-of-2 configuration

The digital output module have to have a common on-load voltage supply.

Connection examples are available in Appendix F and in the SIMATIC FAQs at `http://www.siemens.com/automation/service&support` under the keyword “Redundant I/O”.

Wiring with external diodes <–> without external diodes

The table below shows which of the digital output modules you interconnect by means of external diodes (cf. diagram 7-9) for operation in redundant mode:

Table 7-2 Digital output module connected through/without diodes

Modules	with diodes	without diodes
6ES7 422-7BL00-0AB0	X	–
6ES7 422-1FH00-0AA0	–	X
6ES7 326-2BF00-0AB0	X	X
6ES7 322-1BL00-0AA0	X	–
6ES7 322-1BF01-0AA0	X	–
6ES7 322-8BF00-0AB0	X	X
6ES7 322-1FF01-0AA0	–	X
6ES7 322-8BH00-0AB0	X	–
6ES7 322-5SD00-0AB0	X	–

Notes on diodes

- Suitable is any diode of the 1N4003 ... 1N4007 series, or any other with U_r >=200 V and I_F >= 1 A
- You should separate the chassis ground of the modules from load ground and install a potential equalization circuit between them

Additional marginal conditions for various modules

DO 8xDC24V/0,5A 6ES7 322-8BF00-0AB0

- A definite evaluation of the “P short-circuit” and “M short-circuit” diagnosis is not possible. Deselect these function individually in your configuration.

DO32xDC24V/0,5A 6ES7 422-7BL00-0AB0

- A definite evaluation of the “P short-circuit” and “M short-circuit” diagnosis is not possible

DO 16xDC24V/0,5A 6ES7 322-8BH00–0AB0

- Equipotential bonding of the load circuit should always be referenced to one point (preferably load minus).
- Channel diagnostics is not supported.

DO 16xDC24V/10mA Ex 6ES7 322-5SD00-0AB0

- Please note the relevant maximum current and voltage specifications for the operation of modules in Ex applications.
- Equipotential bonding of the load circuit should always be referenced to one point (preferably load minus).

Using analog input modules as redundant I/O

The following parameters are set to configure analog input modules for redundant operation:

- Tolerance window (configured as a percent of the end value of the measuring range).
  Two analog values are 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).
  A fault is occurs when there is an input value discrepancy after expiration of the configured discrepancy time.
  If you connect identical sensors to the two analog input modules, the default value for the discrepancy time is usually sufficient. If you connect different sensors, especially when they are temperature sensors, you will have to increase the discrepancy time.
- Applied value
  The applied value is the value from the two analog input values that is entered into the user program.

The system checks if the two read analog values are within the configured tolerance window. If this is the case, the applied value is written to the lower data memory area of the input’s process image. If there is a discrepancy and it is the first discrepancy, it is marked and the discrepancy time is started.

When the discrepancy time is running the most recently valid value is written to the process image of the module with the lower address and made available to the current process. When the discrepancy time is expired the module with the configured standard value is declared as valid and the other **module** is passivated. If the maximum value from both modules is configured as the standard value, this value is then taken for further program execution and the other **module** is passivated. If the minimum value is set, this module supplies the data for the process and the module with the maximum value is passivated. The passivated module is registered in the diagnostic buffer in any case.

When the discrepancy ceases within discrepancy time, the analysis of the redundant input signals continues.

Notice

The time that the system actually needs to determine a discrepancy depends on several factors: bus operating times, cycle and call-up time of the user program, conversion time, etc. Redundant input signals may therefore be different longer than the discrepancy time.

Note

You have to deactivate non-switched inputs in HW Config (parameter “Measuring type”).

Redundant analog input modules with non-redundant sensors

Analog input modules in a 1-out-of-2 configuration are used for non-redundant sensors:

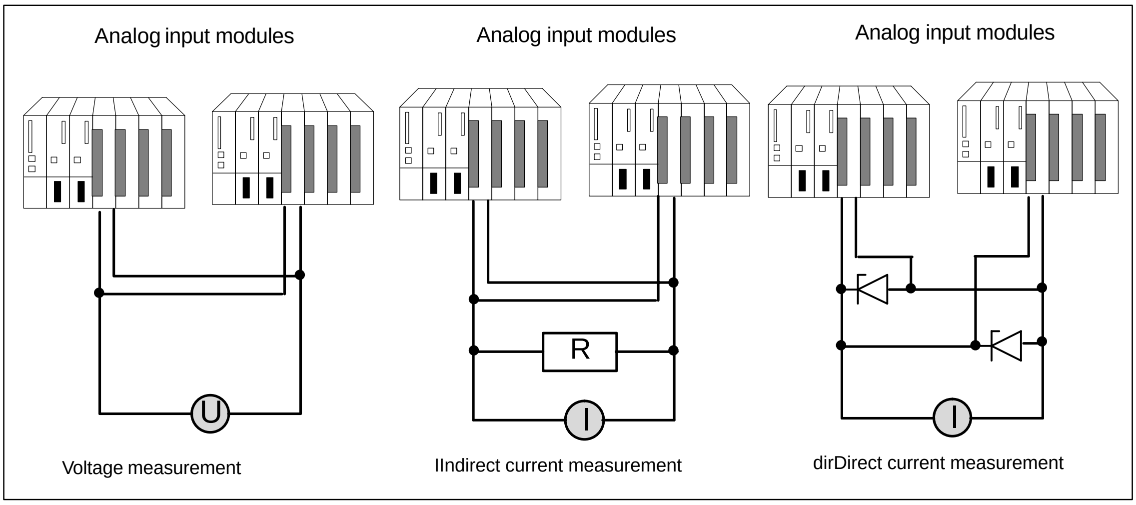


Figure 7-10 Fault-tolerant analog input modules in a 1-out-of-2 configuration with one sensor

Pay attention to the following when connecting a sensor to several analog input modules:

- Connect the voltage sensors in parallel to the analog input modules (left in illustration).
- You can convert a current into voltage using external impedance to enable you to use voltage analog input modules connected in parallel (right in illustration).
- 2-wire transducers are powered externally to enable you to repair the module online.

The use of redundant fail-safe analog input modules increases their availability.

Connection examples are available in Appendix F and in the SIMATIC FAQs at `http://www.siemens.com/automation/service&support` under the keyword “Redundant I/O”.

Redundant analog input modules for voltage measurement

Module not suitable for voltage measurement with non-redundant encoder:

AI 4x15bit Ex 6ES7 331-7RD00-0AB0 I-Input

Redundant analog input modules for indirect current measurement

To note when wiring analog input modules as shown in the diagram above:

- Suitable for use in the circuit shown above are active measurement transducers with voltage output and thermocouples
- The “wire break” diagnostic function may not be enabled in HW Config when the module is operated with measurement transducers or thermocouples
- Suitable sensor types are active 4-wire and passive 2-wire-measuring transducers with output ranges +/–20mA, 0...20mA and 4...20mA. 2-wire-measuring transducers are supplied via an external auxiliary voltage.
- The resistance and input voltage range is selected according to the measurement precision, number format, maximum resolution and possible diagnostics criteria.
- Other input resistance and voltage combinations according to ohms law are also possible in addition to the options listed. However, note that the number format, diagnostic options and resolutions will be lost. Likewise is the measurement error highly dependent on the amount of the shunt resistance for certain modules.
- Use a measurement resistance of type tolerance +/– 0,1% and TK 15ppm.

Module not suitable for use in the circuit shown above:

AI 4x15bit Ex	6ES7 331-7RD00-0AB0 I-Input

Additional marginal conditions for various modules

AI 8x12bit	6ES7 331-7K..01-0AB0
AI 8x12bit	6ES7 331-7K..02-0AB0

- The modules have a low common mode voltage of 2.5 V. Careful layout of the wiring circuit is therefore vital, particularly when using encoders referenced to ground (encoders with floating potential do not have this high demand on wiring quality).
- The rated accumulated input resistance is reduced from > 150 Ohm to 50 Ohm when two inputs with the measuring range > 2.5 V are wired in parallel. Depending on accuracy requirements, it is useful to calculate accuracy based on the source and line resistance.
- The “wire break” diagnostic function may not be enabled in HW Config when the module is operated with measurement transducers or thermocouples
- You can use a 50 Ohm or 250 Ohm shunt resistor for voltage measurements:

Resistance	50 Ohm	250 Ohm	
Current measuring range	+/–20mA	+/–20mA	4...20mA
Input range to be configured	+/–1V	+/–5 V	1...5V
Measuring range cube positioning	“A”	“B”	
Resolution	12bit+sign	12bit+sign	12bit
S7 number format	x	x	
switching cond. meas. error 1)			
– 2 parallel inputs	–	0.5%	
– 1 input	–	0.25%	
Diagnostics “wire break”	–	–	x *)
Load for 4-wire-measurement transducer	50 Ohm	250 Ohm	
Input voltage for 2-wire-measurement transducer	> 1,2 V	>6V	

*) The AI 8x12bit outputs diagnostic interrupt and measuring value “7FFF” in the event of wire break

The listed measurement error is caused only by the connection of one or two inputs to a shunt resistor. Neither the resistance tolerance, nor the basic / operational error limits of the modules are here taken into account.

The measurement error at one or two inputs indicates the difference in the measurement result, depending on whether one or two inputs record the current of the measurement transducer when an error occurs.

AI 8x16bit 6ES7 331-7NF00-0AB0

- For voltage measurements: The “wire break” diagnostic function may not be enabled in HW Config when the module is operated with measurement transducers or thermocouples
- You can use a 250 Ohm shunt resistor for voltage measurements:

Resistor	250 Ohm *)	
Current measurement range	+/–20mA	4...20mA
Input range to be configured	+/–5V	1...5V
Resolution	15 bits + sign	15 bits
S7 number format	X	
Measurement error caused by circuit		
– 2 parallel inputs	–	
– 1 input	–	
“wire break” diagnosis	X	X
Load resistance for 4-wire measurement transducer	250 Ohm	

*) You may be able to connect the free internal 250 Ohm resistors of the module

AI 16x16bit 6ES7 431-7QH00-0AB0

- For voltage measurements: The “wire break” diagnostic function may not be enabled in HW Config when the module is operated with measurement transducers or thermocouples
- You can use a 50 Ohm or 250 Ohm shunt resistor for voltage measurements:

Resistor	**50 OHM**	**250 Ohm *)**	
Current measurement range	+/–20 mA	+/–20 mA	4...20 mA
Input range to be configured	+/–5 V	+/–5 V	1...5 V
Measurement range selector position	A	A	
Resolution	15 bits + sign	bits + sign	15 bits
S7 number format		X	
Measurement error caused by circuit			
– 2 parallel inputs		–	–
– 1 input		–	–
“wire break” diagnosis		X	x
Load resistance for 4-wire measurement transducer	50 Ohm	250 Ohm	
Input voltage for 2-wire measurement transducer	> 1.2 V	>6 V	

Redundant analog input module for direct current measurements

The following applies to the analog input module circuit shown in the diagram above:

- Suitable encoder types are: Active 4-wire and passive 2-wire measurement transducers with an output range of +/–20 mA, 0...20 mA and 4...20 mA. 2-wire measurement transducers are connected to an external auxiliary voltage.
- The “wire break” diagnostic function supports only the input range 4...20 mA. All other unipolar or bipolar ranges are not supported.
- Suitable diodes: The BZX85 or 1N47..A (Zener diodes 1.3W) series, of the voltage range specified in the module data. For the selection of other elements you should note that the off-state forward current is as low as possible.
- In this type of circuit and when using the named diodes, a principal measurement error is caused by the off-state forward current of maximum 1∝A. In the 20-mA range with 16-bit resolution, this value results in an error < 2 bits. In the circuit above, various analog inputs return an additional error. For further information, refer to the marginal conditions. These and all other error values specified in the module manual form a cumulative error.
- The 4-wire measurement transducers used must be capable of driving the load of the above circuit. For further information, refer to the marginal conditions.
- Please note that the installation of a Zener diode circuit forms a heavy influence on the voltage requirements of 2-wire measurement transducers, which is why the necessary input voltages are specified in the technical data of the various modules. The internal supply ($_{IS}$) of the measurement transducer ($_{MT}$) determines the minimum supply voltage and is calculated as follows:
  $L+ > U_{in–2Dr} + U_{IS–MT}$

This module is not suitable for the use in the circuit shown above:

AI 8x12bit	6ES7 331-7KF02-0AB0

Additional marginal conditions for various modules

AI 8x16bit 6ES7 331-7NF00-0AB0

- Suitable Z diodes: BZX85C8v2 or 1N4738A (8.2 V because of 250 Ohm input resistance)
- Cumulative circuit error: When one of the modules fails, the error value of the other may increase instantaneously by approx. 0.1%
- Load capability of 4-wire measurement transducers: $R_B > 610$ Ohm (worst case calculation: 1 input + 1 Zener diode with an S7 saturation value of 24 mA; $R_B = (R_E * I_{max} + U_{z\ max}) / I_{max}$)
- Input voltage of 2-wire measurement transducers: $U_{in-2Dr} < 15$ V (worst case calculation: 1 input + 1 Zener diode with an S7 saturation value of 24 mA; $U_{in-2Dr} = R_E * I_{max} + U_{z\ max}$)

AI 16x16bit 6ES7 431-7QH00-0AB0

- Suitable Z diodes BZX85C6v2 or 1N4734A (6.2 V because of 50 Ohm input resistance)
- Cumulative circuit error: —
- Load capability of 4-wire measurement transducers: $R_B > 325$ Ohm (worst case calculation: 1 input + 1 Zener diode with an S7 saturation value of 24 mA; $R_B = (R_E * I_{max} + U_{z\ max}) / I_{max}$)
- Input voltage of 2-wire measurement transducers: $U_{in-2Dr} < 8$ V (worst case calculation: 1 input + 1 Zener diode with an S7 saturation value of 24 mA; $U_{in-2Dr} = R_E * I_{max} + U_{z\ max}$)

Note

The circuit shown above operates only with active 4-wire measurement transducers, or with passive 2-wire measurement transducers connected to an auxiliary load voltage supply. The module channels always have to configured for “4-wire measurement transducer” operation.

The module (2DMU) can not supply the MT voltage.

AI 4x15bit Ex 6ES7 331-7RD00-0AB0

- Note the relevant specifications when operating the module in Ex areas.
- Suitable Zener diodes: BZX85C6v2 or 1N4734A (6.2 V because of 50 Ohm input resistance)
- Cumulative circuit error: —
- Load capability of 4-wire measurement transducers: RB > 325 Ohm (worst case calculation: 1 input + 1 Zener diode with an S7 saturation value of 24 mA; $R_B = (R_E * I_{max} + U_{z\ max}) / I_{max}$)
- Input voltage of 2-wire measurement transducers: Uin-2Dr < 8 V (worst case calculation: 1 input + 1 Zener diode with an S7 saturation value of 24 mA; Uin-2Dr = $R_E * I_{max} + U_{z\ max}$)

Note

This circuit supports only 2-wire measurement transducers with external 24-V power supply or 4-wire measurement transducers. For this circuit you can not use the integrated measurement transducer supply voltage, because its output voltage is only 13V and in worst case it would thus only supply 5 V to the transducer.

Redundant analog input modules with redundant sensors

Analog input modules in a 1-out-of-2 configuration are preferred for double redundant sensors:

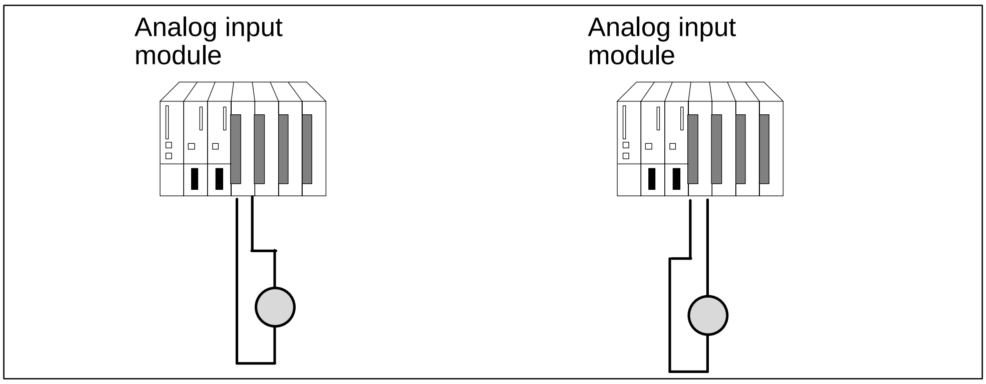


Figure 7-11 Fault-tolerant analog input modules in a 1-out-of-2 configuration with two sensors

The use of redundant sensors increases their availability.

Discrepancy analysis also detects external errors – except for the failure of a non-redundant on-load voltage supply.

Connection examples are available in Appendix F and in the SIMATIC FAQs at `http://www.siemens.com/automation/service&support` under the keyword “Redundant I/O”.

The general information in the introductory section applies.

Additional marginal conditions for various modules

AO 4x15bit Ex 6ES7 332-5RD00-0AB0

Please note the relevant maximum current and voltage specifications for the operation of modules in Ex applications.

Redundant sensor <–> Non–redundant sensor

The following table lists the analog input modules you can use in redundant mode with redundant or non-redundant sensors:

Table 7-3 Analog input modules and sensors

Modules	Redundant sensor	Non-redundant sensor
6ES7 431-7QH00-0AB0	X	X
6ES7 336-1HE00-0AB0	X	–
6ES7 331-7KF02-0AB0	X	X
6ES7 331-7NF00-0AB0	X	X
6ES7 331-7RD00-0AB0	X	X

You can use a redundant sensor for the AI8x12Bit,
6ES7 331-7KF02-0AB0 with the following voltage settings:

+/– 80 mV	(only without wire break monitoring)
+/– 250 mV	(only without wire break monitoring)
+/– 500 mV	(wire break monitoring not configured)
+/– 1 V	(wire break monitoring not configured)
+/– 2,5 V	(wire break monitoring not configured)
+/– 5 V	(wire break monitoring not configured)
+/– 10 V	(wire break monitoring not configured)
1...5 V	(wire break monitoring not configured)

Redundant analog output modules

Redundant control of a final control element is achieved by interconnecting two outputs of two analog output modules in parallel (1-of-2 structure)

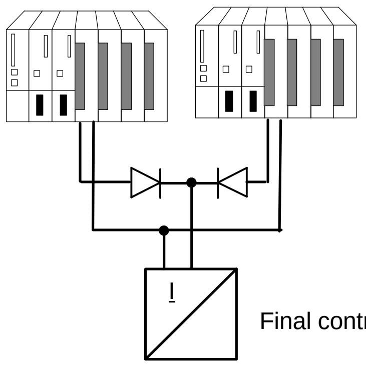


Figure 7-12 Redundant analog output modules in a 1-of-2 structure

To wire the analog output module circuit shown above:

- Wire the ground lines in star pattern in order to avoid output errors (limited common-mode suppression for the analog output modules).

Depassivation of modules

Passivated modules are reactivated by the following events:

- When fault-tolerant system starts up
- When the fault-tolerant system switches to the “Redundant” operating mode
- Following a system modification during ongoing operation
- By the function FC 451 “RED DEPA” when at least one redundant module is passivated.
  The functionality and use of FC 451 are described in the corresponding online help.

The depassivation is performed in FB 450 “RED IN” when one of these events occur,. When the all of modules have been depassivated, an entry is made in the diagnostics buffer.

When you use redundant I/O in a one-way central device or one-way DP slave, you have to depassivate the redundant modules after the station failure/return or replacement of a defective module. You can trigger a complete depassivation with FC 451.

Note

If a redundant module is assigned a process image partition but the corresponding OB is not available in the CPU, the complete passivation can take approximately 1 minute.

7.4.1 Determining the status of the passivation

Procedure

First determine the status of the passivation with the status byte in the status word / control word “FB_RED_IN.STATUS_CONTROL_W”. If you find that a module has been passivated, you can determine the status of this module – or the corresponding modules pair – in the MODUL_STATUS_WORD.

Determining the passivation status with the status byte

The status word / control word “FB_RED_IN.STATUS_CONTROL_W” is located in the instance DB of FB 450 “RED_IN”. The status byte provides information about the status of the redundant I/O.

Table 7-4 Assignment of the status byte

Bit	Meaning
Status byte (byte 1)	
0	Standby
1	Standby
2	0 = No analog output module available 1 = at least one analog output module available
3	0 = No passivation by OB 85 1 = at least one passivation by OB 85
4	0 = No passivation by OB 82 1 = at least one passivation by OB 82
5	0 = No channel information available 1 = at least channel information available
6	0 = No module passivated 1 = at least one module passivated
7	0 = Complete depassivation not running 1 = Complete depassivation running

Status of the passivation of individual module pairs determined by MODUL_STATUS_WORD

MODUL_STATUS_WORD is in the instance DB of FB 453 “RED_STATUS”. The two status bytes provide information about the status of individual module pairs.

MODUL_STATUS_WORD is an output parameter of FB 453 and can be connected accordingly.

Table 7-5 Assignment of the status bytes

Bit	Meaning
Status byte 1	
0	0 = Passivation of module_L triggered by OB 82 1 = No passivation of module_L triggered by OB 82
1	0 = Passivation of module_H triggered by OB 82 1 = No passivation of module_H triggered by OB 82
2	0 = Overflow or underflow (for analog input modules) 1 = No overflow or underflow
3	0 = Channel information is available 1 = Channel information is not available
4	0 = Discrepancy time expired (for input modules) 1 = Discrepancy time not expired
5	0 = Module pair is discrepant (for input modules) 1 = Module pair is not discrepant
6	0 = Module_L passivated 1 = Module_L depassivated
7	0 = Module_H passivated 1 = Module_H depassivated
Status byte 2	
0	Standby
1	Standby
2	0 = No enable for depassivation of module_L after outgoing event of OB 85 1 = Enable for depassivation of module_L after outgoing event of OB 85
3	0 = No enable for depassivation of module_H after outgoing event of OB 85 1 = Enable for depassivation of module_H after outgoing event of OB 85
4	0 = No enable for depassivation of module_L after outgoing event of OB 82 1 = Enable for depassivation of module_L after outgoing event of OB 82
5	0 = No enable for depassivation of module_H after outgoing event of OB 82 1 = Enable for depassivation of module_H after outgoing event of OB 82
6	0 = Passivation of module_L triggered by OB 85 1 = No passivation of module_L triggered by OB 85
7	0 = Passivation of module_H triggered by OB 85 1 = No passivation of module_H triggered by OB 85

7.5 Other possibilities for connecting redundant I/O

Redundant I/O on the user level

If you cannot use the redundant I/O (Chapter 7.4) supported by the system (perhaps because the redundancy module is not included in the list of supported modules), you may be able to use redundant I/O on the user level.

Configurations

The following configurations having a redundant I/O are possible (Figure 7-13):

1. Redundant system with one-way central and/or distributed I/O.

   One I/O module is inserted for this purpose in the subsystems of CPU 0 and one in the subsystem of CPU 1.

2. Redundant configuration with a switched I/O

   Two I/O modules are inserted into two ET 200M distributed I/O devices with an active backplane bus.

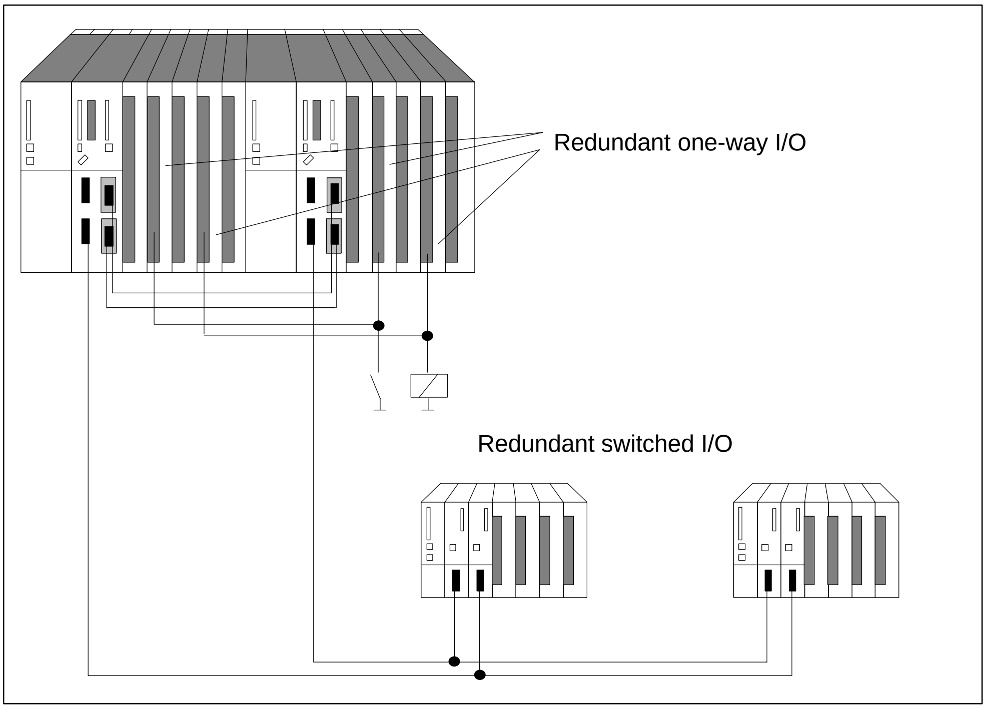


Figure 7-13 Redundant one-way and switched I/Os

Notice

When using redundant I/O, an extra value might have to be added to the calculated monitoring times; refer to Section 6.3.2.

Hardware installation and configuration of the redundant I/O

If you wish to use a redundant I/O, we would recommend you the following strategy:

1. Use the I/O in the following manner:
   - With a one-way configuration, one I/O module in each subsystem
   - With a switched configuration, two I/O modules in two distributed ET 200M I/O devices.
2. Wire the I/O in such a way that it can be addressed by both subsystems.
3. Configure the I/O modules for different logical addresses.

Notice

We do not recommend configuration of the output modules you use to the same logical addresses as the input modules; if it is done nevertheless, you have to query the type (input or output) of the defective group in OB 122, in addition to the logical address.

The user program must update the process image for redundant one-way output modules in single mode too (e.g. direct accesses). If subprocess images are used, the user program must update the subprocess images in OB 72 (redundancy return) accordingly (SFC 27 “UPDAT_PO”). If it did not, old values would initially be read out to the single-channel, one-way output modules of the standby CPU following transition to redundant system mode.

Redundant I/O in the user program

The following example program shows the use of two redundant digital input modules:

- module A in rack 0 with logical base address 8 and
- module B in rack 1 with logical base address 12.

One of the two modules is read directly in OB1. It is assumed for the following, without limiting general applicability, that it is module A (the value of variable BGA is TRUE). If no error occurred, processing continues with the value read.

If an I/O access error has occurred, module B will be read by direct access (“second attempt” in OB1). If no error has occurred, processing continues with the value read by module B. However, if an error has similarly occurred in this instance, both modules are currently defective, and work continues with a substitute value.

The example program is based on the fact that following an access error to module A, module B is always processed first in OB1 after the former has been replaced. Module A is not processed first again in OB1 until an access error to module B occurs.

Notice

Variables BGA and PZF_BIT must also be valid outside OB1 and OB122. The variable VERSUCH2, on the other hand, is used only in OB1.

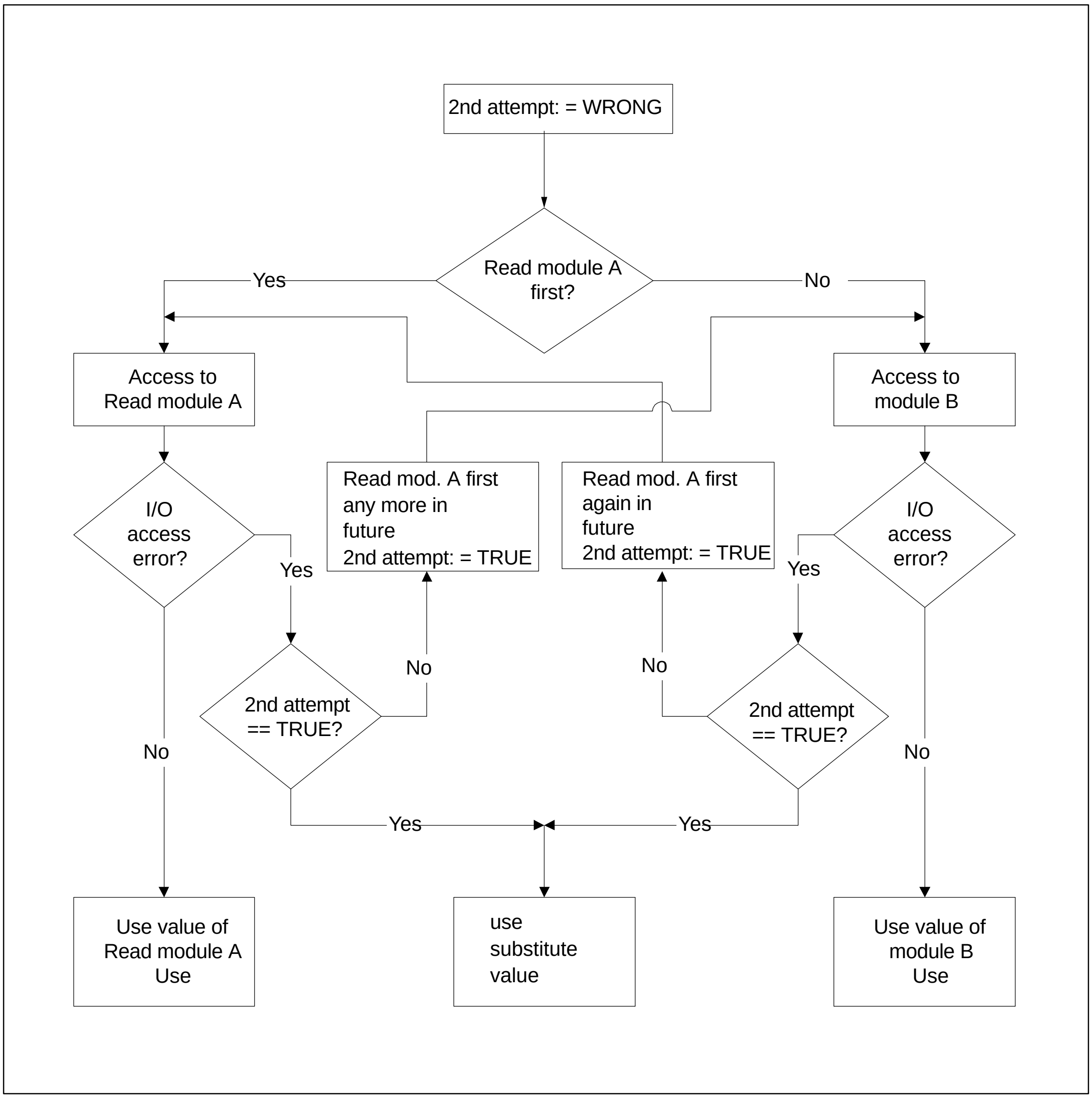


Figure 7-14 Flowchart for OB1

Example of STL

The requisite sections of the user program (OB1, OB 122) are listed below.

Table 7-6 OB 1

STL		Explanation
	NOP 0;	
	SET;	
	R VERSUCH2;	//Initialization
	A BGA;	//Read module A first?
	JCN WBGB;	//If No, continue with module B
WBGA:	SET;	
	R PZF_BIT;	//Delete PZF bit
	L PED 8;	//Read CPU 0
	U PZF_BIT;	//Was PZF detected in OB 122?
	SPBN PZOK;	//If no, process access OK
	U VERSUCH2;	//Was this access the second attempt?
	SPB WBG0;	//If yes, use substitute value
	SET;	
	R BGA;	//Do not read module A first any more //in future
	S VERSUCH2;	
WBGB:	SET;	
	R PZF_BIT;	//Delete PZF bit
	L PED 12;	//Read CPU 1
	U PZF_BIT;	//Was PZF detected in OB 122?
	SPBN PZOK;	//If no, process access OK
	U VERSUCH2;	//Was this access the second attempt?
	SPB WBG0;	//If yes, use substitute value
	SET;	
	S BGA;	//Read module A first again in future
	S VERSUCH2;	
	JU WBGA;	
WBG0:	L ERSATZ;	//Substitute value
PZOK:		//The value to be used is in Accumulator1

Table 7-7 OB 122

STL		Explanation
		// Does module A cause PZF?
	L OB122_MEM_ADDR;	//Logical base address affected
	L W#16#8;	
	== I;	//Module A?
	SPBN M01;	//If no, continue with M01
		//PZF upon access to module A
	SET;	
	= PZF_BIT;	//Set PZF bit
	SPA CONT;	
		// Does module B cause PZF?
M01:	**NOP 0;**	
	L OB122_MEM_ADDR;	//Logical base address affected
	L W#16#C;	
	== I;	//Module B?
	SPBN CONT;	//If no, continue with CONT
		//PZF upon access to module B
	SET;	
	= PZF_BIT;	//Set PZF bit
CONT:	**NOP 0;**	

Communication Functions 8

In this chapter you will find an introduction to communications with fault-tolerant systems and their specific characteristics.

You will learn the basic concepts, the bus systems you can use for fault-tolerant communications and the types of connection.

You will learn how communications take place via fault-tolerant connections and standard connections, and how to configure and program them.

- You will find examples of communication via **fault-tolerant S7 connections** and will learn about their advantages.
- By way of comparison, you will learn how communication takes place over **S7 connections** and also how you can communicate in redundant mode by means of S7 connections.

8.1 Fundamentals and Basic Concepts

Overview

Fault-tolerant controllers make it possible for controllers, including their I/O, to feature redundancy. With growing demands on the availability of an overall system it is necessary to raise the fault tolerance of communications – in other words, communications have to be configured so that they are also redundant.

You will find below an overview of the fundamentals and basic concepts which you ought to know with regard to using fault-tolerant communications.

Redundant communication system

The availability of the communication system can be enhanced by redundancy of the media, duplication of subcomponents, or duplication of all bus components.

Monitoring and synchronization mechanisms ensure that should one component fail, communications in routine operation are continued by means of standby components.

A redundant communications system is a requirement for the configuration of fault-tolerant S7 connections.

Fault-tolerant communications

Fault-tolerant communications means the use of SFBs in S7 communications via fault-tolerant S7 connections.

Fault-tolerant S7 connections are only possible with the use of redundant communications systems.

Redundant nodes

Redundant nodes represent the fault tolerance of communications between two fault-tolerant systems. A system with multi-channel components is represented by redundant nodes. The independence of a redundant node is given when the failure of a component within the node does not result in reliability constraints in other nodes.

Connection (S7 Connection)

A connection is the logical assignment of two communication peers to implement a communication service. Every connection has two endpoints containing the information required for addressing the communication peer and other attributes for establishing the connection.

An S7 connection is the communication connection between two standard CPUs or from one standard CPU to a CPU in a fault-tolerant system.

In contrast to a fault-tolerant S7 connection, which contains at least two partial connections, an S7 connection actually consists of just one connection Communications are terminated should this one connection fail.

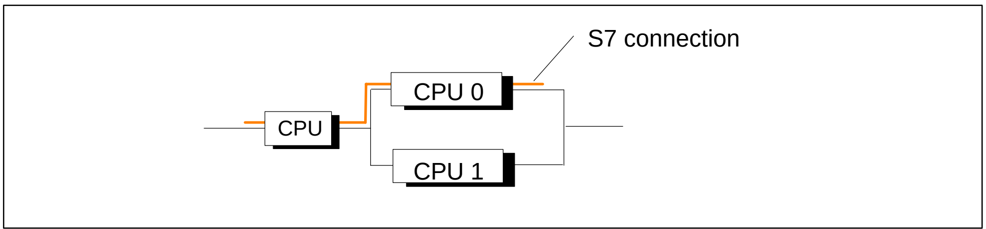


Figure 8-1 Example of an S7 connection

Note

Generally speaking, “connection” in this manual means the “configured S7 connection”. For other types of connection please refer to the manuals *SIMATIC NET NCM S7 for PROFIBUS* and *SIMATIC NET NCM S7 for Industrial Ethernet*.

Fault-tolerant S7 connections

The requirement for higher availability by means of communication components – for example, CPs and buses – necessitates redundant communication connections between the systems involved.

Unlike the S7 connection, a fault-tolerant S7 connection consists of at least two lower-level partial connections. From the point of view of the user program, the configuration and the connection diagnostics, the fault-tolerant S7 connection with its subordinate partial connections is represented by exactly one ID (like a standard S7 connection). Depending on the configuration set, it can consist of up to four partial connections, of which two are always made (active) so as to maintain communications in the event of an error. The number of partial connections depends on possible alternative paths (refer to Figure 8-2) and is determined automatically.

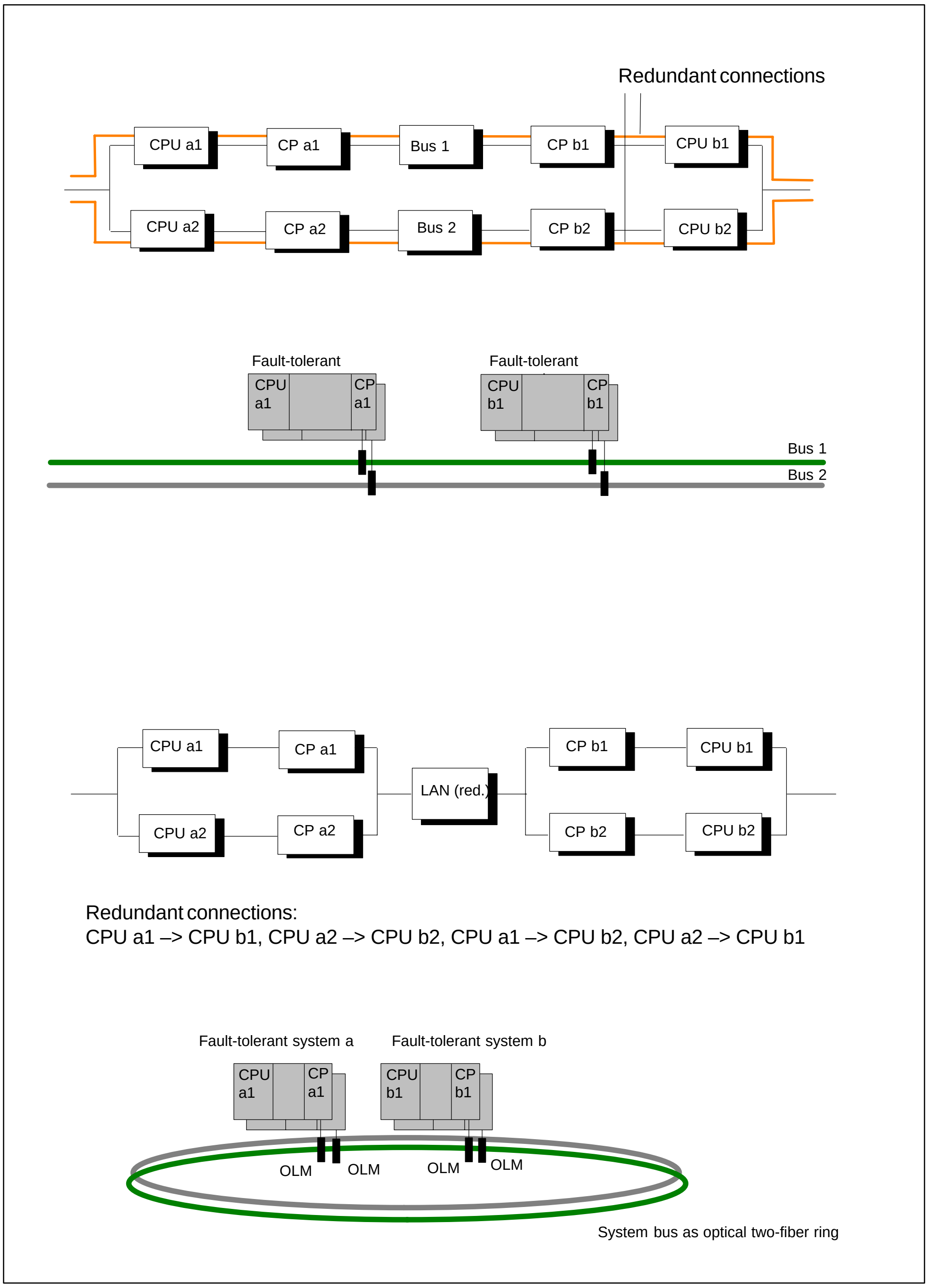


Figure 8-2 Example of the number of resulting partial connections being dependent on the configuration

Should the active partial connection fail, a previously established second partial connection assumes responsibility for communications.

Resource requirements of fault-tolerant S7 connections

The fault-tolerant CPU permits the operation of 64/32 (cf. Technical Data) fault-tolerant S7 connections. On the CP each partial connection requires a connection resource.

Note

If you have configured several fault-tolerant S7 connections for a fault-tolerant station, setting them up may take a considerable length of time. If the configured maximum communication delay has been set too short, link-up and updating is cancelled and redundant system mode is no longer reached (see Section 6.3).

8.2 Suitable Networks

The choice of physical transfer medium depends on the desired expansion, the fault tolerance aimed at and the transmission rate. The following bus systems are used for communications with fault-tolerant systems:

- Industrial Ethernet (fiber-optic cable, triaxial or twisted pair copper cable)
- PROFIBUS (fiber-optic cable or copper cable)

You will find further information on suitable networks in the manuals "*Communication with SIMATIC*", *"Industrial Twisted Pair Networks"* and *"PROFIBUS Networks*".

8.2.1 Industrial Ethernet

The industrial Ethernet is a communications network for cells in baseband transmission technology complying with IEEE 802.3, with the CSMA/CD access procedure.

An industrial Ethernet network can be configured as a redundant medium with either electrical or optical components. A very wide range of electrical and optical network components is available for the industrial Ethernet.

Electrical network

The electrical network can be configured as a classical bus structure with triaxial cabling for the transmission medium.

An addition and an alternative to conventional bus cabling for connections to terminals are electrical link modules (ELMs) or industrial twisted pairs (ITPs). With them star networks complying with IEEE 802.3 can be configured.

Optical network

The optical industrial Ethernet network (transmission medium: fiber-optic cable) can be configured as a line-type, ring or star network. The configuration is accomplished for a transmission rate of 10 Mbps with optical link modules (OLMs) and/or star hubs for the fast Ethernet of 100 Mbps with optical switching modules (OSMs) and optical redundancy manager (ORM).

8.2.2 PROFIBUS

PROFIBUS is a communications network for cells and fields in accordance with PROFIBUS Standard EN 50 170, Volume 2, with the hybrid token bus and master slave access procedure. Networking takes place over two-wire cables or fiber-optic cables.

The PROFIBUS bus system can be used as a redundant medium with electrical or optical components. The number of connected stations should not exceed 30. An Industrial Ethernet bus system is recommended for larger plants.

The transmission rate can be adjusted in steps from 9.6 kb’s to 12 Mbps.

Electrical network

The transmission medium of the electrical network is a shielded, twisted pair.

The RS 485 interface operates with voltage differences. It is therefore less sensitive to interference than a voltage or current interface. In the case of PROFIBUS the nodes are connected through a bus terminal or a bus connector to the bus (up to 32 nodes per segment). The different segments are interconnected by means of repeaters.

The maximum segment size depends on the transmission rate.

Apart from RS-485 transmission technology, there is PROFIBUS PA to IEC 1158 for process automation. PROFIBUS PA transmission technology aims at the intrinsically safe EX area and thus operates with a synchronous, low-energy transmission method. Up to ten nodes can be operated in the intrinsically safe Exi area on a single PROFIBUS PA segment, provided that the overall power requirement never exceeds 100 mA. In the non-intrinsically safe area as many as 30 nodes can operated on one PROFIBUS PA segment. The transmission rate used is then 31.25 kbytes.

Optical network

The optical PROFIBUS network uses fiber-optic cables as a transmission medium.

The fiber-optic cable variant is insensitive to electromagnetic interference, is lightning-proof, does not require electrical equipotential bonding and is suitable for long distances (glass fiber-optic cable).

The maximum segment length does not depend on the transmission rate (except redundant optical rings). Optical rings can be configured as one- or two-fiber rings (enhanced network availability).

Configuration of the fiber-optic cable networks is accomplished by means of optical link modules (OLMs). A network can be configured with OLMs as a line-type, ring or star network.

8.3 Supported Communication Services

The following services can be used:

- S7 communications over fault-tolerant S7 connections via PROFIBUS and Industrial Ethernet
- S7 communications over S7 connections via MPI, PROFIBUS and Industrial Ethernet
- Standard communications (FMS, for example) via PROFIBUS
- S5-compatible communications (SEND and RECEIVE blocks, for example) via PROFIBUS and Industrial Ethernet

The following are not supported:

- Basic communications
- Global data communication

8.4 Communications via Fault-tolerant S7 Connections

Availability of communicating systems

Fault-tolerant communications add additional, redundant communication components, such as CPs and LAN cables, to the overall SIMATIC system. To illustrate the actual availability of communicating systems when using an optical or electrical network, a description is given below of the possibilities for communication redundancy.

Prerequisite

A requirement for the configuration of fault-tolerant connections with STEP 7 is a configured hardware installation.

The hardware configuration of the two subsystems integrated in a fault-tolerant system **must** be identical. This is especially true of the slots.

Depending on the network being used, the following CPs can be used for fault-tolerant communications:

- Industrial Ethernet:
  S7: CP 443-1
- PROFIBUS:
  S7: CP 443-5 Extended (not configured as DP master system)

To be able to use fault-tolerant S7 connections between a fault-tolerant system and a PC, you must install the “S7-REDCONNECT” software package on the PC. Please refer to the Product Information Leaflet on “S7-REDCONNECT” to learn more about the CPs you can use at the PC end.

Configuration

The availability of the system, including communications, is set during configuration. Please refer to the STEP 7 documentation to find out how to configure connections.

Only S7 communication is used for fault-tolerant S7 connections. To do this, select in the “New Connection” dialog box the “S7 Connection Fault-Tolerant” as the type.

The number of required redundant connections is determined by STEP 7 as a function of the redundant nodes. If the network architecture allows them, up to four redundant connections are generated. Higher redundancy cannot be achieved by using more CPs.

In the “Properties - Connection” dialog box you can modify specific properties of a fault-tolerant connection, should you require to do so. If you are using more than one CP, you can also switch the connections in this dialog box. This may be practical since, by default, all connections are routed initially through the first CP. If all the connections have been assigned there, the other connections are routed through the second CP etc.

Programming

Fault-tolerant communication can be used on the fault-tolerant CPU and takes place by means of S7 communication.

This is possible solely within an S7 project.

The programming of fault-tolerant communications with STEP 7 is accomplished by means of communication system function blocks. With these blocks, data can be transmitted over subnets (Industrial Ethernet, PROFIBUS). The standard communication SFBs integrated in the operating system offer you the option of acknowledged data transmission. Not only data transmission is possible; other communication functions for controlling and monitoring the communication peer can also be used.

User programs written for standard communications can be run for fault-tolerant communications as well, without being modified. Cable and connection redundancy has no effect on the user program.

Note

You will find tips on programming communications in the S7 standard documentation – for example, *Programming with STEP 7*.

The communication functions START and STOP act on exactly one CPU or on all CPUs of the fault-tolerant system (for more details refer to the Reference Manual *System Software for S7-300/400, System and Standard Functions*).

8.4.1 Communications between Fault-Tolerant Systems

Availability

The simplest method of enhancing the availability of interconnected systems is to use a redundant system bus configured with an optical two-fiber ring or a duplicated electrical bus system. In this case the connected nodes may consist of simple standard components.

An increase in availability can best be obtained with an optical two-fiber ring. Should the two-fiber optic cable rupture, communications continue to exist between the systems involved. The systems then communicate as if they were connected to a bus system (line). A ring system contains two redundant components as a matter of principle and therefore automatically forms a 2-out-of-2 redundant node. An optical network can also be configured in line-type or star topology. There is no cable redundancy with line-type topology, however.

Should one electrical cable segment fail, communications between the systems involved similarly continue to exist (2-out-of-2 redundancy).

The following examples illustrate the differences between the two versions.

Note

The number of connection resources required on the CPs depends on the network you are using.

If you are using an optical two-fiber ring (refer to Figure 8-3), two connection resources are required per CP. In contrast to this, only one connection resource is required per CP if a duplicated electrical network (refer to Figure 8-4) is being used.

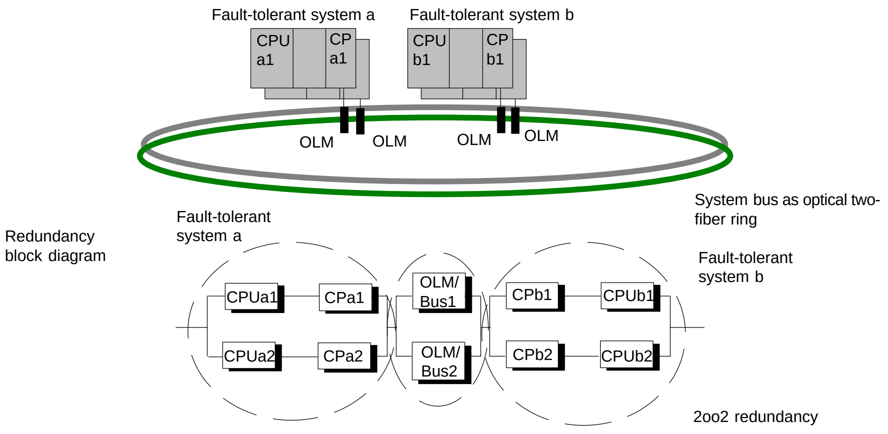


Figure 8-3 Example of redundancy with fault-tolerant system and redundant ring

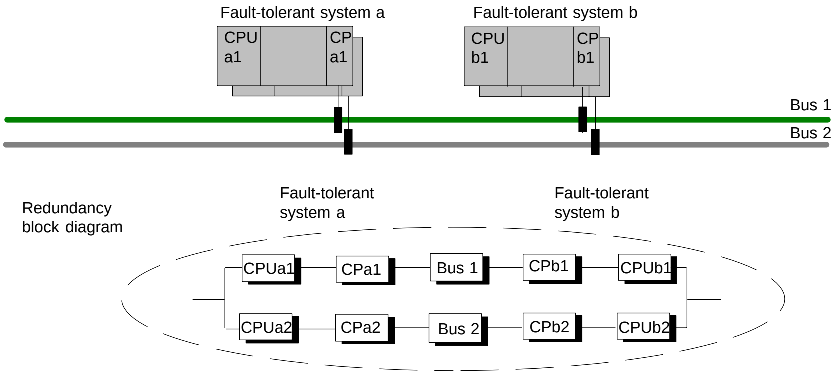


Figure 8-4 Example of redundancy with fault-tolerant system and redundant bus system

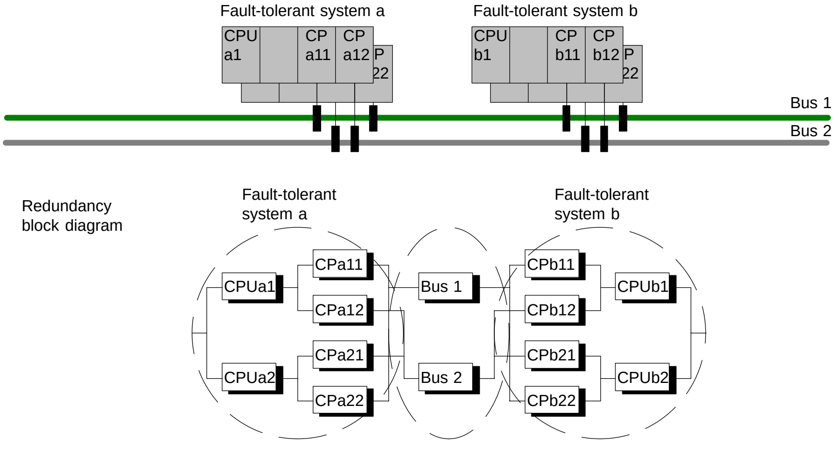


Figure 8-5 Example of a fault-tolerant system with additional CP redundancy

Response to failure

Only a double error within a fault-tolerant system (e.g. CPUa1 and CPa2 in a system) in the case of a two-fiber ring leads to total failure of communications between the redundant systems concerned (refer to Figure 8-3).

If a double error (CPUa1 and CPb2, for example) occurs in the first case of a redundant electrical bus system (see Figure 8-4), a this results in a complete failure of communication between the systems involved.

In the case of a redundant electrical bus system with CP redundancy (see Figure 8-5), only a double error within a fault-tolerant system (CPUa1 and CPUa2, for example) or a triple error (CPUa1, CPa22 and bus2, for example) will result in a complete failure of communication between the systems involved.

Redundant S7 connections

Interruptions of a connection unit while communication requests are being processed will lead to extended runtimes.

8.4.2 Communications between Fault-Tolerant Systems and a Fault-Tolerant CPU

Availability

Availability can be enhanced by using a redundant system bus and by using a fault-tolerant CPU on a standard system.

If the communication partner is a fault-tolerant CPU, fault-tolerant connections can also be configured here,in contrast to a CPU 416, for example.

Note

Fault-tolerant connections occupy two connection resources on CP b1 for the redundant connections. One connection resource each is assigned to CP a1 and CP a2.

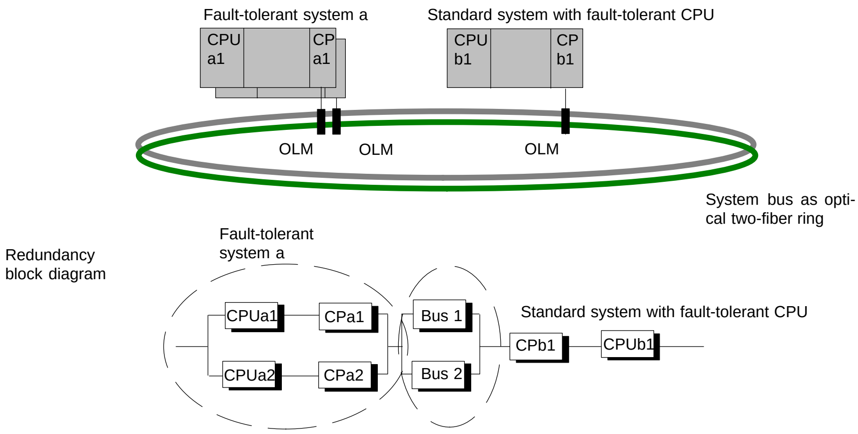


Figure 8-6 Example of redundancy with fault-tolerant system and fault-tolerant CPU

Response to failure

Double faults in the fault–tolerant system (in other words, CPUa1 and CPa 2) and a single fault in the standard system (CPb1) result in a complete failure of communication between the systems involved (refer to Figure 8-6).

Fault-Tolerant S7 Connections

Interruptions of a partial connection result in a prolonging of the runtime for ongoing communication jobs via fault-tolerant S7 connections.

8.4.3 Communications between Fault-Tolerant Systems and PCs

Availability

When fault-tolerant systems are connected to a PC, the availability of the overall system concentrates not only on the PCs (OS) and their data management but also on data acquisition on the programmable logic controllers.

PCs are not fault-tolerant on account of their hardware and software characteristics. They can be arranged in a redundant manner in a system, however. The availability of this kind of PC (OS) system and its data management is ensured by means of suitable software such as WinCC Redundancy.

Communications take place via fault-tolerant connections.

The “S7-REDCONNECT” software package as of V1.3 is a requirement for fault-tolerant communication on a PC. It makes it possible to connect a PC to an optical network with a CP or to a redundant bus system with two CPs.

Configuring connections

No additional configuration of fault-tolerant communications is required at the PC end. Connection configuration is taken care of by the STEP 7 project in the form of an XDB file at the PC end.

You can find out how to use STEP 7 fault-tolerant S7 communications to integrate a PC in your OS system in the WinCC documentation.

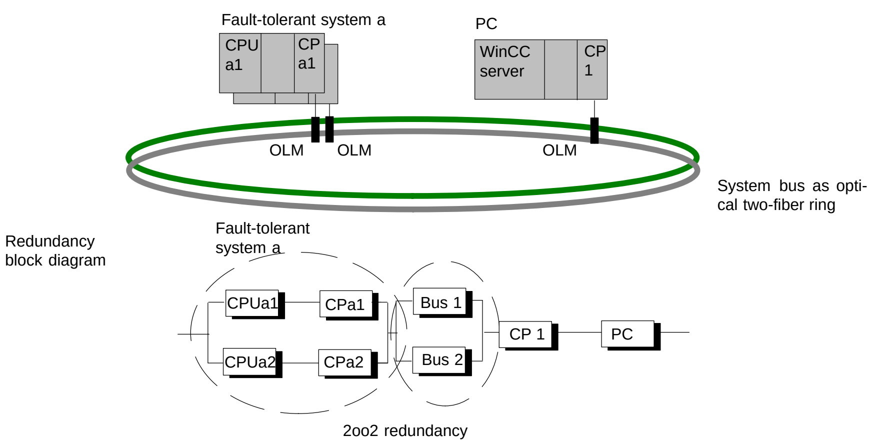


Figure 8-7 Example of redundancy with fault-tolerant system and redundant bus system

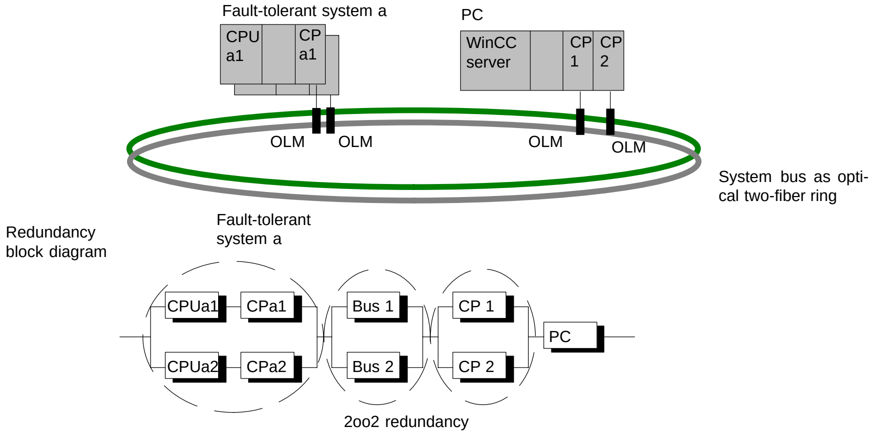


Figure 8-8 Example of redundancy with a fault-tolerant system, redundant bus system and CP redundancy in the PC

Response to failure

Double faults in the fault–tolerant system (in other words, CPUa1 and CPa 2) and the failure of the PC result in a complete failure of communication between the systems involved (refer to Figures 8-7and 8-8).

8.5 Communications via S7 Connections

Communications with standard systems

Fault-tolerant communications are not possible between fault-tolerant and standard systems. The following examples illustrate the actual availability of the communicating systems.

Configuration

Standard connections are configured with STEP 7.

Programming

If standard communications are used on a fault-tolerant system, all the communication functions apart from “global data communications” can be used for them.

The standard communication SFBs are used for programming communications with STEP 7.

Note

The communication functions START and STOP act on exactly one CPU or on all CPUs of the fault-tolerant system (for more details refer to the Reference Manual *System Software for S7-300/400, System and Standard Functions*).

8.5.1 Communications via S7 Connections – One-Sided Mode

Availability

Availability is similarly enhanced by using a redundant system bus for communications from a fault-tolerant system to a standard system.

If the system bus is configured as an optical two-fiber ring, communications between the systems involved continue to exist in the event of the two-fiber optic cable rupturing. The systems then communicate as if they were connected to a bus system (line), see Figure 8-9.

When fault-tolerant systems and standard systems are interconnected, the availability of communications cannot be enhanced by means of a twin electrical bus system. In order to be in a position to use the second bus system as a redundant bus, you have to use a second S7 connection, which has to be managed accordingly in the user program (refer to Figure 8-10).

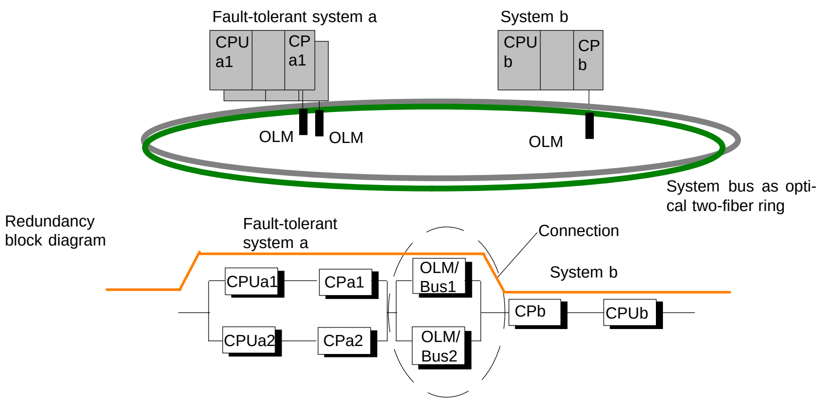


Figure 8-9 Example of interconnected standard and fault-tolerant systems on a redundant ring

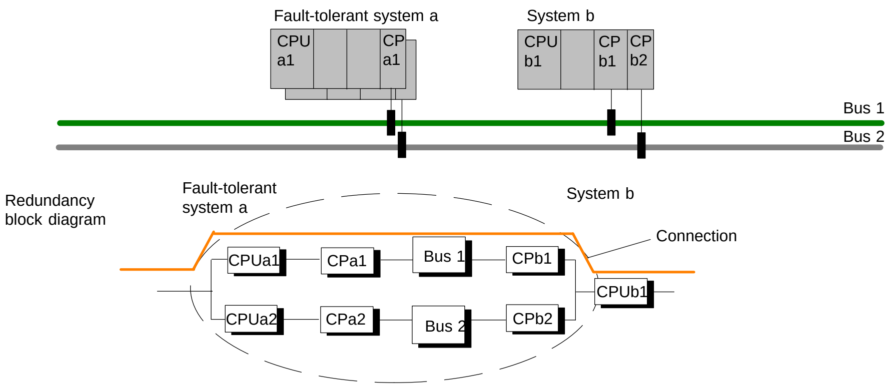


Figure 8-10 Example of interconnected standard and fault-tolerant systems on a redundant bus system

Response to failure

Two-fiber ring and bus system

Since standard S7 connections are used in this particular instance (the connection terminates at the CPU of the subsystem, in this instance CPUa1), an error on the fault-tolerant system – for example, CPUa1 or CPa1 – and an error on system b – for example, CP b – both result in a complete failure of communication between the systems involved (refer to Figures 8-9 and 8-10).

There are no differences specific to the bus system’s response to failure.

8.5.2 Communications over Redundant S7 Connections

Availability

Availability can be enhanced by using a redundant system bus and by using two separate CPs on a standard system.

Redundant communications can be operated even with standard connections. Two separate S7 connections have to be configured for this. Connection redundancy has to be implemented by means of programming for this purpose. Communication monitoring has to be implemented for both connections at the user program level to detect a communications failure and to switch to the second connection.

Figure 8-11 shows an example of such a configuration.

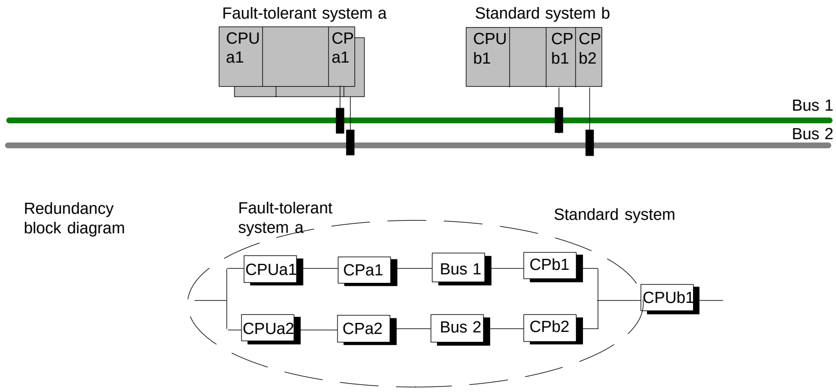


Figure 8-11 Example of redundancy with fault-tolerant systems and redundant bus system with redundant standard connections

Response to failure

Double faults in the fault-tolerant system (in other words, CPUa1 and CPa 2), double faults in the standard system (CPb1 and CPb2) and a single fault in the standard system (CPb1) result in a complete failure of communication between the systems involved (refer to Figure 8-11).

8.5.3 Communications via a Point-to-Point CP on the ET 200M

Connection via ET 200M

Connections of fault-tolerant systems to single-channel systems are frequently possible only through a point-to-point connection since many systems have no other connection option.

To have the data of a single-channel system available on the CPUs of the fault-tolerant system as well, the point-to-point CP (CP 341) has to be inserted in a distributed mounting rack with two IM 153-2s.

Configuring connections

Redundant connections between the point-to-point CP and the fault-tolerant system are not necessary.

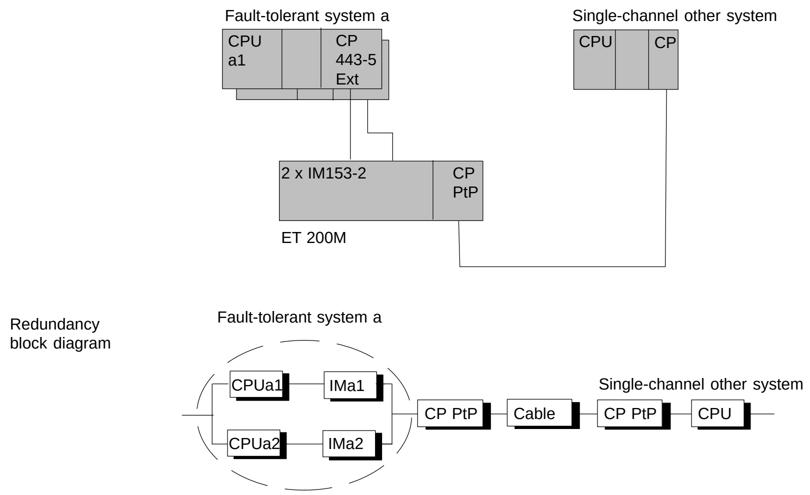


Figure 8-12 Example of interconnection of a fault-tolerant system and a single-channel third-party system

Response to failure

Double faults in the fault-tolerant system (in other words, CPUa1 and IM153-2) and a single fault in the third-party system result in a complete failure of communication between the systems involved (refer to Figure 8-12).

The point-to-point CP can alternatively be inserted centrally in “fault-tolerant system a”. But with this configuration even a failure of the CPU results in a complete failure of communication.

8.5.4 Random Connection with Single-channel Systems

Connection via a PC as gateway

When fault-tolerant systems are linked to single-channel systems, they can alternatively be connected via a gateway (no connection redundancy). The gateway is connected via one or two CPs to the system bus, depending on availability requirements. Fault-tolerant connections can be configured between the gateway and the fault-tolerant systems. The gateway makes it possible to link any kind of single-channel system – for example, TCP/IP with a specific manufacturer's protocol).

A software instance written by the user in the gateway implements the single-channel transition to the fault-tolerant systems. Any single-channel system can be linked in this way to a fault-tolerant system.

Configuring connections

Fault-tolerant connections are not required between the gateway CP and the single-channel system.

The gateway CP is located on a PC system that has fault-tolerant connections to the fault-tolerant system.

In order to be able to use fault-tolerant S7 connections between fault-tolerant system A and the gateway, the S7-REDCONNECT" software package is required on the gateway. Data conversion for routing via the single-channel connection has to be implemented in the user program.

You will find further information on this point in the catalog called "*Industrial Communications IK10*".

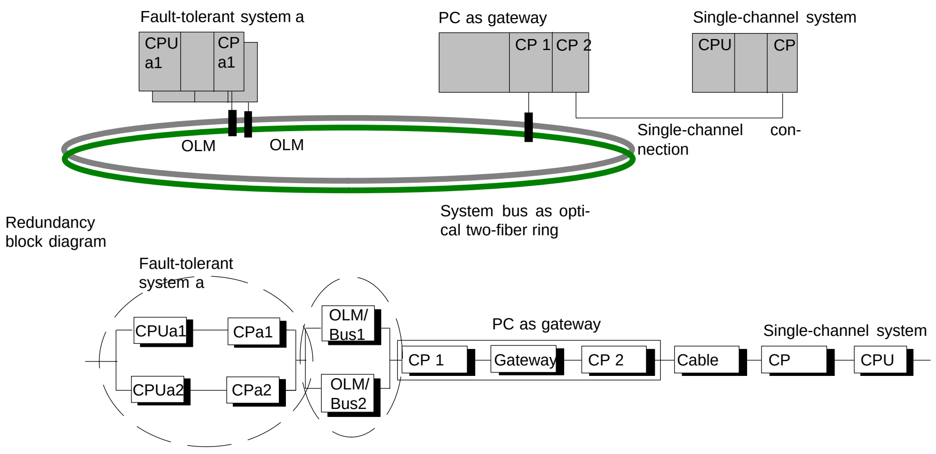


Figure 8-13 Example of interconnection of a fault-tolerant system and a single-channel third-party system

8.6 Communication Performance

The following explanation applies to:

- CPU 414-4H with order number 6ES7 414-4HJ00-0AB0, all releases.
- CPU 417-4H with order number 6ES7 417-4HL01-0AB0, all releases.

In an H-system the communication performance (response time and data throughput) during redundant operation is considerably lower in an H-CPU during single operation or in a standard CPU.

This description is meant to provide the assessment criteria, with which you can evaluate the effects of the different communication mechanisms on the communication performance.

Definition of Communication Load

Communication is the sum of all jobs sent to the CPU via the communication mechanisms per second plus the jobs and messages output by the CPU.

The bigger the communication load, the larger the CPU response time, this means the CPU requires a longer period of time to respond to a job (e.g., read job) or to output jobs and messages.

Work Area

In every automation system there is a linear work area, in which an increase in the communication load will lead to an increase in the data throughput. This will lead to clear reaction times, which are usually acceptable for the respective automation task.

If there is further increase in the communication load, the throughput will enter the saturation area. The amount of the requests may no longer be processed in the automation system whithin required the response time. The data throughput will reach a maximum and the reaction time will increase exponentially, see diagram below.

The data throughput will decrease in part due to additional internal device load.

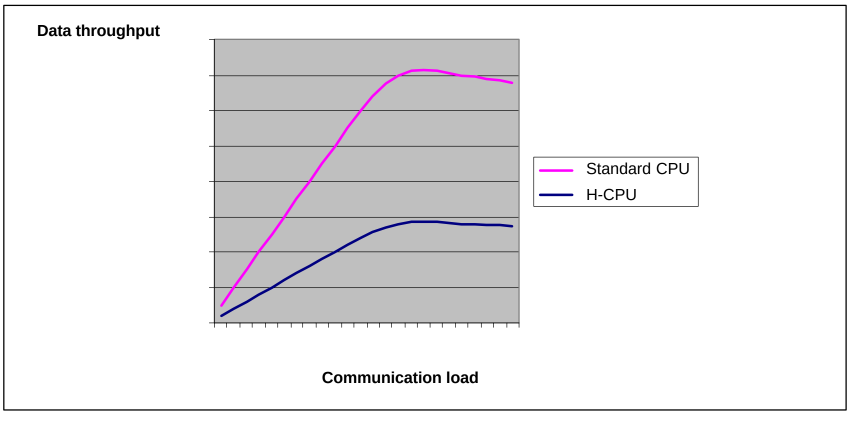


Figure 8-14 Data throughput via communication load (basic trend)

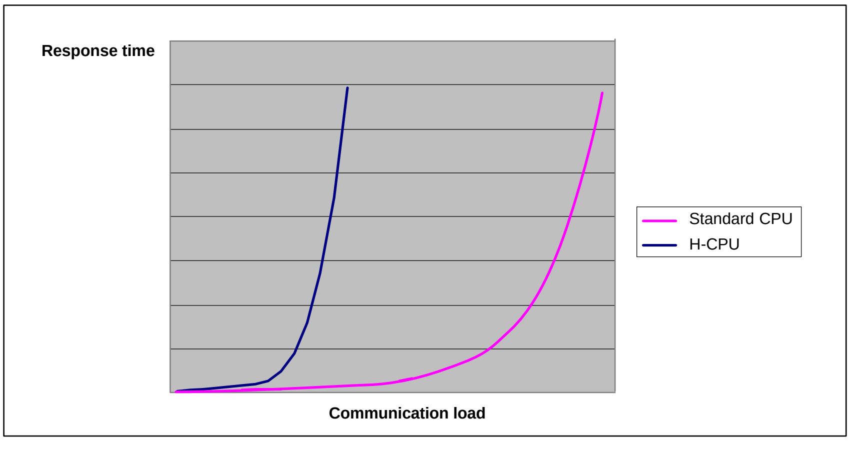


Figure 8-15 Response time via communication load (basic trend)

Standard and H systems

The descriptions so far, apply to standard and H systems. Saturation is rarely reached in todays plants because the communication performance of the standard systems is substantially higher than that of the redundant H systems.

On the other hand, synchronizations are required for H systems to retain the synchronous run. This increases the runtime of the block and reduces the communication performance. This is why the performance limit is reached earlier.If the redundant H system running has not reached the performance limit, the approximate value of the performance will be less by factor 2 to 3 compared to the standard system.

Which sizes influence the communication load?

The communication load is influenced by the following sizes:

- Number of connections /connected operator control and monitoring systems
- Number of variables and number of variables in pictures displayed via WinCC or on OPs.
- Communication type(operator control and monitoring, S7 communication, S7-messagefunctions, S5 compatible communication, ...)
- The extension of the configured maximun cycle via communication.

The subsequent section will show you the factors that influence the communication performance.

General Information on Communication

Reduce the amount of the communication jobs per second as much as possible. Use the maximum user data length for the communication jobs by grouping some variables and data areas in one read job.

Each job requires a processing period, its status should therefore not be checked until the expiration of this period.

A free tool for estimating the processing time is available for download at:

http://www4.ad.siemens.de/view/cs/de/1651770, article ID 1651770

Call the communication jobs in a way that allows event–controlled data transfer. You can only continue to check the result of the data transfer until the completion of the job.

Call the communication blocks at time intervals and in slow cycles to distribute the communication load evenly.

If no user data is to be transferred, you can skip the block call with a conditional jump.

If you use S7 communication functions instead of instead of S5 compatible commnunication functions, you will get a considerably higher communication performance with the S7 components.

Use S5 compatible communication (FB “AG_SEND”, FB “AG_RECV”, AP_RED) only when S7 components are not to communicate with non–S7 components because S5 compatible communication functions (FB “AG_SEND”, FB “AG_RECV”, AP_RED) produce a substantially higher communication load.

Connecting Standard Systems to H Systems

Driver block“S7H4_BSR”: you can use the driver block “S7H4_BSR” to connect an H system to a STEP7 library. This block can be ordered at:

http://www.khe.siemens.de/it/index1360712_1.htm

Alternative SFB 15 “PUT” and SFB 14 “GET” in H System: Use SFB 15 “PUT” alternatively via two standard connections. The first block will be called first. If no error message is output during the execution of the block, the transfer will be considered successful. If an error message is output, the data transfer will be repeated via the second block. Even if an interruption in communication is discovered later, the data will be transferred again to avoid any loss of information. You can apply the same method to an SFB 14 “GET”.

If possible use the S7 communication mechanisms for communication.

AP Red Software package : Limit your user data size to 240 bytes when using the software “AP_RED”. If a larger amount of data is required, transfer it by calling the blocks sequentially.

The software package “AP_RED” uses the FB “AG_SEND” und FB “AG_RCV” mechanisms. Use APRED to link to only SIMATIC S5 / S5 H controls or devices from other manufacturers which support S5 compatible communication.

S7 Communication (SFB 12 “BSEND” and SFB 13 “BRCV”)

Bear in mind that an SFB 12 “BSEND” in the user program is not called more often than the corresponding SFB 13 “BRCV” in the communications partner.

S7 Communication (SFB 8 “USEND” and SFB 9 “URCV”)

Use an SFB 8 “USEND” only as event–driven because this bus causes a high communication load.

Bear in mind that a SFB 8 “USEND” in the user program is not called more often than corresponding SFB 9 “URCV” in the communications partner.

SIMATIC OPs, SIMATIC MPs

Use a maximum of 4 OPs or 4 MPs in an H system. If more OPs/MPs are required, you have to examine your entire automation task. In this case, consult your local SIMATIC sales representative.

Do not select less than 1s for the picture update and increase this value to 2 s where applicable.

Make sure that all the variables of a picture are requested with the same cycle time so the jobs for reading variables can be grouped optimally.

OPC Server

If several HMI devices OPC are connected to the H system for visualization, then keep the number of the OPC servers accessing the H system low. The OPC clients should access a common OPC server, which then reads the data from the H system.

You can optimize data exchange by using WinCC and its client/server concept.

Some HMI devices of other manufacturers support the S7 communication protocol, use this option.

9 Configuring with STEP 7

This chapter presents an overview of the special features and possibilities of the S7-400H options package.

The first section describes how to install the options package.

The second section lists the extensions of the STEP 7 options package and summarizes some central points which you have to take into account when you are configuring a fault-tolerant system.

The third section deals with the programming device functions contained in the STEP 7 options package.

You will find a more detailed description in basic Help dealing with options packages, *Configuring Fault-tolerant Systems*. You will find the help information under the **Help > Help topics > Help on option packages** menu command.

9.1 Installation of the Options Package

Software requirements

In order to install the “S7 fault-tolerant system” option package, version 2 or higher, you must have the STEP 7 standard package, V5.2 (or higher) installed on your PG or PC.

Installing the options package

1. Start the PC or programming device on which you have installed the STEP 7 standard package and make sure that no STEP 7 applications are open.
2. Insert the product CD for the options package.
3. Call the SETUP.EXE program on the CD.
4. Follow the instructions given by the setup program and select the options you require.

Reading the Readme file

Important late-breaking information on the software supplied is recorded in a readme file. You can view this file when you have completed the Setup program or open it at a later point of time. It is located in the **S7hsys** directory of STEP 7.

Starting the options package

The options package does not contain any applications that have to be started explicitly. The additional options are integrated in the familiar user interface.

Displaying integrated Help

The dialog boxes of the options package have integrated help information, which you can call at any stage of configuration either by pressing F1 or clicking the **Help** button. You can obtain more detailed information by choosing **Help > Help Topics** from the menu.

9.2 Configuring with STEP 7

The basic approach to configuring the S7-400H is no different from that used to configure the S7-400 – in other words

- creating projects and stations
- configuring hardware and networking
- loading system data onto the programmable logic controller.

Even the different steps that are required for this are identical for the most part to those with which you are familiar from the S7-400.

Notice

The following error OBs must be loaded to the CPU in the S7-400H: OB 70, OB 72, OB 80, OB 82, OB 83, OB 85, OB 86, OB 87, OB 88, OB 121 and OB 122. If these OBs are not loaded, the H- system goes into the STOP system state when a fault occurs.

Creating a fault-tolerant station

The SIMATIC fault-tolerant station is offered as a separate station type by SIMATIC Manager. It allows the configuration of two central controllers, each having a CPU and thus the redundant fault-tolerant station configuration.

9.2.1 Rules for Fitting a Fault-Tolerant Station

The following rules have to be complied with for a fault-tolerant station, in addition to the rules that generally apply to the arrangement of modules in the S7-400:

- The central processing units must be inserted in the same slots in each case.
- Redundantly used external DP master interfaces or communication modules must be inserted in the same slots in each case.
- External DP master interface modules for redundant DP master systems should only be inserted in central racks and not in expansion racks.
- Redundantly used modules (for example, CPU 417-4H, DP slave interface module IM 153-2) must be identical – in other words, they must have the same order number, the same version, and the same firmware version.

Installation rules

- A fault-tolerant station may contain up to 20 expansion racks.
- Even-numbered mounting racks can be assigned only to central controller 0, whereas odd-numbered mounting racks can be assigned only to central controller 1.
- Modules connected to a communication bus can be operated only in mounting racks 0 through 6.
- Communication-bus capable modules are not permissible in switched I/Os.
- Pay attention to the mounting rack numbers when operating CPs for fault-tolerant communications in expansion racks:

  The numbers must be directly sequential and begin with the even number – for example, mounting racks numbers 2 and 3, but not mounting racks numbers 3 and 4.
- A mounting rack number is also assigned for DP master No. 9 onwards when equipping a central controller with DP master modules. The number of possible expansion racks is reduced as a result.

Compliance with the rules is monitored automatically by STEP 7 and taken into account in an appropriate manner during configuration.

9.2.2 Configuring Hardware

The simplest way of achieving a redundant hardware configuration consists in initially equipping **one** mounting rack fully with all the redundant components, assigning parameters to them and then copying them.

You can then specify the various addresses (for one-way I/O only!) and arrange other, non-redundant modules in individual racks.

Special features in presenting the hardware configuration

To make it possible for a redundant DP master system to be detected quickly, it is represented by two closely parallel DP cables.

9.2.3 Assigning Parameters to Modules in a Fault-Tolerant Station

Introduction

Assigning parameters to modules in a fault-tolerant station is no different to assigning parameters to modules in S7-400 standard stations.

Procedure

All the parameters of the redundant components (with the exception of MPI and communication addresses) must be identical.

Central processing unit (exception)

CPU parameters can only be set for CPU0 (CPU on rack 0). Any values that you specify for it are automatically allocated to CPU1 (CPU on rack 1). The settings of CPU1 cannot be changed with the exception of the following parameters:

- MPI address of the CPU
- Station and diagnostics addresses of the integrated PROFIBUS DP interfaces

Modules in the I/O address area

A module that is addressed in the I/O address area must either be completely within or completely outside the process image. Otherwise, consistency cannot be guaranteed, and the data may be corrupted.

9.2.4 Recommendations for Setting the CPU Parameters

CPU parameters that determine cyclic behavior

You specify the CPU parameters that determine the cyclic behavior of the system on the “Cycle/Clock memory” tab.

Recommended settings:

- As long a scan cycle monitoring time as possible (e.g.6000 ms)
- As small a process input image as possible (slightly larger than the number of inputs actually used)
- As small a process output image as possible (slightly larger than the number of outputs actually used)
- OB 85 call when there is an I/O access error: only with incoming and outgoing errors

Number of messages in the diagnostics buffer

You specify the number of messages in the diagnostics buffer on the “Diagnostics/Clock” tab.

We recommend that you set a large number (1500, for example).

Monitoring time for transferring parameters to modules

You specify this monitoring time on the “Startup” tab. It depends on the configuration of the fault-tolerant station. If the monitoring time is too short, the CPU enters the W#16#6547 event in the diagnostics buffer.

For some slaves (e.g. IM 157) these parameters are packed in system data blocks. The transmission time of the parameters depends on the following factors:

- Baud rate of the bus system (high baud rate => short transmission time)
- Size of the parameters and the system data blocks (long parameter => long transmission time)
- Load on the bus system (many slaves => long transmission time);
  Note: The bus load is at its peak during restart of the DP master, for example, following Power OFF/ON

Suggested setting: 600 corresponds to 60 sec.

Note

The special H CPU parameters and the associated monitoring times are calulated automatically. This involves setting a default value for the total memory load of all data blocks specifically for a CPU. If your H system does not link up, check the memory load setting (HW Config –> CPU Properties –> H Parameters –> Work memory used for all data blocks).

Notice

CP443-5 Extended may be only used in an S7-400H or S7-400FH when connecting a DP/PA-Link or Y-Link (IM157) with a transmission rate up to 1.5 Mbaud. (Help: see FAQ 11168943 at http://www.siemens.com/automation/service&support)

9.2.5 Configuring Networks

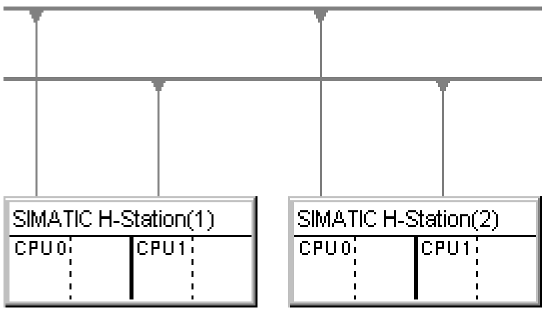
The fault-tolerant S7 connection is a separate connection type of the “Configure Networks” application. The following communication peers can communicate with each other:

- S7 fault-tolerant station (with 2 fault-tolerant CPUs)–> S7 fault-tolerant station (with 2 fault-tolerant CPUs)
- S7 400 station (with 1 fault-tolerant CPU) –> S7 fault-tolerant station (with 2 fault-tolerant CPUs)
- SIMATIC PC stations –> S7 fault-tolerant station (with 2 fault-tolerant CPUs)

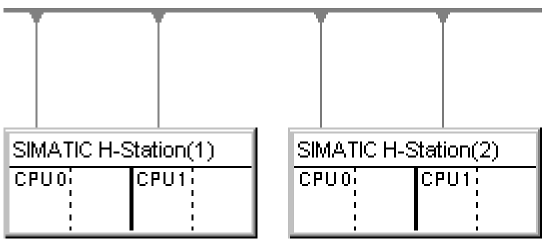
Fault-tolerant connections are only permissible if at least one communications terminal is an S7 fault-tolerant station.

When this type of connection is being configured, the application automatically determines the number of possible connection paths:

- If two independent but identical subnets are available which are both suitable for an S7 connection (DP master systems), two connection paths will be used. In practice these are generally electrical networks, each a CP in a subnet:



- If only one DP master system is available – in practice typically fiber-optic cables – four connection paths are used for a connection between two fault-tolerant stations. All the CPs are in this subnetwork:



Downloading the network configuration to the fault-tolerant station

The network configuration can be downloaded to the entire fault-tolerant station in one go. To do this, the same requirements must be met as for downloading the network configuration to a standard station.

9.3 Programming Device Functions in STEP 7

Display in SIMATIC Manager

In order to do justice to the special features of a fault-tolerant station, the way in which the system is displayed and edited in SIMATIC Manager differs from that of a S7-400 standard station as follows:

- In the offline view, the S7 program is displayed only under CPU0 of the fault-tolerant station. No S7 program is visible under CPU1.
- In the online view, the S7 program is displayed under both central processing units and can be selected in both locations.

Communication functions

For programming device functions that lead to the establishment of an online connection – for example, downloading and deleting blocks – one of the two CPUs has to be selected even if the function affects the entire system over the redundant link.

- Data which are modified in one of the central processing units in redundant operation affect the other CPUs over the redundant link.
- Data which are modified when there is no redundant link – in other words, in single mode – initially affect only the edited CPU. The blocks are applied by the master CPU to the standby CPU during the next link-up and update procedure. Exception: after a configuration modification no new blocks are applied (only the unchanged data blocks). Loading the blocks is then the responsibility of the user.

Failure and Replacement of Components During Operation 10

One factor that is crucial to the uninterrupted operation of the fault-tolerant controller is the replacement of failed components during operation. Rapid repair quickly reestablishes the fault tolerance.

We will show you in the sections that follow how simple and fast it can be to repair and replace components in the S7-400H. Please pay attention to the tips in the corresponding sections of the installation manual, *S7-400/M7-400 Programmable Controllers, Hardware and Installation*

10.1 Failure and Replacement of Components in Central Racks and Expansion Racks

Which components can be replaced?

The following components can be replaced during operation:

- central processing units – for example, CPU 417-4H
- power supply modules – for example, PS 405 and PS 407
- signal and function modules
- communication processors
- synchronization submodules and fiber-optic cables
- interface modules – for example, IM 460 and IM 461

10.1.1 Failure and Replacement of a Central Processing Unit (Fault-Tolerant CPU)

Complete replacement of the CPU is not always necessary. If the failure affects only the load memory, all you have to do is replace the memory card concerned. Both cases are described below.

Starting situation for replacement of the complete CPU

Failure	How Does the System React?
The S7-400H is in redundant system mode and a **CPU** fails.	• Partner CPU switches to single mode. • Partner CPU reports the event in the diagnostics buffer and via OB 72.

Requirements for a replacement

The module replacement described below is possible only if the “new” central processing unit

- has the same operating system version as the failed CPU and
- the same main memory and load memory as the failed CPU.

Notice

New CPUs are always delivered with the latest operating system version. To be able to use this type of CPU as a replacement module, you must create an operating system update card for the operating system version of the failed CPU and use it to transfer the operating system to the replacement CPU.

Procedure

To change a central processing unit, perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Turn off the power supply module.	• Entire subsystem is turned off (system operating in single mode).
2	Replace the central processing unit.	-
3	Plug in the synchronization submodules. Make sure the rack number is set correctly.	-
4	Plug in the fiber-optic cable connections of the synchronization submodules.	-

Step	What Has To Be Done?	How Does the System React?
5	Switch the power supply module on again.	• CPU executes the self-tests and goes to STOP.
6	Perform Memory Reset on the replaced CPU.	-
7	Start the replaced CPU (e.g. STOP→RUN or Start via programming device).	• CPU performs automatic LINK-UP and UPDATE. • CPU changes to RUN and operates as the standby CPU.

Starting situation for replacement of the load memory

Failure	How Does the System React?
The S7-400H is in redundant system mode and an **error access to the load memory** is executed.	• Affected CPU switches to STOP and makes a reset request. • Partner CPU switches to single mode.

Procedure

To change the load memory, perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Change the memory card on the stopped CPU.	-
2	Perform a reset on the CPU with the replaced memory card.	-
3	Start the CPU.	• CPU performs automatic LINK-UP and UPDATE. • CPU changes to RUN and operates as the standby CPU.

10.1.2 Failure and Replacement of a Power Supply Module

Initial situation

Both central processing units are at RUN.

Failure	How Does the System React?
The S7-400H is in redundant system mode and one power supply module fails.	• Partner CPU switches to single mode. • Partner CPU reports the event in the diagnostics buffer and via OB 72.

Procedure

To change a power supply module in the central rack, perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Turn off the power supply (24 V DC for PS 405 or 120/230 V AC for PS 407).	• Entire subsystem is turned off (system operating in single mode).
2	Replace the module.	-
3	Switch the power supply module on again.	• CPU executes the self-tests. • CPU performs automatic LINK-UP and UPDATE. • CPU changes to RUN (Redundant system mode) and now operates as the standby CPU.

Note

If you use a redundant power supply (PS 407 10A R), two power supply modules are assigned to one fault-tolerant CPU. If a part of the redundant PS 407 10A R power supply module fails, the corresponding CPU keeps on running. The defective part can be replaced during operation.

Other power supply modules

If the failure concerns a power supply module outside the central rack (e.g. in the expansion rack or in the I/O device) the failure is reported as a rack failure (central) or station failure (remote). In this case, simply switch off the power supply to the power supply module concerned.

10.1.3 Failure and Replacement of an Input/Output or Function Module

Initial situation

Failure	How Does the System React?
The S7-400H is in redundant system mode and an input/output or function module fails.	• Both CPUs report the event in the diagnostics buffer and via appropriate OBs.

Procedure

To replace signal and function modules (central or remote), perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Disconnect the wiring.	• Call OB 82 if the module concerned is diagnosis-interruptible and diagnostics interrupts are released via the configuration. – Call OB 122 if you are accessing the module by direct access – Call OB 85 if you are accessing the module by means of the process image
2	Extract the failed module (in RUN mode).	• Both CPUs process the insert/remove-module interrupt OB 83 in synchronism.
3	Insert the new module.	• Both CPUs process the insert/remove-module interrupt OB 83 in synchronism. • Parameters are assigned automatically to the module by the CPU concerned and the module is addressed again.
4	Connect the wiring.	Call OB 82 if the module concerned is diagnosis-interruptible and diagnostics interrupts are released via the configuration.

10.1.4 Failure and Replacement of a Communication Processor

This section describes the failure and replacement of communication processors for the PROFIBUS and Industrial Ethernets.

The failure and replacement of communication processors for the PROFIBUS-DP are described in Section 10.2.1

Initial situation

Failure	How Does the System React?
The S7-400H is in redundant system mode and one communication processor fails.	• Both CPUs report the event in the diagnostics buffer and via appropriate OBs. • With communications via standard connections Connection failed • With communications via redundant connections Communications are maintained without interruption over an alternative channel.

Procedure

To replace a communication processor for a PROFIBUS or an industrial Ethernet, perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Extract the module.	Both CPUs process the insert/remove-module interrupt OB 83 in synchronism.
2	Make sure that the new module has no parameter data in its integrated FLASH EPROM and plug it in.	• Both CPUs process the insert/remove-module interrupt OB 83 in synchronism. • The module is automatically configured by the appropriate CPU.
3	Turn the module back on.	The module resumes communications (system establishes communication connection automatically).

10.1.5 Failure and Replacement of a Synchronization Submodule or Fiber-Optic Cable

In this section three different error scenarios are to be differentiated:

- Failure of a synchronization submodule or fiber-optic cable
- Successive failure of the two synchronization submodules or fiber-optic cables
- Simultaneous failure of the two synchronization submodules or fiber-optic cables

Initial situation

Failure	How Does the System React?
Failure of a Fiber–Optic or Synchronization Module: The S7-400H is in redundant system mode and a fiber-optic cable or a synchronization submodule fails.	• Master CPU reports the event in the diagnostics buffer and via OB 72. • Master CPU remains in RUN mode; standby CPU goes into STOP

Procedure

To replace a synchronization submodule or fiber-optic cable, perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Replace the fiber-optic cable first. [1]	-
2	Start the standby CPU (e.g. STOP→RUN or Start via programming device).	The following reactions are possible: 1. CPU goes into RUN mode. 2. CPU goes into STOP mode. In this case continue with step 3.
3	Unplug the faulty synchronization submodule from the standby CPU. To do so, screw the threaded pin in the additional front panel of the synchronization submodule into the thread of the module.	-
4	Insert the new synchronization submodule in the standby CPU.[1] Make sure the rack number is set correctly.	-
5	Plug in the fiber-optic cable connections of the synchronization submodules.	-
6	Start the standby CPU (e.g. STOP→RUN or Start via programming device).	The following reactions are possible: 1. CPU goes into RUN mode. 2. CPU goes into STOP mode. In this case continue with step 7.

Step	What Has To Be Done?	How Does the System React?
7	If in step 6 the standby CPU has gone to STOP: Extract the synchronization submodule from the master CPU.	• Master CPU executes insert/remove-module interrupt OB 83 and redundancy error OB 72 (incoming).
8	Plug the new synchronization submodule into the master CPU. Make sure the rack number is set correctly.	• Master CPU executes insert/remove-module interrupt OB 83 and redundancy error OB 72 (outgoing).
9	Plug in the fiber-optic cable connections of the synchronization submodules.	-
10	Start the standby CPU (e.g. STOP→RUN or Start via programming device).	• CPU performs automatic LINK-UP and UPDATE. • CPU changes to RUN (Redundant system mode) and now operates as the standby CPU.

1 The CPU displays by means of LEDs and by means of the diagnosis whether the lower or upper redundant link has failed. After the defective parts (fiber-optic cable or synchronization submodule) have been replaced, LEDs IFM1F and IFM2F go out. Not until then can you perform the next step.

Note

If both fiber-optic cables or synchronization submodules are successively damaged or replaced the system reactions are the same as described above.

The only exception is that the standby CPU does not go to STOP mode but instead requests a reset.

Initial situation

Failure	How Does the System React?
Simultaneous Failure of a Fiber–Optic or Synchronization Module: The S7-400H is in redundant system mode and **both** fiber-optic cables or synchronization submodules fail.	• Both CPUs report the event in the diagnostics buffer and via OB 72. • Both CPUs become the master CPU and remain in RUN mode.

Procedure

The double error described results in loss of redundancy. In this event proceed as follows:

Step	What Has To Be Done?	How Does the System React?
1	Switch off a subsystem.	-
2	Replace the faulty components.	-
3	Turn the subsystem back on.	LEDs IFM1F and IFMF2F go out. The standby LED lights.
4	Start the CPU (e.g. STOP→RUN or Start via programming device).	• CPU performs automatic LINK-UP and UPDATE. • CPU changes to RUN (Redundant system mode) and now operates as the standby CPU.

10.1.6 Failure and Replacement of an IM 460 and IM 461 Interface Module

The IM 460 and IM 461 interface modules make it possible to connect expansion racks.

Initial situation

Failure	How Does the System React?
The S7-400H is in redundant system mode and one interface module fails.	• Connected expansion unit is turned off. • Both CPUs report the event in the diagnostics buffer and via OB 86.

Procedure

To change an interface module, perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Turn off the power supply of the central rack.	• The partner CPU switches to single mode.
2	Turn off the power supply of the expansion unit in which you want to replace the interface module.	-
3	Extract the interface module.	-
4	Insert the new interface module and turn the power supply of the expansion unit back on.	-
5	Switch the power supply of the central rack back on and start the CPU.	• CPU performs automatic LINK-UP and UPDATE. • CPU changes to RUN and operates as the standby CPU.

10.2 Failure and Replacement of Components of the Distributed I/O

Which components can be replaced?

The following components of the distributed I/O can be replaced during operation:

- PROFIBUS-DP master
- PROFIBUS-DP interface module (IM 153-2 or IM 157)
- PROFIBUS-DP slave
- PROFIBUS-DP cable

Note

Replacement of I/O and function modules located in remote stations is described in Section 10.1.3.

10.2.1 Failure and Replacement of a PROFIBUS-DP Master

Initial situation

Failure	How Does the System React?
The S7-400H is in redundant system mode and one DP master module fails.	• With single-channel, one-way I/O: DP master can no longer process connected DP slaves. • With switched I/O: DP slaves are addressed via the DP master of the partner.

Procedure

To replace a PROFIBUS-DP master, perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Turn off the power supply of the central rack.	The fault-tolerant system goes to single mode.
2	Unplug the DP Profibus cable for the affected DP master module.	-
3	Replace the affected module.	-
4	Plug in the DP Profibus cable again.	-
5	Turn on the power supply of the central rack.	• CPU performs automatic LINK-UP and UPDATE. • CPU changes to RUN and operates as the standby CPU.

10.2.2 Failure and Replacement of a Redundant PROFIBUS-DP Interface Module

Initial situation

Failure	How Does the System React?
The S7-400H is in redundant system mode and a PROFIBUS-DP interface module (IM 153-2, IM 157) fails.	Both CPUs report the event in the diagnostics buffer and via OB 70.

Replacement procedure

To replace PROFIBUS-DP interface module, perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Turn off the supply for the affected DP interface module.	-
2	Unplug the connected bus connector.	-
3	Insert the new DP Profibus interface module and turn the supply back on.	-
4	Plug the bus connector back on.	• CPUs process the mounting rack failure OB 70 in synchronism (outgoing event). • Redundant access to the station is again possible for the system.

10.2.3 Failure and Replacement of a PROFIBUS-DP Slave

Initial situation

Failure	How Does the System React?
The S7-400H is in redundant system mode and one DP slave fails.	Both CPUs report the event in the diagnostics buffer and via the appropriate OB.

Procedure

To replace a DP slave, perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Turn off the supply for the DP slave.	-
2	Unplug the connected bus connector.	-
3	Replace the DP slave.	-
4	Plug the bus connector on and turn the supply back on.	• CPUs process the mounting rack failure OB 86 in synchronism (outgoing event). • DP slave can be addressed by the relevant DP master system.

10.2.4 Failure and Replacement of PROFIBUS-DP Cables

Initial situation

Failure	How Does the System React?
The S7-400H is in redundant system mode and the PROFIBUS-DP cable is defective.	• With single-channel, one-way I/O: Rack failure OB (OB 86) is started (incoming event). DP master can no longer process connected DP slaves (station failure). • With switched I/O: I/O redundancy error OB (OB 70) is started (incoming event). DP slaves are addressed via the DP master of the partner.

Replacement procedure

To replace PROFIBUS-DP cables, perform the following steps:

Step	What Has To Be Done?	How Does the System React?
1	Check the wiring and localize the interrupted PROFIBUS-DP cable.	-
2	Replace the defective cable.	-
3	Switch the failed modules to RUN.	CPUs process error OBs in synchronism • With one-way I/O: Mounting rack failure OB 86 (outgoing event) DP slaves can be addressed via the DP master system. • With switched I/O: I/O redundancy error OB70 (outgoing event). DP slaves can be addressed via both DP master systems.

Modifying the System During Operation 11

In addition to the options described in Chapter 10 on how to replace failed components during operation, you can also modify the system with the CPU 417-4H as of firmware version V2.0.0 and with the CPU 414-4H without interrupting the current program.

The procedure depends on whether you are working on your user software in PCS 7 or STEP 7.

The procedures described below for making modifications during operation are each structured so as to start from redundant system mode (see Section 5.2) and then to return to this mode again.

Notice

Keep strictly to the rules described in this chapter with regard to modifications of the system during routine operation. If you contravene one or more rules, the response of the fault-tolerant system can result in its availability being restricted or even failure of the entire programmable logic controller.

Security-relevant components are not taken into account in this description. For more details of dealing with fail-safe systems refer to the manual *S7-400F and S7-400FH Programmable Controllers*.

11.1 Possible Hardware Modifications

How is a hardware change made?

If the hardware components concerned are suitable for unplugging or plugging in live the hardware modification can be carried out in redundant system mode. However, since loading a modified hardware configuration in redundant system mode would result in the fault-tolerant system stopping this must temporarily be put into single mode. In single mode the process is then controlled by only one CPU while the desired configuration modifications are carried out on the other CPU.

Notice

You should load configuration changes into the CPU only from “Configure Hardware”.

Since in this process the load memory content of both CPUs has to be modified more than once, expansion of the integrated load memory with a RAM card is to be recommended (at least temporarily) is recommended.

You may only perform the substitution of the FLASH card with required for this with a RAM card if the FLASH card has as much storage space at most as the largest RAM card available. If your FLASH card is larger than the largest available RAM card, you must perform the necessary configuration and program changes in such small steps that there is space for them in the integrated load memory.

Caution

Whenever you make hardware changes, ensure that the synchronization link between the two CPUs is re-established **before** the standby CPU is started or activated. When the power supplies of the CPUs are switched on, the IFM1F and IFM2F LEDs – which are used to indicate faults on the interfaces for memory submodules **– must go out on both CPUs.**.

Which components can be modified?

The following modifications can be made to the hardware configuration during operation:

- Adding or removing modules to/from the central or expansion units (e.g. one-way I/O module).

Notice

The addition or removal of the IM460 and IM461 interface modules, the external DP master interface module CP443-5 Extended and the associated connecting cables is only permitted in a deenergized state.

- Adding or removing components of the remote input/output station, such as
  - DP slaves with a redundant interface module (e.g. ET 200M, DP/PA link or Y link)
  - One-way DP slaves (in any DP master system)
  - Modules in modular DP slaves
  - DP/PA couplers
  - PA devices
- Use of a free channel on an existing module
- Reconfiguration of a module
- Changing certain CPU parameters
- Changing the parameters of an installed module
- Changing the Memory Components of the CPU

With all modifications observe the rules for the configuration of a fault-tolerant station (see Section 9.2.1).

Refer to the information text in the “Hardware Catalog” window to determine which ET 200M modules (signal modules and function modules) can be reconfigured during ongoing operation. The special reactions of individual modules are described in the respective technical documentation.

What should I note at the system planning stage?

In order for switched I/O to be able to be expanded during operation the following points are to be taken into account at the system planning stage:

- In both cables of redundant DP master system sufficient numbers of branching points are to be provided for spur lines or dividing points (spur lines are not permissible at transmission rates of 12 million bps). These may either be provided at regular intervals or at all well accessible points.
- Both cables are to be uniquely identified so that the line which is currently active is not accidentally cut off. This identification should be visible not only at the end points of a line but also at each possible new connection point. Different colored cables are excellent for this.
- Modular DP slave stations (ET 200M), DP/PA links and Y links must always be installed with an active backplane bus and fitted with all the bus modules required, wherever possible, because the bus modules cannot be installed and removed during operation.

- PROFIBUS DP and PROFIBUS PA LAN cables are to be equipped with active bus terminators at both ends so that the lines continue to be correctly terminated during the modification work.
- PROFIBUS PA bus systems should be built up using components from the SpliTConnect product range (see interactive catalog CA01) so that separation of the lines is not required.
- Loaded data blocks must not be deleted and created again. In other words, SFCs 22 (CREATE_DB) and 23 (DEL_DB) may not be applied to DB numbers occupied by loaded DBs.
- Make sure that at the time the system modification is made on the PG/ES the current status of the user program is still available as a STEP 7 project in modular form. It is not sufficient for the user program from one of the CPUs to be loaded back into the PG/ES or compiled again from a STL source file.

Modification of the hardware configuration

With a few exceptions, all segments of the configuration can be modified during operation. As a rule, a configuration modification also results in a modification in the user program.

The following must not be modified:

- certain CPU parameters (for details refer to the relevant subsections)
- the transmission rate (baud rate) of redundant DP master systems
- S7 and S7H connections

Modifications to the user program and the connection configuration

The modifications to the user program and the connection configuration are loaded into the PLC in redundant system mode. The procedure depends on the software used. For more details refer to the *Programming with STEP 7 V5.1* manual and the *PCS 7, Configuration Manual*.

Special Features

- Do not carry out more modifications than you can keep an overview of. We recommend that you modify only one DP master and/or a few DP slaves (e.g. no more than 5) per reconfiguration run.
- During routine operation, you can add or remove modules in DP stations with a redundant PROFIBUS-DP interface module only with the interface modules IM 153-2, IM 153-2FO or IM 157 specified in Section 7.3.
- In the case of IM 153-2 bus modules can only be plugged in is the power supply is interrupted.
- Before making a change, check the fault tolerance parameter in HW Config. If this parameter is set to 0, have the parameter calculated again in HW Config using the Properties CPU –> H Parameter.

Notice

The following should be taken into consideration when using redundant I/O modules that you have installed as one–way modules on the user level (see Chapter 7.5):

During link–up and synchronization following a change to the system, the I/O modules of the master CPU used up until this point may disappear from the process image for a short time before the (changed) I/O modules of the “new” master CPU are completely entered into the process image.

This may lead to the false impression during the initial updating of the process image following a change to the system, that the redundant I/O modules are completely down or there are redundant I/O modules. The redundancy status can therefore only be correctly evaluated when the process image has been completely updated.

This phenomenon does not occur with modules that have been released for redundant operation (see Chapter 7.4).

Preparations

To minimize the time during which the fault-tolerant system has to run in single mode, you should perform the following steps **before** making the hardware change:

- Make sure that the memory components of the CPUs are sufficient for the new configuration and the new user program. If necessary, first expand the memory components (see Section 11.7).
- Make sure that modules that are plugged in but not configured do not have any effect on the process.

11.2 Adding Components in PCS 7

Initial situation

You have ensured that the CPU parameters (e.g. the monitoring times) suit the planned new program. If necessary you must first change the CPU parameters accordingly (see Section 11.6).

The fault-tolerant system is working in redundant system mode.

Procedure

Carry out the steps listed below to add hardware components to a fault-tolerant system in PCS 7. Details of each step are listed in a subsection.

Step	What Has To Be Done?	Refer to Section
1	Modification of Hardware	11.2.1
2	Offline Modification of the Hardware Configuration	11.2.2
3	Stopping the Standby CPU	11.2.3
4	Loading New Hardware Configuration in the Standby CPU	11.2.4
5	Switch to CPU with modified configuration	11.2.5
6	Transition to Redundant System Mode	11.2.6
7	Changing and Loading User Program	11.2.7

Exceptions

This procedure for system modification does not apply in the following cases:

- Use of Free Channels on an Existing Module
- When adding interface modules (see Section 11.2.8)

11.2.1 PCS 7, Step 1: Modification of Hardware

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. Add the new components to the system.
   – Plug new central modules into the rack.
   – Plug new module into existing modular DP stations
   – Add new DP stations to existing DP master systems.

Notice

With switched I/O: Complete all changes on **one** line of the redundant DP master system first before making changes to the second line.

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2. Connect the required sensors and actuators to the new components.

Result

Plugging in modules that have not yet been configured will have no effect on the user program. The same applies to adding DP stations.

The fault-tolerant system continues to work in redundant system mode.

New components are not yet addressed.

11.2.2 PCS 7, Step 2: Offline Modification of the Hardware Configuration

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. Perform all the modifications to the hardware configuration relating to the added hardware offline. Assign appropriate icons to the new channels to be used.
2. Compile the new hardware configuration, but do **not** load it into the PLC just yet.

Result

The modified hardware configuration is in the PG/ES. The PLC continues to work with the old configuration in redundant system mode.

Configuring connections

Connections from or to newly added CPs must be configured on both connection partners **after** modification of the hardware configuration is completed.

11.2.3 PCS 7, Step 3: Stopping the Standby CPU

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, select the standby CPU and click the **Stop** button.

Result

The standby CPU switches to STOP mode, the master CPU remains in RUN mode, the fault-tolerant system works in single mode. One-way I/O of the standby CPU are no longer addressed.

Whilst I/O access errors of the one-way I/O will result in OB 85 being called, due to the superior CPU redundancy loss (OB 72) these will not be reported. OB 70 (I/O redundancy loss) will not be called.

11.2.4 PCS 7, Step 4: Loading New Hardware Configuration in the Standby CPU

Initial situation

The fault-tolerant system is working in single mode.

Procedure

Load the compiled hardware configuration in the standby CPU that is in STOP mode.

Notice

The user program and the connection configuration must not be overloaded in single mode.

Result

The new hardware configuration of the standby CPU does not yet have an effect on current operation.

11.2.5 PCS 7, Step 5: Switch to CPU with Modified Configuration

Initial situation

The modified hardware configuration is loaded into the standby CPU.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, click the **Toggle button.**
3. In the **Toggle** dialog box, select the option **with modified configuration** and click the **Toggle** button.
4. Confirm the query that follows with **OK**.

Result

The standby CPU links up, is updated (see Chapter 6) and becomes the master. The former master CPU switches to STOP mode, the fault-tolerant system works with the new hardware configuration in single mode.

Behavior of the I/O

Type of I/O	One-way I/O of previous master CPU	One-way I/O of new master CPU	Switched I/O
Added I/O modules	Are not addressed by the CPU.	Are configured and updated by the CPU. Driver blocks are not yet present. Any process or diagnostics interrupts occurring will be recognized but not reported.	
I/O modules that continue to be present	Are no longer addressed by the CPU. Output modules output the configured substitute or holding values.	Are re-parameterized[1)] and updated by the CPU.	Continue to work without interruption.
Added DP stations	Are not addressed by the CPU.	as for added I/O modules (see above)	

1) Central modules are additionally first reset. Output modules briefly output 0 during this time (instead of the configured substitute or holding values).

Response if monitoring times are exceeded

If one of the monitored times exceeds the maximum value configured the update is interrupted and no change of master takes place. The fault-tolerant system remains in single mode with the previous master CPU and in certain conditions attempts to perform the change of master later. For more details refer to Section 6.3.

11.2.6 PCS 7, Step 6: Transition to Redundant System Mode

Initial situation

The fault-tolerant system works with the new hardware configuration in single mode.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, select the standby CPU and click the **Restart (warm restart)** button.

Result

Standby CPU links up again and is updated. The fault-tolerant system works with the new hardware configuration in redundant system mode.

Behavior of the I/O

Type of I/O	One-way I/O of standby CPU	One-way I/O of master CPU	Switched I/O
Added I/O modules	Are configured and updated by the CPU. Driver blocks are not yet present. Any interrupts occurring are not reported.	Are updated by the CPU. Driver blocks are not yet present. Any process or diagnostics interrupts occurring will be recognized but not reported.	
I/O modules that continue to be present	Are re-parameterized[1)] and updated by the CPU.	Continue to work without interruption.	
Added DP stations	as for added I/O modules (see above)	Driver blocks are not yet present. Any interrupts occurring are not reported.	

1) Central modules are additionally first reset. Output modules briefly output 0 during this time (instead of the configured substitute or holding values).

Response if monitoring times are exceeded

If one of the monitored times exceeds the maximum value configured the update is interrupted. The fault-tolerant system remains in single mode with the previous master CPU and in certain conditions attempts to perform the link-up and update later. For more details refer to Section 6.3.

11.2.7 PCS 7, Step 7: Changing and Loading User Program

Initial situation

The fault-tolerant system works with the new hardware configuration in redundant system mode.

Caution

The following program modifications are not possible in redundant system mode and result in the system mode Stop (both CPUs in STOP mode):

- structural modifications to an FB interface or the FB instance data
- structural modifications to global DBs
- compression of the CFC user program.

Before the entire program is recompiled and reloaded due to such modifications the parameter values must be read back into the CFC, since otherwise the modifications to the block parameters could be lost. More details of this can be found in the manual *CFC for S7, Continuous Function Chart*.

Procedure

1. Perform all the program modifications relating to the added hardware. You can add the following components:
   – CFC and SFC charts
   – blocks in existing charts
   – connections and parameter settings
2. Assign parameters to the added channel drivers and connect these to the newly assigned icons (see Section 11.2.2).
3. In SIMATIC Manager, select the charts folder and choose the **Extras > Charts > Generate module drivers** menu command.
4. Compile only the modifications in the charts and load these into the PLC.

Notice

Until the first FC is called the value of its coil is undefined. This is to be taken into account in the connection of the FC outputs.

5. Configure the connections from or to the newly added CPs on both connection partners and load these into the PLC.

Result

The fault-tolerant system processes the entire system hardware with the new user program in redundant system mode.

11.2.8 Adding Interface Modules in PCS 7

The addition of the IM460 and IM461 interface modules, the external DP master interface module CP443-5 Extended and the associated connecting cables is only permitted in a deenergized state.

The power supply of the entire subsystem must be switched off. To ensure this has no effect on the process, it must be executed when this subsystem is in STOP mode.

Procedure

1. Change the hardware configuration offline (see Section 11.2.2)
2. Stop the standby CPU (see Section 11.2.3)
3. Download the new hardware configuration to the standby CPU (see Section 11.2.4)
4. If you want to add to the subsystem of the present standby CPU, carry out the following steps:
   - Turn off the power supply for the standby subsystem.
   - Plug the new IM460 in the central controller and establish the link to a new expansion unit.

     or
   - Add a new expansion unit to an existing line.

     or
   - Plug in the new external DP master interface, and install a new DP master system.
   - Turn on the power supply for the standby subsystem again.
5. Switch to the CPU with the modified configuration (see Section 11.2.5)
6. If you want to expand the subsystem of the original master CPU (currently in STOP mode), carry out the following steps:
   - Turn off the power supply for the standby subsystem.
   - Plug the new IM460 in the central controller and establish the link to a new expansion unit.

     or
   - Add a new expansion unit to an existing line.

     or
   - Plug in the new external DP master interface, and install a new DP master system.
   - Turn on the power supply for the standby subsystem again.
7. Switch to redundant system mode (see Section 11.2.6)
8. Modify and download the user program (see Section 11.2.7)

11.3 Removing Components in PCS 7

Initial situation

You have ensured that the CPU parameters (e.g. the monitoring times) suit the planned new program. If necessary you must first change the CPU parameters accordingly (see Section 11.6).

The modules to be removed and the associated sensors and actuators are no longer of any significance for the process to be controlled. The fault-tolerant system is working in redundant system mode.

Procedure

Carry out the steps listed below to remove hardware components from a fault-tolerant system in PCS 7. Details of each step are listed in a subsection.

Step	What Has To Be Done?	Refer to Section
I	Offline Modification of the Hardware Configuration	11.3.1
II	Changing and Loading User Program	11.3.2
III	Stopping the Standby CPU	11.3.3
IV	Loading New Hardware Configuration in the Standby CPU	11.3.4
V	Switch to CPU with modified configuration	11.3.5
VI	Transition to Redundant System Mode	11.3.6
VII	Modification of Hardware	11.3.7

Exceptions

This procedure for system modification should not be used to remove interface modules (see Section 11.3.8).

11.3.1 PCS 7, Step I: Offline Modification of the Hardware Configuration

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. Perform offline only the configuration modifications relating to the hardware to be removed. As you do, delete the icons to the channels that are no longer used.
2. Compile the new hardware configuration, but do **not** load it into the PLC just yet.

Result

The modified hardware configuration is in the PG/ES. The PLC continues to work with the old configuration in redundant system mode.

11.3.2 PCS 7, Step II: Changing and Loading User Program

Initial situation

The fault-tolerant system is working in redundant system mode.

Caution

The following program modifications are not possible in redundant system mode and result in the system mode Stop (both CPUs in STOP mode):

- structural modifications to an FB interface or the FB instance data
- structural modifications to global DBs
- compression of the CFC user program.

Before the entire program is recompiled and reloaded due to such modifications the parameter values must be read back into the CFC, since otherwise the modifications to the block parameters could be lost. More details of this can be found in the manual *CFC for S7, Continuous Function Chart*.

Procedure

1. Perform only the program modifications relating to the hardware to be removed. You can remove the following components:
   - CFC and SFC charts
   - blocks in existing charts
   - channel drivers, connections and parameter settings
2. In SIMATIC Manager, select the charts folder and choose the **Extras > Charts > Generate module drivers** menu command.

   This removes the driver blocks that are no longer required.
3. Compile only the modifications in the charts and load these into the PLC.

Notice

Until the first FC is called the value of its coil is undefined. This is to be taken into account in the connection of the FC outputs.

Result

The fault-tolerant system continues to work in redundant system mode. The modified user program will no longer attempt to access the hardware to be removed.

11.3.3 PCS 7, Step III: Stopping the Standby CPU

Initial situation

The fault-tolerant system is working in redundant system mode. The user program will no longer attempt to access the hardware to be removed.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, select the standby CPU and click the **Stop** button.

Result

The standby CPU switches to STOP mode, the master CPU remains in RUN mode, the fault-tolerant system works in single mode. One-way I/O of the standby CPU are no longer addressed.

11.3.4 PCS 7, Step IV: Loading New Hardware Configuration in the Standby CPU

Initial situation

The fault-tolerant system is working in single mode.

Procedure

Load the compiled hardware configuration in the standby CPU that is in STOP mode.

Notice

The user program and the connection configuration must not be overloaded in single mode.

Result

The new hardware configuration of the standby CPU does not yet have an effect on current operation.

11.3.5 PCS 7, Step V: Switch to CPU with Modified Configuration

Initial situation

The modified hardware configuration is loaded into the standby CPU.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, click the **Toggle button.**
3. In the **Toggle** dialog box, select the option **with modified configuration** and click the **Toggle** button.
4. Confirm the query that follows with **OK**.

Result

The standby CPU links up, is updated (see Chapter 6) and becomes the master. The former master CPU switches to STOP mode, the fault-tolerant system works with the new hardware configuration in single mode.

Behavior of the I/O

Type of I/O	One-way I/O of previous master CPU	One-way I/O of new master CPU	Switched I/O
I/O modules to be removed1)	Are no longer addressed by the CPU. Driver blocks are no longer present.		
I/O modules that continue to be present	Are no longer addressed by the CPU. Output modules output the configured substitute or holding values.	Are re-parameterized 2) and updated by the CPU.	Continue to work without interruption.
DP stations to be removed:	as for I/O modules to be removed (see above)		

1) No longer contained in the hardware configuration, but still plugged in

2) Central modules are additionally first reset. Output modules briefly output 0 during this time (instead of the configured substitute or holding values).

Response if monitoring times are exceeded

If one of the monitored times exceeds the maximum value configured the update is interrupted and no change of master takes place. The fault-tolerant system remains in single mode with the previous master CPU and in certain conditions attempts to perform the change of master later. For more details refer to Section 6.3.

11.3.6 PCS 7, Step VI: Transition to Redundant System Mode

Initial situation

The fault-tolerant system works with the new hardware configuration in single mode.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, select the standby CPU and click the **Restart (warm restart)** button.

Result

Standby CPU links up again and is updated. The fault-tolerant system works with the new hardware configuration in redundant system mode.

Behavior of the I/O

Type of I/O	One-way I/O of standby CPU	One-way I/O of master CPU	Switched I/O
I/O modules to be removed[1)]	Are no longer addressed by the CPU. Driver blocks are no longer present.		
I/O modules that continue to be present	Are re-parameterized [2)] and updated by the CPU.	Continue to work without interruption.	
DP stations to be removed:	as for I/O modules to be removed (see above)		

1) No longer contained in the hardware configuration, but still plugged in

2) Central modules are first reset in addition. Output modules briefly output 0 during this time (instead of the substitute or holding values configured).

Response if monitoring times are exceeded

If one of the monitored times exceeds the maximum value configured the update is interrupted. The fault-tolerant system remains in single mode with the previous master CPU and in certain conditions attempts to perform the link-up and update later. For more details refer to Section 6.3.

11.3.7 PCS 7, Step VII: Modification of Hardware

Initial situation

The fault-tolerant system works with the new hardware configuration in redundant system mode.

Procedure

1. Disconnect all the sensors and actuators from the components to be removed.
2. Unplug modules of the one-way I/O that are no longer required from the rack.
3. Unplug components that are no longer required from the modular DP stations.
4. Remove DP stations that are no longer required from the DP master systems.

Notice

With switched I/O: Complete all changes on **one** line of the redundant DP master system first before making changes to the second line.

Result

Unplugging modules that have been removed from the configuration has no effect on the user program. The same applies to the removal of DP stations.

The fault-tolerant system continues to work in redundant system mode.

11.3.8 Removing Interface Modules in PCS 7

The removal of the IM460 and IM461 interface modules, the external DP master interface module CP443-5 Extended and the associated connecting cables is only permitted in a deenergized state.

The power supply of the entire subsystem must be switched off. To ensure this has no effect on the process, it must be executed when this subsystem is in STOP mode.

Procedure

1. Change the hardware configuration offline (see Section 11.3.1)
2. Modify and download the user program (see Section 11.3.2)
3. Stop the standby CPU (see Section 11.3.3)
4. Download the new hardware configuration to the standby CPU (see Section 11.3.4)
5. If you want to remove an interface module from the subsystem of the current standby CPU, carry out the following steps:
   - Turn off the power supply for the standby subsystem.
   - Remove an IM460 from the central controller.

     or
   - Remove an expansion unit from an existing line.

     or
   - Remove an external DP master interface.
   - Turn on the power supply for the standby subsystem again.
6. Switch to the CPU with the modified configuration (see Section 11.3.5)
7. If you want to remove an interface module from the subsystem of the original master CPU (currently in STOP mode), carry out the following steps:
   - Turn off the power supply for the standby subsystem.
   - Remove an IM460 from the central controller.

     or
   - Remove an expansion unit from an existing line.

     or
   - Remove an external DP master interface.
   - Turn on the power supply for the standby subsystem again.
8. Switch to redundant system mode (see Section 11.3.6)

11.4 Adding Components in STEP 7

Initial situation

You have ensured that the CPU parameters (e.g. the monitoring times) suit the planned new program. If necessary you must first change the CPU parameters accordingly (see Section 11.6).

The fault-tolerant system is working in redundant system mode.

Procedure

In order to add hardware components to a fault-tolerant system under STEP 7 the steps listed below are to be performed. Details of each step are listed in a subsection.

Step	What Has To Be Done?	Refer to Section
1	Modification of Hardware	11.4.1
2	Offline Modification of the Hardware Configuration	11.4.2
3	Expanding and Loading Organization Blocks	11.4.3
4	Stopping the Standby CPU	11.4.4
5	Loading New Hardware Configuration in the Standby CPU	11.4.5
6	Switch to CPU with modified configuration	11.4.6
7	Transition to Redundant System Mode	11.4.7
8	Changing and Loading User Program	11.4.8

Exceptions

This procedure for system modification does not apply in the following cases:

- Use of Free Channels on an Existing Module
- When adding interface modules (see Section 11.4.9)

11.4.1 STEP 7, Step 1: Modification of Hardware

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. Add the new components to the system.
   – Plug new central modules into the rack.
   – Plug new module into existing modular DP stations
   – Add new DP stations to existing DP master systems.

Notice

With switched I/O: Complete all changes on **one** line of the redundant DP master system first before making changes to the second line.

---

2. Connect the required sensors and actuators to the new components.

Result

Plugging in modules that have not yet been configured will have no effect on the user program. The same applies to adding DP stations.

The fault-tolerant system continues to work in redundant system mode.

New components are not yet addressed.

11.4.2 STEP 7, Step 2: Offline Modification of the Hardware Configuration

Initial situation

The fault-tolerant system is working in redundant system mode. The modules added will not yet be addressed.

Procedure

1. Perform all the modifications to the hardware configuration relating to the added hardware offline.
2. Compile the new hardware configuration, but do **not** load it into the PLC just yet.

Result

The modified hardware configuration is in the PG. The PLC continues to work with the old configuration in redundant system mode.

Configuring connections

Connections from or to newly added CPs must be configured on both connection partners **after** modification of the hardware configuration is completed.

11.4.3 STEP 7, Step 3: Expanding and Loading Organization Blocks

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. Make sure that the interrupt OBs 4x, 82, 83, 85, 86 and 122 react in the desired way to interrupts from the newly added components.
2. Load the modified OBs and the program segments affected by these into the PLC.

Result

The fault-tolerant system is working in redundant system mode.

11.4.4 STEP 7, Step 4: Stopping the Standby CPU

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, select the standby CPU and click the **Stop** button.

Result

The standby CPU switches to STOP mode, the master CPU remains in RUN mode, the fault-tolerant system works in single mode. One-way I/O of the standby CPU are no longer addressed. OB 70 (I/O redundancy loss) is not called due to the superior CPU redundancy loss (OB 72).

11.4.5 STEP 7, Step 5: Loading New Hardware Configuration in the Standby CPU

Initial situation

The fault-tolerant system is working in single mode.

Procedure

Load the compiled hardware configuration in the standby CPU that is in STOP mode.

Notice

The user program and the connection configuration must not be overloaded in single mode.

Result

The new hardware configuration of the standby CPU does not yet have an effect on current operation.

11.4.6 STEP 7, Step 6: Switch to CPU with Modified Configuration

Initial situation

The modified hardware configuration is loaded into the standby CPU.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, click the **Toggle button.**
3. In the **Toggle** dialog box, select the option **with modified configuration** and click the **Toggle** button.
4. Confirm the query that follows with **OK**.

Result

The standby CPU links up, is updated and becomes the master. The former master CPU switches to STOP mode, the fault-tolerant system works with the new hardware configuration in single mode.

Behavior of the I/O

Type of I/O	One-way I/O of previous master CPU	One-way I/O of new master CPU	Switched I/O
Added I/O modules	Are not addressed by the CPU.	Are configured and updated by the CPU. Output modules briefly output the substitute values configured.	
I/O modules that continue to be present	Are no longer addressed by the CPU. Output modules output the configured substitute or holding values.	Are re-parameterized[1)] and updated by the CPU.	Continue to work without interruption.
Added DP stations	Are not addressed by the CPU.	as for added I/O modules (see above)	

1) Central modules are first reset in addition. Output modules briefly output 0 during this time (instead of the substitute or holding values configured).

Response if monitoring times are exceeded

If one of the monitored times exceeds the maximum value configured the update is interrupted and no change of master takes place. The fault-tolerant system remains in single mode with the previous master CPU and in certain conditions attempts to perform the change of master later. For more details refer to Section 6.3.

11.4.7 STEP 7, Step 7: Transition to Redundant System Mode

Initial situation

The fault-tolerant system works with the new hardware configuration in single mode.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, select the standby CPU and click the **Restart (warm restart)** button.

Result

Standby CPU links up again and is updated. The fault-tolerant system works with the new hardware configuration in redundant system mode.

Behavior of the I/O

Type of I/O	One-way I/O of standby CPU	One-way I/O of master CPU	Switched I/O
Added I/O modules	Are configured and updated by the CPU. Output modules briefly output the substitute values configured.	Are updated by the CPU.	Are updated by the CPU. Generate plug in interrupt; must be ignored in OB 83.
I/O modules that continue to be present	Are re-parameterized[1)] and updated by the CPU.	Continue to work without interruption.	
Added DP stations	as for added I/O modules (see above)	Are updated by the CPU.	

1) Central modules are additionally first reset. Output modules briefly output 0 during this time (instead of the configured substitute or holding values).

Response if monitoring times are exceeded

If one of the monitored times exceeds the maximum value configured the update is interrupted. The fault-tolerant system remains in single mode with the previous master CPU and in certain conditions attempts to perform the link-up and update later. For more details refer to Section 6.3.

11.4.8 STEP 7, Step 8: Changing and Loading User Program

Initial situation

The fault-tolerant system works with the new hardware configuration in redundant system mode.

Restrictions

> **Caution**
>
> Structural modifications to an FB interface or the instance data of an FB are not possible in redundant system mode and result in the system mode Stop (both CPUs in STOP mode).

Procedure

1. Perform all the program modifications relating to the added hardware.

   You can add, modify or remove OBs, FBs, FCs and DBs.
2. Load only the program modifications into the PLC.
3. Configure the connections from or to the newly added CPs on both connection partners and load these into the PLC.

Result

The fault-tolerant system processes the entire system hardware with the new user program in redundant system mode.

11.4.9 Adding Interface Modules in STEP 7

The addition of the IM460 and IM461 interface modules, the external DP master interface module CP443-5 Extended and the associated connecting cables is only permitted in a deenergized state.

The power supply of the entire subsystem must be switched off. To ensure this has no effect on the process, it must be executed when this subsystem is in STOP mode.

Procedure

1. Change the hardware configuration offline (see Section 11.4.2)
2. Add and download the organization blocks (see Section 11.4.3)
3. Stop the standby CPU (see Section 11.4.4)
4. Download the new hardware configuration to the standby CPU (see Section 11.4.5)
5. If you want to add to the subsystem of the present standby CPU, carry out the following steps:
   - Turn off the power supply for the standby subsystem.
   - Plug the new IM460 in the central controller and establish the link to a new expansion unit.

     or
   - Add a new expansion unit to an existing line.

     or
   - Plug in the new external DP master interface, and install a new DP master system.
   - Turn on the power supply for the standby subsystem again.
6. Switch to the CPU with the modified configuration (see Section 11.4.6)
7. If you want to expand the subsystem of the original master CPU (currently in STOP mode), carry out the following steps:
   - Turn off the power supply for the standby subsystem.
   - Plug the new IM460 in the central controller and establish the link to a new expansion unit.

     or
   - Add a new expansion unit to an existing line.

     or
   - Plug in the new external DP master interface, and install a new DP master system.
   - Turn on the power supply for the standby subsystem again.
8. Switch to redundant system mode (see Section 11.4.7)
9. Modify and download the user program (see Section 11.4.8)

11.5 Removing Components in STEP 7

Initial situation

You have ensured that the CPU parameters (e.g. the monitoring times) suit the planned new program. If necessary you must first change the CPU parameters accordingly (see Section 11.6).

The modules to be removed and the associated sensors and actuators are no longer of any significance for the process to be controlled. The fault-tolerant system is working in redundant system mode.

Procedure

In order to remove hardware components from a fault-tolerant system under STEP 7 the steps listed below are to be performed. Details of each step are listed in a subsection.

Step	What Has To Be Done?	Refer to Section
I	Offline Modification of the Hardware Configuration	11.5.1
II	Changing and Loading User Program	11.5.2
III	Stopping the Standby CPU	11.5.3
IV	Loading New Hardware Configuration in the Standby CPU	11.5.4
V	Switch to CPU with modified configuration	11.5.5
VI	Transition to Redundant System Mode	11.5.6
VII	Modification of Hardware	11.5.7
VIII	Modifying and Loading Organization Blocks	11.5.8

Exceptions

This procedure for system modification should not be used to remove interface modules (see Section 11.5.9).

11.5.1 STEP 7, Step I: Offline Modification of the Hardware Configuration

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. Perform offline all the modifications to the hardware configuration relating to the hardware to be removed.
2. Compile the new hardware configuration, but do **not** load it into the PLC just yet.

Result

The modified hardware configuration is in the PG. The PLC continues to work with the old configuration in redundant system mode.

11.5.2 STEP 7, Step II: Changing and Loading User Program

Initial situation

The fault-tolerant system is working in redundant system mode.

Restrictions

Caution

Structural modifications to an FB interface or the instance data of an FB are not possible in redundant system mode and result in the system mode Stop (both CPUs in STOP mode).

Procedure

1. Perform only the program modifications relating to the hardware to be removed.

   You can add, modify or remove OBs, FBs, FCs and DBs.
2. Load only the program modifications into the PLC.

Result

The fault-tolerant system continues to work in redundant system mode. The modified user program will no longer attempt to access the hardware to be removed.

11.5.3 STEP 7, Step III: Stopping the Standby CPU

Initial situation

The fault-tolerant system is working in redundant system mode. The user program will no longer attempt to access the hardware to be removed.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, select the standby CPU and click the **Stop** button.

Result

The standby CPU switches to STOP mode, the master CPU remains in RUN mode, the fault-tolerant system works in single mode. One-way I/O of the standby CPU are no longer addressed.

11.5.4 STEP 7, Step IV: Loading New Hardware Configuration in the Standby CPU

Initial situation

The fault-tolerant system is working in single mode.

Procedure

Load the compiled hardware configuration in the standby CPU that is in STOP mode.

Notice

The user program and the connection configuration must not be overloaded in single mode.

Result

The new hardware configuration of the standby CPU does not yet have an effect on current operation.

11.5.5 STEP 7, Step V: Switch to CPU with Modified Configuration

Initial situation

The modified hardware configuration is loaded into the standby CPU.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, click the **Toggle button.**
3. In the **Toggle** dialog box, select the option **with modified configuration** and click the **Toggle** button.
4. Confirm the query that follows with **OK**.

Result

The standby CPU links up, is updated (see Chapter 6) and becomes the master. The former master CPU switches to STOP mode, the fault-tolerant system continues to work in single mode.

Behavior of the I/O

Type of I/O	One-way I/O of previous master CPU	One-way I/O of new master CPU	Switched I/O
I/O modules to be removed[1)]	Are no longer addressed by the CPU.		
I/O modules that continue to be present	Are no longer addressed by the CPU. Output modules output the configured substitute or holding values.	Are re-parameterized [2)] and updated by the CPU.	Continue to work without interruption.
DP stations to be removed:	as for I/O modules to be removed (see above)		

1) No longer contained in the hardware configuration, but still plugged in

2) Central modules are first reset in addition. Output modules briefly output 0 during this time (instead of the substitute or holding values configured).

Response if monitoring times are exceeded

If one of the monitored times exceeds the maximum value configured the update is interrupted and no change of master takes place. The fault-tolerant system remains in single mode with the previous master CPU and in certain conditions attempts to perform the change of master later. For more details refer to Section 6.3.

11.5.6 STEP 7, Step VI: Transition to Redundant System Mode

Initial situation

The fault-tolerant system works with the new (restricted) hardware configuration in single mode.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, select the standby CPU and click the **Restart (warm restart)** button.

Result

Standby CPU links up again and is updated. The fault-tolerant system is working in redundant system mode.

Behavior of the I/O

Type of I/O	One-way I/O of standby CPU	One-way I/O of master CPU	Switched I/O
I/O modules to be removed[1)]	Are no longer addressed by the CPU.		
I/O modules that continue to be present	Are re-parameterized [2)] and updated by the CPU.	Continue to work without interruption.	
DP stations to be removed:	as for I/O modules to be removed (see above)		

1) No longer contained in the hardware configuration, but still plugged in

2) Central modules are first reset in addition. Output modules briefly output 0 during this time (instead of the substitute or holding values configured).

Response if monitoring times are exceeded

If one of the monitored times exceeds the maximum value configured the update is interrupted. The fault-tolerant system remains in single mode with the previous master CPU and in certain conditions attempts to perform the link-up and update later. For more details refer to Section 6.3.

11.5.7 STEP 7, Step VII: Modification of Hardware

Initial situation

The fault-tolerant system works with the new hardware configuration in redundant system mode.

Procedure

1. Disconnect all the sensors and actuators from the components to be removed.
2. Remove the desired components from the system.
   – Unplug central modules from the rack.
   – Unplug modules from modular DP stations
   – Remove DP stations from DP master systems.

Notice

With switched I/O: Complete all changes on **one** line of the redundant DP master system first before making changes to the second line.

Result

Unplugging modules that have been removed from the configuration has no effect on the user program. The same applies to the removal of DP stations.

The fault-tolerant system continues to work in redundant system mode.

11.5.8 STEP 7, Step VIII: Modifying and Loading Organization Blocks

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. Make sure that the interrupt OBs 4x and 82 no longer react to interrupts from the removed components.
2. Load the modified OBs and the program segments affected by these into the PLC.

Result

The fault-tolerant system is working in redundant system mode.

11.5.9 Removing Interface Modules in STEP 7

The removal of the IM460 and IM461 interface modules, the external DP master interface module CP443-5 Extended and the associated connecting cables is only permitted in a deenergized state.

The power supply of the entire subsystem must be switched off. To ensure this has no effect on the process, it must be executed when this subsystem is in STOP mode.

Procedure

1. Change the hardware configuration offline (see Section 11.5.1)
2. Modify and download the user program (see Section 11.5.2)
3. Stop the standby CPU (see Section 11.5.3)
4. Download the new hardware configuration to the standby CPU (see Section 11.5.4)
5. If you want to remove an interface module from the subsystem of the current standby CPU, carry out the following steps:
   - Turn off the power supply for the standby subsystem.
   - Remove an IM460 from the central controller.

     or
   - Remove an expansion unit from an existing line.

     or
   - Remove an external DP master interface.
   - Turn on the power supply for the standby subsystem again.
6. Switch to the CPU with the modified configuration (see Section 11.5.5)
7. If you want to remove an interface module from the subsystem of the original master CPU (currently in STOP mode), carry out the following steps:
   - Turn off the power supply for the standby subsystem.
   - Remove an IM460 from the central controller.

     or
   - Remove an expansion unit from an existing line.

     or
   - Remove an external DP master interface.
   - Turn on the power supply for the standby subsystem again.
8. Switch to redundant system mode (see Section 11.5.6)
9. Modify and download the organization blocks (see Section 11.5.8)

11.6 Changing the CPU Parameters

Only certain parameters (object properties) of the CPUs can be modified during operation. They are identified in the screen form by blue text (if you have set blue as the color for dialog box text on the Windows Control Panel, the modifiable parameters are shown in black).

Notice

If you modify parameters that should not be changed, there is no automatic transfer to the CPU whose parameters have been modified. In this case the event W#16#5966 is entered in the diagnostics buffer. You must reassign the previously valid values in the configuration to the parameters you incorrectly modified.

Table 11-1 Modifiable CPU parameters

Tab	Modifiable Parameter
Startup	Monitoring time for signaling readiness by modules
	Monitoring time for transferring parameters to modules
Scan cycle/clock memory	Scan cycle monitoring time
	Cycle load due to communications
	Size of the process image of inputs
	Size of the process image of outputs
Memory	Local data (for the different priority classes)
	Communication resources: maximum number of communication jobs (you are only allowed to increase this parameter compared to its previously configured value.)
Time-of-day interrupts (for every time-of-day interrupt OB)	“Active” check box
	“Execution” list box
	Starting date
	Time
Watchdog interrupt (for every watchdog interrupt OB)	Execution
	Phase offset
Diagnostics/clock	Correction factor
Security	Protection level and password

Table 11-1 Modifiable CPU parameters, continued

Tab	Modifiable Parameter
Fault-tolerant parameters	Test scan cycle time
	maximum scan-cycle time extension
	Maximum communication delay
	Maximum retention time for priority classes > 15
	minimum I/O retention time

The new values are to be chosen to suit both the user program currently loaded and the new user program planned.

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

To change the CPU parameters of a fault-tolerant system the steps listed below are to be performed. Details of each step are listed in a subsection.

Step	What Has To Be Done?	Refer to Section
A	Changing the CPU Parameters Offline	11.6.1
B	Stopping the Standby CPU	11.6.2
C	Loading Modified CPU Parameters in the Standby CPU	11.6.3
D	Switch to CPU with modified configuration	11.6.4
E	Transition to Redundant System Mode	11.6.5

11.6.1 Step A: Changing the CPU Parameters Offline

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. Change the desired properties of the CPU offline in the hardware configuration.
2. Compile the new hardware configuration, but do **not** load it into the PLC just yet.

Result

The modified hardware configuration is in the PG/ES. The PLC continues to work with the old configuration in redundant system mode.

11.6.2 Step B: Stopping the Standby CPU

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, select the standby CPU and click the **Stop** button.

Result

The standby CPU switches to STOP mode, the master CPU remains in RUN mode, the fault-tolerant system works in single mode. One-way I/O of the standby CPU are no longer addressed.

11.6.3 Step C: Loading Modified CPU Parameters in the Standby CPU

Initial situation

The fault-tolerant system is working in single mode.

Procedure

Load the compiled hardware configuration in the standby CPU that is in STOP mode.

Notice

The user program and the connection configuration must not be overloaded in single mode.

Result

The modified CPU parameters in the new hardware configuration of the standby CPU do not yet have an effect on ongoing operation.

11.6.4 Step D: Switch to CPU with Modified Configuration

Initial situation

The modified hardware configuration is loaded into the standby CPU.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, click the **Toggle button.**
3. In the **Toggle** dialog box, select the option **with modified configuration** and click the **Toggle** button.
4. Confirm the query that follows with **OK**.

Result

The standby CPU links up, is updated and becomes the master. The former master CPU switches to STOP mode, the fault-tolerant system continues to work in single mode.

Behavior of the I/O

Type of I/O	One-way I/O of previous master CPU	One-way I/O of new master CPU	Switched I/O
I/O modules	Are no longer addressed by the CPU. Output modules output the configured substitute or holding values.	Are re-parameterized[1] and updated by the CPU.	Continue to work without interruption.

1) Central modules are first reset in addition. Output modules briefly output 0 during this time (instead of the substitute or holding values configured).

Response if monitoring times are exceeded

If one of the monitored times exceeds the maximum value configured the update is interrupted and no change of master takes place. The fault-tolerant system remains in single mode with the previous master CPU and in certain conditions attempts to perform the change of master later. For more details refer to Section 6.3.

If the values for the monitoring times in the CPUs are different then the higher value always applies.

11.6.5 Step E: Transition to Redundant System Mode

Initial situation

The fault-tolerant system works with the modified CPU parameters in single mode.

Procedure

1. In SIMATIC Manager, select a CPU of the fault-tolerant system, and choose the **PLC > Operating Mode** menu command.
2. In the **Operating Mode** dialog box, select the standby CPU and click the **Restart (warm restart)** button.

Result

Standby CPU links up again and is updated. The fault-tolerant system is working in redundant system mode.

Behavior of the I/O

Type of I/O	One-way I/O of standby CPU	One-way I/O of master CPU	Switched I/O
I/O modules	Are re-parameterized[1] and updated by the CPU.	Continue to work without interruption.	

1) Central modules are additionally first reset. Output modules briefly output 0 during this time (instead of the configured substitute or holding values).

Response if monitoring times are exceeded

If one of the monitored times exceeds the maximum value configured the update is interrupted. The fault-tolerant system remains in single mode with the previous master CPU and in certain conditions attempts to perform the link-up and update later. For more details refer to Section 6.3.

If the values for the monitoring times in the CPUs are different then the higher value always applies.

11.7 Changing the Memory Components of the CPU

Redundant system mode is only possible if the two CPUs have the same memory components. For this, the following conditions must be met:

- The main memory of the two CPUs must be the same size.
- The load memory of the two CPUs must be the same size and of the same type (RAM or FLASH).

The memory components of the CPUs can be modified during operation. Possible memory modifications in S7-400H are:

- Expansion of the main memory and/or load memory
- Changing the type of load memory

11.7.1 Expanding the Main and/or Load Memory

The following methods of memory expansion are possible:

- expanding the main memory by plugging in additional or larger memory modules
- expanding the load memory by plugging in a larger memory card of the same type instead of the existing one
- expanding the load memory by plugging in a RAM card if no memory card was plugged in previously

With this type of memory change the complete user program is copied from the master CPU to the standby CPU on link-up (see Section 6.2.1).

Restrictions

Expanding the load memory is only meaningful in the case of RAM Cards, since only then can the user program be copied to the load memory of the standby CPU on link-up.

In principle it is also possible to expand the load memory in the form of FLASH cards, but it is then the user’s responsibility to load the complete user program and the hardware configuration into the new FLASH card (see procedure in Section 11.7.2).

Initial situation

The fault-tolerant system is working in redundant system mode.

Procedure

Perform the steps below in the order specified:

Step	What Has To Be Done?	How Does the System React?
1	Switch the standby CPU to STOP mode using the PG.	The system is working in single mode.
2	If you want to expand the main memory: A Turn off the power supply for the standby CPU. B Unplug the standby CPU from the central controller (CC). C Install the desired memory modules as described in the installation manual *S7-400, M7-400 Programmable Controllers, Hardware and Installation*. D Plug the CPU back into in the CC. E Make sure that the synchronization link is re-established and that the mode selector of the standby CPU is switched to RUN or RUN-P. F Turn the power supply for the standby CPU back on.	Subsystem is disabled for periods.
3	If you want to expand the load memory: Unplug the existing memory card from the CPU and plug in a memory card of the same type with the desired (larger) capacity.	Standby CPU requests reset.
4	Reset the standby CPU using the PG.	–
5	Start the standby CPU by means of the menu command **PLC > Mode > Switch to CPU with... expanded memory configuration**.	• Standby CPU links up, is updated and becomes the master. • Previous master CPU goes into STOP. • System works in single mode.
6	Turn off the power supply for the second CPU.	Subsystem is disabled.
7	Modify the memory components of the second CPU as you did for the first CPU in steps 2 to 4.	–
8	Start the second CPU using the programming device.	• Second CPU links up and is updated. • System works redundant system mode again.

11.7.2 Changing the Type of Load Memory

The following types of memory cards are available as load memory:

- RAM card for the test and commissioning phase
- FLASH card for the permanent storage of the finished user program

The size of the new memory card is irrelevant here.

With this type of memory modification no program segments are transferred from the master CPU to the standby CPU, only the contents of the blocks in the user program that remain unchanged (see Section 6.2.3).

It is the user's responsibility to load the entire user program into the new load memory.

Initial situation

The fault-tolerant system is working in redundant system mode.

The current status of the user program is available on the PG/ES as a STEP 7 project in modular form.

Caution

You cannot use a user program loaded from the PLC here.

It is not permissible to recompile the user program from an STL source file since then all the blocks will be given a new time stamp. No block contents will then be copied on master/standby switch-over.

Procedure

Perform the steps below in the order specified:

Step	What Has To Be Done?	How Does the System React?
1	Switch the standby CPU to STOP mode using the PG.	The system is working in single mode.
2	Unplug the existing memory card from the standby CPU and plug in a memory card of the desired type.	Standby CPU requests reset.
3	Reset the standby CPU using the PG.	–
4	Load the user program and the hardware configuration into the standby CPU.	–
5	Start the standby CPU by means of the menu command **PLC > Mode > Switch to CPU with... modified configuration**.	• Standby CPU links up, is updated and becomes the master. • Previous master CPU goes into STOP. • System works in single mode.

Step	What Has To Be Done?	How Does the System React?
6	Modify the memory components of the second CPU as you did for the first CPU in step 2.	–
7	Load the user program and the hardware configuration into the second CPU.	–
8	Start the second CPU using the programming device.	• Second CPU links up and is updated. • System works redundant system mode again.

Notice

If you want to change to FLASH cards you can load these outside the CPU with the user program and hardware configuration. You can then omit steps 4 and 7.

However, the memory cards in the two CPUs must be loaded using the same procedure. Changing the order of the blocks in the load memories will result in cancellation of the link-up.

Writing to a FLASH Card in the H System

You can write to a FLASH card in an H system in the RUN mode without having to stop the H system. To do this the online data of the hardware configuration and the user program in the CPUs have to match the corresponding offline data in the engineering station.

Proceed as follows:

1. Set the standby CPU to STOP and insert the FLASH card in the CPU.
2. Perform a memory reset for the CPU using STEP 7.
3. Download the hardware configuration with STEP 7.
4. Download the program data using the STEP 7 command “Download User Program to Memory Card“. Attention: Be sure to select the correct CPU in the selection dialog.
5. Switch to the CPU with the changed configuration using the “Operating Mode“ dialog. The master-standby switch-over is performed; the CPU with the Flash card is no the master CPU. The standby CPU is now in STOP.
6. Now insert the Flash card into the CPU in the STOP mode. Perform a memory reset for the CPU using STEP 7.
7. Carry out step 4: Download the program data using the STEP 7 command “Download User Program to Memory Card“. Attention: Be sure to select the correct CPU in the selection dialog.
8. Perform a warm restart of the standby CPU using the “Operating Mode“ dialog. The system now goes to the “Redundant” system mode.

The online and offline data consistency described above also applies when you remove FLASH Cards from an H- system. In addition, the available RAM cannot be less than actual size of the STEP 7 program (STEP7 Program > Block Container > Properties “Blocks”).

1. Set the standby CPU to STOP and remove the FLASH card. Check the RAM configuration if necessary.
2. Perform a memory reset for the CPU using STEP 7.
3. Download the block container using STEP 7.
4. Switch to the CPU with the changed configuration using the “Operating Mode“ dialog.
5. Remove the FLASH card from the CPU now in the STOP state. Check the RAM configuration if necessary and perform a memory reset for the CPU.
6. Perform a warm restart of the standby CPU using the “Operating Mode“ dialog. The system now goes to the “Redundant” system mode.

Synchronization Module 12

Chapter Overview

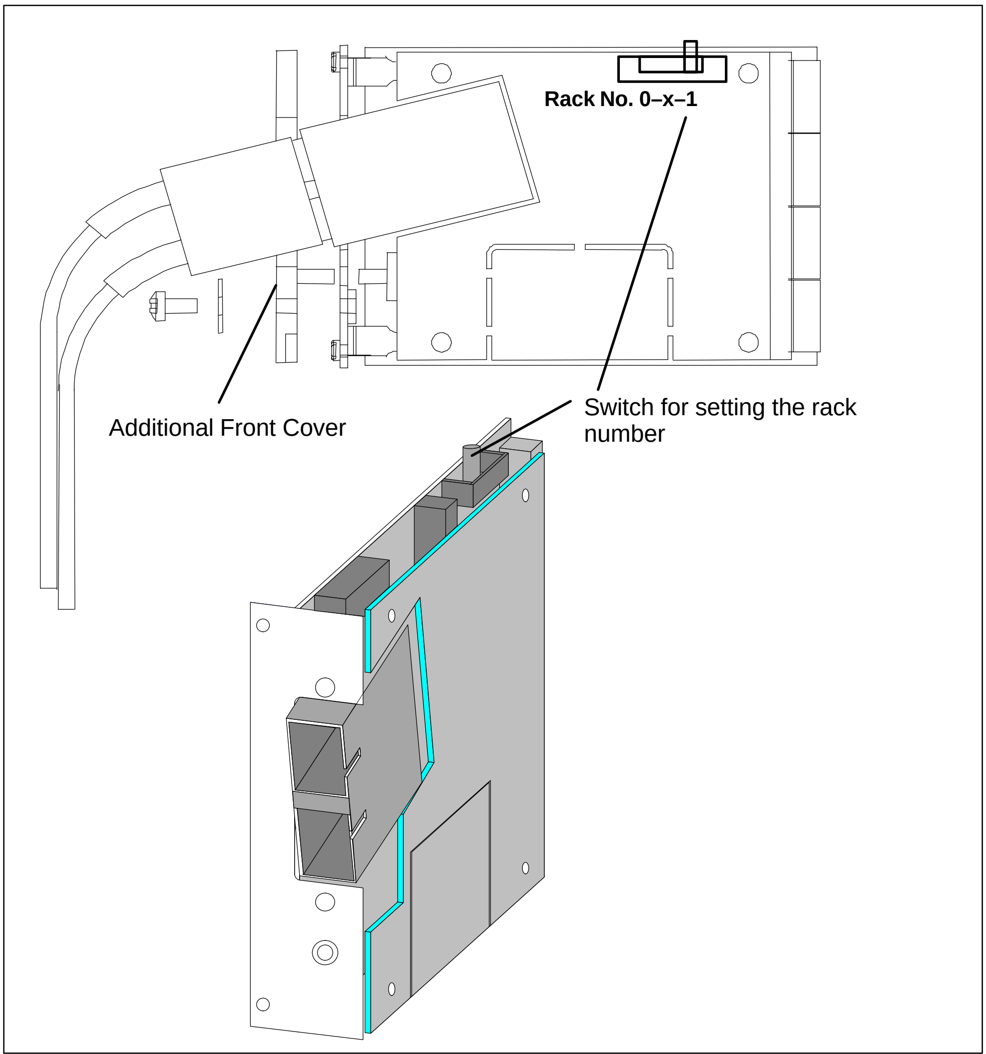
12.1 Synchronization Module for S7-400H

Function of the Synchronization Module

The synchronization module serves as the point-to-point communication of two redundant S7-400H CPUs with two channels. You require two synchronization modules per CPU for the fault-tolerance of 1 of 2 systems. You can connect the modules in pairs via a fiber optic cable.

You can replace the synchronization module when voltage is applied. This supports the repair behavior of H systems and thus tackles the failure of the redundant connection without having to bring the plant to a halt.

Mechanical Configuration



Caution

The synchronization module contains a laser system and is classified as "CLASS 1 LASER PRODUCT" according to IEC 60825-1. Please read the operating instructions thoroughly for the right use of this module and save it as reference. If you encounter problems with this model, please contact the Siemens Service Partner close to you. The casing must remain closed to avoid direct contact with the laser ray.

CLASS 1 LASER PRODUCT
CLASS 1 LASER PRODUCT
TO EN 60825

Removing and Inserting when Voltage is Applied

You have to switch off the power supply when removing or inserting a synchronization module in an (PS). The synchronization module has a second front cover which you have to unscrew before removing the module. If you unscrew the front cover, the synchronization module will be disconnected from the voltage and you can remove it without any damage. After inserting the synchronization module, a connection will not be made to the voltage until you have screwed back the the front cover.

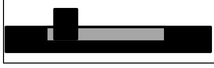
Note

The reserved CPU will go to STOP when you unscrew the synchronization module or the fiber optic cable in the redundant mode of the system. The master CPU remains in RUN.

Setting the Rack Number

To be able to differentiate between the two subsystems, the CPU must be able to output the rack numbers. A CPU has rack number 0 and the others have rack number 1. Set the rack number to the synchronization module. There is a miniature slide switch on the module for this and it permits 3 points. The rack number is applied during POWER ON and a manual memory reset.

The partner module must have different points for the CPU to startup properly, this means the synchronization module must have the rack number 0 and the other must have rack number 1. The two synchronization modules in a CPU must have the same rack number.

Switch Position	Meaning
	The CPU has rack number 1
	The CPU has not been assigned a rack number
	The CPU has rack number 0

Fiber optic cable for connecting two synchronization modules

Length	Order Number
1M	6ES7960-1AA00-5AA0
2M	6ES7960-1AA00-5BA0
10M	6ES7960-1AA00-5KA0

Changing the Operating Mode of an H CPU

To change the operating mode of an H CPU, carry out one of following procedures depending on the operating mode you wish to change to and the module rack number of the CPU:

Changing from redundant to single mode

1. Remove the interface module.
2. Perform a power on without backup e.g., by removing and inserting the CPU.
3. Load a project into the CPU in which it is configured for single mode.

Changing from Single to Redundant Mode, Module Rack Number 0

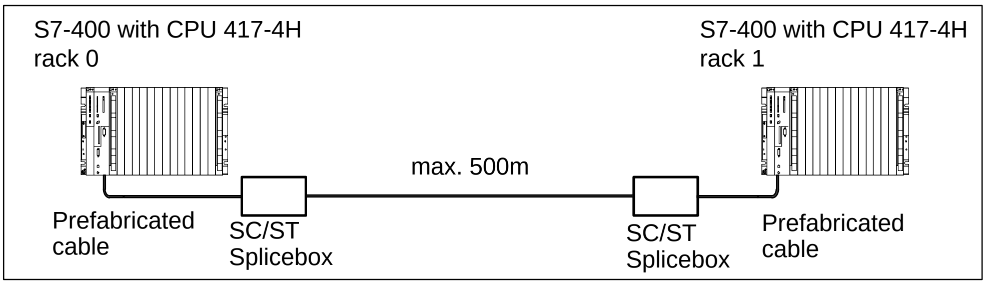
1. Connect the synchronization modules set for rack number 0.
2. Perform a power on without backup e.g., by removing and inserting the CPU.
3. Load a project into the CPU in which it is configured for redundant mode.

Changing from single to redundant mode, module rack number 1

1. Connect the synchronization modules set for rack number 1.
2. Perform a power on without backup e.g., by removing and inserting the CPU.
3. Load a project into the CPU in which it is configured for redundant mode.

Cable length up to 500m

You can use the synchronization module in 2 pairs with fiber optic cables of up to 500m as of product release 2 .



The following points are important:

- You can use the synchronization modules with product release 1 and 2 together and this will make a cable length of up to 10m possible.
- Make sure there is enough strain relief on the modules if you use fiber optic cables longer than 10m.
- Adhere to the specified ambient conditions for using fiber optic cables (bending radius, pressure, temperature...)
- Note the technical specifications of the fiber optic cable (attenuation, bandwidth...)

During the storage of unused modules, you have to seal the fiber optic cable interfaces with blind plugs to protect the optic (blind plugs are in the synchronization module in the delivery state).

Technical Specification

Technical Specifications	
Supply Voltage	Supplied from CPU
Current consumption from	0.6 A
Module ID	85_H
Power loss	3 W
Dimensions B x H x T (mm)	18.2 x 67 x 97
Weight	0.080 kg

12.2 Routing Cables Using Fiber Optics

Cable Routing

Indoor fiber-optic cables (e.g., for connecting synchronization modules) are permitted for use in buildings, cable ducts and channel trunking.

The maximum strain during installation is 1000 N and 150 N during operation.

Bending Radius

You may not go below the bending radius when laying the cable:

- Next to connector: 55 mm
- Otherwise: 30 mm

Laying Fiber Optic Cables for Synchronized Coupling of S7-400H

In addition, make sure the two fiber-optic cables are always laid isolated from each other when routing the cable. Laying them separately enhances their availability and protects then from potential dual faults in the event, say, of simultaneous interruption of the fiber-optic cables.

Always make sure the fiber optic cables are connected to both CPUs before switching on the power supply or the system, otherwise the CPUs may process the user program as the master CPU.

Technical Specifications 13

Chapter Overview

13.1 Technical Specifications of the CPU 414-4H; (6ES7 414-4HJ00-0AB0)

CPU and Version	
MLFB	6ES7 414-4HJ00-0AB0
• Hardware version	01
• Firmware version	3.1 V
Associated programming package	beginning with STEP7 V 5.2; optional package S7 H System
Memory	
Working memory	
• Integrated	384 Kbytes for code 384 Kbytes for data
• Expandable	No
Load memory	
• Integrated	256 Kbytes RAM
• Expandable FEPROM	With memory card (FLASH) up to 64 Mbytes
• Expandable RAM	With memory card (RAM) up to 64 Mbytes
Backup	Yes
• With battery	All data
• Without battery	None
Processing Times	
Processing times for	
• Bit operations	Min. 0.1 µs
• Word instructions	Min. 0.1 µs
• Integer math instructions	Min. 0.1 µs
• Floating-point math instructions	Min. 0.6 µs
Timers/Counters and Their Retentivity	
S7 counters	256
• Retentivity can be set	From Z 0 to Z 255
• Preset	From Z 0 to Z 7
• Counting range	1 to 999
IEC counter	Yes
• Type	SFB
S7 timers	256
• Retentivity can be set	From T 0 to T 255
• Preset	No retentive timers
• Time range	10 ms to 9990 s
IEC timers	Yes
• Type	SFB

Data Areas and Their Retentivity	
Total retentive data area (incl. memory markers, timers, counters)	Total working and load memory (with backup battery)
Memory markers	8 Kbytes
• Retentivity can be set	From MB 0 to MB 8191
• Preset retentivity	From MB 0 to MB 15
Clock memories	8 (1 memory byte)
Data blocks	Max. 4095 (DB 0 reserved)
• Size	Max. 64 Kbytes
Local data (can be set)	Max. 16 Kbytes
• Preset	8 Kbytes
Blocks	
OBs	See instruction list
• Size	Max. 64 Kbytes
Nesting depth	
• Per priority class	24
• Additionally in an error OB	2
FBs	Max. 2048
• Size	Max. 64 Kbytes
FCs	Max. 2048
• Size	Max. 64 Kbytes
Address Areas (Inputs/Outputs)	
Total I/O address area	8 Kbytes/8 Kbytes
• Of which distributed	
MPI/DP interface	2 Kbytes/2 Kbytes
DP interface	6 Kbytes/6 Kbytes
Process Image	8 Kbytes/8 Kbytes (can be set)
• Preset	256 bytes/256 bytes
• Number of partial process images	Max. 8
• Consistent data	Max. 244 bytes
Digital channels	65536/65536
• those central	65536/65536
Analog channels	4096/4096
• those central	4096/4096

Configuration	
Central racks/expansion units	Max. 1/21
Multicomputing	No
Number of plug-in IMs (overall)	Max. 6
• IM 460	Max. 6
• IM 463-2	maximum 4, only in single operation
Number of DP masters	
• Integrated	2
• Via CP	Max. 10
Operable function modules and communication processors	
• FM, see Appendix E	Limited by the number of slots and the number of connections
• CP 441	Limited by the number of connections (maximum of 30)
• Profibus and Ethernet CPs including CP 443-5 Extended	Max. 14
Time	
Clock	Yes
• Buffered	Yes
• Resolution	1 ms
• Accuracy at	
– Power off	Deviation per day 1.7 s
– Power on	Deviation per day 8.6 s
Runtime meter	8
• Number	0 to 7
• Value Range	0 to 32767 hours
• Granularity	1 hour
• Retentive	Yes
Time synchronization	Yes
• In PLC, on MPI and DP	as master or slave
Time of day difference in the system for synchronization via	
• ETHERNET	maximum 10 ms
• MPI	maximum 200 ms

S7 Message Functions	
Number of stations that can log on for message functions (e.g. WIN CC or SIMATIC OP)	Max. 8
• Simultaneously active ALARM-S/SQ blocks and ALARM-D/DQ blocks	Max. 100
ALARM-8 blocks	Yes
• Number of communication jobs for ALARM-8 blocks **and** blocks for S7 communication (can be set)	Max. 600
• Preset	300
Statuses	Yes
Number of archives that can log on simultaneously (SFB 37 AR_SEND)	16
Test and Startup Functions	
Monitor/modify tag	Yes
• Variables	Inputs/outputs, memory markers, DB, distributed inputs/outputs, timers, counters
• Number of variables	Max. 70
Force	Yes
• Variables	Inputs/outputs, memory markers, distributed inputs/outputs
• Number of variables	Max. 256
Status block	Yes
Single sequence	Yes
Diagnostics buffer	Yes
• Number of entries	Max. 3200 (can be set)
• Preset	120
Number of breakpoints	4

Communication Functions	
Programming device/OP communication	Yes
Number of connectable OPs	8 with message processing 31 without message processing
Number of connection resources for S7 connections via all interfaces and CPs	32, with one each of those reserved for PG and OP
S7 communication	Yes
S7 basic communication	no
Global data communication	no
• User data per job	Max. 64 Kbytes
– Of which consistent	32 bytes
S5-compatible communication	yes (via CP –max. 10 simultaneously– and FC AG_SEND and FC AG_RECV)
• User data per job	Max. 8 Kbytes
– Of which consistent	240 bytes
Standard communication (FMS)	yes (via CP and loadable FB)
Interfaces	
1st Interface	
Type of interface	Integrated
Physical	RS 485/Profibus
Isolated	Yes
Power supply to interface (15 VDC to 30 VDC)	Max. 150 mA
Number of connection resources	MPI: 32 DP: 16
Functionality	
• MPI	Yes
• PROFIBUS DP	DP Master

1st Interface in MPI mode	
• Utilities	
– Programming device/OP communication	Yes
– Routing	Yes
– Global data communication	No
– S7 basic communication	No
– S7 communication	Yes
• Transmission rates	Up to 12 Mbps
1st Interface in DP mode	
• Utilities	
– Programming device/OP communication	Yes
– Routing	Yes
– Global data communication	no
– S7 basic communication	no
– S7 communication	yes
– Equidistance	No
– SYNC/FREEZE	No
– Enable/disable DP slaves	No
• Transmission rates	Up to 12 Mbps
• Number of DP slaves	Max. 32
• Address area	Max. 2 Kbytes inputs/ 2 Kbytes outputs
• User data per DP slave	Maximum of 244 bytes E, maximum of 244 bytes A, divided into 244 Slots with 128 bytes each
2nd Interface	
Type of interface	Integrated
Physical	RS 485/Profibus
Isolated	Yes
Power supply to interface (15 VDC to 30 VDC)	Max. 150 mA
Number of connection resources	16

Functionality	
• PROFIBUS DP	DP Master
DP Master	
• Utilities	
– Programming device/OP communication	Yes
– Routing	Yes
• Transmission rates	Up to 12 Mbps
• Number of DP slaves	Max. 96
• Address area	Max. 6 Kbytes inputs/6 Kbytes outputs
• User data per DP slave	Maximum of 244 bytes E, maximum of 244 bytes A, divided inot 244 slots with 128 bytes each
3rd Interface	
Type of interface	Plug-in interface submodule (fiber-optic cable)
Insertable interface submodule	Synchronization module IF 960 (only during redundancy mode; during single mode the interface is free/covered)
4th Interface	
Type of interface	Plug-in interface submodule (fiber-optic cable)
Insertable interface submodule	Synchronization module IF 960 (only during redundancy mode; during single mode the interface is free/covered)
Programming	
Programming language	LAD, FBD, STL, SCL
Instruction set	See instruction list
Bracket levels	8
System functions (SFC)	See instruction list
Number of SFCs active at the same time	
• WR_REC	8
• WR_PARM	8
• PARM_MOD	1
• WR_DPARM	2
• DPNRM_DG	8
• RDSYSST	1 ... 8
System function blocks (SFC)	See instruction list
Number of SFBs active at the same time	
• RD_REC	8
• WR_REC	8
User program protection	Password protection
Access to consistent data in the process image	Yes
Dimensions	
Mounting dimensions B×H×T (mm)	50×290×219
Slots required	2
Weight	Approx. 1.07 kg
Voltages, Currents	
Current consumption from S7-400 bus (5 VDC)	Typ. 1.6 A Max. 1.8 A
Current consumption from the S7-400 bus (24 VDC) The CPU does not consume any current at 24 V, and it only makes this voltage available at the MPI/DP interface.	Total current consumption of the components connected to the MPI/DP interfaces, with a maximum of 150 mA per interface
Backup current	Typ. 40 µA Max. 420 µA
Incoming supply of external backup voltage to the CPU	5 VDC to 15 VDC
Power loss	Typ. 8 W

CPU as DP Slave

You must **not** configure the CPU as DP slave.

13.2 Technical Specifications of the CPU 417-4H; (6ES7 417-4HL01-0AB0)

CPU and Version	
MLFB	6ES7 417-4HL01-0AB0
• Hardware version	01
• Firmware version	3.1 V
Associated programming package	beginning with STEP7 V 5.2; optional package S7 H System
Memory	
Working memory	
• Integrated	2 Mbytes for code2 Mbytes for data
• Expandable	Up to 10 Mbytes for codeUp to 10 Mbytes for data
Load memory	
• Integrated	256 Kbytes RAM
• Expandable FEPROM	With memory card (FLASH) up to 64 Mbytes
• Expandable RAM	With memory card (RAM) up to 64 Mbytes
Backup	Yes
• With battery	All data
• Without battery	None
Processing Times	
Processing times for	
• Bit operations	Min. 0.1 µs
• Word instructions	Min. 0.1 µs
• Integer math instructions	Min. 0.1 µs
• Floating-point math instructions	Min. 0.6 µs
Timers/Counters and Their Retentivity	
S7 counters	512
• Retentivity can be set	From Z 0 to Z 511
• Preset	From Z 0 to Z 7
• Counting range	1 to 999
IEC counter	Yes
• Type	SFB
S7 timers	512
• Retentivity can be set	From T 0 to T 511
• Preset	No retentive timers
• Time range	10 ms to 9990 s
IEC timers	Yes
• Type	SFB

Data Areas and Their Retentivity	
Total retentive data area (incl. memory markers, timers, counters)	Total working and load memory (with backup battery)
Memory markers	16 Kbytes
• Retentivity can be set	From MB 0 to MB 16383
• Preset retentivity	From MB 0 to MB 15
Clock memories	8 (1 memory byte)
Data blocks	Max. 8191 (DB 0 reserved)
• Size	Max. 64 Kbytes
Local data (can be set)	Max. 64 Kbytes
• Preset	32 Kbytes
Blocks	
OBs	See instruction list
• Size	Max. 64 Kbytes
Nesting depth	
• Per priority class	24
• Additionally in an error OB	2
FBs	Max. 6144
• Size	Max. 64 Kbytes
FCs	Max. 6144
• Size	Max. 64 Kbytes
Address Areas (Inputs/Outputs)	
Total I/O address area	16 Kbytes/16 Kbytes
• Of which distributed	
MPI/DP interface	2 Kbytes/2 Kbytes
DP interface	8 Kbytes/8 Kbytes
Process Image	16 Kbytes/16 Kbytes (can be set)
• Preset	1024 bytes/1024 bytes
• Number of partial process images	Max. 8
• Consistent data	Max. 244 bytes
Digital channels	131072/131072
• those central	131072/131072
Analog channels	8192/8192
• those central	8192/8192

Configuration	
Central racks/expansion units	Max. 1/21
Multicomputing	No
Number of plug-in IMs (overall)	Max. 6
• IM 460	Max. 6
• IM 463-2	maximum 4 in single operation
Number of DP masters	
• Integrated	2
• Via CP	Max. 10
Number of plug-in S5 modules via adapter casing (in the central rack)	None
Operable function modules and communication processors	
• FM	Limited by the number of slots and the number of connections
• CP 441	Limited by the number of connections (maximum of 30)
• Profibus and Ethernet CPs including CP 443-5 Extended	Max. 14
Time	
Clock	Yes
• Buffered	Yes
• Resolution	1 ms
• Accuracy at	
– Power off	Deviation per day 1.7 s
– Power on	Deviation per day 8.6 s
Runtime meter	8
• Number	0 to 7
• Value Range	0 to 32767 hours
• Granularity	1 hour
• Retentive	Yes
Time synchronization	Yes
• In PLC, on MPI and DP	as master or slave
Time of day difference in the system for synchronization via	
• ETHERNET	maximum 10 ms
• MPI	maximum 200 ms

S7 Message Functions	
Number of stations that can log on for message functions (e.g. WIN CC or SIMATIC OP)	Max. 16
– With 100 ms grid	Max. 1
– With 500, 1000 ms grid	Max. 10
Block-related messages	Yes
• Simultaneously active ALARM-S/SQ blocks and ALARM-D/DQ blocks	Max. 200
ALARM-8 blocks	Yes
• Number of communication jobs for ALARM-8 blocks **and** blocks for S7 communication (can be set)	Max. 10000
• Preset	1200
Statuses	Yes
Number of archives that can log on simultaneously (SFB 37 AR_SEND)	64
Test and Startup Functions	
Monitor/modify tag	Yes
• Variables	Inputs/outputs, memory markers, DB, distributed inputs/outputs, timers, counters
• Number of variables	Max. 70
Force	Yes
• Variables	Inputs/outputs, memory markers, distributed inputs/outputs
• Number of variables	Max. 512
Status block	Yes
Single sequence	Yes
Diagnostics buffer	Yes
• Number of entries	Max. 3200 (can be set)
• Preset	120
Number of breakpoints	4

Communication Functions	
Programming device/OP communication	Yes
Number of connectable OPs	16 with message processing 63 without message processing
Number of connection resources for S7 connections via all interfaces and CPs	64, with one each of those reserved for PG and OP
S7 communication	Yes
– Global data communication	no
– S7 basic communication	no
• User data per job	Max. 64 Kbytes
– Of which consistent	32 bytes
S5-compatible communication	yes (via CP –max. 10 simultaneously– and FC AG_SEND and AG_RECV)
• User data per job	Max. 8 Kbytes
– Of which consistent	240 bytes
Standard communication (FMS)	Yes (via CP and downloadable FC)
Interfaces	
1st Interface	
Type of interface	Integrated
Physical	RS 485/Profibus
Isolated	Yes
Power supply to interface (15 VDC to 30 VDC)	Max. 150 mA
Number of connection resources	MPI: 44 DP: 32
Functionality	
• MPI	Yes
• PROFIBUS DP	DP Master
1st Interface in MPI mode	
• Utilities	
– Programming device/OP communication	Yes
– Routing	Yes
– Global data communication	no
– S7 basic communication	no
– S7 communication	Yes
• Transmission rates	Up to 12 Mbps

1st Interface in DP mode	
• Utilities	
– Programming device/OP communication	Yes
– Routing	Yes
– Global data communication	no
– S7 basic communication	no
– S7 communication	yes
– Equidistance	no
– SYNC/FREEZE	no
– Enable/disable DP slaves	no
• Transmission rates	Up to 12 Mbps
• Number of DP slaves	Max. 32
• Address area	Max. 2 Kbytes inputs/2 Kbytes outputs
• User data per DP slave	Maximum of 244 bytes E, maximum of 244 bytes A, divided into 244 Slots with 128 bytes each
2nd Interface	
Type of interface	Integrated
Physical	RS 485/Profibus
Isolated	Yes
Power supply to interface (15 VDC to 30 VDC)	Max. 150 mA
Number of connection resources	32
Functionality	
• PROFIBUS DP	DP Master
DP Master	
• Utilities	
– Programming device/OP communication	Yes
– Routing	Yes
• Transmission rates	Up to 12 Mbps
• Number of DP slaves	Max. 125
• Address area	Max. 8 Kbytes inputs/ 8 Kbytes outputs
• User data per DP slave	Maximum of 244 bytes E, maximum of 244 bytes A, divided into 244 slots with 128 bytes each

3rd Interface	
Type of interface	Plug-in interface submodule (fiber-optic cable)
Insertable interface submodule	Synchronization module IF 960 (only during redundancy mode; during single mode the interface is free/covered)
4th Interface	
Type of interface	Plug-in interface submodule (fiber-optic cable)
Insertable interface submodule	Synchronization module IF 960 (only during redundancy mode; during single mode the interface is free/covered)
Programming	
Programming language	LAD, FBD, STL, SCL
Instruction set	See instruction list
Bracket levels	8
System functions (SFC)	See instruction list
Number of SFCs active at the same time	
• WR_REC	8
• WR_PARM	8
• PARM_MOD	1
• WR_DPARM	2
• DPNRM_DG	8
• RDSYSST	1 ... 8
System function blocks (SFB)	See instruction list
Number of SFCs active at the same time	
• RD_REC	8
• WR_REC	8
User program protection	Password protection
Access to consistent data in the process image	Yes

Dimensions	
Mounting dimensions B×H×T (mm)	50×290×219
Slots required	2
Weight	Approx. 1.07 kg
Voltages, Currents	
Current consumption from S7-400 bus (5 VDC)	Typ. 1.8 A Max. 2.0 A
Current consumption from the S7-400 bus (24 VDC) The CPU does not consume any current at 24 V, and it only makes this voltage available at the MPI/DP interface.	Total current consumption of the components connected to the MPI/DP interfaces, with a maximum of 150 mA per interface
Backup current	Typically 75 μA Maximum 860 μA
Incoming supply of external backup voltage to the CPU	5 VDC to 15 VDC
Power loss	Typ. 9 W

CPU as DP Slave

You must **not** configure the CPU as DP slave.

13.3 Run Times of the FCs and FBs for Redundant I/O

Table 13-1 Run times of the blocks for redundant I/O

Block	Run time in single/single mode	Run time in redundant mode
FC 450 RED_INIT Specifications are based on the startup	2 ms + 300 µs / configured module pairs The specification for a module pair is a mean value. The run time may be < 300 µs for a few modules. For the great majority of redundant modules the value may even be > 300 µs.	–
FC 451 RED_DEPA	160 µs	360 µs
FB 450 RED_IN Invoked from the corresponding sequence level.	750 µs + 60 µs / module pair of the current TPA The specification for a module pair is a mean value. The run time may be additionally increased if discrepancies occur resulting in passivation and logging to the diagnostics buffer. The run time may also be increased by a depassivation carried out in the individual sequence levels of FB RED_IN. Depending on the number of modules in the sequence level, the depassivation may increase the run time of the FB RED_IN by 0.4 to 8 ms. An 8 ms increase can be expected in redundant operation of modules totalling more than 370 pairs of modules in a sequence level.	1000 µs + 70 µs/ module pair of the current TPA The specification for a module pair is a mean value. The run time may be additionally increased if discrepancies occur resulting in passivation and logging to the diagnostics buffer. The run time may also be increased by a depassivation carried out in the individual sequence levels of FB RED_IN. Depending on the number of modules in the sequence level, the depassivation may increase the run time of the FB RED_IN by 0.4 to 8 ms. An 8 ms increase can be expected in redundant operation of modules totalling more than 370 pairs of modules in a sequence level.
FB 451 RED_OUT Invoked from the corresponding sequence level.	650 µs + 2 µs / module pair of the current TPA The specification for a module pair is a mean value. The run time may be < 2 µs for a few modules. For the great majority of redundant modules the value may even be > 2 µs.	860 µs + 2 µs / module pair of the current TPA The specification for a module pair is a mean value. The run time may be < 2 µs for a few modules. For the great majority of redundant modules the value may even be > 2 µs.

Table 13-1 Run times of the blocks for redundant I/O, continued

Block	Run time in single/single mode	Run time in redundant mode
FB 452 RED_DIAG	Invoked in OB 72: 160 μs Invoked in OB82, 83, 85: 250 μs + 5 μs / configured module pairs The run time of FB RED_DIAG is always increased by addresses which are not located at the beginning of the DB. If these are interrupt trigger addresses that do not belong to the redundant I/O, the run time may increase up to approx. 1.5 ms. This is the case when the working DB is 60 Kb or larger.	Invoked in OB 72: 360 μs Invoked in OB82, 83, 85: 430 μs (basic load) + 6 μs / configured module pairs The run time of FB RED_DIAG is always increased by addresses which are not located at the beginning of the DB. If these are interrupt trigger addresses that do not belong to the redundant I/O, the run time may increase up to approx. 1.5 ms. This is the case when the working DB is 60 Kb or larger.
FB 453 RED_STATUS	160 μs + 4 μs / configured module pairs The run time depends on the (random) position of the module being searched for in the working DB. When a module address is not redundant, the entire working DB is searched. This results in the longest run time of FB RED_STATUS. Maximum run time = 160 μs + 4 μs/ configured module pairs * total number of module pairs) The number of module pairs is based either on all inputs (DI/AI) or all outputs (DO/AO).	350 μs + 5 μs / configured module pairs The run time depends on the (random) position of the module being searched for in the working DB. When a module address is not redundant, the entire working DB is searched. This results in the longest run time of FB RED_STATUS. Maximum run time = 350 μs + 5 μs/ configured module pairs * total number of module pairs) The number of module pairs is based either on all inputs (DI/AI) or all outputs (DO/AO).

Notice

These are typical and not absolute values. The actual value may deviate from these specifications in some cases. This overview is intended as a guide and should help you estimate how the use of the RED_IO library may change the cycle time.

Characteristic Values of Redundant Programmable Logic Controllers

A

The present appendix presents a brief introduction to the characteristic values of redundant programmable logic controllers and shows the practical effects of redundant configuration types by means of a few selected configurations.

An overview of the MTBF for a variety of SIMATIC products is available in the SIMATIC FAQs at
`http://www.siemens.com/automation/service&support`
under the ID 1160399.

A.1 Basic Concepts

The parameters normally used for a quantitative assessment of redundant programmable logic controllers are reliability and availability, which are described in further detail below.

Reliability

Reliability is the characteristic of a technical device to fulfill its function during its operating period. This is usually no longer possible when a component fails.

The criterion frequently specified for reliability is therefore **MTBF** (**M**ean **T**ime **B**etween **F**ailures). It can be determined statistically by systems that are operating or by calculating the failure rates of the components used.

Reliability of modules

The reliability of SIMATIC components is extremely high as a consequence of wide-ranging quality assurance measures in development and manufacture.

The following average values apply to SIMATIC modules:

- MTBF of a central processing unit: 15 years
- MTBF of an I/O module: 50 years

Reliability of programmable logic controllers

The use of redundant modules prolongs the MTBF of a system to a very large extent. In connection with the high-quality self-tests and the mechanisms for error detection, which are integrated in the CPUs of the S7-400H, virtually all errors are discovered and localized. The diagnostics coverage (dc) is approximately 95 percent.

Starting from the reliability of a single system (1-out-of-1 systems having an $MTBF_{1oo1}$), it is possible to calculate the reliability of the S7-400H as a two-channel (2-out-of-2) fault-tolerant system from the following formula:

$$MTBF_{1v2} = \frac{{MTBF_{1v1}}^{2}}{2MDT + 2(1 - dc) \cdot MTBF_{1v1}}$$

The MTBF of the S7-400H is determined by its **MDT** (**M**ean **D**own **T**ime). This time consists essentially of the time for error detection and the time required to repair or replace defective modules.

The error detection time is half the configured test cycle time (by default, 90 min.). The repair time for a modular system such as the S7-400H is normally four hours.

Availability

Availability is the probability of a system being capable of operation at a specified point of time. It can be enhanced by means of redundancy – for example, by using redundant I/O modules or by using multiple sensors at one sampling point. Redundant components are arranged such that system operability is not affected by the failure of a single component. Here, again, an important element of availability is a detailed diagnostics display.

The availability of a system is expressed as a percentage. It is determined by the mean time between failure (MTBF) and the mean repair time (MTTR). The availability of a two-channel (2-out-of-2) fault-tolerant system can be calculated from the following formula:

$$V = \frac{MTBF_{1v2}}{MTBF_{1v2} + MDT} 100\%$$

A.2 Comparison of MTBFs for Selected Configurations

The following sections compare systems with a central I/O.

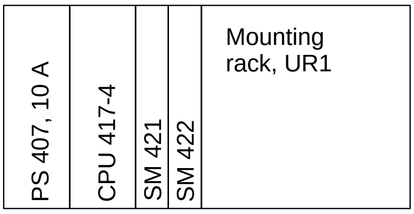
The following framework conditions are set for the calculation.

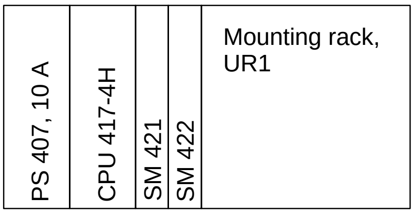
- MDT (Mean Down Time) 4 hours
- ambient temperature 40 degrees
- buffer voltage is guaranteed

A.2.1 System Configurations With Central I/O

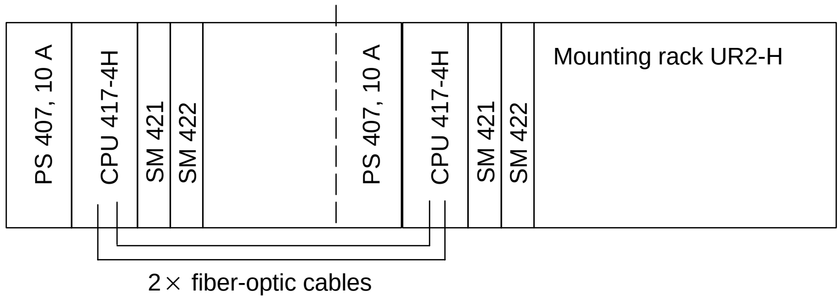
The following system with a standard CPU (e.g. CPU 417-4) is taken as a basis for calculating a reference factor which specifies the multiple of availability that other systems with a central I/O have, compared with the baseline.

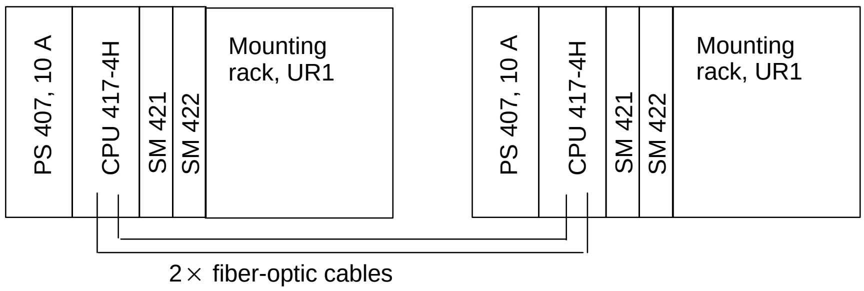
Standard and fault-tolerant CPU in single operation

Standard CPU (e.g. CPU 417-4)	Baseline
	1

Fault-Tolerant CPU in Single Operation (e.g. CPU 417-4H)	Factor
	1

Redundant CPUs in different mounting racks

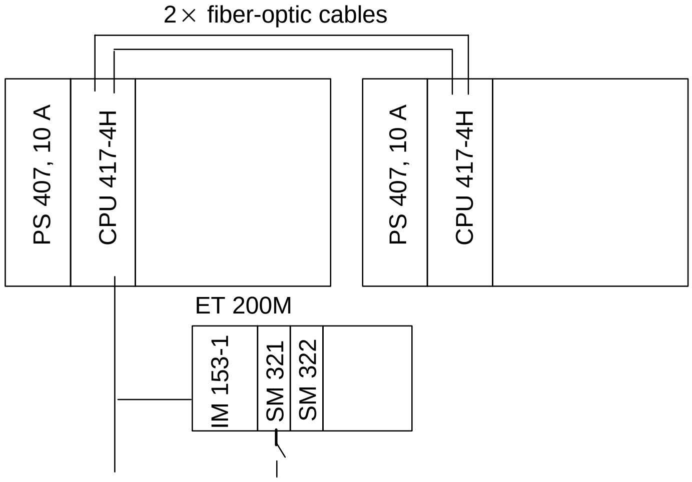
Redundant CPU 417-4 H in split mounting rack	Factor
	57

Redundant CPU 417-4H in separate mounting racks	Factor
	59

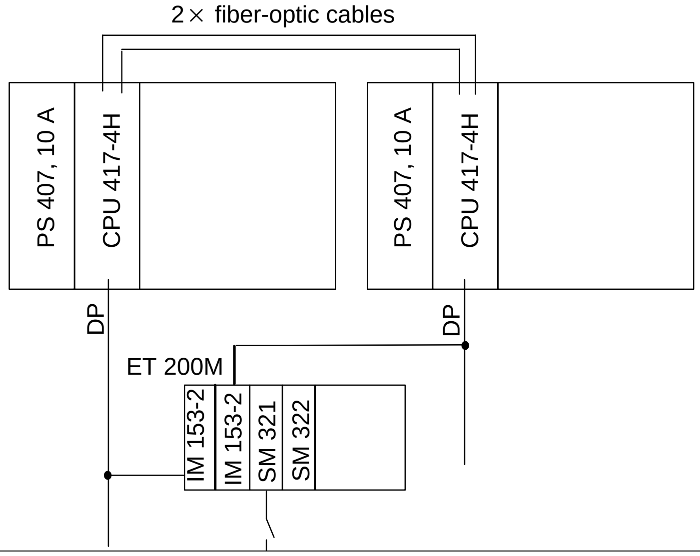
A.2.2 System Configurations With Distributed I/O

The following system with two fault-tolerant CPUs 417-4 H and a one-way I/O is taken as a basis for calculating a reference factor which specifies the multiple of the availability of the other systems with a distributed I/O compared with the baseline.

Redundant CPUs with a single-channel, one-way or switched I/O

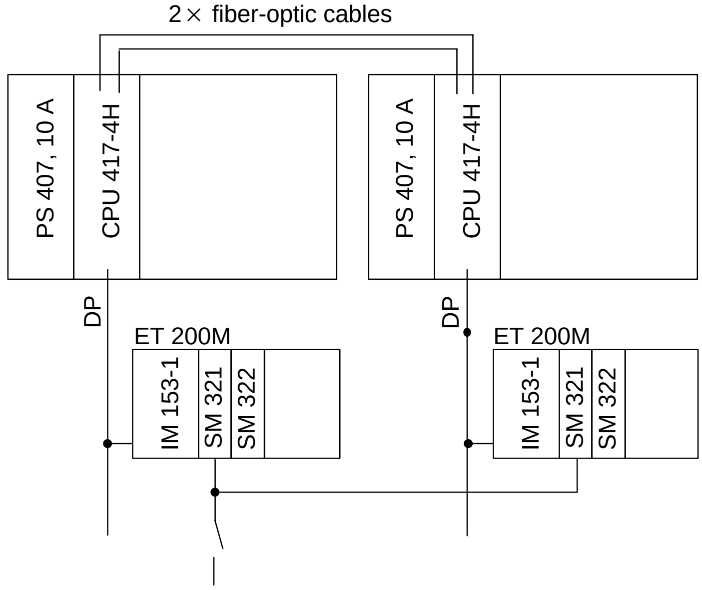
<table>
<tr><th>One-way, distributed I/O</th><th>Baseline</th></tr>
<tr><td>


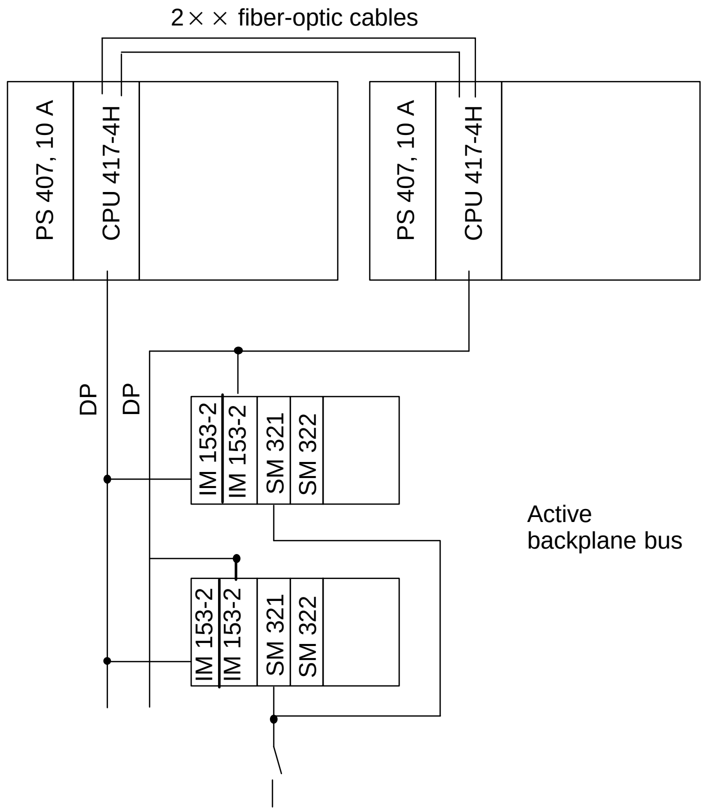
</td><td>1</td></tr>
</table>

<table>
<tr><th>Switched distributed I/O</th><th>Factor</th></tr>
<tr><td>


</td><td>3 or. 12 *</td></tr>
<tr><td colspan="2">* A factor of 3 applies to the condition when the failure of an I/O module has resulted in the entire system stopping. A factor of 12 applies when the failure of an I/O module has not resulted in the entire system stopping.</td></tr>
</table>

Redundant CPUs with redundant I/O

Single–channel, one–way I/O	MTBF factor
	65

Single–channel switch I/O	MTBF factor
	70

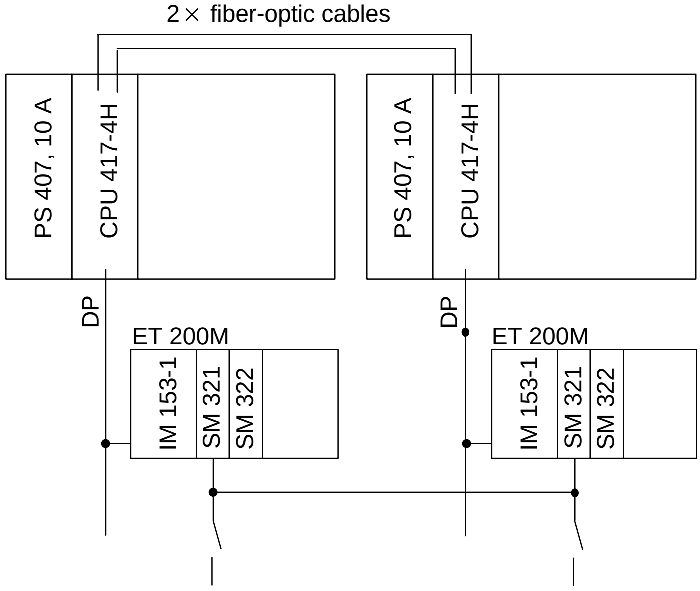
Redundant I/O	MTBF factor
	see table below

Table A-1 MTBF factor for redundant I/O

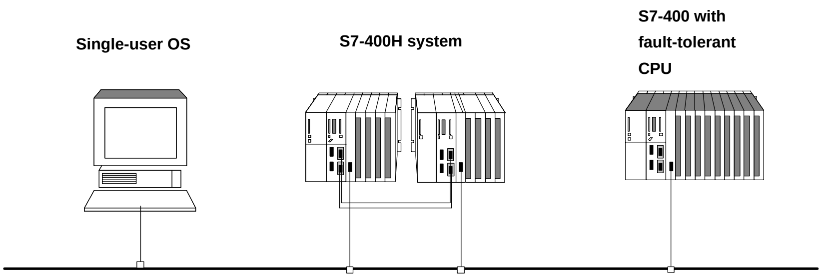
Modules	MLFB	MTBF factor
Digital input module, distributed		
DI 24xDC24V	6ES7 326-1BK00-0AB0	500
DI 8xNAMUR [EEx ib]	6ES7 326-1RF00-0AB0	500
DI16xDC24V, interrupt	6ES7 321-7BH00-0AB0	20
Analog input module, distributed		
AI 6x13Bit	6ES7 336-1HE00-0AB0	500
AI8x12Bit	6ES7 331-7KF02-0AB0	25
Digital output module, distributed		
DO 10xDC24V/2A	6ES7 326-2BF00-0AB0	500
DO8xDC24V/2A	6ES7 322-1BF01-0AA0	3
DO32xDC24V/0.5A	6ES7 322-1BL00-0AA0	3

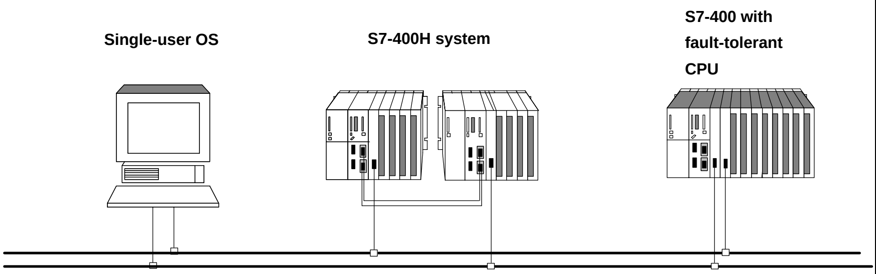
A.2.3 Comparison of System Configurations With Standard and Fault-Tolerant Communications

The following section gives you a comparison between standard and fault-tolerant communication for a configuration consisting of a fault-tolerant system, a fault-tolerant CPU in single operation and a single-channel OS.

By comparison, only the communication components CP and cable were taken into account.

Systems with standard and fault-tolerant communications

Standard communication	Baseline
	1

Fault-tolerant communication	Factor
	83

Single Operation

B

Overview

This appendix gives you the information you need for single operation of a fault-tolerant CPU (CPU 414-4H or CPU 417-4H). You will learn in the following

- how single operation is defined
- when single operation is necessary
- what you have to take into account with single operation
- how the fault tolerant-specific LEDs respond
- how to configure a fault-tolerant CPU for single operation
- how you can expand it to form a fault-tolerant system

The differences compared to a standard S7-400 CPU that you have to take into account when configuring and programming the fault-tolerant CPU are contained in Appendix D.

Definition

By single operation, we understand use of a fault-tolerant CPU in a standard SIMATIC-400 station.

Reasons for single operation

The following applications are only possible with a fault-tolerant CPU. In other words, they are not possible with standard CPUs in the S7-400 range.

- Use of fault-tolerant connections
- Configuration of the S7-400F fail-safe programmable logic controller

  A fail-safe user program can only be compiled as being executable if the fault-tolerant CPU is used with a fail-safe runtime license (for more information refer to the manual *S7-400F and S7-400FH Programmable Controllers*.).

Note

The fault-tolerant CPU self-test can also be performed in single operation.

What do you have to take into account for single Operation of a fault-tolerant CPU

Notice

Synchronization submodules must not be inserted when a fault-tolerant CPU is used in single operation.

Compared to a standard S7-400 CPU, a fault-tolerant CPU has additional functions, but it does not support certain other functions. You must therefore know on which CPU your user program should run, especially when you are programming your programmable logic controller. A user program that you have written for a standard S7-400 CPU will therefore not normally run on a fault-tolerant CPU in single operation without adjustments.

The following table lists the differences between the operation of a standard S7-400 CPU and the single operation and redundant operation of a fault-tolerant CPU.

Table B-1 Differences between S7-400 and S7-400H

Function	Standard S7-400 CPU	H-CPU in single operation	H-CPU redundantsystem mode
Use of symbol-oriented messages (SCAN)	Yes	No	No
Multicomputing (OB60, SFC35)	Yes	No	No
Startup without configuration loaded	Yes, if no IMs, no CPs and FMs are plugged in and no expansion units are connected	No	No
Insertion of DP modules in the module slots for interface modules	Yes	No. The module slots are only intended for the synchronization submodules.	No. The module slots are only intended for the synchronization submodules.
Connection of S5 modules via IM or adapter casings	Yes	beginning with firmware version 3.1 through IM 463-2	No
A high-quality RAM test after POWER ON	No	Yes	Yes
Self-test in RUN	No	Yes	Yes
Redundancy error OBs (OB70, OB72)	No	Yes, but no calls	Yes
Background processing (OB90)	Yes	No	No
Restart (OB101)	Yes	No	No

Table B-1 Differences between S7-400 and S7-400H, continued

Function	Standard S7-400 CPU	H-CPU in single operation	H-CPU redundantsystem mode
Specify the rack number and the CPU in the OB start information	No	Yes	Yes
SSL ID W#16#0019 (status of all LEDs)	No data records for the fault tolerant-specific LEDs	Data records for all LEDs	Data records for all LEDs
SSL ID W#16#0222 (data record for the specified interrupt)	No data record for the redundancy error OBs (OB70, OB72)	Data records for all interrupt OBs	Data records for all interrupt OBs
SSL ID W#16#0232 index W#16#0004 byte 0 of the word “index” in the data record	W#16#00	W#16#F8	Single mode: W#16#F8 or W#16#F9 Redundant: W#16#F8 and W#16#F1 or W#16#F9 and W#16#F0
SSL ID W#16#xy71 fault-tolerant CPU group information	No	Yes	Yes
SSL ID W#16#0174 (status of a module LED)	No data record for the fault tolerant-specific LEDs	Data records for all LEDs	Data records for all LEDs
Specify the rack number and the CPU in diagnostics buffer entries	No	Yes	Yes
Multi-DP master mode	Yes	Yes	No
Direct communication between DP slaves	Yes	No	No
Equidistance of DP slaves	Yes	No	No
Groups of DP slaves synchronize with SFC11 “DPSYC_FR”	Yes	No	No
Global data communication	Yes	No: neither cyclically, nor by means of SFC60 “GD_SND” and SFC61 “GD_RCV”	No: neither cyclically, nor by means of SFC60 “GD_SND” and SFC61 “GD_RCV”
S7 basic communication	Yes	No	No
SFC90 “H_CTRL”	No	Yes	Yes
Central use of FMs	Yes	Yes	No
Operator panel can be operated on the MPI	Yes	Yes	Yes
Operator panel can be operated on the PROFIBUS-DP	Yes	Yes	No

Table B-1 Differences between S7-400 and S7-400H, continued

Function	Standard S7-400 CPU	H-CPU in single operation	H-CPU redundantsystem mode
Operation as DP slave	Yes	No	No
Dynamic modifications to the system	Yes, as described in the manual “System Modification during Operation Using CIR”.	Yes, as described in the manual “System Modification during Operation Using CIR”.	Yes, as described in the Chapter 11 for redundant operation.

Special fault tolerant LEDs

LEDs REDF, IFM1F, IFM2F, MSTR, RACK0 and RACK1 show the response specified in the following table.

LED	Response
REDF	Dark
IFM1F	Dark
IFM2F	Dark
MSTR	Lights
RACK0	Lights
RACK1	Dark

Configuring single operation

Requirement: The “S7 Fault-Tolerant Systems” option pack must be installed. No synchronization module should be in the H CPU.

Perform the following steps:

1. Insert a SIMATIC-400 station in your project.
2. Configure the station with the fault-tolerant CPU in accordance with your hardware setup. For single operation, you must insert the fault-tolerant CPU in a standard rack (Insert > Station > S7-400 Station in SIMATIC Manager).
3. Assign parameters to the fault-tolerant CPU. You can use the default values or customize the necessary parameters.
4. Configure the necessary networks and connections. For single operation, you can configure “fault-tolerant S7 connection” type connections.

You will find help on the procedure in the SIMATIC Manager Help topics and in the Help of the “S7 Fault-Tolerant Systems” option pack.

Upgrading to a fault-tolerant system

Note

Upgrading to a fault-tolerant system is only possible if you have not assigned any odd numbers for expansion units in single operation.

If you want to upgrade the fault-tolerant CPU later to a fault-tolerant system, proceed as follows:

1. Open a new project and insert a fault-tolerant station.
2. Copy the complete rack from the standard SIMATIC-400 station and insert it twice in the fault-tolerant station.
3. Insert the necessary subnets.
4. If required, copy the DP slaves from the old single operation project in the fault-tolerant station.
5. Reconfigure the communication links.
6. Perform modifications as necessary – by inserting one-way I/O.

The procedure for configuration is described in the online help system of the add-on package of “S7 H Systems”.

Installing and starting the fault-tolerant system

We recommend you to perform the following steps when installing and starting up the fault-tolerant system.

1. Save the configured H system on a Flash Memory Card or to the engineering system (ES) when using PCS7.
2. When installing the synchronization submodules, make sure the rack numbers are set correctly.
3. Do not connect the synchronization submodules with fiber-optic cables.
4. Plug the flash memory card into the central processing unit concerned and start it. Then the Stop LED flashes (reset request).
5. Perform a manual reset for both central processing units.
6. Now connect the two synchronization modules with fiber–optic cables.
7. Start the two central processing units.

The fault-tolerant system then works in Redundant system mode.

Changing the operating mode of an H CPU

To change the operating mode of an H CPU, carry out one of following procedures depending on the operating mode you wish to change to and the module rack number of the CPU:

Changing from redundant to single mode

1. Remove the interface module.
2. Perform a power on without backup.
3. Load a project into the CPU in which it is configured for single mode.

Changing from single to redundant mde, mdule rack number 0

1. Connect the synchronization modules set for rack number 0.
2. Perform a power on without backup.
3. Load a project into the CPU in which it is configured for redundant mode.

Changing from single to redundant mode, module rack number 1

1. Connect the synchronization modules set for rack number 1.
2. Perform a power on without backup.
3. Load a project into the CPU in which it is configured for redundant mode.

Converting from S5-H to S7-400H

C

This appendix will help you to convert to fault-tolerant S7 systems if you are already familiar with fault-tolerant systems of the S5 family.

Generally speaking, knowledge of the STEP 7 configuration software is required for converting from the S5-H to the S7-400H.

C.1 General Information

Documentation

The following manuals are available for learning how to use the STEP 7 base software:

- *Configuring Hardware and Communication Connections STEP 7 V5.2*
- *Programming with STEP 7 V5.2*

The following reference manuals describe the individual programming languages.

- *System and Standard Functions*
- *AWL, KOP, FUP for S7-300/400*

The *From S5 to S7* manual will support you while you are converting and provides detailed information.

C.2 Configuration, Programming and Diagnostics

Configuration

In STEP5, configuration was performed with a separate configuration package – for example, COM 155H.

In STEP 7 we use the standard software in conjunction with the option package “S7 H Systems” to configure the fault-tolerant CPUs. Using SIMATIC Manager, create a fault-tolerant station and configure it with HWCONFIG. The special features of the fault-tolerant CPUs are summarized in a few registers. The integration in networks and the configuration of connections are performed with NetPro.

Diagnostics and programming

Error diagnostics on the S5 is implemented with the help of the error data block, into which the system enters all errors. The error OB 37 is started automatically for every entry. Further information has been stored in the H memory word.

The H memory word consists of a status byte and a control byte. Control information can be set bit by bit in the STEP5 user program.

In STEP 7, system diagnostics is accomplished by means of the diagnostics buffer or by displaying what are known as partial lists from the system status list (specific information for fault-tolerant systems, for example, are located in SSL71). This check can be performed with the help of the programming device or by the user program with SFC 51 “RDSYSST”.

OB 70 and OB 72 are available for I/O redundancy loss and CPU redundancy loss, respectively.

The function of the control byte is implemented in STEP 7 by means of the SFC 90 H_CTRL.

Subject with S5	Equivalent in S7
Error OB37	Error OBs OB 70 and OB 72
Memory control word	SFC 90 “H_CTRL”
Memory status word	SZL71
Error block	Diagnostics buffer

Differences Between Fault-Tolerant Systems and Standard Systems

D

When you configure and program a fault-tolerant programmable logic controller with fault-tolerant CPUs, certain differences to the standard S7-400 CPUs will become apparent. On the one hand, compared to a standard S7-400 CPU, a fault-tolerant CPU has additional functions, while on the other hand a fault-tolerant CPU does not support certain other functions. This has to be taken in account particularly if you wish to run a program that was created for a standard S7-400 CPU on a fault-tolerant CPU.

The items in which the programming of fault-tolerant systems differs from that for standard systems are summarized below. You will find further differences in Appendix B.

If you use one of the calls concerned (OBs and SFCs) in your user program, you will need to adapt your program accordingly.

Additional functions of fault-systems

Function	Additional Programming
Redundancy error OBs	• I/O redundancy error OB (OB 70) • CPU redundancy error OB (OB 72) You can find detailed information in the *System and Standard Functions* reference manual.
Additional information in OB start information and in diagnostics buffer entries	The rack number and the CPU (master/standby) are specified. You can evaluate this additional information in the program.
SFC for fault-tolerant systems	You can control the processes in fault-tolerant systems with the SFC 90 “H_CTRL”.
Fault-tolerant communication connections	Fault-tolerant connections are configured, no further programming is required. You can use the SFBs for configured connections when you are using fault-tolerant connections.
Self-test	The self-test is performed automatically, no further programming is required,
Switched I/O	No additional programming is required, see Section 7.3.

Function	Additional Programming
Information on the system status list	• You also obtain data records for the fault tolerant-specific LEDs by means of the partial list with the SSL ID W#16#0019. • You also obtain data records for the redundancy error OBs by means of the partial list with the SSL ID W#16#0222. • You obtain information on the current state of the fault-tolerant system by means of the partial list with SSL ID W#16#xy71. • You also obtain data records for the fault tolerant-specific LEDs by means of the partial list with the SSL ID W#16#0174. • The partial list with the SSL-ID W#16#xy75 provides you with information on the status of the communications between the fault-tolerant system and switched DP slaves.
Monitoring during update	The operating system monitors the following four configurable timers: • maximum scan-cycle time extension • Maximum communication delay • Maximum retention time for priority classes > 15 • minimum I/O retention time No additional programming is required for this. For more details refer to Chapter 6.

Restrictions for the Fault-Tolerant CPU Compared to a Standard CPU

Function	Restriction for the Fault-Tolerant CPU
Use of symbol-oriented messages (SCAN)	Use of symbol-oriented messages is not possible.
Warm Restart	A warm restart is not possible. OB 101 is not supported
Multicomputing	Multicomputing is not possible. OB 60 and SFC 35 are not supported
Startup without configuration loaded	Startup without loaded configuration is not possible.
Background OB	OB 90 is not supported.
CPU hardware error	OB 84 is not supported. Should a sporadic interface error occur, the CPU enters the error in the diagnostics buffer and continues running.
Global data communication	GD communication is not possible (neither cyclically nor by calling system functions SFC 60 “GD_SND” and SFC 61 “GD_RCV”)

Function	Restriction for the Fault-Tolerant CPU
Basic communication	Communication functions (system functions) for basic communication are not supported.
Multi-DP master mode	The H-CPUs do not support multi-DP master mode in the REDUNDANT operating mode.
Direct communication between DP slaves	Cannot be configured in STEP 7
Equidistance of DP slaves	No equidistance for DP slaves in the fault-tolerant system
Synchronizing DP slaves	The synchronization of DP slave groups is not possible. SFC 11 “DPSYC_FR” is not supported.
Deactivating and Activating DP Slaves	It is not possible to deactivate and activate DP slaves. SFC 12 “D_ACT_DP” is not supported.
Non-initialized local data	When local data are stored in a data area (memory markers, data blocks, etc.) or if they influence program execution, the local data have to be initialized. Non-initialized local data result in a synchronization error on a fault-tolerant system. The system goes to single mode with one CPU at STOP.
Runtime response	The command execution time in the case of the CPU 414-4H and CPU 417-4H is slightly greater than for the corresponding standard CPU (CPU 414-and CPU 417-4) (see *S7-400 Operations List*). This is to be taken into account in all time-critical applications. You may need to increase the scan cycle monitoring time.
DP cycle time	The DP cycle time is slightly longer for CPU 414-4H and CPU 417-4H than for corresponding standard CPUs.
Delays and blocks	During update: • the asynchronous SFCs for data records are given a negative acknowledgement • messages are delayed • all priority classes up to 15 are initially delayed • communications jobs are refused or delayed • finally all priority classes are blocked. For more details refer to Chapter 6.
S5 connection	It is not possible to connect S5 modules via an adapter module. The connection of S5 modules via an IM 463-2 can only be made in single mode.
CPU as DP Slave	Not possible

Function Modules and Communication Processors Used on the S7-400H

E

You can use the following function modules (FMs) and communication processors (CPs) on a S7-400:

FMs and CPs used centrally

Module	Order no.	Release	one-way	redundant
Counter module FM 450	6ES7450-1AP00-0AE0	Vesion 2 or later	Yes	No
Communication processor CP441-1 (point-to-point connection)	6ES7441-1AA02-0AE0	Vesion 2 or later	Yes	No
	6ES7441-1AA03-0XE0	Version 1 or later with firmware V1.0.0		
Communication processor CP441-2 (point-to-point connection)	6ES7441-2AA02-0AE0	Vesion 2 or later	Yes	No
	6ES7441-2AA03-0XE0	Version 1 or later with firmware V1.0.0		
Communications processor CP443-1 Multi (SINEC H1 (Ethernet), TCP/ISO transport)	6GK7443-1EX10-0XE0	Version 1 or later with firmware V1.0.1	Yes	Yes
	6GK7443-1EX11-0XE0	Version 1 or later with firmware V1.1.0	Yes	Yes
Communications processor CP443-5 Basic (PROFIBUS; S7 communications)	6GK7443-5FX01-0XE0	Version 1 or later with firmware V3.1	Yes	Yes
Communication processor CP443-5 Extended (PROFIBUS; master on PROFIBUS-DP) 1)	6GK7443-5DX02-0XE0	Version 2 or later with firmware V3.2.3	Yes	Yes
Communication processor CP443-5 Extended (PROFIBUS DPV1) 1) 2)	6GK7443-5DX03-0XE0	Version 2 or later with firmware V4.0.0	Yes	Yes

1) Only these modules should be used as external master interfaces on the PROFIBUS DP.

2) Only this module supports DPV1 as external DP master interface (in accordance with IEC 61158/ EN 50170).

FMs and CPs for distributed one-way use

Note

You can use all the FMs and CPs released for the ET 200M with the S7-400H distributed and one-way.

FMs and CPs for distributed switched use

Module	Order no.	Release
Communication processor CP 341-1 (point-to-point connection)	6ES7341-1AH00-0AE0 6ES7341-1BH00-0AE0 6ES7341-1CH00-0AE0	Version 3 or later
	6ES7341-1AH01-0AE0 6ES7341-1BH01-0AE0 6ES7341-1CH01-0AE0	Version 1 or later with firmware V1.0.0
Communication processor CP 342-2 (ASI bus interface module)	6GK7342-2AH01-0XA0	Version 1 or later with firmware V1.10
Communication processor CP 343-2 (ASI bus interface module)	6GK7343-2AH00-0XA0	Version 2 or later with firmware V2.03
Counter module 350-1	6ES7350-1AH01-0AE0 6ES7350-1AH02-0AE0	Vesion 1 or later
Counter module 350-2	6ES7350-2AH00-0AE0	Vesion 2 or later
Controller module FM 355 C	6ES7355-0VH10-0AE0	Vesion 4 or later
Controller module FM 355 S	6ES7355-1VH10-0AE0	Version 3 or later
High Speed Boolean Processor FM 352-5	6ES7352-5AH00-0AE0	Version 1 or later with firmware V1.0.0
Controller module FM 355–2 C	6ES7355-0CH00-0AE0	Version 1 or later with firmware V1.0.0
Controller module FM 355–2 S	6ES7355-0SH00-0AE0	Version 1 or later with firmware V1.0.0

Notice

One–way and switched function and communication modules are **not** synchronized in H system even if there are two of them in the system. Two FM 450 that are both operated one–way, for example, do **not** synchronize their counters.

Connection Examples for Redundant I/O F

This appendix contains examples for connecting redundant I/O. To simplify the illustrations, only the first channel of the two redundant modules is shown in the diagrams.

More connection examples are available in the SIMATIC FAQs at `http://www.siemens.com/automation/service&support` under the keyword “Redundant I/O”.

F.1 SM 321; DI 8 x AC 120/230 V, 6ES7 321-1FF01-0AA0

The following diagram shows the connection of two redundant sensors to two SM 321; DI 8 x AC 120/230 V. The sensors are always connected to Channel 0.

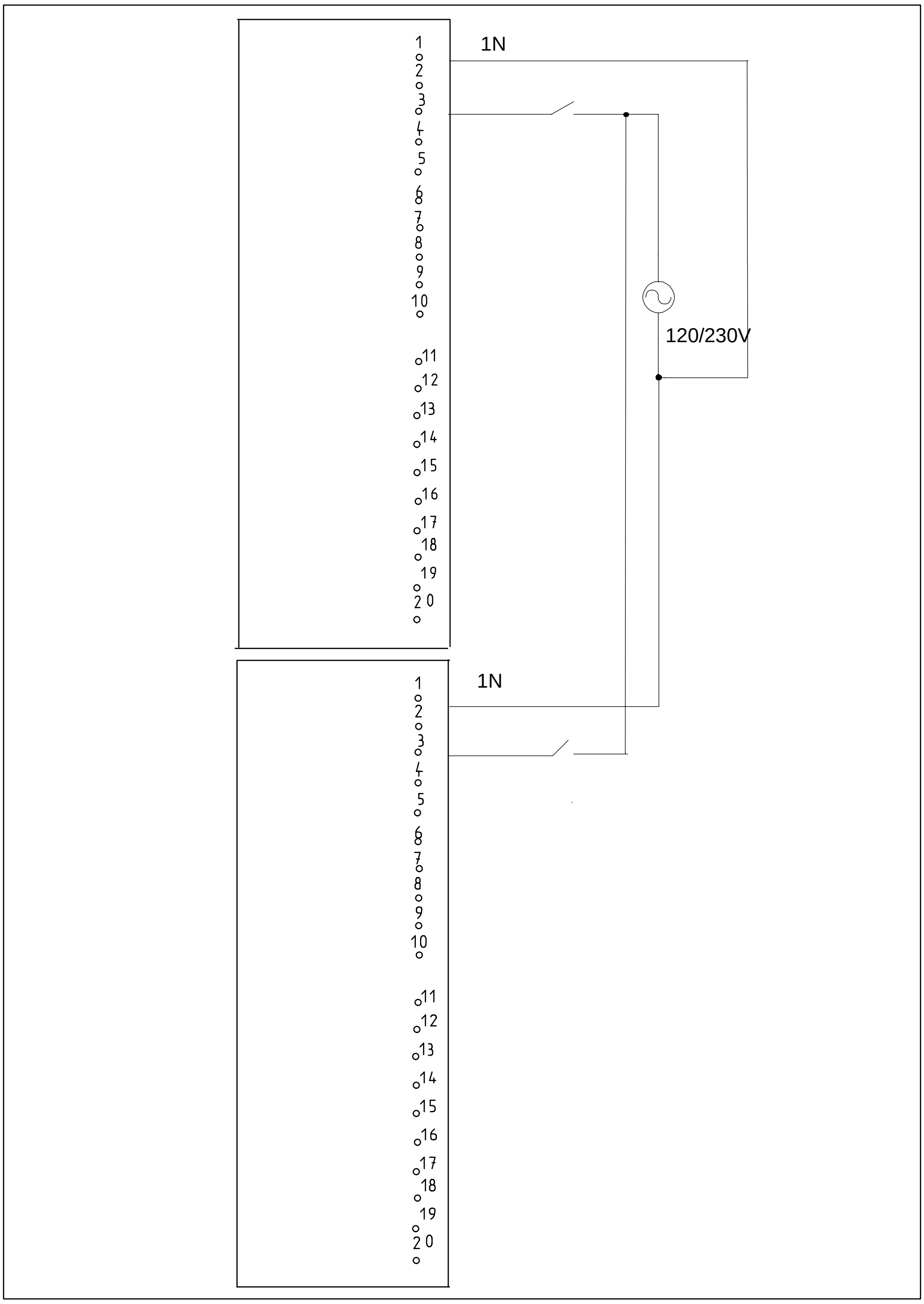


Figure F-1 Connection example SM 321; DI 8 x AC 120/230 V

F.2 SM 322; DO 8 x AC 230 V/2 A, 6ES7 322-1FF01-0AA0

The following diagram shows the connection of an actuator to two redundant SM 322; DI 8 x AC 230 V/2 A. The actuator is always connected to Channel 0.

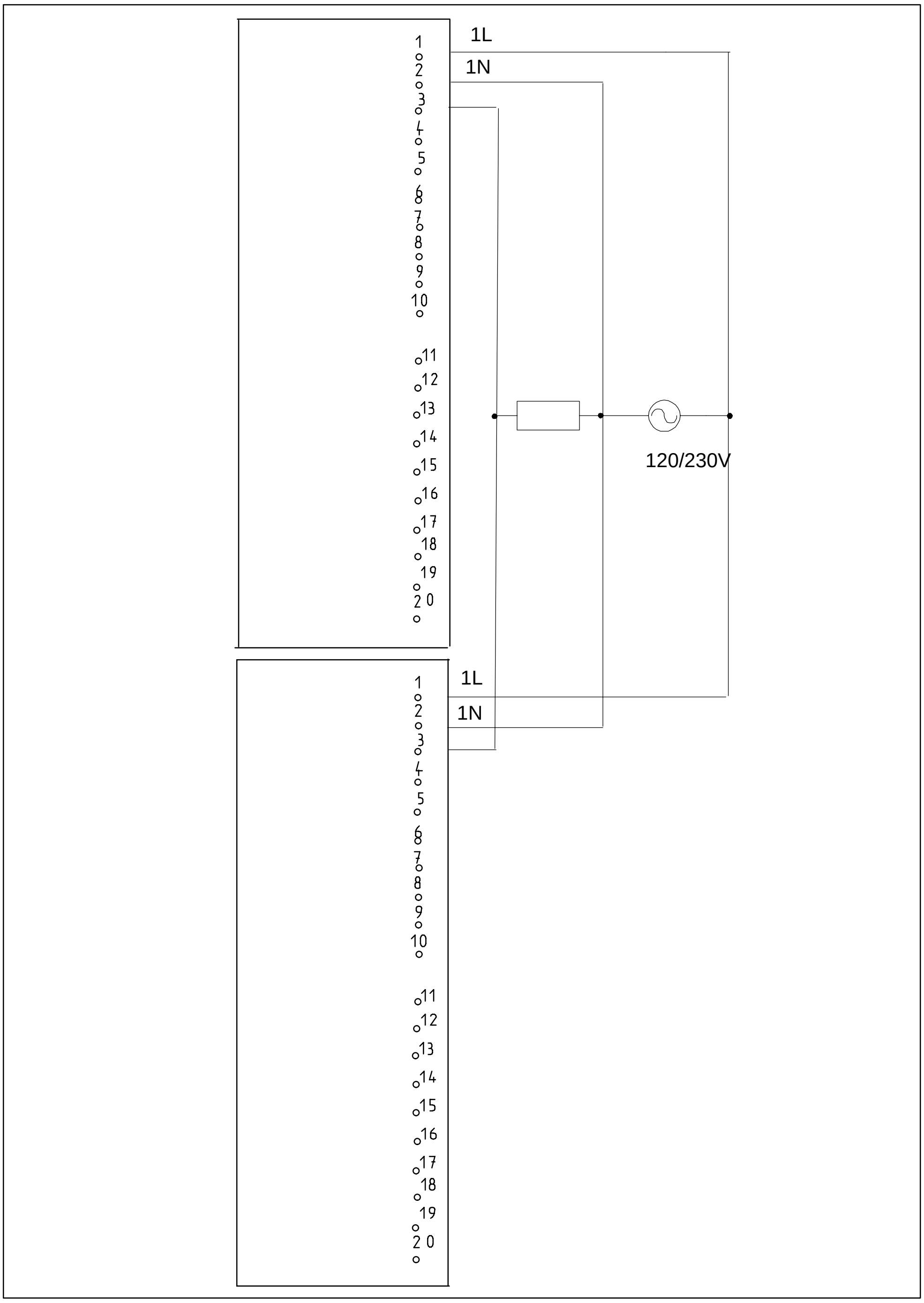


Figure F-2 Connection example SM 322; DO 8 x AC 230 V/2 A

F.3 SM 321; DI 16 x AC 120/230 V, 6ES7 321-1FF00-0AA0

The following diagram shows the connection of two redundant sensors to two SM 321; DI 16 × AC 120/230 V. The sensors are always connected to Channel 0.

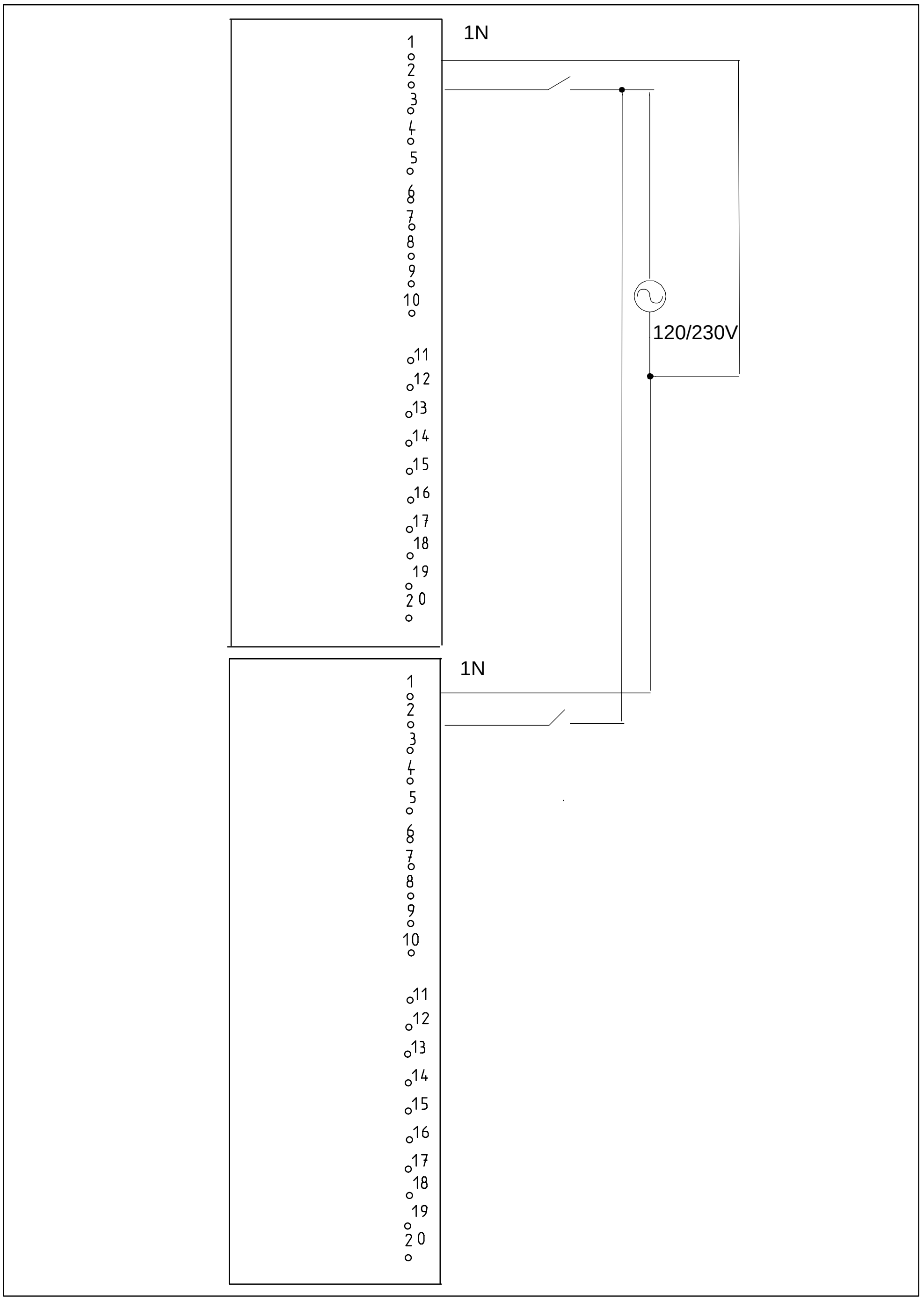


Figure F-3 Connection example SM 321; DI 16 x AC 120/230 V

F.4 SM 331; AI 8 x 16 Bit; 6ES7331-7NF00-0AB0

The following diagram shows the connection of a transmitter to two redundant SM 331; AI 8 x 16 Bit. The transmitter is always connected to Channel 0.

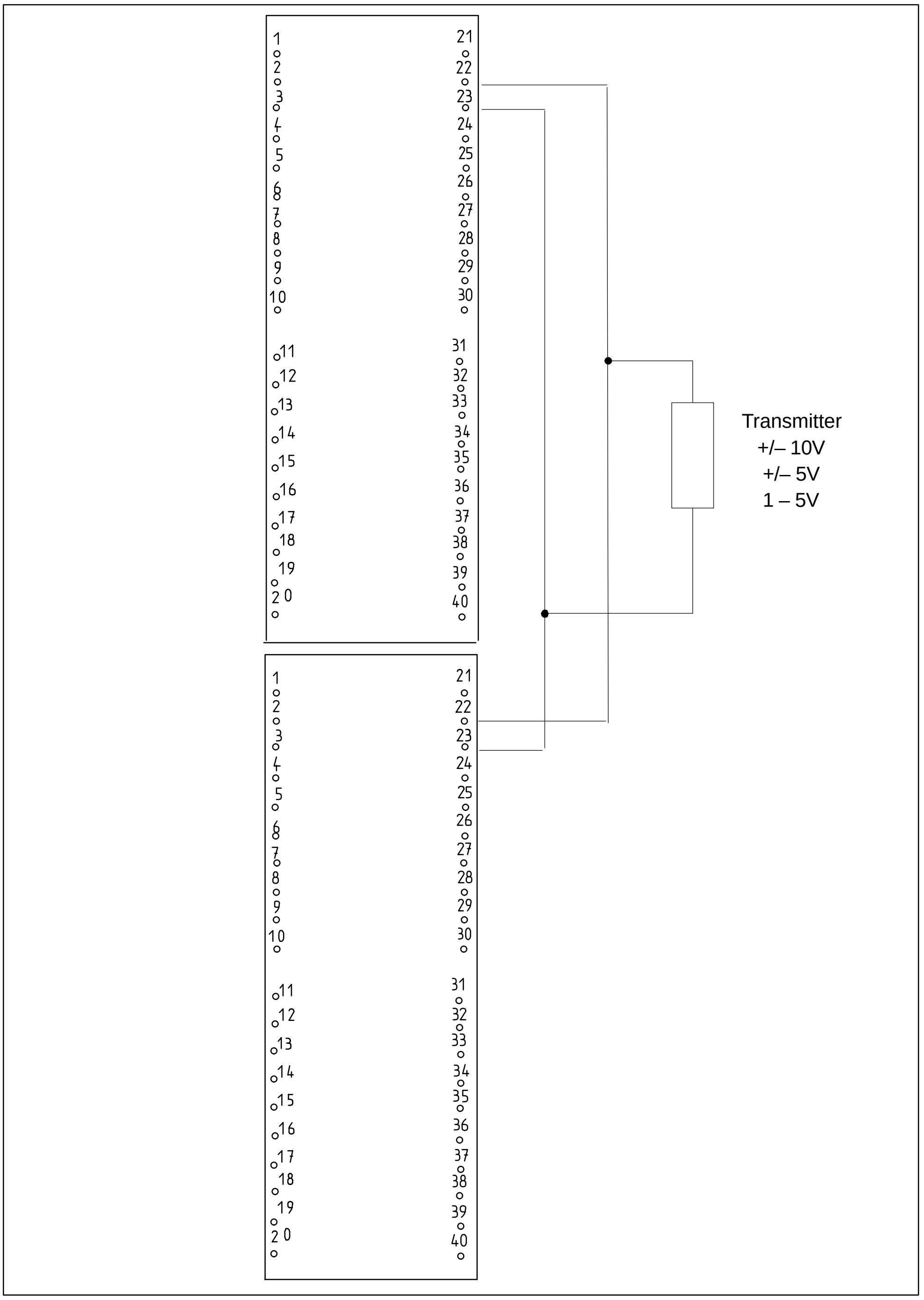


Figure F-4 Connection example SM 331; AI 18 x 16 Bit

F.5 SM 332; AO 4 x 12 Bit; 6ES7 332-5HD01-0AB0

The following diagram shows the connection of an actuator to two redundant SM 332; AO 4 x 12 Bit. The actuator is always connected to Channel 0.

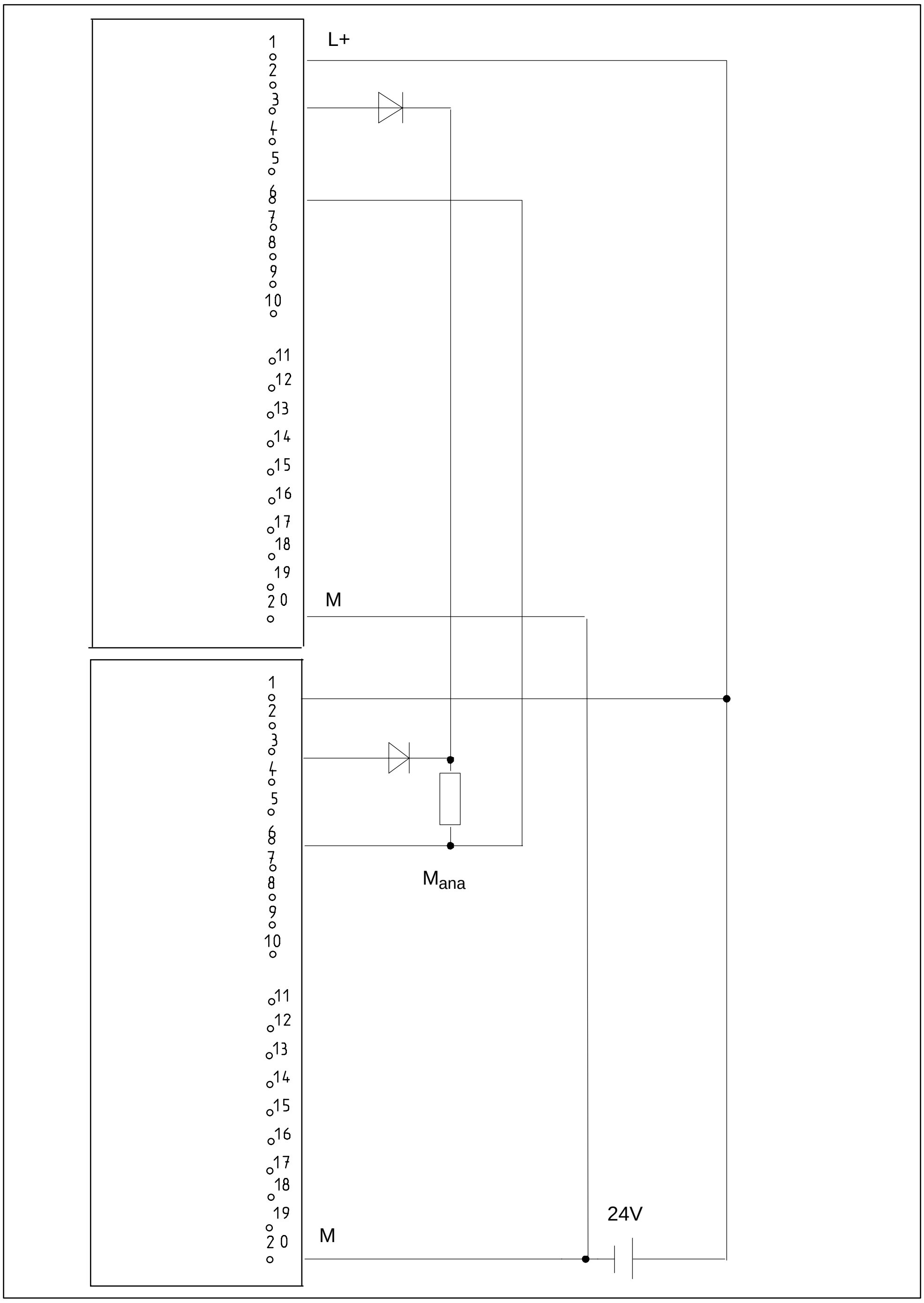


Figure F-5 Connection example SM 332, AO 4 x 12 Bit

F.6 SM 421; DI 32 x UC 120 V, 6ES7 421-1EL00-0AA0

The following diagram shows the connection of two redundant sensors to two SM 421; DI 32 × UC 120 V. The sensors are always connected to Channel 0.

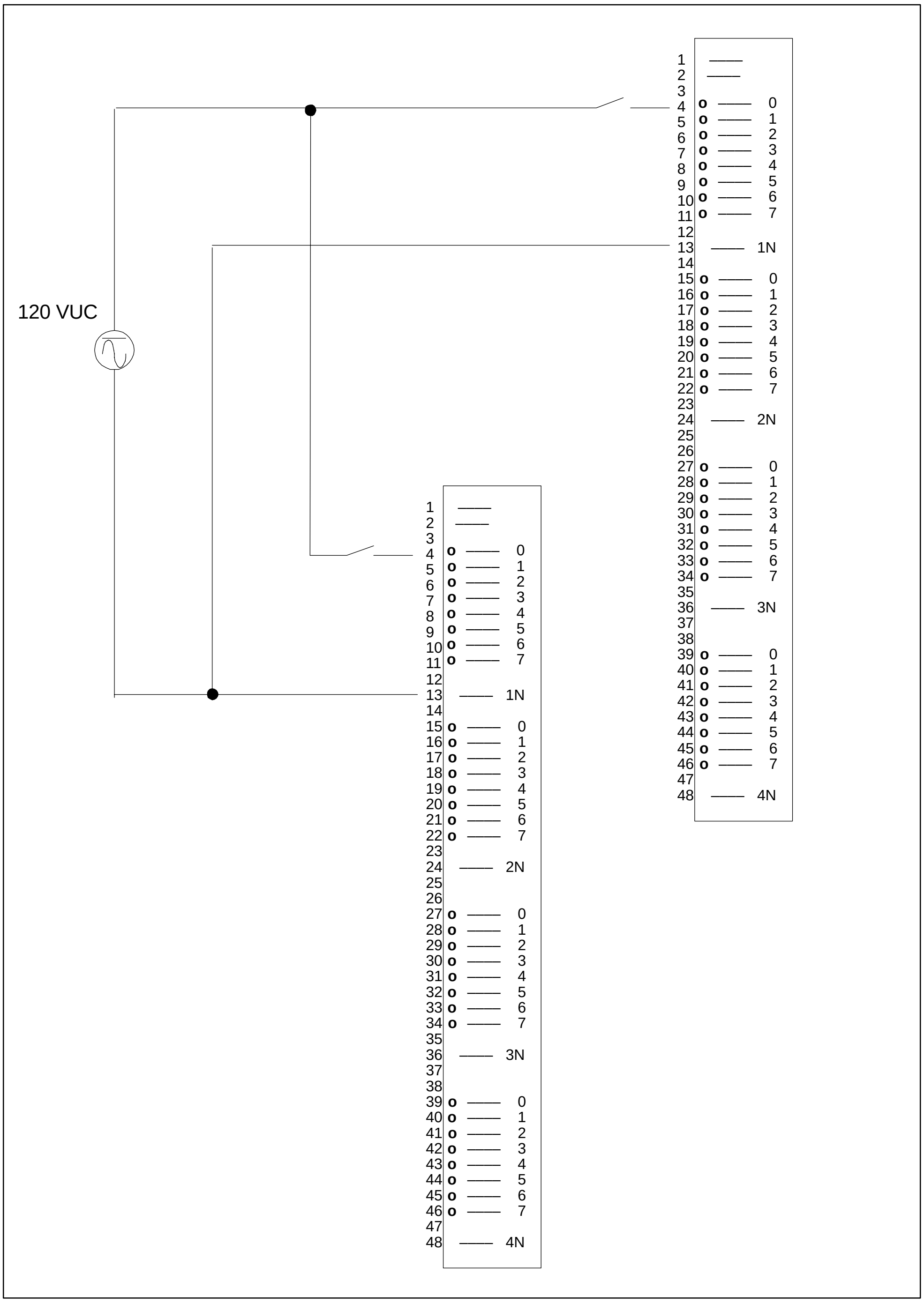


Figure F-6 Connection example SM 421; DI 32 x UC 120 V

F.7 SM 422; DO 16 x AC 120/230 V/2 A, 6ES7 422-1FH00-0AA0

The following diagram shows the connection of an actuator to two redundant SM 422; DO 16 x AC 120/230 V/2 A. The actuator is always connected to Channel 0.

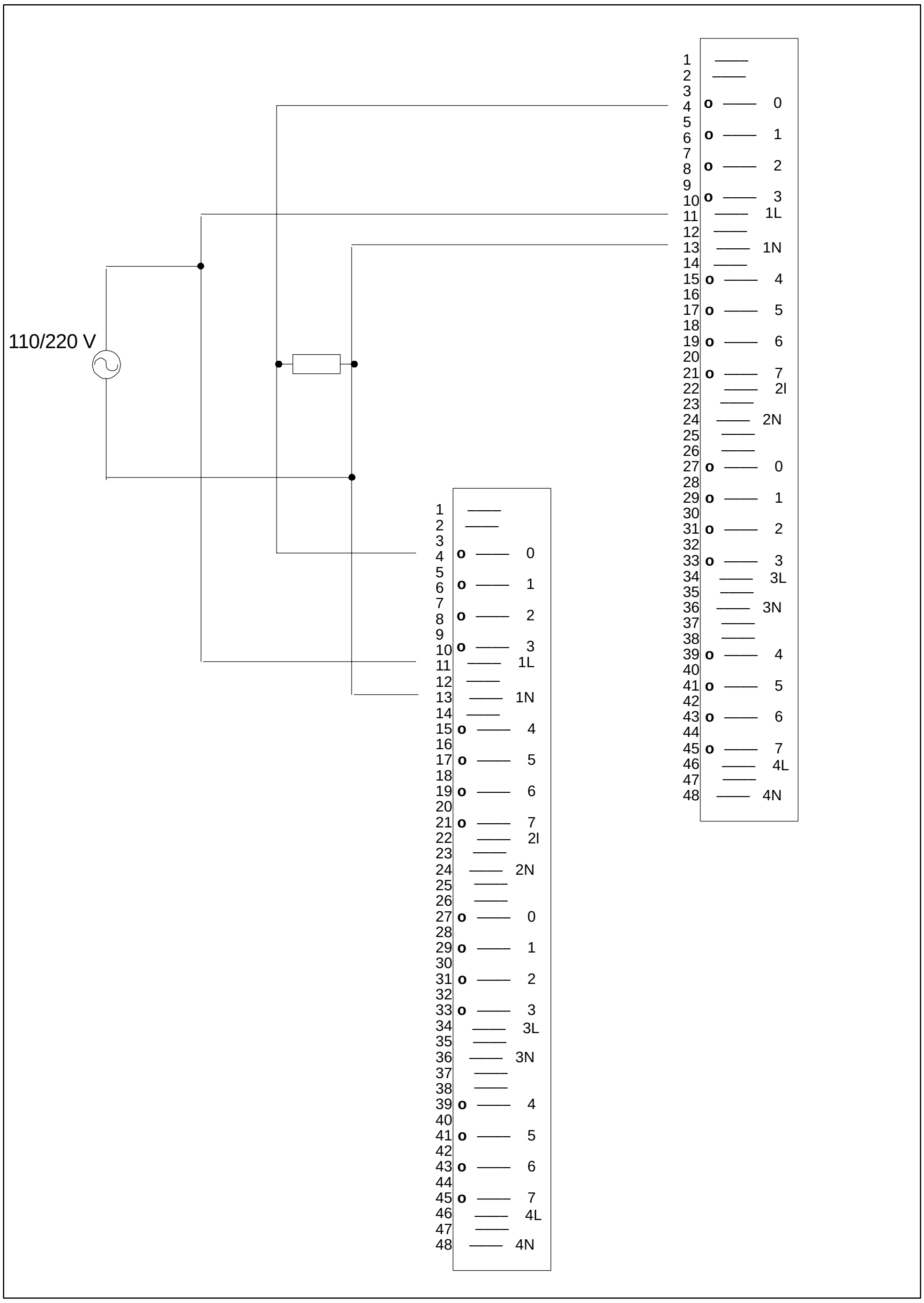


Figure F-7 Connection example SM 422; DO 16 x AC 120/230 V/2 A

F.8 SM 321; DI 16 × DC 24 V, 6ES7 321-7BH00-0AB0

The following diagram shows the connection of two redundant sensors to two SM 321; DI 16 × DC 24 V. The sensors are always connected to Channel 0 or Channel 8.

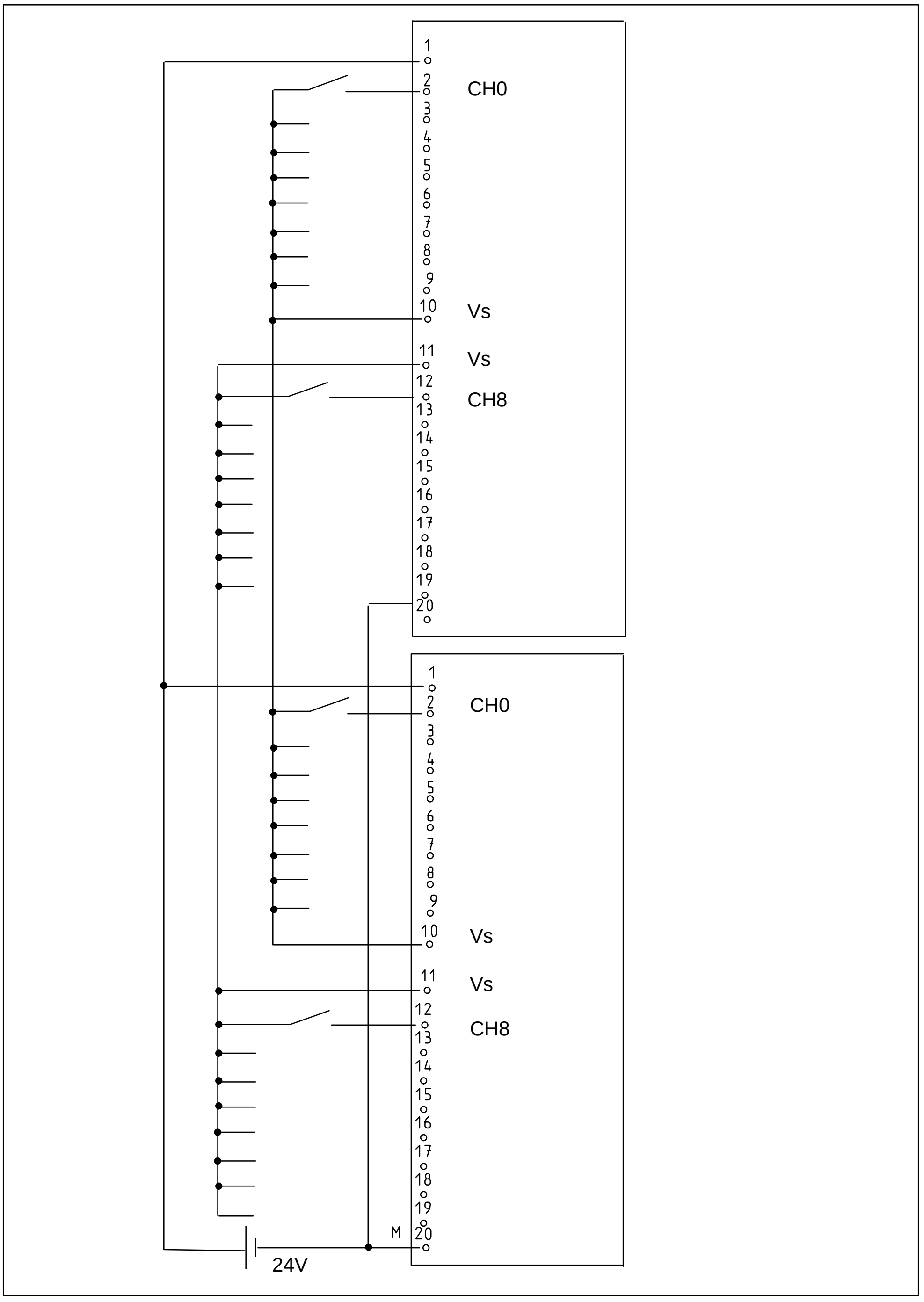


Figure F-8 Connection example SM 321; DI 16 x DC 24V

F.9 SM 322; DO 32 × DC 24 V/0.5 A, 6ES7 322-1BL00-0AA0

The following diagram shows the connection of an actuator to two redundant SM 322; DO 32 × DC 24 V/0.5 A. The actuator is always connected to Channel 1.

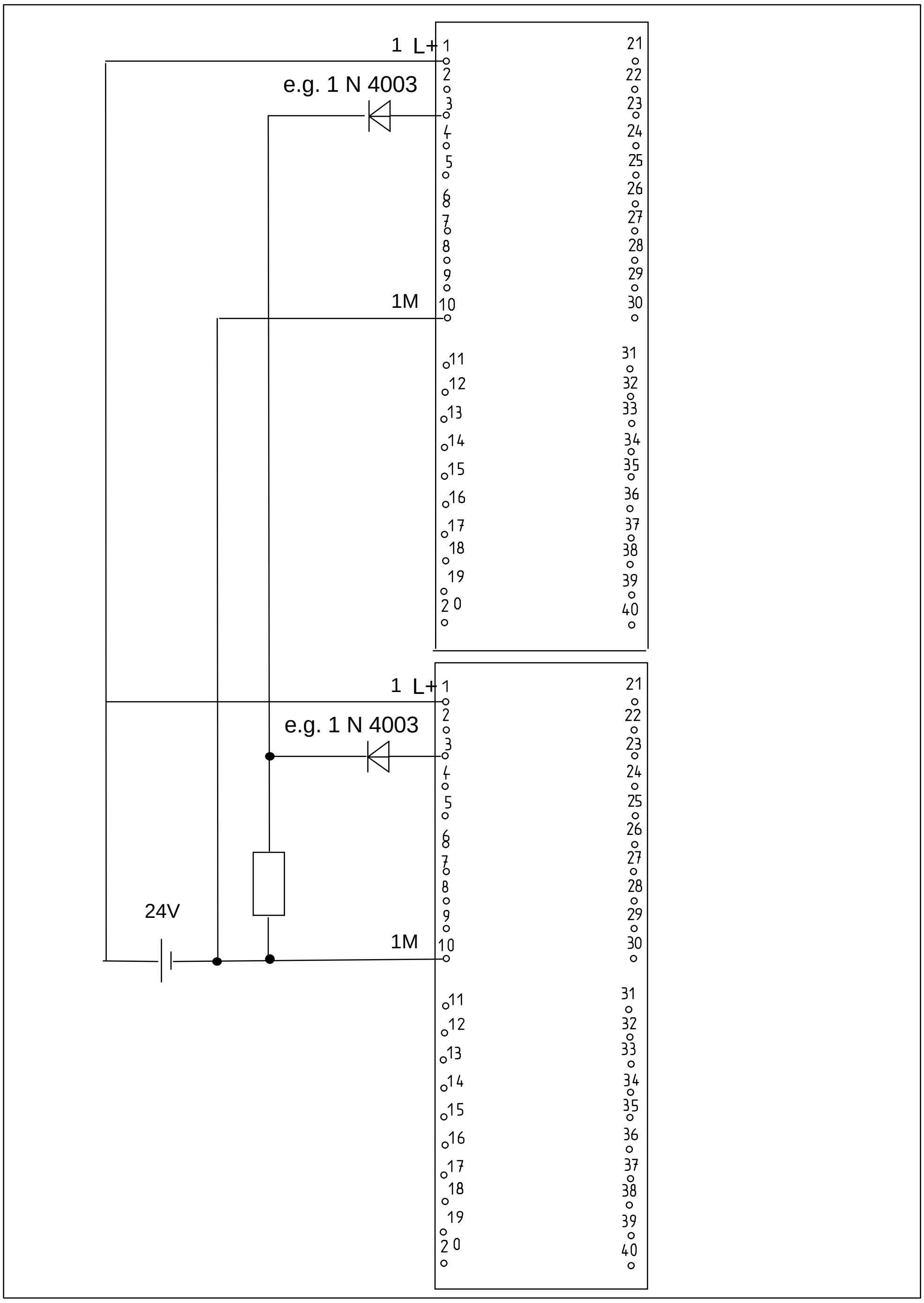


Figure F-9 Connection example SM 322; DO 32 x DC 24 V/0.5 A

F.10 SM 331; AI 8 × 12 Bit, 6ES7 331-7KF02-0AB0

The following diagram shows the connection of a transducer to two SM 331; AI 8 x 12 Bit. The transducer is always connected to Channel 1.

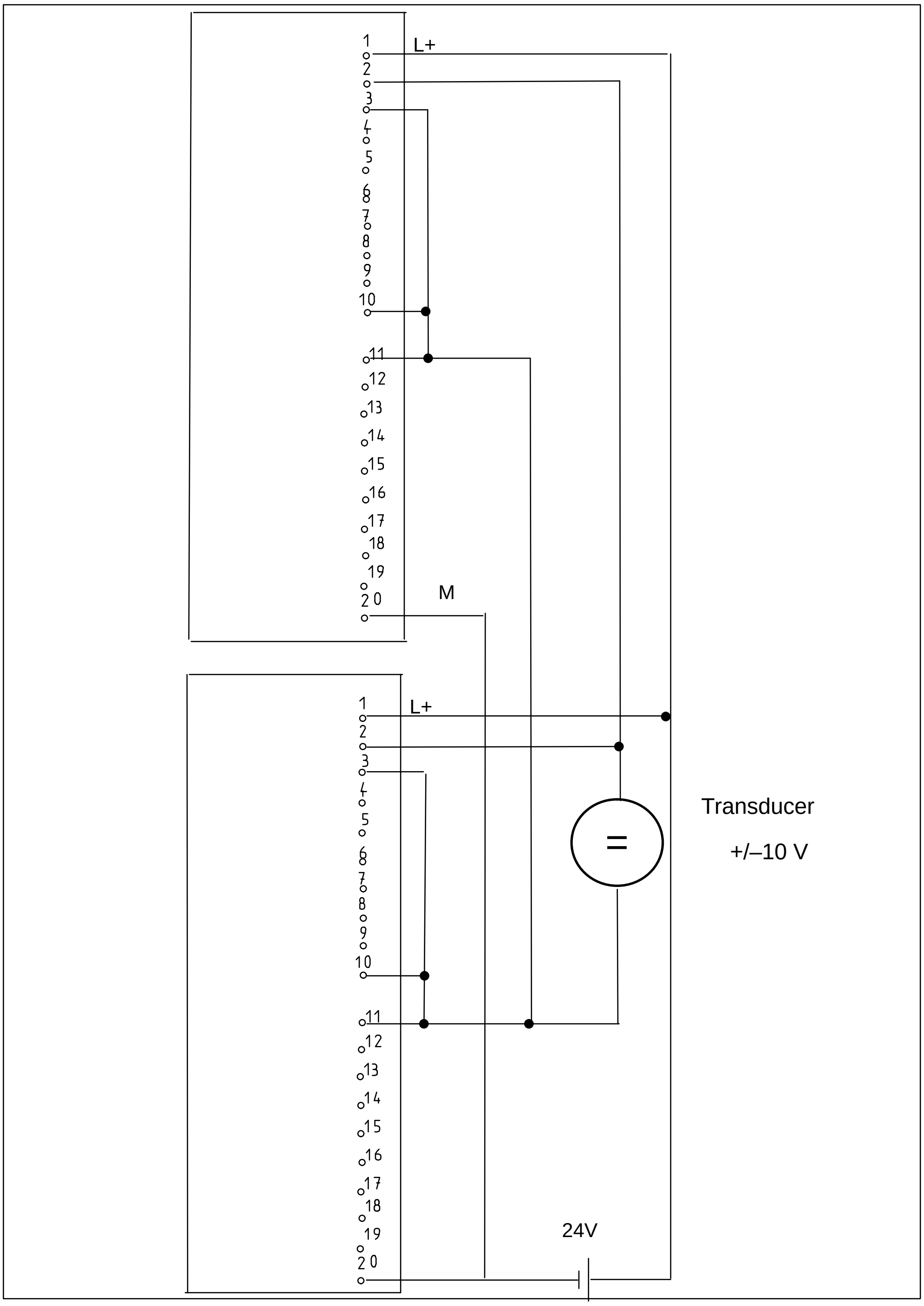


Figure F-10 Connection example SM 331; AI 8 x 12 Bit

Glossary

1–out–of–2 system

See **Dual–channel H system**

Comparison error

An error that may occur while memories are being compared on a fault–tolerant system.

Dual–channel H system

H system with two central modules

Fail–safe systems

Fail–safe systems are characterized by the fact that they remain in a safe state when certain failures occur or go directly to another safe state.

Fault-tolerant systems

Fault–tolerant systems are designed to reduce production downtime. Availability can be enhanced, for example, by means of component redundancy.

H station

A station containing two central processing units (master and standby).

H system

Fault–tolerant system consisting of at least two central processing units (master and standby). The user program is processed identically in both the master and standby CPUs.

I/O, one–way

We speak of a one–way I/O when an input/output module can be accessed by only one of the redundant central processing units. It may be single–channel or multi–channel (redundant).

I/O, redundant

We speak of a redundant I/O when there is more than one input/output module available for a process signal. It may be connected as one–way or switched. Usage: ”redundant one–way I/O” or ”redundant switched I/O”

I/O, single–channel

We speak of a single–channel I/O when – in contrast to a redundant I/O – there is only one input/output module for a process signal. It may be connected as one–way or switched.

I/O, switched

We speak of a switched I/O when an input/output module can be accessed by all of the redundant central processing units on a fault–tolerant system. It may be single–channel or multi–channel (redundant).

Linking

In the link–up system mode of a fault–tolerant system the master CPU and the standby CPU compare the memory configuration and the contents of the loadmemory. If they establish differences in the user program, the master CPU updates the user program of the standby CPU.

Master CPU

The central processing unit that is the first redundant central processing unit to start up. It continues to operate as the master when the redundancy connection is lost. The user program is processed identically in both the master and standby CPUs.

Meantime between failures (MTBF)

The average time between two failures and, consequently, a criterion for the reliability of a module or a system.

Meantime down time (MDT)

The mean down time**MDT** essentially consists of the time until error detection and the time required to repair or replace defective modules.

Meantime to repair (MTTR)

”Meantime to repair” denotes the average repair time of a module or a system, in other words, the time between the occurrence of an error and the time when the error has been rectified.

Redundancy, functional

Redundancy with which the additional technical means are not only constantly in operation but also involved in the scheduled function. Synonym: active redundancy.

Redundant mode

In redundant system mode of a fault–tolerant system the central processing units are in RUN mode and are synchronized over the redundant link.

Redundant systems

Redundant systems are characterized by the fact that important automation system components are available more than once (redundant). When a redundant component fails, processing of the program is not interrupted..

Redundant link

A link between the central processing units of a fault–tolerant system for synchronization and the exchange of data.

Self-test

In the case of fault–tolerant CPUs defined self–tests are executed during startup, cyclical processing and when comparison errors occur. They check the contents and the state of the CPU and the I/Os.

Single mode

In the single system mode of a fault–tolerant system, the master CPU is in RUN mode, whereas the standby CPU is in the STOP, TROUBLE-SHOOTING or DEFECTIVE mode.

Single operation

Referring to single operation, we mean the use of a fault-tolerant CPU in a standard SIMATIC-400 station.

Standby CPU

The redundant central processing unit of a fault–tolerant system that is linked to the master CPU. It goes to STOP mode when the redundancy connection is lost. The user program is processed identically in both the master and standby CPUs.

STOP

With fault–tolerant systems: in the Stop system mode of a fault–tolerant system the central processing units of the fault–tolerant system are in STOP mode.

Synchronization module

An interface module to the redundant link on a fault–tolerant system

TROUBLESHOOTING

An operating mode of the standby CPU of a fault–tolerant system in which the CPU performs a complete self–test..

Update

In the update system mode of a fault–tolerant system, the master CPU updates the dynamic data of the standby CPU (synchronization).

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