SIMATIC S5

S5-115H
Programmable Controller

Manual

Edition 03

EWA 4NEB 811 6111-02b

EWA 4NEB 811 6111-02b

Contents

Page

Page

Page

Page

Page

Page

Page

Page

Appendices

Page

Preface

The S5-115H is a fault tolerant programmable controller for the lower and mid performance ranges. It is at home wherever process downtimes must be avoided.
The S5-115H is always put into service when

- the probability of a controller failure must be reduced to an ablolute minimum
- expensive raw materials cannot withstand process interruptions
- production downtimes cost a great deal of money.

Whether in sophisticated chemical processes, in manufacturing or in power supply systems, the high-availability S5-115H can be assembled economically and with little configuring overhead from standard SIMATC S5 components.
Servicing, corrective maintenance and repairs can be done during operation because the system is able to tolerate the failure of any redundant module.
The S5-115H allows you to utilize the full advantages of the S5-115U-range programmable controllers in high-availability systems. You simply write your process-related control program in the usual way and then enter the configuring data with the COM 115H system software.

Note:
The S5-115H is not a failsafe system despite its fault tolerance and reaction-free design.
It must not be used in plants where a fault in the PLC (e.g. the extremely unlikely total failure of both central controllers) could lead to hazardous operating states and so constitute a danger to personnel, machinery or environment.
For such failsafe automation tasks either a saftey-oriented PLC must be used (e.g. the S5-115F, prototype-tested by the Bavarian Technical Inspectorate), or the S5-115H must incorporate an interlock facility or protective systems which prevent the occurrence of such hazardous operating states.

To put the controller to optimum use, the user requires a certain amount of detailed information.

The primary objective of this manual is to provide this information in compact form without overloading the user with superfluous knowledge. This means:

- Standardization of terminology
- More detailed breakdown of subjects
- Illustration of individual problems
- User-friendly arrangement of the contents
- Numerous examples

The idea behind all this has been to make sure you receive all the information you require for working with the S5-115H. The manual is intended for:

- Users with little knowledge of the subjects covered
- SIMATIC S5 specialists
- Configuring engineers
- Start-up engineers
- Maintenance personnel

However, not all problems that might occur in the many and varied applications can be handled in detail in one manual. If you have a problem that is not discussed in the manual, contact your nearest SIEMENS office or representative. You will find a list in the Appendix.

Introduction

The following pages contain information to help you familiarize yourself with the manual.

Description of contents

The contents of the manual can be broken down subject-wise into a number of blocks:

- Description
  (System overview, technical description)
- Installation and operation
  (installation guidelines, system startup, addressing)
- Use of the COM 115H system software
  (Introduction to COM 115H, configuring the I/Os)
- Debugging facilities
  (Programming test, error diagnostics)
- Special capabilities
  (Anlalog value processing, integral blocks, communications)
- Startup guide
  (Application example)
- Technical Specifications Overview

You will find additional information in tabular form in the appendices.

Please use the forms at the back of the manual for any suggestions or corrections you may have and return the forms to us. This will help us to make the necassary improvements in the next edition.

Training courses

Siemens offer comprehensive training facilities for users of SIMATIC S5.

Details can be obtained from your nearest Siemens office or representative.

Reference literature

The manual contains a comprehensive description of the S5-115H. Subjects that are not specially related to the S5-115H have only been treated in brief, however. More detailed information is available in the following literature:

- **Programmable controls**
  Volume 1: Logic and sequence controls; from the control problem to the control program

  Günter Wellenreuter, Dieter Zastrow
  Brunswick 1987

  Contents:
  - Theory of operation of a programmable control system
  - Theory of logic control technology using the STEP 5 programming language for SIMATIC S5 programmable controllers.

  Order No. ISBN 3-528-04464-0

- **Automating with the S5-115U**
  SIMATIC S5 Programmable Controllers

  Hans Berger
  Siemens AG, Berlin and Munich 1989

  Contents:
  - STEP 5 programming language
  - Program scanning
  - Integral software blocks
  - I / O interfaces

  Order No. ISBN 3-8009-1526-X

Information on the programmable controller hardware is to be found in the following catalogues:

- ST 52.3 ”S5-115U Programmable Controller”
- ST52.4 ”S5-115F Programmable Controller”
- ST 57 ”Standard Function Blocks and Driver Software for Programmable Controllers of the U Range”
- ST 59 ”Programmers”
- ET 1.1 ”ES 902 C Modular 19 in. Packaging System”
- MP 11 ”Thermocouples; compensating boxes”

The relevant manuals are available for other components and modules (e.g. CPs and SINEC L1). Reference is made to these sources of information at various points in the manual.

The S5-115H programmable controller is designed to VDE 0160 and UL 508. The corresponding IEC and VDE (Association of German Electrical Engineers) standards are referred to in the text.

Conventions

In order to improve readability of the manual, a menu-styled breakdown was used, i.e.:

- The individual chapters can be quickly located by means of a thumb register.
- There is an overview containing the headings of the individual chapters at the beginning of the manual.
- Each chapter is preceeded by a breakdown to its subject matter.
  The individual chapters are subdivided into sections. Boldface type is used for further subdivisions.
- Figures and tables are numbered separately in each chapter. The page following the chapter breakdown contains a list of the figures and tables appearing in that particular chapter.

Certain conventions were observed when writing the manual. These are explained below.

- A number of abbreviations have been used.
  Example: Programmer (PG)
- Footnotes are identified by superscripts consisting of a small digit (e.g. ”1”) or ”*”. The actual footnote is generally at the bottom left of the page or below the relevant table or figure.
- Cross references are shown as follows:
  ”(Section 7.3.2)” refers to section 7.3.2.
  No references are made to individual pages
- All dimensions in drawings etc. are given in millimetres followed by inches in brackets. Example: 187 (7.29).
- Values may be expressed in binary, decimal or hexadecimal form. The number system in question is indicated with a subscript, e.g. $F000_H$.
- Information of particual importance is framed in grey-bordered rectangles. The upper border indicates the importance of the information

Manuals can only describe the current version of the programmer. Should modifications or supplements become necessary in the course of time, a supplement will be prepared and included in the manual the next time it is revised. The relevant version or edition of the manual appears on the cover. The present manual is edition ”3”. In the event of a revision, the edition number will be incremented by ”1”.

Safety-Related Guidelines for the User

This document provides the information required for the intended use of the particular product. The documentation is written for technically qualified personnel.

Qualified personnel as referred to in the safety guidelines in this document as well as on the product itself are defined as follows.

- System planning and design engineers who are familiar with the safety concepts of automation equipment.
- Operating personnel who have been trained to work with automation equipment and are conversant with the contents of the document in as far as it is connected with the actual operation of the plant.
- Commissioning and service personnel who are trained to repair such automation equipment and who are authorized to energize, de-energize, clear, ground, and tag circuits, equipment, and systems in accordance with established safety practice.

Danger Notices

The notices and guidelines that follow are intended to ensure personal safety, as well as protect the products and connected equipment against damage.

The safety notices and warnings for protection against loss of life (the users or service personnel) or for protection against damage to property are highlighted in this document by the terms and pictograms defined here. The terms used in this document and marked on the equipment itself have the following significance.

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 or property damage can result if proper precautions are not taken.

Note

contains important information about the product, its operation or a part of the document to which special attention is drawn.

Proper Usage

Warning

- The equipment/system or the system components may only be used for the applications described in the catalog or the technical description, and only in combination with the equipment, components, and devices of other manufacturers as far as this is recommended or permitted by Siemens.
- The product will function correctly and safely only if it is transported, stored, set up, and installed as intended, and operated and maintained with care.

1 System Overview

Figures

Tables

1 System Overview

The S5-115H programmable controller is used worldwide in almost all fields in a wide range of applications. Each of its modular components handles a specific task. Therefore you can expand the system according to your needs using virtually only SIMATIC S5 standard modules. Various communications systems pass information among multiple controllers. The S5-115H system provides operator panels, monitoring devices, and various programmers to suit your needs. The STEP 5 programming language and an extensive software catalog make programming easy.

1.1 Application

Many different industries use the S5-115H. Even though each automation task is different, the S5-115H adapts optimally to the most varied jobs, whether they involve simple open-loop control or complex closed-loop control.

Present areas of application include the following:

- Automobile Industry
  Automatic drill, assembly and test equipment, painting facilities, shock absorber test bays

- Plastics Industry
  Blow, injection, and thermal molding machines, synthetics production systems

- Heavy Industry
  Molding equipment, industrial furnaces, rolling mills, automatic pit shaft temperature control systems

- Chemical Industry
  Proportioning and mixing systems

- Food and Beverages Industry
  Brewery systems, centrifuges

- Machinery
  Packing, woodworking, and custom-made machines, machine controls, machine tools, drilling mills, fault alarm centers, welding technology

- Building Services
  Elevator technology, climate control, ventilation, lighting

- Transport Systems
  Transport and sorting equipment, high-bay warehouses, conveyor and crane systems

- Energy, Gas, Water, Air
  Pressure booster stations, standby power supply, pump control, water and air treatment, filtering and gas recovery systems

1.2 Redundancy Structure

1.2.1 Hardware

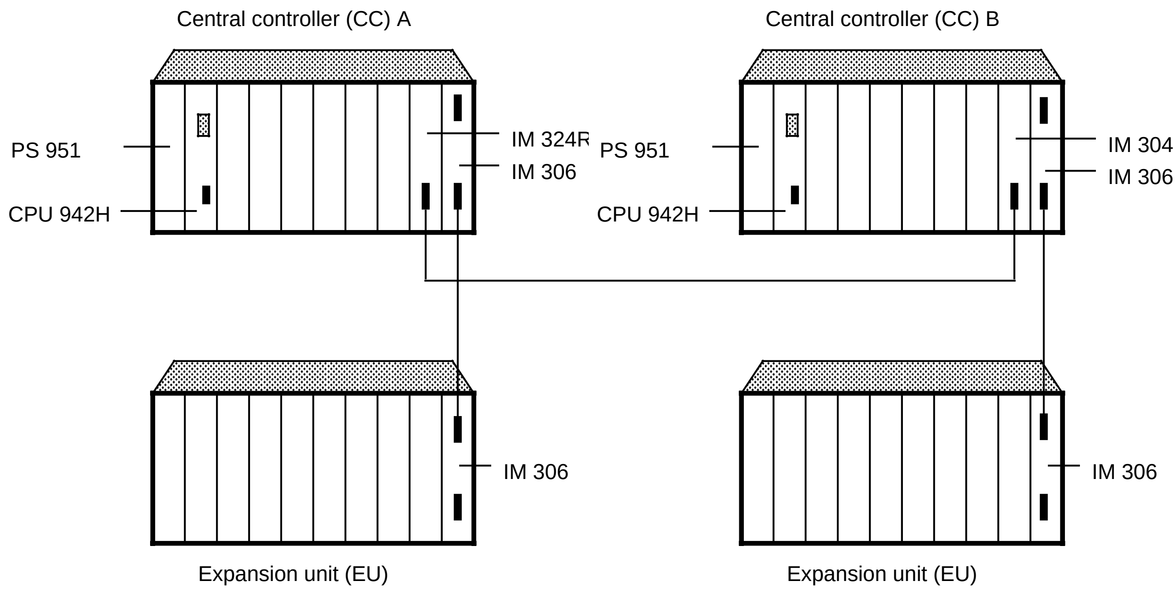
The CPU 942H and the two-channel I/Os have a redundant structure. The two CCs, referred to from here on in as subunits, are connected over a high-speed parallel interface. Operating system and application program are the same in both subunits.

The parallel interface enables the CPUs to synchronize, compare images and interchange data.Synchronization is event-dependent, and is always performed when events (commands) are encountered which may produce different states in the CPUs. Examples of such events are

- direct access to I / Os
- process interrupts
- timed interrupts
- block changes

Both CPUs work with the same control programs, which means that programs are executed in coincidence. In contrast, the operating system does not execute in coincidence. In this way, the operating system can also control unsymmetrical subunit hardware structures, such as

- a programmer on one subunit
- a SINEC L1 LAN on one subunit
- single-channel, non-redundant I / Os
- switched I / Os for higher availability applications.



Features:

- Event-synchronous processing of the application program
- Data interchange over high-speed parallel interface
- Upgraded operating system: Self-test, time synchronization, image comparison
- Bumpless switchover from master to standby controller

Figure 1-1. Hardware Structure Overview

1.2.2 Additional Operating System Tasks

The operating system used in the S5-115H is an S5-115U operating system which was upgraded to include redundancy functions.
The additional tasks performed by the operating system in the S5-115H include the following:

- Subunit synchronization
  - Synchronization of the control program
  - Standardization of the input data
  - Standardization of the timers used in the control program
  - Transfer of data from components interfaced to only one subunit (such as programmers, single-port SINEC L1 bus, single-channel I / Os) to the other subunit
- Components Test
  - Cyclic I / O module test with discrepancy analysis of the input signals
  - Testing of functional units such as processors, memory, parallel link and I / Os
- Error analysis, error processing and error handling for
  - Subunit synchronization
  - Components test
  - CPU defects
  - Incorrect programming, configuring, and handling
  - Power failures
- Error localization on redundant digital modules in the event of
  - permanent "0"
  - permanent "1"

1.2.3 Control Programs

You write your control program in the easily assimilated STEP 5 programming language. The instruction set is the same as that for the S5-115U.
You need only one statement (e.g. A I 1.0) in your program to scan a two-channel redundant input because the operating system standardizes the signal states in both CPUs. By the same token, you need only one statement in the control program (e.g. S Q 4.0) to output a control command to a two-channel output.
Please note that the typical statement execution times may be increased.(Appendix A.2)

1.2.4 Programmer Functions

In addition to programming in the STEP 5 language and startup aids (such as "Status"), functions already familiar to you from the S5-115U, the programmer can be used in conjunction with the S5-115H for

- initializing operating system parameters
- initializing I / Os
- output of error messages in plaintext.

These additional functions are made possible by the COM 115H software, which provides a modern, menu-driven operator interface.

1.3 System Components

The S5-115H system is made up of various modular components, as pictured in Figure 1-2. These components include the following:

- power supply modules
- central processing units
- input and output modules
- intelligent input / output modules
- communications processors
- interface modules

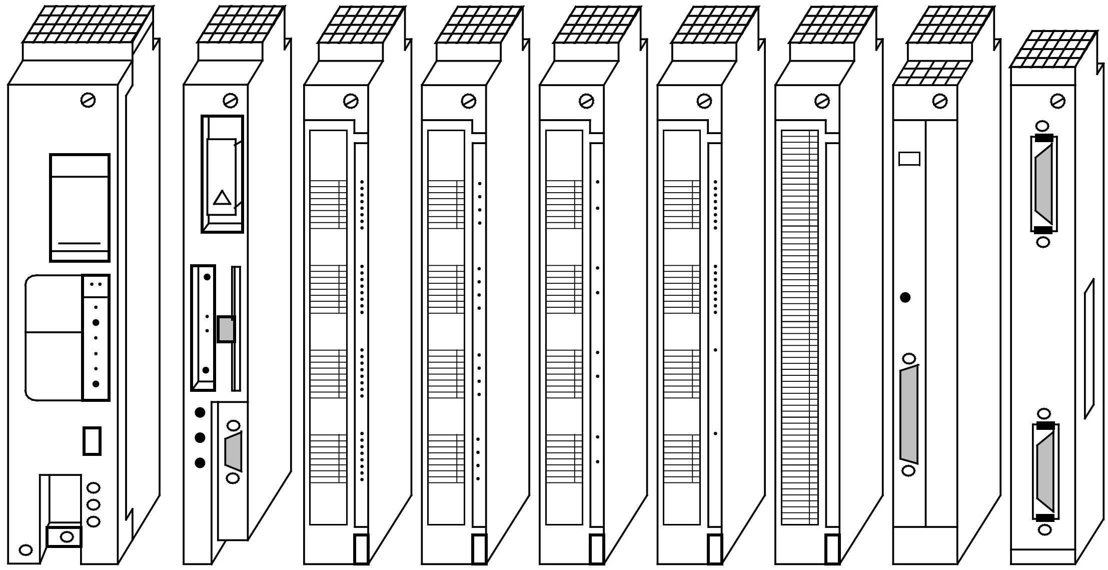


Figure 1-2. S5-115H Components

1.3.1 Power Supply

The power supply modules (PS) convert the external power supply into the internal operating voltages. Supply voltages for the S5-115H include 24 V DC, 115 V AC, and 230 V AC.

Screw-type terminals connect the power supply lines to the bottom of the PS. Three maximum output currents are available. Choose 3 A, 7 A, or 15 A according to the number of modules you have or according to their power consumption. A fan is not necessary for output currents up to 7 A.
A lithium battery backs up the program memory (RAM) and the internal retentive flags, timers, and counters in the event of a power failure, An LED signals battery failure. If you change the battery when the power is shut off, connect a back-up voltage from an outside source to the sockets povided for this purpose on the power supply module.

1.3.2 Central Processing Units

The central processing unit (CPU) is the ”brain” of the programmable controller. It executes the control program.

The CPU 942H, in conjunction with analog modules and the appropriate software, can be used for PID control, as a PID algorithm is an integral part of its operating system. Sampling times of up to 100 ms are possible for a control loop. As many as eight control loops can be implemented.

1.3.3 Input and Output Modules

Inplut and output modules are the interfaces to the sensors and actuators of a machine or controlled system.
The following features make the S5-115H modules easy to handle:
- fast installation
- mechanical coding
- large labeling areas

Digital Modules

Digital modules conform to the voltage and current levels of your machine. You do not have to adapt the existing level to the programmable controller. The S5-115H adapts itself to your machine.
Digital modules have the following convenient features:
- connection of signal lines via front connectors
- a choice of screw-type or crimp snap-in connections

Analog Modules

As a programmable controller's degree of performance increases, so does the significance of its analog value processing. The significance of the analog input and output modules increases accordingly.

Analog modules handle mainly closed-loop control tasks, such as automatic level, temperature, or speed control.

The S5-115H offers floating and non-floating analog input modules. They use one range card for every four channels to adapt the desired signal level.

This feature allows you to do the following:

- have up to four different measuring ranges on one module, depending on the number of channels a module has
- change the measuring ranges simply by exchanging range cards

Three analog output modules cover the various voltage or current ranges of analog actuators

1.3.4 Intelligent Input / Output Modules

Counting rapid pulse trains, detecting and processing position increments, measuring time and speed, closed-loop control, and positioning are just a few of many time-critical jobs. The central processor of a programmable controller usually cannot execute such jobs fast enough in addition to its actual control task. The S5-115H provides intelligent input / output modules (IPs) to handle these time-critical jobs. Use these modules to handle measuring, closed-loop control, and open-loop control tasks rapidly in parallel to the program. Most of the modules have their own processor to handle tasks independently. All these modules have a high processing speed and are easy to handle. Standard software puts them into operation.

1.3.5 Communications Processors

The S5-115H offers a number of special communications processors (CPs) to make communication easier between man and machine or machine and machine.

The two main groups of CPs are as follows:

- CPs for local area networks
- CPs for linking, signalling, and logging

1.4 Expansion Capability

If the connection capability of one central controller (CC) is no longer sufficient for your machine or system, increase the capacity with expansion units (EUs).

Interface modules connect a CC to EUs and connect EUs to each other. Choose an interface module suitable to the controller configuration you need.

1.4.1 Centralized Configuration

A centralized configuration allows you to connect up to three EUs to one CC. The interface modules for this purpose connect bus lines and supply voltage to the EUs. The EUs in such configurations therefore need no power supplies of their own.
In this way you can connect up to 3 expansion units to one central controller.
The cables between the individual controllers have a total maximum length of 2.5 m (8.2 ft).

1.4.2 Distributed Configuration

A distributed configuration allows you to relocate expansion units nearer to the sensors and actuators of your machine.
Distributed configurations reduce cabling costs for these devices.

1.4.3 Switched Configuration

This configuration always requires an ER701-3LH expansion rack. This rack contains the modules for switched I / O operation. Both central controllers can drive the I / Os.

1.5 Communications Systems

Controller flexibility is critical to manufacturing productivity. Complex control tasks can be divided and distributed over several controllers to achieve the greatest flexibility possible.

Distribution offers the following advantages:
- small units that are easier to manage. You can plan, start up, diagnose, modify, and operate your system more easily, and observe the entire process more easily
- enhanced system availability because, if one unit fails, the rest of the system continues to function

Information must flow between distributed controllers to ensure the following:
- data exchange between programmable controllers
- central monitoring, operation, and control of manufacturing systems
- collection of management information such as production and warehouse data

For this reason, we offer the following communications facilities for the S5-115H programmable controller:
- point-to-point connection with the CP 523, CP 524, and CP525 communications processors
- local area network communications via SINEC L1 and
- SINEC H1

1.6 Operator-Process Communication, Monitoring, and Programming

Today, users expect good process visualization with the capability to intervene where necessary. Previously, they had to hard wire indicating lights, switches, potentiometers, and pushbuttons, even for simple requirements. For more complex processes, they had to use expensive video display terminals. Inflexible or expensive solutions are now a thing of the past.

In price and performance, the S5-115H offers you a graduated spectrum of operator panels and monitoring devices - from a small hand-held operator panel to a convenient color vidio display terminal.

The S5-115H enables you to react optimally to the most varied automation requirements, even where programming is concerned.

To help you with this, a graduated and compatible spectrum of programmers is available.

All the programmers feature high performance, simple handling, user-friendly operator prompting, and the standard, easily learned STEP 5 programming language. For details of our range of programmers, see Catalog ST59.

1.7 Software

Until now, prices for hardware components tended to drop constantly and prices for software tended to increase. The reasons were as follows:

- the processes to be automated became more and more complex
- safety requirements increased
- personnel costs increased
- ergonomic demands increased

Siemens has put an end to this trend. SIMATIC provides the following solutions to keep software costs down:

- the user-friendly STEP 5 programming language with its various methods of representation and convenient structuring capabilities
- an extensive software catalog
- user-friendly programmers

1.8 Accessories

The following accessories help you to optimize and expand the configurations of your control system.

1.8.1 Backup Battery

The backup battery ensures complete retention of both program and data, even when the S5-115H is switched off. A new battery provides backup for approximately two years.

Note:
The existing regulations for the transport of dangerous materials must be observed when transporting lithium batteries!

1.8.2 Memory Submodules

Three types of memory submodules are available for the S5-115H for storing the control program or for transferring programs to the programmable controller:

- EPROM submodules are used as read-only memory. EPROMs can be erased only with a UV eraser.
- EEPROM submodules are used as read-only memory. They can be programmed and erased using programmers.
- RAM submodules are used not only as program store, but also to test the control program during the start-up phase. RAMs should be used for storing programs only when a backup battery has been installed.

All submodules are available with different storage capacities (see Table 1-1).

Table 1-1. Permissible Memory Submodules

Memory Submodule		Order No.	Programming No.	Orga-niza-tion
Type	Capacity*			
EPROM	8 Kbytes	6ES5 375-0LA15	11	byte
EPROM	16 Kbytes	6ES5 375-0LA21	12	byte
EPROM	32 Kbytes	6ES5 375-0LA41	17	byte
EEPROM	8 Kbytes	6ES5 375-0LC31	211	byte
EEPROM	16 Kbytes	6ES5 375-0LC41	212	byte
RAM	8 Kbytes	6ES5 375-0LD11	---	---
RAM	16 Kbytes	6ES5 375-0LD21	---	---
RAM	32 Kbytes	6ES5 375-0LD31	---	---

* 2 Kbytes is equivalent to approximately 1000 STEP 5 statements.

Note:
Always make sure that the memory submodules in both CPUs have the same Order Number.

2 Technical Description

Figures

Tables

2 Technical Description

This chapter desribes the design and principle of operation of an S5-115H with accessories.

2.1 Modular Design

The S5-115H consists of various functional units that can be combined to suit the particular problem.

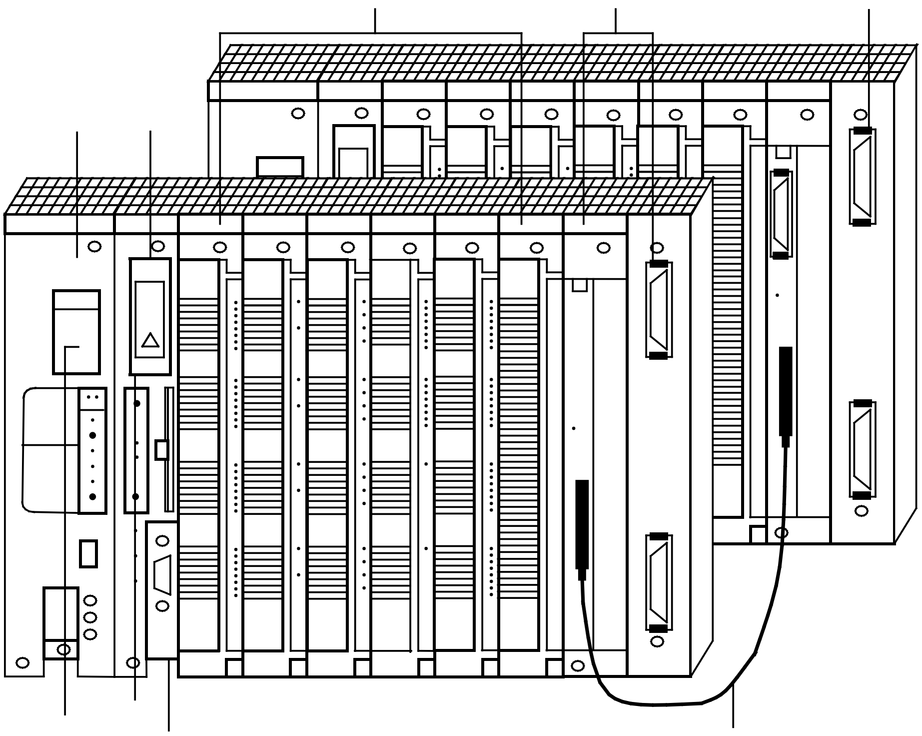


Figure 2-1. The S5-115H (Central Controller)

The numbered information below briefly describes the most important components of the S5 115H:

Power Supply Module (PS 951)
The PS 951 power supply module generates the operating voltage for the PLC from the 115 V AC or 24 V DC power system voltages. This module uses a battery or an external power supply to back up the RAM.
The PS power supply module also performs monitoring and signalling functions.

Central Processing Unit (CPU)
The central processing unit reads in input signal states, processes the control program, and controls the outputs. In addition to program scanning functions, the CPU provides internal flags, timers, and counters. You can preset the restart procedure and diagnose errors using the CPU's LEDs. Use the Overall Reset switch on the CPU to delete the RAM contents (Overall & Reset).
Use a programmer or a memory submodule to transfer the control program to the CPU.

Input / Output Modules (I / Os)
- Digital input modules adapt digital signals, e. g. from pressure switches or BERO proximity switches, to the internal signal level of the S5-115H.
- Digital output modules convert the internal signal level of the S5-115H into digital process signals, e. g. for solenoid valves.
- Analog input modules adapt analog process signals, e. g. from transducers or resistance thermometers, to the S5-115H, which functions digitally.
- Analog output modules convert internal digital values of the S5-115H to analog process signals, e. g. for speed controllers.

Interface Modules (IMs)
The S5-115H is installed on mounting racks with a specific number of mounting locations (slots). A configuration comprising power supply, CPU, and input / output modules is called a central controller. If the slots on the central controller's mounting rack are insufficient, you can install expansion units (systems without CPUs) on additional mounting racks. Interface modules connect an expansion unit to a central controller.

Mounting Racks
A mounting rack consists of an aluminum rail to which all the modules are fastened mechanically. It has one or two backplanes that connect the modules to each other electrically.

TTY Interface
Connect a programmer or an operator panel at the TTY interface. You can also set up a SINEC L1 interface here.

Memory Subdmodules

Battery Compartment

Parallel link

Not shown:

Communications Processors (CPs)
Communications processors can be used in the S5-115H for communication between man and machine and between machines. Communications processors perform the following functions:
- operator monitoring and control of machine functions or process sequences;
- reporting and listing of machine and process states.

You can connect various peripheral devices to these processors, e. g. printers, keyboards, CRTs , and monitors as well as other controllers and computers.

Not shown:

Intelligent Input / Output Modules (IPs)
Intelligent input / output modules are available for handling special tasks
- counting rapid pulse trains;
- measuring and processing positioning increments;
- measuring speed and time;
- controlling temperatures and drives; and so on

Intelligent input / output modules generally have their own processor and thus off-load the CPU. Consequently, they can process measuring and open- and closed-loop control tasks quickly while the CPU handles other jobs.

2.2 Function Units and Operating Principle of the Programmable Controller

The follwing sections describe:
- the PLC's function units
- the PLC's method of operation
- processing of the control program

2.2.1 Function Units

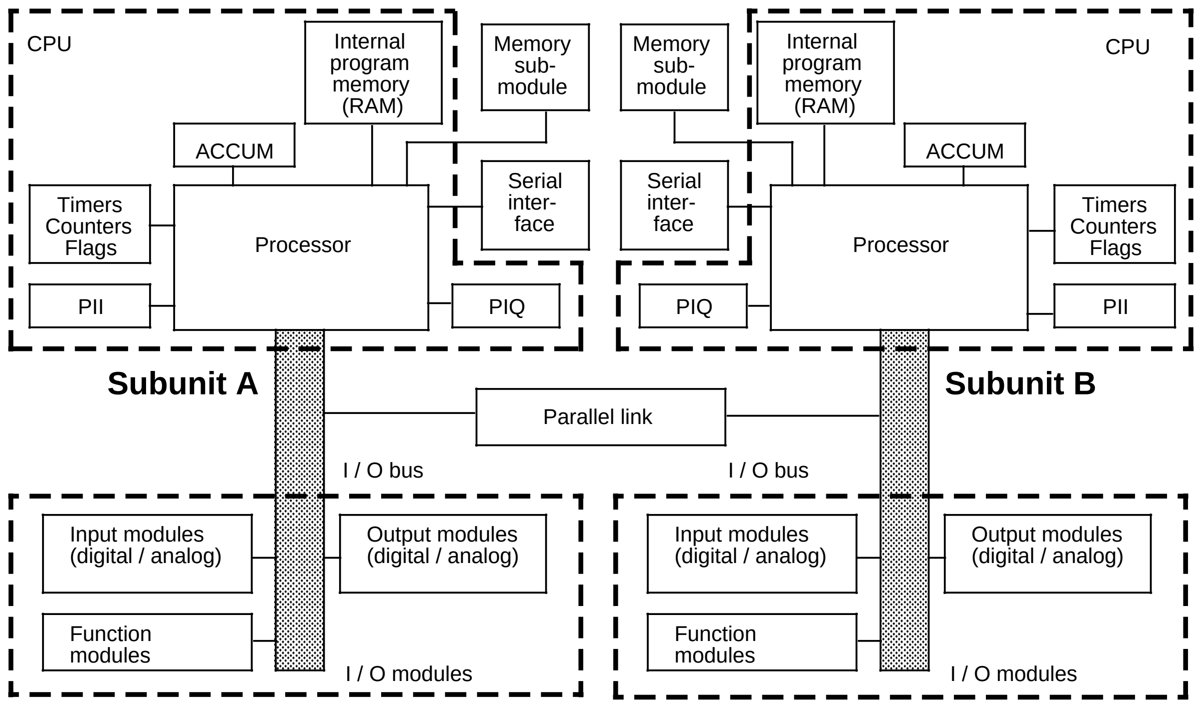


Figure 2-2. Function Units of the S5-115H

Program Memory

The control program is stored in the memory submodule or in internal RAM. To safeguard against losing the program, dump it in an external EPROM memory submodule. In contrast to these memory submodules, the internal RAM or a RAM memory submodule has the following characteristics:

- The memory contents can be changed quickly.
- User data can be stored and changed.
- When the power fails and there is no battery, the memory contents are lost.

Process Images (PII, PIQ)

Signal states of input and output modules are stored in the CPU in ”process images”. Process images are reserved areas in CPU RAM.
Input and output modules have separate images as follows:

- Process input image (PII)
- Process output image (PIQ).

Serial Interface

You can connect programmers, operator panels, and monitors over the CPU 942H's serial interface. This interface can also be used to connect the PLC (as slave) to the SINEC L1 local area network.

Flags, Timers, and Counters

The CPU provides internal flags (memory locations for storing signal states), timers, and counters that the control program can call. Table 2-1. gives information on the number and characteristics of these elements.

Table 2-1. Flags, Timers, and Counters on the CPU 942H

	Flags	Timers	Counters
Number	2048	128	128
Optionally retentive	1024 (M0.0 to M127.7)	64 (T0 to T63)	64 (Z0 to Z63)
Not retentive	1024 (M128.0 to 255.7)	64 (T64 toT127)	64 (Z64 to Z127)

Note:

The timers used in your control program are updated:

- before OB 1 is processed
- following interrupt enable command RA
- after every IU and IC block call

Accumulator (ACCUM)

The accumulator is an arithmetic register for loading, for example, internal times and counts. Comparison, arithmetic, and conversion operations are also executed in the accumulator.

Processor

The processor calls statements in the program memory in sequence and executes them in accordance with the control program. It processes the information from the PII and takes into consideration the values of internal timers and counters as well as the signal states of internal flags.

I / O Bus

The I / O bus establishes the electrical connection for all signals that are exchanged between the CPU and the other modules in a central controller or an expansion unit.

Parallel Link

The parallel link is the electrical connection of the two central controllers. All data interchange, and the sychronization of the CPUs, takes place over this communication link.

2.2.2 Basic PLC Configuration

The S5-115U programmable controller has a two-channel configuration and comprises two subunits. Each subunit comprises at least one central controller without expansion units. The minimum configuration of a subunit consists of a central rack (CR), a CPU 942H, a PS 951 power supply unit, an IM304 or IM324R interface module for interfacing the two central controllers and an IM306 interface module addressing the I / Os.

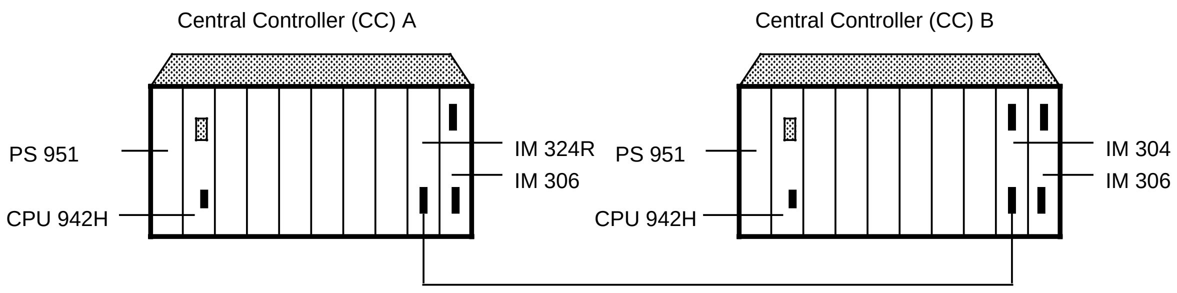


Figure 2-3. Minimum Configuration of an S5-115H

2.2.3 Operating States of the Subunits

The subunits may assume different operating states in RUN mode. A distinction is made between:

- Redundant mode
- Solo mode
- Diagnostic mode
- Standby link-up mode

Redundant Mode

In redundant mode, one subunit is the master and one the standby controller.
The two CPUs process the same user programs in parallel. Program processing is synchronized only when events occur which could cause the central controllers to assume different internal states. Examples of such events are direct access to I / Os, process interrupts and timed interrupts. During synchronization, the CPUs interchange current data over the parallel communications link. On the basis of these data, the standby controller decides whether the master controller is working properly.
If the standby controller detects a problem with the master controller, it assumes control bumplessly and the process continues.

Solo Mode

In this mode, the master controller stands alone. The standby controller is either in the Stop state or in diagnostic mode, and is not participating in the process.
When the master controller is operating in stand-alone mode, it is as if you were using an S5-115U. The two subunits are no longer synchronized, but the master controller continues to execute self-tests.

Diagnostic Mode

In diagnostic mode, the master controller processes the user program while the standby controller executes the self-test and localizes any errors that have occurred. Diagnostic mode is initiated when the 115H operating system discovers that the RAM contents or process images in the master and in the standby are not identical.

Standby Link-up Mode

Before the standby controller can be linked up to the master (following repairs for instance), the internal states of the two subunits must first be made identical.

After the standby controller has executed the self-test, the following comparisons are made to check the subunits for uniformity:

- Memory configuration (hardware),
- Operating system code
- User program code.

The standby controller goes to Stop with an appropriate error indication when:

- the operating system code shows discrepancies
- the memory configurations are not identical

If discrepancies are found in the user program code,

- the standby controller goes to STOP with an appropriate error message when the memory submodules are EPROMs or EEPROMS
- the user program is copied from the master to the standby controller when the memory submodules are RAMs.

Care is thereby taken that

- the master's cycle time is increased as little as possible
- data which change during the PLC cycle or during servicing of an interrupt are always updated in the standby controller.

When the master is operating in solo mode and the standby controller is to be linked (or relinked) to the process, for instance following repairs, the 115H operating system transfers all current data from the master to the standby. If necessary, the user program is transferred first (when RAMs are used as memory). The transfer of this static data may be distributed over several cycles.
The standby controller is then "updated". "Updating" is a procedure in which the 115H operating system copies the dynamic data from the master to the standby controller in one cycle. Dynamic data includes flags, timers, counters, data blocks and locations from the CPU's system data area.
The standby link-up is complete when the internal states of master and standby are identical.

2.3 PLC Cycle

Following POWER ON or on a transition from STOP to RUN, the operating system executes the restart routine. This routine, which the operating system invokes autonomously, comprises the following:

- Address list generation
- Definition of the subunit IDs
- PLC self-test
- Comparing of the control programs in the two CPUs
- Copying of the RAM contents from the master CPU to the standby CPU
- Testing of the facilities for error localization

Organization block OB 21 or OB 22 is executed following completion of the restart routine. The user programs the S5-115H's RESTART characteristics in these OBs. The RESTART blocks (OB21, OB22) execute only once following a cold restart.

Once the RESTART routine in OB 21 or OB 22 has executed, cyclic program scanning begins. The input signals on the input modules are scanned cyclically and mapped to the PII, and the interprocessor communication input flags are updated. The control program processes this information together with the current flag, timer and counter data.
The control program comprises a series of statements. The processor fetches these statements one by one from program memory and executes them. The results are mapped to the PIQ.
After the program has been scanned, the data in the PIQ is transferred to the output modules and the interprocessor communication output flags to the CPs.

It is possible to react quickly to signal changes even during cyclic program scanning by:

- Programming statements for direct I / O access (such as L PW and T PW)
- Multiple programming of direct I / O scans in the control program
- Programming organization blocks to service interrupts.

Scan Time

The scan (or cycle) time is the time required to process the cylic program. The processor starts a watchdog timer (scan time trigger) at the beginning of each scan cycle. This timer is preset to approximately 600 ms, but can be programmed. If the watchdog timer is not restarted within this time, for instance because of a CPU malfunction, the PLC stops. If the control program is so complex that the scan time will in all probability be exceeded, you should retrigger the watchdog timer in the control program itself.

Note:
If the scan time is exceeded (”CYC”), the master controller goes to STOP. To increase system availability, the scan time for the standby controller is lengthened by 100 ms, thus enabling the standby controller to withstand minor scan time overruns.

Note:
The scan time is shorter in solo mode than in redundant mode, as there is no data exchange between the CPUs in solo mode.

Figure 2-4 shows the processing of a cyclic program in simplified form.

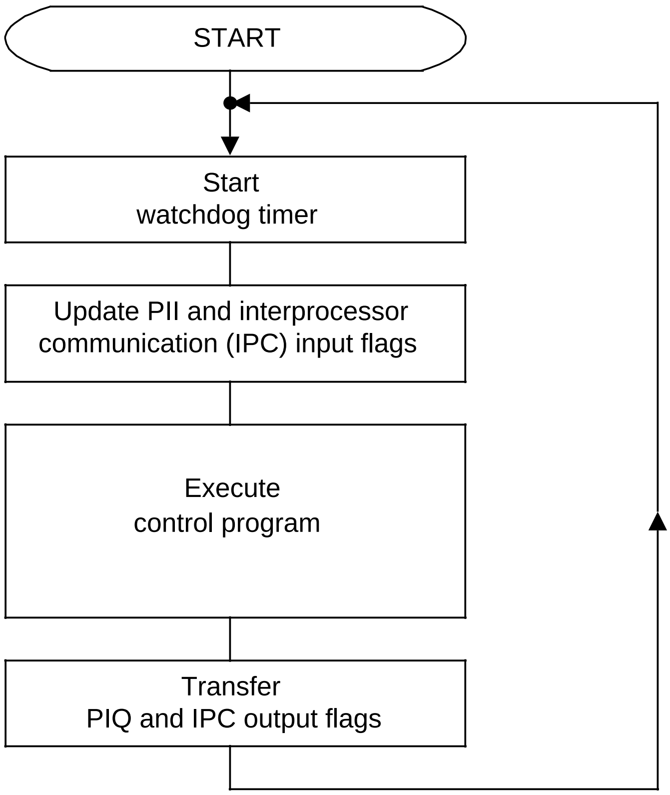


Figure 2-4. Block Diagram of a Cyclic Program Scan

Determining the Mean Scan Time
The mean scan time is easy to compute. Insert a flag word in your cyclic program and use it to count e. g. 1000 PLC scans. You can compute the mean scan even more accurately by adding up the time required for the 1000 scans.

Ready Delay Time

The Ready delay time is the time that elapses between the arrival of the Request signal in the module and the module's Ready signal.

The delay time depends on

- the Ready delay time of the module itself
- the interface module used and
- the length of the cable.

In a distributed configuration, the communications link delay must also be taken into account. The signal propagation rate is 6 µs/km, i. e. a distance-velocity lag of 2 x 6 µs=12 µs must be taken into account for a cable with a length of 1000 m (3,300ft.).
If the CPU does not receive the Ready signal within 160 µs, it stops and signals ”QVZ” (time-out) error.

Table 2-2. Ready Delay Times of the Various I / O Modules

I / O Modules	Ready Delay Time in µs
Digital modules	2
Analog modules	16
313 watchdog modules	1
IP 240	1
IP 242 (Release A00)	140
IP 242 (Release A01)	50
IP 243 (Analog module)	35
IP 244	150
IP 245	0,5
IP 246	1,5
IP 247	1,5
IP 252	10
IP 260	2
IP 261	2
CP 523	100
CP 524	1
CP 525	3
CP 526	3
CP 527	3
CP 530	130
CP 535	1
CP 551	3
CP 552	3

2.4 System Response Time and Discrepancy Times

2.4.1 System Response Time

The system response time is the time between a change in the process input signal and a change in the process output signal.
This period is typically the sum of

- the input module's inherent delay
- the program scan time
- the output modules' inherent delay

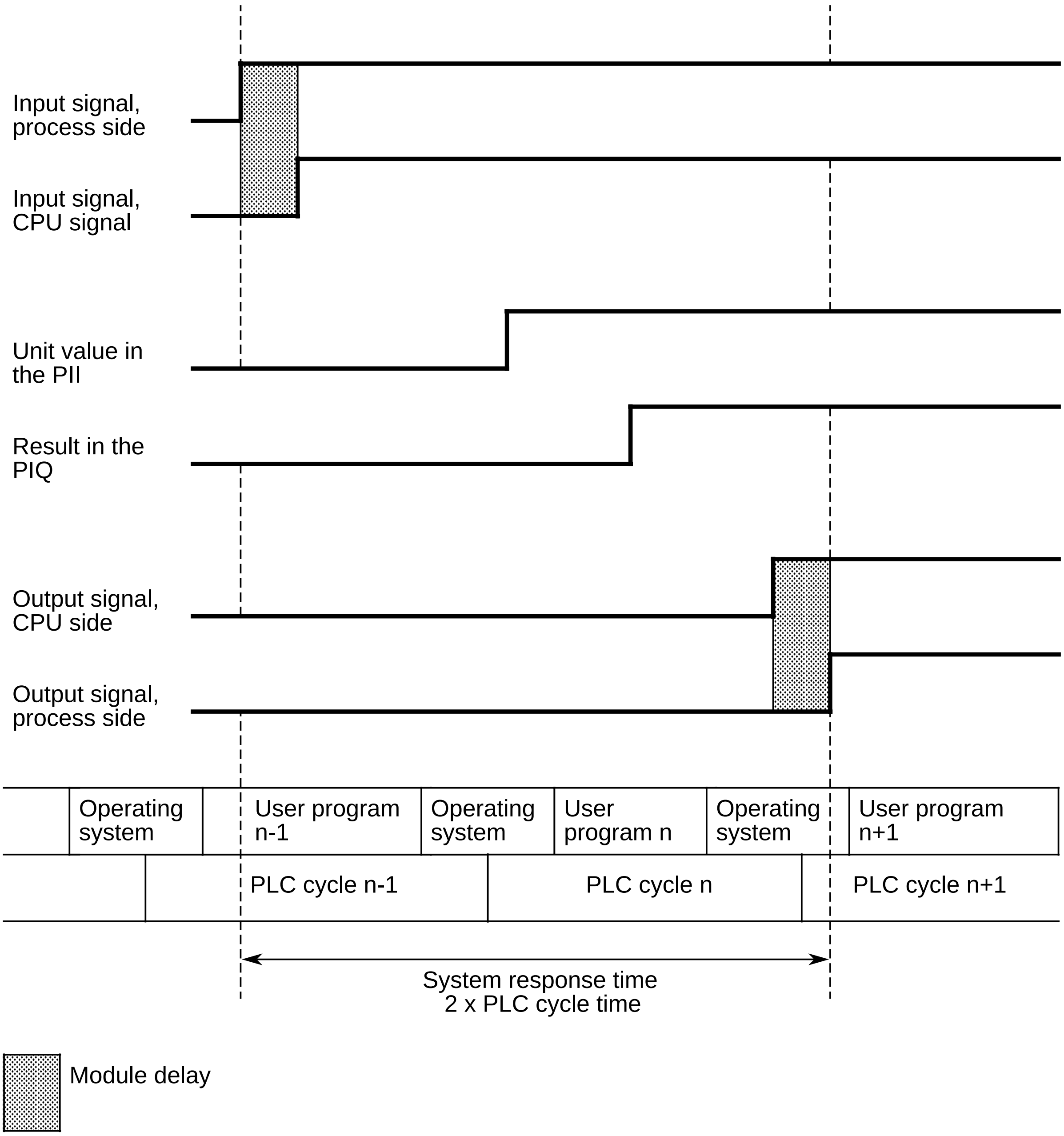


Figure 2-5. Response Time

Note:

In a worst-case situation, the system response time is twice the PLC cycle time.

2.4.2 Discrepancy Times

The operating system checks the logical signal level of the digital inputs in both subunits. Non-conformance of the signal levels of a DI bit in the two subunits is referred to as a discrepancy.

A discrepancy may be caused by:

- temporary errors (e.g. edge change)
- permanent errors (e.g. hardware faults)

Each type 3 redundant digital input is monitored by the operating system.
During configuring with COM 115H, the user defines a uniform discrepancy time for the DI bits in a byte. The discrepancy time must be at least one PLC cycle.

Note:

The operating system checks the digital inputs for a discrepancy only once during each PLC cycle. The discrepancy time begins the instant a discrepancy is detected, and ends

- when the operating system detects identical signals at the digital inputs or
- when the permissible discrepancy time has elapsed.

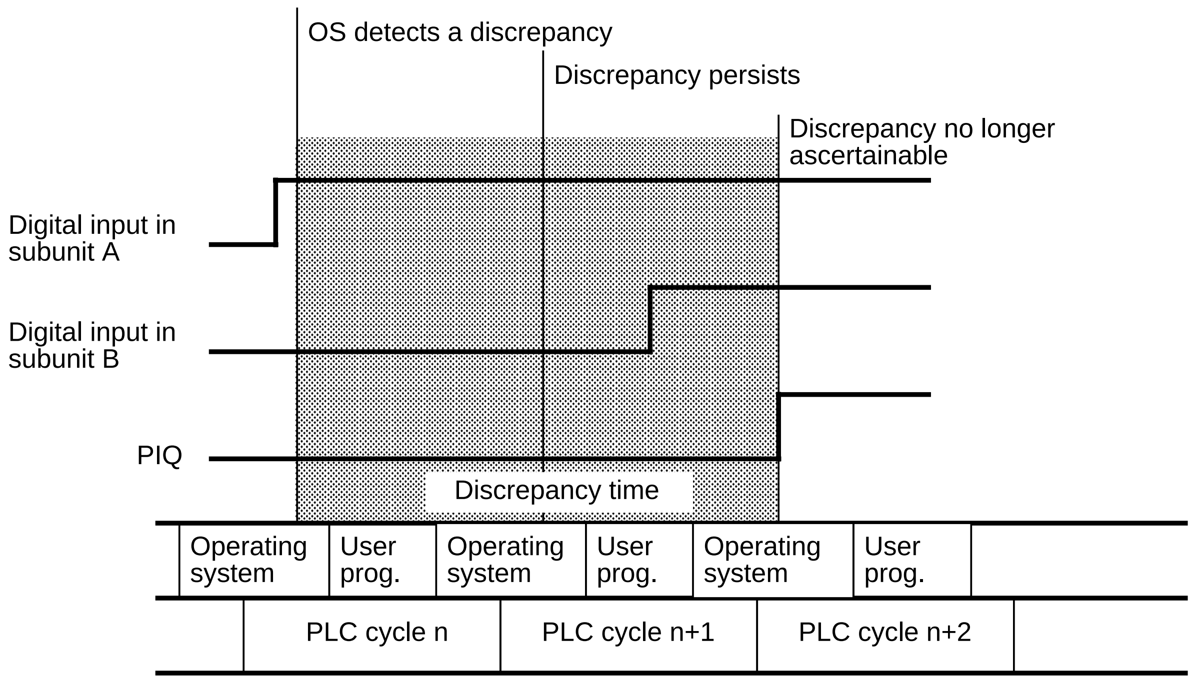


Figure 2-6. Discrepancy Time

2.5 Central Processing Unit

The table below shows the most important features of the CPU 942H.

Table 2-3. Central Processing Unit

Features of the CPU 942H	
OS execution time, typical (depends on configuration)	15.0 ms basic execution time + 5.0 ms times number of test slices configured + 0.5 ms times number of I/O bytes in switched configuration + 0.8 ms times number of I/O bytes in redundant configuration + 0.5 ms times number of communication flag bytes used
Execution time per - 1000 statements	ca. 15 ms
Internal memory (RAM) for user program	8.50 x 2^{10} Byte
Program memory (max.)	32 x 2^{10} Byte
Cycle monitoring time	Preset to 600ms
Program scanning	cyclic, time-controlled, interrupt-driven
Adress range max. (digital inputs)	1024 digital inputs I 0.0 to I 127.7
Adress range max. (digital outputs)	1024 digital outputs Q 0.0 to Q 127.7
Adress range max. (analog inputs)	64 channels PW 128 to PW 254
Adress range max. (analog outputs)	64 channels PW 128 to PW 254
Flags	2048 FW 0 to 254
Timers	T0 toT127
Counters	Z0 to Z127
Time range	0.01 to 9990 s
Counting range	0 to 999
Operation set	Approx. 170 operations
Integral control OB	Yes

For the execution times of individual statements, please refer to the Operations List (Appendix A).

CPU 942H

CPU 942H contains a microprocessor and one application-specific integrated circuit (ASIC[1]). The microprocessor handles all programmer interface functions, processes, the integral timers, and the word operators, and controls the S5 bus. The microprocessor also controls the ASIC that is responsible for high-speed processing of the bit operations and some word operations and for cycle time monitoring.Besides the operating system memory, the CPU 942H contains an internal RAM and can store up to 8.75 Kbytes of user data.Memory submodules with a storage capacity of from 8 K to 32 Kbytes may also be inserted.

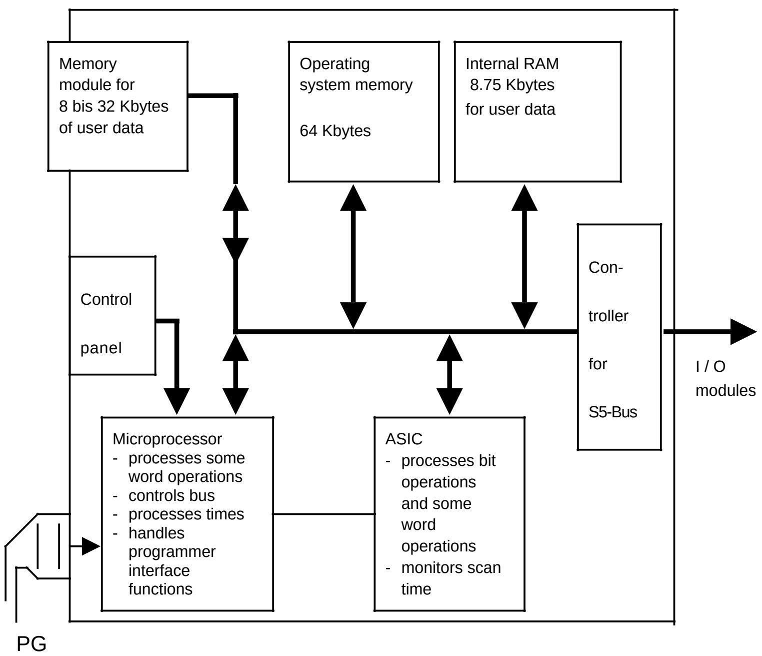


Figure 2-7. Schematic of the CPU 942H

Note:
Two CPU 942Hs of the same version are always required to construct an S5-115H. You can read and check the system software version using the "SYSPAR" (system parameter) programmer function.

1 **a**pplication **s**pecific **i**ntegrated **c**ircuit

3 Installation Guidelines

Figures

Figures

Tables

3 Installation Guidelines

Programmable controllers of the S5-115H system consist of two central controllers to which one or more expansion units can be connected if necessary. The modules that make up the S5-115H programmable controller (PLC) are mounted on racks.

3.1 Mounting Racks

Various mounting racks are available to suit the performance or the degree of expansion the control system is to have
Each mounting rack consists of an aluminum mounting rail for fastening all modules mechanically and one or two backplanes for connecting the modules to each other electrically. The module locations (slots) are numbered in ascending order form left to right.

3.1.1 Central Controllers (CCs)

A central controller has a power supply module (PS), a central processing unit (CPU), and various input / output modules (I / Os). Depending on requirements, digital or analog modules, communications processors (CPs), or intelligent input / output modules (IPs) can be used. The IM 304/324R interface modules are required for parallel interfacing of the central controllers. Additional interface modules are needed when using expansion units.

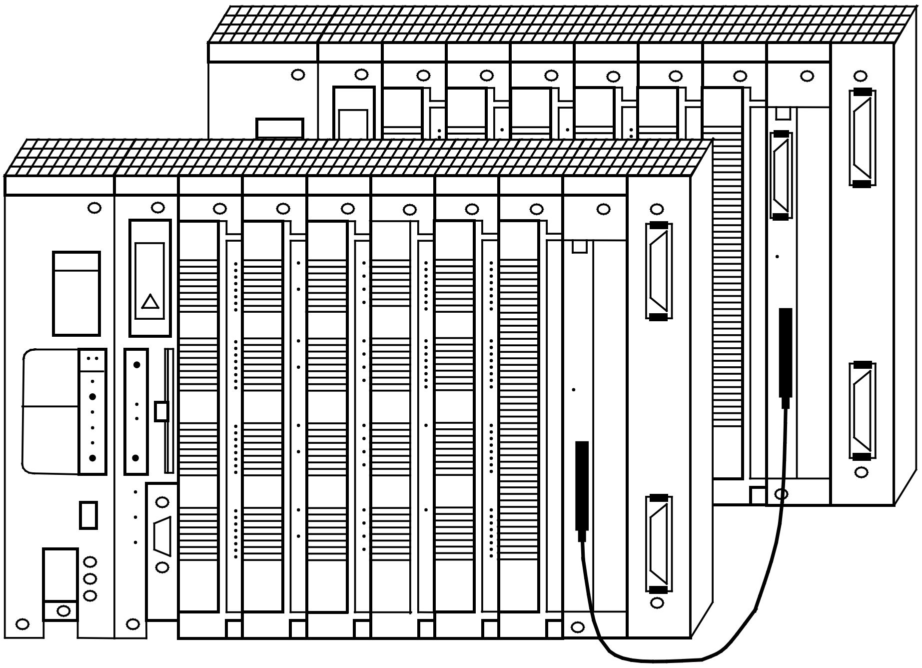


Figure 3-1. Programmable Controller without Expansion Unit

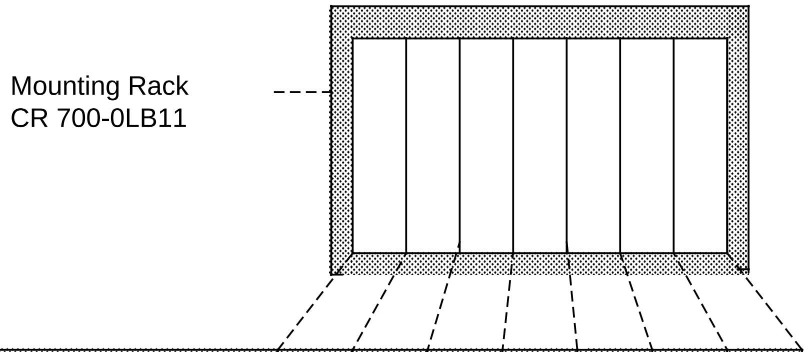
The following four mounting racks (CRs) are available for installing a central controller:

- for central controller ”0” (ZG0LB): CR 700-0LB11
- for central controller ”2” (ZG 2): CR 700-2
- for central controller ”2F” (ZG 2F): CR 700-2F
- for central controller ”3” (ZG 3): CR 700-3

They differ in the number of slots and configuration possibilities (connector pin assignment see Appendix C).

Possible Configurations on Mounting Rack CR 700-0 (6ES5 700-0LB11)

The CR700-0LB mounting rack is suitable for configuring small-scale control systems.
You can use adapter casings with two printed-circuit boards in the case of the CR 700-0 (6ES5 700-0LB11). There are also slots for a power supply module (PS), a central processing unit (CPU), block type digital / analog modules, intelligent input / output modules (IPs) and communications processors (CPs).



Slots	PS	CPU	0*		1	2	3*		IM
Power Supply Module 1	■								
Central Processing Unit		■							
Digital Modules					■	■			
Analog Modules					■	■			
CP 523/524/525/530-3/552-1			▩	▩	▩	▩			
CP 526 Basic Board			▩	▩	▩	▩			
CP 526 Expansion Board 2				■					
CP 530-7LA12					■	■			
CP 552-2			▩	3					
IP 245 / 252/ CP 535-3MA12			▩	3	▩	▩			
IP240/242..244/246/247/260/261			▩	▩	▩	▩			
DIMOS-VISRAM5			▩	▩	▩	▩			
AS 301/ IM 304/ 3075/324R							▩	▩	
IM 306 4									■

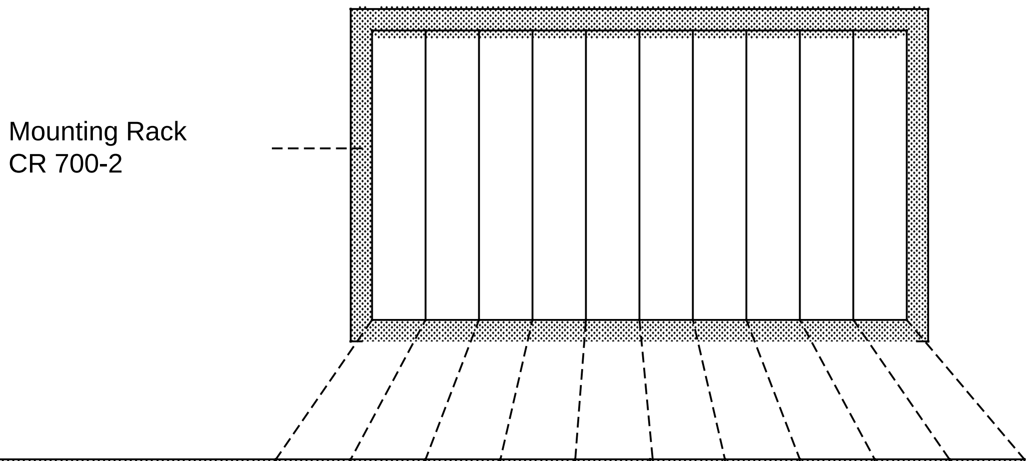
▩ Only with adapter casing 6ES5 491-0LB11

- * These slots may contain only adapter casing 6ES5 491-0LB11
- 1 Use of the 246/247 and the CP 524 / 525 / 526 is not permissible with a 3 A power supply module
- 2 In conjunction with a CP 526 basic board in a 6ES5 491-0LB11 adapter casing only
- 3 Slot not available because of double-width module
- 4 Terminating connector may not be removed if no interface module has been inserted
- 5 Under development

Figure 3-2. Possible Configurations on Mounting Rack CR 700-0 (6ES5 700-0LB11)

Possible Configurations on Mounting Rack CR 700-2

Use central mounting rack CR 700-2 to install larger-scale control systems in 19-inch cabinets. It has slots for a power supply module (PS), a central processing unit (CPU), and up to six input / output modules (I / Os). Such a configuration makes up a central controller 2. In addition to digital and analog modules, you can also plug in intelligent I / O modules IPs) and communications processors (CPs) (see Figure 3-3).



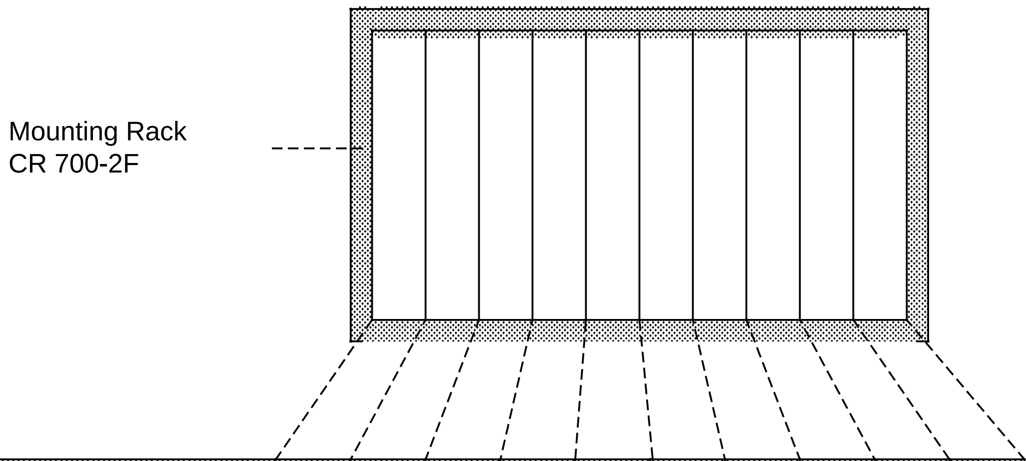
Slots	PS	CPU	0	1	2	3	4	5	6	IM
Power Supply Module 1	■									
Central Processing Unit		■								
Digital Module			■	■	■	■	■	■		
Analog Module 2			■	■	■	■	■	■		
IM 306 3										■
IM 304/324R									■	
CP 523 to 526/530/535/552-1			■	■	■	■	■	■		
IP 240/ 242 to 246/247/260/261			■	■	■	■	■	■		
IP 252 4			■	■	■	■	■	■		
DIMOS Interface Module5			■	■	■	■	■	■		

1 Use of the IP 246/247 and the CP 524 / 525 / 526 is not permissible with a 3 A power supply module
2 Plug analog modules into slots 4, 5 and 6 only if an IM 306 is used
3 Do not remove the terminating connector if no interface module is plugged in
4 Direct I / O access not permitted
5 Under development

Figure 3-3. Possible Configurations on Mounting Rack CR 700-2

Possible Configurations on Mounting Rack CR 700-2F

Use central mounting rack CR 700-2F to install larger-scale control systems in 19-inch cabinets. It has slots for a power supply module (PS), a central processing unit (CPU), and up to six input / output modules (I / Os). Such a configuration makes up a central controller 2F. You can plug in an interface module (AS, IM) to connect expansion units (EUs). You can also mount intelligent input / output modules and communications procesors (CPs) (see Figure 3-4).



Slots	PS	CPU	0	1	2	3	4	5	6	IM
Power Supply Module [1]	■									
Central Processing Unit		■								
Digital Module			■	■	■	■	■	■		
Analog Module [2]			■	■	■	■	■	■		
IM 306 [3]										■
AS 301/ IM 304/307[5]/324R								■	■	
CP 523 to 526/530/535/552-1			■	■	■	■	■	■		
IP 240/ 241 to 246/247/260/261			■	■	■	■	■	■		
IP 252 [4]			■	■	■	■	■	■		
DIMOS Interface Module[5]			■	■	■	■	■	■		

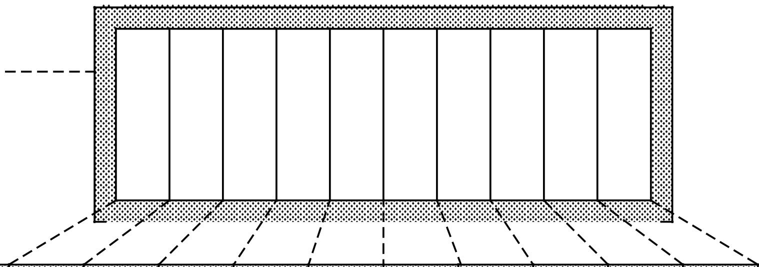
1 Use of the IP 246 / 247 and the CP 524 / 525 / 526 is not permissible with a 3 A power supply module
2 Plug analog modules into slots 4, 5, and 6 only if an IM 306 is used
3 Do not remove the terminating connector if no interface module is plugged in
4 Direct I / O access is not permitted
5 Under development

Figure 3-4. Possible Configurations on Mounting Rack CR 700-2F

Possible Configurations on Mounting Rack CR 700-3

Use central mounting rack CR 700-3 to install large control systems in 19-inch cabinets. In contrast to central mounting racks CR 700-2F and CR 700-2, you can use adapter casings with two printed circuit boards. CR 700-3 also has slots for a power supply module (PS), a central processing unit (CPU), digital and analog block-type modules, intelligent input / output modules (IPs), and communications processors (CPs). You can plug in an interface module to connect expansion units. A configuration on the CR 700-3 makes up a central controller 3 (see Figure 3-5).

Mounting Rack
CR 700-3



Slots	PS	CPU	0*		1*		2*		3	4	5	6*		IM
Power Supply Module [1]	▒													
Central Processing Unit		▒												
Digital Module									▒	▒	▒			
Analog module									▒	▒	▒			
CP 523/524/525/530-3/ 552-1			⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠			
CP 526 Basic Module			⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠			
CP 52 6 Expansion Module [2]				▒		▒		▒						
CP 530-7LA12									▒	▒	▒			
CP 551 (Mass storage unit)			▦	▦	▦	▦	▦	▦						
CP 552-2			⊠	4	⊠	4	⊠	4						
IP 245/ 252[3] / CP 535-3MA12			⊠	4	⊠	4	⊠	4	⊠	⊠	⊠			
IP 240/242..244/246/247/260/261			⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠			
DIMOS-VISRAM[6]			⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠			
AS 301/ IM 304/307[6]/324R												⊠	⊠	
IM 306 [5]														▒

⊠ Plug in these modules only with adapter casing 6ES5 491-0LB11

▦ only with adapter casing 6ES5 491-0LC11

* Only modules in adapter casings may be plugged into these slots
1 Use of the IP 246/247 and the CP 524 / 525 / 526 is not permissible with a 3 A power supply module
2 This module can be used only in combination with the CP 526 basic module in adapter casing 6ES5 491-0LB11
3 No digital I / O access permitted
4 Slot cannot be used because of double-width module
5 Do not remove the terminating connector if no interface module is plugged in (Addressing Chapter. 5.2.1.)
6 Under development

Figure 3-5. Possible Configurations on Mounting Rack CR 700-3

3.1.2 Expansion Units (EUs)

If the slots of a central controller are not sufficient for the installation of a control system, one or more expansion units can be connected to the central controller. Four mounting racks are available for expansion units. The type used depends on the configuration.

- ER 701-1 for expansion unit ”1” (EU 1)
- ER 701-2 for expansion unit ”2” (EU 2)
- ER 701-3 LA for expansion unit ”3” (EU 3)
- ER 701-3LH Expansion unit for switched I / Os
  (Connector pin assignment see Appendix)

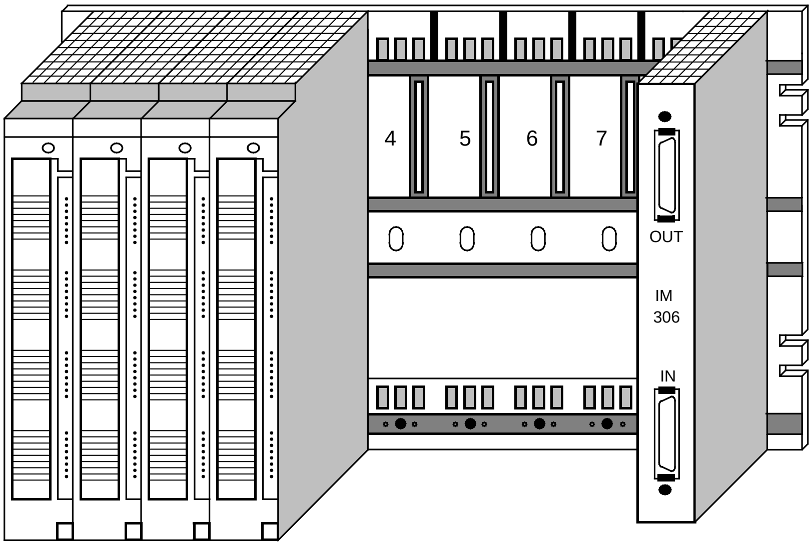


Figure 3-6. Expansion Unit 1

The following expansion unit interface modules connect expansion units to a central controller in centralized configurations (see section 3.2.5)

- interface module IM 306

The following interface modules connect expansion units to a central controller in distributed configurations (see section 3.2.6) :

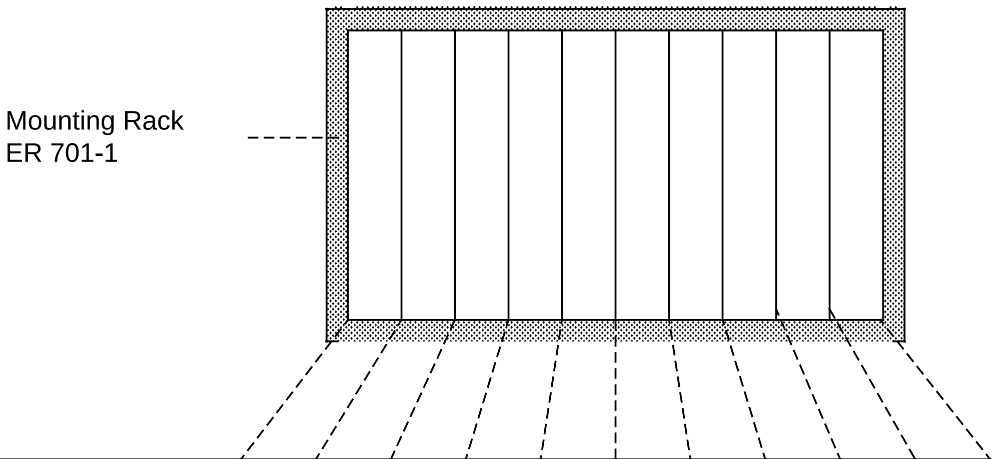
- interface module AS 301 / AS 310
- interface module IM 304 / IM 314
- interface module IM 307 / IM 317 (use in the S5-115H is under development)

The following interface modules connect expansion units with switched I / Os to a central controller:

- IM 304 / IM 314R

Possible Configurations on Mounting Rack ER 701-1

Use expansion mounting rack ER 701-1 to install expansion unit EU 1. EU 1 is suitable for centralized configurations, i.e., connection to a local central controller of type OLB / 2 / 2F / 3. The ER 701-1 has nine slots for digital and analog input or output modules and one slot for an IM 306 interface module. You can connect up to three expansion units to one central controller or to one EU 2 expansion unit.



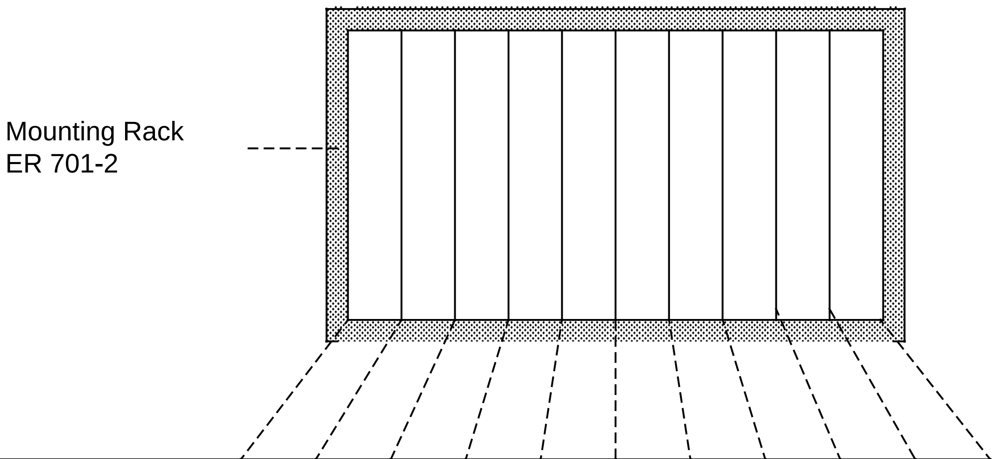
Slots	0	1	2	3	4	5	6	7	8	IM
Digital Modules [1]	■	■	■	■	■	■	■	■	■	
Analog Modules [2]	■	■	■	■	■	■	■	■	■	
IM 306										■

1 Input module 434-7 cannot be plugged into these slots.
2 Plug analog modules into these slots only if an IM 306 is used.

Figure 3-7. Possible Configurations on Mounting Rack ER 701-1

Possible Configurations on Mounting Rack ER 701-2

Use expansion mounting rack ER 701-2 to install expansion unit EU 2. EU 2 is suitable for connection to a centrally configured or remote CC 0LB, CC 2F or CC 3 central controller. The ER 701-2 has slots for a power supply module (PS), digital and analog input or output modules, one central controller interface module, and one IM 306 expansion unit interface module. The IM 306 lets you connect up to three EU 1 expansion units to one EU 2 expansion unit.



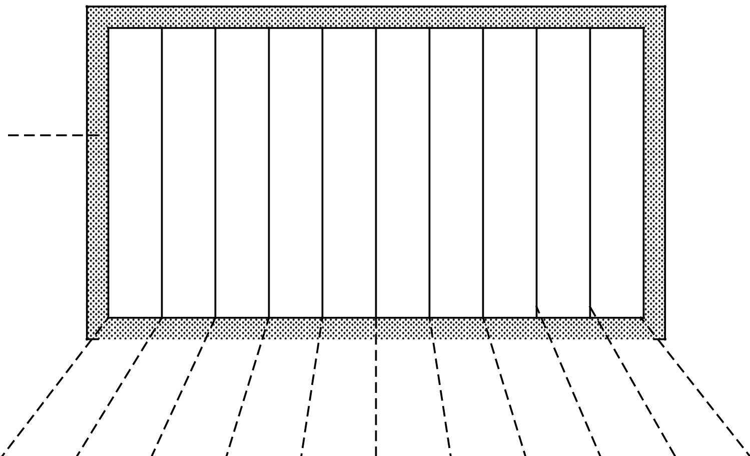
Slots	PS	0	1	2	3	4	5	6	7	IM
Power Supply Module	X									
Digital Modules [1]		X	X	X	X	X	X	X	X	
Analog Modules [2]		X	X	X	X	X	X	X	X	
IM 306										X
AS 310 / IM 314 / 317 [3]									X	
CP 523								X		

1 Input module 434-7 cannot be plugged into these slots.
2 Plug analog modules into these slots only if an IM 306 is used.
3 Under development

Figure 3-8. Possible Configurations on Mounting Rack ER 701-2

Possible Configurations on Mounting Rack ER 701-3LA

Use expansion mounting rack ER 701-3LA to install expansion unit EU 3. EU 3 is suitable for connection to a centrally configured or remote CC OLB, CC 2F or CC 3 central controller. ER 701-3LA has slots for a power supply module (PS), digital and alalog input or output modules, communications processors and intelligent input / output modules (without interrupt processing), one central controller interface module, and one IM 306 expansion unit interface module. The IM 306 lets you connect up to three EU expansion units to one EU 3 expansion unit.
Use the AS 310, IM 314 and 317[4] central controller interface modules to connect the EU 3 to the S5-135U, S5-150U and S5-155U programmable controllers.



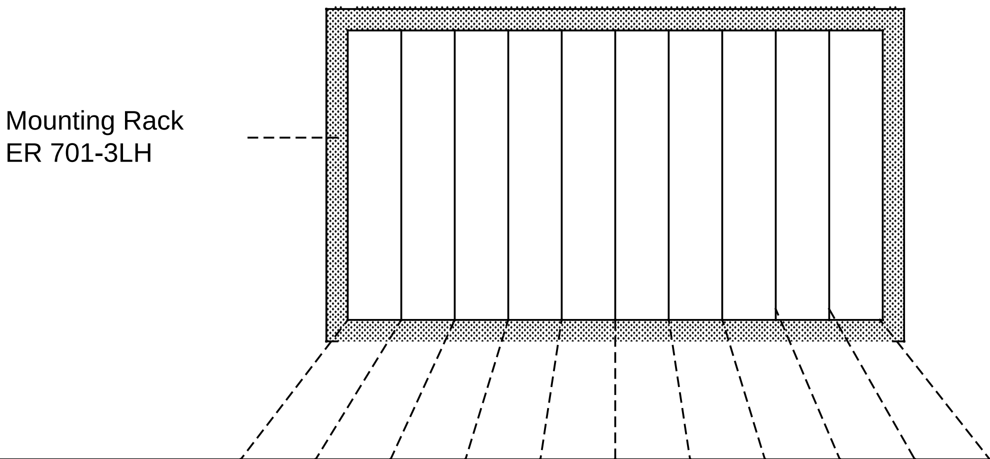
Slots	PS	0	1	2	3	4	5	6	7	IM
Power Supply Module [1]	■									
Digital Modules [2]		■	■	■	■	■	■	■		
Analog Modules		■	■	■	■	■	■	■		
IM 306										■
AS 310 / IM 314 / 317[4]									■	
CP 523 to 526 / 530 / 535 / 552		■	■	■	■	■	■	■		
IP 240 [4] / 242 to 245 / 260 / 261		■	■	■	■	■	■	■		
IP [3] 246 / 247 / 252		■	■	■	■	■	■	■		
DIMOS Interface Modules [4]		■	■	■	■	■	■	■		

1 Use of the IP 246 / 247 and the CP 524 / 525 / 526 is not permissible with a 3 A power supply module.
2 Input module 6ES5 434-7 cannot be plugged into these slots.
3 Only in conjunction with an IM 304/314
4 Under development

Figure 3-9. Possible Configurations on Mounting Rack ER 701-3LA

Possible Configurations on Mounting Rack ER 701-3LH

The modules on an ER 701-3LH mounting rack form an expansion unit for switched I / Os. The switched EU is suitable for connection to a CC OLB11, CC 2F or CC 3 central controller. The ER 701-3LH has slots for a power supply module (PS), digital and analog input and output modules, communications processors and intelligent I / O modules (without interrupt processing), IM 314R interface modules, and an IM 306 interface module for variable I /O addressing.



Slots	PS	0	1	2	3	4	5	6	7	IM
Power Supply Module [1]	■									
Digital Modules [2]		■	■	■	■	■	■	■		
Analog Modules		■	■	■	■	■	■	■		
IM 306										■
IM 314R								■	■	
CP 523 to 526 / 530 / 535 / 552		■	■	■	■	■	■	■		
IP 240 [3] / 242 to 245 / 260 / 261		■	■	■	■	■	■	■		
IP [3] 246 / 247 / 252		■	■	■	■	■	■	■		
DIMOS Interface Module [4]		■	■	■	■	■	■	■		
IM 314									■	

1 Use of the IP 246 / 247 and CP 524 / 525 / 526 is not permitted with a 3 A power supply module
2 Input module 6ES5 434-7 cannot be plugged into these slots
3 Only in conjunction with an IM 304 / 314 or 304 / 314R
4 Under development

Figure 3-10. Possible Configurations on Mounting Rack ER 701-3LH

3.2 PLC Configuration

The S5-115H programmable controller has a two-channel configuration. Each of the subunits consists of at least one central controller without expansion units. The minimum configuration of a subunit comprises a central rack (CR), a CPU 942H, a PS 951 power supply module and an IM interface module for linking the two central controllers. The two central controllers are linked over IM 304 / IM 324R interface modules. The two interface modules are connected over a 721 connecting cable (max. 100 m in length).

Figure 3-11 shows the configuration of a basic unit.

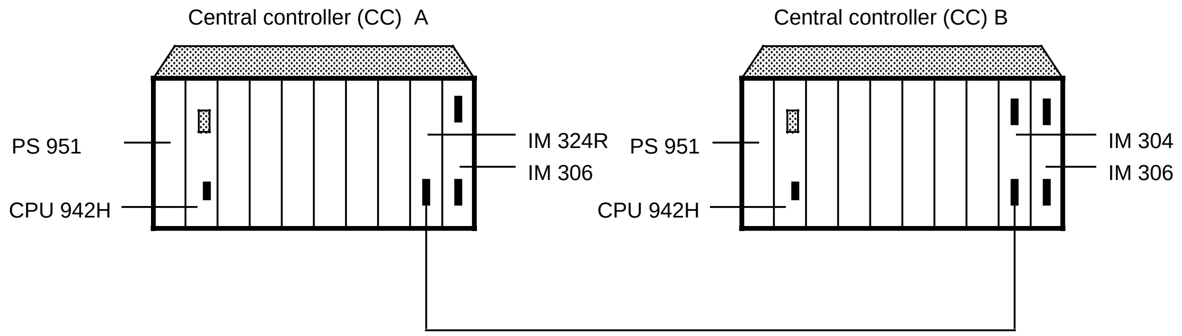


Figure 3-11. S5-115H Basic Unit

3.3 I / O Configuration

There are various possibilities for the operation of I / O modules, which can be combined in any mix:

- Single-channel I / O configuration
- Switched I / O configuration
- Two-channel I / O configuration

Single-channel I / O configuration

In this configuration, the I / O modules are always assigned to only one subunit, allowing you to attain the ***standard availability*** of an S5-115U.

Switched I / O configuration

This configuration always requires a switched expansion unit. The expansion unit contains the I / O modules for switched I / O operation. The switched I / O modules can be driven from either of the two central controllers.
This operating mode gives the user ***increased availability*** compared with the S5-115U. It is possible with an ER 701-3LH mounting rack only. The mounting rack is connected to both central controllers over two sets of IM 304 / IM 314R interface modules. It is possible to set up to two I / O bus chains, and to connect as many as four switched expansion units to each chain.

Figure 3-12 shows a switched I / O configuration with expansion unit.

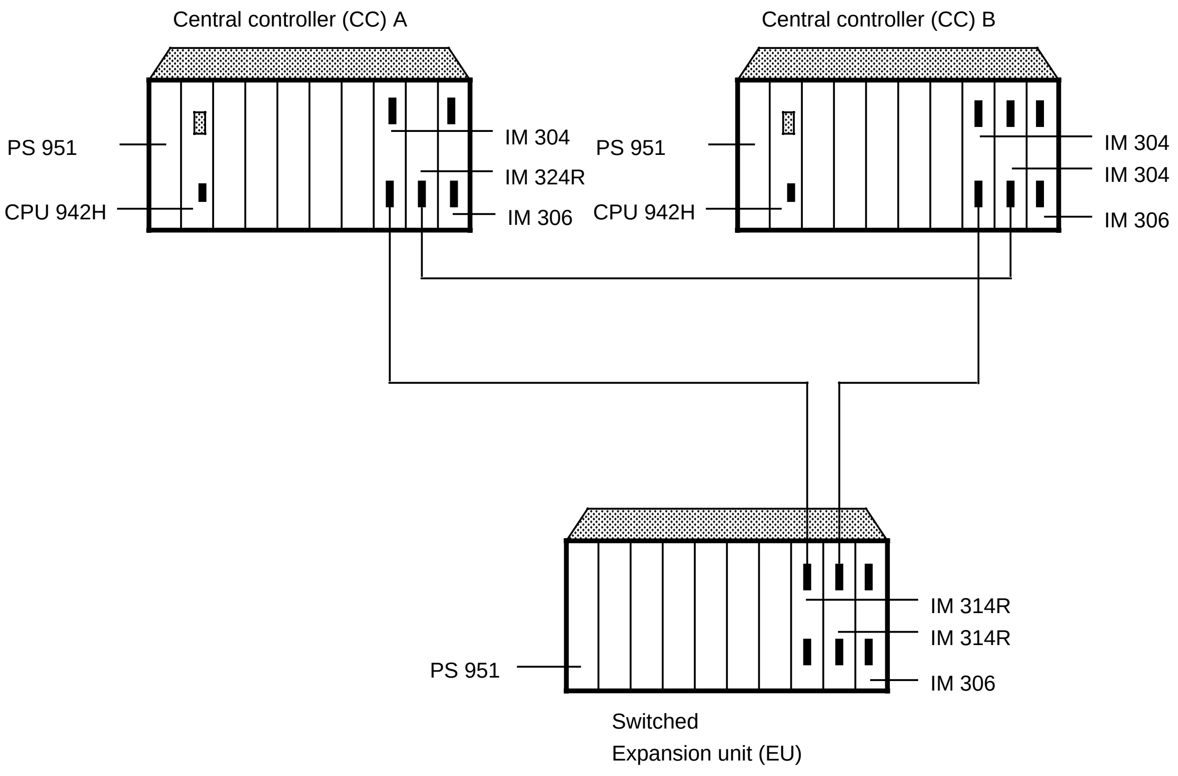


Figure 3-12. Switched I / O Configuration

Two-channel I / O configuration

This configuration always requires two identical I / O modules. The I / O modules in both subunits are allocated the same addresses, and can be plugged into either the central controller or an expansion unit. This configuration gives the user the ***highest availability***, since the failure of an I / O module, a central controller or an expansion unit can be tolerated.

Figure 3-13 shows a two-channel I / O configuration.

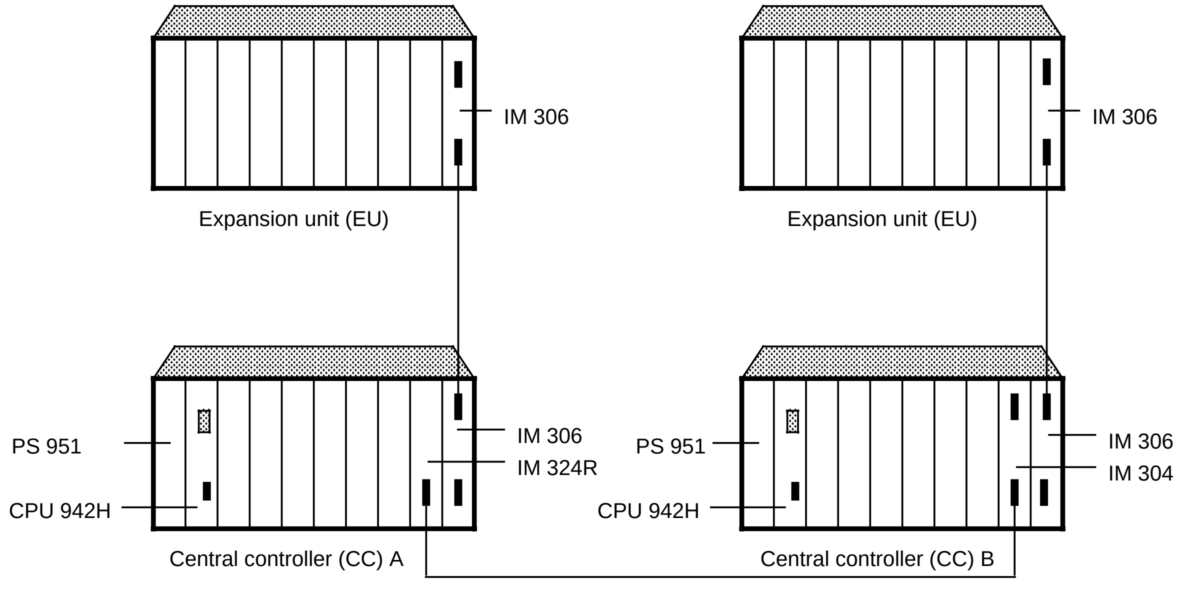


Figure 3-13. Two-Channel I / O Configuration

3.4 Mechanical Installation

Fasten all modules on the appropriate mounting racks. You can install the mounting racks in cabinets with dimensions in inches or millimeters. You can also fasten the racks to surfaces that are at an angle of up to 15° from a vertical surface. Block-type modules are mounted directly on the rack. Place printed circuit boards in double-height Eurocard format in adapter casings.

3.4.1 Installing the Modules

Install block-type modules according to the following procedure:

- Remove the protective caps from the socket connectors on the backplane.
- Hook the top of the module into place between the two guides on the top of the mounting rack.
- Swing the module back until it engages with the socket connectors on the backplane.
- Fasten the screws at the top and bottom of the module.

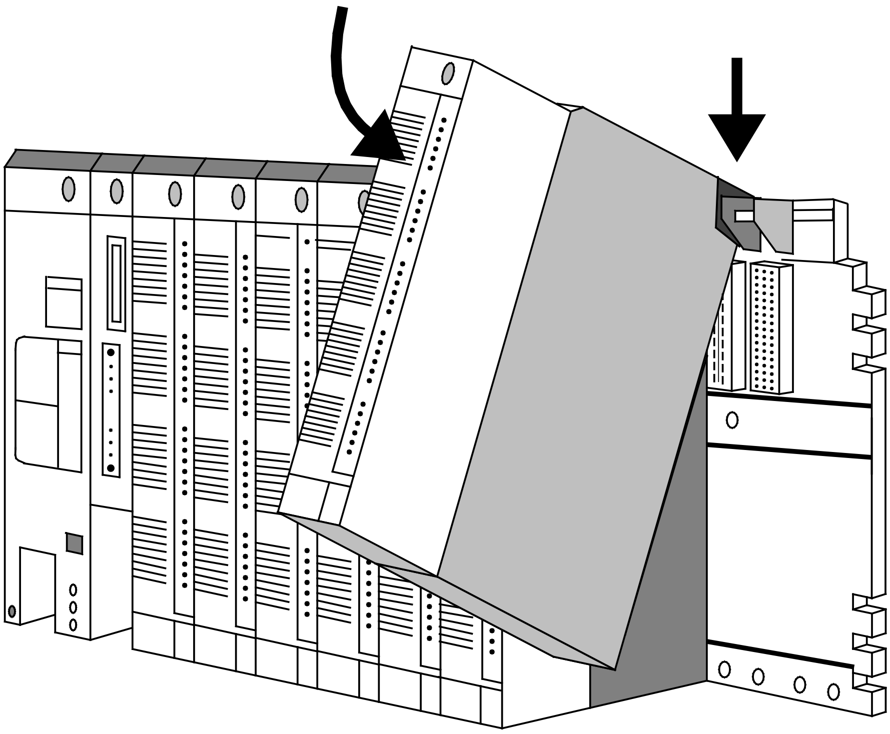


Figure 3-14. Installing the Modules

If the modules are subjected to mechanical vibration, they should be installed as close together as possible.

CAUTION:

Plug in or remove modules only when the power supply has been turned off.

Mechanical Slot Coding

On the back of each module, with the exception of the power supply and central processing unit, is a slot coding element in the form of a two-part plastic cube. This coding element ensures that when one module is replaced, only another module of the same type will be plugged in its place.

The coding element consists of two parts, one like a lock and one like a key. The two parts fit together in a defined position. When you install the module, the back of the coding element is inserted into the mounting rack. When you swing the module out, the key-shaped part of the element stays in the mounting rack and the lock-shaped part stays on the module.

Now you can install only this particular module or an identical one in this slot. If you want to install a different module, you have to remove the coding element from the mounting rack.

You can also work without slot coding. To do this, you must pull the coding element off the module before you swing the module into place for the first time.

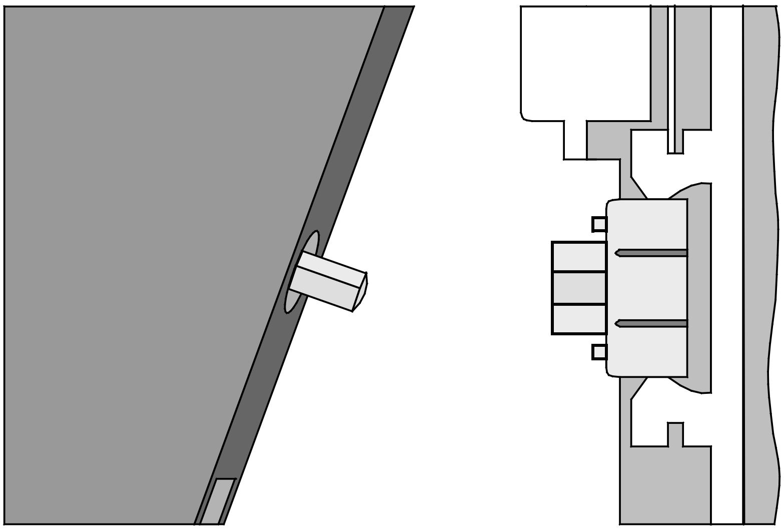


Figure 3-15. Slot Coding Element

Adapter Casing

Use an adapter casing (6ES5 491-OLB11 or 6ES5 491-0LC11) to fasten printed circuit boards in double-height Eurocard format to a mounting rack as you would fasten block type modules.

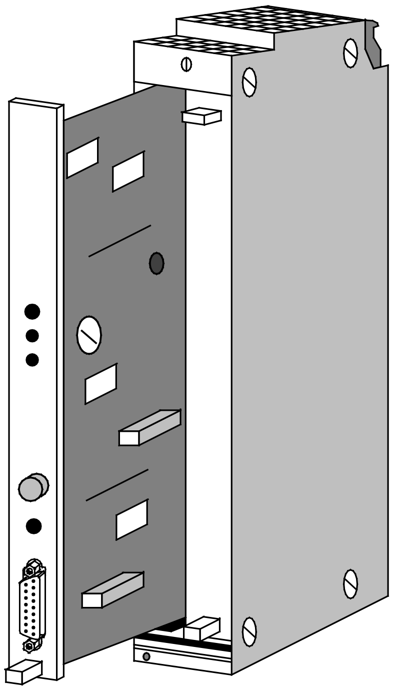


Figure 3-16. Installation of a Printed Circuit Board into an Adapter Casing (6ES5 491-0LB11)

Push the printed circuit board into the casing along the guide tracks.
Lock the module into place with the eccentric locking collar at the top of the casing.

If an opening remains in the front after the module has been inserted, cover it with a blanking plate.
Hang the completed unit on the mounting rack and fasten the screws at the top and bottom of the adapter casing.

CAUTION:
A fan is required for adapter casings with two printed circuit boards.

3.4.2 Installing Fans

Install a fan subassembly under the following conditions:

- the power supply modules carry a load of more than 7 A
- the controller uses modules with a high power consumption, e.g., certain communications processors and intelligent input / output modules (see chapter 17 ”Technical Specifications”).

The fan subassembly has two fans, a dust filter, and fan monitors with floating changeover contact.
You need a set of installation parts to mount the fan subassembly. The set consists of two installation brackets and a cable duct. The brackets support the fan subassembly and the cable duct. The cable duct enables you to run the field cables off neatly to the side.

Install the subassembly as follows:

Use screws to fasten the installation brackets onto the uprights of the cabinet or on the mounting surface under the mounting rack.
The guide tracks on the brackets should be at the bottom. Hook the fan subassembly onto the guide tracks of the installation brackets and
push it back.
Push the fan assembly up
and latch it into place with the two slides at the top of the installation brackets.
If the machine is subject to vibration, secure the fan subasssembly to the installation brackets with screws (M 4x20 screws with washers).
Hook the cable duct into the installation brackets.

Special features of the fan subassembly and installation parts enable you to do the following:

- use the cable duct without the fan subassembly
- install or remove the fan subassembly even when the cable duct is hooked on
- screw the fan subassembly to the installation brackets through the cable duct
- replace the filters while the unit is in operation (see Appendix B)

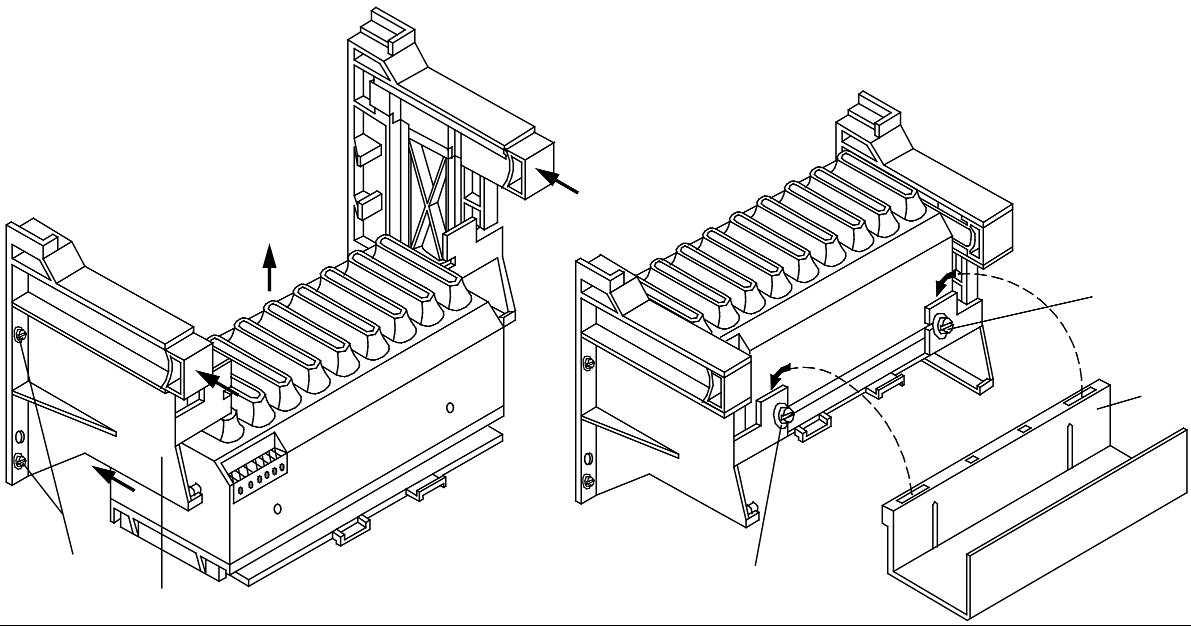
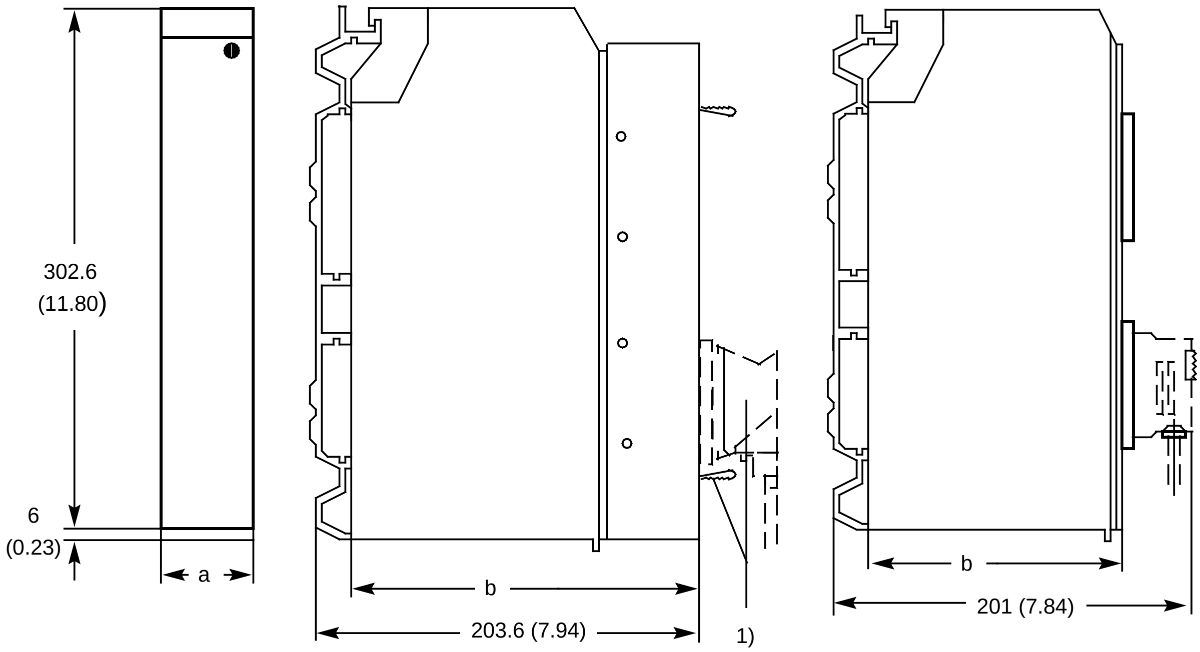


Figure 3-17. Installing the Fan Subassembly

3.4.3 Dimension Drawings



1 Control panel and plug connectors (e.g., when an adapter casing is used) extend beyond the front (e.g., CP 525).

Figure 3-18. Dimension Drawings of Modules and Mounting Racks

Table 3-1. Dimension Drawings of Modules

	a mm (in.)	b mm (in.)	Mechanical Slot Coding
Power Supply Module	65 (2.54)	187 (7.29)	none
Central Processing Unit	43 (1.68)	187 (7.29)	none
Digital and Analog Modules			built in
Adapter Casing			
Interface Module	25 (0.98)	133 (5.19)	none

3.4.4 Cabinet Installation

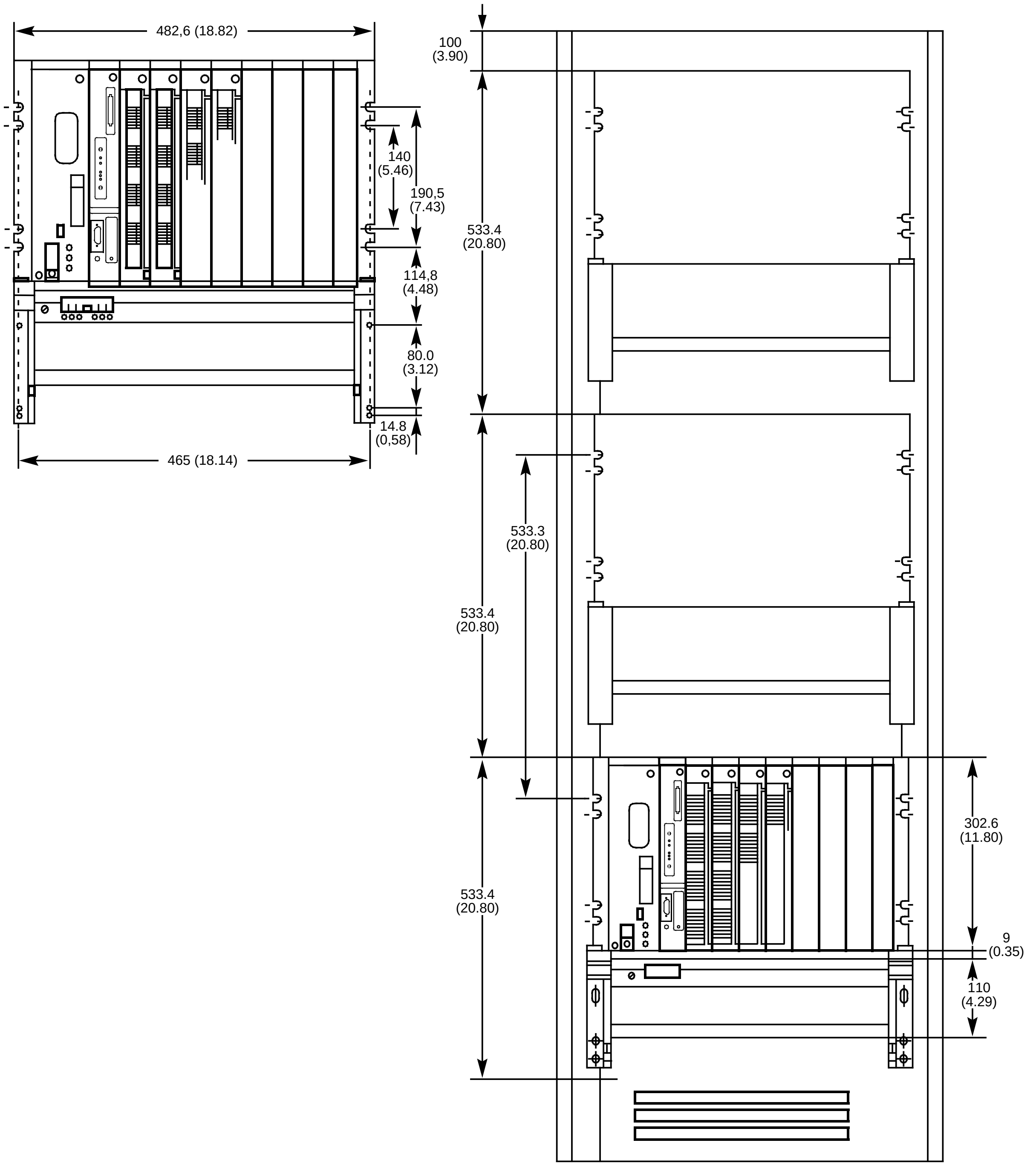


Figure 3-19. Dimensions for Installation in a 19-inch Cabinet

CAUTION:

The 533.4 mm spacing must be maintained even if a fan is not used.(5.46)

3.4.5 Parallel Interfacing of the Central Controllers

The two central controllers are interfaced in parallel over the IM 304 and IM 324R interface modules.
The IM 304 and IM 324R are interconnected over a 721 connecting cable with a maximum length of 100 m. The cable is connected to the lower interface of the IM 304.

Note:
Always use the following for parallel interfacing of the central controllers:
- interface module IM 304-3UB11 or a newer version
- interface module IM 324-3UR11 version 6 or a newer version

Please set the switches and jumpers as shown in Figures 3-20 and 3-21 for parallel interfacing of the subunits.

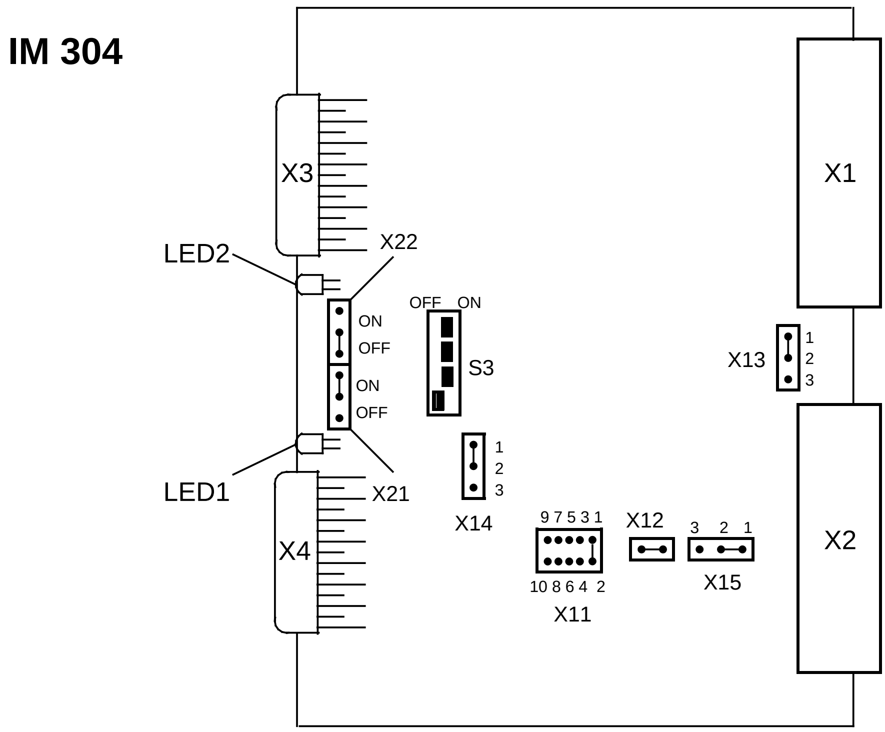


Figure 3-20. Switches and Jumper Settings on the IM 304-3UB11 for Parallel Interfacing of the Central Controller

Note:
If cable 721 for connecting both central processing units is longer than 10m, insert the jumper between contacts 3 and 4 in the jumper block X11. This setting reduces the baud rate between the CPUs. All other switch and jumper settings on the IM 304 must be retained as shown in Figure 3-20.

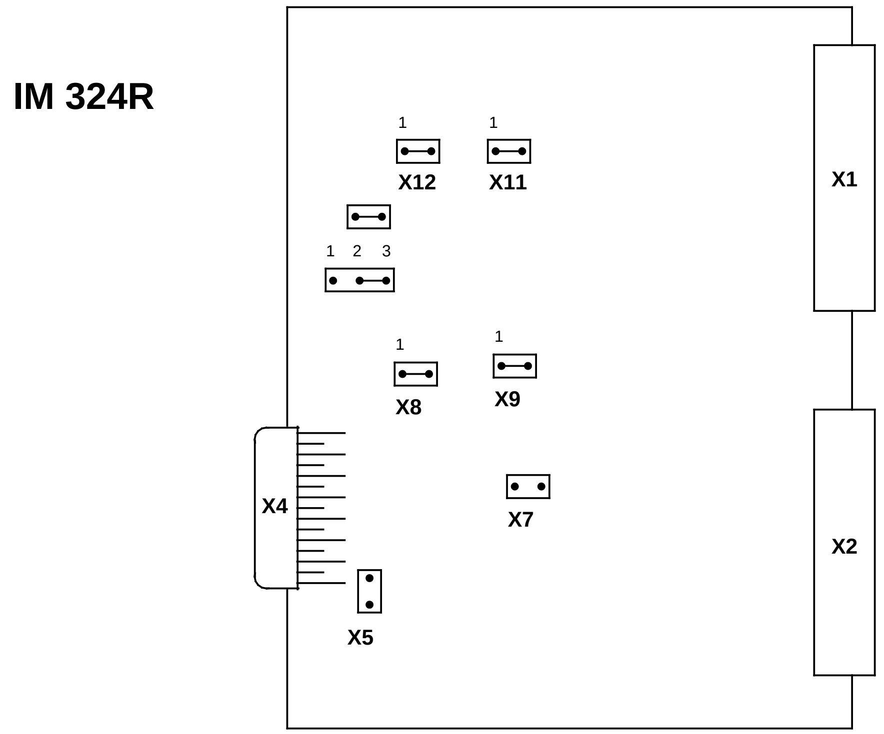


Figure 3-21. Jumper Configuration on the IM 324R for Parallel Interfacing of the Central Controllers

Note:
The IM 324R jumper configuration shown in the Figure must not be modified in any way as regards parallel interfacing of the central controllers.

3.4.6 Connection for Switched I / O Operation

In a switched I / O configuration, each central controller is connected to between two and four expansion units. Please observe the following:

- The IM 304 must be plugged into the central controller
- The IM 314R must be plugged into the ER 701-3LH expansion rack
- The length of the cable from the central controller to the last EU may not exceed 600 m

Figure 3-22 shows the switch settings and jumper configuration on the IM 304 and IM 314R interface modules for a switched I / O configuration.

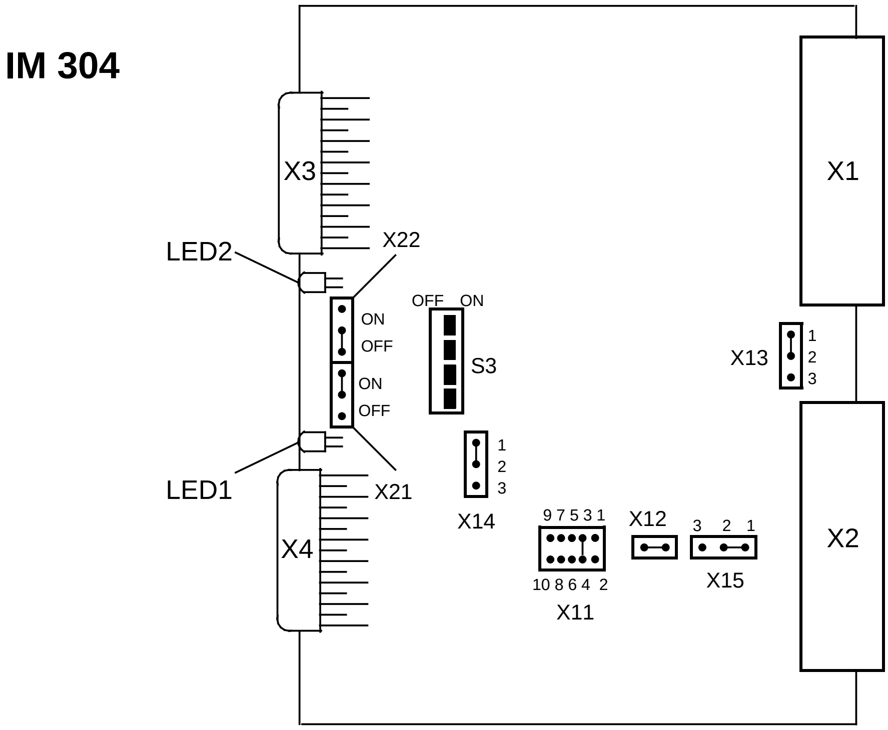


Figure 3-22. Switch Settings and Jumper Configuration on the IM 304-3UB11 for a Switched I / O Configuration

In Figure 3-22, the IM 304 has been set for the following:

- Cable length max. 100 m (X11); setting for other cable lengths see Fig. 3-29
- COM 115H evaluates CPU signal PEU when **one** interface is "not ready" (X14)
- COM 115H evaluates CPU signal PEU (I / O not ready) (X15)

Points to watch:

- You use jumpers X21 and X22 on the IM 304 to determine whether only one (X3 or X4) or both of the interfaces X3 and X4 is in operation.
  Switch in ON position: interface in operation
  Switch in OFF position: interface not in operation
- The bottom front connector (X4) on the last IM 314 must always be fitted with a 6ES5 760-1AA11 terminating connector.

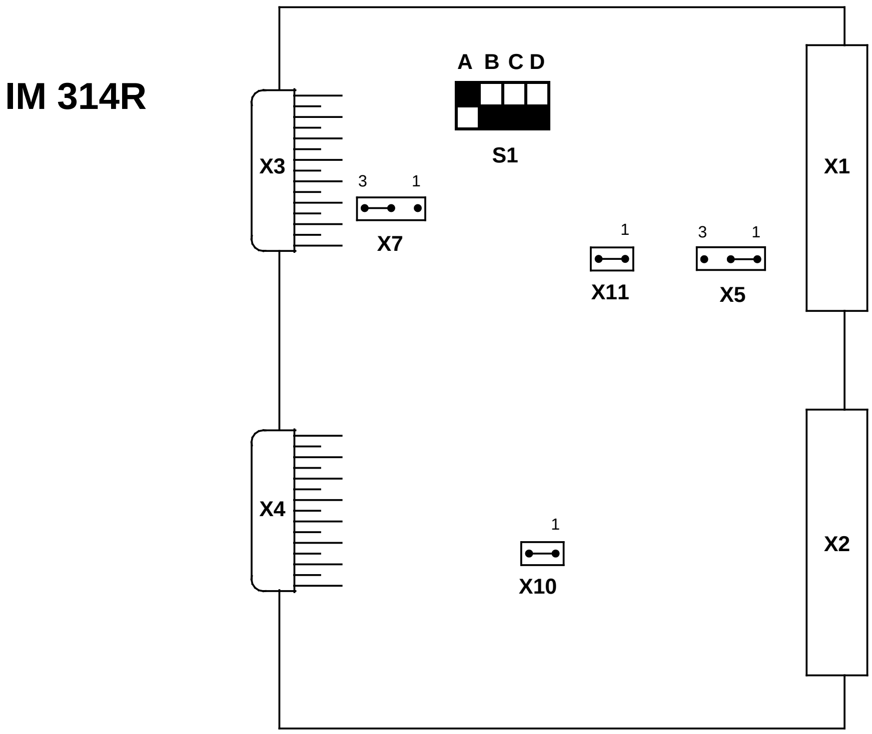


Figure 3-23. Switch Settings and Jumper Configuration on the IM 314R for a Switched I / O Configuration

Set the EU number with DIL switch S1 (see Figure 3-23). The table below shows the switch settings for the various EU numbers. EU numbers 1 to 8 are permissible in an S5-115H system.

Table 3-2. Switch Settings on the IM 314R Interface Module

EU Number	Switch Setting Switch Bank S1 A B C D	EU Number	Switch Setting Switch Bank S1 A B C D
1	▀ ▄ ▄ ▄	5	▀ ▄ ▀ ▄
2	▄ ▀ ▄ ▄	6	▄ ▀ ▀ ▄
3	▀ ▀ ▄ ▄	7	▀ ▀ ▀ ▄
4	▄ ▄ ▀ ▄	8	▄ ▄ ▄ ▀

Note:
In order to ensure that error messages regarding switched expansion units are unequivocal, you must
- assign each switched expansion unit a different EU number
- set the same EU number on both of the EU's IM 314Rs

Note:
The bottom front connector on the **last IM 314R** must be fitted with a terminating connector with Order No. 6ES5 760-0HA11.

The frontplate of the IM 314R is equipped with four LEDs for indicating the current state of the module. The table below tells you what each LED means.

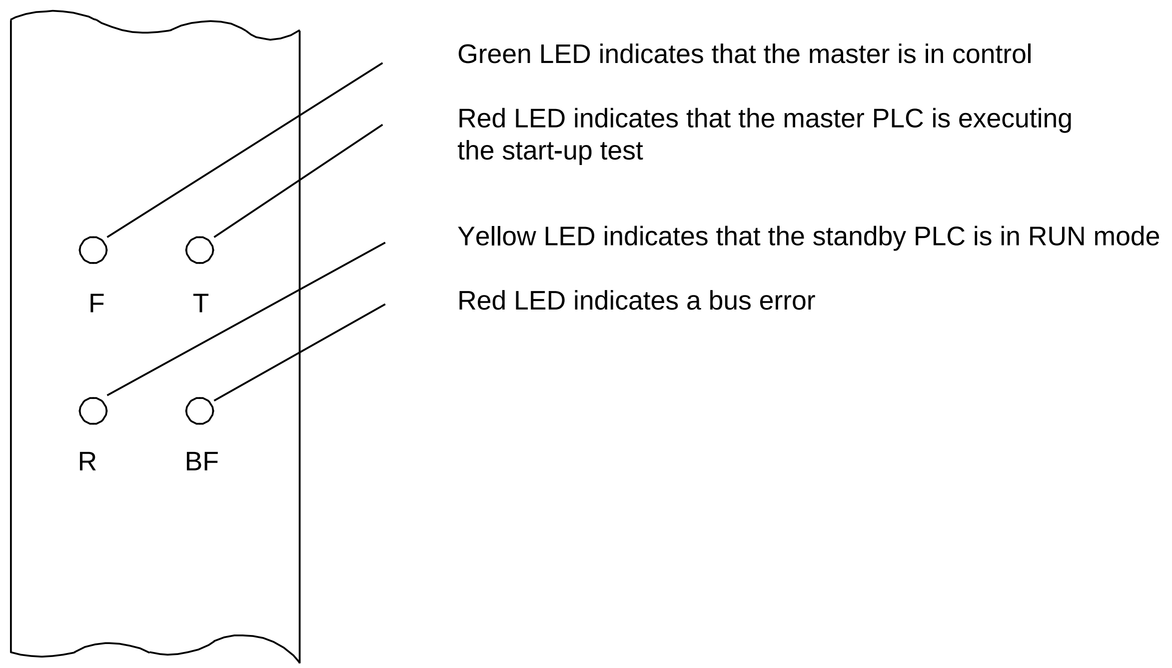


Figure 3-24. LEDs on the IM 314R Interface Module

Table 3-3. Descriptions of the LEDs on the IM 314R

LED	Description
F	The master is connected to the IM 314R
T	The green "F" LED and the red "T" LED light up when the master is executing the start-up test
R	The standby controller is in RUN mode
BF	Interfaced subunit is at STOP

3.4.7 Centralized Configurations

A central controller connected to as many as three EU 1 expansion units makes up a centralized configuration. Use only the IM 306 interface module to connect an ER 701-1 mounting rack.

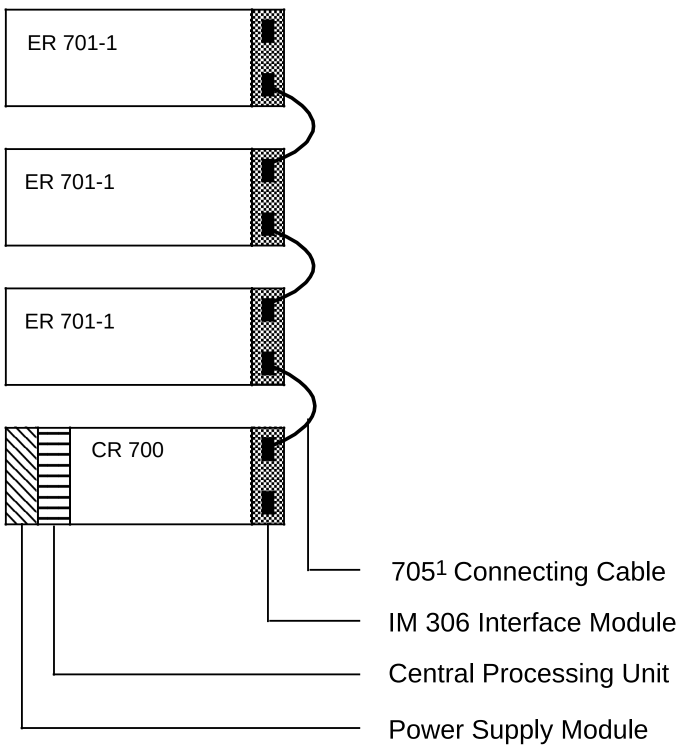
Please note the following:

- The 0.5 m (1.6 ft.) connecting cable is not long enough to connect the EU next to the CC.

Table 3-4. Centralized Configuration with IM 306 Interface Modules

	Configuration with IM 306
Number of EUs (maximum)	3
Total cable length	maximum 2.5m (8.2ft.)
Slot addressing	variable (for CC and EU)
Current supplied to EUs (maximum)	2 A *

* The EU with the most current supplied should be as close to the CC as possible



1 You can also order a 1.25 m (4.1 ft.) 705 connecting cable (Order No. 6ES5 705-0BB20) to mount two EUs next to each other.

Figure 3-25. Centralized Configuration with the IM 306 Interface Module

3.4.8 Distributed Configuration

Central controllers connected to expansion units installed over long distances make up a distributed configuration. The interface module used determines the distance and the number of EUs that can be connected. The different types of distributed configuration are described on the pages that follow.
See the relevant manual for a description of the IM 307 / 317 interface module (Order No. 6ES5 998-0LW21).

Please note the following points concerning all distributed configuration versions:

- Each ER 701-2 or ER 701-3 expansion rack requires a PS 951 power supply module and an IM 306 interface module for addressing input / output modules.
- See section 3.4.4 (shielding)!
- If you use digital input modules on the ER 701-2 or ER 701-3, it is recommended that you use modules with version level ”2” (or higher).

Table 3-5. Technical Specifications for Distributed Configuration Interface Modules

	AS 301	AS 310	IM 304	IM 314	IM 307	IM 317
Maximum no. of connectable EUs	4		8		14 *	
Maximum total cable	max. 200m		max. 600m		50-1500m	
Current consumption at 5V	0.8A	0.7A	1.2A	0.85A	1A	1A

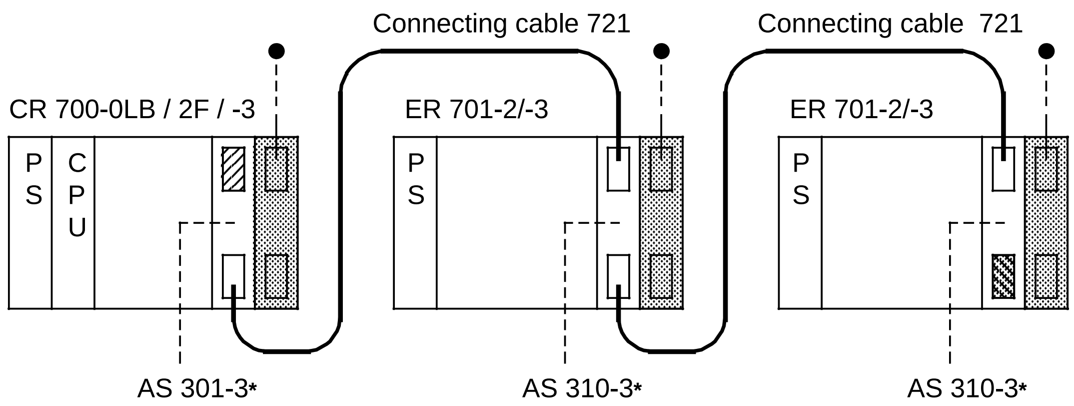
* *Depends on the length of the fiber-optic cable and on the modules´Ready delay time.*
A distributed configuration with IM 307 / IM 317 interface modules is under development.

Connection with AS 301 / AS 310 Interface Modules

Plug the AS 301 interface module into a CR 700-0LB / -2F / -3 central rack to connect as many as four EUs to the CC. Plug an AS 310 into each ER 701-0 / -2F / -3 expansion rack. Connect the interface modules with the 6ES5 721-.... connecting cable as shown in Figure 3-26.

Connections with the AS 301 / AS 310 interface modules have the following special features:

- Provide the following termination connectors for unused front connectors:
  EU AS 301 interface module: terminating connectors 6ES5 760-0AB11
  CC AS 310 interface module: terminating connectors 6ES5 760-0AA11
- No jumper settings are necessary if you use the basic address range.
- You cannot use the extended address range (Q range) for the S5-115H programmable controllers.
- CPs and intelligent I / Os cannot be plugged into the expansion racks.



Terminating connector 6ES5 760-0AB11

Terminating connector 6ES5 760-0AA11

IM 306 interface module

● You can connect up to three ER 701-1 expansion racks here.

* In adapter casing

Figure 3-26. Distributed Configuration with AS 301 / AS 310

Connection with IM 304 / IM 314 Interface Modules

Plug the IM 304 interface module into a CR 700-0LB / -2F / -3 central rack to connect as many as four EUs per interface to the CC. You can thus connect as many as eight distributed EUs to the CC over the IM 304. Plug an IM 314 into each ER 701-2 or ER 701-3 expansion rack. Connect the interface modules with the 6ES5 721-.... connecting cable as shown in Figure 3-27.

Connections with the IM 304 / IM 314 interface modules have the following special features:

- Use jumper X21 and X22 to determine wheter only one interface (X3 or X4) should operate.
  With the switch in the ON position, the appropriate interface is operative.
  With the switch in the OFF position, the appropriate interface is not operative.
- Always insert a 6ES5 760-1AA11 terminating connector in the receptacle for the lower front connector (X4) on the last IM 314.

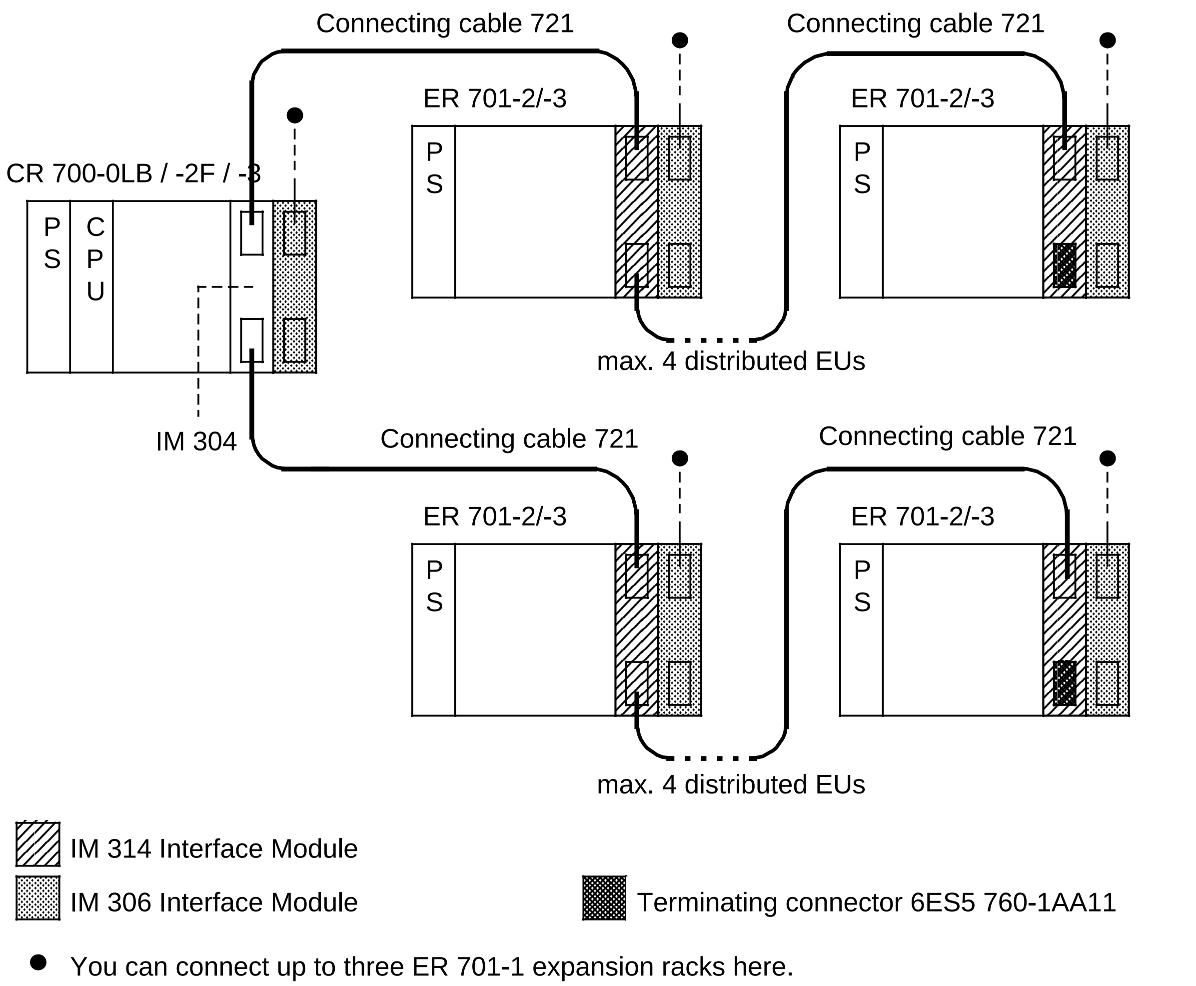


Figure 3-27. Distributed Configuration with IM 304 / IM 314

Switch and Jumper Settings on the IM 304 Interface Module for a Distributed Configuration

Figure 3-28 shows the locations of the switches and jumpers on the IM 304 interface module. When using an IM 304 in a distributed configuration, please set the jumpers on jumper header X11 as shown in the Figure.
All switches on selector switch S1 must be set to "ON".

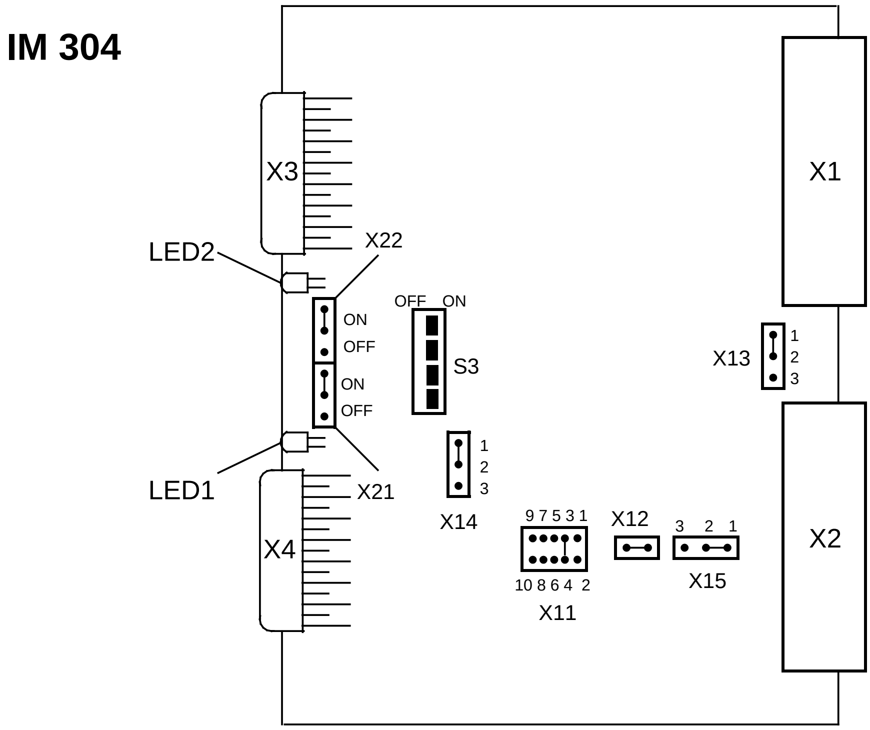


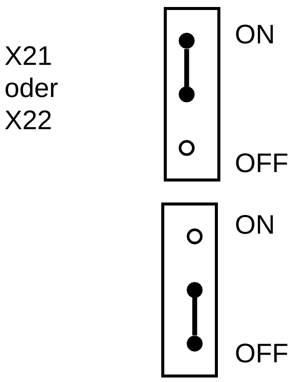
Figure 3-28. Switches and Jumper Settings on the IM 304 for a Distributed Configuration

In Figure 3-28, the IM 304 has been set for a distributed configuration.

- Maximum permissible cable length 100 m (X11)
- COM 115H evaluates the CPU signal PEU when **one** interface reports "not ready" (X14)
- COM 115H evaluates the CPU signal PEU (I / Os not ready) (X15)
- Both interfaces in operation (X21 and X22)

You can reconfigure jumpers X21, X22 and X11, X14 and X15.as shown on the following pages.

Interfaces can be activated or disactivated through the jumpers X21,X22.



expansion unit connected

No expansion unit connected

- With jumper X11, you set the total length of the 721 connecting cable for one interface down to the last EU. The longest connection at interface X3 or X4 is determined by the jumper setting at X11.

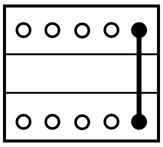
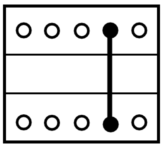
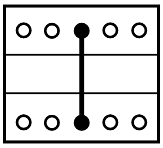
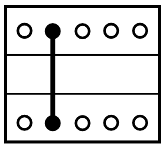
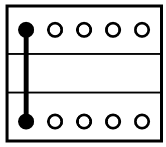
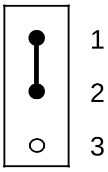
	Jumper block X11				
Jumper setting	9 7 5 3 1  10 8 6 4 2	9 7 5 3 1  10 8 6 4 2	9 7 5 3 1  10 8 6 4 2	9 7 5 3 1  10 8 6 4 2	9 7 5 3 1  10 8 6 4 2
cable length	only permissible for parallel link between central controllers	up to 100 m	100 ... 250 m	250 ... 450 m	450 ... 600 m

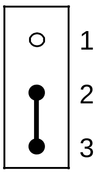
Fig. 3-29. Jumper Settings for the Cable Length to the IM 304

- Set the jumpers on X 14 and X 15 as follows for a distributed configuration with IM 304 / 314 :

X14

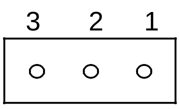


COM 115H generates PEU if **one** interface reports ”not ready”.

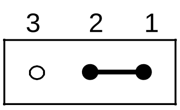


COM 115H generates PEU if **both** interfaces report ”not ready”.

X15



COM 115H does not evaluate PEU.



COM 115H evaluates PEU.
Caution: When power is turned on, Cold Restart (RN-ST-RN) is also necessary.

Note:

If the PEU bit is not evaluated, provision must be made in the restart routine to make sure that the expansion unit is ready before the central controller or that the process images are updated in OB1.

Switch and Jumper Settings on the IM 314 Interface Module for a Distributed Configuration

Figure 3-30 shows the locations of the switches and jumpers on the IM 314 module. When using the IM 314 interface module for a distributed configuration, please set the switches and jumpers as shown in the Figure.
All switches on selector switch S1 must be set to "OFF".

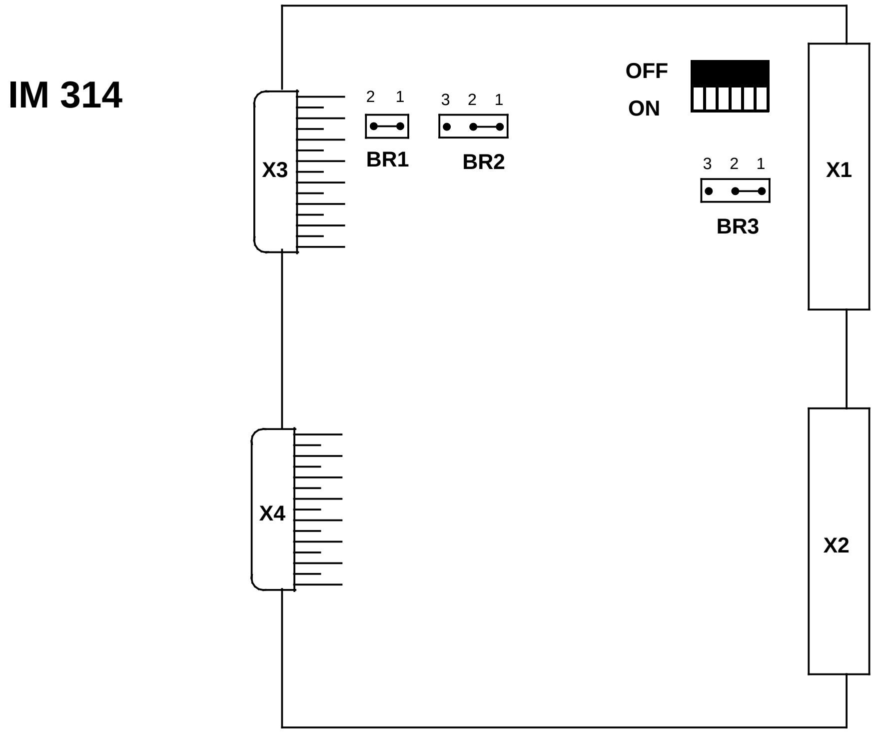


Figure 3-30. Switches and Jumper Settings on the IM 314 for a Distributed Configuration

Note:

When the IM 314 is used in a distributed configuration, the settings shown in the Figure above must not be altered in any way.

3.5 Wiring

The backplanes on the mounting racks establish the electrical connection between all modules.

Make the following additional wiring connections:

- The PS 951 power supply module to the power line
- The sensors and actuators to the digital or analog modules. Connect the sensors and actuators to a front connector that plugs into the contact pins on the front of each module. You can connect the signal lines to the front connector before or after you plug it into the module. The connection diagram of each module is on the inside of the front door. Perforated label strips are included with each input and output module. Use these strips to note the addresses of the individual channels on the module. Slip the strips along with their protective transparent covers into the guides in the front door.
  Chapter 7 ”Analog Value Processing” describes how transducers are connected up to analog input modules and the feedback modules of the analog output modules.

Sections 3.3.1 through 3.3.6 explain how to connect individual modules.

Please consult the appropriate operator's guide or manual for information on wiring the intelligent input / output modules and communications processors.

3.5.1 Connecting the PS 951 Power Supply Module

Connect the PS 951 as follows:

Set the voltage selector switch to the appropriate voltage (only in the case of AC modules).

Connect the power cable to terminals L1, N and ⏚.

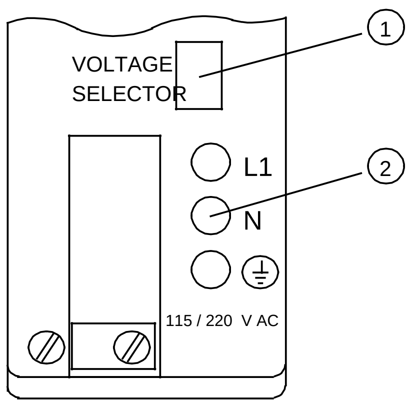


Figure 3-31. PS 951 Power Supply Module

3.5.2 Connecting Digital Modules

Digital modules are available in nonfloating and floating versions. for the nonfloating modules, the reference voltage of the external process singals (M_{ext}) has to be connected to the internal reference voltage (M_{int}, i. e. PE) (Figure 3-32). For floating modules, an optocoupler separates the external voltages from the internal ones.

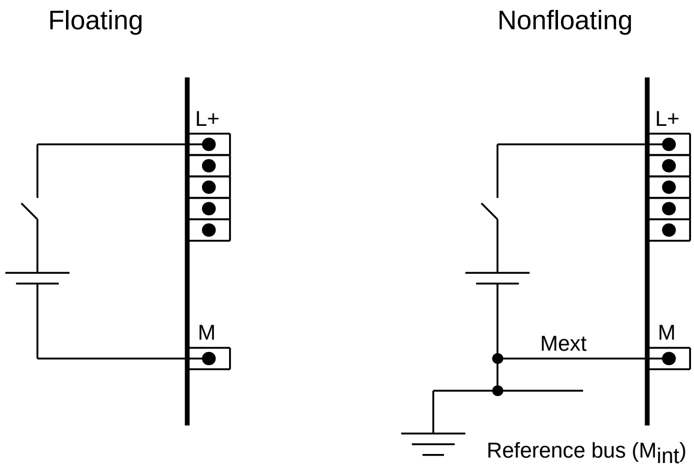


Figure 3-32. Connection to Floating and Nonfloating Modules

Note:
See Chapter 5 ”Addressing / Address Assignment” for information on address assignment in the case of digital modules.

3.5.3 Front Connectors

Table 3-6 shows the available front connectors:

Table 3-6. Front Connector Overview

Order No.	Terminals per Front Connector	Connection Method	Wire Cross Section per Terminal [1]
6ES5 490-7LB11	24	Screw-type connection (SIGUT)	1 x (1.0 ... 2.5) mm^2 or 2 x (0.5 ... 1.5) mm^2 *
6ES5 490-7LC11	46	Spring-loaded connection	1 x (0.25 ... 1.5) mm^2 ** or max. 1.5mm^2 for combinations of conductors with end sleeve
6ES5 490-7LB21	46	Screw-type connection *** (box terminal)	
6ES5 497-4UB11	42		
6ES5 490-7LA11 (with crimp contacts)	46	Crimp snap-in (mini spring contact)	1 x (0.5 ... 2.5) mm^2 or 2 x (0.5 ... 0.75) mm^2
6ES5 490-7LA12 (without crimp contacts)[2]			

1 When plug-in jumpers are used, the conductor cross-sections are reduced

2 Use crimp contacts with Order No. 6XX5 070 (pack of 250)

***** Flexible conductor with end sleeves: 0.75 to 1.5 mm^2

****** With end sleeves: 0.5 to 1.5 mm^2

******* 1.5 mm^2 with jumper comb

We recommend the use of end sleeves, especially in corrosive environments.

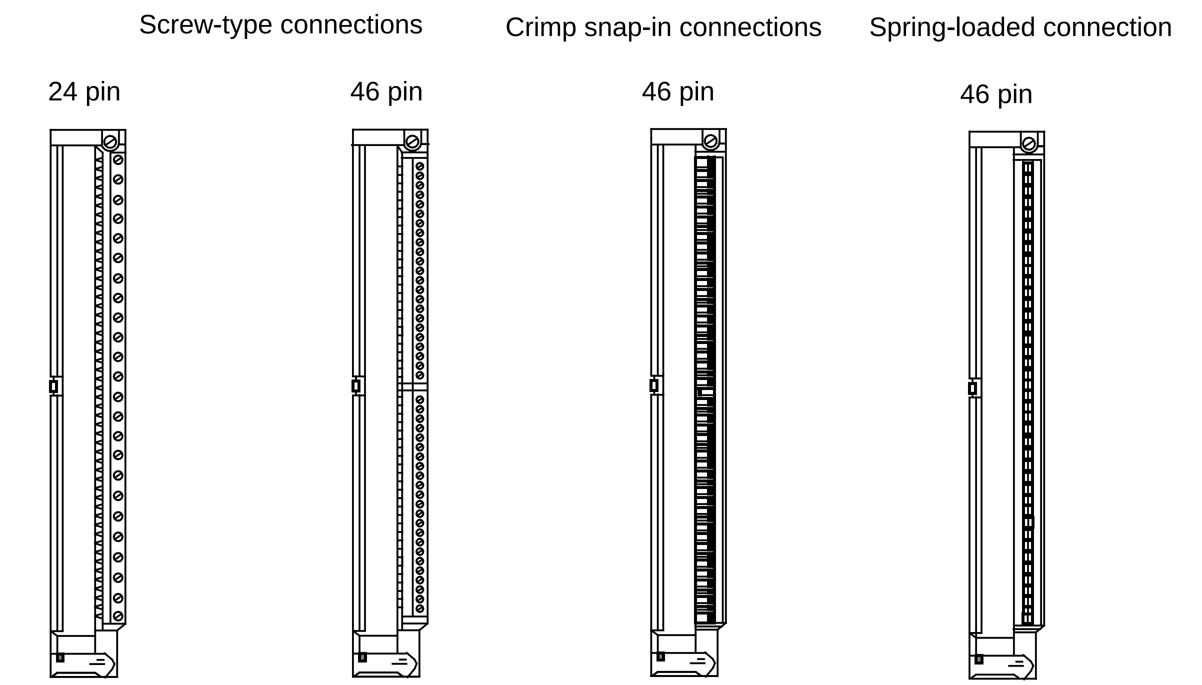


Figure 3-33. Front Views of Front Connectors

The connectors have openings at the bottom for standard strain-relief clamps.

Installing the Front Connector

Install the front connector as follows:

1. Open the front door of the module
2. Hook the front connector in the pivot at the bottom of the module.
3. Swing the front connector up and in until it engages with the module.
4. Tighten the screw at the top of the front connector to secure it.

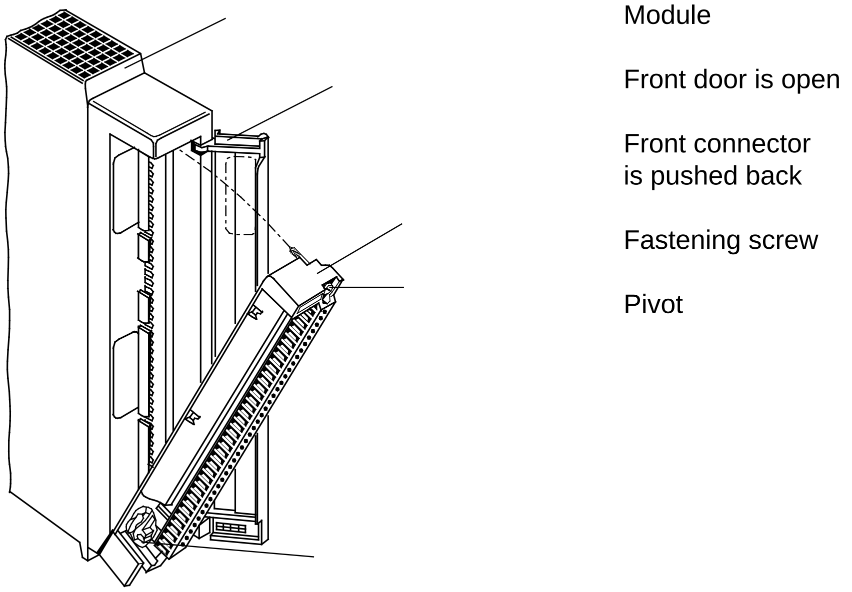


Figure 3-34. Installing the Front Connector

3.5.4 Simulator

You can use an appropriate simulator instead of a front connector. Use the toggle switches on the front of this device to simulate input signals (Figure 3-35). A simulator needs an external power supply.

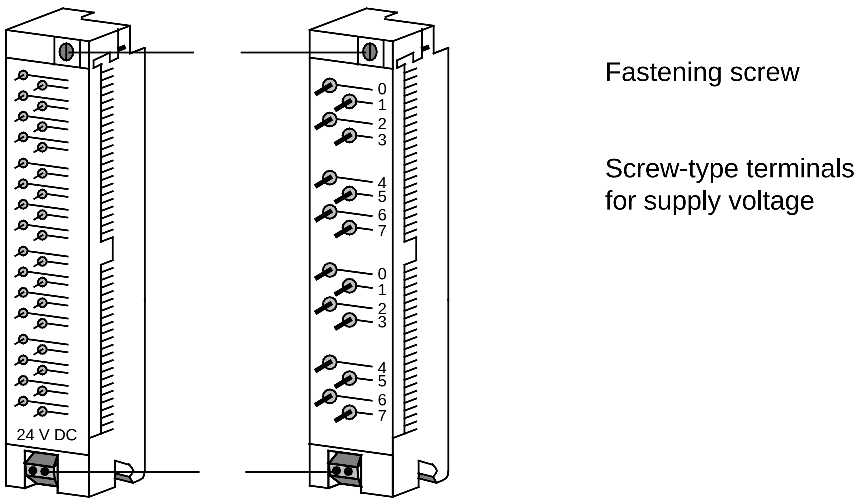


Figure 3-35. Simulators

3.5.5 Connecting the Fan Subassembly

Figure 3-36 shows the wiring necessary to operate a fan subassembly.

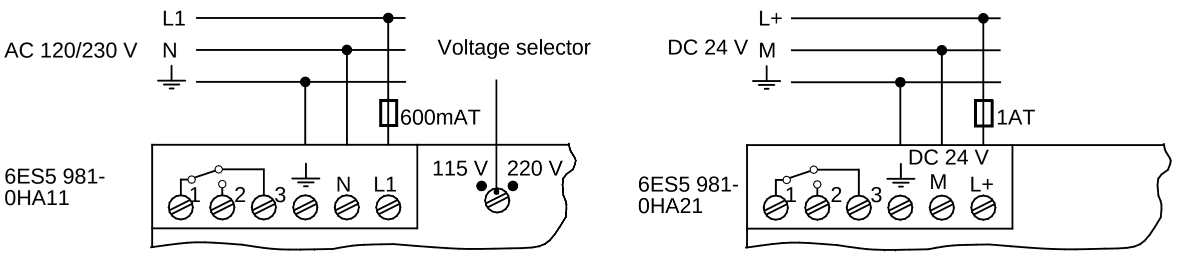


Figure 3-36. Fan Subassembly Terminal Assignment

A floating changeover contact gives a fault signal via terminals 1, 2, and 3 if the fan fails.
The diagram in Figure 3-36 shows the switch positions in the case of a fault! Under normal operating conditions, the contacts 1 - 2 are closed and the contacts 1 - 3 open.

3.6 Electrical Installation

The following chapter explains the electrical installation of the S5-115H.

3.6.1 Power Supply

You require the following for a completely configured SIMATIC S5 controller

- Power supply with internal PLC circuits (control power supply module)
  and
- Load power supply modules for the input and output circuits (load power supply module).

PS 951 Control Power Supply Module

The control power supply module supplies the following:

- CPU
- Programmer interface
- Control circuits of the I/O modules.

The following table gives you an overview of the power supply modules for an S5-115H.

Table 3-7. Overview of the Power Supply Modules

Input Voltage	Output Current	Galvanic Isolation	Power Supply Module	Output Voltages
120/230 V AC	7 A (15 A with fan)	Yes	6ES5 951-7LD21	
24 V DC	3 A	No	6ES5 951-7NB21	5 V DC 5.2 V DC 24 V DC
24 V DC	7 A (15 A with fan)	No	6ES5 951-7ND51	
24 V DC	7 A (15 A with fan)	Yes	6ES5 951-7ND41	

Note:
Please ensure that the control power supply module is not overloaded. Estimate the power consumption of all modules.

When using the different PS 951 power supply modules, you must note the following:

- For the 6ES5 951-7ND41 floating module, the input voltage must be a functional extra-low voltage in accordance with VDE 0100 or a comparable standard. Otherwise, the PE terminal must be connected to the protective ground wire.
- For the 6ES5 951-7ND51/7ND41/7NB21 power supply modules, there is no galvanic isolation between the 24 V side and the 5 V side, whose reference potential is permanently connected to the mounting rack.
- The use of the following modules is ***not*** permissible due to the missing DSI signal in the case of the 3 A power supplies:
  - IP 246/247
  - CP 513/526/527/535/580/581/143.
- The CP 524/524 must not be used with 3 A power supply modules since their power consumption is too high.
- Magnetic voltage stabilizers must ***not*** be connected direct on the input side of power supply modules!
  If you use magnetic voltage stabilizers in parallel network branches, you must expect overvoltages to occur as a result of mutual interference. These voltage peaks can destroy the power supply module! If such a case arises, please consult the department responsible.

The Load Power Supply

The load power supply supplies the following:

- Input/output circuits (load circuits)
  and
- Sensors and actuators.

W A R N I N G !

For SIMATIC modules supplied with functional extra-low voltages (V 120 V DC, V 50 V AC), you require load power supply units with safe (electrical) isolation to DIN VDE 0106, Part 101. All Siemens power supply units of the 6EV1 range meet this requirement.

Dimensioning the Load Power Supplies

The electronic short-circuit protection of DQ modules activates only when the triple nominal current has been exceeded. For this reason, dimension the load power supply units in such a way that the power supply can deliver the current required for switching off in the case of a short-circuit at an output.

If the load power supply unit has not been sufficiently dimensioned, this can result in a current higher than the nominal current flowing for an extended period in the case of a short-circuit at digital outputs, without the short-circuit protection of the DQ module activating. Operation at overload can destroy the module.

Load Power Supply for Nonfloating Modules

If you use nonfloating modules, you must create a common reference potential for the internal control circuits of the PLC and for the load circuits. For this reason, connect the reference potential of the load power supply unit with the ground connection of the PLC (PE terminal or ⏚). The ground connection is permanently connected to the internal reference potential of the controller.

Load Power Supply for Floating Modules

Note:
If you use switched-mode power supply units to supply floating analog modules and BEROs, you must first run this supply over a mains filter.

3.6.2 Electrical Installation with Field Devices

The following figures each show an example circuit for connecting control power supply and load power supply. They also show the grounding concept for operation from the following:

- Grounded supplies
- Centrally grounded supplies
- Nongrounded supplies.

Please note the following when installing your controller. The text contains reference numbers which you can find in Figures 3-37 to 3-39.

Master Switch and Short-Circuit Protection

- You must provide a master switch to DIN VDE 0113, Part 1, or a disconnecting device to DIN VDE 0100, Part 460, for the programmable controller, sensors and actuators.
  These devices are not required in the case of subsystems where the relevant device has been provided at a higher level.
- You can provide the circuits for sensors and actuators with short-circuit protection and/or overload protection in groups. According to DIN VDE 0100, Part 725, single-pole short-circuit protection is required in the case of grounded secondary side and all-pole protection is required in all other cases.
- For nonfloating input and output modules, connect terminal M of the load power supply unit with the PE ground conductor of the control circuit's PS 951 power supply module.

Load Power Supply

- For 24 V DC load circuits, you require a load power supply unit with safe electrical isolation.
- You require a back-up capacitor (rating: 200µF per 1 A load current) for nonstabilized load power supply units. Connect the capacitor in parallel to the output terminals of the load power supply module.
- For controllers with more than five electromagnetic operating coils, galvanic isolation by a transformer is required by DIN VDE 0113, Part 1; it is recommended by DIN VDE 0100, Part 725 .
- For nonfloating input and output modules, connect terminal M of the load power supply unit with the PE ground conductor of the control circuit's PS 951 power supply module.

Grounding

- You should ground load circuits where possible . Provide a removable connection to the protective conductor on the load power supply unit (terminal L- or M) or at the isolating transformer in secondary circuit.
- To protect against stray noise, use copper conductors of at least 10 mm^2 cross section to ground the mounting racks by the shortest possible route.

W A R N I N G !

You must provide insulation monitoring devices for nongrounded power supply modules

- If hazardous plant conditions could arise from double-line-to-ground faults or double fault to frame faults
- If no safe (electrical) isolation is provided
- If circuits are operated with voltages > 120 V DC
- If circuits are operated with voltages > 50 V AC.

- The mounting racks of the S5-115U must be connected to the protective conductor. This grounds the reference potential of the controller.
  Nongrounded operation of S5-115U controllers is only permissible if all the circuits are operated with functional extra-low voltage. In this case, connect the mounting rack or DIN rail over an RC network with the protective conductor.

Operating a Programmable Controller with Field Devices on Grounded Supply

Operation from grounded power supplies offers the best protection against interference.

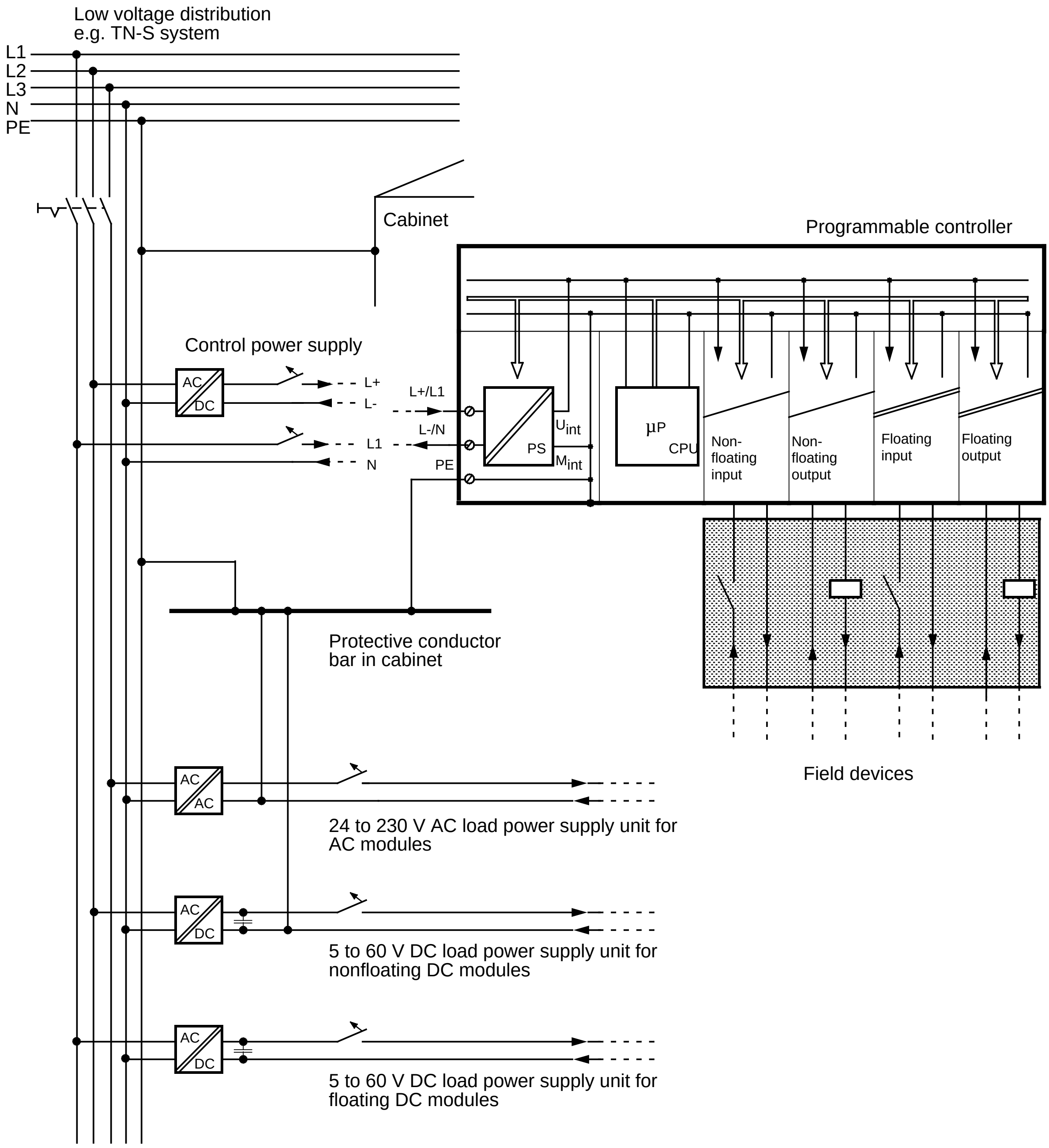


Figure 3-37. Operating a Programmable Controller with Field Devices on Grounded Supply

Operating a Programmable Controller with Field Devices on a Centrally Grounded Supply

In plants with their own transformers or generators, the PLC is connected to the central grounding point. A removable connection must be provided for measuring ground faults.

Installation of the PLC must be such that there is insulation between the cabinet potential and the protective conductor potential. In order to maintain the insulation, all connected devices must be ***grounded capacitively or they must be nongrounded***. For this reason, programmers must be supplied only over an isolating transformer.

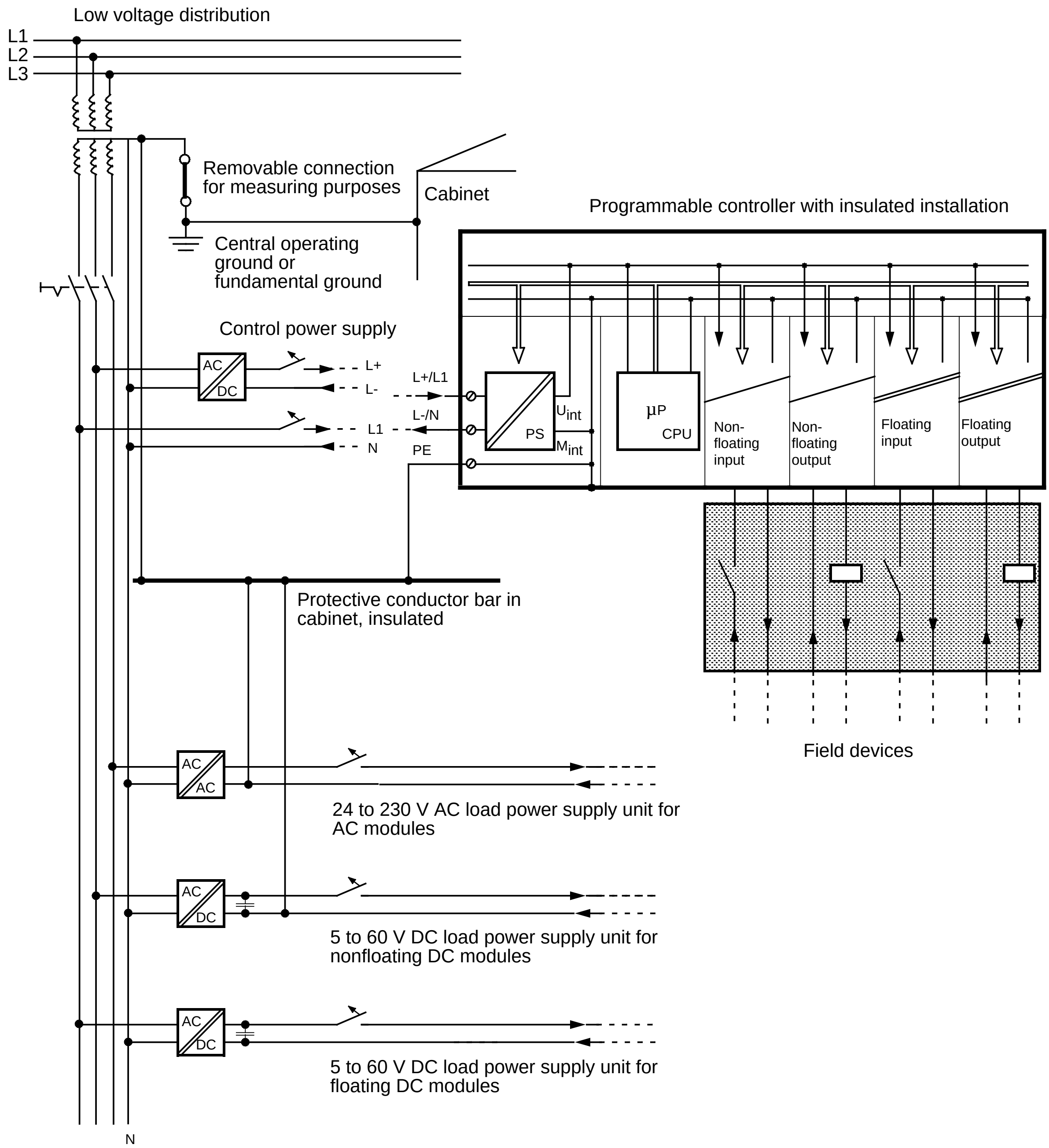


Figure 3-38. Operating a Programmable Controller with Field Devices on Centrally Grounded Supply

Operating a Programmable Controller with Field Devices on Ungrounded Supply

Neither the outer conductor nor the neutral are connected to the protective conductor in the case of nongrounded supplies. Operation of the PLC with nonfloating power supply modules is ***not*** permissible.

Please note the following when connecting power supply modules:

In networks with 3 x 230 V, you can connect the power supply module direct to two outer conductors (see Figure 3-39).

In networks with 3 x 400 V, connection between the outer conductor and the neutral conductor is not permissible (unacceptably high voltage in the case of ground fault). Use intermediate transformers in these networks.

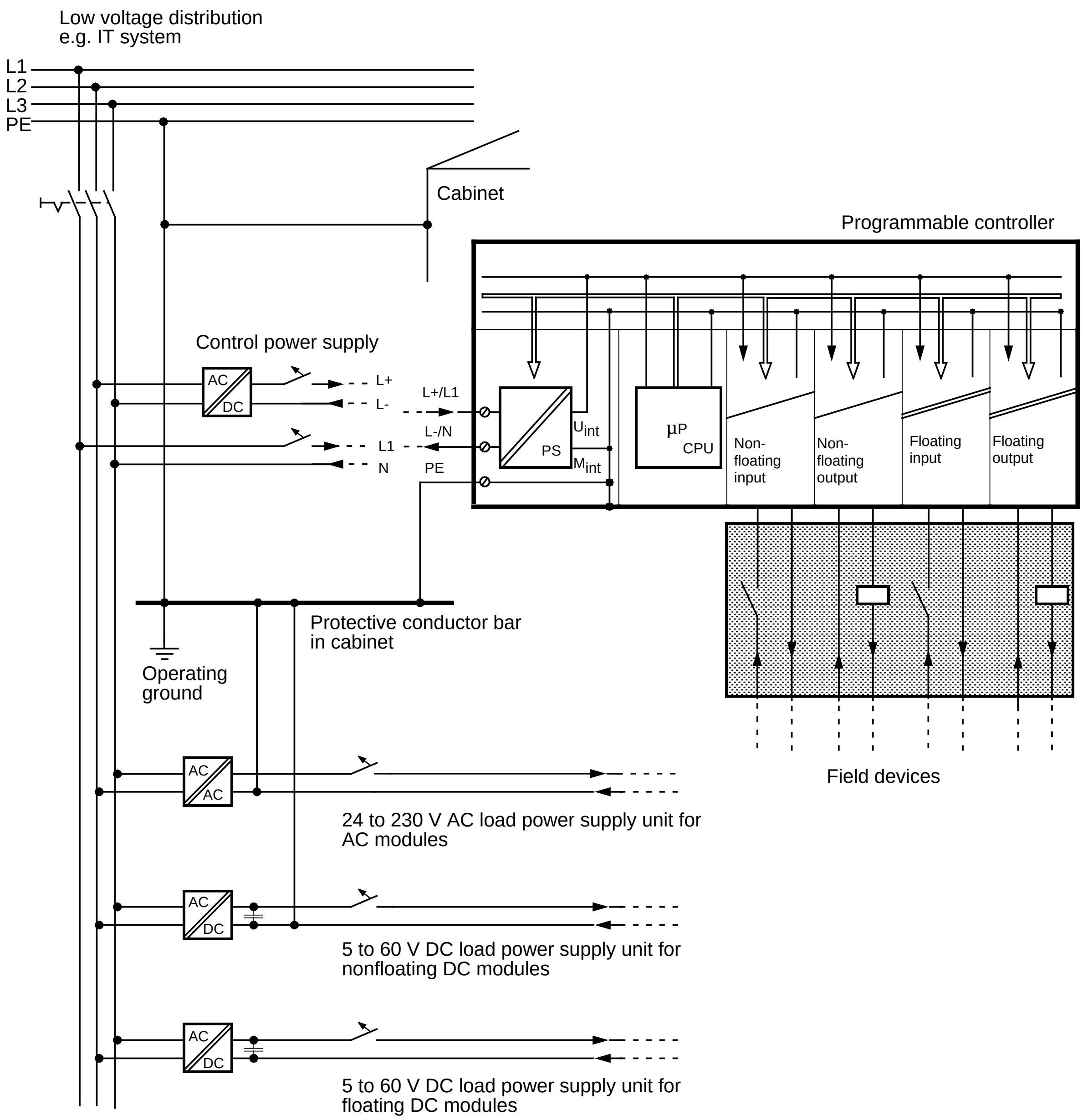


Figure 3-39. Operating a Programmable Controller with Field Devices on Nongrounded Supply

3.6.3 Connecting Nonfloating and Floating Modules

The following sections show the special features involved in installations with nonfloating and floating modules.

Installation with Nonfloating Modules

In installations with nonfloating modules, the reference potential of the control circuit ($M_{internal}$) and the load circuits ($M_{external}$) are not galvanically isolated.

The reference potential of the control circuit ($M_{internal}$) is at the PE terminal or ⏚ and must be connected to the reference potential of the load circuit via a line to be run externally.

Figure 3-40 shows a simplified representation of an installation with nonfloating modules. The installation is independent of the grounding concept. The connections for the grounding measures are therefore ***not*** shown:

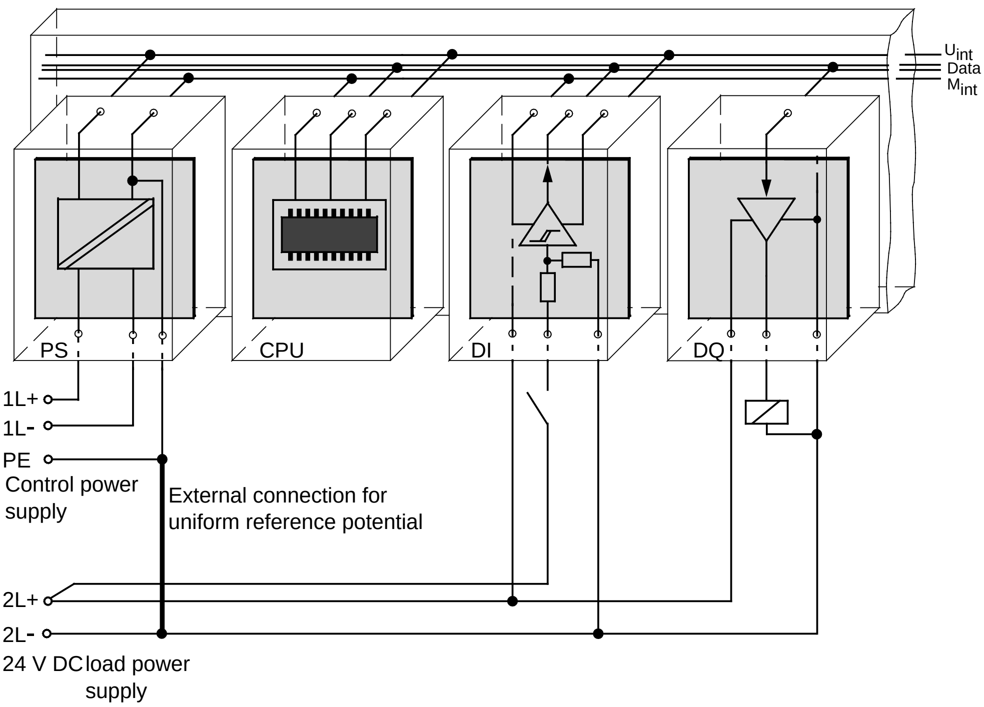


Figure 3-40. Simplified Representation of an Installation with Nonfloating Modules

Voltage drop on line must not exceed 1 V, otherwise the reference potentials will shift and result in failures of the module.

Note:
It is imperative that you connect the reference potential of the load power supply unit with the L- terminal of the module in the case of 24 V DC DO modules. If this connection is missing (e.g. wirebreak), a current of typically 15 mA can flow at the outputs. This output current can be sufficient to ensure that

- Energized contactors do not drop out
  and
- High-resistance loads (e.g. miniature relays) can be driven.

Installation with Floating Modules

Control circuit and load circuit are galvanically isolated in the case of floating modules.

Installation with floating modules is necessary in the following cases:

- All AC load circuits
  and
- Non-connectable DC load circuits.
  The reasons for this are, e.g. different reference potentials of the sensors or the grounding of the plus poles of a battery, ...

Figure 3-41 shows the simplified representation of an installation with floating modules. The installation is independent of the grounding concept. The connections for grounding measures are therefore ***not*** shown.

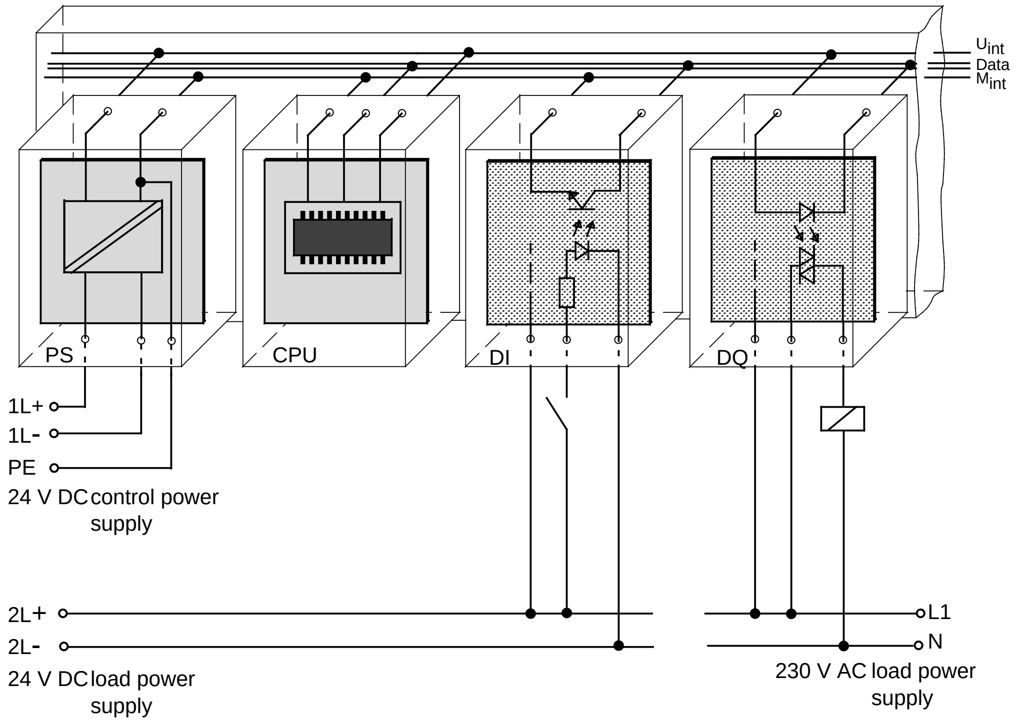


Figure 3-41. Simplified Representation for Installation with Floating Modules

3.7 Installing Programmable Controllers in Conformity with EMC Guidelines

Measures to suppress interference are frequently only taken when the controller is already in operation and reception of a signal has already been affected. In most cases, such interference is attributable to inadequate reference potentials caused by faulty installation of the programmable controller.

When installing the programmable controller, you must ensure that all inactive metal parts have surface contact grounding.
Correct grounding creates a uniform reference potential for the controller and reduces the effects of strays.

Grounding means the conductive connection of all inactive metal parts. The total of all interconnected inactive parts is called the ground.

Inactive metal parts are all conductive parts that have at least basic electrical isolation from active parts and that are energized only in case of a fault.

Even in case of a fault, the ground must ***not carry a dangerous touch voltage***. The ground must therefore be connected with the protective conductor. To avoid ground loops, you must always connect locally separated ground configurations (cubicles, structural parts and machine parts) to the protective conductor system in a star configuration.

Note the following when grounding:

- Connect the inactive metal parts as carefully as the active parts.
- Make sure that the metal-to-metal connections are of low impedance, e.g. through large-surface contacting with good conductivity.
- If you include enamelled or anodized metal parts in the grounding, these insulating protective layers must be penetrated. For this purpose, use special contact washers or remove the insulation layers.
- Protect joints against corrosion, for example, by means of grease.
- Movable ground parts (e.g. cubicle doors) must be connected via flexible grounding strips. The grounding strips should be short and have a large surface, since the surface is decisive for the discharge of high-frequency interference.

3.8 Wiring Arrangement

This section describes the wiring arrangements for bus cables, signal cables, and power supply cables that guarantee the electromagnetic compatibility (EMC) of your installation.

3.8.1 Running Cables Inside and Outside a Cabinet

Dividing the lines into the following groups and running the groups separately will help you to achieve electromagnetic compatibility (EMC).

Group A: Shielded bus and data lines (for PG, OP, SINEC L1, SINEC L2, printer, etc.)
Shielded analog lines
Unshielded lines for DC voltage 60 V
Unshielded lines for AC voltage 25 V
Coaxial lines for monitors

Group B: Unshielded lines for DC voltage > 60 V and 400 V
Unshielded lines for AC voltage > 25 V and 400 V

Group C: Unshielded lines for DC and AC voltage > 400 V

Group D: Lines for SINEC H1

You can use the following table to see the conditions which apply to the running of the various combinations of line groups.

Table 3-8. Rules for Common Running of Lines

	Group A	Group B	Group C	Group D
Group A				
Group B				
Group C				
Group D				

Legend for table:

Lines can be run in common bundles or cable ducts
Lines must be run in separate bundles or cable ducts (without minimum distance)
Inside cabinets, lines must be run in separate bundles or cable ducts and outside cabinets but inside buildings, lines must be run on separate cable trays with a gap of a least of 10 cm between lines.
Lines must be run in separate bundles or cable ducts with at least 50 cm between lines.

3.8.2 Running Cables Outside Buildings

Run lines outside buildings where possible in metal cable supports. Connect the abutting surfaces of the cable supports galvanically with each other and ground the cable supports.

When you run cables outdoors, you must observe the regulations governing lightning protection and grounding. Note the general guidelines:

Lightning Protection

If cables and lines for SIMATIC S5 devices are to be run outside buildings, you must take measures to ensure internal and external lightning protection.

Outside buildings run your cables
either
- In metal conduits grounded at both ends
  or
- In steel-reinforced concrete cable channels

Protect signal lines from overvoltage by using:
- Varistors
  or
- Lightning arresters filled with inert gas

Install these protective elements at the point where the cable enters the building.

Note:
Lightning protection measures always require an individual assessment of the entire system. If you have any questions, please consult your local Siemens office or any company specializing in lightning protection.

Grounding

Make certain that you have sufficient equipotential bonding between the devices (see Section 3.9).

3.9 Equipotential Bonding

Potential differences may occur between separate sections of the system if

- Programmable controllers and I/Os are connected via non-floating interface modules or
- Cables are shielded at both ends but grounded via different sections of the system.

Potential differences may be caused, for instance, by differences in the system input voltage. These differences must be reduced by means of equipotential bonding conductors to ensure proper functioning of the electronic components installed.

Note the following for equipotential bonding:

- A low impedance of the equipotential bonding conductormakes equipotential bonding more efficient.
- If any shielded signal cables connected to earth/protective earth at both ends are laid between the system sections concerned, the impedance of the additional equipotential bonding conductor must not exceed 10 % of the shield impedance.
- The cross-section of the equipotential bonding conductor must be matched to the maximum compensating currents. The following cross-sections are recommendable:
  - 16 mm^2 copper wire for equipotential bonding line up to 200 m (656.2 ft).
  - 25 mm^2 copper wire for equipotential bonding line over 200 m (656.2 ft).
- Use equipotential bonding conductors made of copper or zinc-plated steel. Equipotential bonding conductors are to be connected to earth/protective earth via a large contact area and to be protected against corrosion.
- The equipotential bonding conductor should be laid in such a way as to achieve a relatively small contact area between equipotential bonding conductor and signal cables
  (see Figure 3-42).

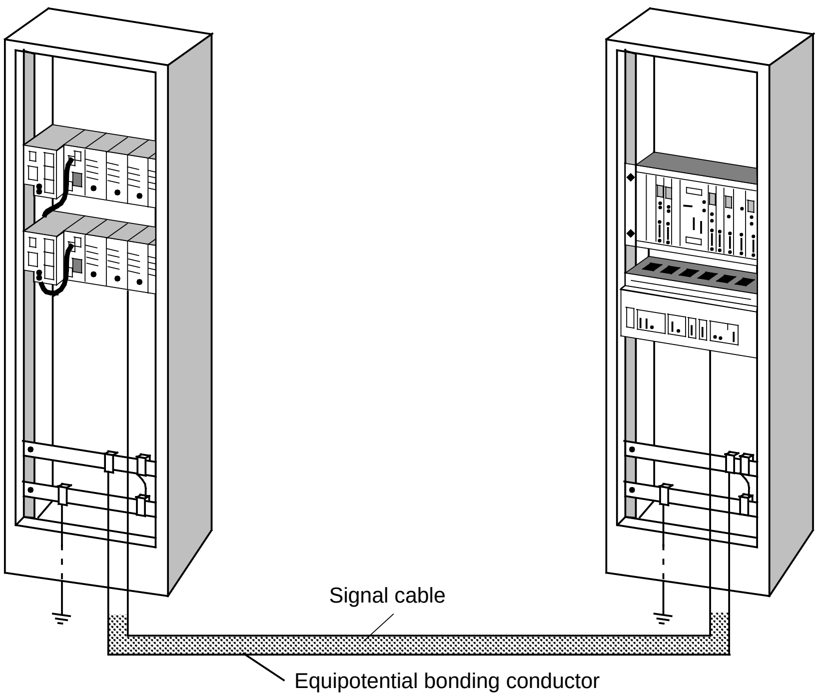


Figure 3-42.   Laying Equipotential Bonding Conductor and Signal Cable

Equipotential bonding in distributed configurations

For distributed configurations, differentiate between the following cases:

- Separate arrangement (up to 200 m/656.2 ft.) of central controllers and expansion units when connected by the IM 304/314 interface modules.
  The IM 304/314 interface modules are nonfloating. In this case, provide equipotential bonding conductor (see VDE 0100. Section 547).
- Signal transfer between separate systems via input and output modules.
  Use floating input and output modules for signal transfer.

3.10 Shielding Cables

Shielding is a measure to weaken (attenuate) magnetic, electric or electromagnetic interference fields.

Interference currents on cable shields are discharged to ground over the shield bar which has a conductive connection to the housing. So that these interference currents do not become a source of noise in themselves, a low-resistance connection to the protective conductor is of special importance.

Use only cables with shield braiding if possible. The effectiveness of the shield should be more than 80%. Avoid cables with foil shielding since the foil can easily be damaged by tension and pressure; this leads to a reduction in the shielding effect.

As a rule, you should always shield cables at both ends. Only shielding at both ends provides good suppression in the high frequency range.

As an exception only, you can connect the shielding at one end. However, this attenuates only the lower frequencies. Shielding at one end can be of advantage in the following cases:
- If you cannot run an equipotential bonding conductor
- If you are transmitting analog signals (e.g. a few microvolts or microamps)
- If you are using foil shields (static shields).

Always use metallic or metalized connectors for data lines for serial connections. Secure the shield of the data line at the connector housing. Do ***not*** connect the shield to the PIN1 of the connector strip!
In the case of stationary operation, you are recommended to insulate the shielded cable without interruption and to connect it to the shield/protective ground bar.

Note:
If there are potential differences between the earthing points, a compensating current can flow over the shielding that is connected at both ends. For this reason, connect an additional equipotential bonding conductor (see Section 3.9).

Note the following when connecting the cable shield:
- Use metal cable clamps for fixing the braided shield. The clamps have to enclose the shield over a large area and make good contact (see Figure 3-43).
- Connect the shield to a shield bar immediately at the point where the cable enters the cabinet. Route the shield to the module; do **not** connect it to the module.

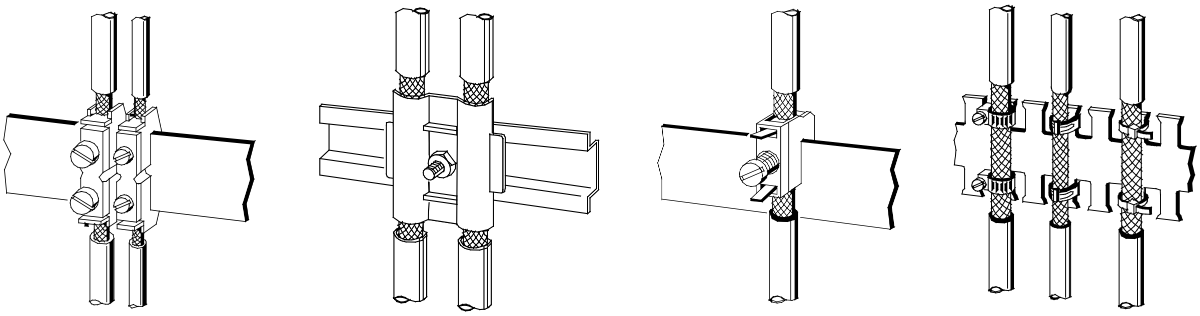


Figure 3-43. Fixing Shielded Cables with Various Types of Cable Clamps

3.11 Special Measures for Interference-Free Operation

Arc Suppression Elements For Inductive Circuits

Normally, inductive circuits(e.g. contactor or relay coils) energized by SIMATIC S5 do not require to be provided with external arc suppressing elements since the necessary suppressing elements are already integrated on the modules.

It only becomes necessary to provide arc supressing elements for inductive circuits in the following cases:
- If SIMATIC S5 output circuits can be switched off by additionaly inserted contactors (e.g. relay contactors for EMERGENCY OFF). In such a case, the integral suppressing elements on the modules become ineffective.
- If the inductive circuits are ***not*** energized by SIMATIC S5.

You can use free-wheeling diodes, varistors or RC elements for wiring inductive circuits.

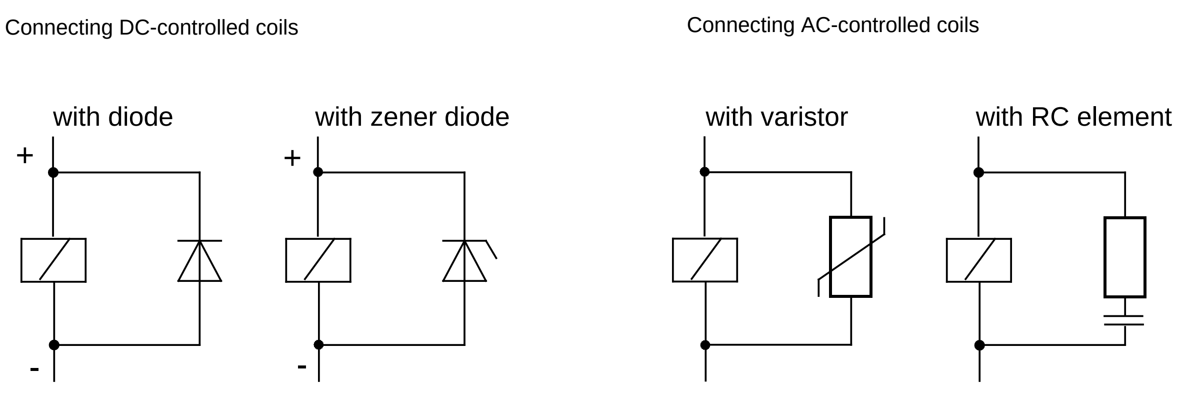


Figure 3-44. Connecting Coils

Mains Connection for Programmers

In each cabinet group, provide a grounding-type receptacle to supply power for the programming devices. The receptacle should be supplied from the distribution board to which the protective ground for the cabinet is connected.

Cabinet Lighting

Take normal lamps for cabinet lighting, e. g. LINESTRA® lamps are more suitable. For reasons of noise immunity, do not use flourescent lamps inside the cabinet. If you must use fluorescent lamps, take the measures shown in Figure 3-41.

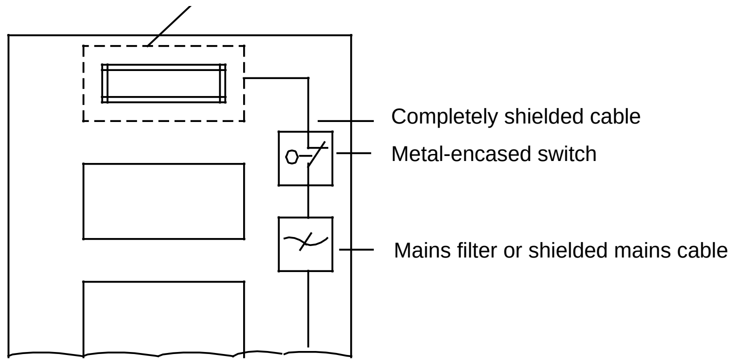


Figure 3-45. Measures for Suppressing Noise from Fluorescent Lamps in the Cabinet

Separating Inductors

Sheet-metal barriers are recommended for the part of the cabinet containing strong inductances such as transformers or contactors.

Protection against Electrostatic Discharge

Metal housings or cabinets closed on all sides and with good metallic contact to the grounding point at the installation location should be used to protect devices and modules from electrostatic discharge.

If you install your controller in a terminal box, use cast or sheet-metal where possible. Plastic housings should always have a metallic surface.
Housing doors and covers must be connected to the housing ground with grounding strips or contact springs.
If you are working on the controller with the cabinet open, please observe the guidelines on protective measures for ESD (electrostatic discharge) endangered components and modules.

Filters for Power Cables and Signal Cables

Filtering of power and signal cables is a measure for suppressing conducted interference. Overvoltages must not occur on power cables within the cabinet.
Suppress overvoltages with the following measures:

- Suppressing interference in power cables
  A mains filter (e.g. B84299-K64, 250 V AC/10 A) should be installed in the supply cable in the case of a mains supply of 230 V. The mains filter must be located at the entrance to the cabinet. Please note that the filter must have a large surface contact and low-impedance connection with the cabinet ground (contact surfaces must be uninsulated).

- Noise suppression capacitors for DC supply voltage
  If a cabinet is connected to a central 24 V supply, noise can reach the controller via this supply cable.
  You are therefore recommended to install 24 V noise suppression capacitors. These should be installed at the cabinet ground or on the shielding bar.

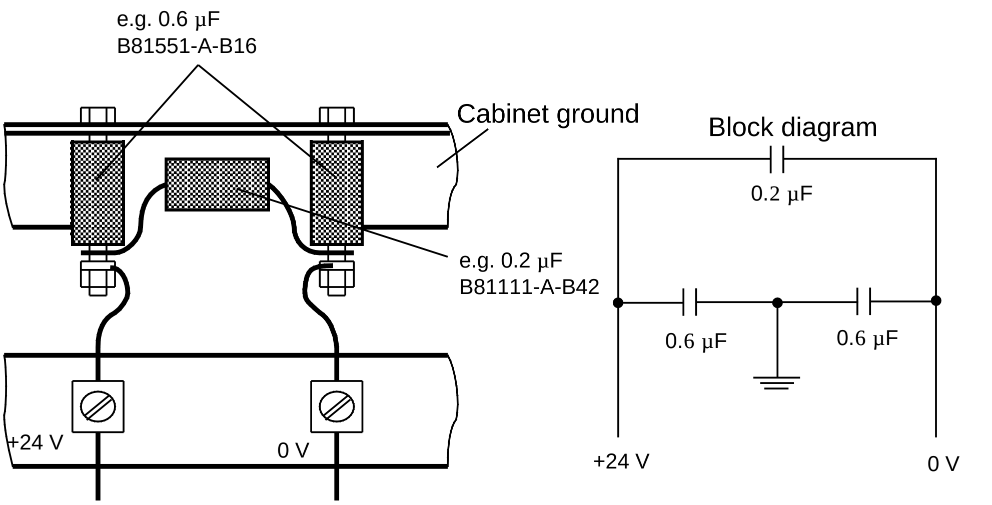


Figure 3-46. Arrangement of Suppression Capacitors

3.12 Checklist for the Installation of Programmable Controllers in Conformity with EMC Guidelines

Table 3-9. Checklist for the Installation of Programmable Controllers in Conformity with EMC Guidelines

EMC Measures	Notes
Connection of inactive metal parts (Section 3.7) Specially check the connections on: • Racks • Supporting bars • Shielding buses and protective conductor bars	
Have all inactive metal parts been connected and grounded with large surface contact and a low impedance?	
Is there a sufficient connection to the ground electrode/protective conductor system?	
Have insulating layers on enamelled and anodized surfaces been removed or have the connections been implemented with special contact washers?	
Have the joints been protected against corrosion, e.g. by means of grease?	
Have the cubicle doors been connected to the cubicle body via grounding strips?	
Wiring arrangement (Section 3.8)	
Cabling divided into cable groups?	
Supply lines (230 to 400 V) and signal cables run in separate ducts or bundles?	
Equipotential bonding (Section 3.9)	
In the case of a distributed configuration, check the installation of the equipotential bonding conductor	
Cable shielding (Section 3.10)	
Have metal connector sockets been used everywhere?	
Have all analog and data lines been shielded?	
Have cable shields been applied to the shield bus or protective conductor bar?	
Have cable shields been fixed with a large surface contact and a low impedance by means of cable clamps?	
Have cable shields been connected at both ends where this is possible?	
Inductive circuits (Section 3.11)	
Have contactor coils that are not energized via SIMATIC contacts been provided with arc suppression elements?	

4 Configuring the I / Os

Figures

Tables

4 Configuring the I / Os

This section describes the various I / O configurations (redundant, switched, single-channel) for the S5-115H programmable controller. Particular emphasis is placed on redundant I / Os and their connection, which are discussed in detail in Section 4.4. Section 4 also describes standard function block FB 252, which is used for redundant analog value input.

The information presented in this section should be studied carefully, as it is of particular importance as regards configuring and operating your I / O modules.

4.1 Overview

The S5-115H programmable controller supports three different I / O modes: single-channel, switched and redundant. These modes can be combined in one S5-115H. Each I / O can be configured separately.

Single-channel I / Os:

The I / O module is assigned to **one** of the two subunits. When this subunit fails, so do the I / Os assigned to it. The degree of availability is thus no higher than that of an S5-115U. The I / O modules can be plugged into either the central controller (CC) or an expansion unit (EU).

Switched I / Os:

The I / O module can be driven by **either of the two** central controllers. This mode gives the user increased availability compared with the S5-115U.

Redundant I / Os:

The I / O module is allocated the **same** address in **both** subunits. This mode gives the user the highest availability, since the failure of a central controller or an I / O module can be tolerated ("Non-stop operation"). The modules can be plugged into either the central controller (CC) or an expansion unit (EU).

Note:
In an S5-115H, it is possible to combine all three modes, i.e. single-channel, switched and redundant.

4.1.1 I / O Types

When digital / analog I / Os and CPs / IPs are configured over COM 115H, each process signal handled by the operating system is assigned a specific type number.

This type number identifies
- the type of signal, i.e. digital, analog, input, output, CP, IP and
- the mode, i.e. single-channel, switched or redundant

The Table below lists all configurable I / O types.

Also observe the information presented in the "COM 115H" operator's guide.

Table 4-1. Configurable I / O Types

Type No.	Description		Availability
1	DI byte	single-channel	Standard (S5-115U)
2	DI byte	switched	Enhanced
3	DI byte	redundant	High
8	DQ byte	single-channel	Standard
9	DQ byte	switched	Enhanced
10	DQ byte	redundant	High
13	AI channel	single-channel	Standard
14	AI channel	switched	Enhanced
15	AI channel	redundant	High
18	AQ channel	single-channel	Standard
19	AQ channel	switched	Enhanced
20	AQ channel	redundant	High
24	CP / IP	single-channel	Standard
25	CP / IP	switched	Enhanced

4.2 Single-Channel I / O Configuration

The I / O module is assigned to **one** of the two subunits. When this subunit fails, so do the I / O modules assigned to it. The degree of availability is thus no higher than that of an S5-115U.

The modules can be plugged into either the central controller (CC) or an expansion unit (EU).

It makes no difference which subunit is the master.

Figure 4-1 shows a single-channel I / O configuration.

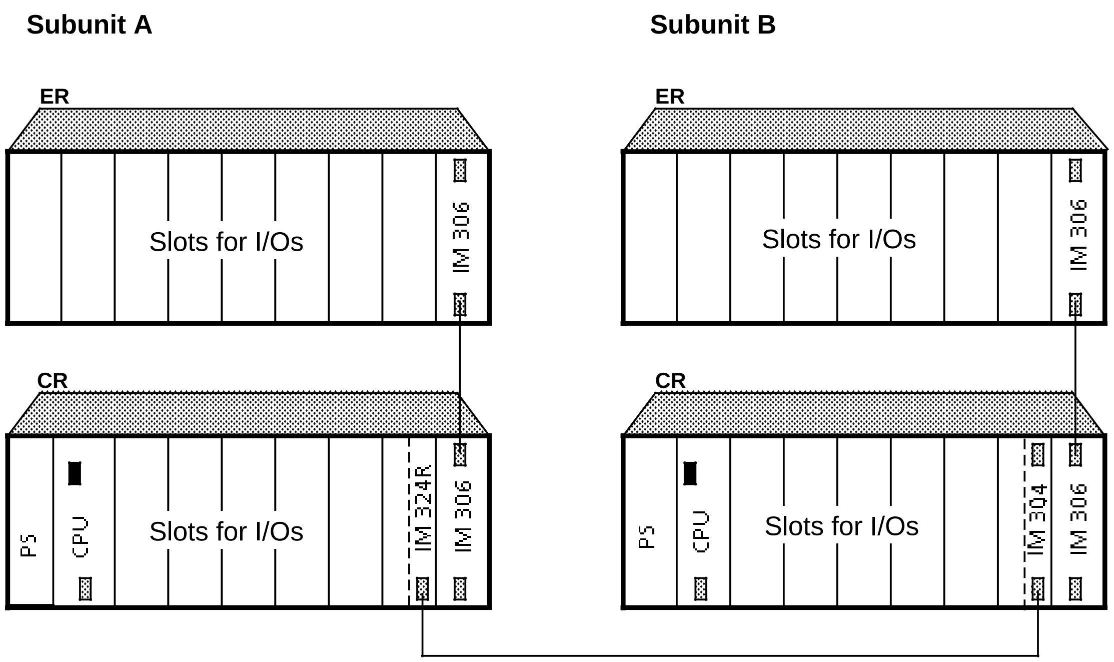


Figure 4-1. Single-Channel I / O Configuration

4.2.1 Digital and Analog I / O Modules

All I / O modules that can be used in the S5-115U can be operated in single-channel mode.

Note:
Single-channel I / Os should be used only for absolutely non-critical subprocesses, as their failure would also result in failure of the subprocess. The standard FBs that control these subprocesses should be implemented in separate blocks, which you then invoke conditionally, i.e. only when the relevant subunit is operational (see the example).

- Sample program: single-channel I / Os assigned to subunit A.
  Flag word FW10 was defined as H system flag word.

Table 4-2. Sample Program

STL	Description
`:O F 10.1`	Flag for "PLC in redundant mode"
`:`	(Bit 2^1 in the high-order byte of the H flag word)
`:O F 10.4`	Flag for "CC is subunit A"
`:`	(Bit 2^4 in the high-order byte of the H flag word)
`:JC FB 20`	FB 20 contains the program for the subprocess

The subprocess is executed only when subunit A is operational.

4.2.2 Communications Processors and Intelligent I / Os (CPs / IPs)

- **Communications processors (CPs)**

In single-channel mode, all CPs that can be used in the S5-115U can also be used in the S5-115H.

The degree of availability is the same as that of the S5-115U. This mode should therefore be used only when a failure can be tolerated.

For single-channel CP mode, you need only configure the interface number, the interprocessor communication flags (if required), and the subunit to which the CP is to be assigned (refer to the COM 115H manual).

- **Intelligent I / Os (IPs)**

In single-channel mode, you can use all IPs which can be operated over the page area (address range 0 to 400H) or I / O area.
The execution times for the integral data handling blocks required for IP operation are longer than those for the S5-115U.

Note:
CPs / IPs should be used only for absolutely non-critical subprocesses, as a PLC failure would also result in failure of the subprocess. The standard FBs which control these CPs / IPs should be invoked conditionally, i.e. only when the relevant subunit is operational.

4.3 Switched I / Os

The I / O can be driven by **either** of the two central controllers. This operating mode gives the user increased availability compared with the S5-115U.

This mode is possible only in conjunction with an ER 701-3LH expansion unit, which is connected to the two 115H central controllers via interface modules. A maximum of eight bus-selectable EUs can be operated in one S5-115H PLC.

Figure 4-2 shows a switched I / O configuration.

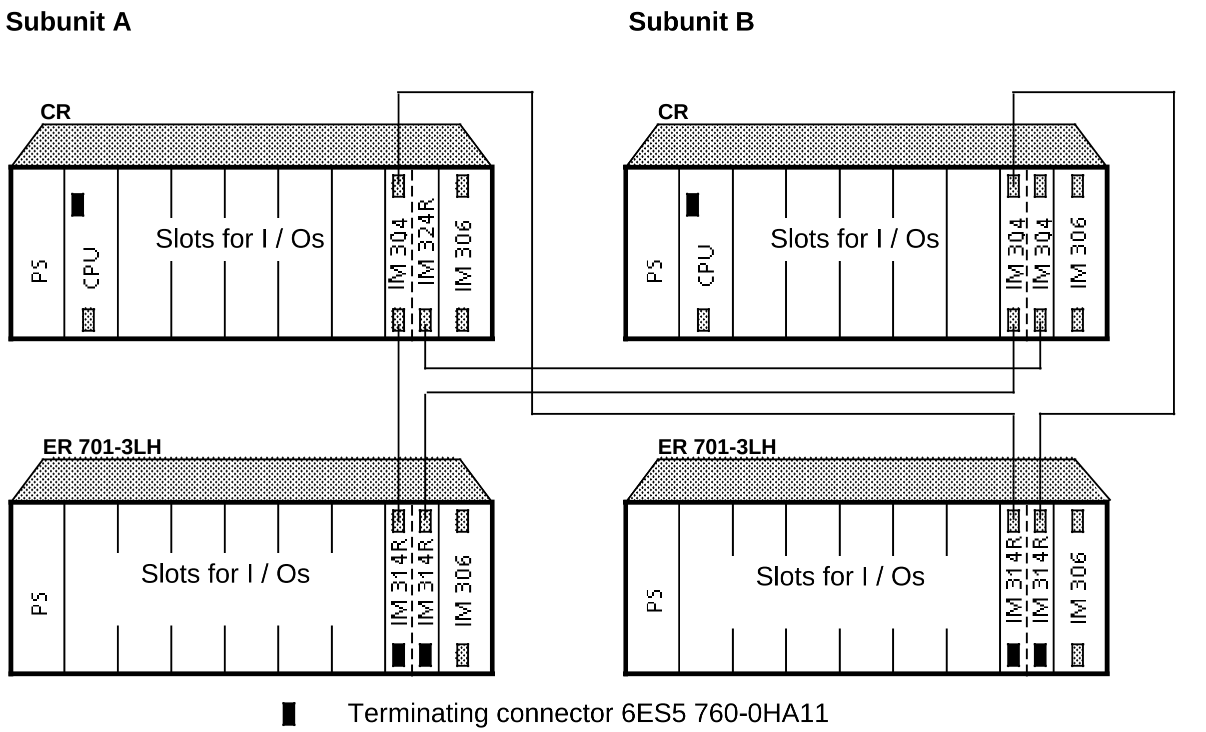


Figure 4-2. Switched I / O Configuration

Note:
At initial start or restart, only the master controller can access the switched I / Os. This means that the standard FBs in the standby controller would receive incorrect check-back signals. For this reason, only the master controller may process the standard FBs during this time.

Example:

```
AN   F 0.2        No master
BEC
JU   FB 20        Block for switched IPs / CPs, e. g. FB 20
BE
```

4.3.1 Digital and Analog Input / Output Modules

All I / O modules that can be used in the S5-115U can be operated in switched I / O mode.

4.3.2 Communications Processors and Intelligent I / Os (CPs / IPs)

- **Communications processors (CPs)**

All CPs that can be operated in an S5-115U expansion unit can also be operated in the S5-115H's switched expansion unit.

There is no loss of data on a transition from master to standby or from standby to master controller, regardless of whether the CPs are driven with data handling blocks or with special function blocks.

When CPS are operated in switched expansion units, several master**/**standby transitions may occur following a power outage.

- **Intelligent I / Os (IPs)**

All IPs that can be operated in an S5-115U expansion unit can also be operated in the S5-115H's switched expansion unit. The execution times for the integral data handling blocks needed for IP operation are longer than those for the S5-115U.

There is no loss of data on a transition from master to standby or from standby to master controller, regardless of whether the IPs are driven with standard data handling blocks or with special function blocks.

4.4 Redundant I / Os

In this mode, the I / O module is allocated the same address in both subunits.

Redundant mode gives the user the highest availability, as the failure of a central controller or an I / O module can be tolerated (NON-STOP operation). The modules can be plugged into either the central controller or the expansion unit.

Figure 4-3 shows a redundant (two-channel) I / O configuration.

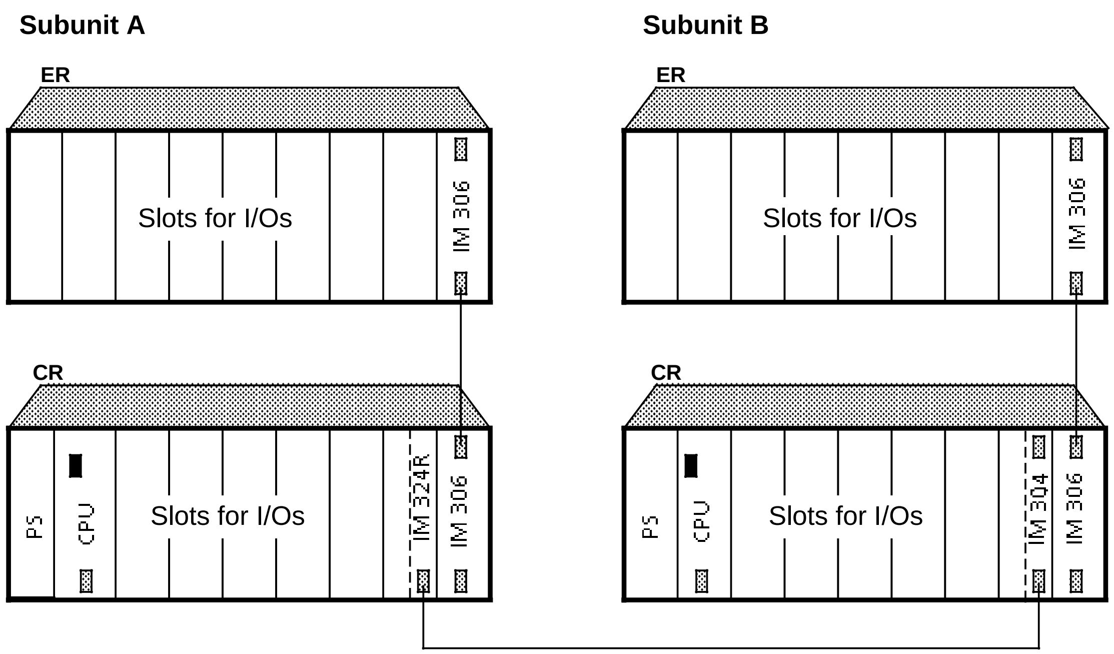


Figure 4-3. Redundant I / O Configuration

4.4.1 Digital and Analog Input / Output Modules

An I / O module that is to be "redundant" is plugged into both subunit A and subunit B, has the same address in both subunits, and can be configured as redundant module over COM 115H.

All I / O modules that can be used in the S5-115U can also be used in the S5-115H.
Exception: The operating system does not support redundant operation of the 470 analog output module.
However, additional hardware circuitry makes it possible to operate this module in redundant mode.

Note:
"NON-STOP DI / DQ" means:
A fault in the DI / DQ, and its subsequent repair, have no effect whatsoever on the process.
Read the following information carefully if you want to operate specific redundant digital inputs or outputs as "NON-STOP DIs" or "NON-STOP DQs"!

Locating Facility (LE)

For each redundant digital input and each redundant digital output that you want to operate as NON-STOP DI or NON-STOP DQ, you must configure a special locating facility that allows the 115H operating system to locate faults quickly.

The location facility (LE) for a NON-STOP DI or a NON-STOP DQ is comprised of

- a locating digital input (L-DI) and
- a locating digital output (L-DQ).

- **Overview**

Table 4-3 lists the performance characteristics of the various redundant I / O types in the S5-115H.

Table 4-3. Redundant I / O Types in the S5-115H and Their Performance Characteristics

Types	Performance Characteristics	
Redundant DI without fault locating Type 3	Fault detection: Fault locating: Response:	Through discrepancy monitoring None Standby DI is passivated
Redundant D I with fault locating Type 3	Fault detection: Fault locating: Response:	Through discrepancy monitoring Through L-DQ Passivation of the bad DI byte
Redundant DQ without fault locating Type 10	On permanent ”1”: Fault detection: Fault locating: Response:	 Through cyclic comparison of PIQ and readback DI none ”DQ in A and B” message; passivation of the readback DI
	On permanent ”0”: Fault detection: Fault locating: Response:	 Through 0 1 test Through 0 1 test Flagging of the bad DQ bit passivation of the readback DI
Redundant DQ with fault locating Type 10	On permanent ”1”: Fault detection: Fault locating: Response:	 Through cyclic comparison of PIQ and readback DI Through disconnection of the group voltage via L-DQ passivation of the bad DQ byte and of all other redundant DQs with the same group voltage
	On permanent ”1”: Fault detection: Fault locating: Response:	 Through 0 1 test Through 0 1 test The bad DQ byte is reported, but is still accessed; the DQ byte is not tested again. The readback DI is passivated.
Redundant AI Type 15	Fault detection: Fault locating: Response:	Through analog value discrepancy monitoring; a minimum or maximum value can be selected in the event of a fault fault-dependent (evaluation via FB 252) Passivation of the bad channel
Redundant AQ Type 20	Fault detection: Fault locating: Response:	Is up to the user Is up to the user Is up to the user

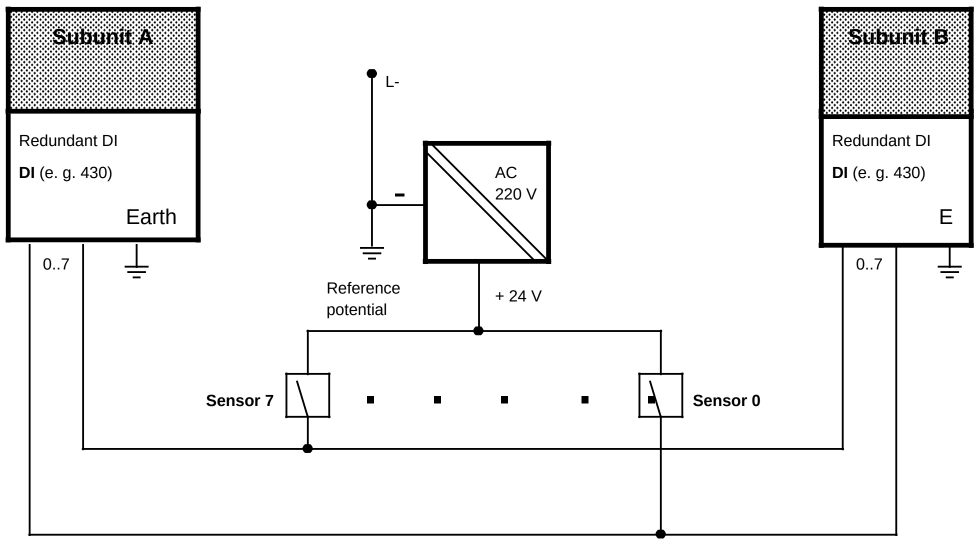
- **Redundant digital inputs (DIs) without locating facility**

For this type of digital input, the fault can be detected but not localized. This means that these DIs cannot be operated as "NON-STOP DI"!

A redundant digital input is an input that is in both subunit A and subunit B, connected to a single-channel sensor (connection of redundant sensors is not permitted).

The 115H operating system compares the signal states of the DIs in both subunits cyclically to see whether they are identical. The comparison takes place during updating of the process input image. If the operating system detects redundant DIs with different signal states, they are marked and the configured discrepancy time is started. The last identical signal state is retained as long as the timer is running. If the signal states of the DIs are still different when the discrepancy time has elapsed, the fault is reported. The signal state of the DI in the master controller is reported as the valid signal state.

In the case of direct I / O access, the signal states of the redundant DIs are also compared. If they differ, the last identical value is retained as signal state.



Note: The example shows two DIs

Figure 4-4. Redundant DIs Without Fault Locating

- **Redundant digital inputs (DIs) without fault locating**

Both fault detection and fault locating are possible for this DI type.

A redundant digital input is an input that is in both subunit A and subunit B, connected to a single-channel sensor (connection of redundant sensors is not permitted).

The 115H operating system locates the defective digital input module with the aid of the circuitry shown in Figure 4-5. The following steps are taken when the discrepancy time has elapsed:

- Both L-DQs (subunit A and subunit B) are set to "0"

- The operating system then waits until both L-DIs (subunit A and subunit B) have detected this, i.e. until both have read signal state "0". If this is not the case by the time the configured DI delay time has elapsed, there is a fault in the locating facility.

- If both L-DIs detect signal state "0", a check is made to see whether the "redundant DI" that read "1" now reads "0". If so, the other DI is the one that is faulty. If not, the one that was tested is faulty.

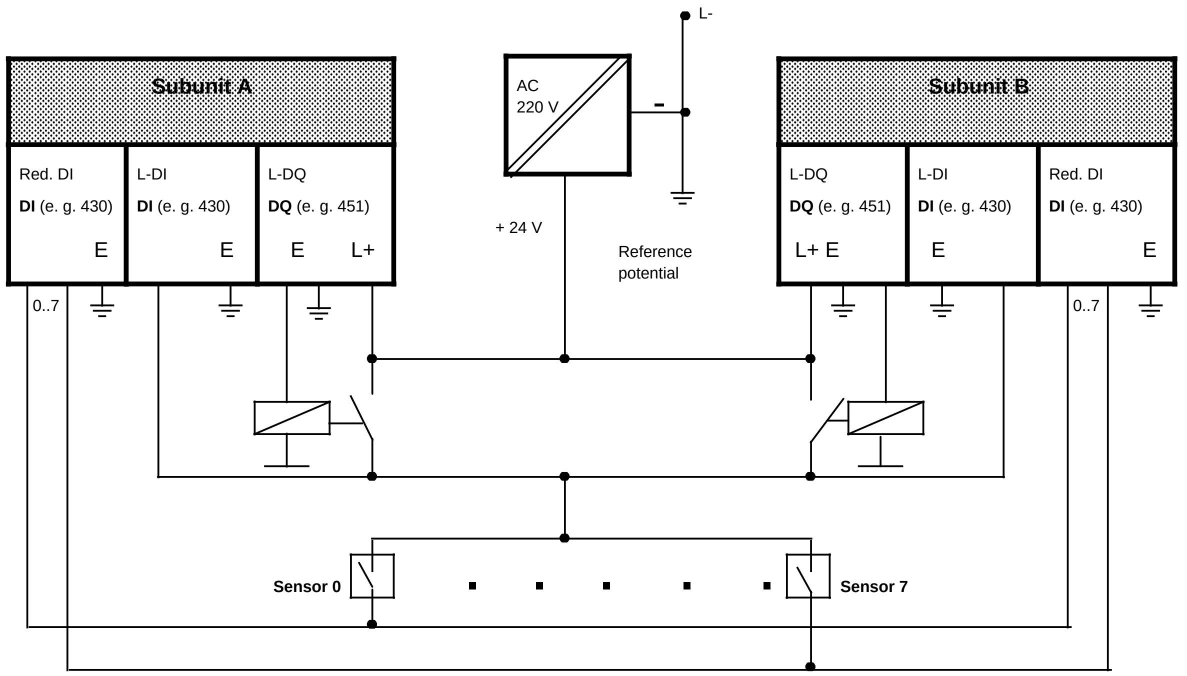
- The L-DQ is then set back to "1".

- The test is completed when both L-DIs read signal state "1" during the check in the next cycle.

The defective module is reported and the DI byte passivated, i.e. this DI byte is no longer accessed (single-channel operation).

Fault locating may extend over several PLC cycles. During this time, the last valid process image is transferred when the affected DI bytes are involved in direct I/O access operations. "Affected" DI bytes are all DI bytes that are supplied by the same group power source.

"Group" is the term used to signify all sensors of redundant DIs or DOs that are supplied by the same L-DQ. The smallest group consists of one redundant byte, the largest possible group all redundant DIs or DQs in an S5-115H.



L-DQ:	Locating DQ	L+Module power supply
L-DI:	Locating DI	
Red. DI:	Redundant DI	
Note:	The relay can be omitted when the output current from one DQ is sufficient to drive the sensors. The example shows two redundant DIs.	

Figure 4-5. Redundant DIs With Fault Locating

- **Redundant digital outputs (DOs) without fault locating (readback DI only)**

Although faults can be detected on this type of digital output, the possibilities for fault locating are either non-existent or limited. The DQ cannot be deactivated or passivated in the event of a permanent "1" signal, so that the DQ cannot be operated as NON-STOP DQ. The 115H operating system handles this DQ as follows:

- The digital output values are read back, taking into account the configured readback delay time. Permanent "1" signals are thus detected, but cannot be located.

Permanent "0" signals are not detected until the next signal edge change from 0 to 1:

- The "1" signal is first output in one subunit, e.g. subunit A, while the other subunit (B) continues to output a "0" signal.

- A "1" must be read back when the configured readback delay time has expired. If this is not the case, the fault is located and reported. When the "1" signal has been detected, the delayed DQ is also set to "1".

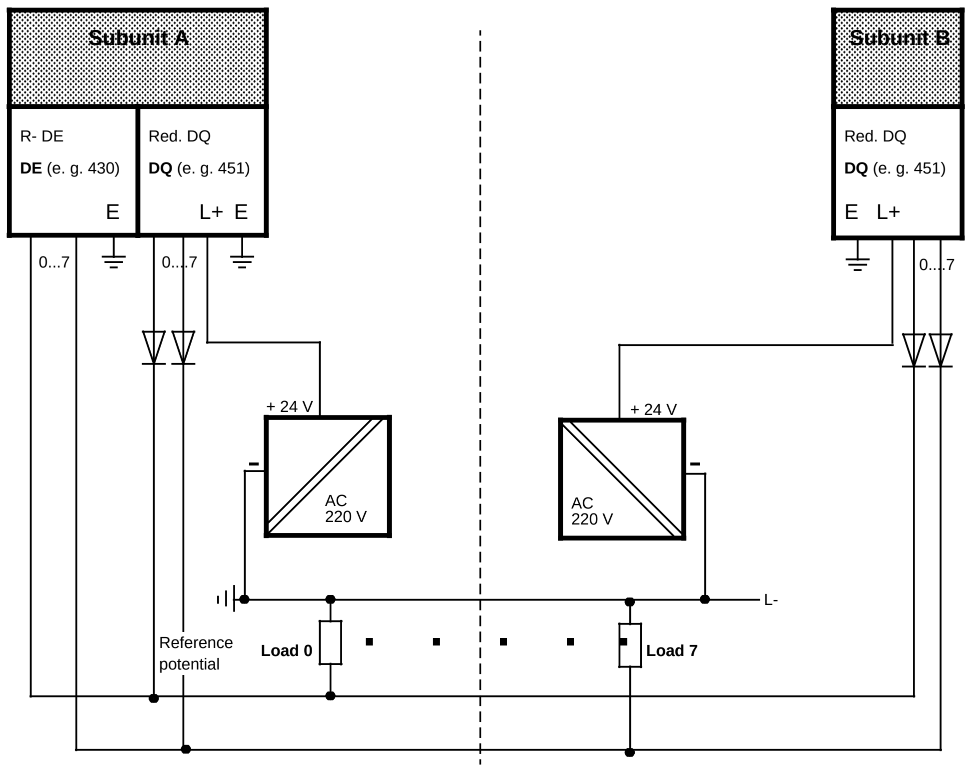
- This DQ test is also executed in the other subunit on every 0 1 edge change.

The test is aborted in the event of direct I / O access to the DQ byte.

Note:
A limited form of permanent 0 error detection only is carried out in the event of direct I / O access to the DQs.

If the S5-115H detects a permanent 0 error, it enters it in the error DB. The process output image continues to be output and direct I/O access still takes place, but the affected outputs remain at ”0”.

Note:
The user must specify the readback delay time for DQs during configuring over COM 115H, as the various digital output modules have different signal propagation times (Chapter12). The configured readback delay time applies for all redundant DQs!



Power may also come from a load voltage source.
Result: When the load voltage fails, the entire DQ group fails with it.

Red. DQ: Redundant DQ   L+ Module power supply
R-DI: Readback DI
Note: The example shows two redundant DQs.

Figure 4-6. Redundant DQs Without Fault Locating

- **Redundant digital outputs (DQs) with locating facility**

Both fault detection and fault locating are possible for this type of digital output, for intermittent outputs only. The operating system handles this type of DQ as follows:

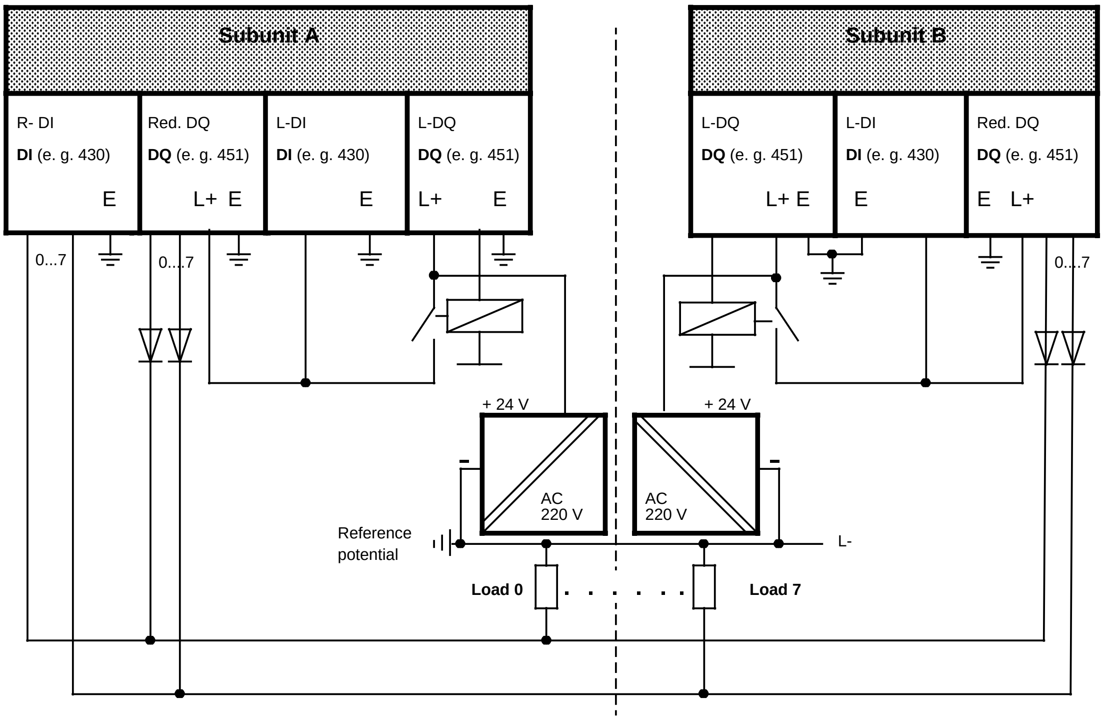
- The digital output values are read back, taking into account the configured readback delay time. Permanent 1 faults are thus detected, and are located by disconnecting the group power supply.

Reaction of the 115H operating system:

If the S5-115H detects a permanent 0 error, it enters it in the error DB. The process output image continues to be output and direct I/O access still takes place, but the affected outputs remain at ”0”.

In the event of a permanent 1 error, the defective DQ byte is passivated. This byte is no longer accessed. The group power supply is disconnected over the L-DQ. All redundant DQs that get their power from this same group source are thus passivated (single-channel operation).

If the DQ byte is accessed directly during the DQ test, the test is aborted.



Power can also be supplied from a load voltage source.

Result: When the load voltage fails, the entire DQ group also fails.

L-DQ: Locating DQ
L-DI: Locating DI
Red. DQ: Redundant DQ
Red. DI: Redundant DI
L+: Module power supply

Note: The example shows two redundant DQs.

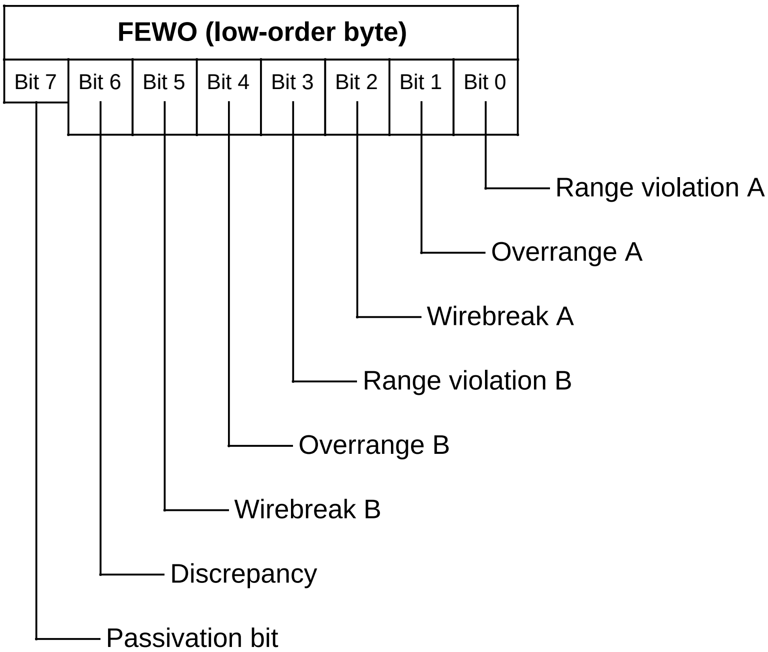
Figure 4-7. Redundant DQs With Fault Locating

Note:
A limited form of permanent 0 fault detection only is carried out in the event of direct I / O access to DQs.

- **Redundant analog inputs (AIs)**

Both fault detection and fault locating are always possible for this type of AI. Standard function block FB 252 "RLG:HAE" is provided for reading in analog values and for fault locating (Section 8.2.1 "Analog Value Matching Blocks"). This FB can be used for 460 and 465 modules.

Additional bits in the FEWO output parameter, which are assigned to either subunit A or subunit B, are used for fault locating.



Function block FB 252 reads an analog value XE from an analog input and, based on that value's nominal range, supplies proportional output values XAA (subunit A) and XAB (subunit B) in the specifiable range from UGR (lower limiting value) to OGR (upper limiting value). The analog value can be read either cyclically or via selective sampling.

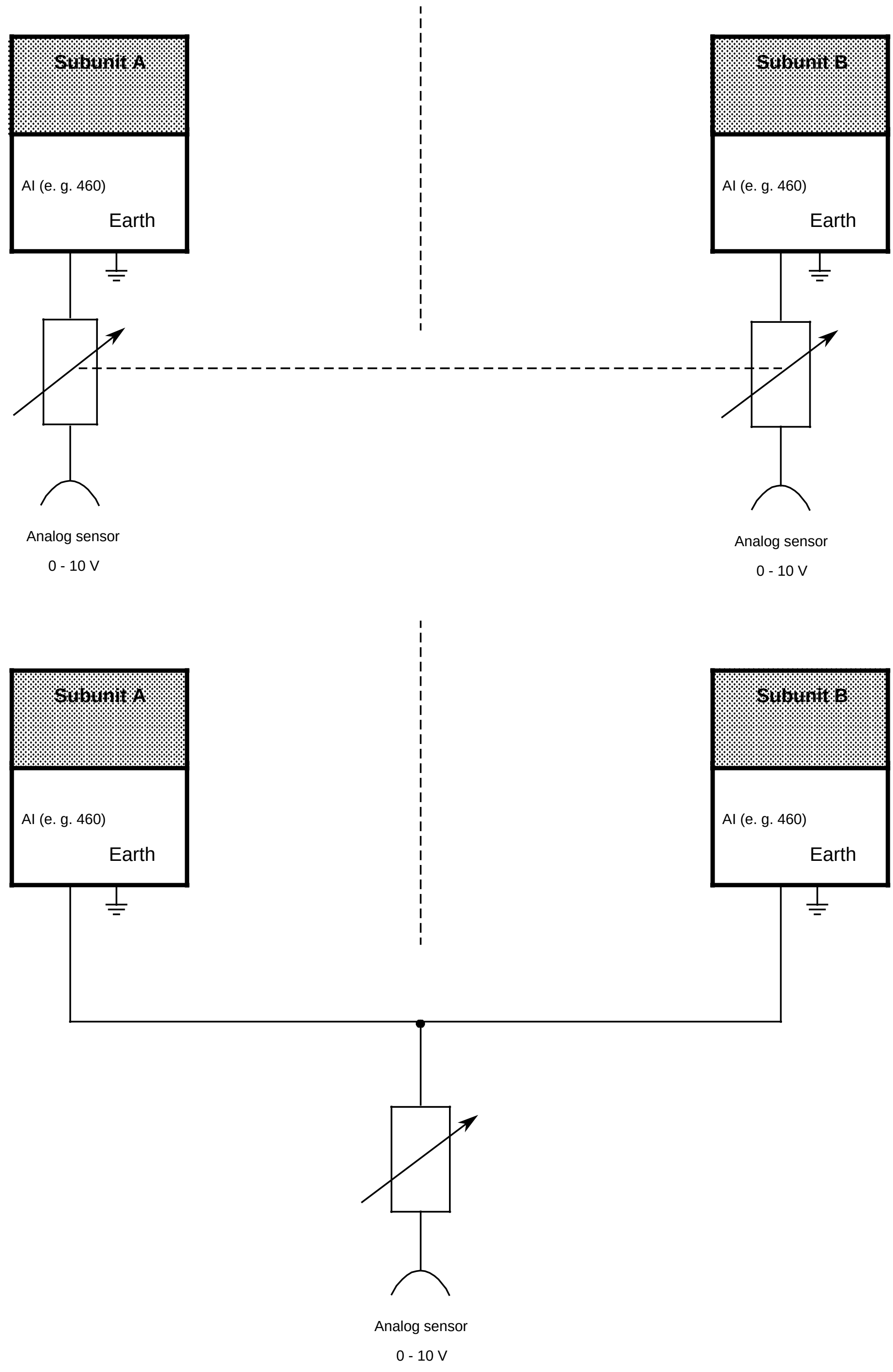


Figure 4-8. Redundant AIs

Fault detection

To detect faults in the S5-115H, the two analog input values are checked for discrepancy. The discrepancy value can be specified via COM 115H in either absolute or relative form. The actual discrepancy is not reported until the specified discrepancy value is exceeded in both absolute and relative form. You can also specify one of the analog input values (minimum or maximum value) as preferred value. This value is then used for post-processing. You can also configure this function with COM 115H.
When FB 252 is invoked, the analog values in both subunits are read, exchanged and standardized. If the 115H operating system detects a discrepancy error, a check is made to see if there is a range violation and, if so, it is reported (FB 252 "RLG:HAE"). An overflow is flagged as fault. If a single-channel locatable fault (time-out, wirebreak) occurs, the module is passivated and is no longer accessed (single-channel operation).

If the two modules flag different faults, selection is priority-based:

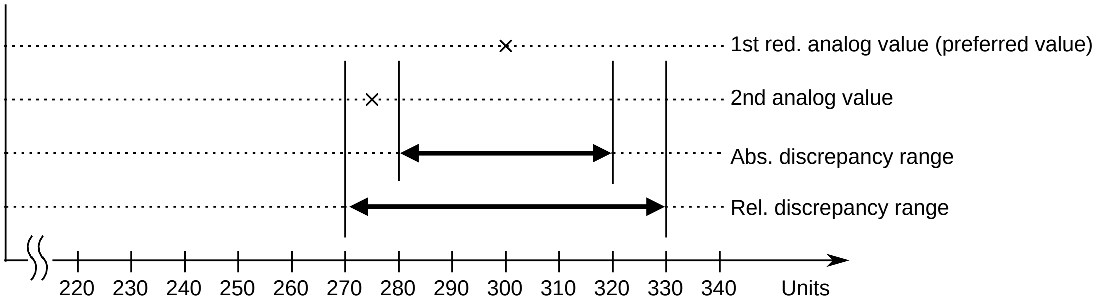
1. Time-out (QVZ)
2. Wirebreak
3. Overflow
4. Range violation.

Note:
Direct I / O access to redundant analog inputs with the STEP 5 operation "L PW" produces a standardized value as result. Depending on the COM 115H configuring data, the value in question is either the lower or the higher raw value.

In order to ensure correct configuring of absolute and relative discrepancy values, it is necessary to understand how these values are related. This can be best illustrated by an example.
The following parameters were configured with COM 115H for type 15 (redundant AIs):

Absolute discrepancy value:	20
Relative discrepancy value:	10 %
Preferred value:	2 (maximum value)

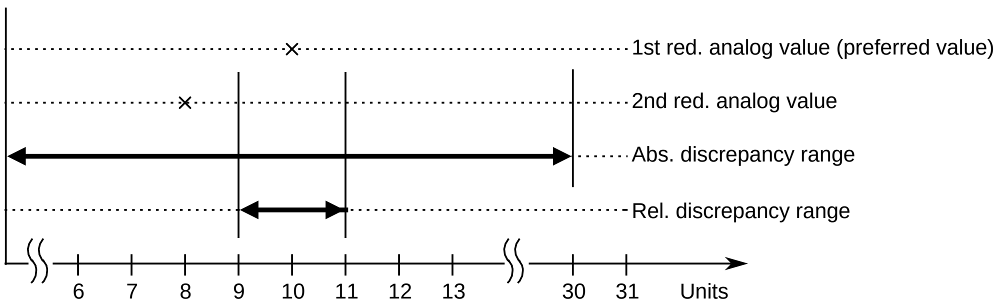
1st case:
The following values are read in over the redundant analog inputs:
1st red. analog value units: 300 (preferred value)
2nd red. analog value in units: 275



The diagram shows that the 2nd redundant analog value is outside the absolute discrepancy range (280 < x < 320) but still in the relative discrepancy range (270 < x < 330).

2nd case:
The following values are read in over the redundant analog inputs:

1st red. analog value: 10 (preferred value)
2nd red. analog value: 8



In this case, the diagram shows that the 2nd redundant analog value is within the absolute discrepancy range but outside the relative discrepancy range.

Note:
When specifying the absolute and relative discrepancy values over COM 115H, note that
- the relative discrepancy value allows for deviation in large analog values
- the absolute discrepancy value allows for slight deviation in small analog values.

- **Redundant analog outputs (AOs)**

Redundant analog outputs exist primarily in the form of a circuit proposal in which only the output of values over the redundant channel is supported. This is done via a TPW statement in which the value is output on both subunits. Readback (FB 251 "RLG:AA") and fault locating must be implemented via an appropriate user program. Figure 4-9 shows a proposal for redundant analog outputs:

Proposal:

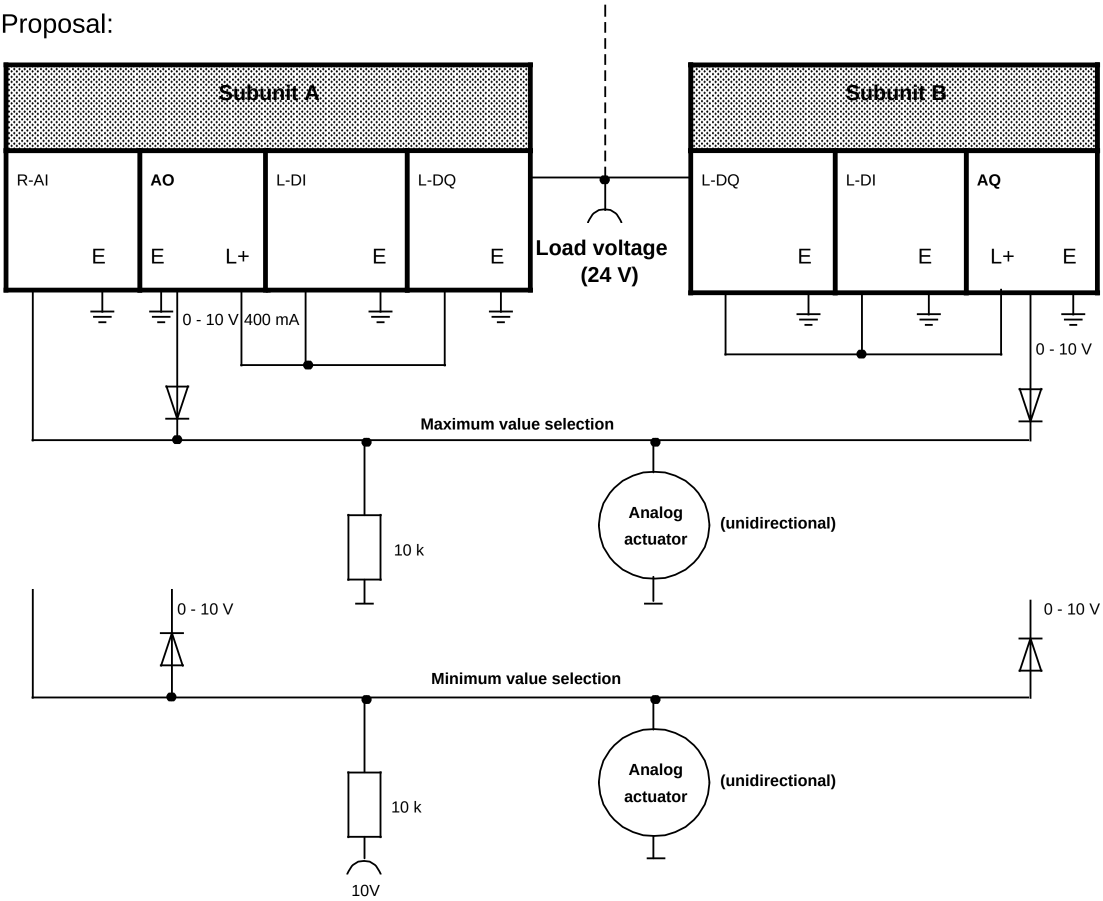


Figure 4-9. Circuit Proposal for Redundant Analog Outputs

4.4.2 Communications Processors and Intelligent I / Os (CP / IPs)

- **Communications processors**

The 115H operating system does not support redundant CPs. This mode, however, can be programmed. Operating system support for redundant CPs is currently under development.

- **Intelligent I / Os (IPs)**

The 115H operating system does not support redundant intelligent I / Os. This mode, however, can be programmed.

4.5 Hybrid I / O Configurations

All three I / O modes - single-channel, switched and redundant - can be combined in a single S5-115H.

Figure 4-10 illustrates such a hybrid configuration.

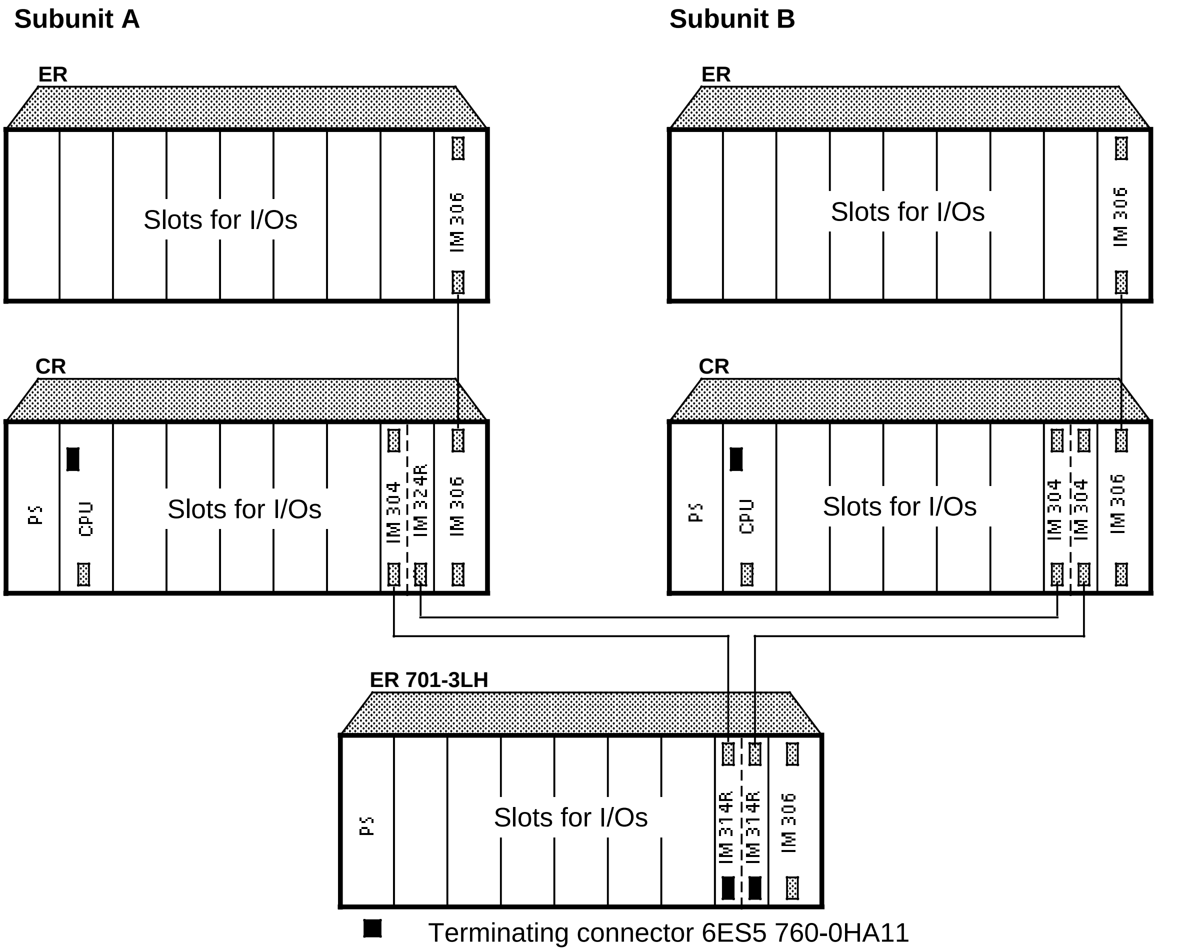


Figure 4-10. Hybrid I / O Configuration

5 Addressing / Address Assignments

Figures

Tables

5 Addressing / Address Assignments

In order to be able to access input / output modules, these modules must be assigned addresses.

5.1 Address Structure

Digital modules generally are addressed by bit, analog modules by byte or word. Consequently, their addresses have different formats.

5.1.1 Digital Module Addresses

One bit represents a channel on a digital module. You must therefore assign a number to each bit. When numbering, note the following:

- The CPU program memory is divided into different address areas (Section 5.3).
- Number individual bytes consecutively in relation to the start address of the relevant address area.
- Number the eight bits of each byte consecutively (0 to 7).

Figure 5-1. shows the format of a digital address:

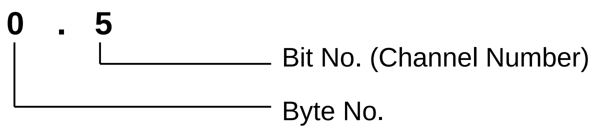


Figure 5-1. Format of a Digital Address

5.1.2 Analog Module Addresses

Each channel of an analog module is represented by two bytes (=one word).
An analog channel address is thus represented by the number of the high-order byte.

5.2 Slot Address Assignments

You can establish addresses for S5-115H modules in the following two ways:

- Fixed Slot Addressing
  Each slot has a fixed address under which you can reference the module plugged into that slot.
- Variable Slot Addressing
  The user can specify an address for each slot.

Fixed slot and variable slot addresses are relevant only for modules of block design. The address of an intelligent I / O module is set on the module itself. In this case, the address need not be set on the IM 306.

5.2.1 Fixed Slot Address Assignments

When the central controllers are used without an IM 306 interface module, the IM slot must be equipped with a 6ES5 760-0HA11 terminating connector.

In this case, fixed addresses are assigned to the slots.

The number of address bytes available for digital and analog modules varies.

Digital Modules

Each slot has four bytes, so that 32 binary inputs or outputs can be addressed. If you plug in digital modules with 8 or 16 channels, use the low-order byte numbers for addressing. In this case, the high-order byte numbers are irrelevant.

Analog Modules

For fixed slot addressing, analog modules can be plugged into slots 0 to 3 of a central controller only.

Each slot has 32 bytes. You can thus address 16 analog channels. If you plug in 8-channel modules, use the 16 low-order byte numbers for addressing. In this case, the 16 high-order byte numbers are irrelevant.

Note the following:

- Input and output modules cannot have the same address.
- If an analog module has been assigned an address for a particular slot, this address cannot be used for digital modules and vice versa.

Figure 5-2 shows the exact assignment of fixed addresses (please observe the "Installation Guidelines" in section 3.1.1).

Slot numbers in the central controller	PS	CPU	0*	1*	2*	3	4	5	6	IM
Digital modules			0.0 . . 3.7	4.0 . . 7.7	8.0 . . 11.7	12.0 . . 15.7	16.0 . . 19.7	20.0 . . 23.7	Reserved for IM 304/324R	Terminating connector required
Analog modules			128 . . 159	160 . . 191	192 . . 223	224 . . 255	Analog modules cannot be addressed			
Modules	**Addresses**									

* Not possible in the CR 700-3 central controller

Figure 5-2. Fixed Slot Addressing in the Central Controllers

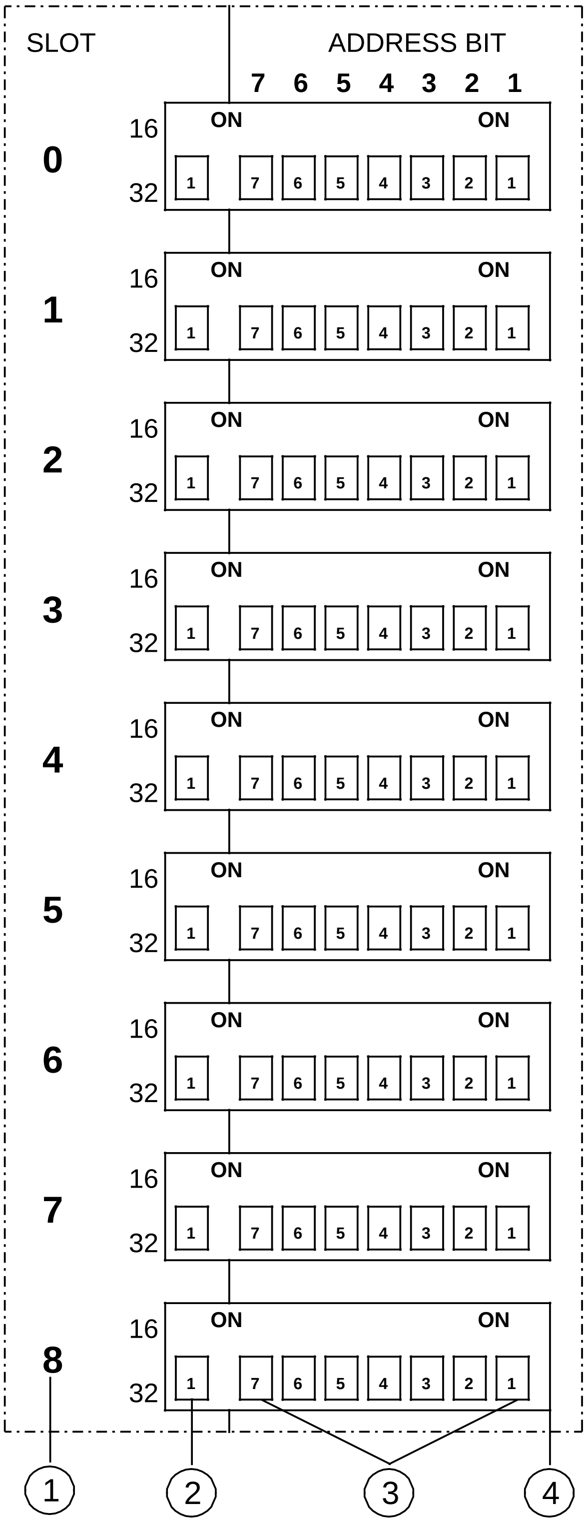
5.2.2 Variable Slot Address Assignments

The S5-115H offers you the possibility of assigning an address to each slot. You can do this if an IM 306 interface module is plugged into the central controller and each expansion unit. For addressing purposes, it does not matter whether the module in question is plugged into a central controller or an expansion unit.

Under a hinged cover on the right side of the interface module is an addressing panel. It has a DIP switch for each slot. Use the DIP switch to set the least significant byte number for a particular slot.

Note:

Input and output modules in different slots can have the same address.



Addresses for digital modules	Address switches (ON=1, OFF=0) 7	6	5	4	3	2	1
0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	1
4	0	0	0	0	0	1	0
6	0	0	0	0	0	1	1
8	0	0	0	0	1	0	0
10	0	0	0	0	1	0	1
12	0	0	0	0	1	1	0
14	0	0	0	0	1	1	1
16	0	0	0	1	0	0	0
18	0	0	0	1	0	0	1
20	0	0	0	1	0	1	0
22	0	0	0	1	0	1	1
24	0	0	0	1	1	0	0
26	0	0	0	1	1	0	1
28	0	0	0	1	1	1	0
30	0	0	0	1	1	1	1
32	0	0	1	0	0	0	0
34	0	0	1	0	0	0	1
36	0	0	1	0	0	1	0
38	0	0	1	0	0	1	1
40	0	0	1	0	1	0	0
42	0	0	1	0	1	0	1
44	0	0	1	0	1	1	0
46	0	0	1	0	1	1	1
48	0	0	1	1	0	0	0
50	0	0	1	1	0	0	1
52	0	0	1	1	0	1	0
54	0	0	1	1	0	1	1
56	0	0	1	1	1	0	0
58	0	0	1	1	1	0	1
60	0	0	1	1	1	1	0
62	0	0	1	1	1	1	1

Addresses for analog modules	Address switches 7	6	5	4	3	2	1
128	1	0	0	0	0	0	0
144	1	0	0	1	0	0	0
160	1	0	1	0	0	0	0
176	1	0	1	1	0	0	0
192	1	1	0	0	0	0	0
208	1	1	0	1	0	0	0
224	1	1	1	0	0	0	0
240	1	1	1	1	0	0	0

: Slot number

: Switch for setting the number of inputs or outputs per slot

: Address switches

: DIP switch

Figure 5-3. Setting Addresses on the Addressing Panel of the IM 306 Interface Module

Setting Addresses

Use the left-hand switch (in Figure 5-3) to indicate what type of module[1] you have plugged into the slot.

Set the switch to OFF: for a 32-channel digital module or a 16-channel analog module.
Set the switch to ON: for a 16-channel digital module or an 8-channel analog module.

Use the seven address switches (in Figure 5-3.) to indicate the least significant address (the address for channel ”0”) for the module in question. This setting establishes the addresses of the other channels in ascending order.

When setting start addresses, note the following:

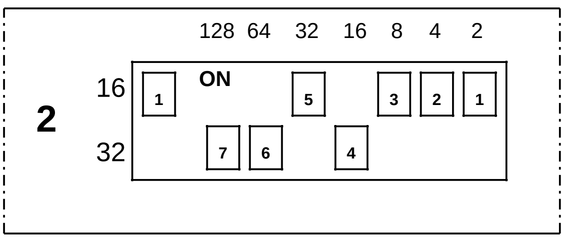
- 32-channel digital modules can only have start addresses whose byte numbers are divisible by 4 (e.g., 0, 4, 8 ...).
- 16-channel digital modules can only have start addresses whose byte numbers are divisible by 2 (e.g., 0, 2, 4 ...).
- 16-channel analog modules can only have the start addresses 128, 160, 192 and 224.
- 8-channel analog modules can only have the start addresses 128, 144, 160...240.

Example

A 16-channel digital input module is plugged into slot 2. Assign it start address 46.0 by performing the following steps:

- Check to see if the byte number of the start address can be divided by 2 since you are dealing with a 16-channel digital module.
  46 : 2 = 23   Remainder 0
- Set the number of input channels (set switch to ON).
- Set the address switches on the DIP switch for slot number 2 as shown in Figure 5-4.

Binary Weight of the Address Bits



The address is equal to the sum of the weights selected by the individual coding switches, e.g.:

2+4+8+32=46

Figure 5-4. Setting a DIP Switch

1 The digital input / output module (6ES5 482-7LA11) is treated in the same way as a 16-channel module

The module is then addressed as follows:

Channel No.	0	1	2 . . .	7	8	9	10 . . .	15
Address	46.0	46.1		46.7	47.0	47.1		47.7

5.3 Handling Process Signals

Input / output module signal states can be read from or written to the addresses shown in Figure 5-5.

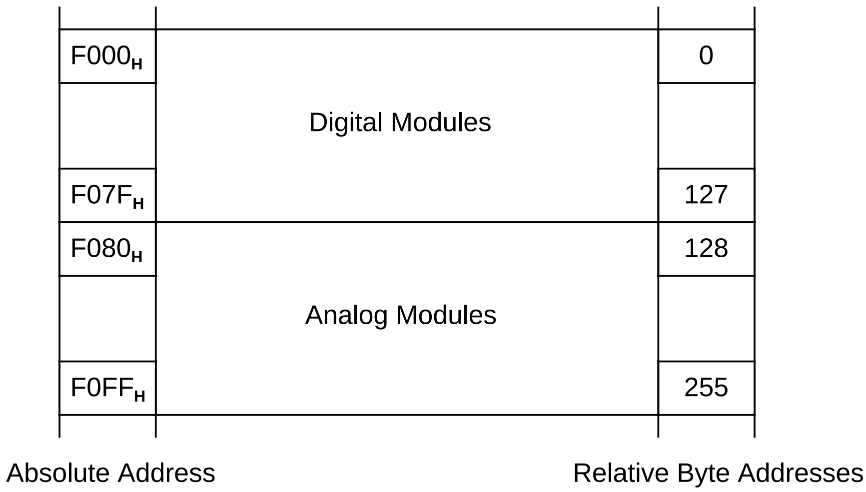


Figure 5-5. Addresses of the Input / Output Modules

Digital module signal states are also stored in a special memory area called the process image. The process image has two sections, namely the process input image (PII) and the process output image (PIQ).

Figure 5-6. shows where the process images are located in the program memory.

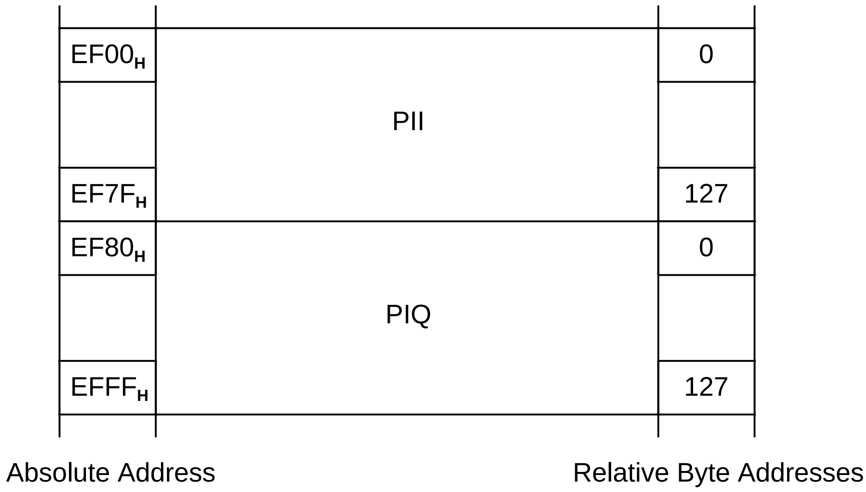


Figure 5-6. Location of the Process Images

Process signals can be read or output either via the process image or directly.

5.3.1 Accessing the PII

At the beginning of cyclic program scanning, the input module signal states are written to the PII. The statements in the control program use a particular address to indicate what information is currently needed. The control logic then reads the data that was current at the beginning of program scanning and works with it.

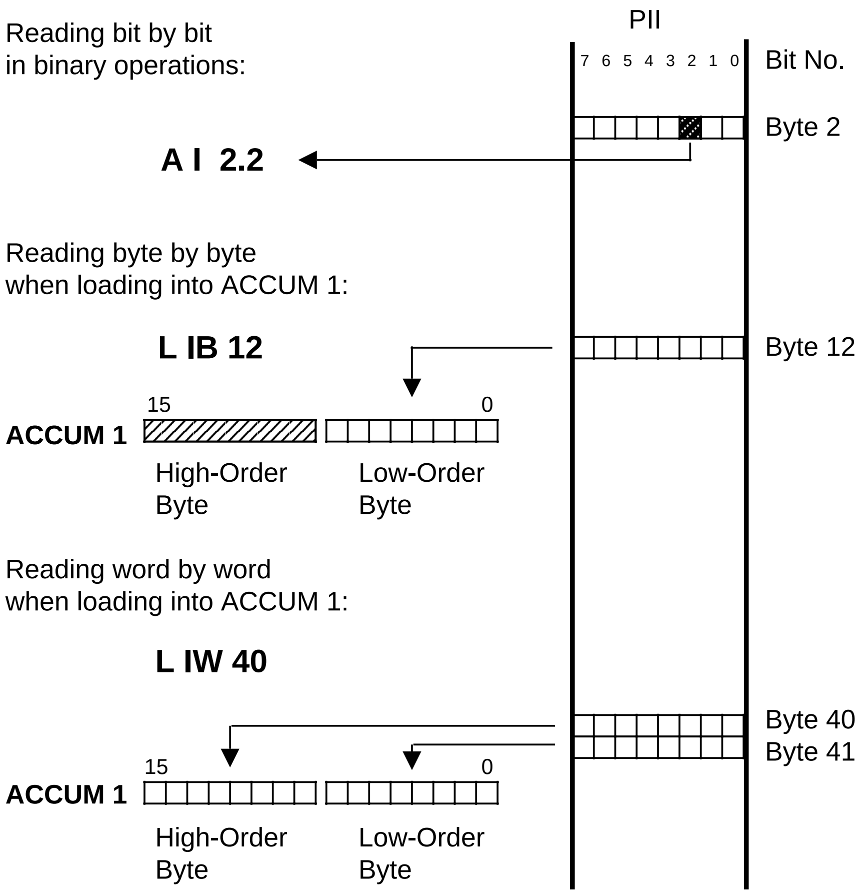


Figure 5-7. Accessing the PII

5.3.2 Accessing the PIQ

New signal states are entered in the PIQ during program scanning. This information is transferred to the output modules at the end of each program scan.

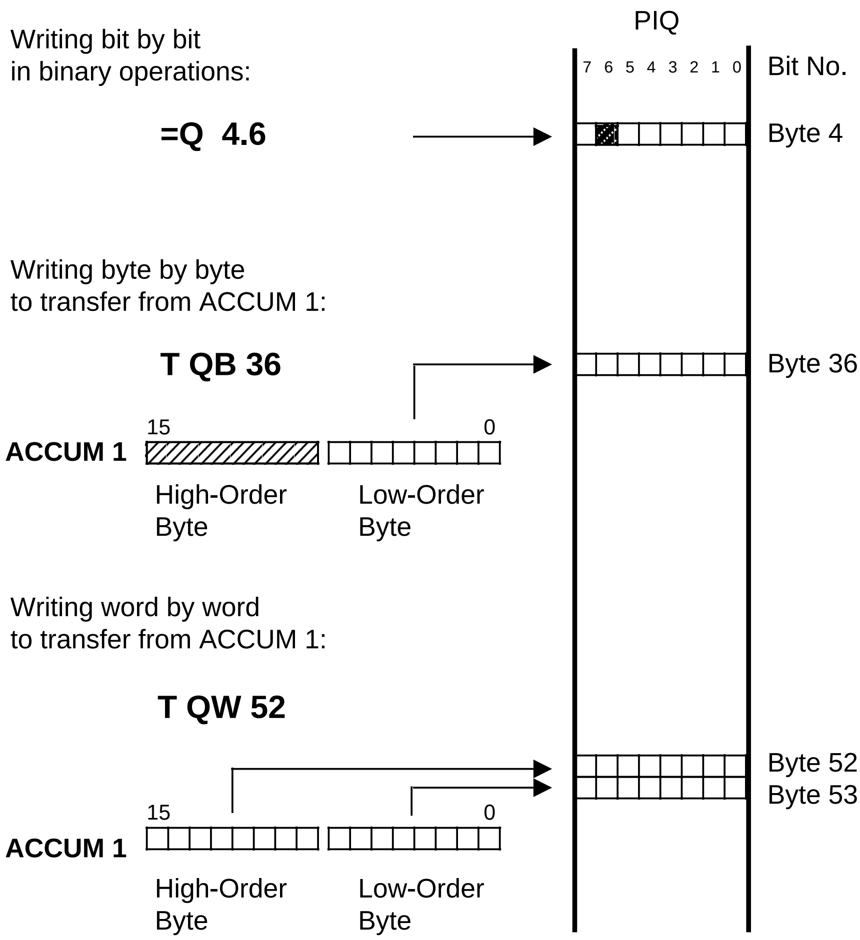


Figure 5-8. Accessing the PIQ

5.3.3 Direct Access

Analog module signal states are not written to the process image. They are read in or transferred to an output module directly with the "L PB / PY x," "L PW x," "T PB / PY x," or "T PW x" statements.
You can also exchange information with digital modules directly. This is necessary when signal states have to be processed immediately in the control program. Figure 5-9 shows differences during the loading of signal states.

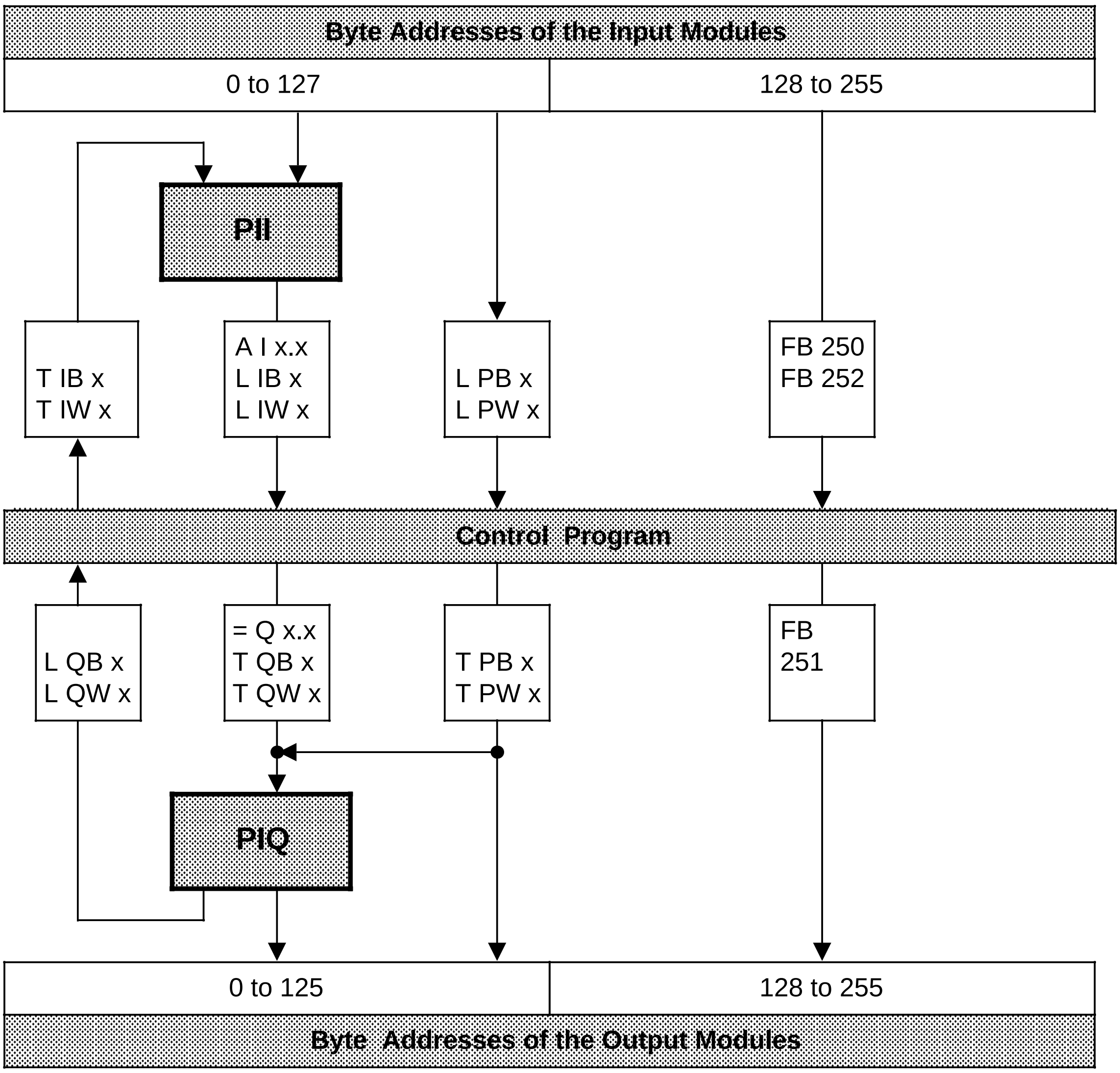


Figure 5-9. Loading Input / Output Modules

Note:
If you use direct access to call an address whose slot is inoccupied, COM 115H issues an appropriate error message.

5.4 Address Allocation on the Central Processing Unit

The following figures show the contents of CPU RAM.

Important memory areas such as those for system data (RS), timers (T), counters (C), flags (F) and the block address list are shown in detail Figures 5-10, 5-11, and in Tables 5-1 to 5-3.

CPU 942 H

Address		Kbytes
0000_H	Intelligent I / Os	0
400_H	IM 324R and IM314R	1
2100_H		8.25
3000_H	Memory submodule: 32 Kbytes	12
7000_H	16 Kbytes	28
9000_H	8 Kbytes	36
$B000_H$	Internal user memory (8.5 KQW)	44
$D200_H$	(Internal data)	52.5
$DC00_H$	Block address list	55
$E600_H$	(Internal data)	57.50
$EA00_H$	System data RS	58.50
$EC00_H$	Timers T	59
$ED00_H$	Counters C	59.25
$EE00_H$	Flags F	59.50
$EF00_H$	PII / PIQ	59.75
$F000_H$	I / O area and internal registers	60
$FFFF_H$		64

Figure 5-10. Memory Allocation on the CPU

The input / output area is subdivided as follows:

Address		Kbytes
0 . .	Intelligent I / Os: In controller B only / In controller A only	
400_H . . 2100_H	IM 324R and IM 314R	1.00 . . 8.25
• • •		• • •
$F000_H$	Digital I / O modules	60
$F080_H$	Analog I / O modules	
$F100_H$ . .		60.25 . .
$F200_H$ . .	Interprocessor communication flags - switched - in one controller only	60.50 . .
$F300_H$ . .		60.75 . .
$F400_H$ . .	Page area - redundant - swtched - single-channel	61 . .
$FC00_H$ . .		63 . .
$FF00_H$ . . $FFFF_H$	(Internal registers)	63.75 . . 64

Figure 5-11. Address Allocation in the I / O Area

The following table lists the system data of relevance to the user and indicates the sections which provide more detailed information.

Table 5-1. Address Allocation in the System Data Area

System Data Word	Address (Hex.)	Description
16 - 31	EA20 : EA3F	List of configured inputs and outputs (digital, analog)
33	EA42 EA43	Address level indicator for memory bank
36	EA48 EA49	Start address of internal RAM
37	EA4A EA4B	End address of internal RAM
57 - 63	EA72 : EA7F	SINEC L1 parameter block
96	EAC0 EAC1	Scan monitoring time (multiple of 12 ms)
97	EAC2 EAC3	Time interval for OB 13
98	EAC4 EAC5	Start address of current data block, from firmware version ZO3
128 - 202	EB00 EB95	Block stack
203 - 251	EB96 EBDD EBF7	Interrupt stack

Note:
Change only RS 96 (cycle time monitoring) in your program. Modification of other system data words could result in unwanted system response. Assign the OB 13 time interval (RS 97) and the SINEC L1 parameters (RS 57 - RS 63) over COM 115H.

Table 5-2. Address Allocation in the Flag, Timer, and Counter Areas

Memory Area		Abs. Address (Hex.)
Flags (F)	FB 0 FB 1 : FB 255	EE00 EE01 : EEFF
Timers (T)	T 0 T 1 : T 127	EC00, EC01 EC02, EC03 : ECFE, ECFF
Counters (C)	C 0 C 1 : C 127	ED00, ED01 ED02, ED03 : EDFE, EDFF

Table 5-3. Block Address List

Block Type	Block Number	Abs. Address (Hex.)
Organization blocks	OB 0 OB 1 : OB 255	DC00, DC01 DC02, DC03 : DDFE, DDFF
Function blocks	FB 0 FB 1 : FB 255	DE00, DE01 DE02, DE03 : DFFE, DFFF
Program blocks	PB 0 PB 1 : PB 255	E000, E001 E002, E003 : E1FE, E1FF
Sequence blocks	SB 0 SB 1 : SB 255	E200, E201 E202, E203 : E3FE, E3FF
Data blocks	DB 0 DB 1 : DB 255	E400, E401 E402, E403 : E5FE, E5FF

6 System Start-Up

Figures

Tables

6 System Start-Up

The following section contains suggestions for configuring and starting up a system containing programmable controllers.

6.1 Suggestions for Configuring and Installing the Programmable Controller

A programmable controller is often used as a component in a larger system. The suggestions contained in the following warning are intended to help you safely install your programmable controller.

W A R N I N G !

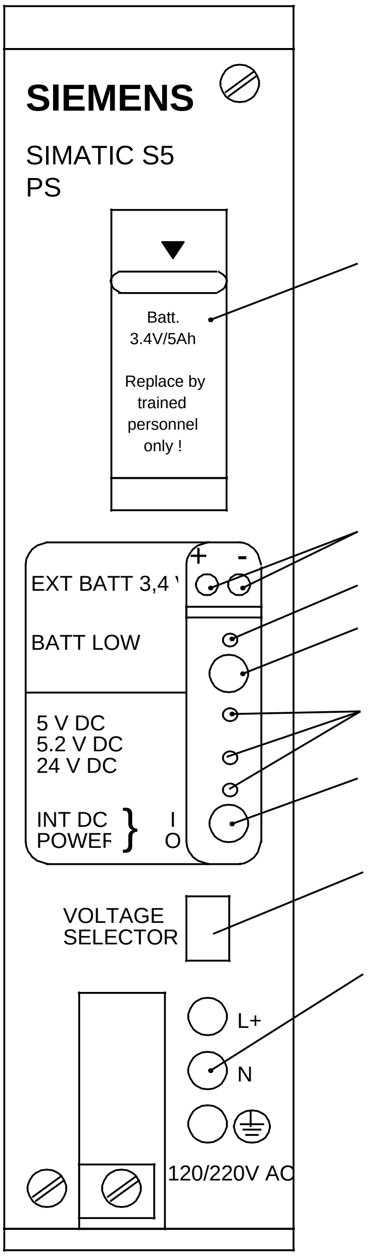
- Adhere to any safety and accident-prevention regulations applicable to your situation and system.
- If your system has a permanent power connection (stationary equipment) that is not equipped with an isolating switch and/or fuses that disconnect all poles, install either a suitable isolating switch or fuses in the building wiring system. Connect your system to a ground conductor.
- Before start-up, if you have units that operate using the main power supply, make sure that the voltage range setting on the equipment matches the local main power voltage.
- When using a 24-V supply, make sure to provide proper electric isolation between the main supply and the 24-V supply. Use only power supplies manufactured according to IEC 364-4-41 or HD 384.04.41 (VDE 0100, part 410).
- Fluctuations or deviations of the supply voltage from the rated value may not exceed the tolerance limit specified in the technical data. If they do, functional failures or dangerous conditions can occur in the electronic modules or equipment.
- Take suitable measures to make sure that programs that are interrupted by a voltage dip or power failure resume proper operation when the power is restored. Make sure that dangerous operating conditions do not occur even momentarily. If necessary, force an EMERGENCY OFF.
- EMERGENCY OFF devices must be in accordance with EN 60204/IEC 204 (VDE 0113) and be effective in all operating modes of the equipment. Make certain to prevent any uncontrolled or undefined restart when the EMERGENCY OFF devices are released.
- Install power supply and signal cables so that inductive and capacitive interference can not affect the automation functions.
- Install your automation system and its operative components so as to prevent unintentional operation.
- Automation equipment can assume an undefined state in the case of a wire break in the signal lines. To prevent this, take the proper hardware and software safety measures when linking the inputs and outputs of the automation equipment.

6.1.1 Operating the Power Supply Module and the Central Processing Unit

Power Supply Module PS 951

You can set the following switches on the PS 951 power supply module:

- The Voltage Selector switch sets the line voltage at either 120 V AC or 230 V AC for AC modules. The PS 951 can also be operated with a 24 V DC power supply.
- The ON / OFF switch turns the operating voltages on or off.
- The RESET switch acknowledges a battery failure indication.



Battery compartment

Sockets for external 3.4 to 9 V DC for backup when battery is changed and power supply is shut off

Battery failure indicator
The LED lights up under the following conditions:

- There is no battery.
- The battery has been installed incorrectly.
- The battery voltage has gone below 2.8 V.

If the LED lights up, the ”BAU” signal is sent to the CPU.

RESET switch
Use this switch to acknowledge a battery failure signal after you have installed a new battery. If you are operating the PS 951 power supply module without a battery, activate this switch to suppress the ”BAU” signal.

Operating voltage displays

- +5 V supply voltage for the input/output modules
- +5.2 V supply voltage for PG 605U or PG 615, OPs, BT 777 bus terminal
- +24 V supply voltage for the 20 mA current loop interface

ON/OFF switch (I=ON, 0= OFF)
When the switch is in the ”OFF” position, the operating voltages are disabled without interrupting the connected line voltage.

120 V AC / 230 V AC voltage selector switch with transparent cover

Screw-type terminals for connecting the line voltage

Figure 6-1. Power Supply Module Control Panel

Central Processing Unit

The following operator functions are possible on the front panel of the CPUs:

- plug in a memory submodule
- connect a programmer (PG) or an operator panel (OP)
- connect SINEC L1
- select the operating mode
- preset retentive feature
- perform an Overall Reset

LEDs indicate the current CPU status. A slot in the CPU front panel contains a plastic card with the most important operating instructions for the PS and CPU.

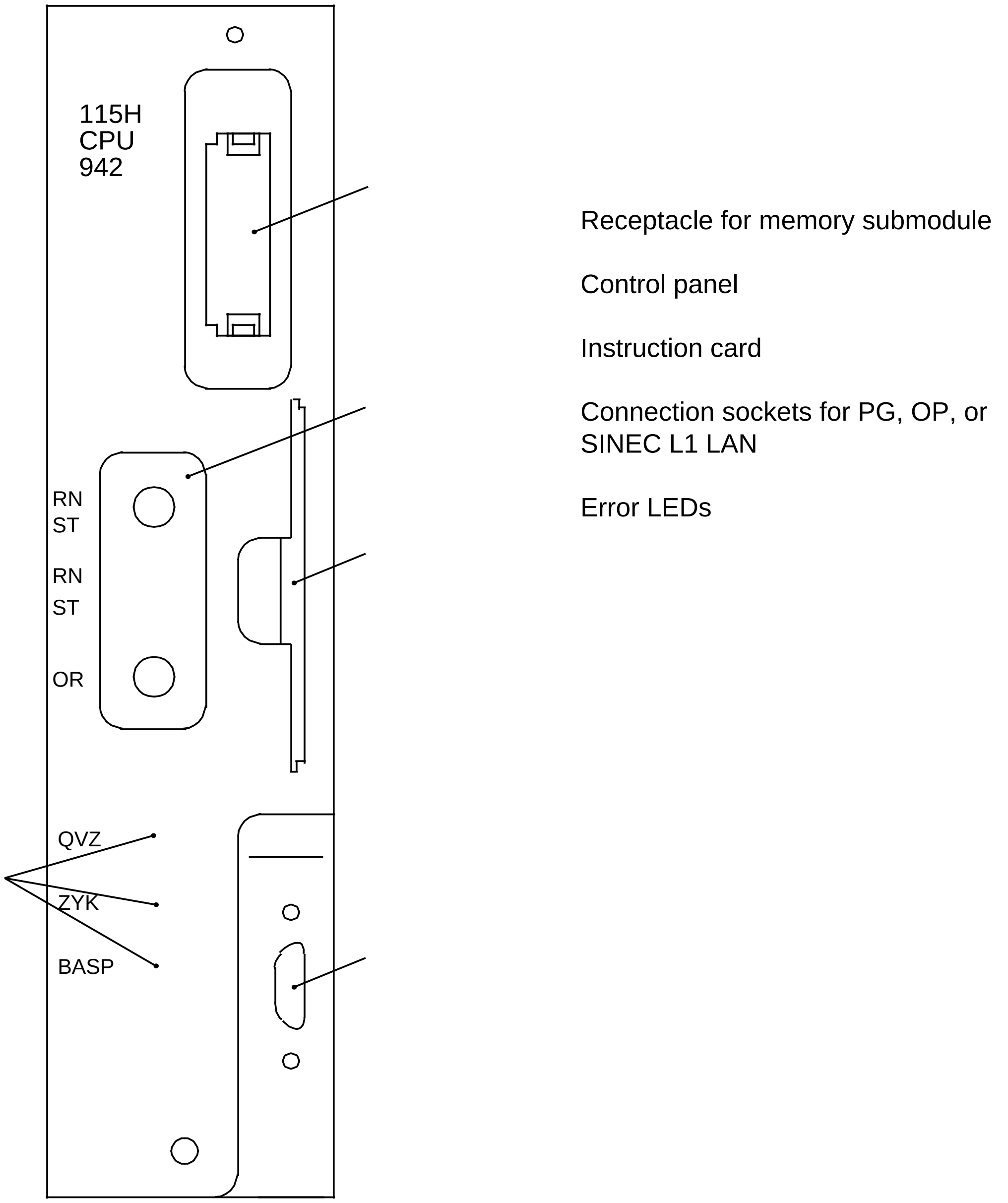


Figure 6-2. Front View of the CPUs

The CPU controls are arranged on a panel. Figure 6-3 shows the control panels of the CPU 942H.

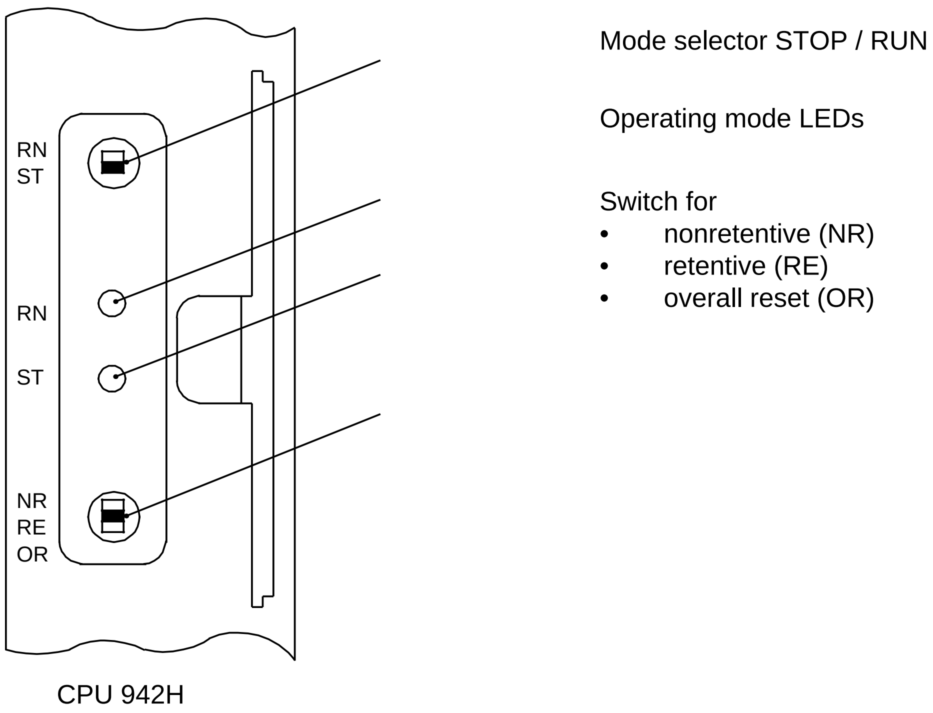


Figure 6-3. CPU Control Panels

6.1.2 Operating Modes

Use the mode selector to set the ”STOP” (ST) or ”RUN” (RN) mode. The CPU executes the ”RESTART” mode automatically between ”STOP” and ”RUN”.

”STOP” Mode

- The program is not scanned.
- The values of the timers, counters, flags, and process images that were current when the CPU went into the ”STOP” state are maintained.
- Output modules are disabled (signal state ”0”). The “BASP” error LED lights up. The BASP (output inhibit) signal is cancelled after OB 21 or OB 22 (RESTART) has been processed.

"RUN" Mode

- The program is processed cyclically.
- Timers that were started in the program run out.
- Input module signal states are read in.
- Output modules are addressed.

Note:
You can also set the "RUN" mode after Overall Reset, i.e., when the program memory is empty.

"RESTART" Mode

- All error LEDs light up.
- Restart block OB 21 or OB 22 is processed.
- Timers are processed.
- All input and output modules are disabled. Outputs have signal state "0".
- All inputs and outputs in the process image have signal state "0".
- Scan time monitoring is inactive.

Meaning of the LEDs

Two LEDs on the control panel of the CPU indicate the status of the CPU (and   in Figure 6-3). Table 6-3 lists the possible indications. A flashing or flickering red LED indicates PC malfunctions.

Table 6-1. Operating Mode LEDs

Red LED	Green LED	Meaning
✳	○	"STOP" mode
○	✳	Master CPU is in "RUN" mode
○	⊓⊔	Standby CPU is in "RUN" mode
✳	✳	CPU is executing the Cold Restart routine or RESTART self-test
⊓⊔	⊓⊔	Updating and RESTART
✳	✳	Diagnostics mode (Phase 1: RESTART self-test)
⊓⊔	⊓⊔	Diagnostics mode (Phase 2: Updating and RESTART)

Legend:

✳	LED is on
○	LED is off
⊓⊔	LED flashes

Changing the Operating Mode

Figure 6-4 shows the conditions for changing the operating mode.

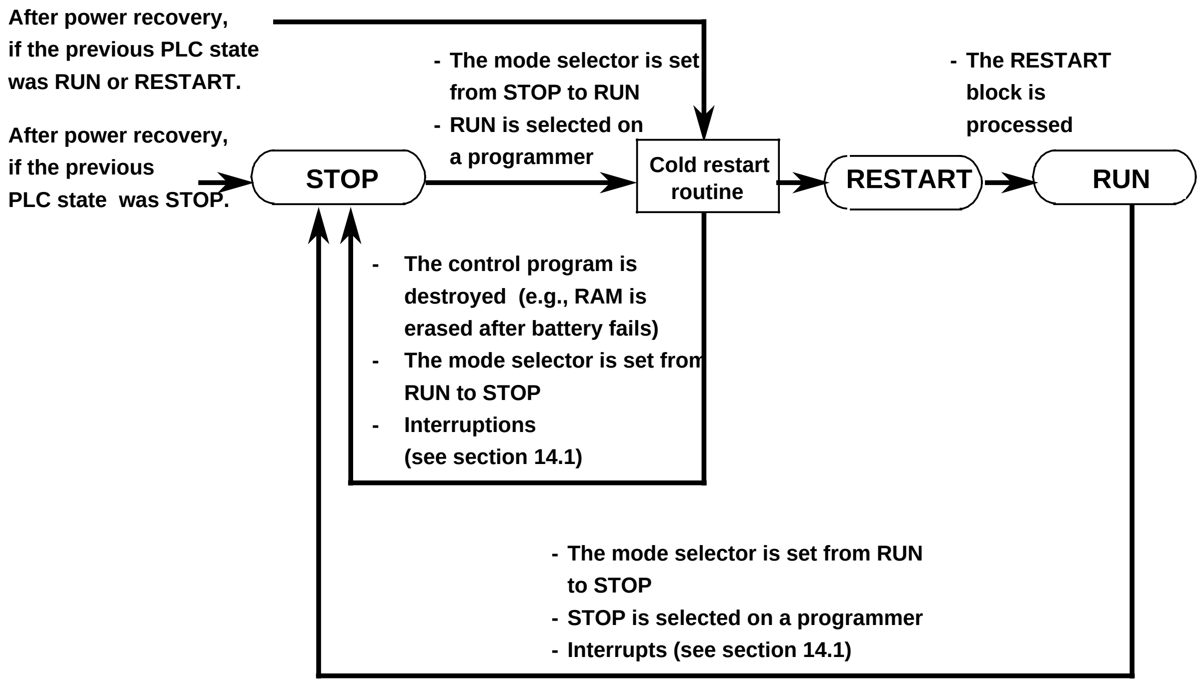


Figure 6-4. Conditions for Changing the Operating Mode

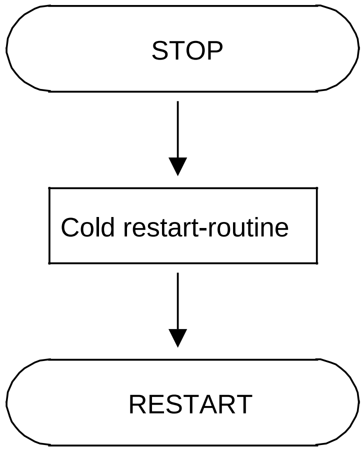
6.1.3 Cold Restart Routine

The CPU executes a Cold Restart routine prior to ”RESTART”. The Cold Restart depends on the event (STOP switch or power recovery) that triggered the Cold Restart.

Cold Restart Procedure from the ”STOP” State

If you initiate a RESTART from the ”STOP” state with the CPU mode selector or with a programmer, the operating system routine executes the following:

- clears the process image
- resets the nonretentive timers and counters
- writes signal state ”0” to the digital outputs
- reads in and stores the configuration of the input and output modules
- tests the memory submodule
- sets up the address list for the control program
- puts the PLC into the ”RESTART” mode



Cold Restart Routine Following Power Recovery

The Cold Restart routine after POWER ON runs as it would for RESTART from the ”STOP” state. In addition, the battery, memory submodule, and status before POWER OFF are evaluated as shown in Figure 6-5.

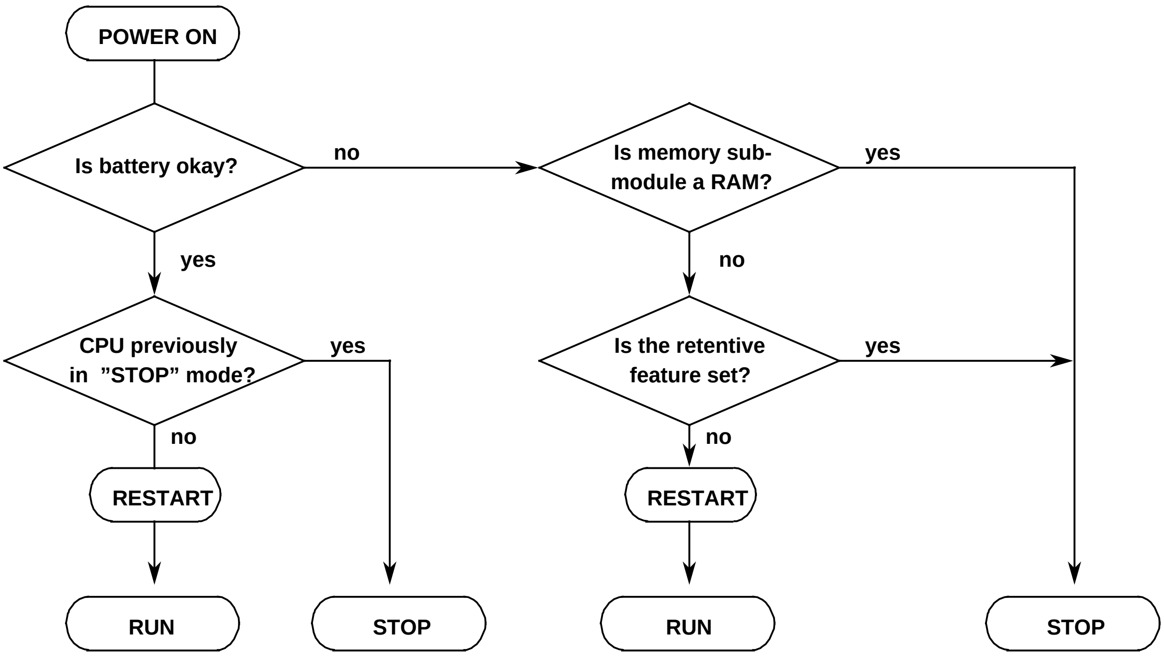


Figure 6-5. Cold Restart Routine Following Power Recovery

6.1.4 Retentive Feature of Timers, Counters and Flags

You can determine the behavior of the CPU during the cold restart routine using the function switch for setting the retentive feature on the control panel of the CPU.

Table 6-2. Switch Positions

Switch position	Meaning
RE (retentive)	Some of the flags, timers and counters are retained in the cold restart routine.
NR (nonretentive)	All flags, timers and counters are reset in the cold restart routine.

The RE switch position is only possible if a backup battery is used.

Table 6-3. Setting the Retentive Feature

Switch position	Flags	Timers	Counters
RE (retentive)	F0.0 to F127.7 retentive F128.0 to 255.7 nonretentive	T0 to T63 retentive T64 to T127 nonretentive	C0 to C63 retentive C64 to C127 nonretentive
NR (nonretentive)	No retentive flags	No retentive timers	No retentive counters

Note:
Note that the retentive feature, if set, always applies to the CPU which serves as master CPU following execution of the cold restart routine.
To avoid confusion, it is recommended that the retentive feature be either set or not set for both CPUs.

6.1.5 Time-Out

A time-out occurs when an input or output module fails to issue a ”Ready” signal within approximately 160Þs of being addressed.
The following table shows the time-out performance of the S5-115H PLC.

Table 6-4. Responses to a Time-Out

Time-Out (QVZ)	Time-Out (QVZ)	Response
Digital input modules and analog input modules	in subunit	- Error indication - Module is passivatized
	in expansion unit for switched I / Os	- Error indication - Module is passivatized
Digital output modules and analog output modules	in subunit	- Error indication - Subunit set to STOP
	in expansion unit (for switched I / Os)	- Error indication - System continues without interruption

Note:
The operating system switches from master to standby upon detection of the ***first*** I / O error in a switched EU.

6.1.6 Overall Reset

It is recommended that you initiate an Overall Reset prior to the initial transfer of the configuring data and the control program.

Overall Reset clears the following:
- the PC program memory
- all data (flags, timers and counters)
- all error bits

Note:
Without Overall Reset, information is maintained even if the program is overwritten.

An Overall Reset in initiated as follows:

1. Hold the relevant switch in the ”OR” position.
2. Flip the mode selector from ”ST” to ”RN” twice.

The red LED goes out briefly during the Overall Reset procedure. You can also use a programmer to perform an Overall Reset, in which case the CPU must be at STOP. Please note that only the CPU to which the programmer is connected is reset.

6.1.7 Steps for System Start-Up

It is recommended that the S5-115H system be put into operation in three steps:
1. Start minimum configuration
2. Start fully configured system without user program
3. Start system (full configuration with user program)

The following flowcharts show what you should also note when starting up the S5-115H. You will find information on how to eliminate possible errors.

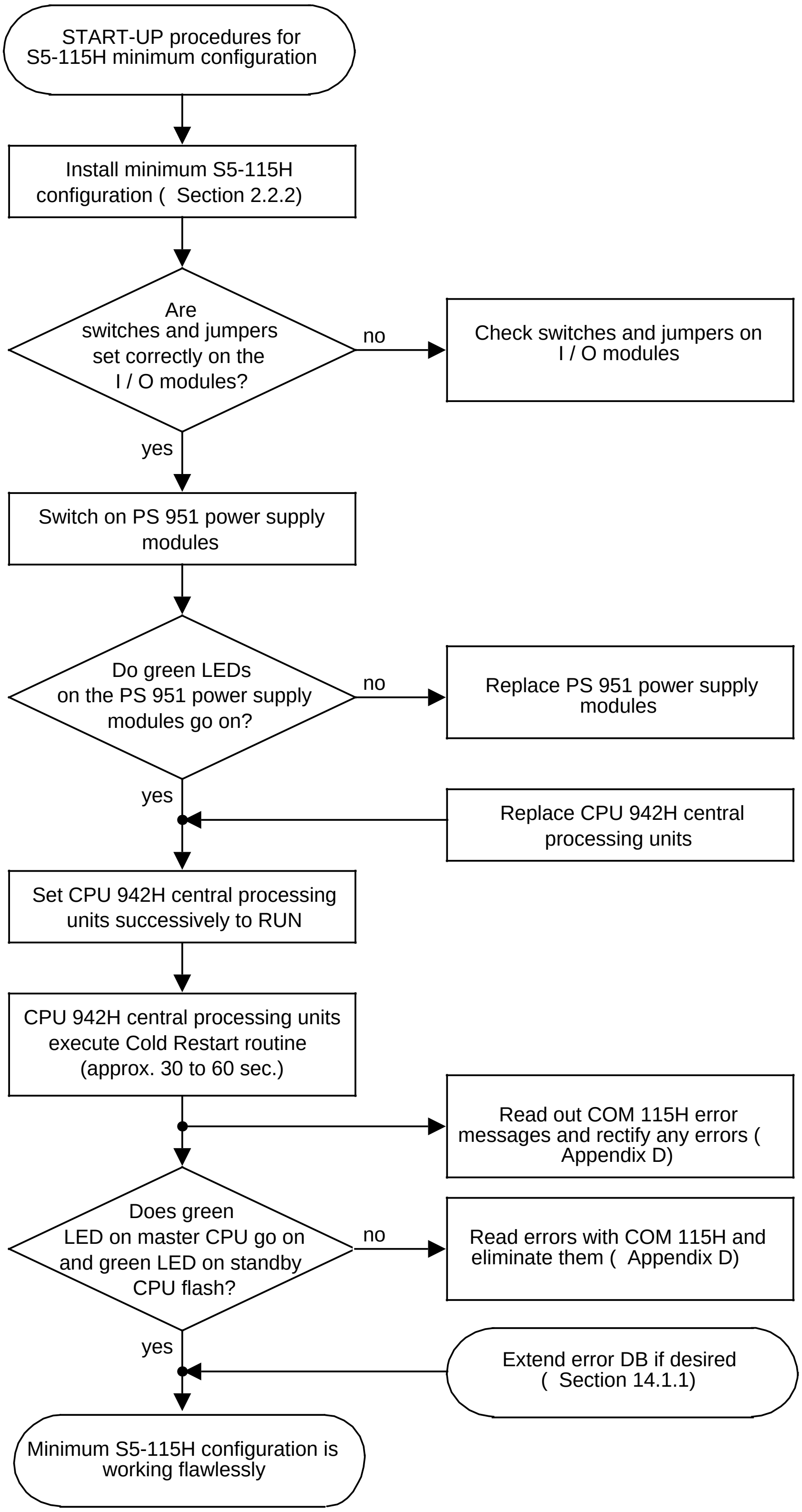


Figure 6-6. Starting the Minimum Configuration

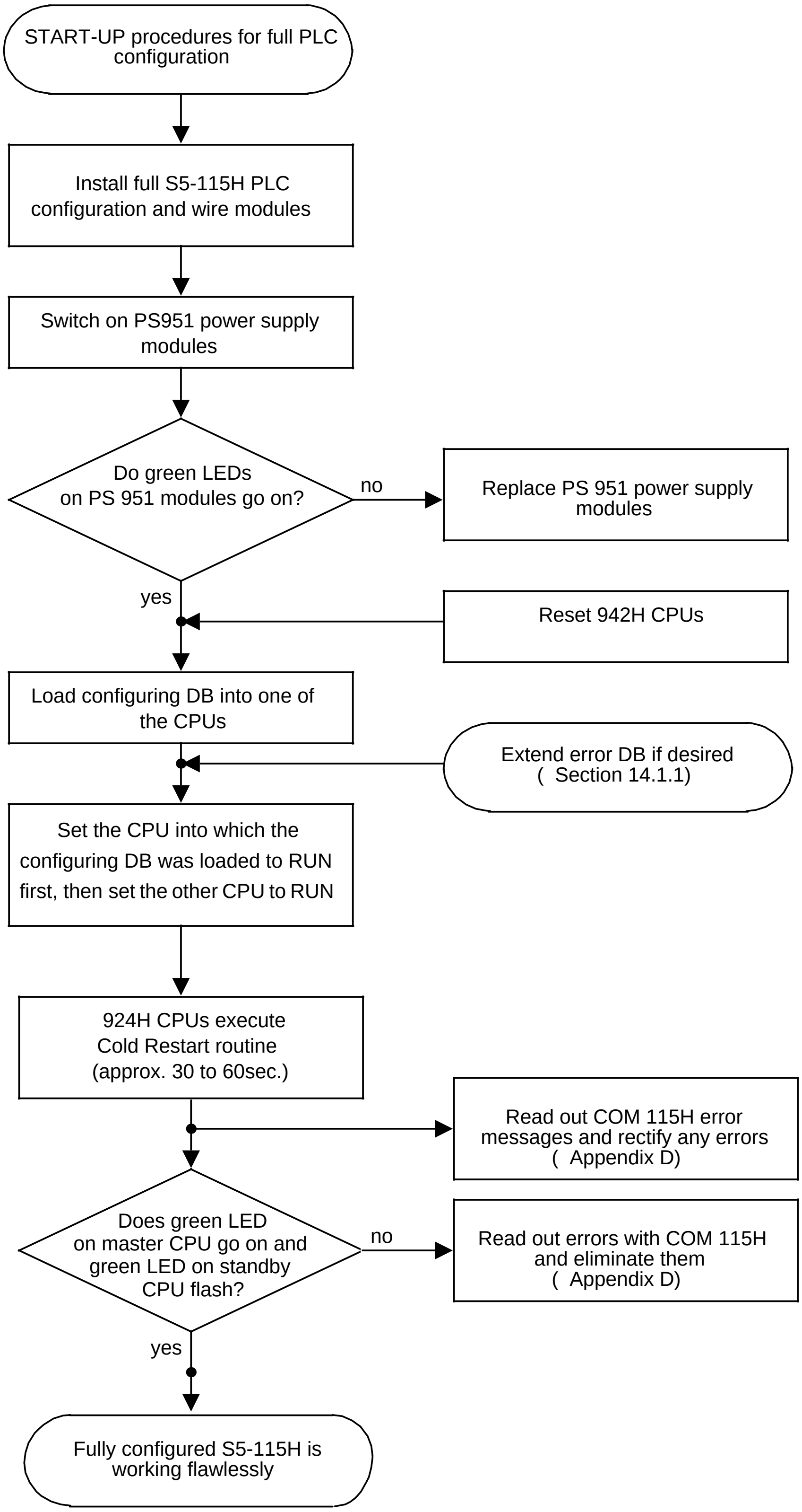


Figure 6-7. Starting a Full Configuration

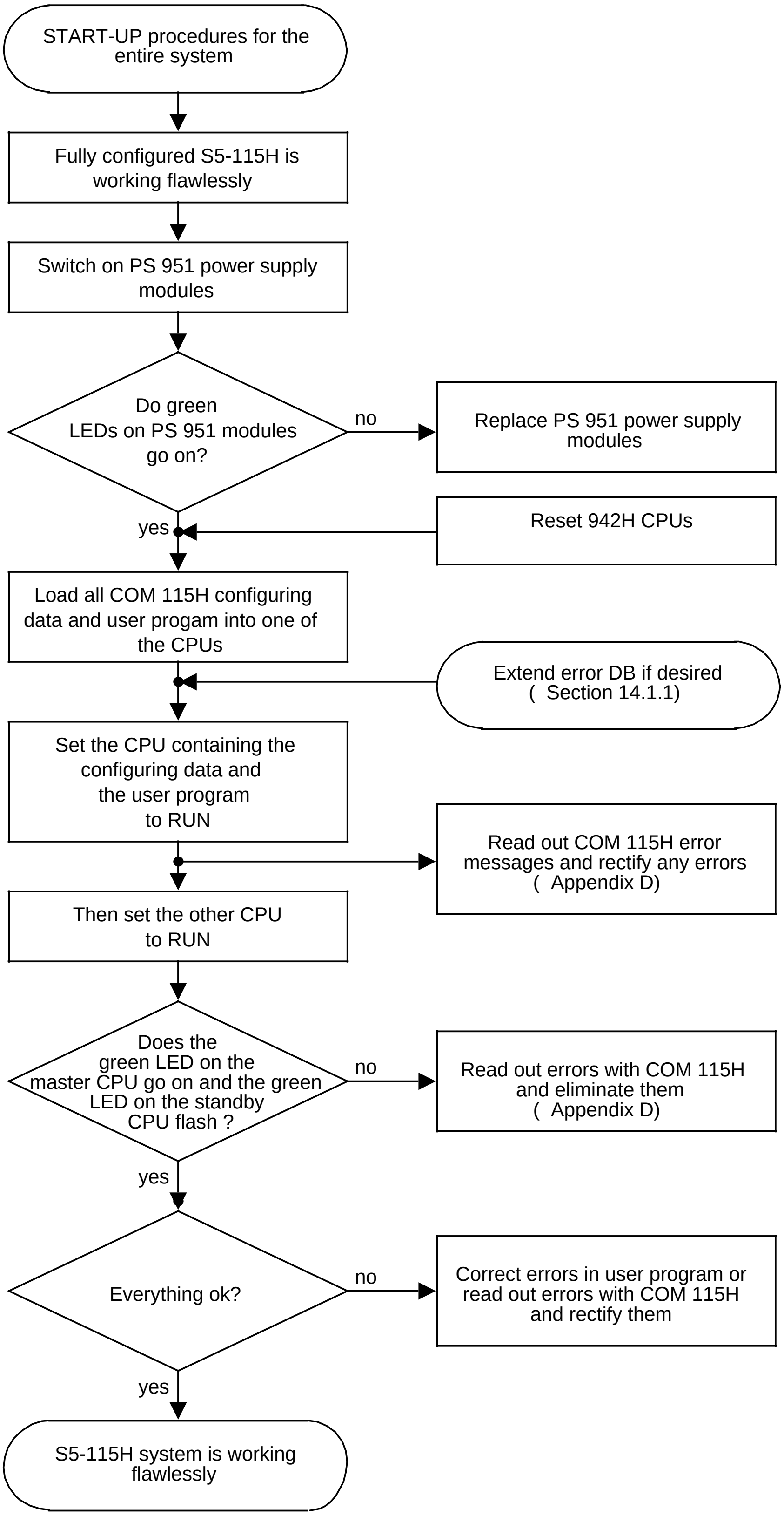


Figure 6-8. Starting the System

6.2 Working with Input / Output Modules

Suitable floating or non-floating modules are available for the various signal levels. The wiring of the power supply, sensors and actuators is printed on the front of the module.
LEDs on the front panel display the signal states of the inputs and outputs. The LEDs are assigned to the terminals of the front connector (see also Chapter 17 ”Technical Specifications”).

C A U T I O N !
Shut off the supply voltage for the central controller and the sensors before plugging in or removing input / output modules.

6.3 System Start-Up Procedures

This section contains information on how to configure a system that has programmable controllers and how to put such a system into operation.

6.3.1 Safety Measures

When configuring systems that have programmable controllers, follow the relevant VDE regulations (e.g., VDE 0100 or VDE 0160). Pay special attention to the following points:

- Prevent conditions that can endanger people or property.
- When a PLC malfunctions, commands for EMERGENCY OFF devices and safety limit switches must remain effective under all circumstances. These safety measures must affect the actuators in the power circuit directly.
- When power is restored after a power failure or after EMERGENCY OFF devices are released, machines must not be able to restart automatically.
- When EMERGENCY OFF devices are activated, safety must be guaranteed for persons and the controlled system as follows:
  - Actuators and drives that could cause dangerous situations (e.g., main spindle drives for machine tools) must be shut off.
  - On the other hand, actuators and drives that could endanger persons or the controlled system by being shut off (e.g., clamping devices) must not be shut off by EMERGENCY OFF devices.
- The programmable controller must be able to record the activation of EMERGENCY OFF equipment and the control program must be able to evaluate it.

6.3.2 Safety Regulations for System Start-Up

Perform each step in the operator procedure shown in Table 6-5. before switching on the power supply.

Table 6-5. Operator Procedure Prior to Switching On the Power Supply

Prerequisite	Check List	Remarks
The system and S5-115H are not live, i.e., the main switch is shut off.	- Check the line voltage connections. Protective ground conductors must be connected. - Make sure that all plugged in modules are screwed tightly to the mounting rack. - Compare the configuration of the I / O modules to the location diagram. (Pay particular attention to fixed and variable addressing.) - For I / O modules, make sure that no high-voltage lines (e.g., 220 V AC) terminate at low-voltage connectors (e.g., 24 V DC). - If nonfloating I / O modules are used, make sure that the M (OV reference) potential of the supply voltages for sensors and actuators is connected to the grounding terminal of the mounting rack (M_{ext}-M_{int} connection).	Visual check of the installation, observing VDE 0100 and VDE 0113.
Disconnect fuses for sensors and actuators. Switch off the power circuits of the actuators	- Switch the PLC without memory submodule to the ”STOP” mode. Connect the programmer to the CPU. - Perform an Overall Reset and then switch the PLC to the ”RUN” mode.	After the power switch is turned on, the green LEDs light up on the power supply and the red ”ST” LED lights up on the CPU. The red ”ST” LED goes out and the green ”RN” LED lights up.
Insert the fuses for the sensors. Leave the fuses for the actuators and power circuits disconnected.	- Activate all sensors in sequence. - You can interrogate each input using the ”STATUS VAR” programmer function.	If the sensors function properly and their signals are received, the appropriate input LEDs must light up on the I / O module.
Insert the fuses for the actuators. Leave the power circuits of the actuators disconnected.	- You can force each output using the ”FORCE VAR” programmer function.	The LEDs of the forced outputs must light up and the circuit states of the corresponding actuators must change.
Leave the power circuits for the actuators disconnected.	- Enter the program using the ”INPUT” programmer function. You can enter the program in the ”STOP” or ”RUN” mode.	The red ”ST” LED or the green ”RN” LED lights up. A battery must be installed if a RAM submodule is used.
	- Test the program block by block and make any necessary corrections. - Dump the program in a memory submodule (if desired).	
Switch on the power circuits for the actuators.	- Switch the PLC to the ”RUN” mode.	The PC scans the program.

7 Analog Value Processing

Figures

Tables

7 Analog Value Processing

Analog input modules convert analog process signals to digital values that the CPU can process. Analog output modules perform the opposite function.

7.1 Principle of Operation of Analog Input Modules

The analog measured value is digitized and stored in a data register on the module. It can then be read and processed further by the CPU.

Signal Interchange Between Module and CPU

The CPU reads the digitized value from the module's memory via FB 250 (RLG:AE), FB 252 (RLG:HAE) or a Load operation (L PW).
The complete measured value (2 bytes) is stored in CPU RAM.

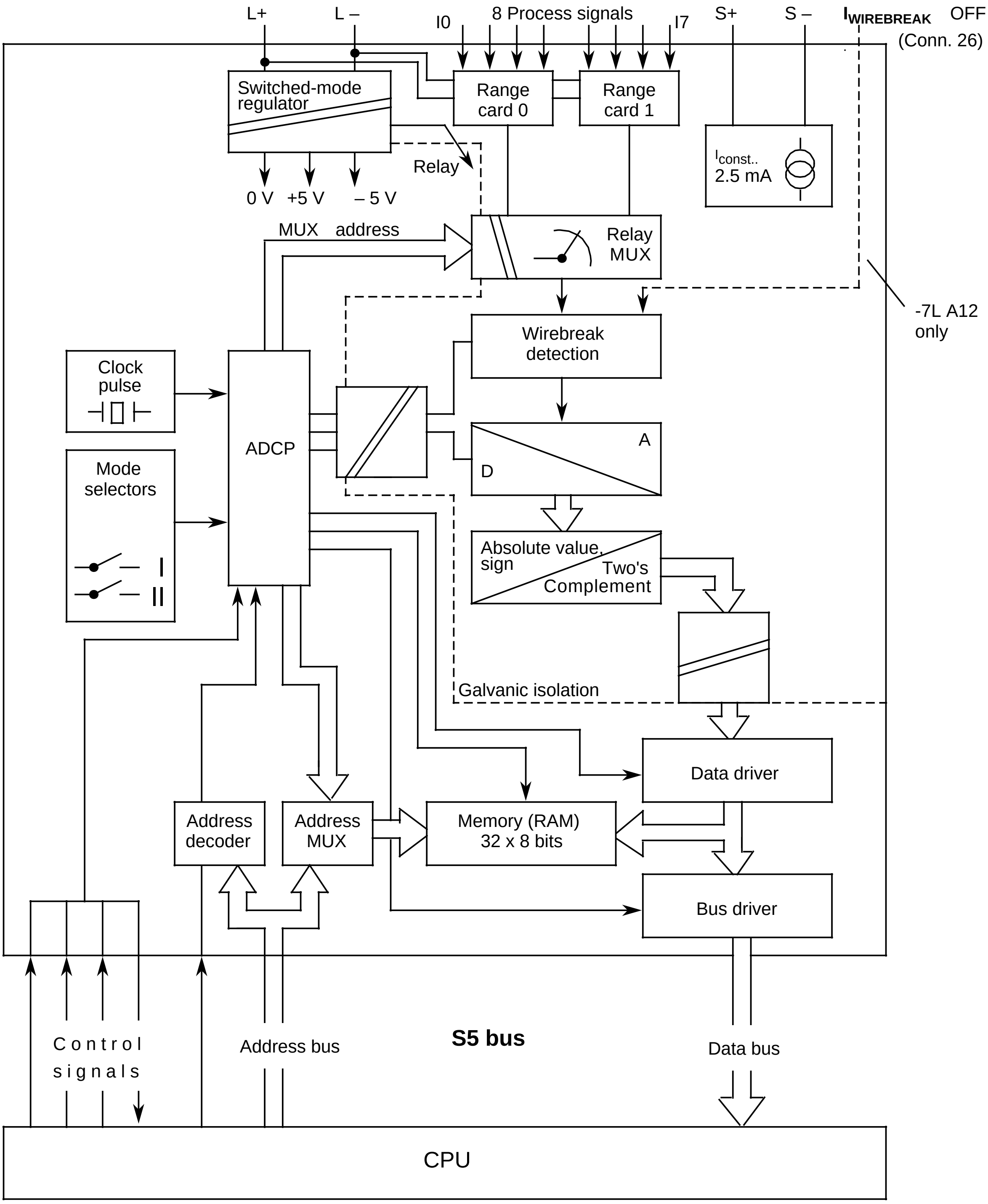
The 460 and 465 Analog Input Modules

Two different types of analog input modules are available:

6ES5 460-7LA11 / -7LA12
- Galvanically isolated
- 8 channels
- 2 range cards
- Maximum permissible isolating voltage 60 V AC / 75 V DC between a channel and ground as well as between channels.

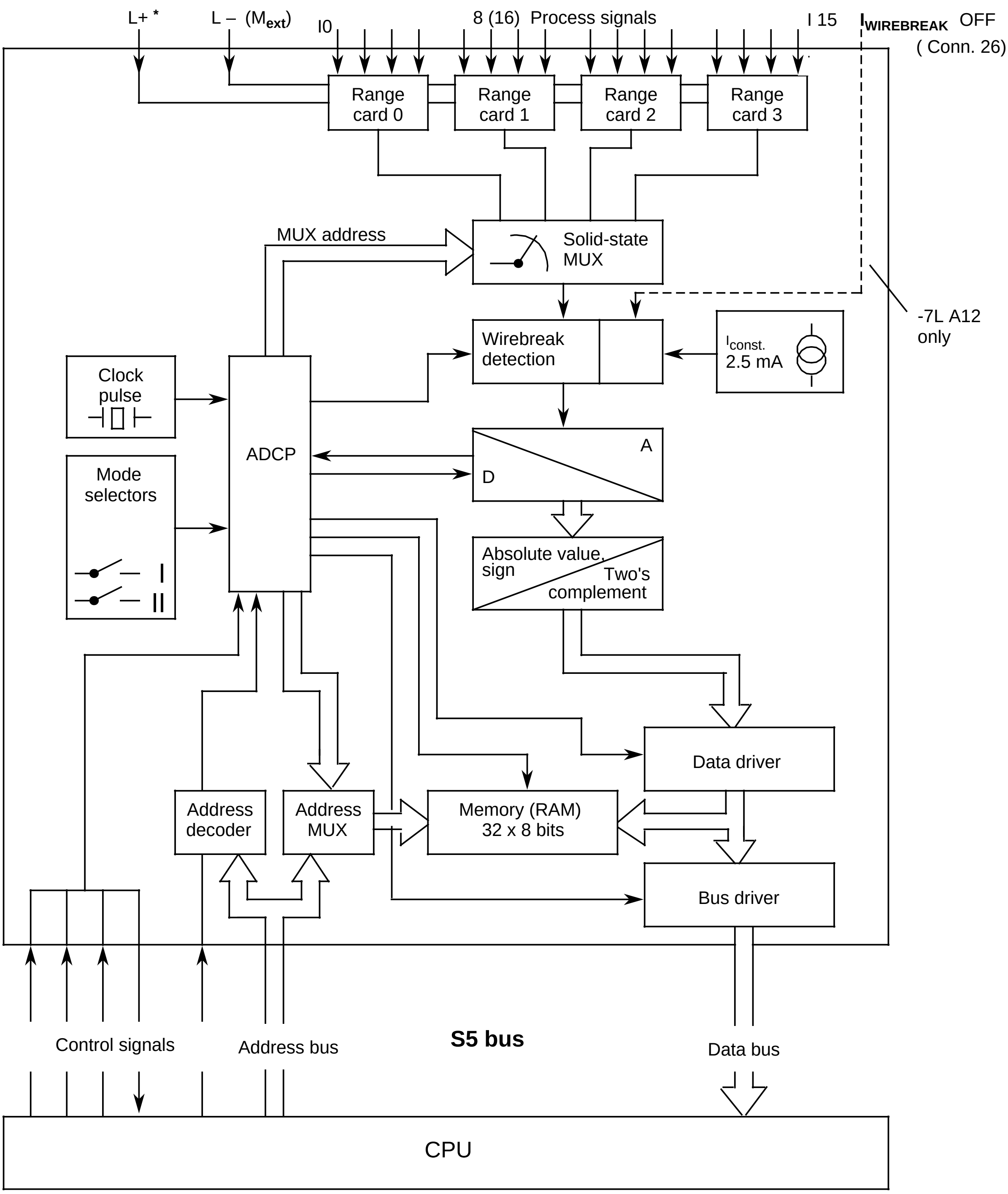
6ES5 465-7LA11 / -7LA12
- Non isolated
- 8/16 channels (selectable)
- 2/4 range cards
- 1 V max. permissible voltage between a channel and ground as well as between channels

The block diagrams (Figures 7-1 and 7-2) illustrate the method of operation as well as signal interchange between the analog input modules and the CPU.
The process signals must be matched to the input level of the module's analog-digital converter (ADC) to suit the application. You can match the signals by plugging a suitable range card (voltage divider or shunt) into the receptacle on the frontplate of the analog input module.
A processor (ADCP) controls the multiplexer, analog-digital conversion and forwarding of the digitized measured values to memory or to the programmable controller's data bus. The module's operating mode, which is set on two switches, is taken into account (Section 7.4).



A / D Analog-digital converter (ADC)
ADCP ADC processor
MUX Multiplexer

Figure 7-1. Block Diagram with Signal Interchange Between a 460 Isolated Analog Input Module and the CPU



A/D	Analog-digital converter (ADC)
ADCP	ADC processor
MUX	Multiplexer

* Required only when using a -1AA51 module

Figure 7-2. Block Diagram with Signal Interchange Between a 465 Nonisolated Analog Input Module and the CPU

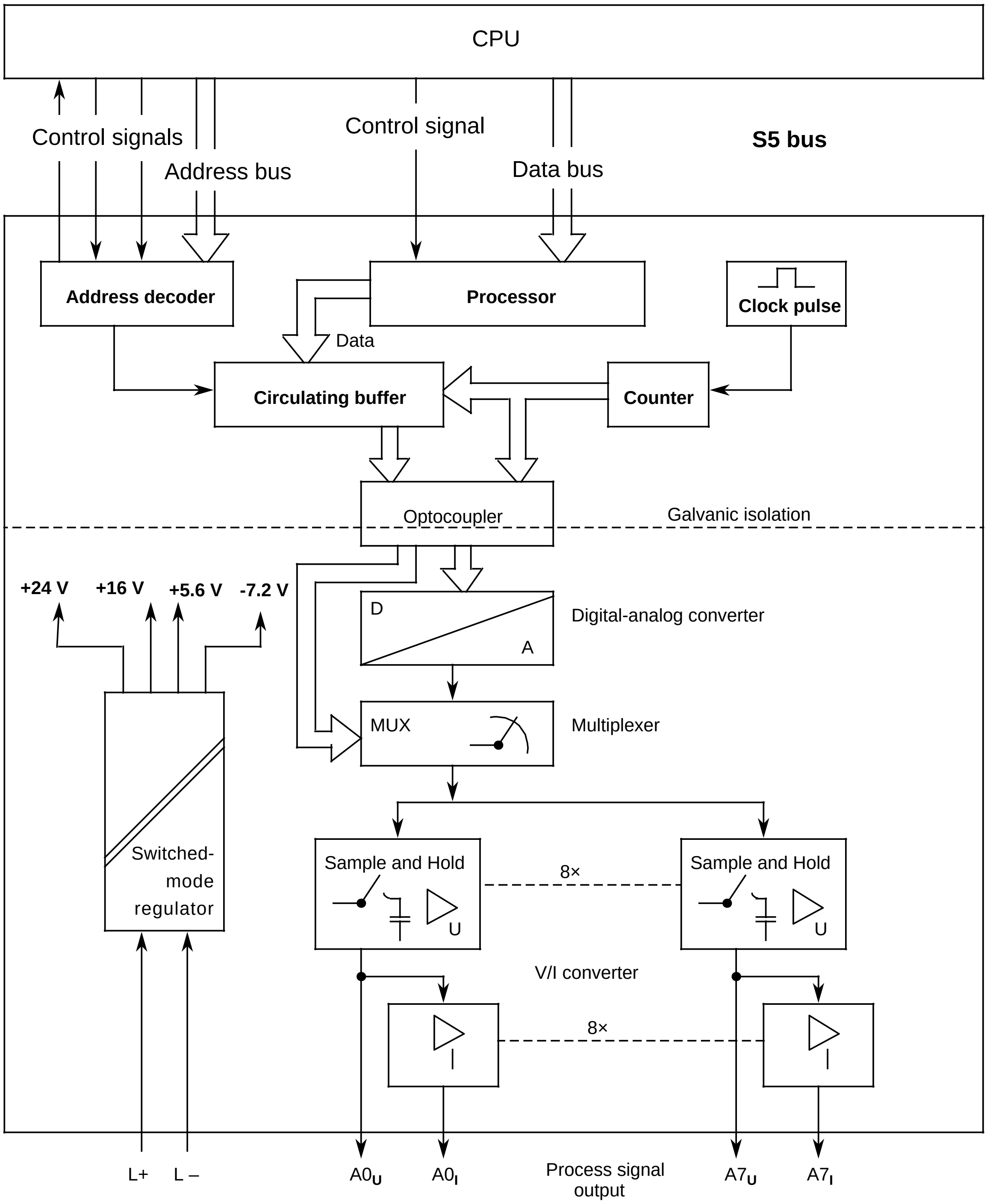
7.2 Principle of Operation of Analog Output Modules

The CPU processes the digital values that the analog output modules convert to the required voltages or currents. Various floating modules cover individual voltage and current ranges.

Signal Interchange between CPU and Module

The CPU transfers a digital value to the module's memory under a specified address.The user starts the transfer via FB 251 (RLG:AA) or a ”T PB / PY*” or ”T PW” operation.
Block diagram7-3 illustrates the principle of operation of the 470 analog output module.

* PY in the case of S5-DOS-PG



MUX Multiplexer
D/A Digital-analog converter

Figure 7-3. Block Diagram with Signal Interchange Between CPU and a 470 Analog Output Module

7.3 Connecting Analog Modules

7.3.1 Connecting Current and Voltage Sensors to Analog Input Modules

You must observe various conditions when connecting current or voltage sensors to analog input modules, depending on what type of sensors are used.

C A U T I O N:

Unused analog inputs (M + / M -) must be short-circuited or fitted with a current or voltage divider (see Table 7-6., excepting 6ES5 498-1AA11).

The 460-7LA11 and 460-7LA12 analog input modules have galvanic isolation between analog inputs and L + or L -. The galvanic isolation, however, is nullified when a 498-1LA51 module is used for a 2-wire transducer!

Note:

Detailed information on address assignment for analog modules is presented in Section 5 (Addressing / Address Assignments). Please observe the information regarding the overall structure (Section 3.4 in this manual).

Also observe the directions in Sections 3.4.3 and 3.4.4 regarding shielding of the signal leads.

Connecting Sensors

Certain precautionary measures must be taken in order to make sure that potential difference UCM is not exceeded. Different measures are required for isolated and non-isolated sensors.

When isolated sensors are used, the measuring circuit can assume a potential to earth that exceeds the permissible potential difference U_{CM} (refer to the maximum values for the various modules).
To prevent this, the sensor's negative potential must be connected to the module's reference potential (reference bus).

Example: Measuring temperature on a busbar with an isolated thermocouple.
In a worst-case situation, the measuring circuit can assume a potential that would destroy the module; this must be prevented through the use of an equipotential bonding conductor (Figure 7-4).
Possible causes:

- Static charge
- Contact resistors through which the measuring circuit assumes the potential of the busbar (e.g. 220 V AC).

When using non-isolated sensors, the permissible potential difference UCM between the inputs and the reference bus must not be exceeded.

Example: Measuring the temperature of the busbar of an electroplating bath with a non-isolated thermocouple. The difference between the potential of the busbar and the reference potential of the module is max. 24 V DC. A 460 analog input module with floating input (permissible UCM is 60 V AC/75 V DC) is to be used.

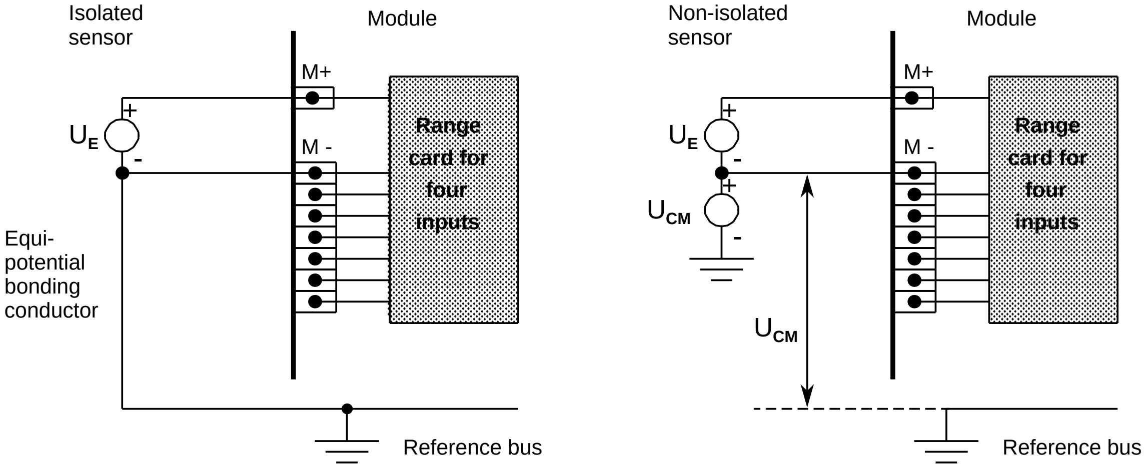


Figure 7-4. Connecting Sensors

Connecting Thermocouples with Compensating Box

The influence of the temperature on the reference junction (in the terminal box, for instance) can be equalized using a compensating box. Please observe the following:

- The compensating box must have an isolated power supply.
- The power supply unit must have a grounded shielding winding.

Compensate as follows when all thermocouples connected to the module's inputs have the same reference junction:

- Provide a separate compensating box for each analog input module
- Bring the compensating box into thermal contact with the terminals
- Apply compensating voltage to pins 23 and 25 (KOMP + and KOMP -) on the analog input module (Figure 7-5)
- Set Function Select switch II on the module for operating a compensating box (see also Tables 7-1 to 7-3)

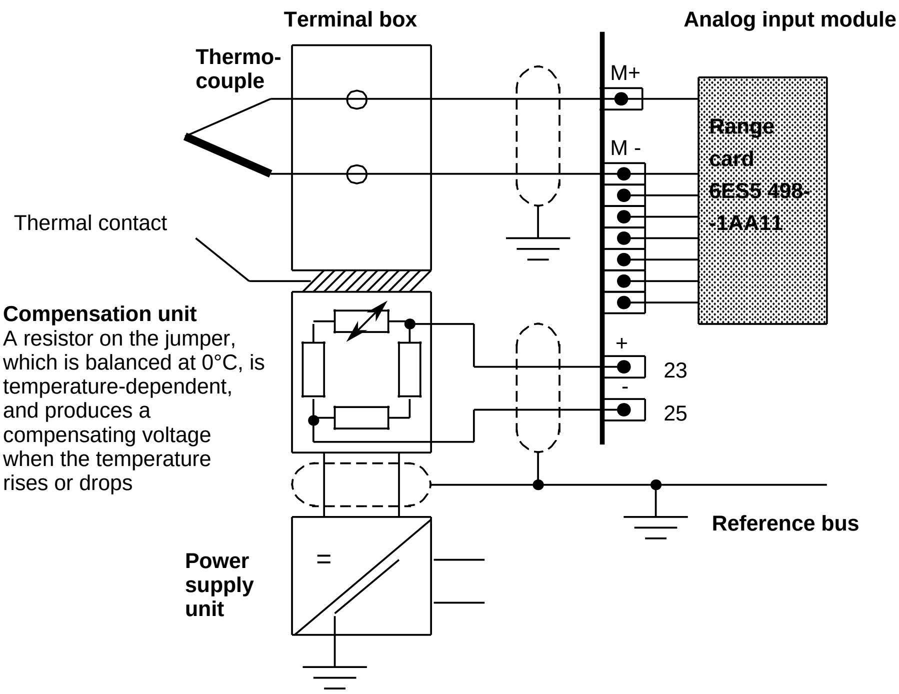


Figure 7-5. Connecting Thermocouples

Detailed information on thermocouples and compensating boxes can be found in Catalog MP 19.

When several thermocouples are distributed over areas with different temperature ranges, it is often advantageous to acquire different reference junction temperatures. In this case, the central compensating input is no longer used. A separate compensating box is used for each analog input channel to be compensated. KOMP + and KOMP - remain unconnected.

- Connect the relevant thermocouple in series with the compensating box.
- Run the remaining terminal leads from compensating box and thermocouple to the analog module (terminal M+ and M - see Figure 7-6).
- Set Function Select switch II on the module to "Without reference junction compensation".

Compensation, i.e. correction of the temperature error, subsequently takes place in the compensating box rather than on the module.
The corrected value is thus available at terminals M + and M - of the relevant analog input channels, and is then converted into a digital value.

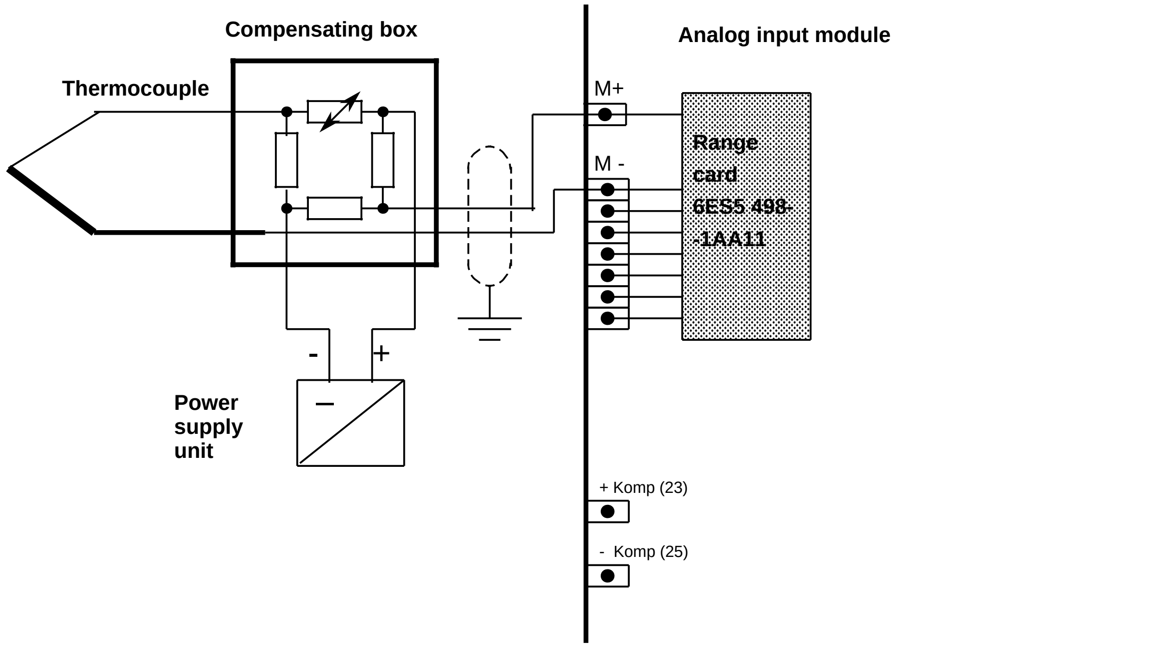


Figure 7-6. Connecting a Compensating Box to the Input of an Analog Input Module

Connecting Resistance Thermometers (e.g. PT 100s)

The power supply differs from one analog input module to another (see Figures 7-7 and 7-8).

6ES5 460 -7LA11 and 6ES5 460 -7LA12:
A constant-current generator supplies the series-connected resistance thermometers (max. 8 PT 100s) with a current of 2.5 mA over pins "S +" and "S -".
If no PT 100 is connected to input channels 4 to 7, other voltages and currents can be measured on these channels using range card 498-1AA21, -1AA31, -1AA41, -1AA51, -1AA61 or -1AA71 (see Figure 7-7, range card 2).
If you use a 498-1AA41, -1AA51 or -1AA71 range card, you do not need a short-circuiting jumper for the unused channels. If you use any other range card, you must terminate unused input channels with a short-circuiting jumper (Figure 7-7 channels 5 and 6).

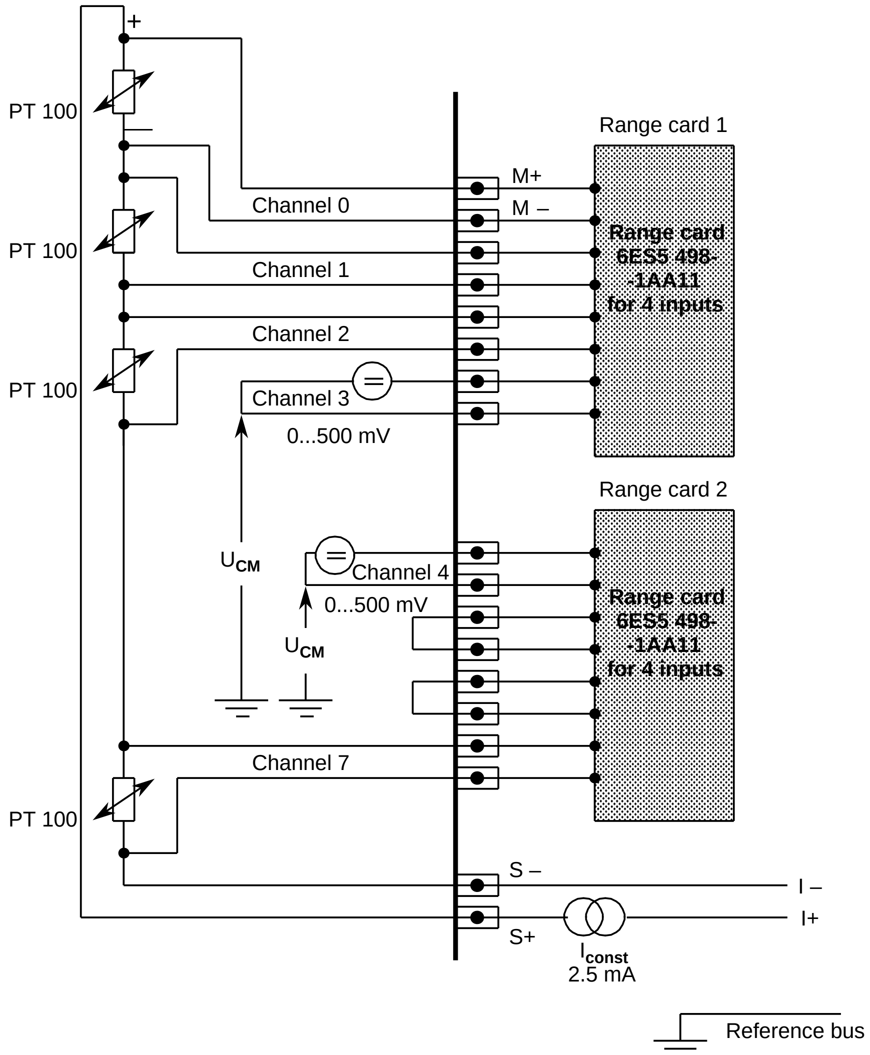
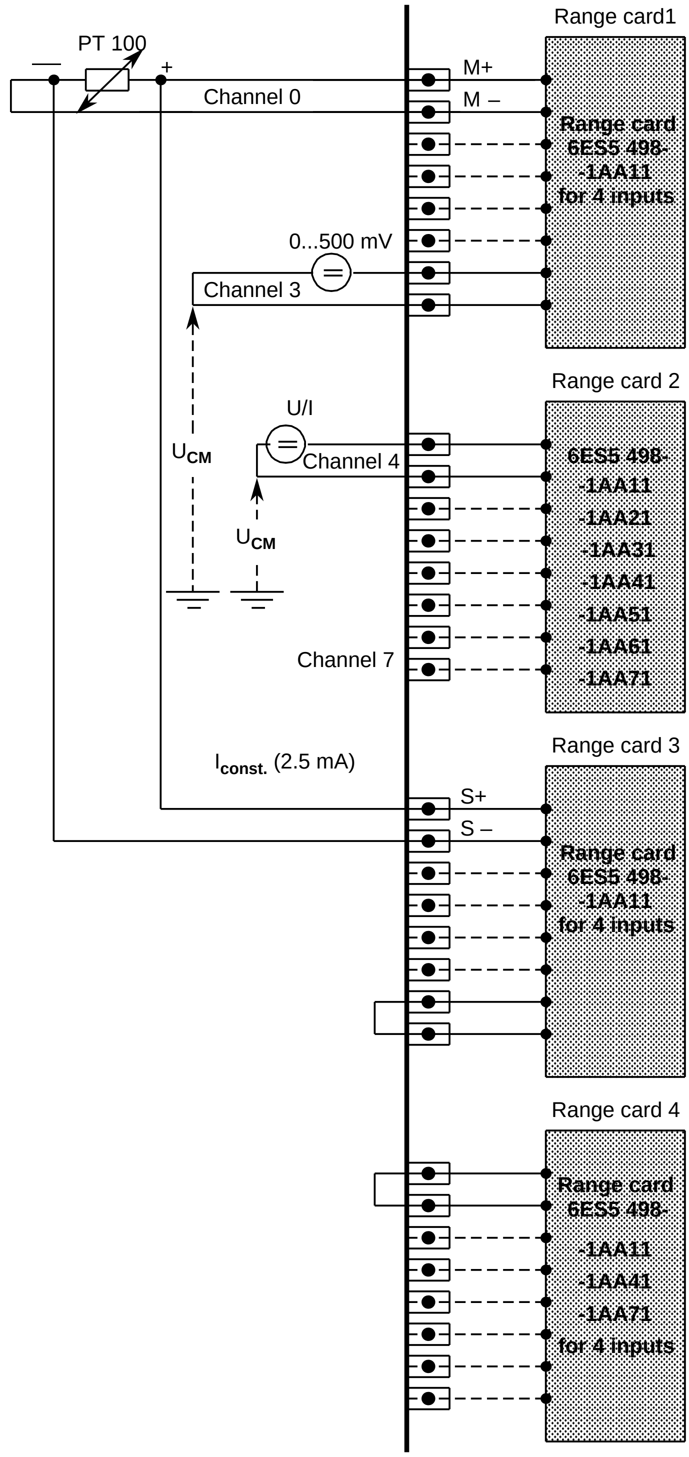


Figure 7-7. Connecting Resistance Thermometers (PT 100s) to a 460 Analog Module

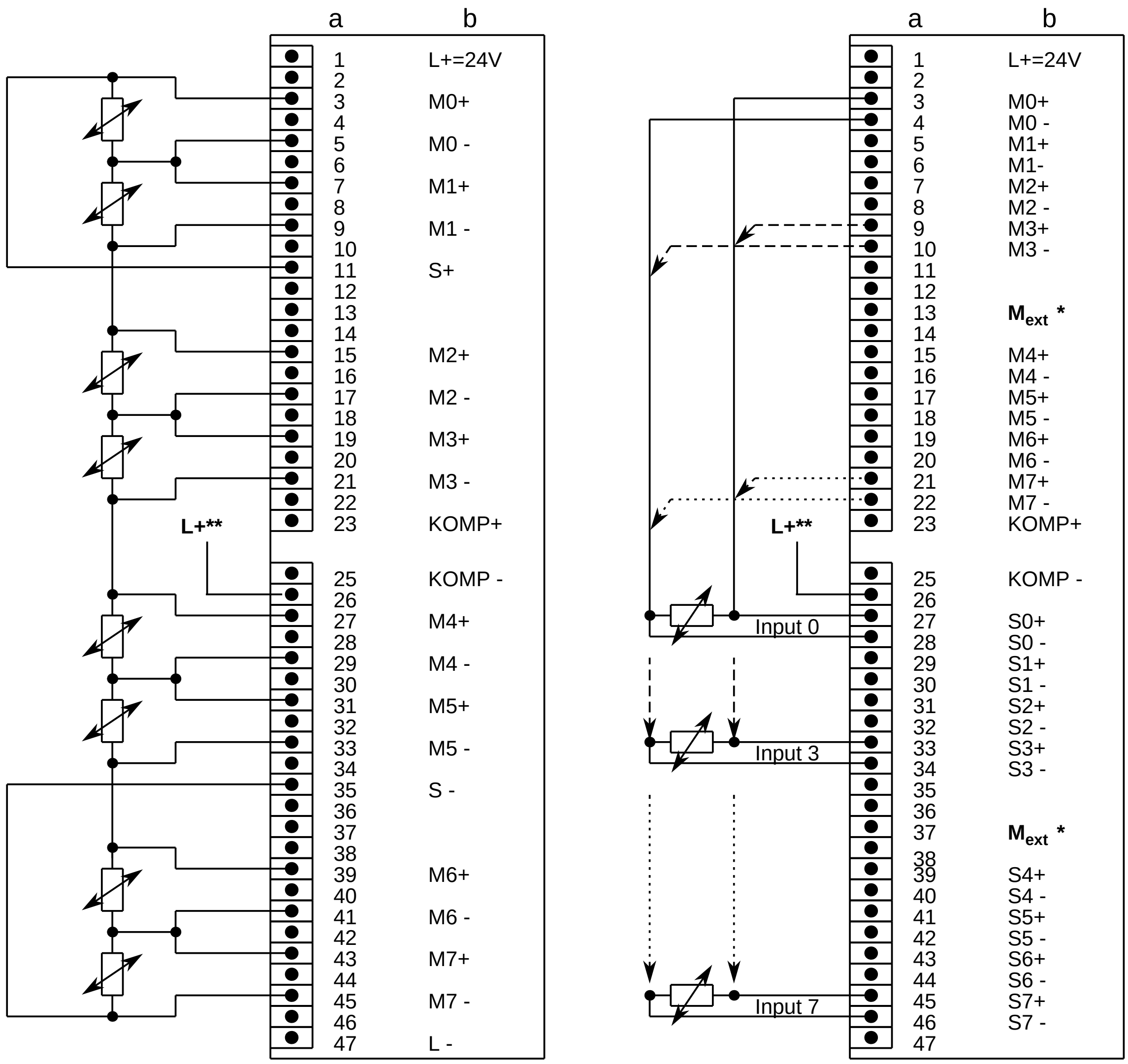


6ES5 465 -7LA11 and 6ES5 465 -7LA12:
A constant-current generator supplies the relevant resistance thermometer with a current of 2.5 mA over pins "S+" and "S -" Via a range card (6ES5 498-1AA11)
(see Figure 7-8).
The voltage on the PT 100 is picked off over inputs "M+" and "M -".
Other potential-free voltage sensors (500 mV voltage range) can be connected to those inputs (M+/ M -) not used for resistance thermometers.
If no PT 100 is connected over input channels 4 to 7, other voltages and currents can be measured over these channels using a 498-1AA21, -1AA31, -1AA41, -1AA51, -1AA61 or -1AA71 range card (see Figure 7-8 range card 2). In this case, you must short-circuit the current outputs (S+, S-) belonging to the relevant card with a jumper. Should you fail to do so, the error bit would be set for the relevant channel and the value "0" decoded. No short-circuiting jumper is needed when a 498-1AA41 or -1AA71 range card is used (see Figure 7-8 range card 4).
If you use a -1AA21, -1AA31 or -1AA61 range card for a channel group, no wirebreak signal may be enabled for that channel group.
A correction of 100 ohms (100 ohms = 0°C) must be made via the control program by specifying the appropriate upper and lower limiting values in FB 250 (HANEI) (Section 8.1.4).

Figure 7-8. Connecting Resistance Thermometers (PT 100s) to a 465 Analog Module

Pin Assignments on the Front Connector

The diagram below shows the pin assignments for resistance thermometers used on analog input modules.



6ES5 460-7LA11/12 6ES5 465-7LA11/12

a=Pin no.
b=Assignment

* Connect to the controller's central grounding point

** -7LA12 modules: Required only for disconnecting the test current when the wirebreak signal is not activated

Figure 7-9. Pin Assignments for Analog Input Modules

Connecting Transducers

When two-wire transducers are used, the inherently short-circuit-proof supply voltage is fed in over the analog input module's range card.
Four-wire transducers have a separate power supply.

The diagram below shows how to connect two-wire and four-wire transducers.

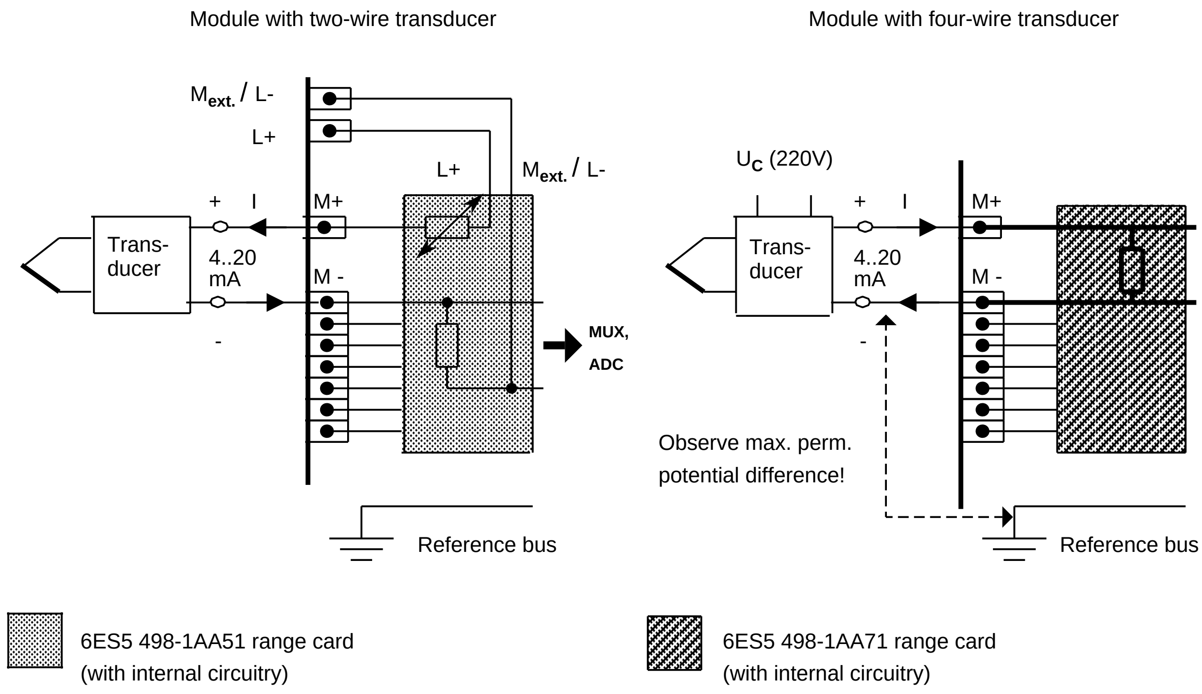
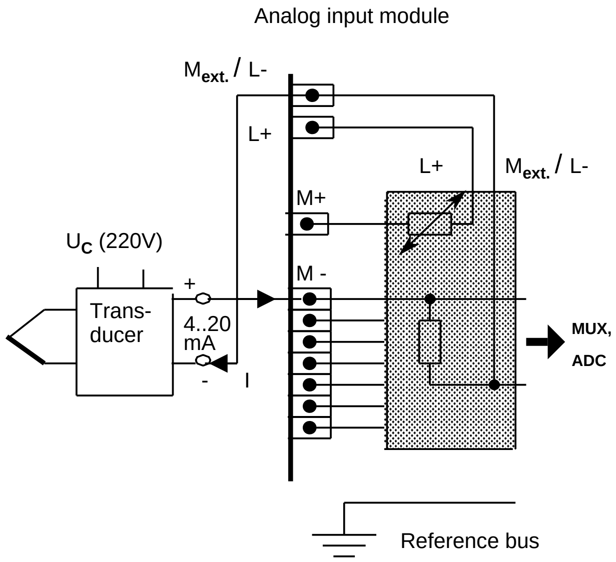


Figure 7-10. Connecting Transducers

The diagram below shows how to connect a four-wire transducer to a two-wire transducer range card (498-1AA51).



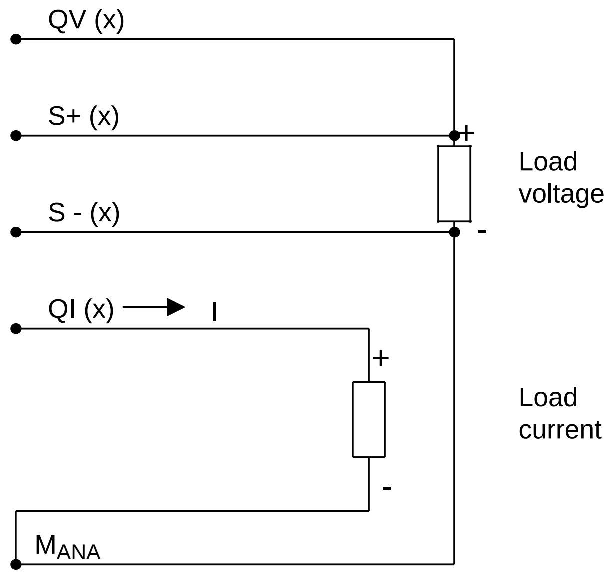
6ES5 498-1AA51 range card
(with internal circuitry)

Figure 7-11. Connecting Transducers (Four-Wire Transducer to a Two-Wire Range Card)

7.3.2 Connecting Loads to Analog Output Modules

When loads are connected to analog output modules, the voltage is measured directly across the load via high-resistance sensing lines (S+/ S -). The output voltage is then corrected so that the load voltage is not falsified by voltage drops on the lines.

In this way it is possible to compensate voltage drops of up to 3 V per line.
Figure 10-12 shows the design of this circuit.

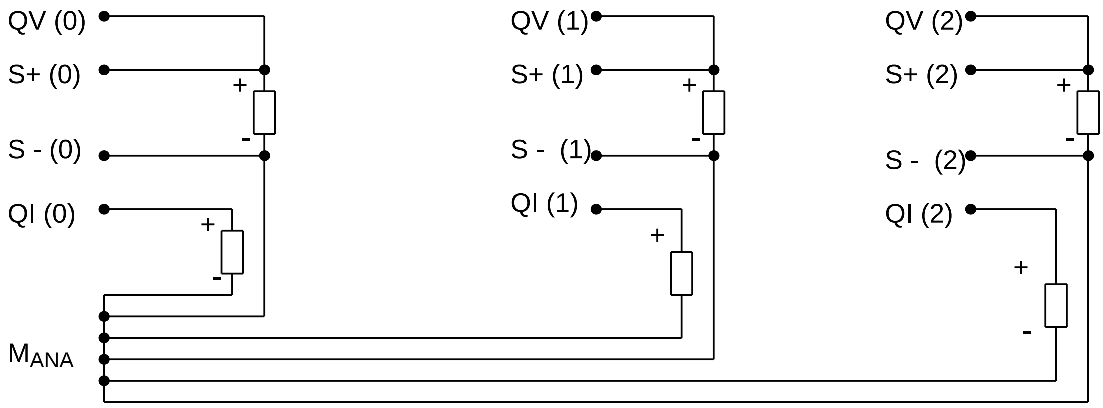


QV	(x)	=	Analog output voltage (QV=Output voltage)
QI	(x)	=	Analog output current (QI=Output current)
S+	(x)	=	Sensing line+ (S+=Sense line+)
S -	(x)	=	Sensing line- (S - =Sense line -)
M_{ANA}		=	Ground terminal of the analog component
	x	=	Channel no. (0 ... 7)

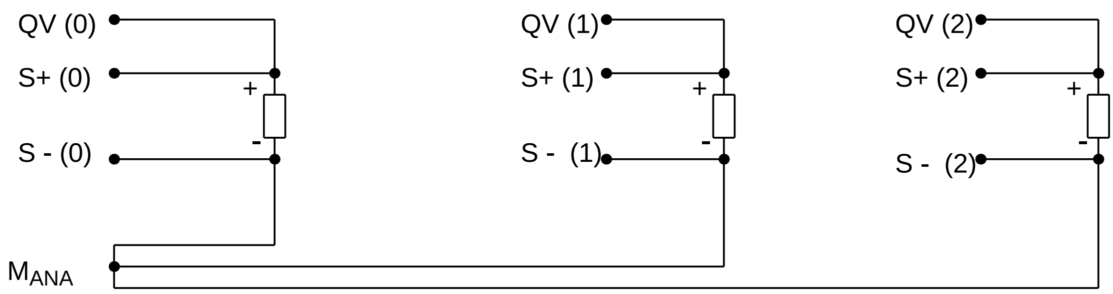
Figure 7-12. Connecting Loads

Connecting Loads to Current and Voltage Outputs

Figure 7-13 shows how to wire the analog output module.



6ES5 470-7LAxx
6ES5 470-7LCxx



6ES5 470-7LBxx

Figure 7-13. Connecting Loads to Current and Voltage Outputs

Note:

If voltage outputs are not used, or if only current outputs are connected, jumpers must be inserted in the front connector for the unused voltage outputs. To do this, connect QV (x) to S+(x) and S - (x) to M_{ANA}.
Unused current outputs remain open.

7.4 Putting Analog Modules into Operation

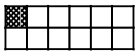
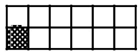
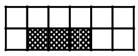
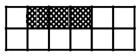
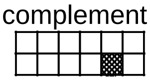
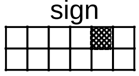
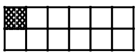
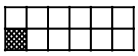
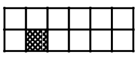
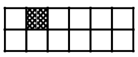
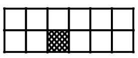
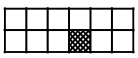
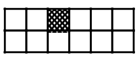
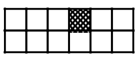
Voltage dividers or shunt resistors can be plugged into the input modules as cards (seeTable 7-6).
They match the process signals to the input level of the module.
These cards make it possible to set different measuring ranges.
The various output modules supply different voltage or current ranges.

Input Modules

You can set various functions on an input module by setting the Function Select switches on the rear of the module accordingly (see Tables 7-1 to 7-3).

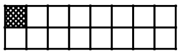
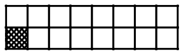
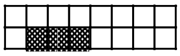
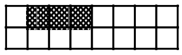
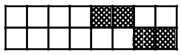
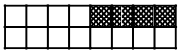
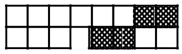
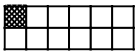
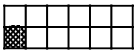
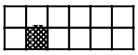
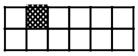
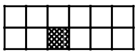
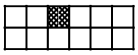
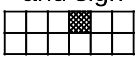
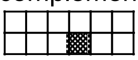
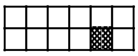
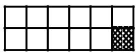
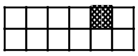
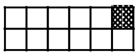
Note:
Selection of a function entails the setting of all switches.

Table 7-1. Setting Functions on the 6ES5 460-7LA11/12 Module

Function	Setting on Switch		Setting on Switch	
Reference junction compensation			Yes 	No 
Measuring range* (nominal value)			50mV 	500mV 
Analog value representation			Two's complement 	Abs. value and sign 
Sampling	Cyclic 	Selective 		
System frequency	50 Hz 	60 Hz 		
Wirebreak signal	Channel 0...3 	Channel 4...7 		
No wirebreak signal	Channel 0...3 	Channel 4...7 		

* Setting for PT 100: Measuring range 500 mV

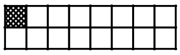
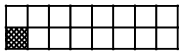
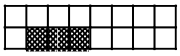
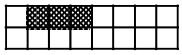
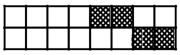
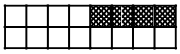
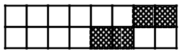
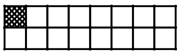
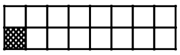
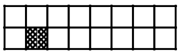
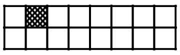
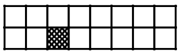
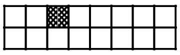
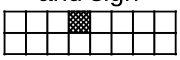
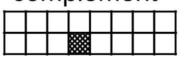
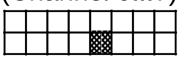
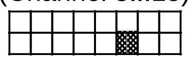
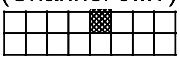
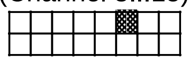
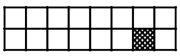
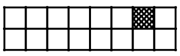
Table 7-2. Setting Functions on the 6ES5 465-7LA11 Module

Function	Setting on Switch		Setting on Switch	
Reference junction compensation			Yes 	No 
Measuring range* (nominal value)			50 mV 	500 mV 
Measure with resistance therm., 4-wire / 8-channel**				
Current or voltage measurment			8 Channels 	16 Channels 
Sampling	Cyclic 	Selective 		
System frequency	50 Hz 	60 Hz 		
Channel operation	8 channels 	16 channels 		
Analog value representation	Abs. value and sign 	Two's complement 		
Wirebreak signal for 8 channels (16 channels)	Channel 0...3 (channel 0...7) 	Channel 4...7 (channel 8...15) 		
No wirebreak signal	Channel 0...3 (channel 0...7) 	Channel 4...7 (channel 8...15) 		

* Setting for PT 100: Measuring range 500 mV

** Additional setting for PT 100: Reference junction compensation: No

Table 7-3. Setting Functions on the 6ES5 465-7LA12 Module

Function	Setting on Switch		Setting on Switch	
Reference junction compensation			Yes 	No 
Measuring range* (nominal value)			50mV 	500mV 
Measure with resistance therm., 4-wire/8-channel **				
Measure current or voltage			8 channels 	16 channels 
Sampling	Cyclic 	Selective 		
System freqency	50 Hz 	60 Hz 		
Channel operation	8 channels 	16 channels 		
Analog value representation	Abs. value and sign 	Two's complement 		
Wirebreak signal for 8 channels (16 channels)	Channel 0...3 (Channel 0...7) 	Channel 4...7 (Channel 8...15) 		
No wirebreak signal	Channel 0...3 (Channel 0...7) 	Channel 4...7 (Channel 8...15) 		
Monitor S + line to the PT 100 resistance therm. for wirebreak	...mV/...mA 	PT 100 		

* Setting for PT 100: Measuring range 500 mV

** Additional setting for PT 100: Reference junction compensation: No

Wirebreak Signal

If a 6ES5 498-1AA11 range card (through-connection card) is used, you can select the "Wirebreak signal" function to monitor the sensors connected to the inputs (see Tables 7-1 to 7-3). You can select wirebreak detection for 8 or 16 inputs for 16-channel operation or for 4/8 inputs for 8-channel operation.

The wirebreak signal is issued under the following conditions:
Before each input value is decoded, a constant current is applied briefly (1.6 ms) to the input terminals and the resulting voltage compared with a limiting value. If the sensor circuit or supply lead is interrupted, the voltage exceeds the limiting value and a wirebreak signal is generated (bit 1 is set in data byte 1; refer to Section 7.5.1). The ADC decodes the value "0".
When the signal at the input is measured with a digital voltmeter, the constant-current pulses may cause apparent fluctuations in the signal. When the input circuit that supplies the analog value has capacitive characteristics, the constant current falsifies the measured value.
Should these apparent fluctuations in the signal prove annoying, e.g. on startup, the test current can be deactivated on the 460-7LA12 and 465-7LA12 analog input modules by applying + 24 V to pin 26 in the front connector and 0 V to pin 47 (I-)/M EXT. In addition, mode selector I must be set to "No wirebreak signal". Only the evaluation of the error bit is suppressed on the 460-7LA11 and 465-7LA11.
A wirebreak signal serves a practical purpose only in conjunction with a 6ES5 498-1AA11 through connection card. It is not possible to detect a wirebreak on the 6ES5 498-1AA41, -1AA51 or -1AA71 range cards, as the measuring inputs are terminated with low-resistance shunts. On all other range cards, a wirebreak signal results in an undefined reaction.

Wirebreak Signal in Conjunction with Resistance Thermometers

An interruption in the supply leads to a resistance thermometer is reported as follows:

Table 7-4. Wirebreak Signal in Conjunction with Resistance Thermometers

Wirebreak on	Digitized Analog Value (460 / 465 Module)	Status of the Error Bit (460 Module)	Status of the Error Bit (465 Module)
M+	0/0	1	1
M -	0/0	1	1
PT 100 (resist.-type sensor)	0*/0	0*	1
S+	0/0	0	0/1**
S -	0/0	0	1

* On the 460 analog input module, the value "0" is also decoded for the unbroken PT 100 resistors and error bit F set to 0.
** This bit is "1" on the 465-7LA12 analog input module

When the "No wirebreak signal" function (mode selector I) is set on the -7LA11 module, a break in a lead to the resistance thermometer is flagged as an overflow. The overflow bit (OV=1) remains set for approximately 1.5 seconds, i.e. in cyclic mode, the overflow bit for all other measuring points is also set (OV=1), while in the case of selective scanning the overflow bit for the other measuring points is set to "1" only when the interval between two decoding operations is equal to or exceeds 1.5 seconds.
On the -7LA12 module, the overflow bit is set separately for each channel.

The S+ lines to the resistance thermometer can be monitored for a wirebreak on the 465 -7LA12 analog input module by setting switch 7 of mode selector I to "PT 100" (PT 100 constant power supply). The error bit is also set to flag a wirebreak in this line.
Unused channels can be used to measure voltages or currents when the current sourcing outputs (S+, S -) associated with the relevant measuring channel are short-circuited with a jumper. Without this jumper, the error bit would be set for this channel and the value "0" decoded.
The S+ lines are not monitored for wirebreak when mode selector II is in the "Current or voltage measurement" position. In this case, the error bit is not set when a wirebreak occurs. This switch setting should be selected when only voltages or currents are to be measured.

The following general rule applies: When the wirebreak signal is to be issued, the measuring circuit must have a low resistance (< 1 k).

Sampling

The analog values can be decoded in one of two ways.

Cyclic sampling:

The module's processor decodes all inputs. The amount of time that elapses before a measured value is updated depends on the number of input channels. The time required for decoding depends on the input value. When V_{inp} = OV, decoding takes 40 ms, when V_{inp} = nominal value, 60 ms.

Table 7-5. Time Required for Cyclic Sampling

Module Type	8 channels	16 channels*
Scan time**	480 ms	960 ms

***** For the 465-7LAxx module only

****** Nominal value applied to all inputs

The digitized measured values are stored in the circulating buffer under the channel address (the high-order byte under address n, the low-order byte under address n + 1), and can be read out from the buffer whenever required (see also Section 7.5.1).

Selective Sampling:

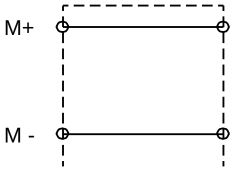
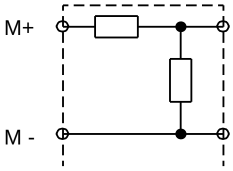
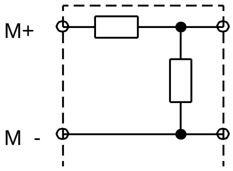
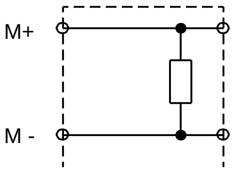
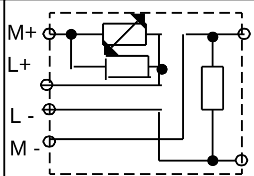
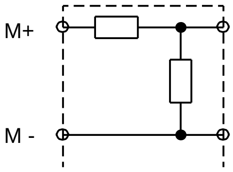
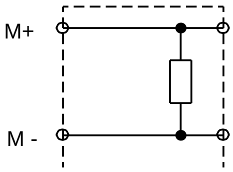
When this function is used, the initiative for decoding a measured value comes from the CPU. The module must be addressed once with a Write command (T PW) under the relevant channel address; the data itself is of no relevance. During decoding, an activity bit is set on the data bus (A = 1; see also Section 7.5.1). The valid digitized measured value can be read out from two bytes once the activity bit has been reset (A = 0, negative-going edge).
Repeated scanning of the activity bit loads both the bus and the CPU. This results in non periodic measured value acquisition when different measured values are involved, and is therefore not desirable for PID control tasks.
A better method is time-controlled program scanning, in which certain program sections, for instance FB 13, are automatically inserted into the program every 100 ms by a time-controlled block (OB 13), thus producing a constant time base while off loading the bus and the CPU.
The associated sample program is written as follows:

FB 13 STL	Description
NAME:SEL-SAMP	EXAMPLE FOR SELECTIVE SAMPLING
:L PW128	READ ANALOG VALUE
:T FW128	TRANSFER TO AUXILIARY FLAG
:A F 129.2	SCAN ACTIVITY BIT
:JC =END	IF = 1, JUMP TO END
:T FW10	IF = 0, TRANSFER MEASURED VAL. TO FW 10
:T PB128	INITIATE SAMPLING
END :	(1ST VAL. IS INVALID FOLLOWING RESTART)
:BE	

Equipping Modules with Range Cards

An analog input module can be fitted with either two or four range cards, depending on the number of channels. A range card determines the measuring range for four inputs. Voltage divider, shunt and through-connection cards are available for various measuring ranges (Table 7-6).

Table 7-6. Range Cards

Range card 6ES5 498-	Circuitry (4 times each)	Function 500 mV/mA/PT100	Function 50 mV
- 1AA11		± 500 mV; PT 100	± 50 mV
- 1AA21		± 1 V	± 100 mV *
- 1AA31		± 10 V	± 1 V *
- 1AA41		± 20 mA	± 2 mA *
- 1AA51**		+ 4 ... + 20 mA two-wire transducer	
- 1AA61		± 5 V	± 500 mV *
- 1AA71		+ 4 ... + 20 mA four-wire transducer	

* Possible measuring range for "50 mV" setting, but with higher incidence of error

** When a -1AA51 range card is used, there is no longer any galvanic isolation between analog inputs and L +!

Note:
Unused inputs must be terminated with a voltage divider or shunt card. When using a 1AA11 through-connection card, you must insert jumpers in the front connector.

7.5 Representation of Digital Input / Output Values

7.5.1 Digital Input Value Representation

After an analog signal is converted, the digital result is stored in the module's RAM. Figure 7-14 explains the individual bits in the two bytes.

	High-Order Byte								Low-Order Byte							
Byte no.	n								n+ 1							
Bit no.	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	A	F	OV

Binary measured value (bits 15 to 3)

Figure 7-14. Representation of an Analog Value in Digital Form

Bits 0 to 2 are irrelevant for the measured value. They provide information on the measured value representation. Table 7-7. describes these bits in detail.

Table7-7. Meaning of Bits 0 to 2 for Analog Input Modules

Bit	Meaning	Signal State	Meaning of the Signal State
OV	Overflow bit	1	Range exceeded*
F	Fault bit	1	Wire break
A	Activity bit	0	Cyclic scan or ”Not active” (for single scan)
		1	Coding procedure for single scan not yet terminated

* Module 7LA11: The overflow bit is set on all channels when an overflow occurs at a measuring point.
Module 7LA12: An overflow at one measuring point has no effect on the overflow bits of the other channels, i.e. the values on the other channels are correct and may be evaluated.

The way in which the analog value is represented depends on the type of module (Tables 7-8 to 7-11).

Table 7-8. Representation as Two's Complement (Nominal Input Range ± 50 mV), Channel Type 6: Bipolar Fixed-Point Value

Input voltage in mV	Units	High-Order Byte								Low-Order Byte								
		2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	A	F	OV	
100.0	4095+OV	0	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	1	Overflow
99.976	4095	0	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	Over-range
50.024	2049	0	1	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	
50.0	2048	0	1	0	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	Nominal range
49.976	2047	0	0	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	
25.0	1024	0	0	1	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	
24.976	1023	0	0	0	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	
0.024	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	
- 0.024	- 1	1	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	
- 24.976	- 1023	1	1	1	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	
- 25.0	- 1024	1	1	1	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	
- 49.976	- 2047	1	1	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	
- 50.0	- 2048	1	1	0	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	
- 50.024	- 2049	1	0	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	Over-range
- 99.976	- 4095	1	0	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	
-100.0	-4095+OV	1	0	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	1	Overflow

Note:

The rated input ranges ± 500mV and ± 20mA are represented in the same form as the ± 50 mV nominal input range.

Table 7-9. Digital Representation of an Analog Value as Absolute Value and Sign (Nominal Input Range± 50 mV), Channel Type 5: Bipolar Absolute Value

Input Voltage in mV	Units	High-Order Byte								Low-Order Byte								
		S	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	A	F	OV	
100.0	4095+ov	0	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	1	Overflow
99.976	4095	0	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	Over-range
50.024	2049	0	1	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	
50.0	2048	0	1	0	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	Nominal range
49.976	2047	0	0	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	
25.0	1024	0	0	1	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	
24.976	1023	0	0	0	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	
0.024	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	
0.0	+ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	
0.0	- 0	1	0	0	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	
- 0.024	- 1	1	0	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	
- 24.976	- 1023	1	0	0	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	
- 25.0	- 1024	1	0	1	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	
- 49.976	- 2047	1	0	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	
- 50.0	- 2048	1	1	0	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	
- 50.024	- 2049	1	1	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	Over-range
- 99.976	- 4095	1	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	
- 100.0	-4095+ov	1	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	1	Overflow

Note

Bit 7 in the high-order byte is the sign (S).
If S is 0, the value is positive. If S is 1, the value is negative.

Table 7-10. Representation for Current Measuring Ranges from 4...20 mA, Channel Type 3: Absolute Value Representation

I_I in mA	Units	V_I in mV	High-Order Byte								Low-Order Byte								
			S	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	A	F	OV	
32.796	4095+ov	1024	0	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0	1	Overflow
31.992	4095	999.76	0	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0	0	Over-range (short circuit of two-wire trans-ducer)
24.0	3072	750.0	0	1	1	0	0	0	0	0	0	0	0	0	0	0/1	0	0	
23.992	3071	749.76	0	1	0	1	1	1	1	1	1	1	1	1	1	0/1	0	0	
20.008	2561	625.24	0	1	0	1	0	0	0	0	0	0	0	0	1	0/1	0	0	
20.0	2560	625.0	0	1	0	1	0	0	0	0	0	0	0	0	0	0/1	0	0	Nominal range
16.0	2048	500.0	0	1	0	0	0	0	0	0	0	0	0	0	0	0/1	0	0	
4.0	512	125.0	0	0	0	1	0	0	0	0	0	0	0	0	0	0/1	0	0	
3.992	511	124.76	0	0	0	0	1	1	1	1	1	1	1	1	1	0/1	0	0	Below nominal range limit
3.0	384	93.75	0	0	0	0	1	1	0	0	0	0	0	0	0	0/1	0	0	
2.992	383	93.5	0	0	0	0	1	0	1	1	1	1	1	1	1	0/1	0	0	
0.0	0	0,0	0	0	0	0	0	0	0	0	0	0	0	0	0	0/1	0	0	Wire break

Set the measuring range of the module to 500 mV and plug in a 6ES5 498-1AA 71 range card.
The measuring range 4...20 mA is resolved into 2048 units from 512 to 2560. For representation in the range 0 ... 2048, 512 units must be subtracted at the software level.

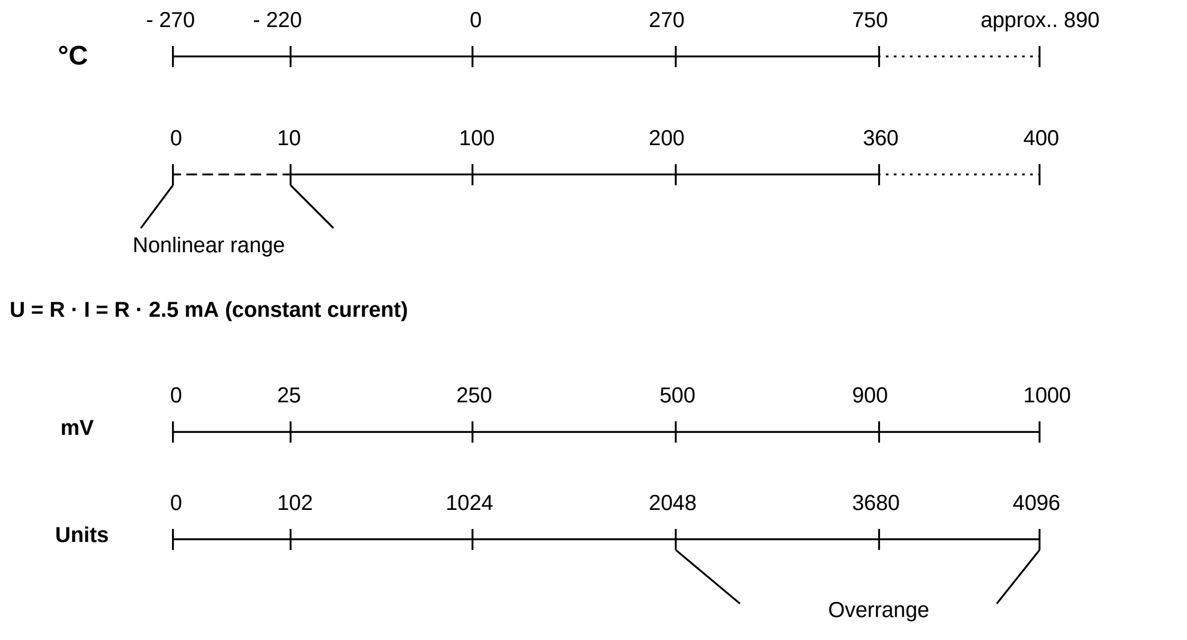
Note

The 31.25 shunt resistor integrated in the 498-1AA71 suppresses the wire break signal (the F bit is not set). You can thus detect a wire break only by comparing the measured value with a lower limiting value in the user program. A measured value lower than, for example, 1 mA (=128 units) would then be interpreted as a wire break.

Table 7-11. Representation for Resistance-Type Sensors, Channel Type 4: Unipolar Representation

Sensor resistance [ ]	Units	High-Order Byte								Low-Order Byte								
		S	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	A	F	OV	
400.0	4095	0	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	1	Overflow
399.90	4095	0	1	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	Over-range
200.098	2049	0	1	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	
200.0	2048	0	1	0	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	Nominal range
199.90	2047	0	0	1	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	
100.0	1024	0	0	1	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	
99.9	1023	0	0	0	1	1	1	1	1	1	1	1	1	1	0/1	0/1	0	
0.098	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0/1	0/1	0	
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0/1	0/1	0	

For the PT 100, the resolution amounts to approximately 1 / 3° C. Ten units correspond to approximately 1 .
You may use the assignments shown in Figure 7-15 for PT 100 resistance-type sensors.



Resolution: 10 units = 1
270 °C : 1024 units = 0.3 °C / unit

Figure 7-15. PT 100 on SIMATIC Analog Input Modules

7.5.2 Digital Representation of an Analog Value

The CPU uses two bytes to represent the value for an output channel.
Figure 7-16 explains the individual bits:

	High-Order Byte								Low-Order Byte							
Byte No.	n								n+ 1							
Bit No.	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	x	x	x	x

Binary signal (bits 15 to 4)

x represents an irrelevant bit

Figure 7-16. Representation of an Analog Output Signal in Digital Form

Table 7-12 lists the output voltages or currents of the individual 470-... analog output modules.

Table 7-12. Analog Output Signals

Resolu-tion in units	Output voltages and currents of the modules ** -7LA/B11 in V	-7LA11 in mA	-7LC11 in V	7LC11 in mA	High-Order Byte 2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	Low-Order Byte* 2^3	2^2	2^1	2^0	
+1280	+12.5	25.0	6.0	24.0	0	1	0	1	0	0	0	0	0	0	0	0	Over-range
+1025	+10.0098	20.0195	5.004	20.016	0	1	0	0	0	0	0	0	0	0	0	1	
+1024	+10.0	20.0	5.0	20.0	0	1	0	0	0	0	0	0	0	0	0	0	Nomi-nal range
+1023	+9.99	19.98	4.995	19.98	0	0	1	1	1	1	1	1	1	1	1	1	
+512	+5.0	10.0	3.0	12.0	0	0	1	0	0	0	0	0	0	0	0	0	
+256	+2.5	5.0	2.0	8.0	0	0	0	1	0	0	0	0	0	0	0	0	
+128	+1.25	2.5	1.5	6.0	0	0	0	0	1	0	0	0	0	0	0	0	
+64	+0.625	1.25	1.25	5.0	0	0	0	0	0	1	0	0	0	0	0	0	
+1	+0.0098	0.0195	1.004	4.016	0	0	0	0	0	0	0	0	0	0	0	1	
0	+0.0	0.0	1.0	4.0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	- 0.0098	0.0	0.996	3.984	1	1	1	1	1	1	1	1	1	1	1	1	
-64	0.625	0.0	0.75	3.0	1	1	1	1	1	1	0	0	0	0	0	0	
-128	- 1.25	0.0	0.5	2.0	1	1	1	1	1	0	0	0	0	0	0	0	
-256	- 2.5	0.0	0.0	0.0	1	1	1	1	0	0	0	0	0	0	0	0	
-512	- 5.0	0.0	- 1.0	0.0	1	1	1	0	0	0	0	0	0	0	0	0	
-1024	- 10.0	0.0	- 3.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	
-1025	-10.0098	0.0	- 3.004	0.0	1	0	1	1	1	1	1	1	1	1	1	1	Over-range
-1280	- 12.5	0.0	- 5.0	0.0	1	0	1	1	0	0	0	0	0	0	0	0	

* Irrelevant bits are not included

** In addition to the 7 to 11 modules, compatible 7 to 12 modules are also available.

Note:

For the two's complement, bit 2^{11} indicates the sign
(0 equals a positive value, 1 a negative value).

7.6 Example of Analog Value Processing

Problem Definition:

A closed container contains a liquid. It should be possible to read the current liquid level on an indicating instrument whenever required. A flag is to be set when the liquid level reaches a specified limiting value.

- A 0 - 20 mA transducer transmits the liquid level signal (between 0 and 10 m) to a 6ES5 460-7LA11 (460 AI) analog input module.
- The analog input module converts the analog current values into digital units (0 - 2048 units), which can be postprocessed by the S5-115H's application program.
- The application program compares the values with a limiting value (max. permissible liquid level), sets a flag if necessary, and sends these values to a 6ES5 470-7LB11 (AO 470) analog output module.
- The analog output module reconverts the values into voltages (0 - 10 V). In response to these voltages, the needle on the analog display swings proportionally to the liquid level.

Figure 7-17 shows the system configuration.

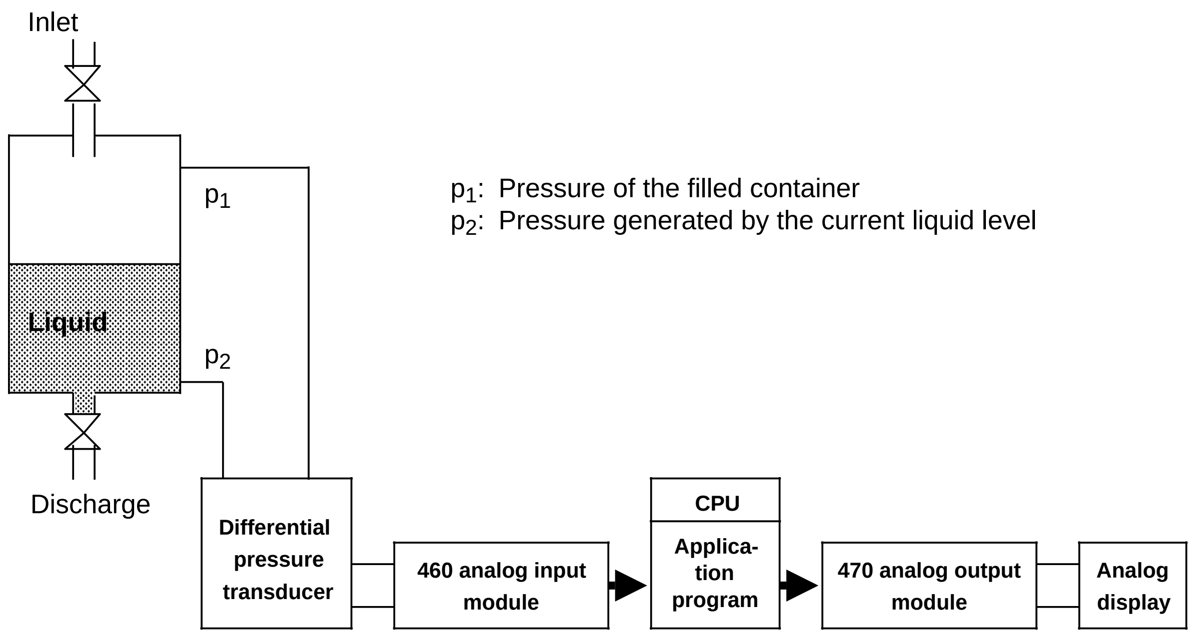


Figure 7-17. Example of Analog Value Processing

Startup Procedures

460 Analog Input Module:

- Connect the transducer directly to the front connector on the AI 460 (Terminals: MO +, MO -). The transducer supplies values between 0 and 20 mA, 0 mA corresponding to a liquid level of 0.00 meters and 20 mA to the maximum liquid level, which is 10.00 meters.
- Plug a ± 20 mA range card (6ES5 498-1AA41) into the AI 460.
  A digital value between 0 and 2048 units, which is subsequently processed by the application program, is then present at the output of the analog input modules's internal ADC (Figure 7-18).

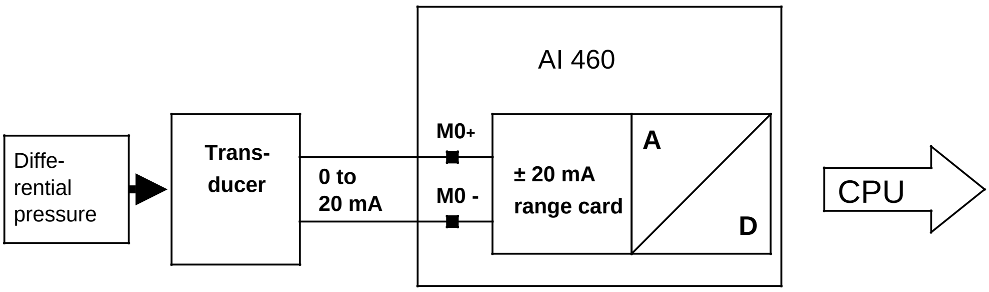


Figure 7-18. Function of the 460 Analog Input Module

- Set the mode selectors at the rear of the module as follows (Figure 7-19):

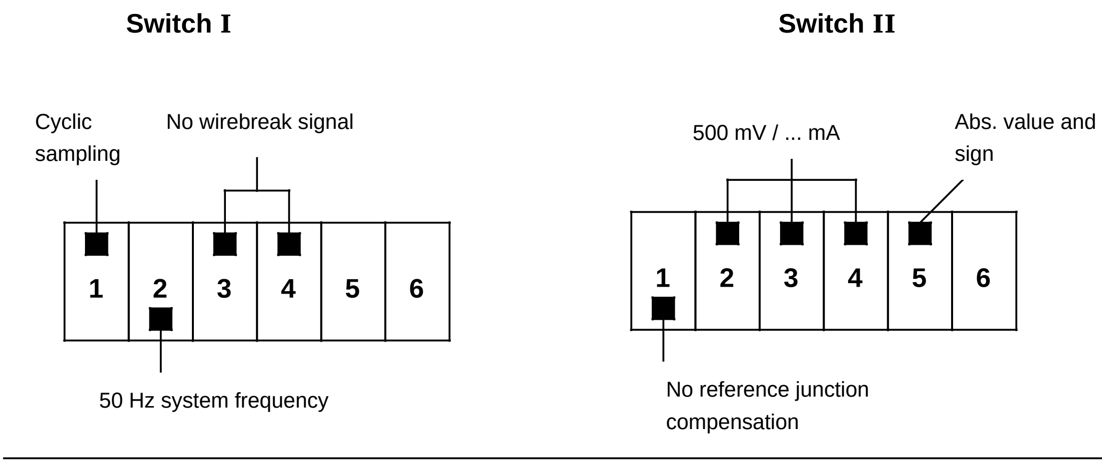


Figure 7-19. Setting Mode Selectors I and II

470 Analog Output Module:

- Connect the indicating instrument directly via the module's front connector (pins: QV0, S + 0, S - 0, M_{ANA}).
  The analog output modules outputs a voltage between 0 and 10 V to the indicating instrument, thus making it possible to read the liquid level as an analog value (Figure 7-20).

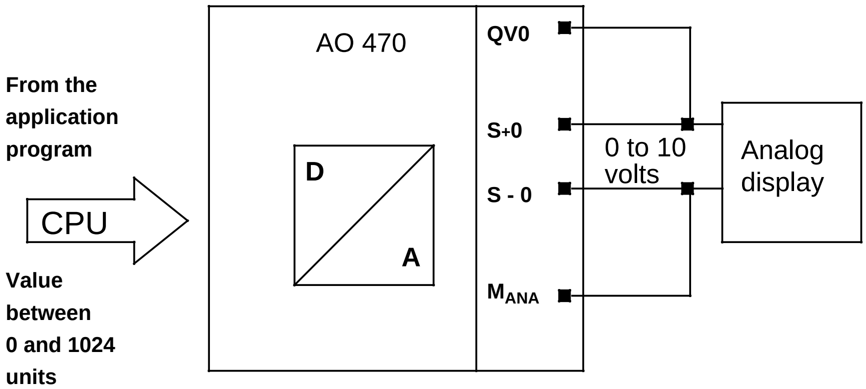


Figure 7-20. Function of the 470 Analog Output Module

Program Structure

- Call and initialize "Read analog value" function block FB 250 (for conversion to a range of from 0 to 1000 cm [XA parameter]).
- Generate the limiting value (PB 9).
  A flag (F 12.6) is set when the liquid level exceeds 900 cm.
- Call and initialize "Output analog value" function block FB 251 (for conversion of a value in the range from 0 to 1000 cm [XE parameter] into a value between 0 and 1024 units for the AO 470).

Integral function blocks FB 250 and FB 251 are discussed in detail in Section 8 under the heading "Integral Blocks".

PB 1 STL	Description
:JU FB 250	
NAME :RLG:AE	
BG :KF +128	Module starting addr: 128 (when slot addressing is fixed: slot 0)
KNKT :KY 0,4	Channel no.: 0; unipolar representation: 4
OGR :KF +1000	Physical measuring range:
UGR :KF +0	0<XA<1000cm
EINZ :F 12.0	Relevant only for selective sampling (Set in example for: cyclic sampling)
XA :FW 10	In FW 10: XA value 0<XA<1000cm
FB :F 12.1	Relevant only when set for wirebreak signal
BU :F 12.2	If level > 1000cm, BU = 1.
TBIT :F 12.3	Relevant only for selective sampling.

PB 1 STL (cont.)	Description
:JU PB 9	Generate limiting value
:JU FB 251	Output analog value
NAME :RLG:AA	
XE :FW 10	XA (FB 250) = XE (FB 251)
BG :KF +160	Module starting addr.; 160 (fixed slot addressing: slot 1)
KNKT :KY 0,0	Channel no.: 0; unipolar representation: 0
OGR :KF +1000	Physical measuring range:
UGR :KF +0	0<XA<1000cm
FEH :F 12.4	When UGR = OGR, FEH = 1
BU :F 12.5	When XA<UGR or XA>OGR, BU = 1.
:BE	

PB 9 STL	Description
:L KF +900	Max. val. for liquid level
:L FW 10	Measured value
:<=F	Measured value > 900 ?
:=F 12.6	If yes, F 12.6 = initiate reaction in same program cycle.
:BE	

8 Integral Blocks

Figures

Tables

8 Integral Blocks

Some standard function and organization blocks are integrated in the operating system of the central processing units. Since these blocks are programmed in machine language, they are processed at a high speed. They do not take up any user memory space.
Integral blocks, like all other blocks, are called in the control program.

Table 8-1. Overview of Integral Blocks

Block			Call Length*	Execution Time**	Function
Type	No.	Name			
FB	240	COD : B4	5	< 1.7	4-tetrad BCD code converter
FB	241	COD : 16	6	< 2.1	16-bit fixed-point converter
FB	242	MUL : 16	7	< 2.0	16-bit binary multiplier
FB	243	DIV : 16	10	< 3.4	16-bit binary divider
FB	244	SEND ***	10	16 to 160 ms	Send data
FB	245	RECEIVE ***	10	16 to 160 ms	Receive data
FB	246	FETCH	10	2.3	Fetch data
FB	247	CONTROL	6	0.6	Monitor job processing
FB	248	RESET	5	6	Delete job request
FB	249	SYNCHRON	5	7 ms to 10 s	Initialize interface
FB	250	RLG : AE	11	4	Read analog value
FB	251	RLG : AA	9	7	Output analog value
FB	252	RLG : HAE	14	4	Read redundant analog values
FB	253	DEPASS	5	7.5 ms to 10 s	Depassivate CP
OB	31			1.1	Restart scan time
OB	251			2.6	PID control algorithm

* In words
** In milliseconds
*** The execution time depends on the size of the data block to be transferred (see section 8.1.3, "Frame Size").

8.1 Integral Function Blocks

Integral function blocks can be devided into various groups according to function.

- Conversion blocks
- Arithmetic blocks
- Data handling blocks
- Analog value matching blocks
- Organization blocks

Note:
The integral standard function blocks can be interrupted after 7 ms at the latest by:
- Process interrupts and timed interrupts
- Operator entry at the programmer
- SINEC processing over the serial interface

8.1.1 Conversion Blocks

Use blocks FB 240 and FB 241 to convert numbers in BCD code to fixed-point binary numbers and vice versa.

Code Converter: B4 - FB 240 -

Use function block FB 240 to convert a number in BCD code (four tetrads) with sign to a fixed-point binary number (16 bits).
A two-tetrad number must be changed to a four-tetrad number before conversion by padding it with “0“.

Call and Parameter Assignments

Parameter	Type	Data Type	Assignment	Meaning	STL
BCD	I	W	-9999...+9999	BCD number	:JU FB 240 Name :COD : B4 BCD : SBCD : BINARY :
SBCD	I	Bi	”1” for ”-” ”0” for ”+”	Sign of the BCD number	
BINARY	Q	W	16 Bits ”0” or ”1”	Binary number	

Code Converter: 16 - FB 241 -

Use function block FB 241 to convert a fixed-point binary number (16 bits) to a number in BCD code with additional consideration of the sign. An eight-bit binary number must be transferred to a 16-bit word before conversion.

Call and Parameter Assignments

Parameter	Type	Data Type	Assignment	Meaning	STL
BINARY	I	W	-32768 to+32767	Binary number	: JU FB 241 Name : COD : 16 BINARY: SBCD : BCD2 : BCD1 :
SBCD	Q	Bi	”1” for ”-” ”0” for ”+”	Sign of the BCD number	
BCD2	Q	By	2 tetrads	BCD number tetrads 4 and 5	
BCD1	Q	W	4 tetrads	BCD number tetrads 0 to 3	

8.1.2 Arithmetic Blocks

Use function blocks FB 242 and FB 243 to multiply and divide.

Multiplier : 16 - FB 242 -

Use function block FB 242 to multiply one fixed-point binary number (16 bits) by another. The product is represented by two fixed-point binary numbers (16 bits each). The result is also scanned for zero. An eight-bit number must be transferred to a 16-bit word prior to multiplication.

Call and Parameter Assignments

Parameter	Type	Data Type	Assignment	Meaning	STL
Z1	I	W	-32768 to+32767	Multiplier	: JU FB 242 Name : MUL : 16 Z1 : Z2 : Z3=0 : Z32 : Z31 :
Z2	I	W	-32768 to+32767	Multiplicand	
Z3=0	Q	Bi	”1”, if the product is zero	Scan for zero	
Z32	Q	W	16 bits	Product, high-order word	
Z31	Q	W	16 bits	Product, low-order word	

Divider: 16 - FB 243 -

Use function block FB 243 to divide one fixed-point binary number (16 bits) by another. The result (quotient and remainder) is represented by two fixed-point binary numbers (16 bits each). The divisor and the result are also scanned for zero. An eight-bit number must be transferred to a 16-bit word prior to division.

Call and Parameter Assignment

Parameter	Type	Data Type	Contents	Meaning	STL
Z1	I	W	-32768 to+32767	Dividend	: JU FB 243
Z2	I	W	-32768 to+32767	Divisor	Name : DIV : 16
OV	Q	Bi	"1", if overflow	Overflow indicator	Z1 :
FEH	Q	Bi	"1" for division by zero		Z2 :
Z3=0	Q	Bi	"0": quotient is zero	Scan for zero	OV :
Z4=0	Q	Bi	"0": remainder is zero	Scan for zero	FEH :
Z3	Q	W	16 bits	Quotient	Z3=0 :
Z4	Q	W	16 bits	Remainder	Z4=0 :
					Z3 :
					Z4 :

8.1.3 Data Handling Blocks

Function blocks FB 244 to FB 249 and 253 make it possible to use communications processors and intelligent I / O modules. These “data handling blocks“ control data exchange between such modules and the CPU.

Data handling blocks offer the following advantages:

- They take up no space in the user memory.
- Transfer from diskette is not necessary.
- No flag*, timer, or counter areas are needed.

Parameters

Data handling blocks use the parameters listed in Table 8-2.

Table 8-2. List of Data Handling Block Parameters

Name	Meaning
SSNR :	Interface number (page number)
A-NR :	Job number
ANZW :	Job status word (doubleword)
QTYP/ZTYP [1] :	Type of data source or data destination
DBNR [1] :	Data block number
QANF/ZANF [1] :	Relative start address within a type
QLAE/ZLAE [1] :	Length of source or destination data
PAFE [2] :	Parameter assignment error byte
BLGR :	Frame size

1 If these parameters are not needed for a call (e.g., for the ALL function), you can skip them when initializing the block by pressing the <CR> key.

2 PAFE must be directly initialized.

Parameter Description

The formal operands that you must supply when using data handling blocks are explained below.

SSNR - Interface Number

The SSNR parameter specifies the logical number of the interface (page) to which a particular job refers.

Parameter		Assignment		
Type	Format			
Data (byte)	KY	KY=	x,y	
			x=0	Direct initialization
			y=0 to 255	Interface number (page address)
			x 0	Indirect initialization
			y=0 to 255	Data word number. The SSNR, A-NR, and ANZW parameters are stored beginning with the next data word in the current DB.

A-NR - Job Number

The jobs for an interface are characterized by this number.

Parameter		Assignment		
Type	Format			
Data (byte)	KY	KY=	x,y	
				Parameter x is ignored
				"y" represents the job number.
			y=0	ALL function [1]
			y=1 to 223	Direct function Number of the job to be executed. [2]

1 The "ALL" function is not permitted for the FETCH block.

2 Refer to the SINEC L1 Local Area Network manual for an explanation of the individual job numbers.

ANZW - Job Status Word

Use this parameter to specify the address of a doubleword (DW* n / DW n+1 or FW n and FW n+2) that indicates the processing status of a particular job.

Parameter		Assignment	
Type	Format		
Address (word)	W	x = 0 to 255	Address of the job status word for direct initialization Permissible areas : DW, FW

QTYP / ZTYP - Type of Data Source or Data Destination

Assign these parameters ASCII characters that specify the type of data source (for SEND) or data destination (for RECEIVE or FETCH).

Parameter		Assignment	
Type	Format		
Data (character)	KC	KC =	DB, QB, IB, FY, TB, CB, AS Direct initialization: The data source (or data destination) is specified directly in the QTYP / ZTYP, DBNR, QANF / ZANF, QLAE, ZLAE parameters.
		KC = NN	No parameter assignment: Data source (or data destination) specifications are located in the job request block on the CP.
		KC = RW/XX	Indirect initialization: Specifications for data source (or data destination) are located in a data area specified by the DBNR and QANF / ZANF parameters.

* DW refers to the current data block

DBNR - Data Block Number

If DB, RW, or XX were assigned to the parameters QTYP/ZTYP, the DBNR parameter must specify the number of the required data block.

Parameter Type	Parameter Format	Assignment
Data (byte)	KY	KY = 0, y y =2 to 255 Number of the data block containing the data

QANF / ZANF - Start Address of the Source or Destination Data Block

When initialization is indirect (QTYP / ZTPP=RW or XX), specify the number of the DW at which the parameter block begins.
When initialization is direct, QANF / ZANF refers to the specified area.

Parameter Type	Parameter Format	Assignment
Data (fixed-point no.)	KF	Permissible range (Table 8-3)

QLAE / ZLAE - Length of the Source or Destination Data Block

When initialization is direct, the source or destination type specification is understood to be the number of either bytes or words.

Parameter Type	Parameter Format	Assignment
Data (constant)	KF	Permissible range (Table 8-3) - 1 : The "joker length" -1 means the following: • For RECEIVE: As much data as the transmitter sends or as much as area limitations permit. • for SEND: Data is transmitted until a particular area boundary is reached.

Summary:

Table 8-3. QTYP / ZTYP Parameters

	QTYP / ZTYP Description	DBNR Description Permissible Values	QANF / ZANF Description Permissible Values	QLAE / ZLAE Description Permissible Values
NN	No source / destination parameters in the block. Parameters have to be in the CP.	Irrelevant	Irrelevant	Irrelevant
XX	Indirect addressing: parameters are stored in the data block (specified with DBNR and QANF).	DB in which the source / destination parameters are stored 2 to 255	DW number with which the parameters begin 0 to 2047	Irrelevant
RW	Indirect addressing without data exchange. Source or destination parameters are stored in a DB.[1]	DB in which the source / destination parameters are stored 2 to 255	DW number with which the parameters begin 0 to 2047	Irrelevant
DB	Source / destination data from / to the data block in main memory	DB from which source data are taken or to which destination data are transferred 2 to 255	DW number beginning with which the data is to be read or written 0 to 2047	Length of the source / destination data in words 1 to 2048
FY	Source / destination data from / to the flag area	Irrelevant	Flag byte number beginning with which the data is to be read or written 0 to 255	Length of the source / destination data in bytes 1 to 255
PB	Source / destination data from / to the process output image (PIQ)	Irrelevant	Output byte number beginning with which the data is to be read or written 0 to 127	Length of the source / destination data in bytes 1 to 128
IB	Source / destination data from / to the process input image (PII)	Irrelevant	Input byte number beginning with which the data is to be read or written 0 to 127	Length of the source / destination data in bytes 1 to 128
CB	Source / destination data from / to counter locations	Irrelevant	Number of the counter location beginning with which the data is to be read or written 0 to 127	Length of the source or destination data in words (counter location = 1 word) 1 to 128
TB	Source / destination data from / to timer locations	Irrelevant	Number of the timer location beginning with which the data is to be read or written 0 to 127	Length of the source or destination data in words (timer location = 1 word) 1 to 128
AS	Source / destination data from / to memory locations absolute-addressed	Irrelevant	Absolute start address beginning with which the data is to be read or written 12288 to 61439	Length of the source / destination data in bytes 1 to 32767

1 Assigning RW to ZTYP is not permitted for the RECEIVE block

"BLGR" - Frame Size

The BLGR parameter specifies the maximum size of the data frame that can be exchanged between a PLC and a CP during one pass of the data handling block (applies only to SYNCHRON and DEPASS).

Parameter Type	Parameter Format	Assignment			
		KY = 0,y	Frame Size	Exec. Time (SEND and RECEIVE)	
				Solo operation	Redundant operation
Data (byte)	KY	y =0	16 bytes *	8 ms	12 ms
		y =1	16 bytes	8 ms	12 ms
		y =2	32 bytes	11 ms	17 ms
		y =3	64 bytes	16 ms	27 ms
		y =4	128 bytes	28 ms	45 ms
		y =5	256 bytes	50 ms	85 ms
		y =6	512 bytes	95 ms	160 ms
		y =7 to 254	same as for y=0		

* The block uses the default parameter. (On the S5-115H, the frame size is set at 16 bytes.)

"PAFE" - Parameter Assignment Error Byte

For PAFE, specify a byte that is set if the block detects a parameter assignment error. The following can be parameter assignment errors:

- No such interface
- The QTYP / ZTYP, QANF / ZANF, or QLAE / ZLAE parameters were assigned incorrectly.

Parameter Type	Parameter Format	Assignment
Address (byte)	BY	QB 0 to 127 FY 0 to 255

Direct and Indirect Initialization

The high-order byte of the SSNR parameter is the selection criterion for direct or indirect initialization:

- High-order byte of SSNR = 0 — means direct initialization.
  SSNR, A-NR, ANZW, or BLGR are specified directly in the block.
- High-order byte of SSNR 0 — means indirect initialization.
  SSNR, A-NR, ANZW, or BLGR are stored in the current data block, beginning with the data word specified in the low-order byte of the SSNR parameter.

SSNR and A-NR have the same data format (KY) in both cases. Representation formats are different for the job status word. While the address of the job status word is specified directly when initialization is direct (e.g., FW 100), an additional specification concerning the area in which the job status word is located must be made when initialization is indirect. This area is specified in ASCII code in the data word preceding the job status word.

FW means that the job status word is located in the flag area, DB that it is located in a data block.

In the next data word of the parameter area in the DB is the ANZW address in KY data format and, if ANZW is located in a data block, the block number (in the first byte of the KY format).

Examples:

Direct Initialization of SSNR, A-NR, and ANZW

- Job Status Word in the Flag Area

Parameter Assignments		Explanation
JU	FB 245	
NAME :	RECEIVE	
SSNR :	KY 0,3	The interface number is 3.
A-NR :	KY 0,100	The job number is 100.
ANZW :	FW 240	Flag words FW 240 and FW 242 are used as job status word.

- Job Status Word in a Data Block

Parameter Assignments		Explanation
C	DB 47	DB 47 is activated.
JU	FB 247	
NAME :	CONTROL	The interface number is 3.
SSNR :	KY 0,3	The job number is 100.
A-NR :	KY 0,100	Data words DW 40 and DW 41 in DB 47 are used as
ANZW :	DW 40	job status word.

Indirect Initialization of SSNR, A-NR, and ANZW

- Job Status Word as Flags

Parameter Assignments		Explanation
C	DB 44	Open DB 44
JU	FB 244	
NAME :	SEND	
SSNR :	KY 255,1	ID for indirect initialization
.		The data area for initialization begins with DW 1
A-NR :	KY 0,0	Irrelevant
ANZW :	FW 0	Irrelevant
DB	44	
DW 1	KY 0,1	The interface number is 1
DW 2	KY 0,31	The job number is 31
DW 3	KC FW	The job status word is in the flag area
DW 4	KY 0,200	The job status word is represented in flag words FW 200 and FW 202

- Job Status Word in a Data Block

Parameter Assignments		Explanation
C	DB 24	Open DB 24
JU	FB 244	
NAME :	SEND	
SSNR :	KY 255,1	ID for indirect initialization
.		The data area for initialization begins with DW 1
.		
A-NR :	KY 0,0	Irrelevant
ANZW :	FW 0	Irrelevant
DB	24	
DW 1	KY 0,1	The interface number is 1
DW 2	KY 0,31	The job number is 31
DW 3	KC DB	The job status word is in a data block
DW 4	KY 222,10	Address of the ANZW (DW 10 and DW 11 in DB 222)
DB	222	
DW 10		Job status word
DW 11		

Indirect Initialization of SSNR and BLGR (SYNCHRON)

Parameter Assignments		Explanation
C	DB 49	Open DB 49
JU	FB 249	
NAME :	SYNCHRON	
SSNR :	KY 255,100	ID for indirect initialization The data area for initialization begins with DW 100.
BLGR :	KY 0,0	Irrelevant
DB	49	
DW 100	KY 0,10	The interface number is 10.
DW 101	KY 0,6	The block size is set at 512 bytes.

Indirect Initialization of QTYP / ZTYP, DBNR, QANF / ZANF, and QLAE / ZLAE

When RW or XX is assigned to QTYP or ZTYP, the information for the source (or destination) is taken from a data area. The QANF parameter specifies the start address of this data area.
When XX is used for indirect initialization, enter the following data in the data block specified by “DBNR“:

Address in the data block	Data type	Assignment	Explanation
QANF + 0	KC	DB, QB, IB, FY, TB, CB, AS, NN	Type of source or destination
+ 1	KY	2 to 255 *	Number of the DB for source or destination type DB (high-order byte = 0)
+ 2	KF	0 to 2047	Start address of the source or destination area QANF / ZANF
+ 3	KF	1 to 2048	Length of the source or destination area

* Only for ”DB”

For indirect initialization with RW, the data in the block with the “DBNR“ number must contain the following information:

Address in the data block	Data type	Assignment	Explanation
QANF + 0	KC	DB, QB, IB, FY, TB, CB, AS, NN	Source type specification
+ 1	KY	2 to 255 *	Number of the DB for source type “DB” (high-order byte =0)
+ 2	KF	0 to 2047	Start address of the source data block
+ 3	KF	1 to 2048	Source data block length
+ 4	KC	DB, QB, IB, FY, TB, CB, AS, NN	Destination type specification
+ 5	KY	2 to 255 *	Number of the DB for destination type ”DB” (high-order byte =0)
+ 6	KF	0 to 2047	Start address of the destination data block
+ 7	KF	1 to 2048	Destination data block length

* Only for ”DB”

Format and Meaning of the Job Status Word

The job status word is used to store information on the status of jobs. Specify the address of the job status word when assigning parameters. Starting at this address, information can be read out and processed further. Assign parameters to the ANZW such that a separate job status word is addressed for each job defined. The job status word is part of a doubleword that is addressed by the ANZW parameter (Table 8-5.).

Table 8-4. Basic Format of the Doubleword for the Job Status

Word No.	Meaning
n	Job status word
n + 1	Length word

Job Status Word

The job status word is divided into four parts. Figure 8-1 explains the individual bits.

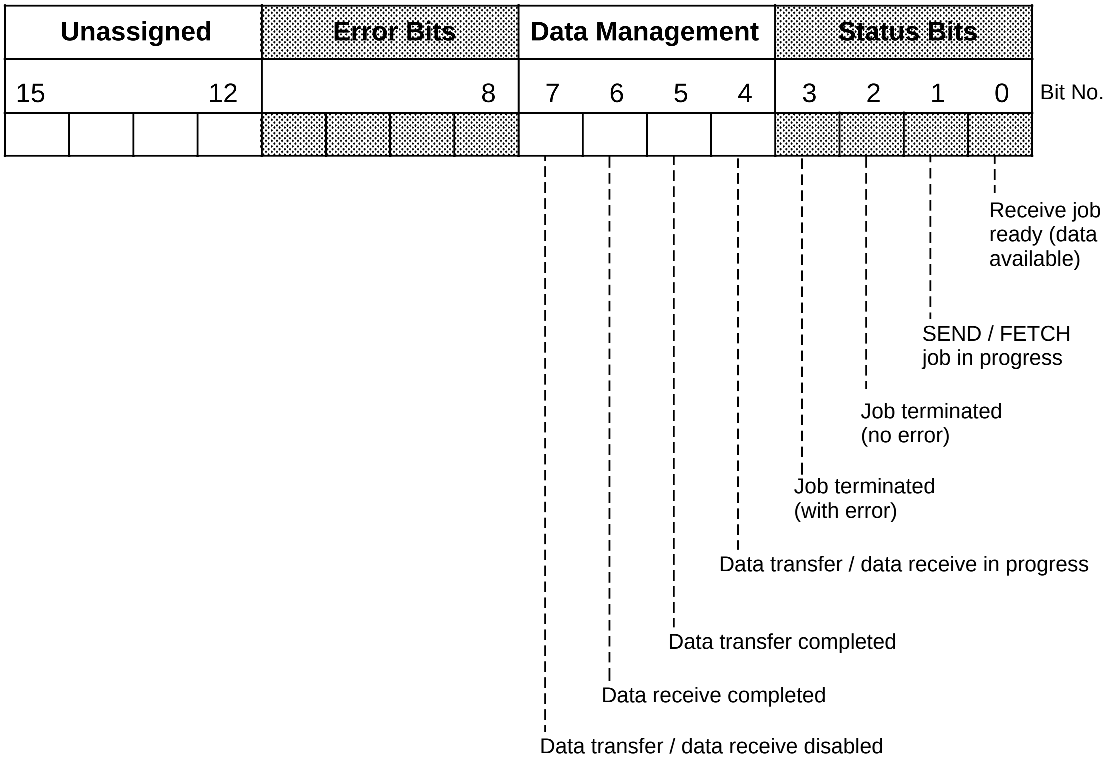


Figure 8-1. Format of the Job Status Word

Description of the Error Bits

Error bits in the job status word are valid only if the “Job terminated with error” bit (bit 3) is set. Table 8-5 lists the possible errors.

Table 8-5. Description of the Error Bits

Value of the error tetrads	Error
0	No error If the “Job terminated with error” bit is set nonetheless, this means that the CP has set up the job again after a Cold Restart or a RESET.
1 to 5	PLC error, error codes the same as in PAFE
6 to F	CP errors CP-specific errors. Use the appropriate CP manual to determine the cause of the error.

Description of the Status and Data Management Bits

The status bits and the data management bits can be set / reset and evaluated both by the user and via data handling blocks (DHBs).

The table below shows the situations in which these bits are set or reset.

Table 8-6. Description of the Bits in the Job Status Word

Bit No.	Set by	Reset / Overwritten by	Evaluated by
0	DHB	DHB	• RECEIVE block (When this bit is set, handshaking with the CP is initiated.) • User (Scan to see if there is a frame.)
1	DHB (as soon as the CP receives a job request)	DHB (when the CP serviced the job request)	• SEND / FETCH block (A new request is sent only after the old job has been processed.) • User (Scan to see if a new job is to be initiated.)
2	DHB (if the job was completed without error)	DHB (if the job is reinitiated)	User (Scan to see if the job was completed without error.)
3	DHB (if the job termi-nated with error). (The cause of the error is stored in the high-order byte of the job status word.)	DHB (if the job is reinitiated)	User (Scan to see if the job was completed without error.)

Table 8-6. Description of the Bits in the Job Status Word (cont.)

Bit-No.	Set by	Reset / Overwritten by	Evaluated by
4	DHB/SEND,RECEIVE (if data exchange has begun for a job Example: initiation with DIRECT function but exchange via	DHB / SEND, RECEIVE (if data exchange is completed for a job)	User (Scan to see if the data frame has just been transferred.) [1]
5	SEND block (if data has been transferred for a job)	• SEND block (if data transfer has been started for a new job) • User (if an evaluation was made)	User (Scan to see if the dataset for a job has already been transferred to the CP and when a new dataset can be made available for a current job.)
6	RECEIVE block (if data reception has been concluded for a job)	• RECEIVE block (if data transfer has been started for a new job) • User (if an evaluation was made)	User (Scan to see if the data frame of a new job has already been transferred to the PLC and when a new data frame was transferred to the PLC for a job currently in progress.)
7	User (Access of the SEND and RECEIVE blocks to an area is prevented at the first data field. Jobs already started are terminated.)	User (The pertinent data area is enabled.)	SEND-RECEIVE block (If the bit is set, the blocks do not execute any data traffic. Instead, they report an error to the CP.)

1 During data transfer between the CP and PLC, you can no longer modify the data for a job. This fact is not critical for small data packets since, in this case, data exchange can be handled in one block pass. However, large amounts of data can be transferred in blocks only. Consequently, data exchange can stretch over several program scans, depending on the frame size specified in the SYNCHRON block.

Length Word:

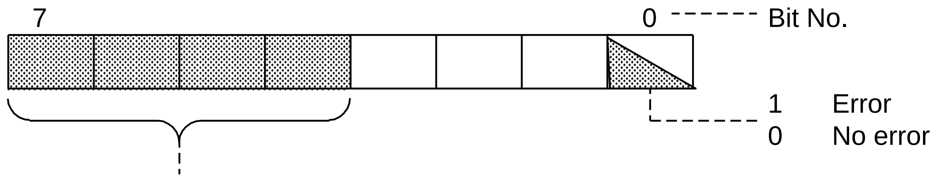
In the length word, the SEND and RECEIVE data handling blocks enter the amount of data (in bytes) already transferred for a particular job. For the ALL functions, the SEND and RECEIVE blocks enter the job number for which they were active in the current pass in the low-order byte. Job number “0“ (empty run) means that no job was processed. Table 8-7 shows how the length word is acted upon.

Table 8-7. Accessing the Length Word

Set by	Reset / Overwritten by	Evaluated by
DHB / SEND, RECEIVE (during data exchange) The contents are calculated from the current number of transfers plus the quantity of (blocked) data already exchanged.	DHB / SEND, RECEIVE FETCH by over-writing during the next job.	User (If bit 2, 5, or 6 is set in the job status word, the current source or destination length is in the length word. If bit 3 is set, the length word contains the amount of data transferred prior to detection of an error.)

“Parameter Assignment Error“ (PAFE) Byte

Only a flag byte is suitable as parameter assignment error byte.
Various parameter assignment errors are reported in the PAFE byte (in the high-order tetrad). When assigning parameters, specify the address under which this information can be accessed. Figure 8-2 describes the individual bits.



0 No error
1 Incorrect ORG format, QTYP / ZTYP illegal (PLC or CP)
2 Area not available (no DB or illegal DB)
3 Area too small
4 Time-out (QVZ) / no access possible
5 Wrong job status word
6 No source or destination parameters for SEND / RECEIVE ALL (system error)
7 No such interface / interface not configured
8 Interface not ready / interface passivated
9 Interface overloaded
A Unassigned
B Illegal A-NR
C No acknowledgement or negative acknowledgement from the interface (CP)
D Parameter / BLGR illegal (first byte) or synchronization running
E Unassigned
F Unassigned

Figure 8-2. Format of the “PAFE” Byte

The SEND Block - FB 244 -

FB 244 requests that data be sent to a module with page addressing.
A distinction is made between two function modes:

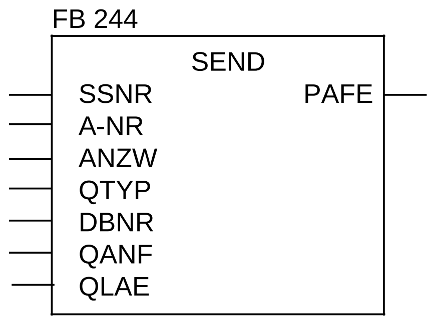
- **SEND ALL**
  The function block is a substitute for direct memory access.
- **SEND DIRECT**
  Data is sent for a specific job request.

Calling Function Block FB 244 (Example: SEND Direct)

STL

```
          : JC    FB    244
NAME      : SEND
SSNR      :       KY    0,10
A-NR      :       KY    0,32
ANZW      :       FW    14
QTYP      :       KC    DB
DBNR      :       KY    0,10
QANF      :       KF    +1
QLAE      :       KF    +33
PAFE      :       FY    13
          : ***
```

CSF / LAD



Description of the SEND ALL Function

For the SEND ALL function, the block requires the following parameters:

- SSNR - interface number
- A-NR - job number (assign “0”)
- ANZW - job status word
- PAFE - parameter assignment error byte

All other parameters are irrelevant for this job, and function only as space reservers. The CP uses the communications area to provide the following information:

- address of the job status word
- type of data
- amount of data
- start address of the data area

The following bits are evaluated or set / reset in the job status word for the pertinent job:

- data transfer disabled
- data transfer completed
- data transfer in progress

The SEND block enters the number of bytes transferred in the data word that follows the job status word.

The SEND block must be called in the control program in ”ALL” mode at least once per interface when

- the CP can request data from a PLC on its own initiative, e.g., the CP 525 for display output or the CP 535 with the job mode ”READ PASSIVE”.
- a CP job is initiated with SEND DIRECT, but the CP asks the PLC for the data for this job via ”background communications”.
- the amount of data to be transmitted to the CP with SEND DIRECT is greater than the specified frame size.

Description of the SEND DIRECT Function

The SEND DIRECT function works with the following parameters:

- SSNR - interface number
- A-NR - job number (assign “ 0”)
- ANZW - job status word
- PAFE - parameter assignment error byte
- QTYP - source type
- DBNR - data block number
- QANF - source start address
- QLAE - amount of source data

Normally, the SEND DIRECT function is called in the cyclic part of the control program. The block can be invoked in an interrupt service routine, but the job status word would not be updated cyclically in this case. This task must then be performed by the CONTROL block.

The following two conditions must be met to transfer data or to activate a SEND job:

- RLO ”1” was forwarded to the function block
- The CP enabled the job. (The ”SEND / FETCH in progress” bit of the job status word is ”0”).

If RLO ”0” is forwarded (empty run), only the job status word is updated.
If ”NN” is entered in the QTYP parameter, the source parameters have to be stored in the CP. If they are not, the job is aborted with error.

Data interchange can proceed as follows:

- The requested data is transferred directly to the CP.
- The CP asks only for the job parameters.
- The amount of data to be transmitted is too large. The block transfers the parameters and the first data block to the CP. Then the CP requests the remaining data or an additional data frame from the PLC via the SEND ALL function.

For the block user, the operator interface is the same in all initiation modes. However, in the last two cases, the instant of data transfer is postponed by at least one program cycle.

Description of the WRITE Function

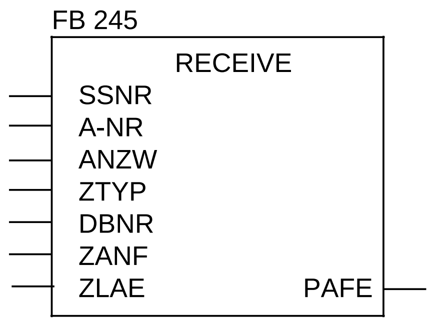
If “RW” is entered in the QTYP parameter, the block transfers the indirectly specified source and destination parameters to the CP. Then the destination parameters are sent along with the useful data (requested via the SEND ALL function) to the communications partner (WRITE function).

The RECEIVE Block - FB 245 -

FB 245 requests reception of data from a module with page addressing. A distinction is made between two function modes:

- **RECEIVE ALL**
  Data can be received for any job. This function block substitutes for direct memory access.
- **RECEIVE DIRECT**
  Data is received for a specific job.

Calling Function Block FB 245

STL	CSF / LAD
see listing below	

```
            : JC      FB      245
NAME        : RECEIVE
SSNR        :         KY      0,10
A-NR        :         KY      0,101
ANZW        :         FW      24
ZTYP        :         KC      DB
DBNR        :         KY      0,10
ZANF        :         KF      +100
ZLAE        :         KF      - 1
PAFE        :         FY      23
            : ***
```


Description of the RECEIVE ALL Function

The block needs the following parameters in RECEIVE ALL mode:

- SSNR - interface number
- A-NR - job number (assign ”0”)
- ANZW - job status word
- PAFE - parameter assignment error byte

All other parameters are irrelevant for this job.

The CP provides the following information via the communications area:

- address of the job status word
- type of data
- amount of data
- start address of the data area

The following bits are evaluated or set/reset in the status word for the pertinent job:

- data transfer disabled
- data transfer completed
- data transfer in progress

The block enters the amount of data transferred for a job in the data word that follows the job status word.

The RECEIVE block must be called in the control program in “ALL” mode at least once per interface when

- The CP wants to give data to the PLC on its own initiative.
- The amount of data to be received with RECEIVE DIRECT exceeds the specified frame size.
- The CP uses RECEIVE DIRECT only to enable receive data, and transfers data to the PLC via “background communications”.

You can call FB 245 in RECEIVE ALL mode in

- the cyclic program (e.g., in OB 1)
- the service routine for timed interrupts (e.g. prompter block)
- the service routine for process interrupts

Description of the RECEIVE DIRECT Function

The RECEIVE DIRECT function works with the following parameters:

- SSNR - interface number
- A-NR - job number (assign “ 0”)
- ANZW - job status word
- PAFE - parameter assignment error byte
- ZTYP - destination type
- DBNR - data block number
- ZANF - destination start address
- ZLAE - amount of destination data

Normally, the RECEIVE DIRECT function is called in the cyclic part of the control program. This block can also be called in an interrupt service routine, but the job status word is not updated cyclically in this case. The CONTROL block must then perform this task.

The RECEIVE block communicates with the CP on a handshaking basis under the following conditions only:

- RLO ”1” has been forwarded to the function block.
- The CP has enabled the job. (The “RECEIVE ready” bit in the job status word is set.)

When RLO “0” is forwarded, only the job status word is updated.

If “NN” is assigned to the ZTYP parameter, the CP must provide the destination parameters. Otherwise, the job is aborted with an error.

If the CP provides the destination parameters, when ZTYP is not ”NN”, only the parameter specifications in the block are noted.

Large amounts of data can be received in the form of frames only. Only one data frame can be received at a time with RECEIVE DIRECT. The remaining data or additional data frames must therefore be transferred to the PLC with RECEIVE ALL.

The FETCH Block - FB 246 -

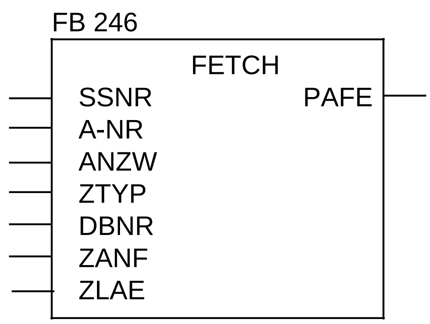
FB 246 requests that data can be fetched from a communications partner over a CP. The data is received via function block FB 245 in RECEIVE ALL mode. You can use the FETCH block only to fetch data for a specific job (FETCH DIRECT function).

Calling the FETCH Block (Example)

STL

```
              : JU      FB      246
NAME          : FETCH
SSNR          :         KY      0,10
A-NR          :         KY      0,101
ANZW          :         FW      9
ZTYP          :         KC      DB
DBNR          :         KY      0,46
ZANF          :         KF      + 5
ZLAE          :         KF      + 20
PAFE          :         FY      14
              : ***
```

CSF / LAD



Description of the FETCH Function

All parameters must be assigned for the FETCH function. The destination parameters (ANZW, ZTYP, DBNR, ZANF, ZLAE) are passed to the CP during handshaking. As soon as the requested data arrives, the CP provides the RECEIVE ALL block with both parameters and data. The FETCH block itself does not transfer or receive data.

The FETCH job is activated under the following conditions:

- RLO “1” has been forwarded to the function block.
- The CP has enabled the function. (The “SEND / FETCH in progress” bit is “0.”)

If “RW” is assigned to the ZTYP parameter, the FETCH block transfers the source and destination parameters and the address of the job status word to the CP.

FETCH can be invoked in the cyclic program or in an interrupt service routine. The FETCH or CONTROL block updates the job status word.

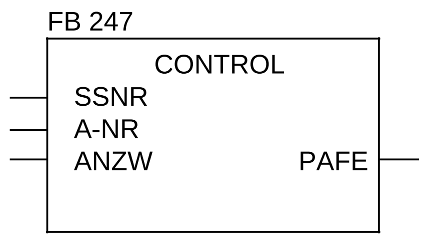
The CONTROL Block - FB 247 -

FB 247 updates the job status word for a specific job or indicates which job is currently in progress.

Calling FB 247 (Example)

STL	CSF / LAD
see listing below	see diagram below

```
              : JU      FB      247
NAME          : CONTROL
SSNR          :         KY      0,10
A-NR          :         KY      0,101
ANZW          :         FW      20
PAFE          :         FY      22
              : ***
```



Description of the CONTROL Function

The CONTROL function requires the following parameters:

- SSNR - interface number
- A-NR - number of the job to be monitored
- ANZW - job status word where the result is to be stored
- PAFE - parameter assignment error byte

The CONTROL block implements different functions depending on the job number.

A-NR = “0”

The CP is asked which job is currently in progress. The CP writes the number of the current job in job location 0. The contents of this location are transferred to the low-order byte of the job status word when the CONTROL block is processed.

A-NR ”0”

The block executes in CONTROL DIRECT mode:

- The status of a specific job is interrogated.
- The job status word is updated.

Processing of this block does not depend on the RLO. However, FB 247 should be called in the cyclic part of the control program.

The RESET Block - FB 248 -

FB 248 resets a job executing over the specified interface. RESET can execute in two different modes:

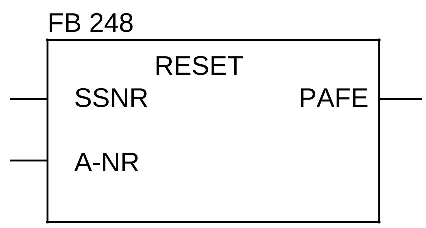
- **RESET ALL**
  If you assign “0” as the job number, all jobs for the specified interface are reset.
- **RESET DIRECT**
  If you assign a number “ 0” as the job number, only the specified job is reset.

Calling FB 248

STL

```
              : JU    FB    248
NAME          : RESET
SSNR          :       KY    0,1
A-NR          :       KY    0,0
PAFE          :       FY    111
              : ***
```

CSF / LAD



Parameter Description

FB 248 requires the following parameters:

- SSNR - interface number
- A-NR - number of the job that is to be reset
- PAFE - parameter assignment error byte

RESET Function Description

In both modes,

- the job data are deleted.
- active jobs are aborted.

FB 248 executes dependent on the RLO, and can be invoked in both the cyclic program and in an interrupt service routine.

The SYNCHRON Block - FB 249 -

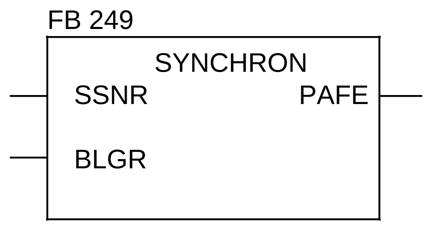
Each time the PLC is restarted, FB 249 initializes the interface on a module with page addressing for communication with the control program. This synchronization is essential for proper execution of the data handling blocks.

Calling FB 249 (Example)

STL

```
              : JU      FB      249
NAME          : SYNCHRON
SSNR          :         KY      0,1
BLGR          :         KY      0,5
PAFE          :         FY      100
              : ***
```

CSF / LAD



Parameter Description

FB 249 requires the following parameters:

- SSNR - interface number
- BLGR - frame size
- PAFE - parameter assignment error byte

SYNCHRON Function Description

After you enter the desired frame size for the BLGR parameter, the CP checks this value according to module-specific criteria and determines the final frame size.

In certain cases, this means that the frame size specified in the parameter is invalid.

The final frame size specifies how much data (bytes) can be transferred directly when the SEND and RECEIVE blocks are called. For larger amounts of data, continuation frames are generated and transferred with the ALL functions of these blocks.

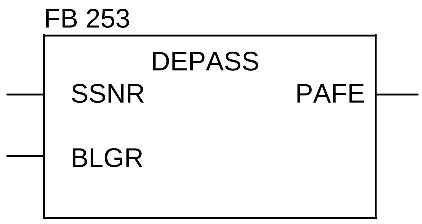
FB 249 synchronizes the PLC and the CP on each PLC restart. Consequently, FB 249 should be called in RESTART blocks OB 21 and OB 22. FB 249 executes when it receives RLO ”1”.

The DEPASS Block - FB 253 -

FB 253 depassivates a faulted CP, and synchronizes the associated interface by invoking FB SYNCHRON (see FB SYNCHRON for details on synchronization).

Calling FB 253 (Example)

STL	CST / LAD

`: JU FB 253`
`NAME : DEPASS`
`SSNR : KY 0,1`
`BLGR : KY 0,5`
`PAFE : MB 100`
`: ***`
	

Parameter Description

DEPASS requires the following parameters:

- SSNR - interface number
- BLGR - frame size (see FB SYNCHRON)
- PAFE - parameter assignment error byte

DEPASS Function Description

When a CP has failed, it must be synchronized and depassivated again after its repair/fault remedy. Synchronization and depassivation are necessary for single-sided and switched CPs.

Synchronization and depassivation of the CP are carried out by the CPU automatically after calling of function block FB 253. The CPU synchronizes the relevant interface of the CP in the course of several cycles and then depassivates it.

As long as synchronization and depassivation are in progress, the PAFE byte has the value $D0_H$. You must call up FB 253 cyclically until the value 00_H is output in the PAFE byte. 00_H indicates that synchronization and depassivation of the CP have successfully been completed.

After the successful synchronization and depassivation of the CP, you must reset the ”depassivation” bit in the H flag word to ensure that the passivation message in the error DB is deleted again.

Please note that FB 249 cannot be used for synchronization and depassivation of the CP because of its long execution time and because it has no depassivation function.

In the following example, an interface is depassivated by setting F 10.0. FB 253 continues to be invoked until the message 00H appears in PAFE. It executes for up to 15 seconds, after which an error is reported to the user (F 11.2 =1). FY 8 is used as the PAFE byte.

STL	Explanation
:O F 10.0	Initiator flag
:L KT 015.2	Time 15 sec.
:SE T 1	ON delay
:	
:O(	
:L FY 8	If PAFE FY 8 = DO_H
:L KH 00D0	
:!=F	
:)	or
:O F 10.0	initiator flag is set
:R F 10.0	reset initiator flag
:= F 11.0	and set auxiliary flag for depass.
:	in progress
:JC FB 253	and call FB 253 conditionally
NAME :DEPASS	
SSNR : KY 0,15	
BLGR : KY 0,5	
PAFE : FY 8	
:	
:A F 8.0	PAFE indicates error, then
:= F 11.1	error message to user,
:BEC	CP not OK
:	
:A F 11.0	As long as depass. in progress
:A T 1	and timer running,
:BEC	conditional end of frame
:	
:	If time has expired
:A F 11.0	and initiator flag is still set
:R F 11.0	reset initiator flag
:S F 11.2	and issue error message to user
:	"Time selected for sync.
:	too short."
:	
:L KB 0	Reset PAFE
:T FY 8	
:BE	

8.1.4 Analog Value Matching Blocks

These blocks match the nominal range of an analog module to a normalized range that you can specify.

Reading and Scaling an Analog Value- FB 250 -

Function block FB 250 reads an analog value from an analog input module and outputs a value XA in the (scaled) range specified. Define the desired range using the “upper limit” (OGR) and “lower limit” (UGR) parameters.
Specify the type of analog value representation (channel type) in the KNKT parameter (Section 7). The BU parameter is set when the analog value exceeds the nominal range.

Call and Parameter Assignments

Parameter	Description	Type	Data Type	Assignment	STL
BG	Module address	D	KF	128 to 224	: JU FB 250 NAME : RLG:AE BG : KNKT : OGR : UGR : EINZ : XA : FB : BU : TBIT :
KNKT	Channel number Channel type	D	KY	KY = x,y x = 0 to 15 y = 3 to 6 3: absolute value representation (4 to 20 mA) 4: unipolar representation 5: absolute value, bipolar 6: bipolar fixed-point number (two’s complement)	
OGR	Upper limit of the output value	D	KF	-32768 to +32767	
UGR	Lower limit of the output value	D	KF	-32768 to +32767	
EINZ	Selective sampling	I	BI	Selective sampling is triggered with “1.”	
XA	Output value	Q	W	Scaled analog value is “0” on wirebreak.	
FB	Error bit	Q	BI	”1” on wirebreak, illegal channel or slot number, illegal channel type or time-out	
BU	Range violation	Q	BI	”1” when nominal range is exceeded	
TBIT	Activity bit of the function block	Q	BI	The function block is in the process of selective sampling when the signal state is “1”.	

A number of FB 250 parameters are described in detail below:

Channel Type KT

The analog input modules provide analog values in four different forms of representation. One of these forms can be selectred via the KT parameter.

KT = 3	:	Absolute value 4 to 20 mA
KT = 4	:	Unipolar representation
KT = 5	:	Bipolar absolute value
KT = 6	:	Bipolar fixed-point value

If any other value is specified for KT, ”Illegal channel type” is output as error message and FB 250's FB output parameter set to ”1”.

Output Value XA

Function block FB 250 converts the value read linearly to accord with the upper and lower limiting values (OGR and UGR) using the following formula:

For channel type 3 (absolute value 4 to 20 mA):

$$XA = \frac{UGR \cdot (2560 - XE) + OGR \cdot (XE - 512)}{2048}$$

For channel type 4 (unipolar representation):

$$XA = \frac{UGR \cdot (2048 - XE) + OGR \cdot XE}{2048}$$

For channel types 5 and 6 (bipolar representation):

$$XA = \frac{UGR \cdot (2048 - XE) + OGR \cdot (XE + 2048)}{4096}$$

Where XA is the value output by the FB and
XE is the analog value read from the module.

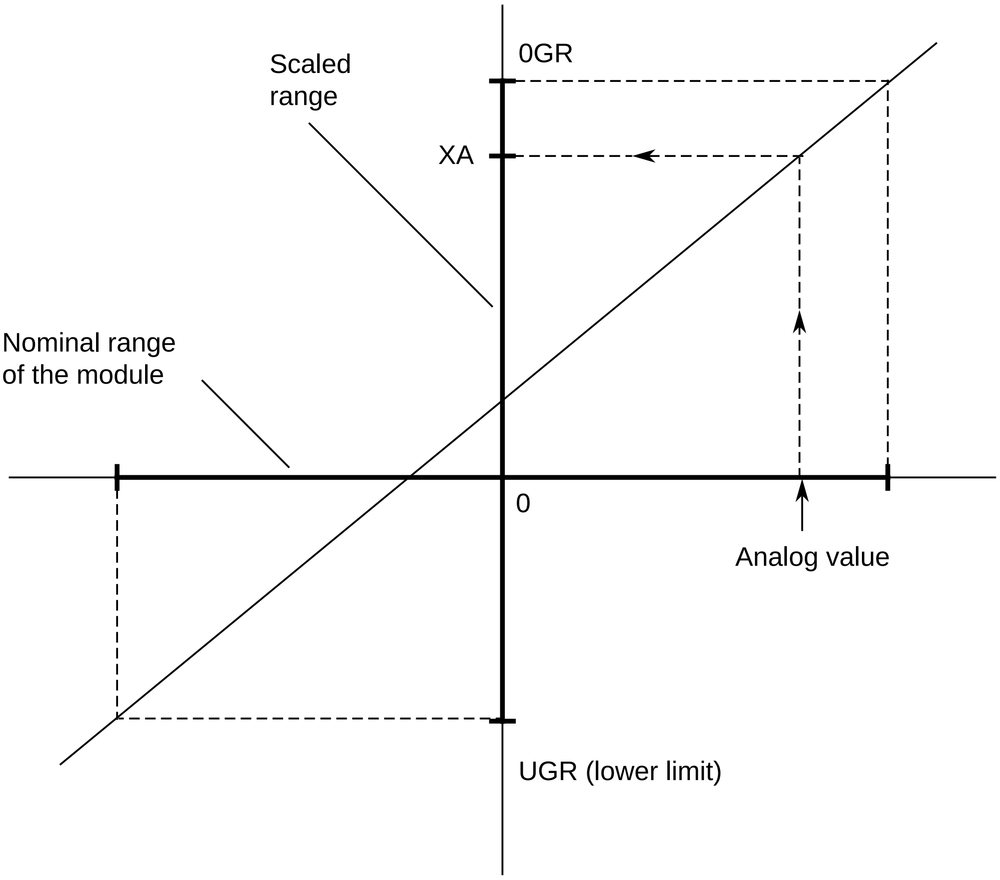


Figure 8-3. Schematic Representation of Conversion

UGR, OGR: Limiting values for the output value

An analog value can be represented as physical value by careful selection of the limiting values.

Example:

Range of analog value	Physical quantity	Range limits		Resolution
0 to10 V	2 to150 °C	2000000+01	1500000+03	0,1 °C

BU: Range violation

BU flags a violation of the nominal range of the analog value. Analog values within the overrange (analog value >+4096 or <- 4096 units), are limited to +4096 / -4096 units.

Wirebreak

A wirebreak is flagged by output parameter FB (FB=”1”).

Selective Sampling

FB 250 (RLG:AE) and FB 252 (RLG:HAE) enable the use of selective sampling for reading an analog value. Setting the EINZ parameter to ”1” causes the analog input module to immediately convert the analog value on the specified channel into a digital value. No further selective sampling activities which access this module may be initiated during conversion (which takes approximately 60 ms). The active FB therefore sets the TBIT to ”1” and maintains this status until the converted value has been read in. When selective sampling has been completed, the TBIT is reset to ”0”.

Outputting an Analog Value -FB 251-

Use function block FB 251 to output analog values to analog output modules. Specify the module's type of analog representation (channel type) in the KNKT parameter (Section 7). Values from the range between the “lower limit” (UGR) and the “upper limit” (OGR) parameters are converted to the nominal range of the relevant module using the following formula:

For channel type 0 (unipolar representation):

$$XA = \frac{1024 \cdot (XE - UGR)}{OGR - UGR}$$

For channel type 1 (bipolar representation):

$$XA = \frac{1024 \cdot (2 \cdot XE - OGR - UGR)}{OGR - UGR}$$

where XE is the digital value specified in the function block and
XA is the value output to the module.

Calling and Initializing -FB 251-

Parameter	Meaning	Type	Data Type	Assignment	STL
XE	Analog value to be output	I	W	Input value (fixed-point) in the UGR to OGR range	: JU FB 251 NAME : RLG:AA XE : BG : KNKT : OGR : UGR : FEH : BU :
BG	Module address	D	KF	128 to 240	
KNKT	Channel number Channel type	D	KY	KY = x,y x = 0 to 7 y = 0;1 0: unipolar representation 1: bipolar fixed-point number	
OGR	Upper limit of the output value	D	KF	-32768 to +32767	
UGR	Lower limit of the output value	D	KF	-32768 to +32767	
FEH	Error when setting the limit value	Q	BI	”1” if UGR = OGR, for illegal channel or slot number, illegal channel type or module time-out	
BU	Input value exceeds UGR or OGR	Q	BI	At ”1,”XE is outside the range (UGR; OGR). XE assumes the limit value	

Reading and Scaling Redundant Analog Values - FB 252 -

In its principle of operation, this function block is identical to FB 250 ”Reading and Scaling Analog Values”. FB 252, however, not only flags errors by setting error bits, but also locates them by setting bits in the FEWO output parameter which are allocated to either subunit A or B. Function block FB 252 reads an analog value XE from an analog input module and outputs proportional values XAA (subunit A) and XAB (subunit B) in the scaled range specified. The analog value can be read in via either cyclic or selective sampling. All other FB 252 parameters are the same as those for FB 250 ”Reading and Scaling Analog Values” (see FB 250)

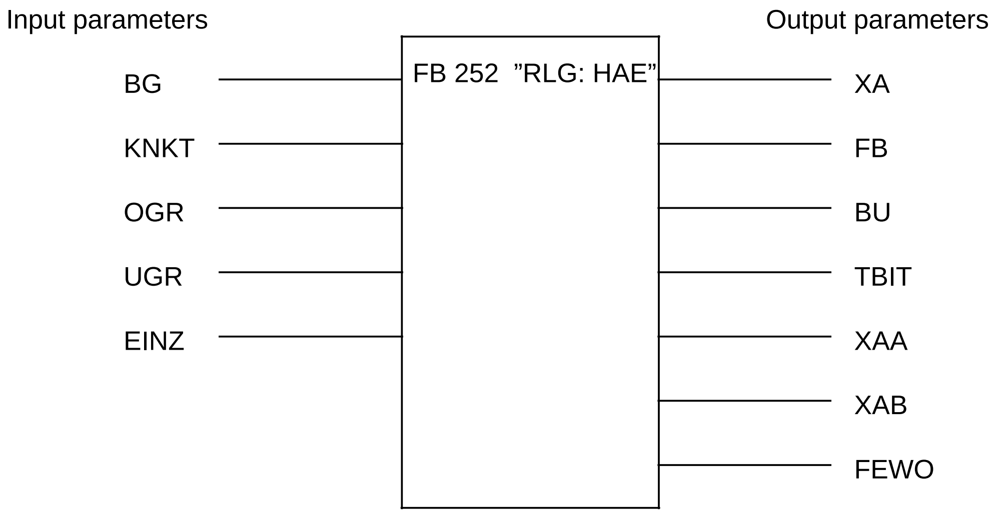


Figure 8-4. Structure of FB 252 ”RLG: HAE”

Call and Parameter Assignments:

Parameter	Description	Type	Data Type	Assignment	STL
BG	Module address	D	KF	128 to 224	: JU FB 252 NAME : RLG: HAE BG : KNKT : OGR : UGR : EINZ : XA : FB : BU : TBIT : XAA : XAB : FEWO :
KNKT	Channel number Channel type*	D	KY	KY = x,y x = 0...15 y = 3...6 3: Absolute value represen-tation (4...20 mA) 4: Unipolar representation 5: Bipolar absolute value 6: Bipolar fixed-point no. (two's complement)	
OGR	Upper limit of the output value	D	KF	- 32768 to+32768	
UGR	Lower limit of the output value	D	KF	- 32768 to+32768	
EINZ	Selective sampling	I	BI	Selective sampling is triggered with ”1”	
XA	Output value	Q	W	Scaled analog value is ”0” on wirebreak	
FB	Error bit	Q	BI	”1” on wirebreak, illegal channel or slot number, illegal channel type or module time-out	
BU	Range violation	Q	BI	”1” when nominal range is exceeded	
TBIT	Activity bit of the function block	Q	BI	The function block is in the process of selective sampling when signal state is ”1”	
XAA	Output value A	Q	W	Scaled analog value for subunit A Is ”0” on wirebreak	
XAB	Output value B	Q	W	Scaled analog value for subunit B Is ”0” on wirebreak	
FEWO	Error word	Q	W	See Error word	

* The following parameters flag an illegal channel type specification:

- FB = ”1”
- FEWO: Bit 7 = ”1” passivation

Error Word FEWO:

Byte	Bits	Description	Assignment
Low-order byte	Bit 0	Range violation A*	”1” when nominal range is exceeded (>2048, <- 2048) in subunit A**.**
	Bit 1	Overrange A	”1” when overrange exceeded (>4095, <- 4095) in subunit A.
	Bit 2	Wirebreak A	”1” on wirebreak to subunit A.
	Bit 3	Range violation B*	”1” when nominal range is exceeded (>2048, <- 2048) in subunit B**.**
	Bit 4	Overrange B	I”1” when overrange exceeded (>4095, <- 4095) in subunit B.
	Bit 5	Wirebreak B	”1” on wirebreak to subunit B
	Bit 6	Discrepancy	”1” when there is a discrepancy between values A and B
	Bit 7	Passivation bit	”1” when both analog modules were passivated, on illegal channel or slot number or illegal channel type.
High-order byte	Bit 0 to 7	Unassigned	

* Bits 0 / 3 are reset when the overrange (>4095, <- 4095) is exceeded.

The table on the next page shows the interplay between parameters XA, FB, BU and FEBY in dependence on output values XAA and XAB and under consideration of the relevant preferred value (which is configured over COM 115H) Section 12.3.2, ”F3 Analog Inputs”.

XAA (A)	XAB (B)	Preferred Value	XA	FB	BU	FEWO
Positive range violation	Nominal range	min.	Nominal range	0	0	Bit 0 = "1" Range violation A
Nominal range	Positive range violation	max.	Positive range violation	0	1	Bit 3 = "1" Range violation B
Positive range violation	Positive range violation	min. max.	Positive range violation	0	1	Bit 0 = "1" Range violation A Bit 3 = "1" Range violation B
Negative range violation	Nominal range	min.	Negative range violation	0	1	Bit 0 = "1"
Nominal range	Negative range violation	max.	Nominal range	0	0	Bit 3 = "1"
Negative range violation	Negative range violation	min. max.	Negative range violation	0	1	Bit 0 = "1" Bit 3 = "1"
Positive Overflow	Nominal range	min.	Nominal range	0	0	Bit 1 = "1" Overrange A
Nominal range	Positive Overflow	max.	Nominal range	0	0	Bit 4 = "1" Overrange B
Positive Overflow	Positive Overflow	min. max.	0	0	1	Bit 1 = "1" Bit 4 = "1"
Negative Overflow	Nominal range	min.	Nominal range	0	0	Bit 1 = "1"
Nominal range	Negative Overflow	max.	Nominal range	0	0	Bit 4 = "1"
Negative Overflow	Negative Overflow	min. max.	0	0	1	Bit 1 = "1" Bit 4 = "1"
Negative Overflow	Positive range violation	max.	Positive range violation	0	1	Bit 1 = "1" Bit 3 = "1"
Negative Overflow	Positive range violation	min.	0	0	1	Bit 1 = "1" Bit 3 = "1"
Wirebreak	Nominal range	min. max.	Nominal range	0	0	Bit 2 = "1" Wire-break A
Nominal range	Wirebreak	min. max.	Nominal range	0	0	Bit 5 = "1" Wire-break B
Wirebreak	Wirebreak	min. max.	0	1	0	Bit 2 = "1" Bit 5 = "1"
Wirebreak	Positive Overrange	min. max.	0	0	1	Bit 2 = "1" Bit 4 = "1"

Legend:

Positive range violation:	2048 to 4095
Nominal range:	- 2047 to 2047
Negative range violation:	- 2048 to - 4095
Positive Overflow:	> 4095
Negative Overflow:	< - 4095
Wirebreak:	XAA, XAB = 0

8.2 Organization Blocks

Besides function blocks, organization blocks are also integrated in the CPUs of the S5-115H programmable controller.

8.2.1 OB 31 Scan Time Triggering

A scan time monitor monitors the program scan time. If program scanning takes longer than the specified scan monitoring time (e.g., 500 msec.), the CPU enters the “STOP” mode.

This situation can occur, for instance, when
- The control program is too long.
- The program enters a continuous loop.

You can retrigger the scan time monitor at any point in the control program by calling OB 31. Calling this block restarts the scan time monitor.

Calling OB 31
- Prerequisite: SYSTEM COMMANDS ”YES” has been specified on the programmer
- JU OB 31 can be programmed at an arbitrary location in the control program

Programming
- OB 31 must be programmed and may contain only a ”BE” statement for retriggering to be effective. The scan time monitor is set in SD 96 (EACO).

8.2.2 OB 251 PID Algorithm

A PID algorithm, which the user may access by invoking organization block OB 251, is integrated in the operating systems of the CPU 942H.

Before invoking OB 251, you must first call a data block (called the controller DB) containing the controller parameters and other controller-specific data. The PID algorithm is invoked periodically (sampling interval), and generates the manipulated variable. The more closely the sampling interval is observed, the more accurately can the controller fulfill its appointed task. The control parameters specified in the controller DB must be matched to the sampling interval.

Typically, timed interrupts are serviced by organization block OB 13. OBs used to service timed interrupts can be invoked at intervals between 10 ms and 10 minutes. The PID algorithm requires no more than 1.7 ms to execute.

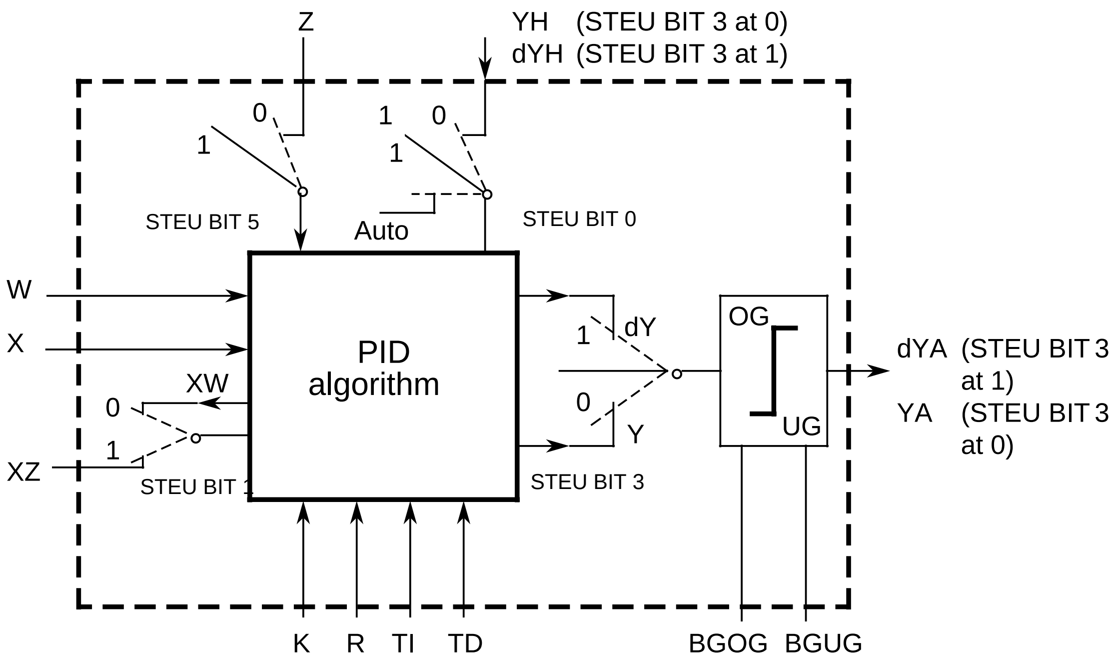


Figure 8-5. Block Diagram of the PID Controller

Legend:

K	= Proportional coefficient K>0 positive control direction K<0 negative control direction	STEU	= Control word
R	= R parameter (usually 1000)	YH	= Value for manual input
TA	= Sampling interval	BGOG	= Upper limiting value
TN	= Integral-action time	BGUG	= Lower limiting value
TV	= Derivative-action time	X	= Actual value
TI	= TA / TN	Z	= Disturbance variable
TD	= TV / TA	XZ	= Substitute variable for system deviation
W	= Setpoint	YA	= Controller output

The contiuous action controller is designed for controlled systems such as those used in pressure, temperature, or flow rate control.

The “R” parameter sets the proportional component of the PID controller.
If proportional action is required, most controller designs use the value R=1.

The individual proportional-action, integral-action, and derivative-action components can be deactivated via their parameters (R, TI, and TD) by presetting the pertinent data words with zero. This enables you to implement all required controller structures without difficulty, e.g., PI, PD, or PID controllers.

You can forward the system deviation XW or, using the XZ input, any disturbance variable or the inverted actual value X to the differentiator. Specify a negative K value for an inverted control direction.
When the correction information (dY or Y) is at a limit, the integral-action component is automatically deactivated in order not to impair the dynamic response of the controller.

The switch settings in the block diagram are implemented by setting the associated bits in control word STEU when the PID controller is initialized.

Table 8-8. Description of the Control Bits in Control Word STEU

Control Bit	Name	Signal State	Description
0	AUTO	0 1	Manual mode The following variables are updated in Manual mode: 1) X_K, XW_{K-1} and PW_{K-1} 2) XZ_K, XZ_{K-1} and PZ_{K-1}, when STEU bit 1=1 3) Z_K and Z_{K-1}, when STEU bit 5=0 Variable dD_{K-1} is set to 0. The algorithm is not computed. Automatic mode
1	XZ EIN	0 1	XW_k is forwarded to the differentiator. The XZ input is ignored. A variable other than XW_k is forwarded to the differentiator.
2	REG AUS	0 1	Normal controller processing When the controller is invoked (OB 251), all variables (DW 18 to DW 48) with the exception of K, R, TI, TD, BGOG, BGUG, YH_k and W_k are reset in the controller DB. The controller is deactivated.
3	GESCHW	0 1	Correction algorithm Velocity algorithm
4	HANDART	0 1	When GESCHW=0: Following the transfer to Manual mode, the specified manipulated variable value YA is adjusted exponentially to the manual value in four sampling steps. Additional manual values are then forwarded immediately to the controller output. When GESCHW=1: The manual values are forwarded immediatley to the controller output. The limiting values are in force in Manual mode. When GESCHW=0: The manipulated variable last output is retained. When GESCHW=1: Correction increment dY_K is set to zero.
5	NO Z	0 1	With feedforward control No feedforward control
6 to 15	-		The PID algorithm uses these bits as auxiliary flags.

The control program can be supplied with fixed values or parameters. Parameters are input via the assigned data words. The controller is based on a PID algorithm. Its output signal can be either a manipulated variable (correction algorithm) or a manipulated variable modification (velocity algorithm).

Velocity Algorithm

The relevant correction increment dY_k is computed at instant $t = k \cdot TA$ according to the following formula:

- Without feedforward control (D11.5=1); XW is forwarded to the differentiator (D11.1=0)

$$dY_k = K[(XW_k - XW_{k-1}) R + TI \cdot XW_k + (TD (XW_k - 2XW_{k-1} + XW_{k-2}) + dD_{k-1})]$$
$$= K (dPW_k R + dI_k + dD_k)$$

- With feedforward control (D11.5=0); XW is forwarded to the differentiator (D11.1=0)

$$dY_k = K[(XW_k - XW_{k-1}) R + TI \cdot XW_k + (TD (XW_k - 2XW_{k-1} + XW_{k-2}) + dD_{k-1})] + (Z_k - Z_{k-1})$$
$$= K (dPW_k R + dI_k + dD_k) + dZ_k$$

- Without feedforward control (D11.5=1); XZ is forwarded to the differentiator (D11.1=1)

$$dY_k = K[(XW_k - XW_{k-1}) R + TI \cdot XW_k + (TD (XZ_k - 2XZ_{k-1} + XZ_{k-2}) + dD_{k-1})]$$
$$= K (dPW_k R + dI_k + dD_k)$$

- With feedforward control (D11.5=0); XZ is forwarded to the differentiator (D11.1=1)

$$dY_k = K[(XW_k - XW_{k-1}) R + TI \cdot XW_k + (TD (XZ_k - 2XZ_{k-1} + XZ_{k-2}) + dD_{k-1})] + (Z_k - Z_{k-1})$$
$$= K (dPW_k R + dI_k + dD_k) + dZ_k$$

P component I component D component Z component k: k^{th} sample

When XW_k is applied:	XW_k	=	$W_k - X_k$
	PW_k	=	$XW_k - XW_{k-1}$
	QW_k	=	$PW_k - PW_{k-1}$
		=	$XW_k - 2XW_{k-1} + XW_{k-2}$
When XZ is applied:	PZ_k	=	$XZ_k - XZ_{k-1}$
	QZ_k	=	$PZ_k - PZ_{k-1}$
		=	$XZ_k - 2XZ_{k-1} + XZ_{k-2}$
The result is:	dPW_k	=	$(XW_k - XW_{k-1})R$
	dI_k	=	$TI \cdot XW_k$
	dD_k	=	$(TD \cdot QW_k + dD_{k-1})$ when XW is applied
		=	$(TD \cdot QZ_k + dD_{k-1})$ when XZ is applied
	dZ_k	=	$Z_k - Z_{k-1}$

Correction Algorithm

The formula used to compute the correction algorithm is also used to compute the velocity algorithm.
In contrast to the velocity algorithm, however, the sum of all correction increments computed (in DW 48), rather than the correction increment dY_k is output at sampling instant t_k.

At instant t_k , manipulated variable Y_k is computed as follows:

$$Y_k = \sum_{m=0}^{m=k} dY_m$$

Initializing the PID Algorithm

OB 251's interface to its environment is the controller DB.
All data needed to compute the next manipulated variable value is stored in this DB. Each controller must have its own controller data block.
The controller-specific data are initialized in a data block that must comprise at least 49 data words.
The CPU goes to STOP with a transfer error (TRAF) if no DB has been opened or if the DB is too short.

C A U T I O N :
Make sure that the right controller DB has been invoked before calling control algorithm OB 251.

Table 8-9. Format of the Transfer Block

Data word	Name	Comments
1	K	Proportional gain (- 32 768 to +32 767) for controllers without a D component Proportional gain (-1500 to +1500) for controllers with D component K is greater than zero when the control direction is positive, and less than zero when it is negative; the specified value is multiplied with a factor of 0.001. 0,001.multipliziert
3	R	R parameter (- 32 768 to + 32 767) for controllers without a D component R parameter (-1500 to +1500) for contollers with D component Normally 1 for controllers with P component; the specified value is multiplied with the factor of 0.001.
5	TI	Constant TI (0 to 9999) $TI= \frac{\text{Sampling interval TA}}{\text{Integral-action time TN}}$ The specified value is multiplied with a factor of 0.001.
7	TD	Constant TD (0 to 999) $TD= \frac{\text{Derivative-action timeTV}}{\text{Sampling interval TA}}$
9	W	Setpoint (- 2047 to +2047)
11	STEU	Control word (bit pattern)
12	YH	Value for Manual operation (- 2047 to +2047)
14	BGOG	Upper limiting value (- 2047 to +2047)
16	BGUG	Lower limiting value (- 2047 to +2047)

1 Greater gains are possible, if step changes in the system error are sufficiently small. Larger changes in the system error should therefore be divided into several smaller changes, e.g. by supplying the setpoint via a ramp function.

Table 8-9. Format of the Transfer Block (Cont.)

Data word	Name	Comments
22	X	Actual value (- 2047 to +2047)
24	Z	Disturbance variable (- 2047 to +2047)
29	XZ	Derivative time (- 2047 to +2047)
48	YA	Output variable (- 2047 to +2047)

All parameters (with the exception of the control word STEU) must be specified as 16-bit fixed point numbers.

CAUTION:
The PID algorithm uses the data words that are not listed in the table as auxiliary flags.

Initializing and Invoking the PID Controller in the STEP 5 Program

A number of different PID controllers can be implemented by invoking OB 251 repeatedly. A data block must be initalized prior to each OB 251 call. These DB's serve as data interface between the controllers and the user.

Note:
Important controller data are stored in the high-order byte of control word DW 11 (DL 11). Make sure that only T DR 11 / SU D 11.0 to D 11.7 or RU D 11.0 to D 11.7 operations are used to modify user-specific bits in the control word.

Selecting the Sampling Interval

The value selected as sampling interval must not be excessively high in order to be able to use the well-known analog method in the case of digital control loops.
Experience has shown that a sampling interval of approximately 1 / 10 of the time constant $T_{RK, dom}$* produces a control result comparable to the equivalent analog result. Time constant $T_{RK, dom}$ determines the step response of the closed control loop.

$$TA = 1 / 10 \cdot T_{RK, dom}$$

In order to ensure the constancy of the sampling interval, OB 251 must always be invoked in the service routine for timed interrupts (OB 13).

* $T_{RK, dom}$ = Dominant system time constant of the closed control loop

Example for the Use of the PID Control Algorithm

Using a PID controller to keep an annealing furnace at a constant temperature.
The temperature setpoint is entered via a potentiometer.
The setpoints and actual values are acquired using an analog input module and forwarded to the controller. The computed manipulated variable is then output via an analog output module.
The controller mode is set in input byte 0 (see control word DW 11 in the controller DB).
You must use the well-known controller design procedure to determine how to tune the controller for each controlled system.

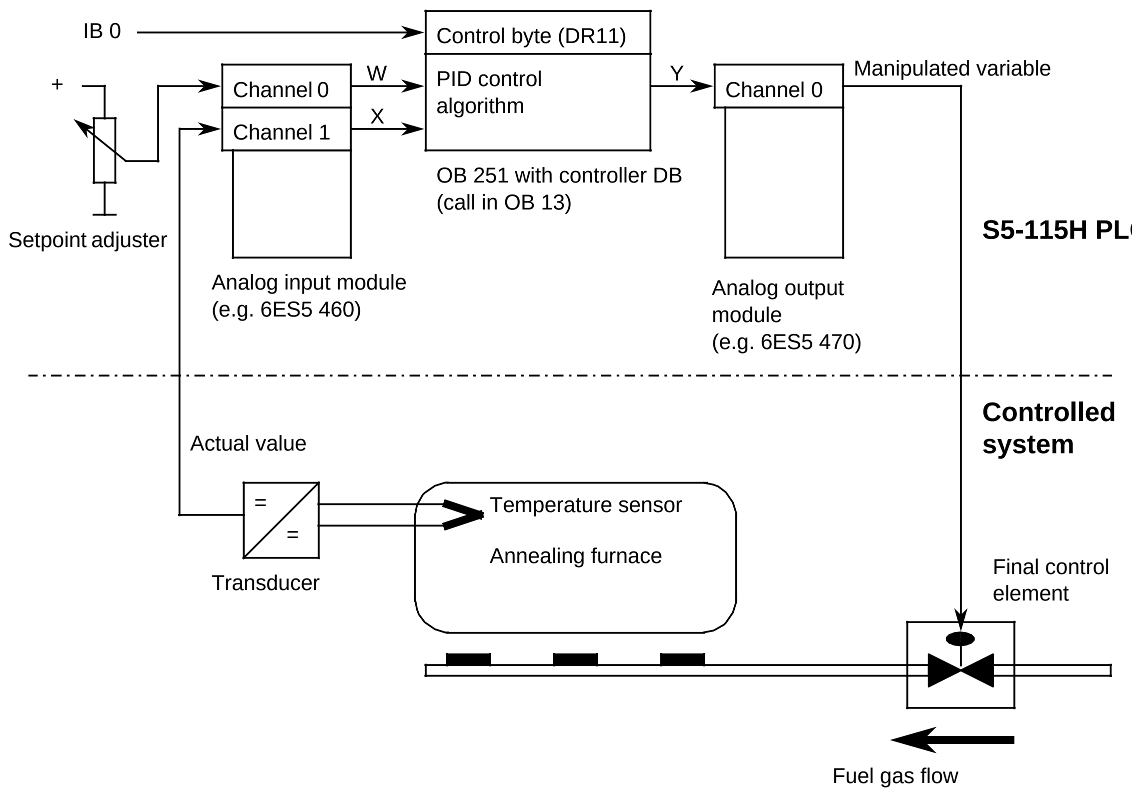


Figure 8-6. Process Schematic

The analog signals of the setpoint and actual values are converted into corresponding digital values in each sampling interval (set in OB 13). OB 251 uses these values to compute the new digital manipulated variable, from which, in turn, the analog output module generates a corresponding analog signal. This signal is then forwarded to the controlled system.

Invoking the Controller in the Program:

OB 13 STL	Description
:	
:JU FB 10	Process controller
NAME :REGLER 1	
:	The controller's sampling interval
:	depends on the time base used
:	to call OB 13 (set in RS 97).
:	The decoding time of the
:	analog input modules must be taken
:	into account when selecting
:	the sampling interval.
:	
:	
:BE	

FB 10 STL	Description
NAME :REGLER 1	
:	
:C DB 30	Select controller's DB
:	
:	*****************************
:	Read controller's control bits
:	*****************************
:	
:L PY 0	Read controller's
:T FY 10	control inputs
:T DR 11	and store in DR11
:	Note carefully:
:	DL11 contains important control
:	data for OB 251
:	The control bit must
:	therefore be transferred with
:	T DL11 to prevent
:	corrupting DL11
:	
:	*****************************
:	Read actual value and setpoint
:	*****************************
:	
: A F 12.0	Flag 0 (for unused functions
: R F 12.0	in FB250)
: AN F 12.1	Flag 1
: S F 12.1	
:	
: JU FB 250	Read actual value
NAME : RLG:AE	
BG : KF +128	Module address
KNKT : KY 0,6	Channel No. 0, fixed-point bipolar
OGR : +2047	Upper limit for actual value
UGR : -2047	Lower limit for actual value
EINZ : F 12.0	No selective sampling
XA : DW 22	Store scaled actual val. in contr. DB
FB : F 12.2	Error bit
BU : F 12.3	Range violation
TBIT : F 12.4	Activity bit
:	
:	
: JU FY 250	Read setpoint

FB 10 (Continued) STL	Description
NAME :RLG: AE	
BG : KF +128	Module address
KNKT : KY 1,6	Channel No. 1, fixed-point bipolar
OGR : KF +2047	Upper limit for setpoint
UGR : KF -2047	Lower limit for setpoint
EINZ : F 12.0	No selective sampling
XA : DW 9	Store scaled setpoint in contr. DB
FB : F 13.1	Error bit
BU : F 13.2	Range violation
TBIT : F 13.3	Activity bit
:	
:A F 10.0	In manual mode, the setpoint is
:JC =WEIT	set to the act. val. to force
:L DW 22	the controller to react
:T DW 9	to a system deviation, if any,
:	with a P step on transfer to
:	Automatic mode
:	
:	
WEIT :	
:	********************************
: JU OB 251	Invoke controller
:	********************************
:	
:	********************************
:	Output manipulated variable Y
:	********************************
:JU FB 251	
NAME :RLG: AA	
XE : DW 48	Forward man. var. to analog output mod.
BG : KF +176	Module address
KNKT : KY 0,1	Channel 0, fixed-point bipolar
OGR : KF +2047	Upper limit for actuating signal
UGR : KF -2047	Lower limit for actuating signal
FEH : F 13.5	Error bit when limiting values defined
BU : F 13.6	Range violation
:BE	

DB 30 STL				Description
0:	KH	=	0000;	
1:	KF	=	+01000;	K parameter (here=1), factor 0.001
2:	KH	=	0000;	(Value range: -32768 to 32767)
3:	KF	=	+01000;	R parameter (here=1), factor 0.001
4:	KH	=	0000;	(Value range: -32768 to 32767)
5:	KF	=	+00010;	TI=TA / TN(here=0.01), factor 0.001
6:	KH	=	0000;	(Value range: 0 to 9999)
7:	KF	=	+00010;	TD=TV / TA(here=10), factor 1
8:	KH	=	0000;	(Value range: 0 to 999)
9:	KF	=	+00000;	Setpoint W, factor 1
10:	KH	=	0000;	(Value range: -2047 to 2047)
11:	KM	=	00000000 00100000;	Control word
12:	KF	=	+00500;	Manual value YH, factor 1
13:	KH	=	0000;	(Value range: -2047 to 2047)
14:	KF	=	+02000;	Upper cont. limit bgog, factor 1
15:	KH	=	0000;	(VALUE RANGE: -2047 TO 2047)
16:	KF	=	-02000;	Lower cont. limit BGUG, factor 1
17:	KH	=	0000;	(Value range: -2047 to 2047)
18:	KH	=	0000;	
19:	KH	=	0000;	
20:	KH	=	0000;	
21:	KH	=	0000;	
22:	KF	=	+00000;	Actual value X, factor 1
23:	KH	=	0000;	(Value range: -2047 to 2047)
24:	KF	=	+00000;	Disturbance variable z, factor 1
25:	KH	=	0000;	(Value range: -2047 to 2047)
26:	KH	=	0000;	
27:	KH	=	0000;	
28:	KH	=	0000;	
29:	KF	=	+00000;	Feedforward XZ for diff.,
30:	KH	=	0000;	Factor 1 (-2047 to 2047)
31:	KH	=	0000;	
32:	KH	=	0000;	
33:	KH	=	0000;	
34:	KH	=	0000;	
35:	KH	=	0000;	
36:	KH	=	0000;	
37:	KH	=	0000;	
38:	KH	=	0000;	
39:	KH	=	0000;	
40:	KH	=	0000;	
41:	KH	=	0000;	
42:	KH	=	0000;	
43:	KH	=	0000;	
44:	KH	=	0000;	
45:	KH	=	0000;	
46:	KH	=	0000;	
47:	KH	=	0000;	
48:	KF	=	+00000;	Controller output Y, factor 1
49:	KH	=	0000;	(Value range: -2047 to 2047)
50:				

9 Communications Capabilities and Interrupt Processing

Figures

Tables

9 Communications Capabilities and Interrupt Processing

The processors of individual modules (CPUs, CPs, or intelligent I / Os) can exchange information in different ways.

9.1 Data Interchange

Section 9.1.1 explains how the data interchange between the CPU and the CPs or intelligent I / Os is organized.

9.1.1 Interprocessor Communication Flags

Binary signals are exchanged between CPU 924H and some communications processors, e.g., CP 526, via interprocessor communication flags. The CPU processes interprocessor communication flags like normal flags. However, they are stored in a special 256-byte memory area between the addresses $F200_{\mathbf{H}}$ and $F2FF_{\mathbf{H}}$.
You can define the interprocessor communication flags using the COM 115H software.

The transfer of interprocessor communication flags is similar to the transfer of inputs and outputs to and from the process images. The procedure is as follows:

- The interprocessor communication input flags are read in and stored in the appropriate memory area prior to program scanning.
- Interprocessor communication output flags are transferred to the appropriate CPs at the end of program scanning.

Interprocessor communication output flags can be treated like normal flags. Interprocessor communication input flags should be scanned only, since the setting or resetting of bits can be reversed during the next data transfer.

Signal Exchange with one CP

Set jumpers on the CP to enable the area required as interprocessor communication flag bytes. The jumpers divide the area between bytes 0 and 255 into eight blocks of 32 bytes each.
Normally the entire interprocessor communication flag area is enabled. Setting is necessary only when you use several CPs with interprocessor communication flags. The IPC flags are defined over COM 115H. The specified bytes must lie within the set area on the CP. You can choose any bytes from this area, but you should use as few bytes as necessary to keep transfer times to a minimum.

Special Points to Observe when Using the CP 525 and CP 526 in RESTART Mode

Note:
If the CP 525 and CP 526 are used in the S5-115H, the interprocessor communication flag area enabled on the CPs should be reset on RESTART in connection with the following CP functions:
CP 525 (6ES5 525-3UA11):
- Component: Event printer if group disable bits are used
- Component: Operator-process communication and visualization with the 3975 display unit if bit set and reset commands are used
  general: Group disable bits should always be located in the interprocessor communication flag area enabled per jumper setting.

CP 526 (6ES5 526-3Lxxx):
- Basic board: If bit set and reset commands are used

Before synchronizing the CPs, an FB should be called in OB 21 / 22. This FB should be programmed as shown in the following example:

Example:

Function block FBxxx (e.g. FB 11) for resetting the interprocessor communication flag area on a CP. The communication flag areas enabled by jumpers on the CP can be reset with the following block. This FB must be specified with its starting flag byte (V-MB) and end flag byte (B - MB) for each contiguous communication flag area.
If a flag byte that does not define an area boundary is specified here, the entire area is still reset.

V-MB	:	FB35	(from)
B-MB	:	FB165	(to)

This resets the communication flag area from flag byte FB 32 to flag FB 191. This area must naturally have been enabled on the CP.

FB 11 STL	Description
NAME : K-MB LOE	FB for resetting IPC flags
DES : V-MB I/Q/D/B/T/C: E BI/BY/W/D: BY	
DES : B-MB I/Q/D/B/T/C: E BI/BY/W/D: BY	
: LW =V-MB	Compute starting address
: L KH00FF	
: AW	
: L KHF200	
: OW	
: L KHFFE0	
: AW	
: T FW250	Starting address
: LW =B-MB	Compute end address
: L KH00FF	
: AW	
: L KHF200	
: OW	
: L KH001F	
: OW	
: L KHFFFE	
: AW	
: T MW252	
M001 :	End address
: L KH0000	
: L FW250	Loop for
: TIR 2	Resetting IPC
: L FW252	Flags
: !=F	
: BEC	
: L FW250	
: ADD KF+2	
: T FW250	
: JU =M001	
: BE	

Signal Exchange with Several CPs

If one CPU addresses several CPs, one or more interprocessor communication flag areas must be enabled on each CP. When setting the jumpers on the CPs, please note the following points:

- The areas on the individual CPs must not overlap (to prevent duplicate address assignment).
- The areas on the individual CPs do not have to be assigned consecutively .

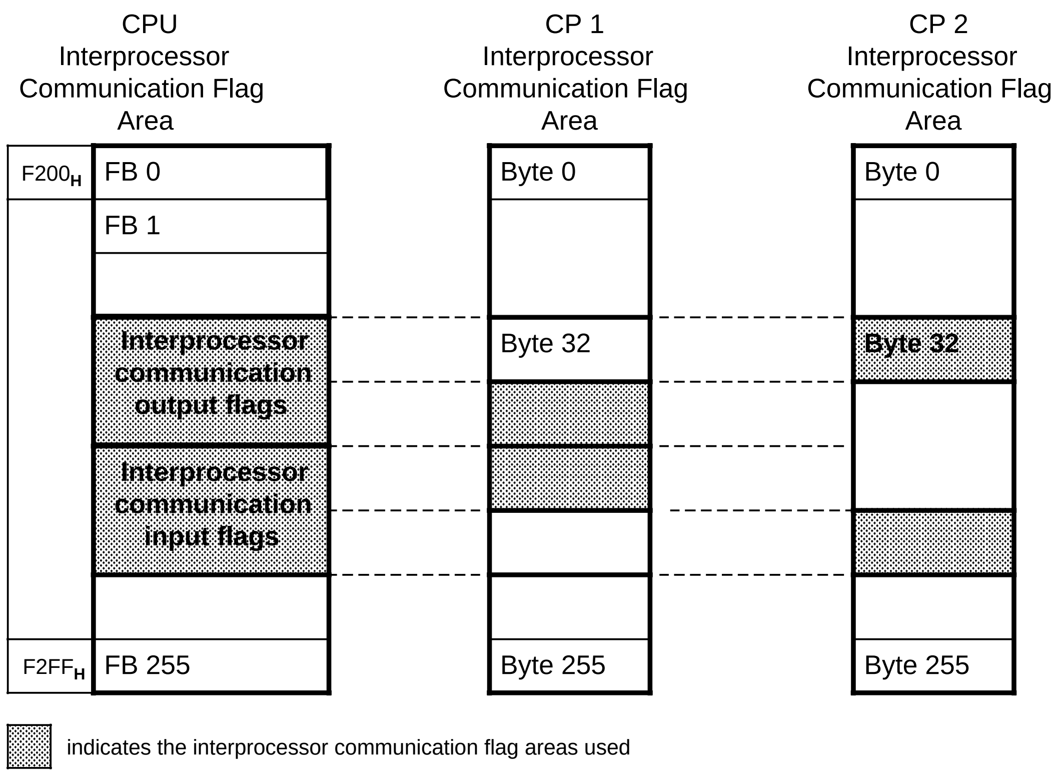


Figure 9-1. Interprocessor Communication Flag Areas When Several CPs Are Used

Define the interprocessor communication flag bytes in the usual manner with COM 115H.

Example:

Use one CPU to address two CPs. Table 9-1 shows the flag bytes needed and possible numbering.

Table 9-1. Definition of Interprocessor Communication Flags When Two CPs Are Used (Example)

CPs	Number of Control Bytes (Outputs)	Number of Scan Bytes (Inputs)	CP Flag Areas Set	CPU Interprocessor Communication Output Flags	CPU Interprocessor Communication Input Flags
CP 1	8	4	Bytes 128 to 159	FB 128 to 135	FB 156 to 159
CP 2	6	10	Bytes 160 to 191	FB 170 to 175	FB 160 to 169

9.1.2 Page Frame Addressing

Modules that can be programmed and initialized (CPs and IPs) process complex jobs in the SIMATIC S5 system. These modules have a one-kilobyte two-channel RAM for data exchange with the PLC. In the CPU, this interface memory is assigned an address range that can be addressed linearly or via a page frame.[1]
For linear addressing, each interface needs a one-kilobyte area in user memory. In order to prevent a loss of capacity when several CPs are used, all CPs and some intelligent I / Os are addressed via a page frame on the S5-115H. In addition to the memory area $F400_H$...$F7FF_H$ for the page frame, only one memory location is needed in the internal register to specify an interface number (address $FEFF_H$) between 0 and 255.

The same numbers are set on the module. This procedure determines which interface is addressed through the page frame. If a module has two interfaces, they are numbered in ascending order.

Data handling blocks are used for data exchange (Section 11.1.3). They must be called by the control program. The essential information for a particular job is entered in the parameter list of the handling block.

9.2 SINEC L1 Local Area Network

SINEC L1 is a communications system that networks SIMATIC S5 programmable controllers of the U range. SINEC L1 can be used, for example, for the following:

- Centralized control and monitoring of production plants for non-time-critical tasks
- Forwarding of machine status
- Management information
- Production statistics
- Remote programming (programmer bus functions)

9.2.1 Principle of Operation of the SINEC L1 Local Area Network

The SINEC L1 LAN works according to the master-slave principle. One master and up to 30 slaves can be interfaced to the network.

- The **master** is a separate PLC that handles the entire coordination and monitoring of data traffic in the local area network. The master PLC must have a CP 530 communications processor.
- A **slave** can be any SIMATIC S5 PLC.

The S5-115U CPUs have integrated data handling blocks that support SINEC L1 master operation.

1 A page frame, or page, is a specific area of the user memory

Each node, master or slave, needs a BT 777 transceiver as level converter.
The BT 777 can be connected to:

- the slave CPU's programmer port (in which case, data is interchanged via Send / Receive mailboxes in CPU memory. Data traffic over the programmer interface is discussed in Section 9.2.3.

or

- the CP 530's SINEC L1 interface, in which case data interchange is handled by data handling blocks integrated in the CPU 942H (Section 8.1.3).
  For detailed information, refer to the "SINEC L 1 Local Area Network" manual, Order No. 6ES5 998-7LA11.

Data is transferred over a 4-wire shielded cable that interconnects the various transceivers.

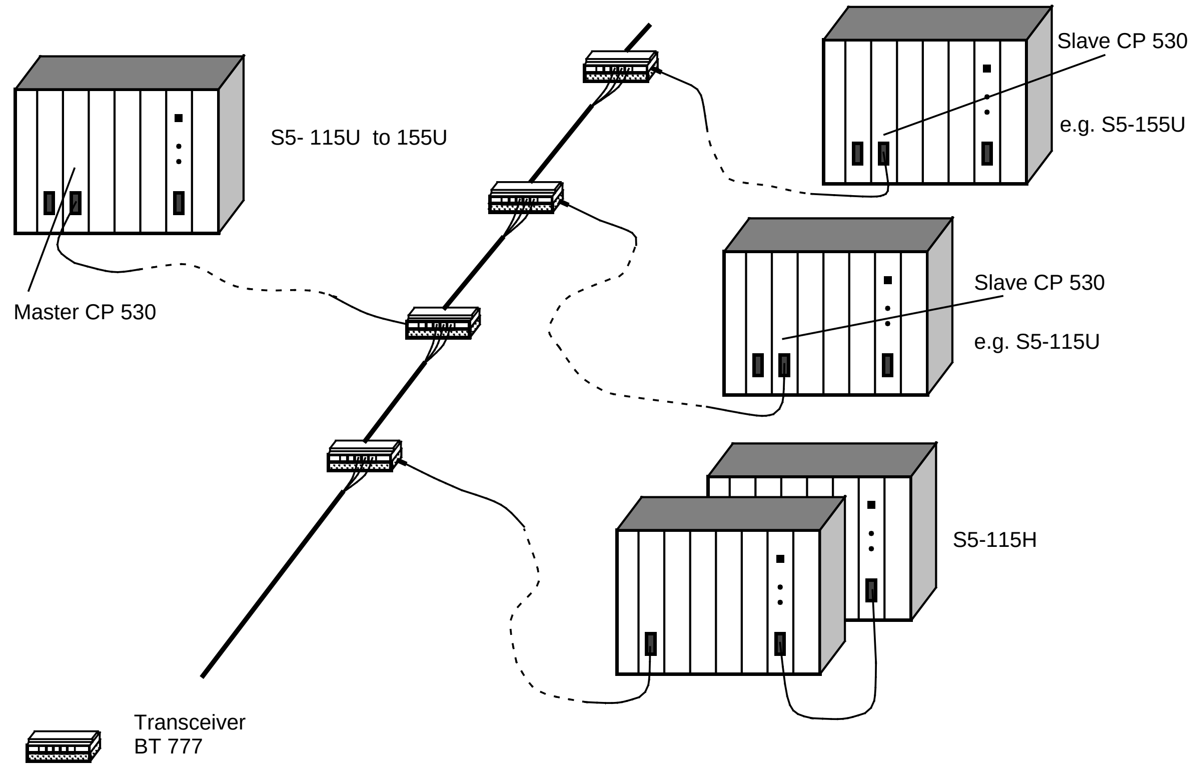


Figure 9-2. PLCs Linked Over the SINEC L1 Local Area Network

You can transfer data over the SINEC L1 local area network in the following two ways:

- from one node to another
  - master slave
  - slave master
  - slave slave
- from one node to all other nodes simultaneously (broadcast)

The following data can be transmitted:

- signal states of inputs, outputs, and flags;
- contents of data words.

Besides data, you can also transmit programmer functions on the SINEC L1 local area network. A programmer that is connected to the master's CP 530 can address individual slaves (SINEC L1 manual 6ES5 998-7LA11).

9.2.2 The S5-115H on the SINEC L1 LAN

The S5-115H can be interfaced to the SINEC L1 local area network in a variety of capacities, of which the following are discussed in this section:

- simple SINEC L1 LAN with one subunit as SINEC L1 slave
- simple SINEC L1 LAN with both subunits as SINEC L1 slaves
- two SINEC L1 LANs, each with one subunit as SINEC L1 slave.

Simple SINEC L1 LAN with one subunit as SINEC L1 slave

Features provided by the operation of one subunit on the SINEC L1 LAN (Figure 9-3):

- Same degree of availability as the S5-115U
- Simple interfacing to the LAN over the CPU's programmer port
- Data transfer to the S5-115H
  - when the subunit is working in solo-mode
  - in redundant mode (i. e. also over the ”standby” unit)
- Same protection against message frame loss

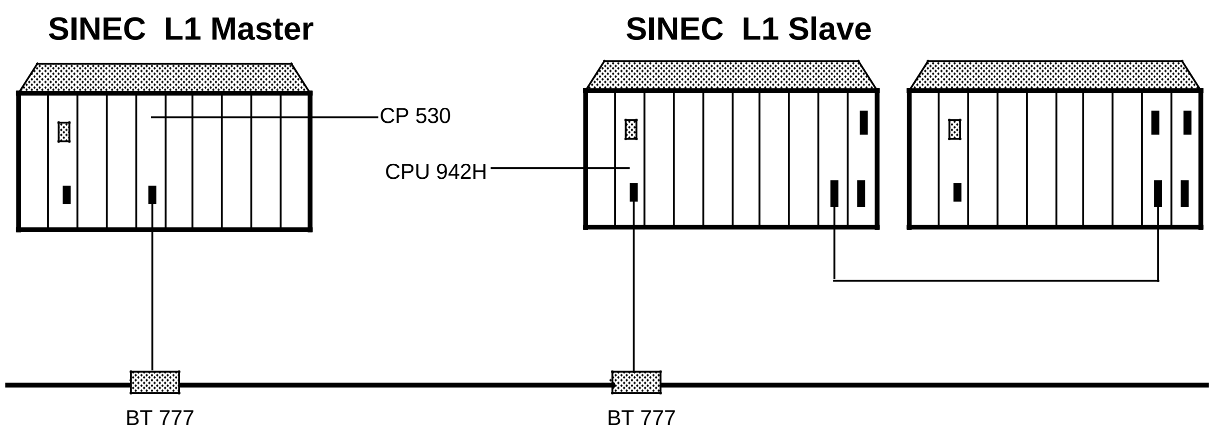


Figure 9-3. Simple SINEC L1 LAN, S5-115H With One SINEC L1 Node

Simple SINEC L1 LAN with Both Subunits

Features provided by the operation of both subunits on one SINEC L1 LAN (Figure 9-4):

- A high degree of availability
- Simple interfacing of the LAN over the CPU's programmer port
- Two separate, autonomous slave PLCs
- Data transfer possible at any time, even when one subunit is at STOP
- Redundancy function through comparison of the transmitted frames in the control prgram possible
- Protection against frame loss through frame comparison in the control program
- Minimal on-loading of cycles through distribution of frames to both subunits

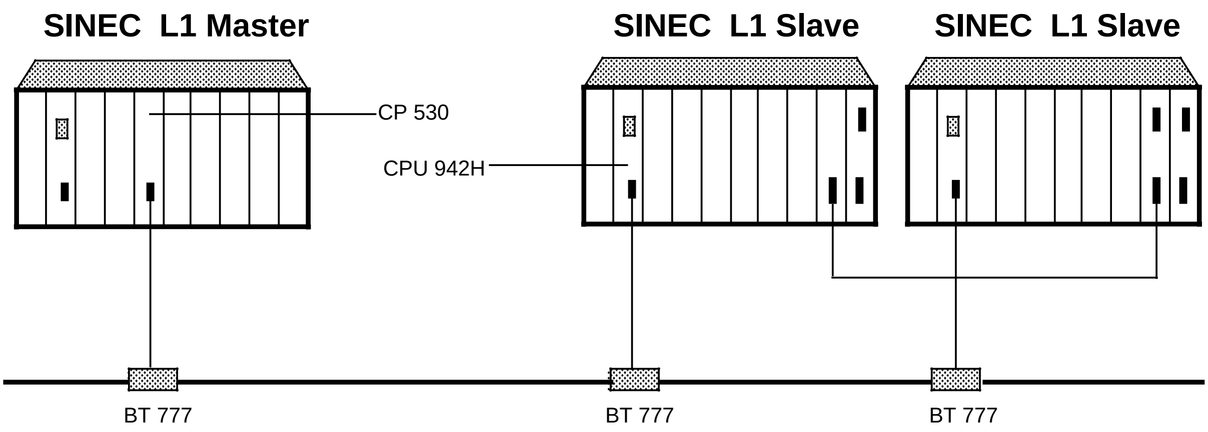


Figure 9-4. Simple SINEC L1 LAN, S5-115H With Two SINEC L1 Nodes

Two SINEC L1 LANs with One Subunit Each as SINEC L1 Slave

Features provided by two SINEC L1 LANs, each with one subunit as slave (Figure 9-5):

- An extremely high degree of availabilty for the entire SINEC L1 system
- Easy interfacing to the LAN over the CPU's programmer port
- Two autonomous slave PLCs
- Data transfer possible at any time, even when one subunit is at STOP
- Redundancy function possible through comparison of the transmitted frames in the control program
- Protection against frame loss through frame comparison in the control program
- Minimal on-loading of cycles through distribution of the telegrams to both subunits.

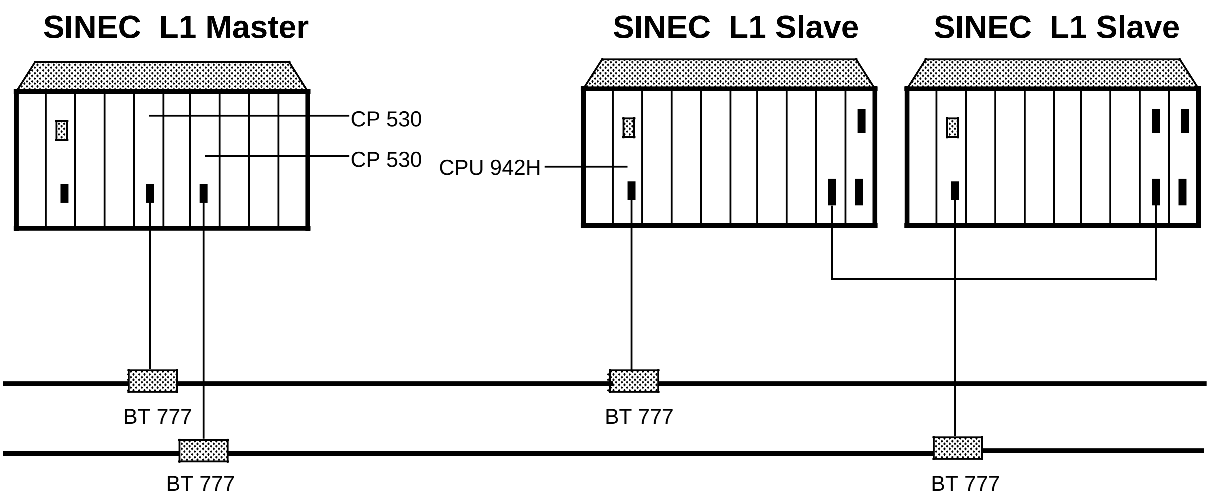


Figure 9-5. Two SINEC L1 LANs, S5-115H With One SINEC L1 Node Each

9.2.3 Data Traffic over the CPU Serial Interface

A slave needs the following to interchange data:

- a slave number (1...30)
- a Send mailbox
- a Receive mailbox
- coordination bytes

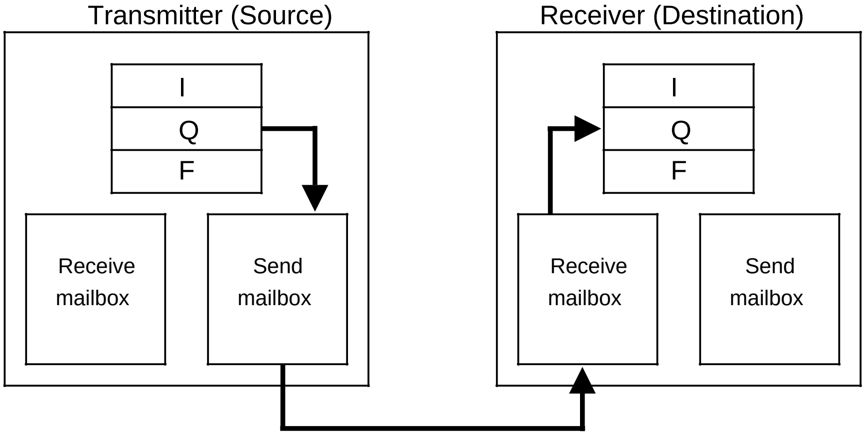


Figure 9-6. Data Transport

Send and Receive Mailboxes

The Send and Receive mailboxes contain send and receive data. They can hold up to 64 bytes of information. They also contain the following:

- Length of the data packet (1 to 64 bytes)
- Type of mailbox
  - The Send mailbox specifies the destination number.
  - The Receive mailbox contains the source number.

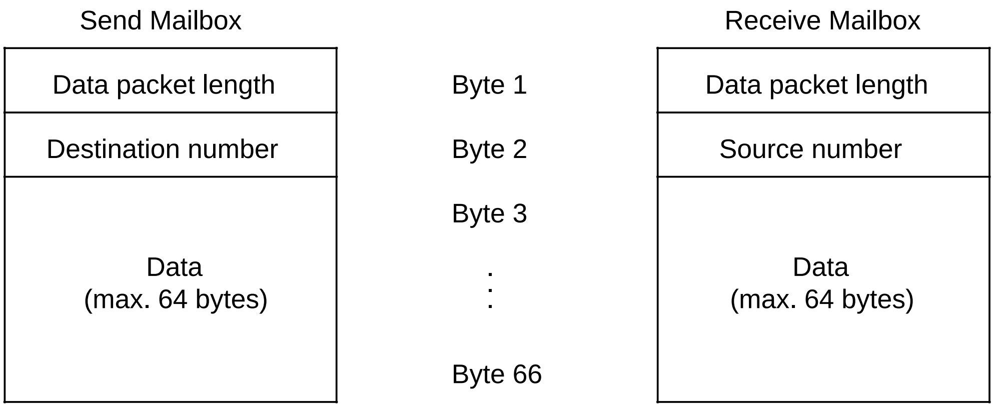


Figure 9-7. Structure of the Send and Receive Mailboxes

The source or destination number indicates the ”device” with which you want to communicate. Refer to Table 9-2 for the meaning of these numbers.

Table 9-2. Destination and Source Number Assignment

Assignment	Partner
0	Master
1 to 30	Slave
31	Broadcast

Use the control program to access the mailboxes.

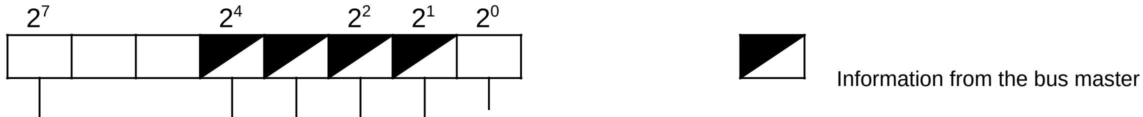
You can assign to the location of the mailboxes.
You can define the starting addresses of the mailboxes in either of the following ways:

- Specify a data block and a data word.
- Specify a flag word.

Coordination Bytes

Coordination bytes form the interface to the PLC's operating system. The control programs for the slaves use these bytes to track the flow of local area network traffic and to influence it. The following Figures describe the meanings of individual bits.

Coordination Byte for "Receive" (CBR) (Flag byte or high byte in data word)



Error
0: no error
1: error during last data transfer

Slave OFF
0: no slave failed
1: at least one slave failed

LAN RUN
0: local area network is in the "STOP" mode
1: local area network is in the "RUN" mode

PG BIT
0: function not defined
1: programmer requests local area network access

Interrupt
0: no signal
1: data packet is coming as express transmission

REC-PERM
0: The program can fetch data from the Receive mailbox. The operating system has no access.
1: The operating system can retrieve data from the local area network via the Receive mailbox. The program has no access.
If REC-PERM = "1," the operating system fills the Receive mailbox with data. Then the operating system resets REC-PERM to "0" (=0).

Figure 9-8. Structure of the Coordination Byte for "Receive"

Coordination Byte for "Send" (CBS) (Flag byte or high byte in data word)

Error during last data transfer
0: no error detected
1: error detected

PG BIT
0: function not defined
1: programmer requests local area network access

Interrupt
0: no signal
1: slave wants to deliver an express transmission or wants to overwrite the old message

SEND-PERM
0: The program can process the Send mailbox. The operating system has no access.
1: The Send mailbox is enabled to transmit on the local area network. The programm has no access.
SEND-PERM = "1" causes the operating system to transmit the contents of the Send mailbox. Afterwards the operating system resets the SEND-PERM bit to "0".

Figure 9-9. Structure of the Coordination Bytes for "Send" and "Receive"

Overflow

When data packets are received which exceed the length of the Receive mailbox, the data which cannot be accommodated in the mailbox are **lost**. The overflow is not reported.

The Receive mailbox ends

- with flag byte 255 if the mailbox is in the flag area.
- with the last data byte if the mailbox is in a data block.

9.2.4 Initializing the Serial Interface

Use COM 115H to define:

- the number of the local slave
- data or flag areas for the Send **and** Receive mailboxes
- the locations of the coordination bytes (CBR and CBS)

If required, you may also define:

- the number of the local programmer for programmer LAN functions

9.3 Interrupt Processing

Cyclic program scanning can be interrupted by
- process interrupts (interrupt-driven program scanning)
- timed interrupts (time-controlled program scanning)

9.3.1 Interrupt-Driven Program Scanning

The program is interrupt-driven when a signal from the process causes the CPU to interrupt cyclic program scanning and execute an interrupt service routine (organization block).
Following execution of the interrupt service routine, the CPU resumes cyclic program scanning at the point of interruption.

Organization blocks OB 2 to OB 5 can be used for programming the interrupt service routines. Each OB is allocated to a particular interrupt circuit (Table 9-3).
Interrupt-generating modules (for example the 434-7 digital input module) and intelligent I / Os are needed to drive the interrupt circuits. A change in the signal state of an interrupt circuit (process interrupt) initiates execution of the associated OB.

Table 9-3. Process Interrupts and Associated Organization Blocks

Process Interrupt	Interrupt Circuit	Associated OB
Interrupt A	$\overline{\text{IRA}}$	OB 2
Interrupt B	$\overline{\text{IRB}}$	OB 3
Interrupt C	$\overline{\text{IRC}}$	OB 4
Interrupt D	$\overline{\text{IRD}}$	OB 5

Note:
When using a 434-7 interrupt module, the CP and IP modules may generate interrupts B, C and D only.

The following are characteristic of interrupt-driven program scanning:

- **Interrupt Sources:**
  Intelligent I / Os and digital input modules which generate process interrupts

- **User interface:**
  The operating system executes the following OBs in the event of hardware interrupts:
  Interrupt A: OB 2
  Interrupt B: OB 3
  Interrupt C: OB 4
  Interrupt D: OB 5

  Cyclic program scanning is continued if the interrupt OBs have not been programmed.

- **Interruption points:**
  A process interrupt can interrupt the cyclic program and the service routine for timed interrupts following a synchronization statement (RA, JU, JC), and can interrupt integral function blocks and the operating system at predefined interruption points.
  In order to ensure interrupt servicing, the TNB statement is interruptable after no more than 7 ms in systems with a CPU 942H.

CAUTION:
If integral function blocks are used in the cyclic program, the service routines for timed interrupts and the service routines for process interrupts, you must disable the interrupts with "IA" prior to each call of an integral FB in the cyclic program and in the service routine for timed interrupts.

- **Disabling interrupts:**
  Interrupts can be disabled with the IA operation and reenabled with the RA operation. One interrupt per interrupt circuit can be queued during the period in which interrupts are disabled.

- **Interrupt priority:**
  It is not possible to interrupt an interrupt service routine. When interrupts occur simultaneously, they are assigned priorities:

Highest priority:	Interrupt A
	Interrupt B
	Interrupt C
Lowest priority	Interrupt D

- **Nesting depth:**
  The nesting depth for blocks, which is 16, also applies to blocks in interrupt service routines.

- **Interrupt reaction time:**
  The reaction time for integral FBs (FB 240 to FB 253) is 7 ms at the most. For all other blocks in the control program, the interrupt reaction time is the amount of time which elapses between
  - two Interrupt Enable (RA) statements
  - an RA statement and a block boundary
  - two block boundaries

  Because of certain hardware restrictions, the process interrupt input cannot accommodate interrupt sequences 12 µs, as otherwise interrupts would be lost.

- **Saving data:**
  If "scratch flags" used in the cyclic program or in the service routine for timed interrupts are also used in the service routines for process interrupts, they must be saved in a data block at the beginning of the process interrupt service routines.

9.3.2 Interrupt Processing with the 434-7 Digital Input Module

The 434-7 is a digital input module with programmable process interrupt generation. This module always generates interrupt A (the highest-priority interrupt).
In the S5-115H, you can use one 434-7 digital input module as redundant interrupt module. All other 434-7s can be used only as single-channel modules.
The 434-7 interrupt module can not be operated in the expansion unit for switched I / Os.
The module reacts to an edge change at the interrupt-generating inputs by:

- Initiating an interrupt request to execute OB 2
- Closing a signalling contact on the module (contact rating 200 mA, switching capacity max. 20 W). A LED signals closing of the contact.
  The signalling contact also remains closed in the event of a power failure, and can be reset only by energizing the 24 V Reset input.

1. Initial Module Addressing
During the Cold Restart routine, the module is entered as input-output module in the address space from $F000_H$ to $F0FF_H$, where it reserves two bytes. In the process image, however, the module is entered as output module only.

Note:
The IM 306 interface module must be set for the 434-7 to 16 channels.

Configuring the 434 Digital Interrupt Input Module
Configure the module with COM 115H as digital input module

- Type 1 for single-channel operation
- Type 3 without error locating for redundant operation

Configure the odd-numbered DI byte first. COM 115H automatically reserves the even-numbered DI byte (ALB). Since the module also reserves the associated output bytes, COM 115H also does so automatically.

Note:
You can configure the interrupt module only when the bytes automatically reserved by COM 115H have not already been reserved.

Initializing the Module in the Control Program
The 434 interrupt module must be initialized in Restart blocks OB 21 and OB 22.
You must specify

- which inputs are to serve as interrupt inputs in the high-order byte
- the type of edge that is to trigger the interrupt in the low-order byte.

Example: Inputs 2, 4 and 6 are to trigger an interrupt on a positive-going edge, inputs 1, 3 and 5 on a negative-going edge.

Bit Address of the Input

Interrupt Enable

7							0
0	1	1	1	1	1	1	0

High-order Byte

Interrupt-Triggering Edge

7							0
░	0	1	0	1	0	1	░

Low-order Byte

░ = Irrelevant, as the relevant bits are "0" in the high-order byte (no interrupt).

The following sequence of statements must be inserted into the Restart OBs:

STL	Description
L KM 01111110 00101010	Bit pattern for high-order and low-order byte is loaded into ACCUM 1.
T PW x	The information is transferred from ACCUM 1 to the module (x = module start address).

C A U T I O N:
Each module that was programmed in OB 21 or OB 22 must be scanned in OB 2.

Evaluating the Interrupts

When an interrupt-triggering edge change takes place at an interrupt input, the module issues an interrupt request to the CPU (PRAL-N* signal over the internal bus system).
When it receives this request, the CPU interrupts the cyclic program or service routine for timed interrupts and executes the interrupt service routine in OB 2.
Each input that is enabled for the interrupt must be scanned in OB 2. You can obtain the address of the inputs by incrementing the module start address by 1.
To do so, load the interrupt register with LPY in OB 2.
The LPY operation

- clears the interrupt register and
- makes it possible to queue new interrupts.

As the interrupts are not forwarded to the process input image, it is recommended that the **interrupt register** be transferred to the PII (for updating purposes). You can then select the interrupt reaction via input operations (e.g. A I x.y).

* Negated form of the PRAL signal (process interrupt).

Example: Inputs 0 and 1 on the module with start address 8 are to be scanned for an interrupt.

STL			Description
L	PY	9	Read interrupt register
T	IB	9	Transfer contents to the PII.
A	I	9.0	Scan input 0.
JC	PB	1	Service interrupt 0 in PB 1.
A	I	9.1	Scan input 1.
JC	PB	2	Service interrupt 2 in PB 2.
BE			

Status
The status scan of the inputs must be programmed in OB 1.
Prior to the scan, the signal states of the status register (even-numbered byte of the module) must be read and transferred to the process input image.

OB 1:

STL			Description
L	PB / PY*	x	Load peripheral byte "x" and transfer to input byte "x".
T	IB	x	(x=module start address)
A	I	x.y	Evaluate inputs (y = bit address).

* PY for programmers with S5-DOS

9.3.3 Programming Example

The digital interrupt input module has the start address "8".
Input 0 is to generate an interrupt on a positive-going edge. FB 12, which sets output byte 13 to FF_H, is to be called in the event of an interrupt request based on the signal state at this input.
Input 1 is to generate an interrupt on a positive-going edge. FB 13, which sets output byte 14 to FF_H, is to be called in the event of an interrupt request based on the signal state at this input.
None of the other inputs have interrupt capabilities. Input 2 will be used to set output 0.0, input 3 to reset this output.

Note:
The IM 306 must be set for 16-channel operation.

OB 21 and 22:

STL	Description
L KM 0000 0011 0000 0010 T PW 8 BE	Initialization of the interrupt inputs and edge generation

OB 2:

STL	Description
L PY 9 T IB 9 A I 9.0 JC FB 12 A I 9.1 JC FB 13 BE	Evaluation of the interrupt request

FB 12 STL	Description
Name: Rise L KH 00FF T QB 13 BE	Description of QB 13

FB 13 STL	Description
Name: Fall L KH 00FF T QB 14 BE	Description of QB 14

OB 1 STL	Decription
L PB / PY* 8 T IB 8 A I 8.2 S Q 0.0 A I 8.3 R Q 0.0 BE	Evaluation of inputs 2 and 3

9.3.4 Time-Controlled Program Scanning

On the CPU 942H, OB 13 is used to program a routine for servicing timed interrupts. The user specifies the interval at which the operating system calls this OB. It is also possible to change the interval during cyclic program scanning.
Cyclic program scanning is continued if this OB has not been programmed.

Note:
OB 13 can interrupt cyclic program scanning, but cannot interrupt the service routines for process interrupts.

- **Setting the Call Interval:**
  The call interval can be set in the system data as a multiple of 10 ms.
  The default value is 100 ms. It is thus possible to set an interval of from 0.01 to 600 s (L KH 0 to FFFF).
  If the relevant location in the system data is initialized to 0, the OB 13 call is suppressed.

  Note:
  Each execution of OB 13 increases the scan time. For this reason, avoid OB 13 call intervals less than 100 ms.

- **Interruption points:**
  The cyclic program can be interrupted after any synchronization command (RA, JU, JC). OBs used as service routines for timed interrupts cannot interrupt integral function blocks or the operating system.

- **Disable OBs for Timed Interrupt Servicing:**
  All calls for the OBs which service timed interrupts can be disabled with RA and reenabled with IA. One call request can be stored during the time in which the calls are disabled.

- **Nesting Depth:**
  The nesting depth for blocks, i.e. 16, also applies to blocks invoked in OBs which service timed interrupts.

Saving Data:
When "scratch flags" are used in the OB for timed interrupts which are also used in the cyclic control program, they must be saved in a data block at the beginning of the interrupt service routine.

10 STEP 5 Programming

Figures

Tables

10 STEP 5 Programming

This chapter explains how to program automation tasks with the S5-115H. It describes how to write a program, how the program is structured, the types of blocks the program uses, and the number representation of the STEP 5 programming language. It also covers special information on programming the S5-115U.

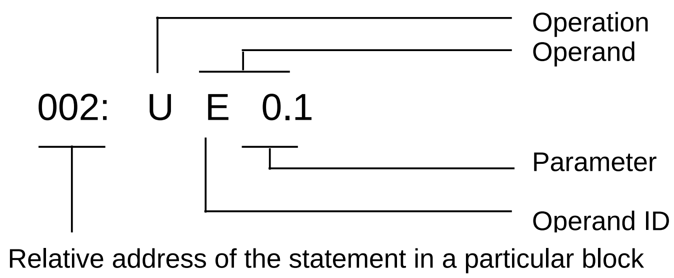
10.1 Writing a Program

A control program specifies a series of operations that tell the programmable controller (PLC) how it has to control a system. You must write the program in a very special language and according to specific rules so that the PLC can ”understand” it. The standard programming language that has been developed for the SIMATIC S5 family is called STEP 5.

10.1.1 Methods of Representation

The following methods of representation are possible with the STEP 5 programming language:

- **Statement List (STL)**
  The STL represents the program as a sequence of operation mnemonics. A statement has the following format:



  The operation instructs the PLC what to do with the operand. The parameter specifies the operand address.

- **Control System Flowchart (CSF)**
  A CSF represents logic operations using symbols.

- **Ladder Diagram (LAD)**
  A LAD represents control functions using circuit diagram symbols.

- **GRAPH 5**
  GRAPH 5 is used for graphics-bosed representation of the structure of sequence controls.

CSF, LAD, and GRAPH 5 are possible only with the PG 635, PG 675, PG 685, PG 695 and PG 750 programmers.

Each method of representation has its special characteristics. Therefore, a program block that has been programmed in STL cannot necessarily be output in CSF or LAD form. The graphic representation modes are not compatible to each other either. However, programs in CSF or LAD can always be converted to STL format. Figure 10-1 illustrates these points in a diagram.

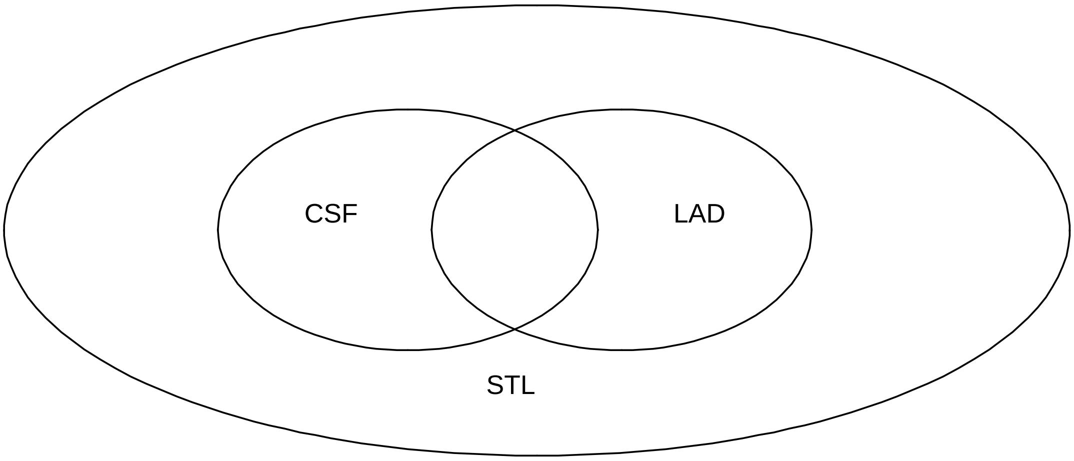


Figure 10-1. Compatibility of STEP 5 Methods of Representation

The STEP 5 programming language distinguishes between three types of operation:

- basic operations
- supplementary operations
- system operations

Table 10-1 provides further information on these operations.

Table 10-1. Comparison of Operation Types

STEP 5 PROGRAMMING LANGUAGE			
	Basic Operations	**Supplementary Operations**	**System Operations**
Application	in all blocks	only in function blocks	only in function blocks
Methods of Representation	STL, CSF, LAD	STL	STL
Special features			for users with good system knowledge

10.1.2 Operand Areas

The STEP 5 programming language recognizes the following operand areas:

I	(inputs)	interfaces from the process to the PLC
Q	(outputs)	interfaces from the PLC to the process
F	(flags)	for storing the intermediate results of binary operations
D	(data)	for storing the intermediate results of digital operations
T	(timers)	for implementing timers
C	(counters)	for implementing counters
P	(peripherals)	interface from the process to the PLC
K	(constants)	defined numeric values
OB, PB, SB, FB, DB	(blocks)	program structuring aids

Refer to Appendix A for a listing of all operations and operands.

10.1.3 Circuit Diagram Conversion

If your automation task is in the form of a circuit diagram, you must convert it to STL, CSF or LAD.

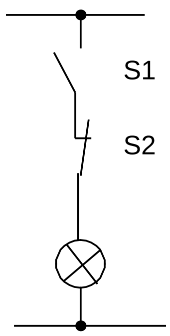
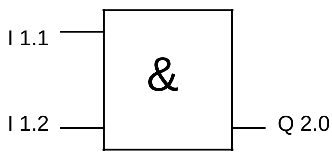
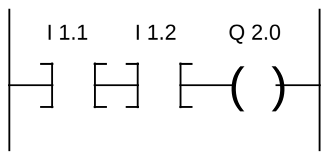
Example: **Hard-Wired Controller**

A signal lamp is to light up when a normally open contact (S1) is activated and a normally closed contact (S2) is not activated.

Programmable Controller

The signal lamp is connected to a PLC output (Q 2.0). The signal voltages of the two contacts are connected to two PLC inputs (I 1.1 and I 1.2). The PLC scans to see if the signal voltages are present (signal state ”1” at the activated normally open contact or nonactivated normally closed contact). The two signal states are ANDed. The result of the logic operation (RLO) is assigned to output 2.0 (the lamp lights up).

Circuit Diagram	STL	CSF	LAD

	`A I 1.1`
	`A I 1.2`
	`= Q 2.0`
			

10.2 Program Structure

An S5-115H program can be either linear or structured.
Sections 10.2.1 and 10.2.2 describe these two options.

10.2.1 Linear Programming

Programming individual operations in one section (block) is sufficient for handling simple automation jobs. For the S5-115H, this is organization block 1 (OB 1) (Section 10.3.1). The S5-115H scans this block cyclically (i.e., after it scans the last statement, it goes back to the first statement and begins scanning again).

Please note the following:

- When OB 1 is called, five words are reserved for the block header (Section 10.3.1).
- Normally, a statement takes up one word in the program memory. Two-word statements also exist (e.g., the operation ”Load constant”). Count these statements twice when calculating the program length.
- Like all blocks, OB 1 must be terminated by a Block End statement (BE).

10.2.2 Structured Programming

To solve complex tasks, it is advisable to divide a program into individual, self-contained sections (blocks).

This procedure has the following advantages:
- simple and clear programming, even for large programs
- capability to standardize sections of the program
- easy alteration
- simple program test
- simple start-up
- subroutine techniques (calling a block from different locations in the program)

There are five types of blocks in STEP 5:

- **Organization Block (OB)**
  Organization blocks manage the control program.

- **Program Block (PB)**
  Program blocks arrange the control program according to function-related or process-related aspects.

- **Sequence Block (SB)**
  Sequence blocks are special blocks for programming sequence control systems. They are handled like program blocks.

- **Function Block (FB)**
  Function blocks are special blocks for programming frequently recurring or especially complex parts of a program (e.g., reporting and arithmetic functions). They are programmable (i.e. can be assigned parameters), and have an extended operation set (e.g., jump operations within a block).

- **Data Block (DB)**
  Data blocks store data needed to process a control program. Actual values, limiting values, and texts are examples of data.

The program uses block calls to exit one block and jump to another. You can therefore nest program, function, and sequence blocks as required in up to 16 levels (Section 10.3).

Note:
When calculating the nesting depth, note that the system program itself can call an organization block under certain circumstances (e.g. OB 31).

The total nesting depth is the sum of the nesting depths of all programmed organization blocks. If nesting goes beyond 16 levels, the PLC goes into the "STOP" mode with the error message "STUEB" (block stack overflow). Figure 10-2 illustrates the nesting principle.

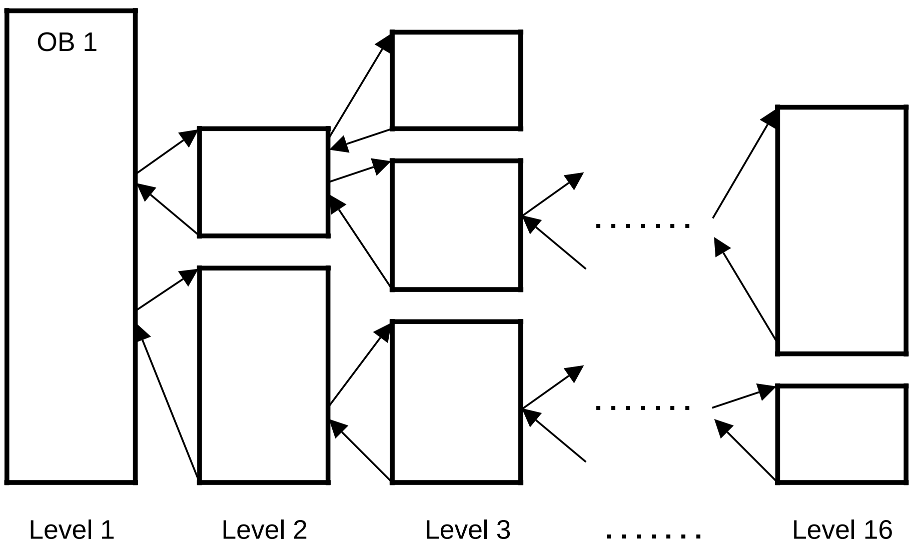


Figure 10-2. Nesting

10.3 Block Types

Table 10-2 lists the most important features of the various block types.

Table 10-2. Comparison of Block Types

	OB	PB	SB	FB	DB
Quantity	256 [1] OB 0...OB 255	256 PB 0...PB 255	256 SB 0 to SB 255	256 [2] FB 0 to FB 255	254 [3] DB 2 to DB 255
Maximum length	8×2^{10} byte	8×2^{10} byte	8×2^{10} byte	8×2^{10} byte	2042 Data Words [4]
Operations set (contents)	Basic operations	Basic operations	Basic operations	Basic, supple-mentary, system operations	Bit patterns Numbers Texts
Representa-tion methods	STL, CSF, LAD	STL, CSF, LAD	STL, CSF, LAD	STL	
Block header length	5 words	5 words	5 words	5 words	5 words

1 The operating system can call special OBs on its own initiative (Section 10.3.1 and Chapter 8).

2 Special function blocks are already integrated in the operating system (Chapter 8).

3 Data blocks DB 0 and DB 1 are reserved.

4 A data block can be referenced up to DW 255 with ”L DW” or ”T DW.”.

Block Structure

Each block consists of the following:
- Block header specifying the block type, number, and length.
  The programmer generates the block header when it converts the block.
- Block body with the STEP 5 program or data.

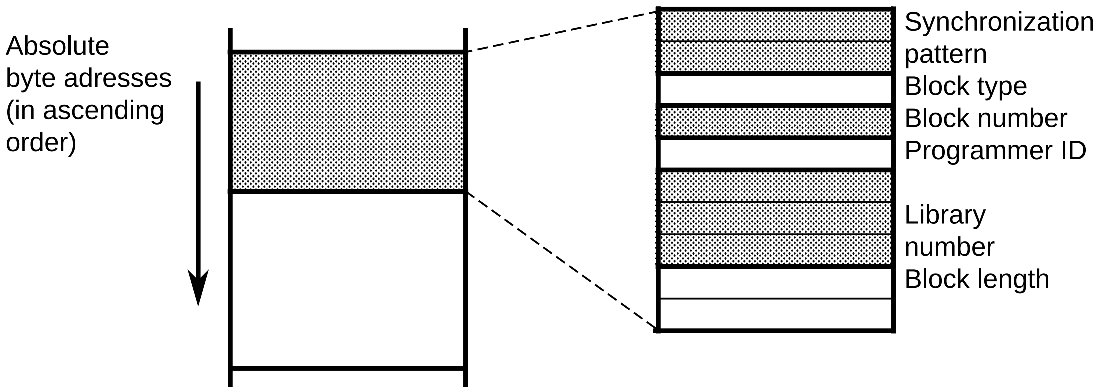


Figure 10-3. Structure of a Block Header

Programming

Program your blocks as follows (does not apply to data blocks):
1. Specify the block type (e.g., PB).
2. Specify the block number (e.g., 27).
3. Enter the control program statements.
4. Terminate the block with the ”BE” statement.

10.3.1 Organization Blocks (OBs)

Organization blocks form the interface between the operating system and the control program.

Organization blocks are handled in either of the following two ways:
- The operating system calls them in response to events or at certain times.
- The control program can call them as operating functions (Chapter 8).

Table 10-3 provides an overview of organization blocks.

All organization blocks can be programmed with parameters in the range from 0 to 255. However, they must be called in the control program.

Table 10-3. Overview of CPU 942H Organization Blocks

OB No.	Function
OB must be user-programmed and is called by the operating system.	
OB 1	Cyclic program scanning
Interrupt- driven program scanning with priorities A, B, C, D	
OB 2	Interrupt A: Digital input module -434 and IP generate interrupt
OB 3	Interrupt B: IP generates interrupt
OB 4	Interrupt C: IP generates interrupt
OB 5	Interrupt D: IP generates interrupt
OB 13	Time-controlled program scanning
Handling of restart procedures	
OB 21	Manual switch-on (STOP RUN)
OB 22	Automatic switch-on when power is restored
Handling of programmer and PLC errors	
OB 34	Battery failure
OB 37	Error OB
OB is already programmed. OB must be called by the user.	
OB 31	Scan time triggering[1]
OB 251	PID control algorithm

1 The CPU 942H requires a ”dummy” OB 31 comrprising nothing but a ”BE” statement.

Figure 10-4 shows how to set up a structured control program. It also illustrates the significance of organization blocks.

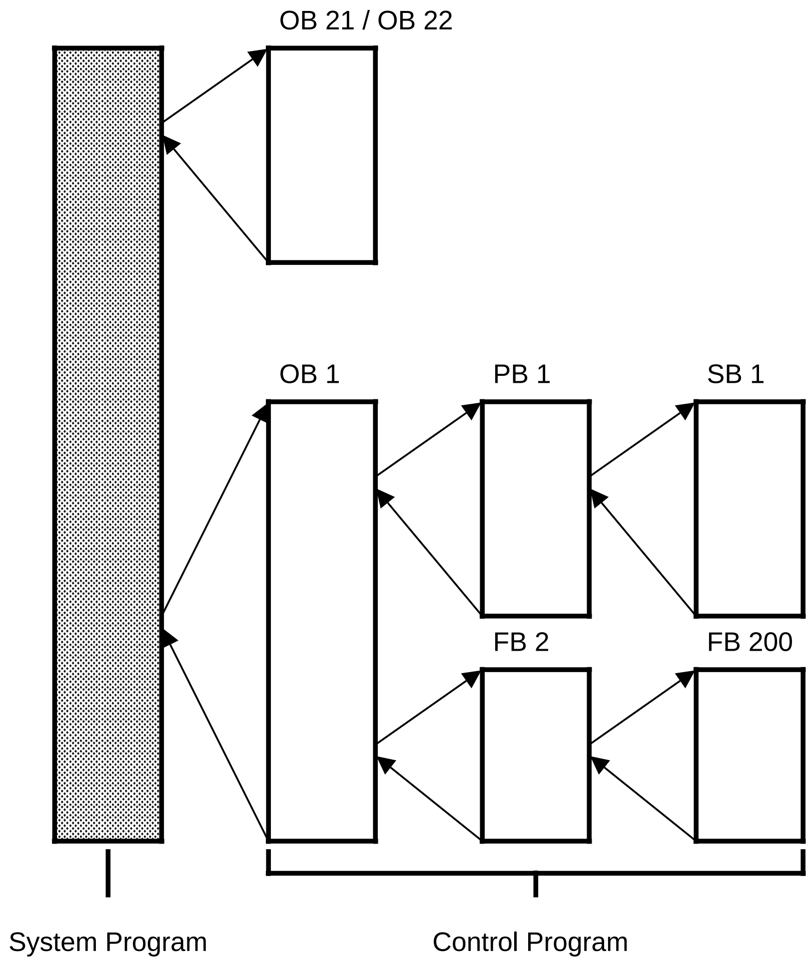


Figure 10-4. Example for the Use of Organization Block

The functions of the various organization blocks are described on the following pages.

OB 1: Cyclic Program Scanning

The structure of the control program is established in OB 1, i.e. OB 1 comprises a string of block calls. The order in which these calls are written determines the order in which the PBs or FBs are executed. Calls can be conditional or unconditional.

OB 2 / 3 / 4 / 5: CPU 942H Interrupt Processing

CPU 942H enables ”interrupt-driven” processing. Interrupt-driven processing occurs when a signal from the process causes the CPU in the PLC to interrupt cyclic scanning and process a specific program. After the CPU processes the special program, it returns to the point of interruption in the cyclic program and continues scanning from there.
Interrupt driven processing is characterized by the following features:

- **Interrupt Sources**
  Intelligent input / output modules and digital input modules with process interrupt capability (Section 9.3).

- **User Interface**
  The CPU processes the following OBs in the event of a hardware interrupt:
  Interrupt A: OB 2
  Interrupt B: OB 3
  Interrupt C: OB 4
  Interrupt D: OB 5

If the interrupt OBs are not programmed, cyclic scanning continues.

- **Interruption points:**
  The cyclic program scan and the service routine for timed interrupts can be interrupted after any synchronization statement (RA, JU, JC). The integral function blocks and the operating system can be interrupted at predefined interruption points.
  To ensure a reaction to an interrupt, the TNB operation can be interrupted after no more than 7 ms on CPU 942 systems.

CAUTION:
When integral function blocks are used in the cyclic program and / or in the service routine for timed interrupts as well as in the service routine(s) for process interrupts, you must disable all interrupts in the cyclic program / service routine for timed interrupts prior to each FB call!

- **Disable Interrupts**
  The IA operation disables interrupt processing; RA reenables it. The default setting is RA. One interrupt per interrupt channel can be queued in the interim.

- **Interrupt Priority**
  An interrupt service routine cannot be interrupted. If several interrupts occur simultaneously, they are serviced according to priority:
  Highest priority: Interrupt A
  Interrupt B
  Interrupt C
  Lowest Priority: Interrupt D

- **Nesting Depth**
  The nesting depth for blocks, i. e. 16 levels, may not be exceeded in the interrupt service routines.

- **Response Time**
  When integral FBs (FB 240 to FB 253) are used, the maximum response time is 7 ms. For all other blocks in the control program, the response time is the interval between synchronization points.
  Synchronization points in the control program are:
  - Block calls JU and JC
  - IA (Interrupt Enable)

  Due to certain hardware limitations, the process interrupt cannot accommodate interrupt sequences 12 µs, as otherwise interrupts would be lost.

- **Saving Data**
  If the process interrupt service routines use ”scratch flags” that are also used in the cyclic program or in the service routine for timed interrupts, these flags must be saved in a data block at the beginning of the process interrupt. If an interrupt block uses ”scratch flags”, that are also used in the cyclic control program, these flags must be saved in a data block during processing of the interrupt.

OB 13: Time-Controlled Program Scanning

CPU 942H provides OB 13 for servicing timed interrupts. The operating system processes the timed interrupt OB at intervals specified by the user. It is also possible to change the interval during cyclic program scanning. Cyclic program scanning is continued if the timed interrupt OB has not been programmed.

Note:
The OB for timed interrupts can interrupt cylic program processing but not the service routines for process interrupts.

- **Setting the Call Interval**
  You can set the call interval in the system data as a multiple of 10 msec. The default setting is 100 msec. You can set times from 0.01 s to 600 s (L KH 0...FFFF).
  A zero value suppresses the timed interrupt OB call.
  Each execution of OB 13 increases the scan time. For this reason, avoid OB 13 call intervals less than 100 ms.

- **Interruption points**
  A timed interrupt can interrupt:
  - the control program at the interruption points (IA, JU, JC statements)
  - the operating system
  - nonintegral function blocks
  - integral function blocks (after no more than 7ms)

  A timed interrupt cannot interrupt OB2.

- **Disabling Timed Interrupt OB Call**
  The IA operation disables all timed interrupt OB calls. The RA operation reenables these calls. One call request can be stored during call disable.

- **Nesting Depth**
  Even when a timed interupt OB is processed, the block nesting depth of 16 levels may not be exceeded.

Saving Data
If a timed interupt OB uses ”scratch flags” that are also used in the cyclic control program, these flags must be saved in a data block at the beginning of the timed interrupt OB.

Table 10-4. Parameter Block for Timed Interrupt OBs

System Data Word	Absolute Address	High-Order Byte	Low-Order Byte
SD 97	EAC2	Time interval for OB 13	

Example:

Setting an Interval of 1 sec. for OB 13:		
OB 21 : JU FB 21 NAME : TIME ON . .	OB 22 : JU FB 21 NAME : TIME ON . .	FB 21 NAME : TIME ON : L KF 100 : T RS 97 : BE

C A U T I O N:
You must select ”System commands: YES” when setting defaults at the programmer. This is no longer required beginning with level 4 of the ”LAD CSF STL” package.

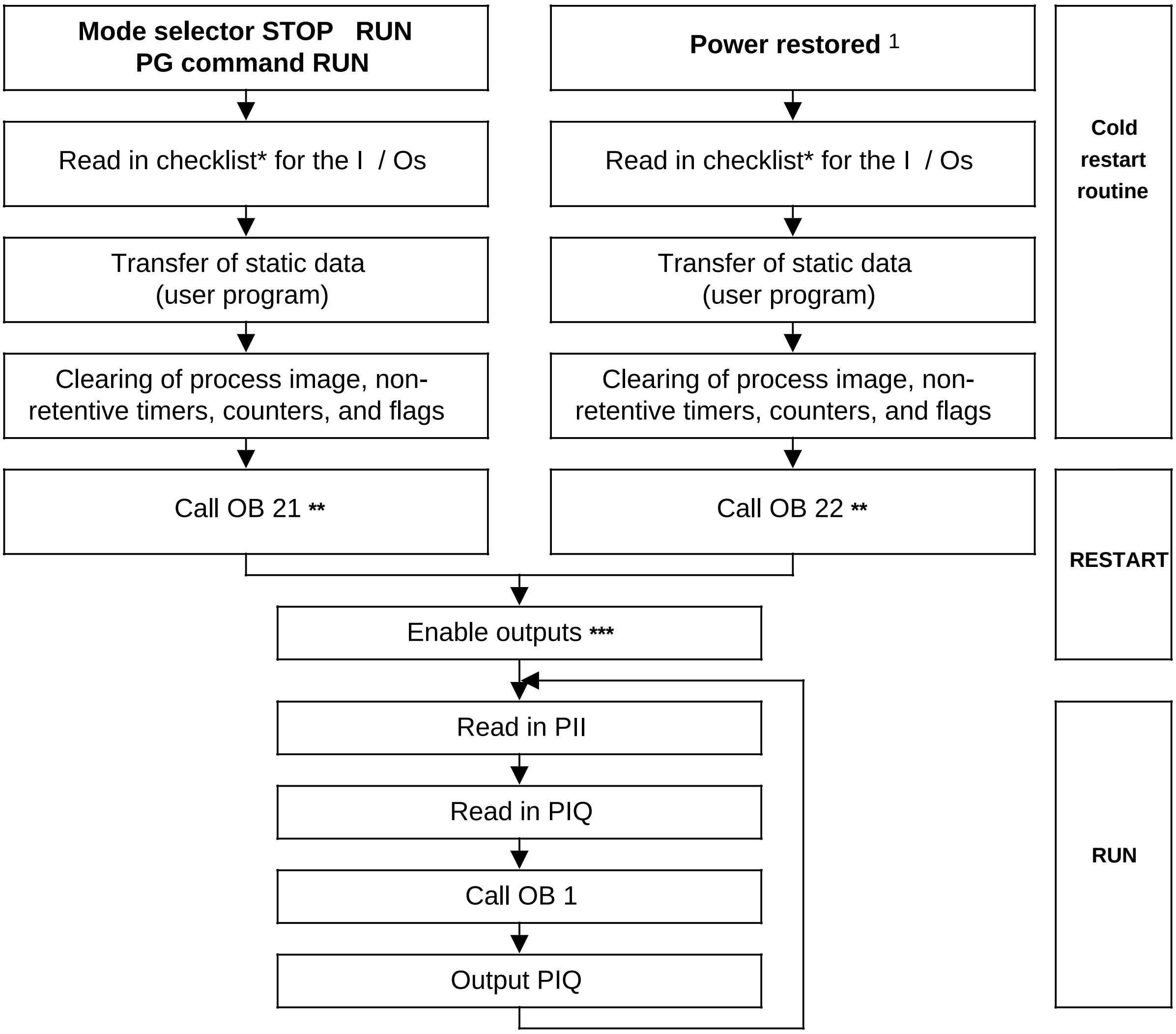
OB 21 / 22: Setting the Restart Characteristics

OB 21 is executed on a manual cold restart, OB 22 on a cold restart after a power failure (Figure 10-5).
You can thus preset certain restart characters by programming these blocks.

If OB 21 or OB 22 is not programmed, the system goes directly into the ”RUN” mode (cyclic program scanning). (See ”RESTART” mode.)
The BASP (command output inhibit) signal is cancelled after both RESTART OBs have been processed.

Features of the restart blocks (OB 21, OB 22) include the following:

- The red and green LEDs go on.
- Timers are processed.
- The scan time monitor is not activated.
- Interrupt service routines are only executed if interrupts are explicitly enabled (RA operation).
- Digital output modules are disabled.



1 This is the procedure if the PLC was in the "RUN" mode when the power went off.

* The digital / analog I / Os are mapped on the checklist

** If OB 21 or OB 22 contains the RA (enable interrupt) operation, it is possible to interrupt the program at this point with a central process interrupt. If this operation has not been written in the RESTART OB, interrupt OBs can only take effect after the RESTART OB has been processed.

*** BASP signal is cancelled

Figure 10-5. Setting the Restart Characteristics

Example 1: Programming OB 21 and FB 1

Flag bytes 0 to 99 art to be preset to ”0” and the contents of flag bytes 100 to 127 retained (because they contain important information) following a cold restart initiated via the mode selector switch.

Prerequisite: Retention switch set to RE (retentive).

STL	Description
`        :   JU    FB  1`	Unconditional FB 1 call
`NAME    :   CLEAR F`	
`        :   BE`	

STL	Description
`NAME    :   CLEAR F`	
`        :   L     KF + 0`	
`        :   T     FW   200`	Preset flag word 200 to ”0”
`M 10    :   L     KF + 0`	Store ”0” in ACCUM 1
`        :   DO    FW   200`	The contents of FW 200 specify the address of the current flag word
`        :   T     FW   0`	Set current flag word to ”0”
`        :   L     FW 200`	
`        :   I          2`	Increment FW 200 by 2
`        :   T     FW   200`	
`        :   L     KF + 100`	Load comparison value ”100” into ACCUM 1
`        :   <F`	Jump to label 10 as long as contents of FW 200 < 100
`        :   JC    = M  10`	
`        :   BE`	Bytes FY 0 to 99 are set to ”0”

OB 31: Scan Time Triggering (Chapter 8)

OB 34: Battery Monitoring

The PLC checks the state of the battery in the power supply unit constantly. If a battery failure (BAU) occurs, OB 34 is executed prior to each cycle until the battery has been replaced and the battery failure signal has been acknowledged on the power supply unit (RESET switch). The response to a battery failure is programmed in OB 34; there is no response if OB 34 has not been programmed.

Note:
If internal RAM is used as program or data memory, OB 34 can be used to evaluate a battery failure even when EPROM / EEPROM submodules are used.

OB 37: Error OB

As soon as the 115H operating system detects an error (e.g. during the self-test) and has entered the error in the error DB, it invokes organization block OB 37.

Use OB 37 to program the desired response to the error once the error DB has been analyzed at the software level.
Section 14.5.1 contains an example which shows you how you can use OB 37 to output operating system error messages over the CP 523(Section 14.1.3).

OB 251: PID Control Algorithm (Chapter 8)

10.3.2 Program Blocks (PBs)

Self-contained program sections are usually programmed in program blocks.

Special feature:
Control functions can be represented graphically in program blocks.

Call

Block calls JU and JC activate program blocks. You can program these operations in all block types except data blocks. Block call and block end staticize the RLO. However, the RLO can be included in the ”new” block and be evaluated there.

10.3.3 Sequence Blocks (SBs)

Sequence blocks are special program blocks for sequence control systems. They are treated like program blocks.

10.3.4 Function Blocks (FBs)

Frequently recurring or complex control functions are programmed in function blocks.

Function blocks have the following special features:
- FBs can be assigned parameters.
  Actual parameters can be assigned when the block is called.
- FBs have a supplementary set of operations not available to other blocks.
- The FB program can be written and documented in STL only.

The S5-115H has the following types of function blocks:
- FBs that you can program
- FBs that are integrated in the operating system (Chapter 11)
- FBs that are available as software packages (Standard Function Blocks, Catalog ST 57)

Block Header

Besides the block header, function blocks have organizational forms that other blocks do not have.

Its memory requirements consist of the following:
- block description as for other blocks (five words)
- block name (five words)
- block parameters for programmable blocks (three words per parameter)

Generating a Function Block

In contrast to other blocks, parameters can be assigned to FBs.
To assign parameters, you must program the following block parameter information:

- Block parameter name (formal operand)
  Each block parameter as formal operand is given a designation (DECL). Under this designation it is replaced by an actual operand when the function block is called.
  The name can be up to four characters long and must begin with a letter of the alphabet. You can program up to 40 parameters per function block.

- Block Parameter Type
  You can enter the following parameter types:
  - I input parameters
  - Q output parameters
  - D data
  - B blocks
  - T timers
  - C counters

In graphic representation, output parameters appear to the right of the function symbol. Other parameters appear to the left.

- Block Parameter Data Type
  You can specify the following data types:
  - BI for operands with bit address
  - BY for operands with byte address
  - W for operands with word address
  - K for constants

When assigning parameters, enter all block parameter specifications.

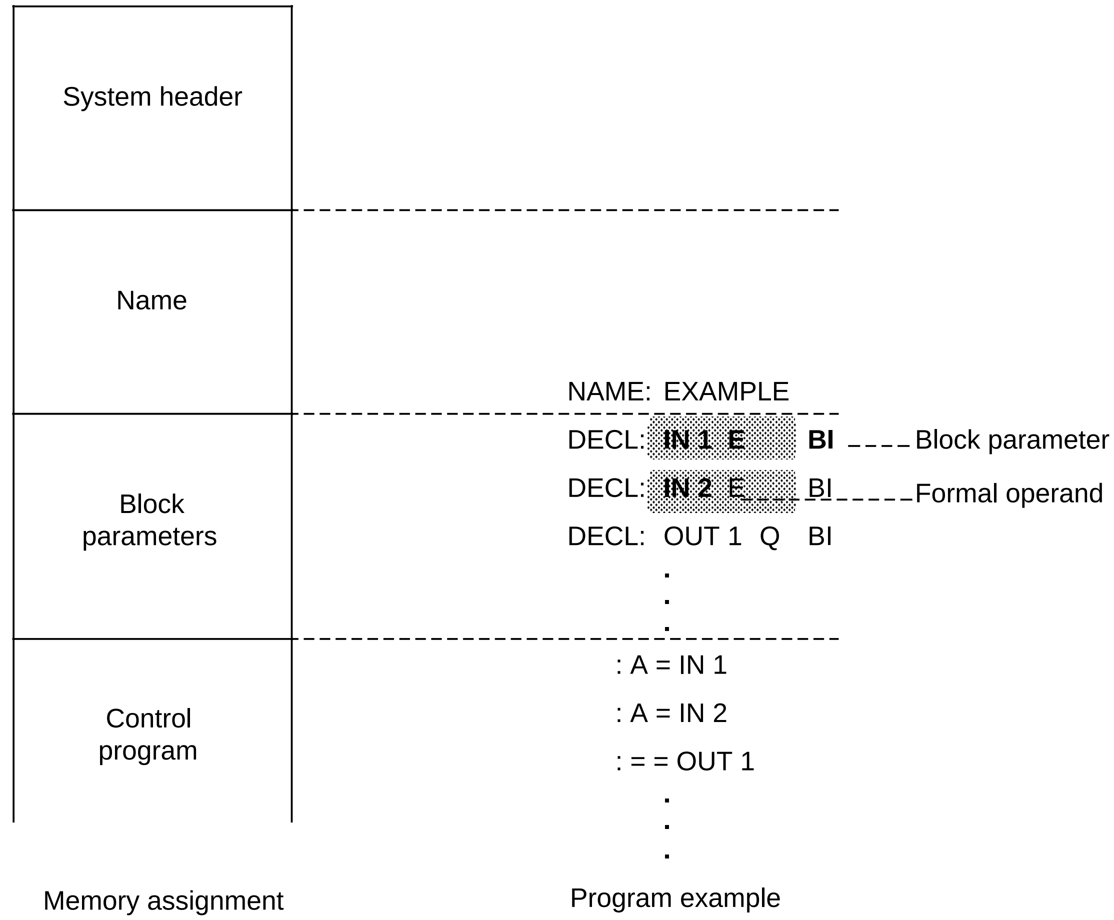


Figure 10-6. Programming a Function Block with Block Parameters

Table 10-5. Block Parameter Types and Data Types and Permissible Actual Operands

Parameter Type	Data Type	Permissible Current Operands
I, Q	BI for an operand with bit address BY for an operand with byte address W for an operand with word address	I x.y inputs Q x.y outputs F x.y flags IB x input bytes QB x output bytes FB x flag bytes DL x data bytes left DR x data bytes right IW x input words QW x output words FW x flag words DW x data words
D	KM for a binary pattern (16 digits) KY for two absolute numbers, one byte each, each in the range from 0 to 255 KH for a hexadecimal pattern (maximum 4 digits) KC for a character (maximum 2 alphanumeric characters) KT for a time (BCD-coded time value) with time base 1.0 to 999.3 KZ for a count (BCD-coded) 0 to 999 KF for a fixed-point number in the range from -32768 to +32767	Constants
B	Type designation not permitted	DB x Data blocks. The C DBx operation is executed. FB x Function blocks (permissible without parameters only) are called unconditionally (JU..x). PB x Program blocks are called unconditionally (JU..x). SB x Sequence blocks are called unconditionally (JU..x).
T	Type designation not permitted	T Timer. The time should be assigned parameters as data or be programmed as a constant in the function block.
C	Type designation not permitted	C Counter. The count should be initialized as data or be programmed as a constant in the function block.

Call

Like other blocks, function blocks are stored under a specific number in the program memory (e.g., FB 47). The numbers 240 to 255 are reserved for integral function blocks. You can program function block calls in all blocks except data blocks.

The call consists of the following parts:

- call statement
  - JUFBx unconditional call
  - JUFBx call if RLO = 1
- parameter list (only when parameters are assigned)

Function blocks can be called only if they have been programmed. When a function block call is being programmed, the programmer requests function block data automatically.

Assigning Parameters

The program in the function block specifies how the formal operands are to be processed.
The block in which the FB is called must specify the operand with which the FB is supposed to work (parameter list). The valid operands are also called actual operands.

Parameter List:

After the call statement, the input and output variables and the data are defined, thus assigning each formal operand an actual operand. The length of the parameter list is based on the number of formal operands. You can therefore program up to 40 actual operands in the parameter list.
When the function block is processed, the actual operands from the parameter list are used in place of the formal operands. The programmer monitors the sequence of the variables.

Figure 10-7 illustrates function block programming.

Other Features:

The function block call takes up two words in the program memory. Each parameter takes up an additional memory word.
Catalog ST 57 gives the run time and the amount of memory space required for standard function blocks.
The designations (DECL) that appear for the function block inputs and outputs during programming on the programmer, as well as the name, are stored in the function block itself. Therefore, you must transfer all necessary function blocks to the program diskette (for off-line programming) or directly into the program memory of the programmable controller before programming on the programmer.

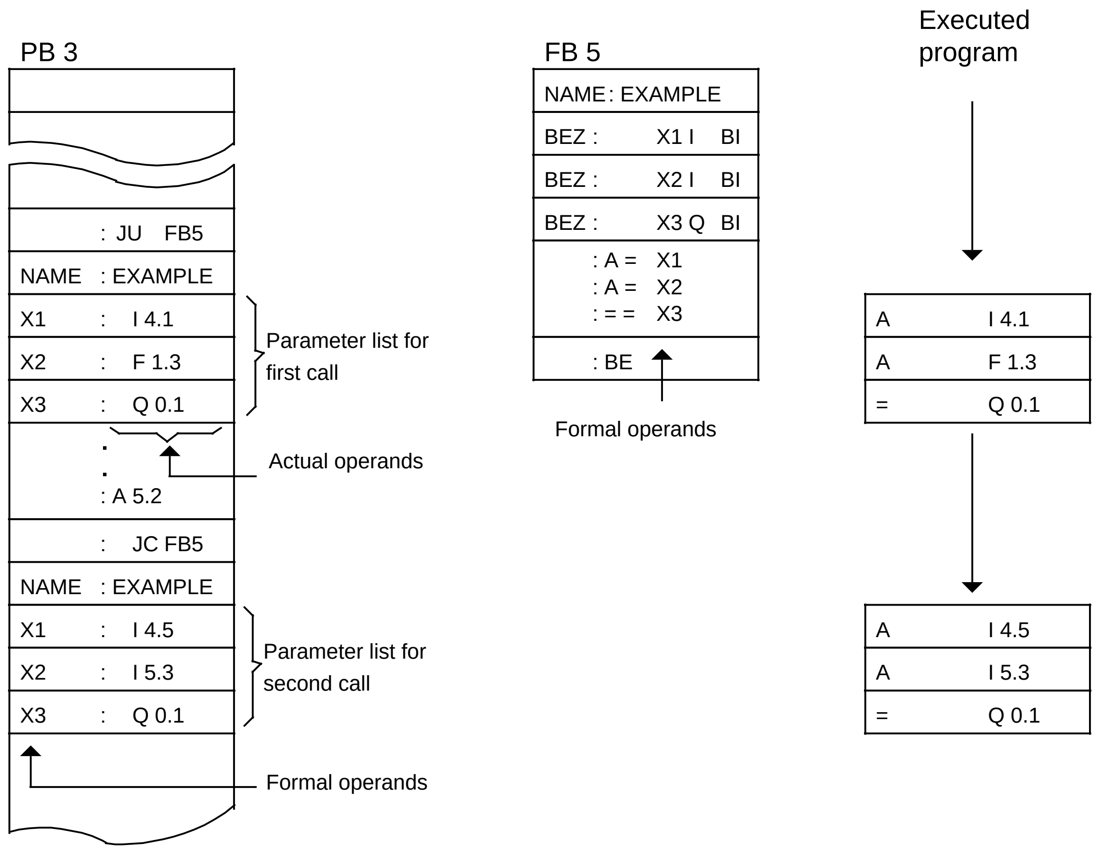


Figure 10-7. Programming a Function Block

10.3.5 Data Blocks (DBs)

Data blocks store data to be processed in a program.

The following data types are permissible:

- bit pattern (representation of controlled system states)
- hexadecimal, binary or decimal numbers (times, results of arithmetic operations)
- alphanumeric characters (message texts)

Programming

Begin data block programming by specifying a block number between 2 and 255. (DB 0 is reserved for the operating system, DB 1 for configuring data). Data is stored in this block in words. If the information takes up less than 16 bits, the high-order bits are padded with zeros. Data input begins at data word 0 and continues in ascending order. A data block can hold up to 2042 data words. You can access a data block up to DW 255 with the ”L DW” and ”T DW” operations. Acess to data words 256 to 2024 is only possible with the ”LIR”, ”TIR” and ”TNB” operations.

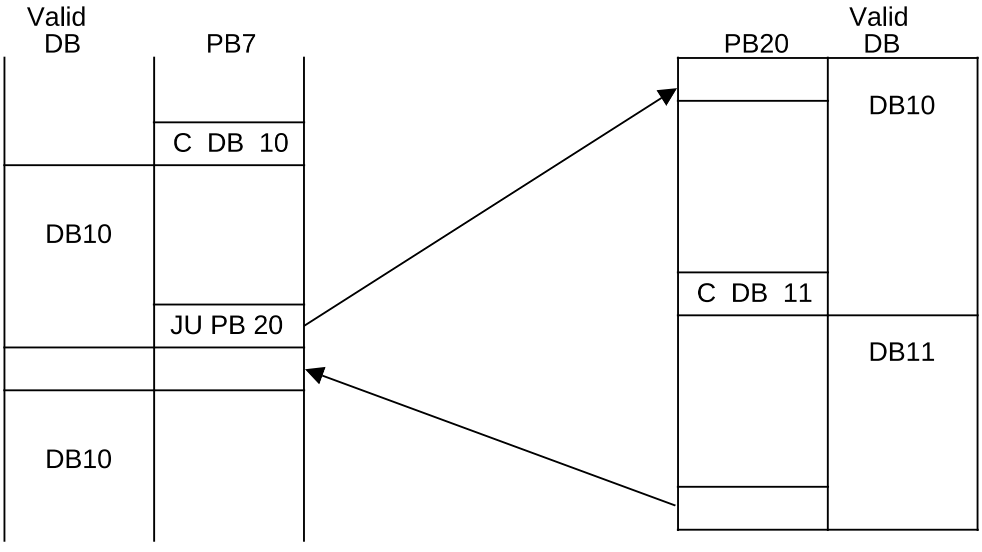
Input				Values Stored	
0000	:	KH =	A13C	DW0	A13C
0001	:	KT =	100.2	DW1	2100
0003	:	KF =	+21874	DW2	5572

Figure 10-8. Data Block Contents

Data blocks can also be created or deleted in the control program (Section 7.1.8).

Program Processing with Data Blocks

- A data block must be called in the program with the C DB x operation (x = no.).
- Within a block, a data block remains valid until another data block is called.
- When the program jumps back into the higher-level block, the data block that was valid before the block call is again valid.
- In all organization blocks (OBs), the data blocks used by the application program must be opened with the relevant C DBxx operation.



When PB20 is called, the valid data area is entered in a buffer.
When the program jumps back, this area is reopened.

Figure 10-9. Validity Areas of Data Blocks

10.4 Processing Blocks

The preceeding sections discussed how to use blocks.

Of course, blocks that have already been programmed can be changed. Possibilities for changing blocks are described here only briefly. The operating instructions for the relevant programmer explain the necessary steps in detail.

10.4.1 Modifying the Program

You can modify the program, regardless of block type, with the following programmer functions:
- ”INPUT”
- ”OUTPUT”
- ”STATUS” (Chapter 13)

With the above functions, you can make the following changes:
- insert, delete, or overwrite statements
- insert or delete segments

10.4.2 Modifying Blocks

Program modifications relate to the contents of a block. You can also delete or overwrite entire blocks. However, this does not delete the blocks in the program memory. Instead, it simply invalidates them. The memory locations of these blocks cannot be reused. As a result, new blocks might not be accepted. The programmer reports the error message ”No memory space”. Eliminate this by compressing the PLC memory.

10.4.3 Compressing the Program Memory

Figure 10-10 explains compression. Internally, one block is shifted per cycle.

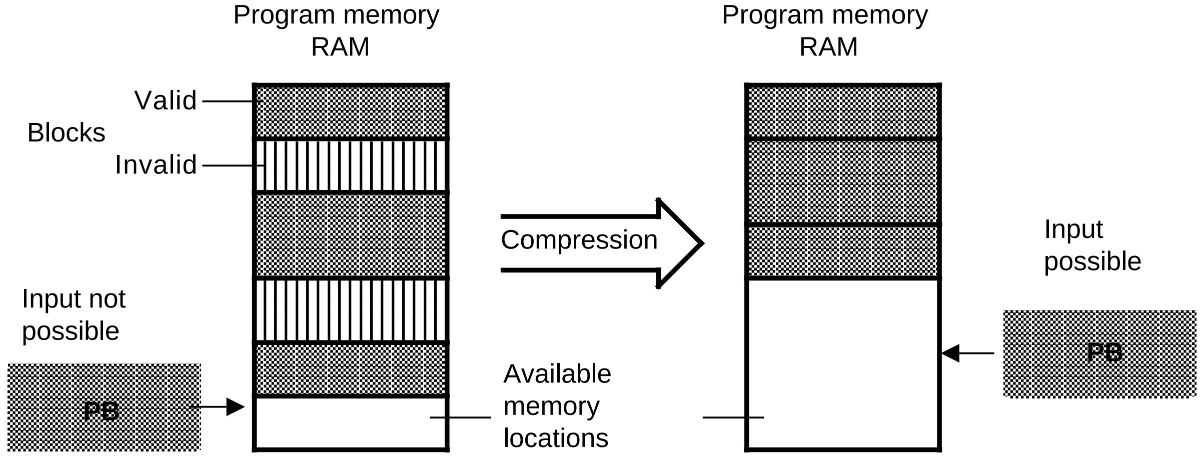


Figure 10-10. Compression

10.5 Number Representation

With STEP 5 you can work with the following forms of numerical representation:

- decimal numbers from -32768 to +32767 (KF)
- hexadecimal numbers from 0000 to FFFF (KH)
- BCD-coded numbers (4 tetrads) from 0000 to 9999
- bit patterns (KM)
- Constant byte (KY) from 0.0 to 255. 255

The S5-115H represents all numbers internally as 16-bit binary numbers or as bit patterns. Negative values are represented by their two's complement.

Word No.	n															
Byte No.	n (high-order byte)								n+ 1 (low-order byte)							
Bit No.	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Significance	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Figure 10-11. Bits in a 16-Bit Fixed-Point Binary Number

Table 10-6 shows two examples of number representation in the PLC.

Table 10-6. Examples of Number Representation in the PLC

Entered Value	Representation in the PLC
KF - 50	1111 1111 1100 1110
KH A03F	1010 0000 0011 1111
KY 3,10	0000 0011 0000 1010

10.6 Programming the S5-115H

This section provides special information on programming the S5-115H.

Synchronization Points

Synchronization is event-dependent, and always takes place when events (commands) are encountered which can produce differenta states in the CPUs.

Synchronization takes place

- in the operating system within no more than 7ms
- in the user program
  - following an RA (Interrupt Enable) command
  - following a block call (with JU or JC)

Interrupt Processing

The interrupt rresponse time, i.e. the period between interrupt request and execution of the interrupt OB, is

- no more than 7 ms at the operating system level
- the time period which elapses between two synchronization statements at the user program level.

Note:

When an interrupt occurs, integral function blocks are also interrupted after no more than 7 ms.

H-System Flag Word

An H-system flag word for H-specific information is defined with COM 115H. This flag word comprises one status byte and one control byte. The status byte provides information on the current states of the two subunits. The control byte enables the user to act upon the performance of the S5-115H (Tables 12-6 and 12-7).

Updating the Timers

The timers used in the application program are updated:

- before OB1 is processed
- following an RA (Interrupt Enable) operation
- after every block call (JU or JC)

Programming While the System is in Operation

The S5-115H provides the following in-operation software modification options (Section 6.1.6):

- Replacement of EPROM / EEPROM submodules
- Replacement of RAM submodules
- Conversion from RAM to EPROM / EEPROM

Clearing Program Memory

The program memory can be cleared only when both PLCs are at OP (Section 6.1.6).

Statement Execution Times

The execution times for STEP 5 operations are different in the S5-115H from those in the S5-115U (see Appendix A).

Reserved Data Blocks

The S5-115H requires a configuring DB and an error DB.

- The configuring DB contains the configuring data entered over COM 115H. The configuring data are always stored in DB 1. You may not store any other data in this data block. The operating system generates DB 1 on a cold restart.
- The operating system enters all errors in the error DB. The operating system generates DB 2 as error DB on a cold restart.
  You can also assign a different number with COM 115H and delete DB 2 in the PLC.

Restrictions on Parameters for Integral Function Blocks

- Specification of a PB (peripheral byte) as parameter is not permitted.
- The AS (absolute start address) parameter must be in the range 12288 to 61439.

Parallel Link

If the PLC is not equipped with an IM 314R interface module, or if the IM 314R is not working properly, and the IM 324R in the subunit is faulty, both subunits assume the RUN mode and both become master.

The green LEDs light up continuosly. Since this mode is illegal, you must set one subunit to STOP in the user program when using an S5-115H without an IM 314R.

The following example illustrates this more clearly:

- Link a single-channel digital output in subunit A (for instance Q 10.0) with a single-channel digital input (for example I 20.0) in subunit B.
- Call FB 20 in OB 1.
- Program OB 20.

Table 10-7. Sample Program

STL	Description
FB 20	
:A F 0.2	Master and in solo mode (Evaluation of the H-system flag word = MW 0)
:= Q 10.0	Single-channel DQ in subunit A
:A F 0.2	
:A I 20.0	Single-channel DI in subunit B
:JC =M001	
:BEU	
M001 :STS	
:BE	

Readback Time

If the readback time exceeds the normal scan time, the scan has elapsed.

Therefore: Keep the readback time to a minimum!

Analog Output with the AA 470 Analog Output Module

During system start-up, the AA 470 analog output module transmits invalid values which you must not use.
Remedy: Switch on the 24 V supply of the AA 470 only after the start of cyclic program processing, via a DQ for example.

The last value output is stored on the AA 470. In redundant mode, the AA 470 will continue to output this value even after one CPU goes to STOP. Since the higher of the two AA 470 values is signigicant for the I / O module, the analog value can no longer be decreased at the I / O module.
Remedy: Switch the 24 V supply of both AA 470 via two single-channel DQs.

11 Programmer Functions

Tables

11 Programmer Functions

This section discusses on-line operator servicing of the S5-115H over the programmer.

Here, once again, is a list of the four S5-115H operating modes:
1. Solo mode (only the master is in RUN mode)
2. Standby link-up mode
3. Redundant mode
4. Diagnostic mode (corresponds to the "Standby link-up mode"; the standby controller executes the entire self-test).

In order to be able to address a programmer in a programmer network, each subunit must be assigned a programmer number. This is done over COM 115H, and is entered in the SYSID block by the 115H operating system in the restart routine.

11.1 Programmer Servicing in Solo Mode

In solo mode, a distinction is made between programmer functions on the master controller and programmer functions on the standby controller.

Programmer On-Line on the Master Controller
The programmer functions are identical in every way to those for the S5-115U.

Programmer On-Line on the Standby Controller (Standby Controller at STOP!)
The programmer functions are identical in every way to those for the S5-115U.

When the "START PLC" function is initiated on the standby controller, solo mode is exited and the transition to the link-up phase begins.

11.2 Programmer Servicing in Standby Link-Up Mode

During the link-up phase, every write operation from the programmer or operator panel to the PLC, regardless of whether the PG or OP is interfaced to the master or the standby controller, is rejected with an error message ("Wrong PLC operating state").

11.3 Programmer Servicing in Redundant Mode

In redundant mode, both central controllers are at RUN, and programmer functions can be executed on both CCs. The master controller and the standby controller have equal priority. SINEC operation is permissible during execution of an on-line PG / OP-to-PLC write operation.

The scope of all programmer functions is the same as that of the programmer functions for the S5-115U. The only exception is the Program Check function, which is not permitted in redundant mode! A request for this function is rejected with an error message ("Incorrect mode on the PLC").

All Read functions in redundant mode correspond to those for the S5-115U. Only the data in the CC to which the programmer is interfaced are output.

All write functions are more sophisticated than those for the S5-115U. The data entered are transferred to the partner CC. All write operations therefore take longer to execute than their S5-115U counterparts.

Not until a block has been completely entered in both CCs is it declared valid (in both CCs simultaneously).

The programmer and COM 115H functions "START" and "STOP" affect only the central controller to which the programmer is interfaced.

Simultaneous servicing of both subunits

- Read functions affecting one CC can, for the most part, be executed at the same time as write functions affecting the other CC.
  Exceptions are
  - Output ADR and, at the same time, a write function (e.g. "Input block") on the second programmer
  - Output ADR on both programmers at the same time.

Note:

Note that the PLC function "Output ADR" is invoked by several programmer functions, e.g. from the Read ISTACK and Output H Status Byte functions. A subunit may not be simultaneously serviced over both a programmer and an operator panel!

- Write functions are allowed from both sides. In the event of simultaneous write functions, only the first one identified is executed; the second is rejected with an error message.

11.4 Programmer Servicing in Diagnostic Mode

The programmer is interfaced to the standby controller, which is still in RUN mode.

Programmer on-line on the standby controller
In this mode, the only permissible programmer functions are read functions.

The programmer function "STOP PLC" sets the standby controller to STOP and aborts the standby controller's diagnostic mode.

Programmer on-line on the master controller
The on-line functions coincide in all respects with those for the S5-115U.
In diagnostic mode, every PG / OP Write to a PLC is rejected on both the master and the standby controller with an error message (”Wrong PLC operating state”).

Note:

The on-line function FORCE (outputs only) is effective only for outputs in the subunit to which the programmer is interfaced.

11.5 Comparison of S5-115U and S5-115 H Programmer Functions

You will find detailed information on the use of programmer functions and on servicing your programmer in your programmer manual.
All programmer functions not discussed in this section are the same as those for the S5-115U. This section covers only the differences between S5-115U and S5-115H programmer functions.

Table 11-1. Overview of Operator Functions

PLC-PG Functions	STOP	RUN	Description
Input DB, FB, PB, OB, SB	•	•	Same as for S5-115U [1)]
Output (with correction) DB, FB, PB, OB, SB	•	•	Same as for S5-115U [1)]
Compare DB, FB, PB, OB, SB	•	•	Same as for S5-115U
Transfer to PLC DB, FB, PB, OB, SB	•	•	Same as for S5-115U [1)]
Transfer from PLC DB, FB, PB, OB, SB	•	•	Same as for S5-115U
Delete blocks form directory	•	•	Same as for S5-115U[1)]
Delete blocks	•		Same as for S5-115U
Start PLC	•		This programmer function starts only the subunit to which your programmer is interfaced.
Stop PLC		•	This programmer function stops only the subunit to which the programmer is interfaced.
Output directory	•	•	Same as for S5-115U
Output memory configuration	•	•	Same as for S5-115U
Output ISTACK / BSTACK	•		Same as for S5-115U
Output SYSPAR	•	•	Same as for S5-115U
Output ADR (memory location) with input	•	•	Same as for S5-115U[1)]
FORCE (outputs only)	•		Same as for S5-115U[1)] This on-line function affects only outputs in the subunit to which the programmer is interfaced. The other subunit may not be equipped with switched EUs!
FORCE VAR (I, Q, F, T, C, D)	•	•	Same as for S5-115U[1)]
STATUS (FB,PB,OB,SB) with correction		•	The "STATUS BLOCK" function (with correction) can increase the time needed to switch from master to standby; otherwise, it is the same as the function for the S5-115U [1)].
STAT VAR (I, Q, F, T, C, D)		•	Same as for S5-115U
COMPRESS memory		•	Same as for S5-115U[1)]
PROGRAM CHECK / END OF PROGRAM CHECK		•	This programmer function is possible in solo mode only.

[1)] Write functions go into force at synchronization points only.

Additional on-line functions for the S5-115H are presented in Chapter 12 ("Introduction to COM 115H"). Refer to the section in Chapter 12 entitled " PLC Functions".

11.6 Software Modification

The standby link-up procedure differs from the standard link-up procedure when the Software Modification bit is set in the master controller. The main difference has to do with the transfer of data to the standby controller.

- **Updating the static data**

Static data (DB 1, FBs, OBs and PBs) is not transferred to the standby controller. If OB 1 is missing in the standby controller, the cyclic program is not processed when the updating procedure has been completed and control passed to the standby controller.

- **Updating the dynamic data**

The standby controller takes over all dynamic blocks (DBs except DB1 and code-modifiable FBs) in the master controller's RAM. If a DB or code-modifiable FB that was in the master controller is not in the standby controller, or if it has a different length than in the master controller, the standby controller goes to STOP with ”Handling error”. The master then takes over the timers, counters, flags, and other important system data.

The S5-115H provides the following software modification options, all of which can be put into effect while the system is in operation:

- Replacing EPROM / EEPROM submodules
- Replacing RAM submodules
- Converting from RAM to EPROM / EEPROM
- Replacing CPUs with new CPU versions

These options are described in detail on the next few pages. The procedures should be followed step by step.

CAUTION:

Be sure to test the effects of your software modifications on the process!
While the PLC is in RUN mode, a software modification is possible only by requesting "EPROM software modification" in COM 115H.

11.6.1 Replacing EPROM / EEPROM Submodules

- Set the standby controller to STOP.
- Replace the EPROM / EEPROM in the standby controller.
- Execute an overall reset on the standby controller.
- Transfer all blocks that are not in the EPROM / EEPROM to the standby controller. DBs and code-modifiable FBs must have the same length as in the master controller.
- Issue the "EPROM software modification" request on the master controller over COM 115H ("PLC functions").
- Execute a cold restart on the standby controller.

The standby controller executes a cold restart with updating. The standby controller then becomes the master, and the controller that had been the master goes to STOP. The "EPROM software modification" parameter is reset automatically.

- Replace the EPROM / EEPROM in the old master controller.
- Execute a cold restart on the old master controller.

The controller that was master until the standby controller took over now assumes standby status.

11.6.2 Replacing RAM Submodules

- Set the standby controller to STOP.
- Connect a programmer to the standby controller.
- Save the applications (i.e. STEP 5 programs) in the standby and / or master controller by writing them to floppy disk.
- Replace the RAM submodule in the standby controller.
- Transfer your applications or modified programs from your backup floppy to the standby controller.
- Load the DB1 that is currently valid (configuring DB) into the standby controller.
- Connect a programmer to the master controller.
- Using COM 115H ("PLC functions"), issue an "EPROM software modification" request on the master controller.
- Execute a cold restart on the standby controller. The operating system switches from master to standby, i.e. the standby controller becomes the master, and the old master controller goes to STOP.

- Replace the RAM submodule in the controller that was previously the master.
- Execute a cold restart on the old master controller.

The controller that was previously the master now assumes standby status.

CAUTION:

During software modification, only the dynamic data (DBs, code-modifiable FBs) not already in the standby controller are transferred when the standby controller assumes master status.

11.6.3 Converting from RAM to EPROM / EEPROM

Follow the procedure for "Replacing EPROM / EEPROM submodules" as described in Section 11.6.1.

11.6.4 Replacing CPUs for New CPU Versions

- Set the standby controller to STOP.
- Connect a programmer to the standby controller.
- Save the applications (STEP 5 programs) stored in the standby controller's RAM submodule by writing them to floppy disk.
- Replace the CPU in the standby controller.
- Transfer your applications or modified programs from the backup floppy to the standby controller.
- Load the currently valid DB1 (configuring DB) into the standby controller.
- Connect a programmer to the master controller.
- Using COM 115H ("PLC functions"), issue an "EPROM software modification" request on the master controller.
- Execute a cold restart on the standby controller. The operating system switches from master to standby, i.e. the standby controller becomes the master, and the old master controller goes to STOP.
- Replace the CPU in the old master controller.
- Execute a cold restart on the old master controller.

The controller that was previously the master now assumes standby status.

12 Introduction to COM 115H

Figures

Tables

12 Introduction to COM 115H

The COM 115H software package provides a sophisticated, user-friendly operator interface to help you
- configure your S5-115H
- document your configuring data
- diagnose errors and faults, displaying error messages in plaintext
- handle your system.

Interactive screen forms and menu guidance are provided for all functions. The relevant program routines can be invoked using function keys. To help acquaint you with the COM 115H software, the first few subsections tell you how to
- make a working copy of the COM 115 floppy
- configure a system
- start COM 115H.

Subsequent sections acquaint you with the hierarchical structure of the COM 115H software package. Section 12.3 gives you general information on the use of screen forms.

Note:

The configuring data generated with COM 115H is stored in data block DB 1.

12.1 Preparations for Working with COM 115H

The first thing you should do is to copy all files you need to floppy disk.

- Standard package

The COM 115H software package is delivered on three floppy disks in the format required by the S5-DOS operating system.

Table 12-1. COM 115H Standard Package

Storage Media	Programmer
1 5 ” floppy disk	PG 675 / PG 685 / PG 750
1 3 ” floppy disk	PG 635

The floppies contain the following files:

Table 12-2. COM 115H Files

S5 PDC 17X.CMD	Main Program of the COM 115H Software Package
S5 XEJ 01X. DAT	COM 115H ”Diagnostic Error Message”
S5 XEJ 02X. DAT	COM 115H ”Help Texts”
S5 XEJ 03X. DAT	COM 115H ”Print List Headers”
S5 XEJ 04X. DAT	COM 115H ”Floppy, EPROM, PLC Error Report”
S5 DEC H2X. VER	Version of the data medium
S5 ST5 8ST. S5D	Contents of FB 48
DB 523 EST. S5D	Error message texts and printer parameters for CP 523

The COM 115 software package can execute on the following programmers (PGs) and personal computers (PCs):

Table 12-3. COM 115H Compatible Programmers and Personal Computers

Programmers	Personal Computers
PG 635 PG 675 PG 685 PG 695 PG 750	Siemens PC 16-11 Siemens PC 16-20 IBM 'XT and 100% compatibles IBM 'AT and 100% compatibles

Note:

All systems must use S5-DOS as operating system.

12.1.1 Making a Working copy of the COM 115H Floppies

Before beginning, make copies of the original floppies and store the originals in a safe place.
You can copy the COM 115H software package with the PCP/M utility "DISK".

12.1.2 System Configuration

Information on generating a ready-to-use version of COM 115H is presented below.

Load the PCP / M operating system
Place the COM 115H floppy in drive A
Copy the floppies to user area 0 on the hard disk (drive B)
For example: Enter `B > USER 0` and press RETURN
Enter `B > PIP B:=A*.*` and press RETURN
If required, assign the copied files the `[RO]` and `[SYS]` attributes.
For example: Enter `B > SET*.* [RO SYS]` and press RETURN.
The `[RO]` attribute protects the files against overwriting.
The `[SYS]` attribute enables access to the files in all user areas.

12.1.3 Starting COM 115H

Proceed as follows to start COM 115H:

Make sure that all required COM 115H files are
- on your computer's hard disk or
- on the floppy currently in the drive.

Start the S5 command interpreter with **S5 <CR>**.
The KOMI form appears briefly during loading:

```
-----------------------------------------------------------------
  SIMATIC S5               S5-KOMI
  Serial-No.:              xxxx-yyyy-zzzzzz          All rights reserved
  Copyright (C) 1989                                 SIEMENS AG
-----------------------------------------------------------------
```

The ”Package Selection” menu, which lists all STEP 5 packages on the floppy or hard disk, is then displayed.

Using the cursor keys, choose COM 115H in the "Program Selection" menu.

Confirm your selection with **F1** "PACKAGE". The DEFAULTS menu is then displayed.

```
 D E F A U L T S
------------------------------------------------------------------------

                                    PROGRAM FILE   : B:@@@@@@ST.S5D

SYMBOLS       : NO                  SYMBOLS FILE   :

FOOTER        : NO                  FOOTER FILE    :

PRINT WIDTH   : NORMAL              PRINTER FILE   :

OP MODE       : OFF

PATH NAME     :                     PATH FILE      :


   F1       F2       F3       F4       F5       F6       F7       F8
                   SELECT                     EXEC
```

Figure 12-1. The COM 115H Defaults Form

In the DEFAULTS form, file names and path names are entered as alphanumeric characters. You can select the values for CPU, symbols, footer and OP mode with function key **F3**. If you are not familiar with the terms used in the DEFAULTS form, please refer to your programmer manual.

Keys used in the DEFAULTS form:

Cursor control keys — The double-arrow keys < > and < > move the cursor to the right or left half of the screen; the single-arrow keys < >,< >, < >,< > move the cursor to the input fields.

F3 (SELECT) — Shows the option at the cursor position

F6 (EXEC) — Confirms all parameters (DEFAULTS) and those which you entered and calls the main menu.

Enter key — The Enter key has the same function as function key **F6** (EXEC).

Abort key — The programmer rejects the parameters when you press this key and redisplays the DEFAULTS menu in its original form.

Confirm the defaults with **F6** "EXEC".
You are now in the COM 115H main menu. If you also press the HELP key, the following form appears on your monitor screen:

```
   COM 115H Main Menu
---------------------------------------------------------------------------


F1  OS        : Initialize operating system
F2  IOCONF    : Configure I/O module
                (DI, DQ, AI, AQ, CP/IP, CF)
F3            :
F4  PLC FCT   : Call PLC functions (RUN/STOP)
F5  DIAG      : Diagnostic functions
                (STAT ERR, HSYS-FW, H-ERROR, S5-PLCINFO)
F6  DEFAULTS  : Call defaults screen form
F7  SYSHAN    : System handling
F8  BACK      : Terminate S5-115H CONFIGURATION
```

F1	F2	F3	F4	F5	F6	F7	F8
OS	IOCONF		PLC FCT	DIAG	DEFAULTS	SYSHAN	BACK

Figure 12-2. The COM 115H Main Menu

Note:

If you want to edit existing configuring data, you must first load the program file from floppy or hard disk into PLC memory with the "System Handling" menu.

12.2 Hierarchical Structure of COM 115H

The diagram below provides an overview of all COM 115H functions. Each screen form or function is represented by a block showing the function key and the name of the function the key invokes.

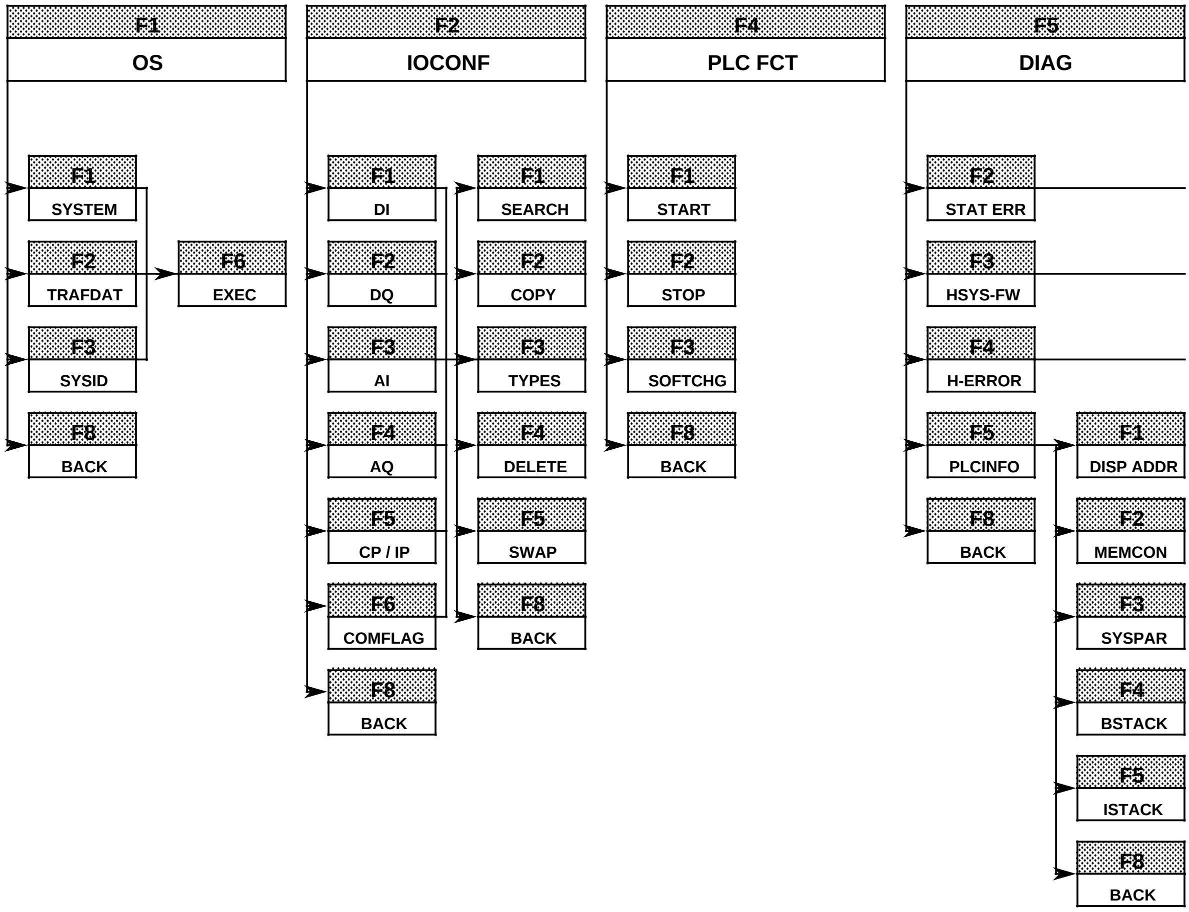


Figure 12-3. Hierarchical Structure of COM 115H

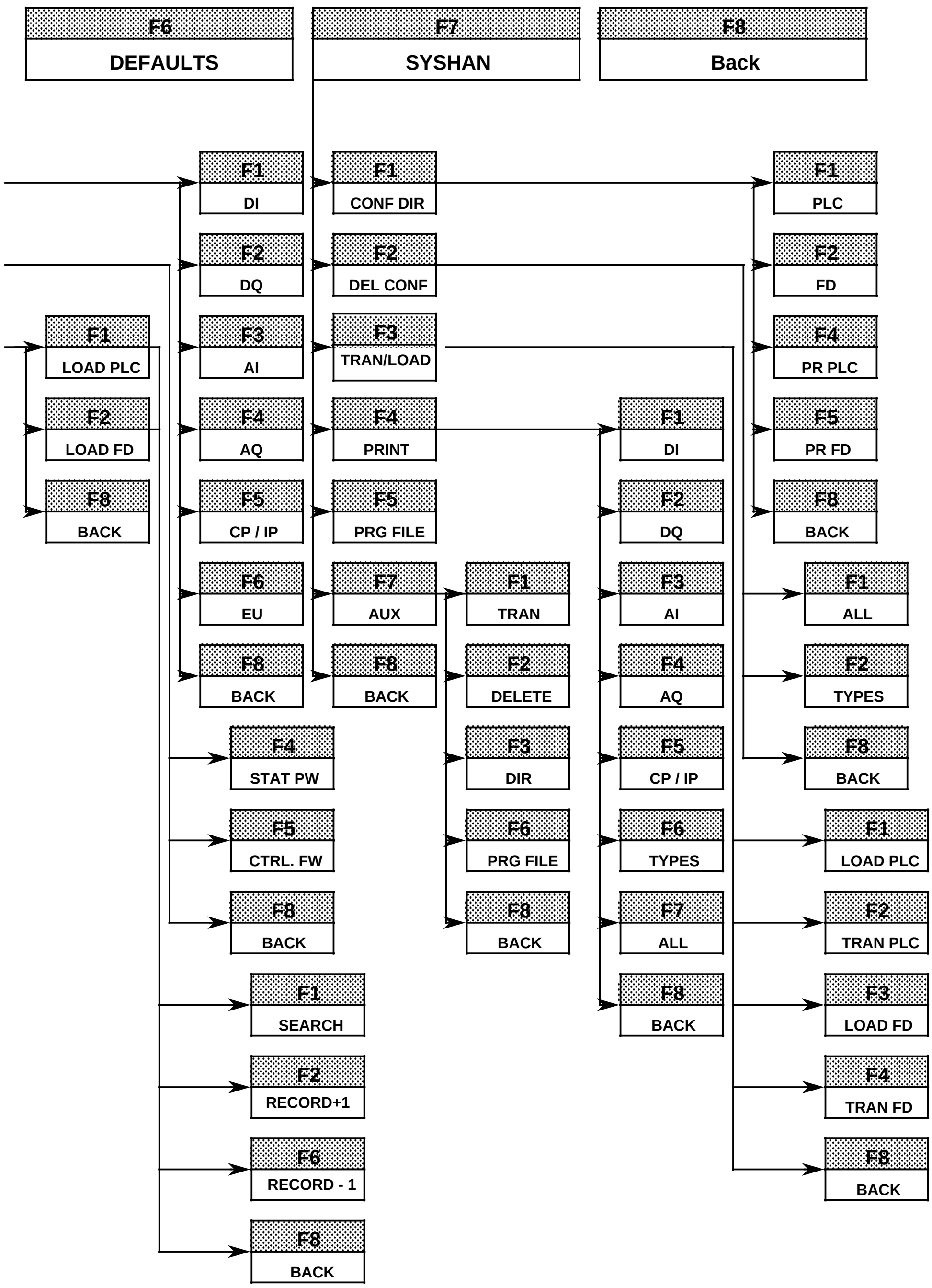


Figure 12-3. Hierarchical Structure of COM 115H (continued)

12.3 The Main Menu

Proceed to the first submenu level by pressing a function key in the main menu. The various function keys and the submenus they invoke are described in detail in the following sections.

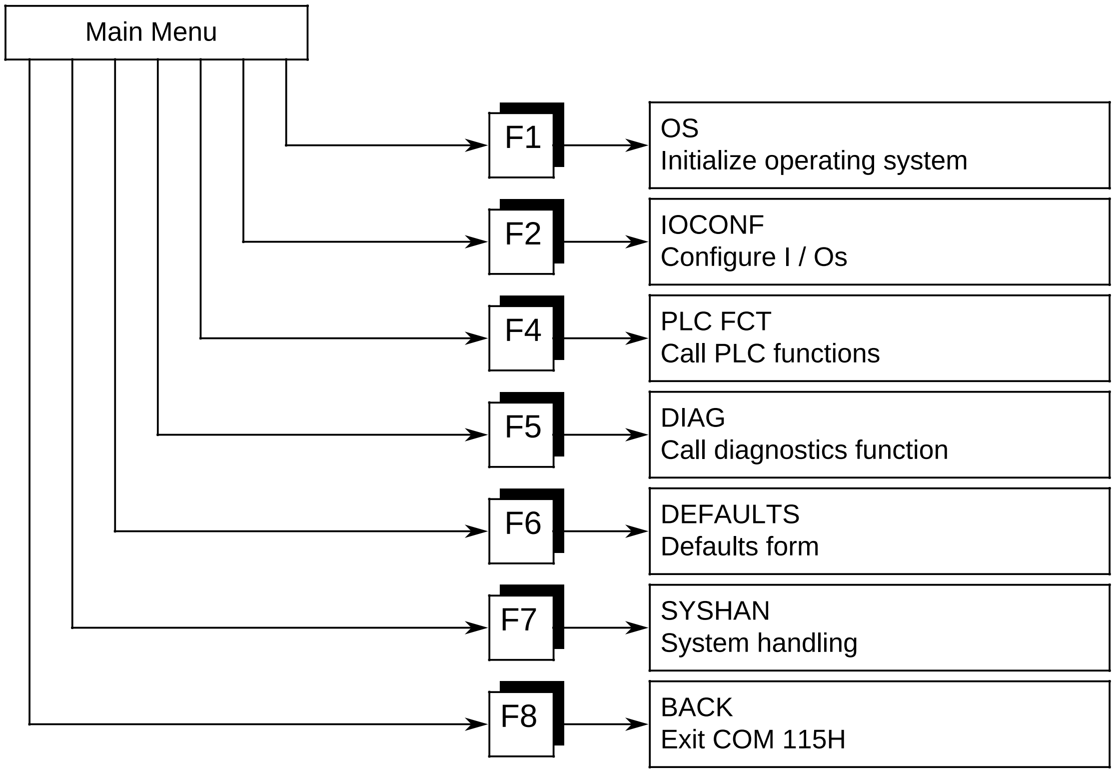


Figure 12-4. The COM 115H Main Menu

12.3.1 F1: Initialize Operating System

You can screen the "Initialize operating system" menu (Figure 12-5) by pressing softkey <F1>. The various submenus are invoked with function keys <F1> to <F3>. Press function key <F8> to exit the "Initialize operating system" menu.

```
  Initialize operating system
------------------------------------------------------------


F1  SYSTEM    : Input operating system parameters
F2  TRAFDAT   : Input transfer data "activate standby"
                (job list "code-modifiable FBs")
F3  SYSID     : Input SYSID parameters for operation of the
                CP 530 on the PG interface
F4            :
F5            :
F6            :
F7            :
F8  BACK      : Return to previous menu
```

F1	F2	F3	F4	F5	F6	F7	F8
SYSTEM	TRAFDAT	SYSID					BACK

Figure 12-5. Initialize Operating System

Table 12-4. Function Keys in the "Initiailize Operating System"

Function Key	Function Name	Description
F1	SYSTEM	Initialize the H operating system
F2	TRAFDAT	Transfer data for standby activation
F3	SYSID	Initialize SINEC L1 over the programmer interface
F8	BACK	Exit the "Initialize operating system" menu

- **F1 SYSTEM**

The "Initialize operating system" menu (Figure 12-6) is displayed when you press softkey <F1>. If the configuration DBs were loaded from PLC, FD (floppy) or EPROM beforehand over the "System handling" menu, the data from the DBs are displayed in the appropriate input fields on the monitor screen. Otherwise the values shown in the input fields are default values.

Move down one line with the <down arrow> key, and up one line with the <up arrow> key. Each entry is subjected to a range check. Invalid entries are rejected with "INVALID PARAMETERS". Confirm the parameters with softkey <F6>.

```
Initialize operating system
------------------------------------------------------------------

              Initializing the H operating system

No. of test slices (n*5ms)       (1....9):      1
H error DB number                (2..255):      2
OB13 time interval       (0.0s..600.00s):      0.10s
Readback delay             (0.0s..1.00s):      0.01s
H system flag word           (0...254):      0
SINEC node no.               (0..1023):      0
Number of switched EUs       (0.....8):      0

IP address areas with linear addressing
Begin single channel I/O subunit A      :       0000H
Begin switched I/O                      :       0000H
```

F1	F2	F3	F4	F5	F6	F7	F8
					EXEC		BACK

Figure 12-6. Initialization Menu for the 115H Operating System

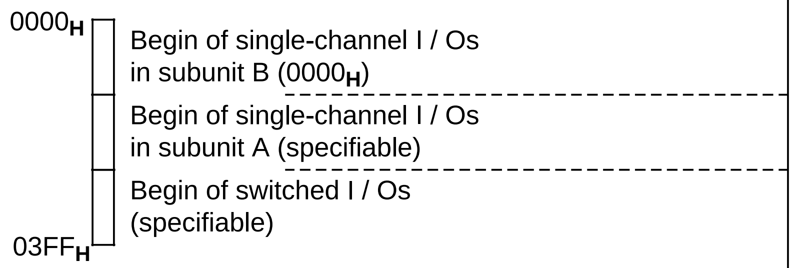
Table 12-5. Field Names and Field Descriptions

Field Name	Field Description
No. of test slices (n * 5 ms)	Enter the number of test slices (1 to 9 * 5ms) required in a PLC cycle to execute the self-test routine. A large number of test slices shortens the error response time but increases the cycle time; the reverse is true if a small number of test slices is specified.
H error DB number	Enter a DB number between 2 and 255. This DB will be used for flagging H system errors. (Default: DB 2)
OB 13 time interval	OB 13 is provided for programming a routine to service timed interrupts. The operating system invokes this OB at user-specified intervals (0.0 s to 600.00 s). OB 13 can interrupt the cyclic program but not the process interrupt service routine. The cyclic program is continued if OB 13 has not been programmed. Press RETURN after entering the integer portion of the number. The cursor is then positioned after the decimal point to allow you to enter the fractional portion of the value.

Table 12-5. Field Names and Field Descriptions (continued)

Field Name	Field Description
Readback delay	Because different digital output modules have different signal propagation delays, it is necessary to specify a readback delay (0.01 to 1 s) for the test and readback digital inputs. The specified readback delay applies for all redundant digital outputs. Press <RETURN> after entering the integer part of the value. The cursor is then positioned behind the decimal point to allow you to enter the fractional part of the number. **Note:** If the readback delay is greater than the PLC cycletime, the latter is increased to accord with the former.
H system flag word	The H system flag word may be an arbitrary flag word for H system-specific status and control information. You can set the control bits and read out the status information in your application program. The H system flag word comprises a status byte (Table 12-6) and a control byte (Table 12-5). COM 115H displays the information taken from the status byte in plaintext. COM 115H generates the control byte on the basis of the information provided. **Note:** It is recommended that the flag word used for H system information be a retentive flag word (0 to126).
SINEC node no.	(Irrelevant at present)
Number of switched EUs	Enter the number of switched expansion units (1 to 8) in this field.

Table 12-5. Field Names and Field Descriptions (continued)

Field Name	Field Description
IP address areas with line setting	In the 115H, addresses 0000_H to $03FF_H$ are provided for IPs with linear addressing. IPs with linear addressing can be used as switched I / Os or single-channel I / Os in subunit A or B. By setting the addresses at the hardware level, you can operate several IPs. The following applies:  When you specify the begin of single-channel I / Os in subunit A at address 0000_H, you are indicating that you will not be operating IPs with linear addressing as single-channel I / Os in subunit B.

- **Structure of the H System Flag Word**

Table 12-6. Structure of the Status Byte

Bits	Meaning of the values	Notes
Bit 0	”1” : PLC is in ”Solo”mode ”0” : PLC is not in ”Solo” mode	no
Bit 1	”1” : PLC is in ”redundant” mode ”0” : PLC is not in ”redundant” mode	no
Bit 2	”1” : CC is master ”0” : CC is standby	In ”redundant” mode bit is generally ”0”
Bit 3	”1” : Standby controller is in the ”activation phase” ”0” : Standby controller is not in the ”activation phase”	no
Bit 4	”1” : PLC is subunit A ”0” : PLC is subunit B	In ”redundant” mode bit is generally ”0”
Bit 5	”1” : Subunit A is master ”0” : Subunit B is master	no
Bit 6	”1” : Standby request issued ”0” : No standby request issued	no
Bit 7	”1” : Automatic switchover from master to standby controller impossible ”0” : Other	CAUTION! Standby faulty

Table 12-7. Structure of the Control Byte

Bit	Meaning of the values	Notes
Bit 0	"1" : No restart test "0" : Restart test	Bit is reset by the OS only after overall reset
Bit 1	Unassigned	
Bit 2	"1" : Standby updating disabled "0" : Standby updating enabled (default)	The "Disable standby update" bit must be reset in the user program, as the programmer does not have write access privileges during the update procedure.
Bit 3	"1" : Mask standard error response "0" : Other (default)	You can use this bit to circumvent the operating system's standard error response (passivation and maskable STOP). Bit is reset by the OS following execution. ***Caution:*** ***Masking the Standard error response is not allowed for redundant I/Os with locating facilities, as otherwise the error location might be never-ending.***
Bit 4	"1" : Depassivation "0" : Other (default)	You have to edge-trigger the depassivation with the operation S x.y (see example below). Bit is reset by the OS following execution. This bit does not depassivate page-addressable CPs / IPs. These CPs / IPs must be depassivated with FB 253. See also the description of FB 253 in section 8.1.3.
Bit 5	"1" : Switchover request "0" : No switchover request (default)	Bit is reset by the OS following execution
Bit 6	"1" : Set standby to STOP "0" : Do not set standby to STOP (default)	Bit is reset by the OS following execution
Bit 7	Unassigned	

Example of edge-triggered depassivation

Depassivation of the I/Os is to be set through the bit I 4.0. Control bit for depassivation in H-System Flag Word is Flag F 1.4.

STL	Explanation
:UN I 4.0	Depassivation bit
:R F 20.0	Auxiliary flag
:U I 4.0	
:UN F 20.0	
:S F 20.0	
:S F 1.4	Control bit for depassivation in H-System Flag Word. (Control bit is reset by OS after depassivation).
:BE	

- **F2 TRAFDAT**

Pressing softkey <F2> screens the "Transfer of code-modifiable FBs" screen form, in which you may enter transfer data (max. 10 FBs) required for standby activation.
Confirm your entries with <F6>.

```
Job list "transfer of code-modifiable FBs"
------------------------------------------------------------

 1. Function block to be transferred : FB
 2. Function block to be transferred : FB
 3. Function block to be transferred : FB
 4. Function block to be transferred : FB
 5. Function block to be transferred : FB
 6. Function block to be transferred : FB
 7. Function block to be transferred : FB
 8. Function block to be transferred : FB
 9. Function block to be transferred : FB
10. Function block to be transferred : FB
```

F1	F2	F3	F4	F5	F6	F7	F8
					EXEC		BACK

Figure 12-7. Transfer Data for Standby Activation

Table 12-8. Names and Descriptions of Fields for the "TRAFDAT" Form

Field Name	Description
Function block to be transferred: FB	Enter all function blocks (max. 10) which modify their code during operation. The master then transfers these FBs when the standby controller is activated.

- **F3 SYSID**

Softkey <F3> screens the "Initialize SYSID SINEC-L1" screen form.

```
No. of SINEC L1 nodes on the PLC interface:
```

The following values may be entered when the above line is displayed:

”1”: You initialize one SYSID and assign it to subunit A or subunit B.

```
Subunit (A or B):
```

This brings you automatically to the "SYSID SINEC-L1" screen form in which you initialize the associated parameters (Table 12-9).

”2”: You initialize two SYSIDs (for subunits A and B), which takes you directly to the "SYSID SINEC-L1" screen form (Figure 12-8 and Table 12-9).

```
 Initialize SYSID SINEC-L1
--------------------------------------------------------------

      Subunit A                              Subunit B

PG bus number (1 to 30):  1     !     PG bus number (1 to 30):  2
Slave number (1 to 30) :  1     !     Slave number (1 to 30) :  2
CBR (D/F)              :  F     !     CBR (D/F)              :  F
CBR (DB/FY no.)        :  O     !     CBR (DB/FY no.)        :  O
                                !
CBS (D/F)              :  F     !     CBS (D/F)              :  F
CBS (DB/FY no.)        :  0     !     CBS (DB/FY no.)        :  0
                                !
SEND M/BOX (D/F)       :  F     !     SEND M/BOX (D/F)       :  F
SEND M/BOX (DB/FY no.) :  0     !     SEND M/BOX (DB/FY no.) :  0
                                !
REC M/BOX (D/F)        :  F     !     REC M/BOX (D/F)        :  F
REC M/BOX (DB/FY no.)  :  0     !     REC M/BOX (DB/FY no.)  :  0

   F1      F2      F3      F4      F5      F6      F7      F8
                                          EXEC            BACK
```

Figure 12-8. "Initialize SYSID SINEC-L1" Form

Table 12-9. Names and Descriptions of Fields for the "SYSID" Form

Field Name	Description
PG bus number (1 to 30):	Enter the bus number of the programmer interface to which the SINEC L1 is to be connected.
Slave number (1 to 30):	Enter the slave number (1 to 30) you want to assign to the subunit.
CBR (D / F):	Specify whether the master's coordination byte for ”RECEIVE” (CBR) is to be located in a data block (D) or flag area (F).
CBR (DB / FY no.):	Specify the data block (DB) or flag byte (FY no.) for the CBR.
CBR (DW no.)	This field appears only when you entered a D (data block) under CBR (D / F). Enter the data word (1 to 255) for the CBR in this field.
CBS (D / F)	Specify whether the master's coordination byte for ”SEND” (CBS) is to be located in a data block (D) or flag area (F).
CBS (DB / FY no.)	Specify the data block (DB) or flag byte (FY no.) for the CBS.
CBS (DW no.)	This field appears only when you enter a D (data block) under CBS (D / F). Enter the data word (1 to 255) for the CBS in this field.
SEND M / BOX (D / F):	Specify whether the send mailbox is to be located in a data block (D) or flag area (F).
SEND M / BOX (DB / FY no.):	Specify the data block (DB) or flag byte (FY no.) for the Send mailbox.
SEND M / BOX (DW no.):	This field name appears only when you enter a D (data bock) under SEND M / BOX (D / F). Enter the data word (1 to 255) for the Send mailbox.
REC M / BOX (D /F) :	Specify whether the Receive mailbox is to be located in a data block (D) or flag area (F).
REC M / BOX (DB / FY no.):	Specify the data block (DB) or flag byte (FY no.) for the Receive mailbox.
REC M / BOX (DW no.):	This field appears only when you entered a D (data block) under REC M / BOX (D / F). Enter the data word (1 to 255) for the Receive mailbox.

12.3.2 F2: Configure I / Os

The "Configure I / Os" screen form (Figure 12-9) is displayed when you press function key <F2> in the main menu. You can choose whether you want to configure digital / analog I / Os or CPs / IPs. Each function key takes you to the appropriate screen form, where you can enter your configuring data.

The configuring forms help you configure

- I / O bytes
- I / O words
- interface numbers (CP / IP)

To make I / O configuring easier, all single-channel and dual-channel process signals which the S5-115H's operating system can handle are divided into "types". A type number identifies the signal type (analog, digital, input, output, CP, IP, interprocessor communication flag) and its mode (single-channel, switched, redundant). Because the I / Os are configured byte by byte, it is not possible to mix types. This means that you can enter an I / O byte either for a switched, single-channel or redundant I / O.

Note:

The amount of user memory required depends on the amount of configuring data you enter.

```
Configure I/Os
-------------------------------------------------------------

F1  DI        : Configure digital inputs
F2  DQ        : Configure digital outputs
F3  AI        : Configure analog inputs
F4  AQ        : Configure analog outputs
F5  CP/IP     : Configure CP/IP interface
F6  COMFLAG   : Configure interprocess comunication flags
F7            :
F8  BACK      : Return to previous menu
```

F1	F2	F3	F4	F5	F6	F7	F8
DI	DQ	AI	AQ	CP / IP	COMFLAG		BACK

Figure 12-9. Configure I / Os

Table 12-10. Function Keys in the "Configure I / Os" Menu

Function key	Function Name	Description
F1	DI	Configure digital inputs
F2	DQ	Configure digital outputs
F3	AI	Configure analog inputs
F4	AQ	Configure analog outputs
F5	CP / IP	Configure CPs / IPs
F6	COMFLAG	Configure IPC flags
F8	BACK	Exit the "Configure I / Os" menu

Note:

In all configuring forms, confirm your configuring data by pressing RETURN.

- **F1 Digital Inputs**

<F1> takes you to the "Configure digital inputs" screen form. In this form, the specified I / O bytes are listed at the left and the types at the right.

You can select a type either by pressing function key <F3> "Types" or entering the relevant type number. In both cases, the configuring form for that type is displayed.

When you branch to the I / O configuring menu from a hierarchically higher menu, the basic screen form displayed is always that for the lower type (e.g. type 1,8) and the cursor is set to the "Type" field. You may select a different type by pressing <F3> "Types" (ring selection, i.e. 1, 2, 3, 1, 2, 3 and so on). The next matrix line is displayed when you confirm the parameters or press the "down arrow" key. The I / O byte is on the second line. When you press "up arrow" to move the cursor up, the preceding matrix line is displayed. You can also implement this "scroll" function by pressing <SHIFT> and < > or < >. When you reach the end of the matrix, the "down" scroll is suppressed.

```
 COM 115H : Initializing the I / Os
----------------------------------------------------------------------------
=========================================================================
    I / O byte                 !    Type number                              Type Field
-------------------------------+-----------------------------------------
DI byte    0                   !
-------------------------------+-----------------------------------------
DI byte    1                   !
=========================================================================
Digital input     0                                                          Symbols line
-------------------------------------------------------------------------
                            !
                            !
Static type characteristics !  Type characteristics by the user              Characteristics field
                            !
                            !
                            !
=========================================================================
                                                                             Status and error line
Status: TYPE INPUT
   F1        F2        F3        F4        F5        F6        F7        F8
 SEARCH     COPY     TYPES     DELETE               SWAP                BACK  Softkey menu
```

Figure 12-10. Configure Digital Inputs

Symbols line:
The symbols line is allocated to the I / O byte (types DI, DQ), and shows the byte at which the cursor is currently positioned (e.g. digital input 0). You can also store symbolics which can be output either in 8-character short symbol format or 40-character long symbol format. Such a line could be e.g.:

```
Digital input 0      VALVE 1     VALVE   PUMP 1  OPEN
```

These symbols must be generated using the available STEP 5 Tools before they can be specified here. If there are no symbols, only the number of the I / O bit or I / O byte is displayed.

Characteristics Field
The lower half of the screen is the so-called characteristics field. This field is allocated to the current type, i.e. the characteristics of the current type are displayed in this field. The characteristic field comprises two sections.

The lefthand section shows the permanent characteristics of a specific type. These are:
- Type number
- I / O number
- Availability
- Wiring
- Number of CPs / IPs

The righthand section contains the user-specifiable data. The contents of the characteristics fields are type-dependent.

Table 12-11. Type Numbers for Digital Inputs (DIs)

<table>
<tr><th>Type Number</th><th>Specifiable Type Characteristics</th><th>Description</th></tr>
<tr><td rowspan="2">TYPE 1
DI byte in single-channel I / O</td><td>Subunit</td><td>Enter the relevant subunit: A / B</td></tr>
<tr><td>Interrupt generating*</td><td>Specify whether the DI byte has interrupt-generating capability: Yes / No (possible for odd-numbered bytes only!)</td></tr>
<tr><td>TYPE 2
DI byte in switched I / O</td><td>Interrupt generating</td><td>Not permitted, as interrupt modules cannot be used in switched EUs.</td></tr>
<tr><td rowspan="3">TYPE 3
DI in redundant I / O</td><td>L-DQ byte / bit**
L-DI byte / bit</td><td>Specify the addresses of the locating facilities:
0.0 to 127.7
You must configure one additional digital input and one additional digital output for each redundant digital input or output for which the 115H OS is to both detect and locate errors.
Because they are used specifically for error locating, these are referred to as locating digital output (L-DQ) and locating digital input (L-DI). Together they form the locating facility.
When an L-DQ byte / bit is entered more than once, the associated L-DI byte / bit is automatically displayed.
Before changing the L-DI byte / bit, you must first change the associated L-DQ byte / bit.</td></tr>
<tr><td>Discrepancy time</td><td>Redundant digital inputs can sometimes assume different signal states within a comparatively short period of time, e.g. because of sensor or component tolerances. The discrepancy time is the period in which the 115H OS tolerates these different signal states.

Example:
You have selected a dual-channel DI of type 3. In the righthand portion of the characteristics field, you can specify a discrepancy time in the range 0.0 s to 320 s (in increments of 10 ms) for the I / O byte and confirm your entry with RETURN. If you do not specify a discrepancy time (0.0 s), the PLC cycle time is taken as current discrepancy time.</td></tr>
<tr><td>Interrupt generating</td><td>See TYPE 1</td></tr>
</table>

* The even-numbered byte may not be used!

** You can also configure a Type 3 DI without error locating (e. g. redundant interrupt DIs).

Note:

Interrupt modules configured for DI type 3 do not require error locating facilities.

Status and Error Line

The status and error line is used to display the current processing status and to show error messages during configuring. The left half of the line is for the status, the right half for error messages.

Softkey Menu

The softkey menu (Table 12-12) allows you to invoke functions such as Search, Copy, Swap, Delete and the like. Various parameters are required for these softkey routines. To make room for them, the type characteristics in the characteristics field are temporarily erased from the screen and the window used to prompt for entry of the relevant parameters. Once the selected function has executed, the type characteristics are faded back onto the screen. The softkeys shown at the bottom of a menu or screen form apply only to that menu or screen form.
These functions are described in detail in the following.

Table 12-12. Function Keys in the ”Configure I / Os” Menu

Function Key	Function Name	Description
F1	SEARCH	This function allows you to select an arbitrary byte, word or interface number quickly and without moving the cursor. After pressing <F1>, enter the byte, word or interface number you want to locate. The cursor then moves to the line containing that byte, word or interface number.
F2	COPY	COPY copies the configuring data for a specific byte, word or interface number to another byte, word or interface number. Each entry is subjected internally to a validity check, and must be confirmed with the <EXEC> key! Errors, if any, are flagged by an appropriate message on the status line. The following prompt is displayed when you press <F2> (whether 'byte(s)', 'word' or 'IF no.' appears in the prompt depends on the I / O type): "From byte(s) / word / IF no.": Enter: • a number to copy a single byte, word or interface number • two numbers, separated by a hyphen, to copy an area The system then waits for you to enter the destination address: "to byte(s) / word / IF no.". The end of the destination area is computed internally, and is displayed with the text "Destination end is word xx" on the status line.

Table 12-12. Function Keys in the "Configure I / Os" Menu (continued)

Function Key	Function Name	Description
		Observe the following rules when entering addresses: • Word numbers must be even numbers between 128 and 254 (e.g. 128, 130, to 254). • The start address must be lower than the destination address. • The destination address may not lie within the block to be copied. • When copying blocks, care must be taken that sufficient locations are available, beginning at the destination address. • Before an entry is terminated, the you can move the cursor with the cursor control keys and erase characters with the space bar. • A blank statement aborts the routine. If a feedback address (e.g. an R-DI) lies within an addressing area (source and destination), the routine aborts with "FEEDBACK I / O".
F3	TYPES	You can fade in the next higher type with <F3> "Types". When the highest type has been reached, the display begins again with the lowest type (ring selection 1,2,3,1,2,3 and so on). Function <F3> "Types" allows you to select individual types. When you have selected a type with <F3>, the appropriate configuring form appears on the screen. If you branch to the relevant configuring form from a hierarchically higher menu, the lowest type (e.g. 1,8) is always displayed as basic screen form when you press <F3>. You can display the next higher type by pressing <F3>. When the highest type has been reached, the display begins again with the lowest type (ring selection 1, 2, 3, 1, 2, 3 and so on). The next matrix line is displayed when you confirm your parameters with RETURN or move the cursor down with "down arrow". The next I / O byte is displayed on the second line.

Table 12-12. Function Keys in the ”Configure I / OS”Menu (continued)

Function Key	Function Name	Description
F4	DELETE	Use this function to delete one or more bytes, words or interface numbers. The "DELETE?" prompt is displayed when you enter a number. Confirm by pressing <EXEC> or press the <ABORT> key. To delete several bytes in succession, enter e.g. "10 - 15". COM 115H then deletes bytes 10, 11, 12, 13, 14 and 15. Word numbers must be even numbers from 128 to 254. An interrupt byte (ALB, R-DI, L-DI, L- DQ) is deleted only when the associated redundant type has been deleted.
F5	SWAP	This function swaps the configuring data for one or more bytes, words or interface numbers. The function is similar to "COPY". Sample prompts: ”SWAP BYTE(S): WITH BYTE(S):” "DESTINATION END AT BYTE X SWAP?" Confirm with <EXEC> or press <ABORT>.
F8	BACK	Exit the configuring form.

- **F2 Digital Outputs**

<F2> screens the "Configure digital outputs" form.

Description: See <F1> "Configure digital inputs".

```
  COM 115H : Initializing the I/Os
-------------------------------------------------------------------------
========================================================================
    I/O byte                  !    Type number
-------------------------------+----------------------------------------
DQ byte    0                   !
-------------------------------+----------------------------------------
DQ byte    1                   !
========================================================================
Digital output   0
------------------------------------------------------------------------
                            !
                            !
static type characteristics !  Type characteristics by the
                            !  user
                            !
                            !
========================================================================

Status: TYPE INPUT
   F1        F2        F3        F4        F5        F6        F7        F8
 SEARCH     COPY     TYPES     DELETE     SWAP                          BACK
```

Figure 12-11. Configure Digital Outputs

Symbols Line

Description: See <F1> "Configure digital inputs"

Characteristics Field

Description: See <F1> "Configure digital inputs"

Table 12-13. Type Numbers for Digital Outputs (DQs)

Type Number	Specifiable Type Characteristics	Description
TYPE 8 DQ in single-channel I / O	Subunit	Enter the relevant subunit: A / B
TYPE 9 DQ in switched I / O		
TYPE 10 DQ in re-dundant I / O	L-DQ byte / bit* L-DI byte / bit*	Specify the addresses of the locating facilities: 0.0 to 127.7 Also see <F1> "Configure digital inputs" Type 3
	R-DI byte	When you configure a readback DI byte, the operating system tests the redundant digital outputs. You must also define a readback delay for the read- back DI in the COM 115H screen form "Initialize operating system", thus taking into account the delay times of the various modules. Error detection is not possible if you do not configure an R-DI byte!
	R-DI in I / O	Enter the type of I / O: 1: Single-channel R-DI subunit A 2: Single-channel R-DI subunit B 3: Switched R-DI

* You can also configure a DQ type 10 without error locating.

Note:

The processor tests the entire address area of the I / O modules word for word. You must therefore configure one word (2 DQ bytes) for each 8-bit module. Be sure that the first DQ byte is an even-numbered byte (2-3, 4-5, to).

Status and Error Line

Description: See <F1> "Configure digital inputs"

Softkey Menu

Description: See <F1> "Configure digital inputs"

- **F3 Analog Inputs**

Screen the "Configure analog inputs" form by pressing <F3>.

```
 COM 115H : Configure I/Os
---------------------------------------------------------------------------
========================================================================
    I/O word                   !    Type number
-------------------------------+----------------------------------------
    AI word 128                !
-------------------------------+----------------------------------------
    AI word 130                !
========================================================================
Analog input    0
------------------------------------------------------------------------
                            !
                            !
Static type characteristics !  Type characteristics by the
                            !  user
                            !
                            !
========================================================================

Status: TYPE INPUT
   F1   |   F2   |   F3   |   F4   |   F5   |   F6   |   F7   |   F8
 SEARCH |  COPY  | TYPES  | DELETE |  SWAP  |        |        |  BACK
```

Figure 12-12. Configure Analog Inputs

Symbols Line

Description: See <F1> "Configure digital inputs"

Characteristics Field

Description: See <F1> "Configure digital inputs"

Table 12-14. Type Numbers for Analog Inputs

Type Number	Specifiable Type Characteristics	Description
Type 13 AI in single-channel I / O	Subunit	Enter the relevant subunit: A / B
Type 14 AI in switched I / O		
Type 15 AI in redundant I / O	Discrepancy value, absolute and/or Discrepancy value, relative	Enter the tolerable discrepancy for analog value inputs (raw values) in accordance with the representation. Absolute discrepency in units (section 7.5) - Types 3 and 4: 0 to 2048 units - Types 5 and 6: 0 to 4096 units Percentage discrepancy: - All types: 0 to 100%
	Preferred value	Enter the preferred value (also applies in the event of a discrepancy): - Minimum value (1: min) or - Maximum value (2: max)

Status and Error Line
Description: See <F1> "Configure digital inputs"

Softkey Menu
Description: See <F1> "Configure digital inputs"

- **F4 Analog Outputs**

<F4> takes you to the "Configure analog outputs" form.

```
 COM 115H : Configure I/Os
----------------------------------------------------------------------
=====================================================================
   I/O word                       !               Type number
---------------------------------+-------------------------------------
     AQ word  128                 !                  18
---------------------------------+-------------------------------------
     AQ word  130                 !
====================================================================
Analog output    0
---------------------------------------------------------------------
Type number     : 18           ! Subunit          (A/B) : A
I/O channels    :  1           !
Availability    : standard     !
                               !
AQ in single-channel I/O       !
                               !

==================================================================
Status: TYPE INPUT
   F1       F2       F3       F4       F5       F6       F7       F8
 SEARCH    COPY     TYPES    DELETE    SWAP                       BACK
```

Figure 12-13. Configure Analog Outputs

Symbols Line
Description: See <F1> "Configure digital inputs"

Characteristics Field
Description: See <F1> "Configure digital inputs"

Table 12-15. Type Numbers for Analog Outputs

Type Number	Specifiable Type Characteristics	Description
Type 18 AQ in single-channel I / O	Subunit	Enter the relevant subunit: A / B
Type 19 AQ in switched I / O		
Type 20 AQ in redundant I / O		

Status and Error Line
Description: See <F1> "Configure digital inputs"

Softkey Menu
Description: See <F1> "Configure digital inputs"

- **F5 CP / IP**

<F5> takes you to the "Configure CPs / IPs" form.
The configuring forms for communications are the aids provided for configuring the CPs and IPs used in the S5-115H programmable controller.

```
 COM 115H : Configure I/Os
------------------------------------------------------------------------
========================================================================
   Interface number            !    Type number
-------------------------------+----------------------------------------
 IF NO.        0               !
-------------------------------+----------------------------------------
 IF NO.        1               !
========================================================================
Interface no.    0
------------------------------------------------------------------------
                            !
                            !
Static type characteristics !  Type characteristics
                            !  by the user
                            !
                            !
======================================================================
Status: TYPE INPUT
```

F1	F2	F3	F4	F5	F6	F7	F8
SEARCH	COPY	TYPES	DELETE	SWAP			BACK

Figure 12-14. Configure CPs / IPs

The type matrix allows you to CPs / IPs and interface number to a specific type. The screen has been split accordingly.

The interface number is displayed in the upper half of the lefthand screen window. The type assigned to each number (24, 25) is displayed in the righthand window.

The first time you switch from the configuring menu to the "Configure CPs / IPs" menu, the lowest type (type 24) is always displayed as basic screen form when you press <F3> "Types". You can select another type by pressing <F3> "Types" (ring selection 24, 25, 24, 25 and so on).

Symbols Line
Description: See <F1> "Configure digital inputs"

Characteristics Field
Description: See <F1> "Configure digital inputs"

Table 12-16. Type Numbers for CPs / IPs

Type Number	Specifiable Type Characterisitcs	Description
Type 24 CP / IP in single-channel I/O	Subunit	Enter the relevant subunit: A / B
Type 25 CP / IP in single-channel I / O		

Status and Error Line
Description: See <F1> "Configure digital inputs"

Softkey Menu
Description: See <F1> "Configure digital inputs"

Note:
You must configure all existing CP / IP interface numbers. This also applies to interface numbers not referenced in the user program.

Note:
When you want to modify already configured CPs / IPs with interprocessor communication flags, you must also reconfigure these flags.

- **F6 COMFLAG**

<F6> "COMFLAG" takes you to the "Configure communication flags" form. The interprocessor communication input and output flags configured in this screen form are allocated to the CPs in the S5-115H.

```
 COM 115H : Configure I/Os
-------------------------------------------------------------------------
========================================================================
    Commun. flag No.          !    Type number
--------------------------------+---------------------------------------
    CF byte   0               !
--------------------------------+---------------------------------------
    CF byte   1               !
========================================================================
Commun. flag No.    0
------------------------------------------------------------------------
                            !
                            !
Static type characteristics !  Type characteristics by the
                            !  user
                            !
                            !
========================================================================

Status: TYPE INPUT
```

F1	F2	F3	F4	F5	F6	F7	F8
SEARCH		TYPES	DELETE	SWAP			BACK

Figure 12-15. Configure Interprocessor Communication Flags

Symbols Line
Description: See <F1> "Configure digital inputs"

Characteristics Field
Description: See <F1> "Configure digital inputs"

Table 12-17. Type Numbers for Interprocessor Communication Flags

Type Number	Specifiable Type Characteristics	Description
Type 30	Interprocessor communication input flags	CP interface no.: Enter the interface number you assigned to the relevant CP in the "Configure CPs" form.
Type 31	Interprocessor communication output flags	CP interface no.: Enter the interface number you assigned to the relevant CP in the "Configure CPs" form.

12.3.3 F4: Call PLC Functions

<F4> takes you to the "PLC Functions" menu. In this menu, you can start or stop the PLC or make a software modification.

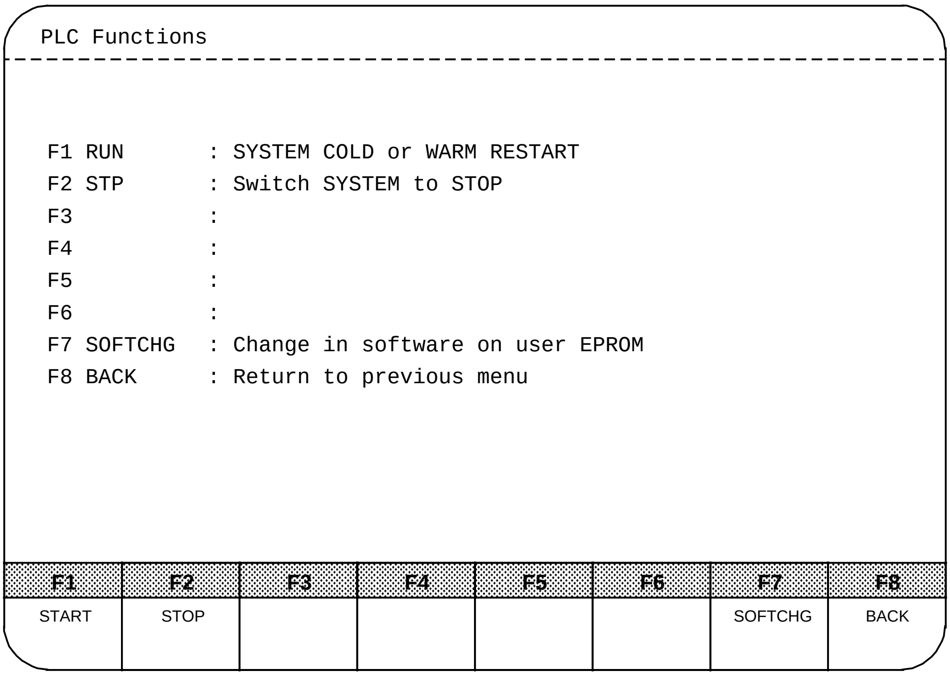


Figure 12-16. "PLC Functions" Form

Table 12-18. Function Keys in the "PLC Functions" Form

Function Key	Function Name	Description
F1	START*	The S5-115H executes a cold restart. "PLC START?" is displayed when you press <F1>. Press <EXEC> to start the PLC or press <ABORT>.
F2	STOP*	The PLC goes to STOP. "PLC STOP?" is displayed when you press <F2>. Press <EXEC> for "YES" or <ABORT> for "NO".
F7	SOFTCHG	During operation, you can make a change in the software on the user EPROM without interrupting program processing. "ID HAS BEEN SET IN THE PC" is displayed when you press <F7>.
F8	BACK	Exit the "PLC Functions" form.

* This COM 115H function affects only the controller that is interfaced to the programmer.

12.3.4 F5: Call PLC Diagnostic Functions

F5 invokes the COM 115H software package's error diagnostic program. If you also press the HELP key, the following menu is displayed on the programmer monitor:

```
Diagnos. functions COM 115H
------------------------------------------------------------

 F1           :
 F2 STAT ERR  : Static error image of the I/Os
 F3 HSYS-FW   : Control/status H system flag word
 F4 H-ERROR   : Display H errors in plaintext (from error DB)
 F5 PLCINFO   : Call S5 overlay PLCINFO
                (DISP ADDR, MEMCON, SYSPAR, BSTACK, ISTACK)
 F6           :
 F7           :
 F8 BACK      : Return to previous menu
```

F1	F2	F3	F4	F5	F6	F7	F8
	STAT ERROR	HSYS-FW	H-ERROR	PLCINFO			BACK

Figure 12-17. "Diagnos. Functions COM 115H" Form

Table 12-19. Function Keys in the "Diagnos. Function COM 115H" Form

Function key	Function Name	Description
F2	STAT ERR	Static error image of the I / Os
F3	HSYS-FW	Control / status H system flag word
F4	H-ERROR	Error diagnostics with COM 115H
F5	PLCINFO	PLC information
F8	BACK	Exit "Diagnostic functions" menu

- **F2 Static Error Image of the I / Os**

<F2> screens the "Static error image of the I / Os" form.

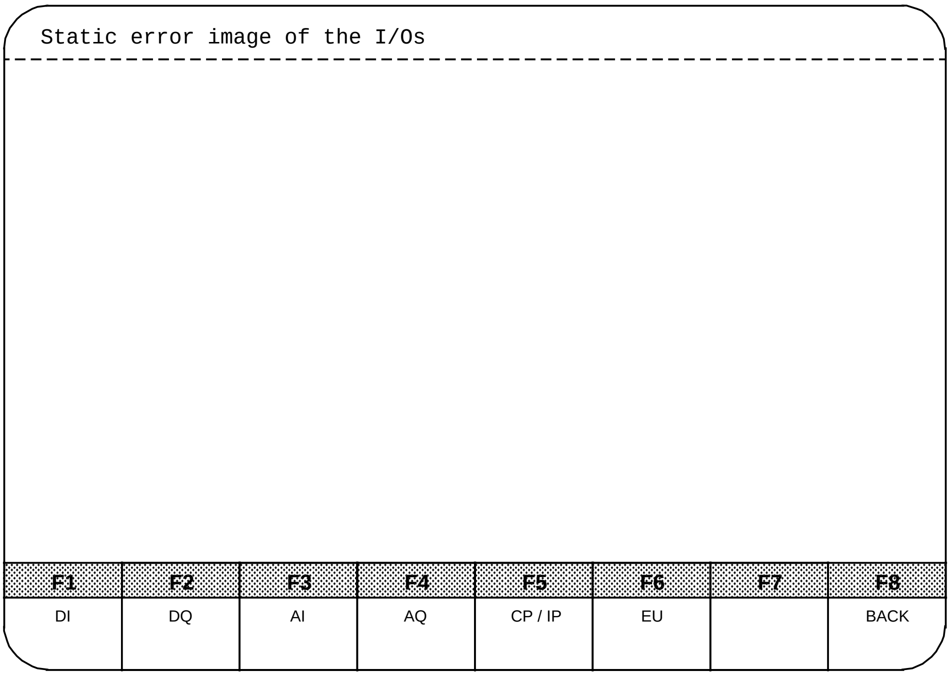


Figure 12-18. "Static Error Image of the I/Os" Form

You can display a static error image of the following I / Os:

F1 : DI "Digital inputs"
F2 : DQ "Digital outputs"
F3 : AI "Analog inputs"
F4 : AQ "Analog outputs"
F5 : CPs / IPs
F6 : EU "Expansion units"

The following menu is displayed when you press one of the function keys in the softkey menu, e.g. <F1> "Digital inputs":

```
 Static error image of the I / Os
--------------------------------------------------------------------------

                          Digital inputs
           Connected PLC is SUBUNIT A and MASTER
             0    1    2    3    4    5    6    7    8    9  !
     ----+----+----+----+----+----+----+----+----+----+----!
      0  !    !    !    !    !    !    !    !    !    !    !
     ----+----+----+----+----+----+----+----+----+----+----!
     10  !    !    !    !    !    !    !    !    !    !    !
     ----+----+----+----+----+----+----+----+----+----+----!
     20  !    !    !    !    !    !    !    !    !    !    !
     ----+----+----+----+----+----+----+----+----+----+----!
     30  !    !    !    !    !    !    !    !    !    !    !
     ----+----+----+----+----+----+----+----+----+----+----!
     40  !    !    !    !    !    !    !    !    !    !    !
     ----+----+----+----+----+----+----+----+----+----+----!
     50  !    !    !    !    !    !    !    !    !    !    !
     ----+----+----+----+----+----+----+----+----+----+----!
     60  !    !    !    !    !    !    !    !    !    !    !
     ----+----+----+----+----+----+----+----+----+----+----+
```

F1	F2	F3	F4	F5	F6	F7	F8
		CONTINUE					BACK

Figure 12-19. "Static Error Image of the I / Os" Form

The errored I / O bytes for the digital inputs are displayed in the matrix. The error code assigned to the relevant digital input is displayed in the appropriate matrix field. You can scroll through the matrix with <F3> "Continue".

Note:

Only those I / Os that were configured with COM 115H are entered in the static error image.

The table below lists the possible error codes:

Table 12-20. Error Codes in the Static Error Image

Error Code	Description
A	Defective I / O in subunit A
B	Defective I / O in subunit B
AB	Defective I / O in subunits A and B
RA	Defective redundant I / O in subunit A
RB	Defective redundant I / O in subunit B
G	Defective switched I / O
R-A	Defective readback DI in subunit A
R-B	Defective readback DI in subunit B
R-G	Defective readback DI in switched I / O
L-A	Defective locating facility in subunit A
L-B	Defective locating facility in subunit B
L-AB	Defective locating facility in subunits A and B

- **F3 Control / Status H System Flag Word**

<F3> "HSYS-FW" screens the "Control / status H system flag word" form.

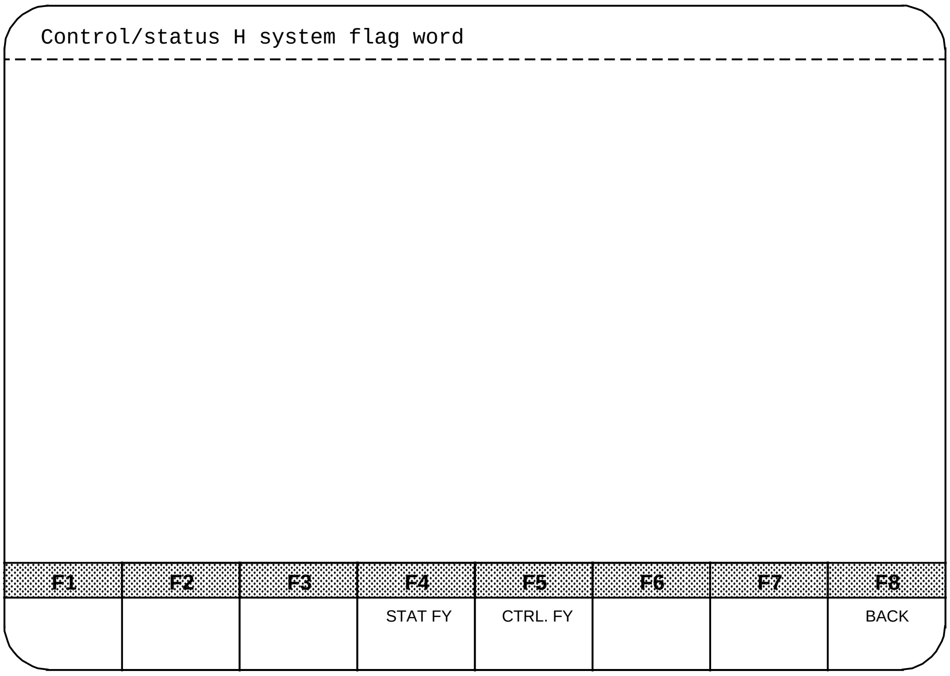


Figure 12-20. "Control / Status H System Flag Word" Form

You can use this screen form to read out (Status) or force (control) the H system flag word. The status of each bit in the H system flag word is displayed when you press <F4> "STAT FY", for example:

```
  Control/status H system flag word
------------------------------------------------------------------------

    FY: 0                     S T A T U S
                  Connected PLC is SUBUNIT A and MASTER
   +----+
0  ! 1  !  System in Solo mode
   +----+
1  ! 0  !
   +----+
2  ! 1  !  CC is MASTER
   +----+
3  ! 0  !
   +----+
4  ! 1  !  PLC is subunit A
   +----+
5  ! 1  !  Subunit A is MASTER
   +----+
6  ! 0  !
   +----+
7  ! 0  !
   +----+
```

F1	F2	F3	F4	F5	F6	F7	F8
							BACK

Figure 12-21. "Status" Form

Press function key <F5> "CTRL. FY" if you want to change or force bits in the H system flag word. Set the cursor to the bit you want to change and enter the relevant value:

”1” Set bit
”0” Reset bit

Confirm your changes with <F6> ”EXEC”.

```
  Control/status H system flag word
--------------------------------------------------------------------------
    FY: 1                     C O N T R O L
   +----+
0  ! 0  !  Switch off startup
   +----+
1  ! 0  !  free
   +----+
2  ! 0  !  Disable update of standby
   +----+
3  ! 1  !  Mask standard error response
   +----+
4  ! 0  !  Depassivation
   +----+
5  ! 1  !  Request transfer
   +----+
6  ! 0  !  Standby stop?
   +----+
7  ! 0  !  free
   +----+
```

F1	F2	F3	F4	F5	F6	F7	F8
					EXEC		BACK

Figure 12-22. "Control" Form

- **F4 Error Diagnostics with COM 115H**

After pressing <F1> "H-ERROR" in the COM 115H diagnostics menu, you must specify whether you want to read out the error data block from the PLC (with <F1>: On-line diagnostics) or the floppy (with <F2>: Off-line diagnostics):

```
Error diagn. with COM 115H
----------------------------------------------------------------

                  PROGRAM FILE : B:@@@@@@ST.S5D

 F1 LOAD PLC  : Load configured error DB from PLC
 F2 LOAD FD   : Load configured error DB from floppy
 F3           :
 F4           :
 F5           :
 F6           :
 F7           :
 F8 BACK      : Return to previous menu
```

F1	F2	F3	F4	F5	F6	F7	F8
LOAD PLC	LOAD FD						BACK

Figure 12-23. "Error Diagn. with COM 115H" Form

After you have pressed the key for the required function, the contents of the H error DB are displayed on the monitor screen. Both subunits use the same error DB. An error message is displayed if you press function key <F1> "LOAD PLC" when you have not connected a PLC.

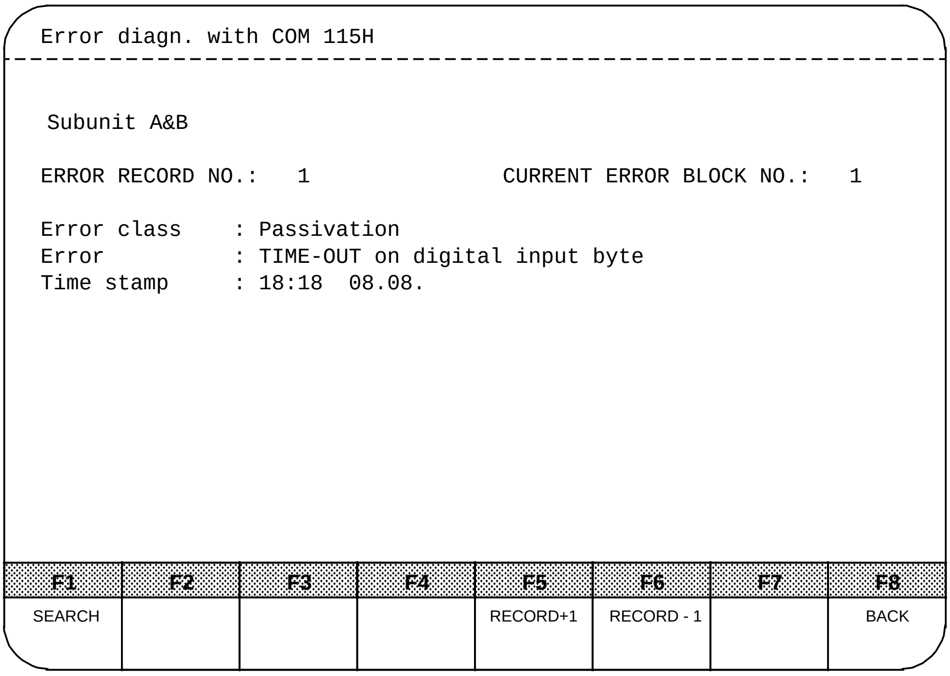


Figure 12-24. "Error Record" Form

If there is more than one error, the one that was entered last is displayed first. Each screen form is for one error record in the error data block.

Table 12-21. Function Keys in the "Error Diagn. with COM 115H" Menu

Function Key	Function Name	Description
F1	SEARCH	If you want to read out a specific error block quickly, press this key and enter the block number. Proceed as follows to search for a particular error number: • Press <F1> "SEARCH" • Move the cursor down (to the right of the error number) • Enter the error number you want and press <RETURN>. The search for the error number begins at the start of the current error record. "Error not found" is displayed if the search is not successful.
F5 F6	RECORD+1 RECORD - 1	These functions allow you to page through the error data block record by record (both forward and backward), thus making it possible to read out all errors currently in the error DB (for both PLCs). "No more error entries" is displayed when the last entry has been read out.
F8	BACK	Exit the "Error record" form

Table 12-22. Terms

<table>
<tr><th>Term</th><th colspan="4">Description</th></tr>
<tr><td>SUBUNIT A / B</td><td colspan="4">In each screen form, you are shown whether the error occurred in subunit A, subunit B, or in subunits A&B.</td></tr>
<tr><td>ERROR RECORD NO. X</td><td colspan="4">You are currently reading out error record X.</td></tr>
<tr><td>CURRENT ERROR</td><td colspan="4">The last error stored is in error record X.</td></tr>
<tr><td>ERROR CLASS</td><td colspan="4">The standard error response is noted here (e.g. passivation).</td></tr>
<tr><td>ERROR</td><td colspan="4">Error message in plaintext.</td></tr>
<tr><td rowspan="6">TIME STAMP</td><td colspan="4">The time and date on which the error occurred.
The time stamp is displayed only when your system is configured with a CP 523.
The CP 523 allows you to choose between various different methods of representation and formats. Here an overview:</td></tr>
<tr><th>Format</th><th>Element</th><th colspan="2">Display</th></tr>
<tr><td rowspan="2">english</td><td>Minute</td><td>12:23 PM</td><td>02.09.</td></tr>
<tr><td>Second</td><td>09.</td><td>12:23:42 PM</td></tr>
<tr><td rowspan="2">german</td><td>Minute</td><td>12:23</td><td>09.02.</td></tr>
<tr><td>Second</td><td>09.</td><td>12:23:42</td></tr>
</table>

- **F5 PLC INFO**

<F5> calls the S5 overlay "PLC INFO".

```
 P L C   I N F O                              SIMATIC S5 / ODSOC
-----------------------------------------------------------------


  F1 DISP ADDR : DISPLAY ARBITRARY PLC MEMORY AREAS
  F2 MEMCON    : PLC MEMORY CONFIGURATION
  F3 SYSPAR    : PLC SYSTEM PARAMS, REVISION LEVELS
  F4 BSTACK    : PLC BLOCK STACK (PLC MUST BE AT STOP)
  F5 ISTACK    : PLC INTERRUPT STACK (PLC MUST BE AT STOP)

  F8 BACK      : RETURN TO FUNCTION SELECTION
```

F1	F2	F3	F4	F5	F6	F7	F8
DISP ADDR	MEMCON	SYSPAR	BSTACK	ISTACK			BACK

Figure 12-25. "PLC INFO" Form

Table 12-23. Function Keys in the "PLC INFO" Form

Function Key	Function Name	Description
F1	DOSP ADDR	Display memory areas
F2	MEMCON	PLC memory configuration
F3	SYSPAR	System parameters
F4	BSTACK	PLC block stack
F5	ISTACK	Interrupt stack
F8	BACK	Exit the "PLC INFO" form

12.3.5 F6: Defaults

<F6> invokes the "Defaults" menu.
(Refer to Section 12.1.3 "Starting COM 115H", Figure 12-1).

12.3.6 F7: System Handling

<F7> screens the "System Handling COM 115H" menu.

In this menu, you can

- delete, transfer or load a configuration data block
- output configuration DB directory to a specifiable external device
- make a hard copy printout of the configuration DB for documentation purposes

```
System handling COM 115H
--------------------------------------------------------------------

                  PROGRAM FILE: B:@@@@@@ST.S5D

   F1 CONF DIR    : Overview of I/O configuring data
   F2 DEL CONF    : Delete configuring data
   F3 TRAN/LOAD   : Transfer/load
   F4 PRINT       : Print
   F5 PRG FILE    : Change program file names
   F6             :
   F7 AUX         : Call STEP 5 auxiliary functions
   F8 BACK        : Return to previous menu
```

F1	F2	F3	F4	F5	F6	F7	F8
CONF DIR	DEL CONF	TRAN / LOAD	PRINT	PRG FILE		AUX	BACK

Figure 12-26. "System Handling" Form

Table 12-24. Function Keys in the "System Handling COM 115H" Menu

Function Key	Function Name	Description
F1	CONF DIR	Overview of configuring data
F2	DEL CONF	Delete configuring data (programmer memory)
F3	TRAN / LOAD	Transfer and load DB 1 (configuration)
F4	PRINT	Print configuring data (DB 1)
F5	PRG FILE	Select program file
F7	AUX	Auxiliary functions
F8	BACK	Exit the "System handling" form

- **F1 Overview of Configuring Data**

<F1> screens the directory menu. This menu allows you to display an overview of your I / O configuring data on the monitor.

If you need an overview of configuring data from the EPROM, you must transfer DB 1 from EPROM to floppy disk (using the S5 command interpreter's EPROM handling function). You can then output the DB1 directory from floppy (CONF DIR FD).
Errored access attempts are indicated by error messages. These error messages disappear from the screen when you press a softkey.

```
Directory configuration DB 1
--------------------------------------------------------------------------

                 PROGRAM FILE: B:@@@@@@ST.S5D

  F1 PLC         : PLC directory on screen
  F2 FD          : FD directory on screen
  F3             :
  F4 PR PLC      : Print PLC directory
  F5 PR FD       : Print FD directory
  F6             :
  F7             :
  F8 BACK        : Return to previous menu
```

F1	F2	F3	F4	F5	F6	F7	F8
PLC	FD		PR PLC	PR FD			BACK

Figure 12-27. "Directory Configuration DB 1" Form

Table 12-25. Function Keys in the "Directory Configuration DB 1" Form

Function Key	Function Name	Description
F1	PLC	The overview of your I / O configuring data is read in from the PLC and output to screen.
F2	FD	The overview of your I / O configuring data is read in from floppy (FD) and output to screen.
F4	PR PLC	The overview of your I / O configuring data is read in from the PLC and output to printer.
F5	PR FD	The overview of your I / O configuring data is read in from floppy (FD) and output to printer.
F8	BACK	Exit the "Directory configuration DB 1" form

- **F2 Delete Configuring Data (Programmer Memory)**

<F2> screens the "I / O delete" form.

```
I/O delete
--------------------------------------------------------------------------

                    PROGRAM FILE: B:@@@@@@ST.S5D

F1 ALL      : Delete entire configuration in the programmer memory
F2 TYPES    : Delete individual types
F3          :
F4          :
F5          :
F6          :
F7          :
F8 BACK     : Return to previous menu



                                    DELETE ENTIRE CONFIGURATION?
```

F1	F2	F3	F4	F5	F6	F7	F8
ALL	TYPES						BACK

Figure 12-28. "I / O Delete" Form

<F1> "ALL" allows you to delete all I / O configuring data in the programmer memory. "Delete whole configuration?" is displayed when you press <F1>. Press <ENTER> to reply with "YES" or <ABORT> to reply with "NO".

A type matrix is displayed when you press <F2> "Types". Using this matrix, you can delete individual DI, DQ, AI, AQ and CP / IP types. The interprocessor communication flags are deleted when you delete the associated interface number.

Set the cursor to the field for the type you want to delete and press <RETURN>. If the specified type was configured, "TYPE DELETED" is displayed as confirmation. If it was not, "TYPE NOT CONFIGURED" is displayed instead.

```
I / O - delete
----------------------------------------------------------------------

                      PROGRAM FILE: B:@@@@@@ST.S5D

                                   DE + DA + AE + AA +CP/IP+
Types single-channel subunit  A  ! X  !    !    !    !     !
---------------------------------+----+----+----+----+-----+
Types single-channel subunit  B  !    !    !    !    !     !
---------------------------------+----+----+----+----+-----+
Types switched                   !    !    !    !    !     !
---------------------------------+----+----+----+----+-----+
Types redundant                  !    !    !    !    !     !
---------------------------------+----+----+----+----+-----+
```

F1	F2	F3	F4	F5	F6	F7	F8
							BACK

Figure 12-29. "Type Matrix" Form

- **F3 Transfer and Load DB 1 (Configuration)**

```
I / O transfer / load
----------------------------------------------------------------------

                      PROGRAM FILE: B:@@@@@@ST.S5D

 F1 LOAD PLC  : Load from PLC
 F2 TRAN PLC  : Transfer to PLC
 F3 LOAD FD   : Load from FD
 F4 TRAN FD   : Transfer to FD
 F5           :
 F6           :
 F7           :
 F8 BACK      : Return to previous menu
```

F1	F2	F3	F4	F5	F6	F7	F8
LOAD PLC	TRAN PLC	LOAD FD	TRAN FD				BACK

Figure 12-30. "I / O Transfer / Load" Form

Table 12-26. Function Keys in the "I / O Transfer / Load" Form

Function Key	Function Name	Description
F1 F3	LOAD PLC LOAD FD	The Load functions read DB 1 from the PLC or floppy (FD) into your programmer's memory.
F2 F4	TRAN PLC TRAN FD	The Transfer functions transfer your data from programmer memory to PLC or floppy.
F8	BACK	Exit the "I / O transfer / load" menu.

The Load function transfers DB 1 to the programmer and then checks to see whether it is a configuration block for the S5-115H. If it is not, it is rejected with "WRONG DB1".

If the PLC was specified for transfer, a second screen form is displayed in which you can specify the program sections to be transferred.

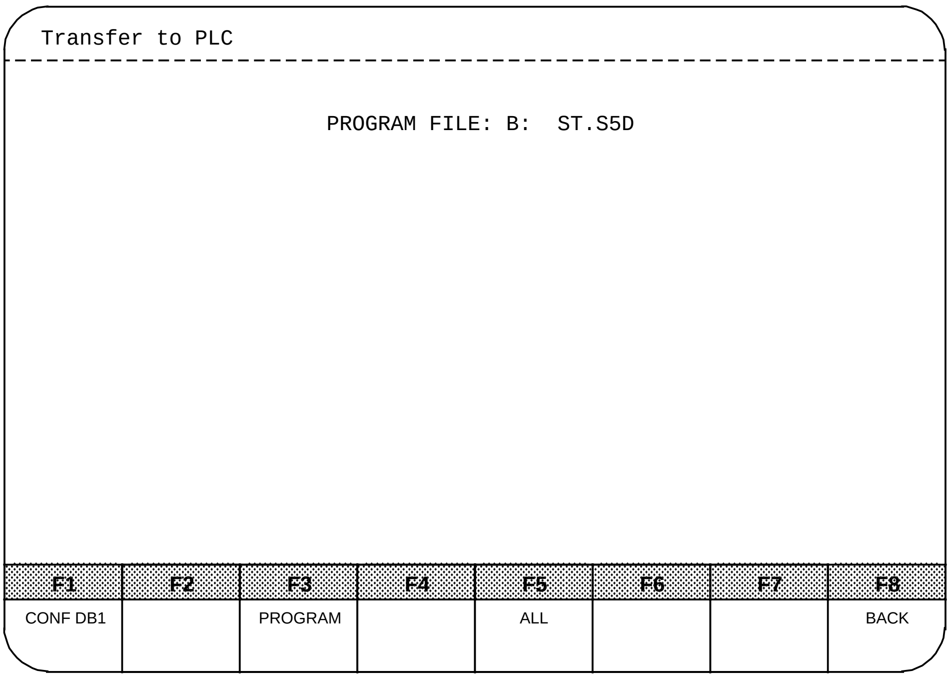


Figure 12-31. "Transfer to PLC" Form

Table 12-27. Function Keys in the "Transfer to PLC" Form

Function Key	Function Name	Description
F1	CONF DB1	Configuration DB: Only the configuration DB generated with COM 115H is transferred.
F3	PROGRAM	Program: The user program (all blocks except the configuration DB) is read from the specified program file and transferred.
F5	ALL	All: Both the configuration DB and the program are transferred.
F8	BACK	Exit the "Transfer to PLC" form

Only the configuration DB is transferred when FD is specified.

"DBxy ALREADY ON (DEVICE), OVERWRITE?" is displayed prior to transfer of a configuration DB. You can overwrite the block (default block) with <ENTER> or abort the function with <ABORT>.

An appropriate error message is displayed should an error occur.

Note:
Data block DB 1 can be transferred only when both PLCs are at STOP.

- **F4 Print Configuration (DB 1)**

<F4> screens the Print menu, which enables you to print out your configuring data in tabular form. Before you can print out the configuration DB from a logical device (PLC, FD or EPROM), you must first load it into the programmer's memory. A footer can be added to each page.

```
COM 115H print menu
------------------------------------------------------------

                    PROGRAM FILE: B:@@@@@@ST.S5D

F1 DI        : Print configured digital inputs
F2 DQ        : Print configured digital outputs
F3 AI        : Print configured analog inputs
F4 AQ        : Print configured analog outputs
F5 CP/IP     : Print configured interfaces
F6 TYPES     : Print differentiated types
F7 ALL       : Print the whole configuration
F8 BACK      : Return to previous menu

  F1     F2     F3     F4     F5      F6     F7     F8
  DI     DQ     AI     AQ   CP / IP  TYPES   ALL   BACK
```

Figure 12-32. "COM 115H Print Menu"

Table 12-28. Function Keys in the "COM 115H Print Menu"

Function Key	Function Name	Description
F1	DI	Print all DIs: Lists the configuration data as per DB1 for all digital inputs.
F2	DQ	Print all DQs: Lists the configuration data as per DB1 for all digital outputs.
F3	AI	Print all AIs: Lists the configuration data as per DB1 for all analog inputs.
F4	AQ	Print all AQs: Lists the configuration data as per DB1 for all analog outputs.
F5	CP/IP	Print all CPs / IPs: Lists the configuration data as per DB1 for all CP / IP types.

Table 12-28. Function Keys in the "COM 115H Print Menu" (continued)

Function Key	Function Name	Description
F6	TYPES	Prints individual types, all configured L-DIs, L-DQs and R-DIs (bit by bit), or your operating system parameters. The types to be printed are selected via a type matrix (Section 12.4.2).
F7	ALL	Print the configuration DB: A printout is made of all configuring data.
F8	BACK	Exit the "COM 115H print menu".

- **F5 Select Program File**

After pressing <F5> in the System Handling menu, you are prompted for entry of a program file. All access operations to hard disk or floppy disk made prior to specification of a program file access file "B:@@@@@@ST.S5D".

After you have specified your program file, you can perform various operations on the floppy-based blocks, such as Delete, Configure, Transfer, Print and so on.

- **F7 Auxiliary Functions**

<F7> invokes the STEP 5 auxiliary functions.

For details, please refer to your programmer manual.

12.4 Documenting with COM 115H

12.4.1 Print Overview of Configuring Data

Press <F7> in the Main menu to screen the "System Handling" menu. <F1> "CONF DIR" takes you to the Directory menu, where you can make a hard copy printout of your configuring data from either PLC (<F4>) or floppy disk (<F5>) for documentation purposes.

Example:

I / O Module	I / O Type	Subunit	Quantity
Digital input modules	Single-channel	A	1
Digital input modules	Single-channel	B	0
Digital input modules	Switched		1
Digital input modules	Redundant		1
Digital output modules	Single-channel	A	0
Digital output modules	Single-channel	B	0
Digital output modules	Switched		0
Digital output modules	Redundant		0
Analog input modules	Single-channel	A	0
Analog input modules	Single-channel	B	1
Analog input modules	Switched		1
Analog input modules	Redundant		1
Analog output modules	Single-channel	A	0
Analog output modules	Single-channel	B	0
Analog output modules	Switched		0
Analog output modules	Redundant		0
CP / IP interfaces	Single-channel	A	0
CP / IP interfaces	Single-channel	B	0
CP / IP interfaces	Switched		0
CP / IP interfaces	Redundant		0

12.4.2 Print Configuration Data Block DB 1

<F4> in the "SYSTEM HANDLING" menu takes you to the COM 115H Print menu, where you can output your configuring data in tabular form.

Before you can output data from PLC or FD, you must first load this data into the programmer's memory. You can do this by pressing <F3> "TRAN / LOAD" in the System Handling menu.

If you specified a hard copy printout, a footer is added at the end of each page.

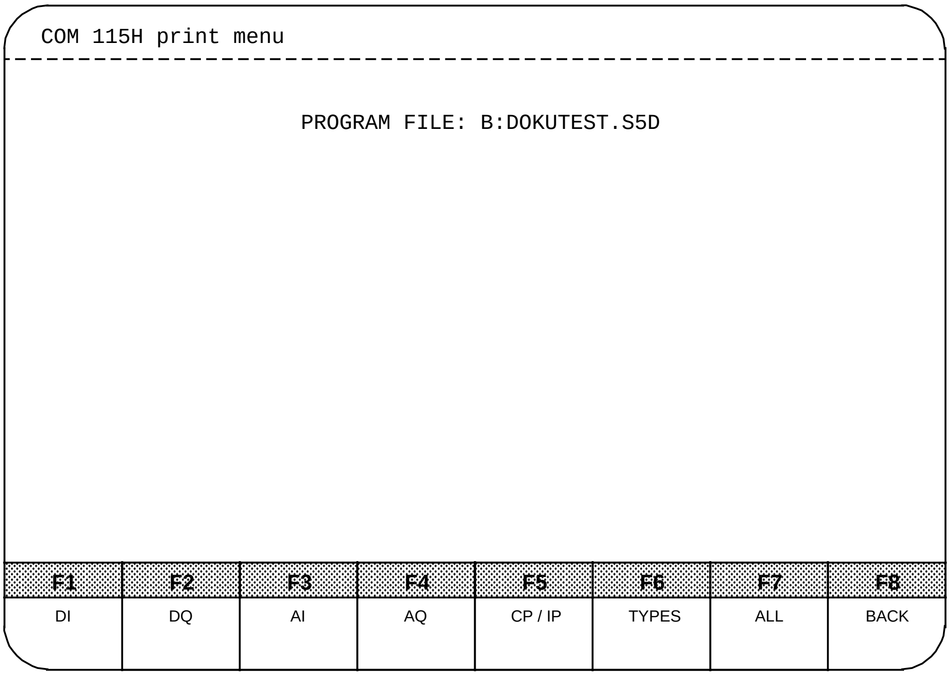


Figure 12-33. "COM 115H Print Menu"

You can execute the following functions with function keys <F1> to <F7>:

- F1 Print All DI Types (Digital Input Bytes)

Example: Table of DI Types (F1)

Digital inputs:

I / O Byte	Short Symbol	Type	Sub-unit
IB 1		2	
IB 127		LDP	

I / O Byte	Short Symbol	Type	Sub-unit
IB 1		2	
IB 127		LDP	

- F2 Print All DQ Types (Digital Output Bytes)
- F3 Print All AI Types (Analog Inputs)
- F4 Print All AQ Types (Analog Outputs)
- F5 Print All CP / IP Types (Interface Nos.)

Example: Table of CP / IP Types (F5)
CP / IP Interfaces:

Interface Number	Type	Sub-unit
0	24	A

Interface Number	Type	Sub-unit
10	24	B

IPC input flags: 0-12, 16, 20
IPC output flags: 21-30, 14, 15
} When CF configured for this interface (IF) number.

- F6 List Individual Types, Configured L-DIs, L-DQs and R-DIs (Bit by Bit) or Operating System Parameters

```
  COM 115H print menu
------------------------------------------------------------------------
                      PROGRAM FILE: B:@@@@@@ST.S5D


                                   DE + DA + AE + AA +CP/IP+
Types single-channel subunit AG A !    !    !    !    !     !
----------------------------------+----+----+----+----+-----+
Types single-channel subunit AG B  !    !    !    !    !     !
----------------------------------+----+----+----+----+-----+
Types switched                    !    !    !    !    !     !
----------------------------------+----+----+----+----+-----+
Types redundant                   !    !    !    !    !     !
----------------------------------+----+----+----+----+-----+
I/O communic. flags               !    !
----------------------------------+----+
L-DI, L-DQ, RDI                   ! X  !
----------------------------------+----+
OS configuration                  !    !
----------------------------------+----+
   F1       F2       F3       F4       F5       F6       F7       F8
```

Figure 12-34. COM 115H Print Menu

A type matrix, in which you can mark the various types, is displayed when you press <F6> "Types".
Set the cursor to the relevant field and press <RETURN> or <ESC>.

Your selections are output to printer.

Example: Redundant DIs

DI-Type 3: Two-channel digital inputs (redundant I / Os)

DI Byte	Short Symbol	Discrep. Time (s)	L-DQ Byte / Bit	L-DI Byte / Bit
IB 5.0		0.05	30.5	6.2
IB 5.1		0.05	30.5	6.2
IB 5.2		0.05	30.5	6.2

Example: L-DI, L-DQ, RDI

Bit assignments for digital outputs:

Bits	0	1	2	3	4	5	6	7
DQ byte 30			DQ-LDQ			DI-LDQ		

Bit 5 of digital output byte 30 is configured as locating digital output for a redundant digital input. The remaining bits are unassigned.

The following are listed when you "check off" the "OS configuration" field in the Print menu:

1. Operating system parameters
2. Transfer data for standby activation
3. I / O areas in the expansion units

• F7 Print Entire Configuration
This function outputs all configuration data to printer:

1. Operating system parameters (see above) and
2. All I / O configuring data

13 Program Test

13 Program Test

Use the following test functions to find and eliminate logic errors in the program. Test blocks are not possible with the S5-115H.

Note:

These functions increase the scan time.

13.1 Signal Status Display

Two test functions indicate operand signal states and the result of a logic operation (RLO). Depending on when signal states are examined, a distinction is made between program-dependent signal status display (STATUS) and direct signal status display (STATUS VAR).

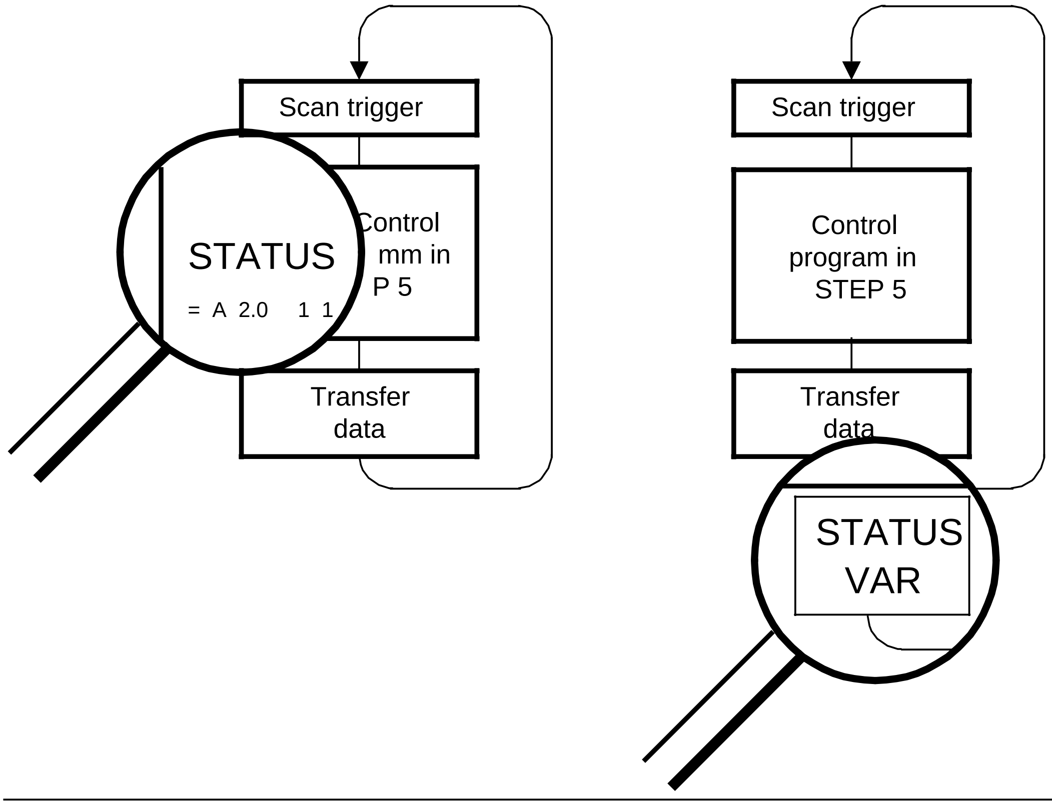


Figure 13-1. Comparison of the "STATUS" and "STATUS VAR" Test Functions

Displaying Signal States

How signal states are displayed on a screen depends on the method of representation.

STL:
Signal states are represented in the form of a list.

CSF / LAD:
Signal states are represented by different types of connecting lines as shown in Figure 13-2:

Signal state 1

Signal state 0

Signal state cannot be represented. (E.g., the signal state is outside the range of the 20 operands that can be represented.)

Figure 13-2. Representation of Signal States on a Screen (for LAD and CSF)

13.1.1 Program-Dependent Signal Status Display ”STATUS”

Use the ”STATUS” test function to display the current signal states and the RLO of the various operands during program scanning. You can also use this function to correct the program.

Note:
The PLC must be in the ”RUN” mode for this test function. In solo mode, you can access the redundant, the switched, and the single-channel I / Os in the subunit.
In redundant mode, you can access all I / Os without any restrictions whatsoever.

13.1.2 Direct Signal Status Display ”STATUS VAR”

Use the ”STATUS VAR” test function to display the state of an arbitrary operand (input, output, flag, data word, counter, or timer) at the end of a program scan. The information is taken from the process image of the operands in question. During Program Check or in the ”STOP” mode, the inputs are read indirectly from the input modules. Otherwise, only the process image of the specified operands is displayed.

13.2 Forcing

You can use the Force functions to influence specific binary and digital operands. A distinction is made between Forcing Outputs (FORCE) and Forcing Variables (FORCE VAR), depending on whether the user wants to act upon the process image or the program scan.

13.2.1 Forcing Outputs ”FORCE”

You can set outputs to a specific signal state directly without using the control program. Use this direct method to check the wiring and functioning of output modules. This procedure does not change the process image but is does cancel the output disable state.

Note:
For the ”FORCE” test function, the PLC must be either set to the Program Check function or in the ”STOP” mode. This means that this on-line function affects only the outputs of the subunit to which the programmer is interfaced. The function must only be executed without the load voltage.

13.2.2 Forcing Variables ”FORCE VAR”

With the ”FORCE VAR” test function, the process image of binary and digital operands is modified regardless of the PLC mode.
The following variables can be modified: I, Q, F, T, C, and D.
Program scanning with the modified process variables is executed in the ”RUN” mode. However, the variables can be modified again in the remaining program run, without a checkback signal.
Process variables are forced asynchronously to the program run.

Special characteristics include the following:

- Modify the variables I, Q, and F only by bytes or by words in the process image.
- For the variables T and C in the KM and KH format, proceed as follows:
  - Enter a ”Y” in the SYSTEM COMMANDS input field in the DEFAULTS menu.
  - Pay particular attention to forcing of edge flags.
- An incorrect format or operand entry aborts the signal status display. The system outputs the message ”NO FORCE POSSIBLE”.

13.3 Search

The Search function looks for specific keys in the program and lists them on the programmer's monitor. You can then make program changes at this point.

You can execute searches with the following programmer functions:

- INPUT
- OUTPUT
- STATUS
- PROGRAM CHECK

Possible search keys include the following:

- statements (e.g., A I 0.1)
- operands (e.g., Q 1.0)
- labels (e.g., X 01), possible only in function blocks!
- addresses (e.g., 006)

Note :
The Search function is executed differently by different programmers. It is described in detail in the appropriate operator's guide.

13.4 Program Check

The programmer's Program Check function permits step-by-step scanning of a random block. When this function is called, program scanning is stopped at a specific point. This breakpoint (a statement in the program) is indicated by the cursor. The PLC scans the program up to the selected statement. The current signal states and the RLO are displayed from this statement on (as with the ”STATUS” test function). You can scan the program in sections by shifting the breakpoint as you require.
Program scanning takes place as follows:

- All jumps in the called block are traced.
- Block calls are executed without delay. The Program Check is continued only after program scanning returns to the point where a block was called.
- Program scanning is terminated automatically when block end (BE) is detected.

The following applies during a Program Check:

- Both mode LEDs are off.
- Inputs and outputs are not scanned. The program writes to the PIQ and reads the PII.
- All outputs are set to zero. The ”BASP” LED lights up.

Corrections are not possible during a Program Check. However, the following test and PLC functions can be executed:

- input and output (program modifications are possible)
- direct signal status display (STATUS VAR)
- forcing outputs and variables (FORCE, FORCE VAR)
- information functions (ISTACK, BSTACK)

If the Program Check function is interrupted by PLC or program errors, the PLC goes into the ”STOP” mode and the corresponding LED lights up on the CPU control panel.

Consult the appropriate operator's guide for information on calling the Program Check function on a programmer.

14 Error Diagnostics and Error Recovery

Figures

Tables

14 Error Diagnostics and Error Recovery

Malfunctions in the S5-115H can have various causes. If a malfunction should occur, the S5-115H offers you the following options for error diagnostics and recovery:

- Error diagnosis with COM 115H (Section 14.1)
- Interrupt analysis (Section 14.2)
- Program errors (Section 14.3)

Note:
To enable a rough distinction between a PLC malfunction and a program error, program OB 1 so that it consists of only a "BE" statement. If the PLC is working properly, it goes to RUN when a cold restart is initiated.

14.1 Error Diagnostics with COM 115H

All errors detected by the S5-115H's operating system are stored in an error data block. You may choose the number of this block when you configure the system with COM 115H.

```
Initialize operating system
-------------------------------------------------------------

                  Initializing the H operating system

   No. of test slices  (n*5ms)    (1....9):      1
   H error DB number              (2..255):      2
   OB 13 time interval    (0.10s..600.00s):      0.10s
   Readback delay           (0.01s..1.00s):      0.01s
   H system flag word            (0...254):      0
   SINEC node no.                (0..1023):      0
   Number of switched EUs        (0.....8):      0

   IP address areas with linear addressing
   Begin single-channel I/O subunit A     :      0000H
   Begin switched I/O                     :      0000H

  F1  |  F2  |  F3  |  F4  |  F5  |  F6  |  F7  |  F8
      |      |      |      |      | EXEC |      | BACK
```

DB number for error data block
Default: DB 2

Figure 14-1. 115H Operating System Initialization Menu

The operating system then generates the error DB in RESTART mode. Errors which occur prior to generation of the DB are flagged in the ISTACK. The error DB normally comprises 135 words (+ 5 words for the block header).

Note:
The contents of the error DB are erased:
- in RESTART mode
- when you request that passivation be revoked by setting the relevant bits in the H flag word.

The following important information is entered in the error DB when an error occurs during program scanning:

- **Entry in the Error Image**
  The 115H operating system forms a static image of the error and maps it into the error DB. This image is such that each "repairable" unit (I / Os, CPs / IPs) is assigned a specific bit. These bits are arranged in order of ascending addresses or interface numbers. In addition, a distinction is made as to whether the repairable units belong to subunit A or subunit B.
  All bits in the error image are originally "0". If the system program detects an error during the self-test, it sets the relevant bit to "1".
  You will find an example for this procedure in Section 14.4.4 under the heading "Static Error Image: DW 6 to 127".

- **Entry in the Status Word**
  Each error is also assigned to a particular error group (for instance "Parallel link errors", "I / O errors" and the like). One bit is reserved in the status word for each group. A group error bit remains set to "1" as long as the error image contains at least one error for that group. A list of the error groups which reserve bits in the status word is presented in Section 14.5.1.

- **Entry in the Error Block**
  Errors detected by the operating system are entered in a so-called error block. In the case of I / O errors, the operating system enters no more than two errors in the error DB per cycle. Entry of the second of these two errors also sets the "Error Burst" bit in status word DW3. No other I / O errors detected in this PLC cycle are entered in the error DB, thus preventing an excessive increase in the cycle time.
  The error flags are entered in so-called error blocks. Each block comprises seven data words. The precise structure of an error block is discussed in Section 14.1.1. Error OB 37 is invoked for each error that is entered in the error DB.

14.1.1 Structure of the Error Data Block

The Table below shows the structure of the error DB:

Table 14-1. Structure of the Error Data Block

Data Word		High-Order Byte		Low-Order Byte
DW 0		Error counter		
DW 1		Write pointer		
DW 2		(Reserved for read pointer)		
DW 3		Status word		
DW 4		Error DB ID (115)		Address of 1st error block (128)
DW 5		Unassigned		
DW 6 to 13 DW 14 to 17 DW 18 to 25 DW 26 to 29 DW 30 to 37 DW 38 to 41 DW 42 to 49 DW 50 to 53 DW 54 to 61 DW 62 to 65 DW 66 to 73 DW 74 to 77		Static error image DI : 0 to 127 Subunit A Static error image AI : 128 to 254 Subunit A Static error image DI : 0 to 127 Subunit B Static error image AI : 128 to 254 Subunit B Static error image DI : 0 to 127 Switched Static error image AI : 128 to 254 Switched Static error image DQ : 0 to 127 Subunit A Static error image AQ : 128 to 254 Subunit A Static error image DQ : 0 to 127 Subunit B Static error image AQ : 128 to 254 Subunit B Static error image DQ : 0 to 127 Switched Static error image AQ : 128 to 254 Switched		
DW 78 to 93 DW 94 to 109 DW 110 to 125		Static error image IF no. : 0 to 255 Subunit A Static error image IF no. : 0 to 255 Subunit B Static error image IF no. : 0 to 255 Switched		
DW 126		Stat. err.im. EUs: 1 to 8 Subunit A		Stat. err.im. EUs: 1 to 8 Subunit B
DW 127		(Reserved)		
DW 128	Error block	Error location	Error class	Error number
DW 129		Auxiliary info 1		
DW 130		Auxiliary info 2		
DW 131		Auxiliary info 3		
DW 132		Maintenance info		
DW 133		Hour (BCD)		Minute (BCD)
DW 134		Month (BCD)		Day (BCD)
DW 135		Circulating buffer		

The following descriptions provide detailed information on the data words in the error DB.

- **DW 0: Error Counter**

  This data word is used to count the errors that occur. The counter stops when it reaches 32767 errors, and is reset on a cold restart or when passivation is revoked.

- **DW 1: Write Pointer**

  The write pointer always points to the start (i.e. to the first data word) of the current error block. The current data block is the block in which the latest error was entered. The write pointer is set to ”121” as long as no error has been entered in the error DB.

- **DW 2:**

  This data word is reserved for the read pointer.

- **DW 3: Status Word**

  H system errors can be divided into several categories, or error groups. Each bit in the status word is reserved for one of these groups, and is ”1” until at least one error has been entered for that group.
  The status word is data word DW 3 in the error DB, and has the following structure:

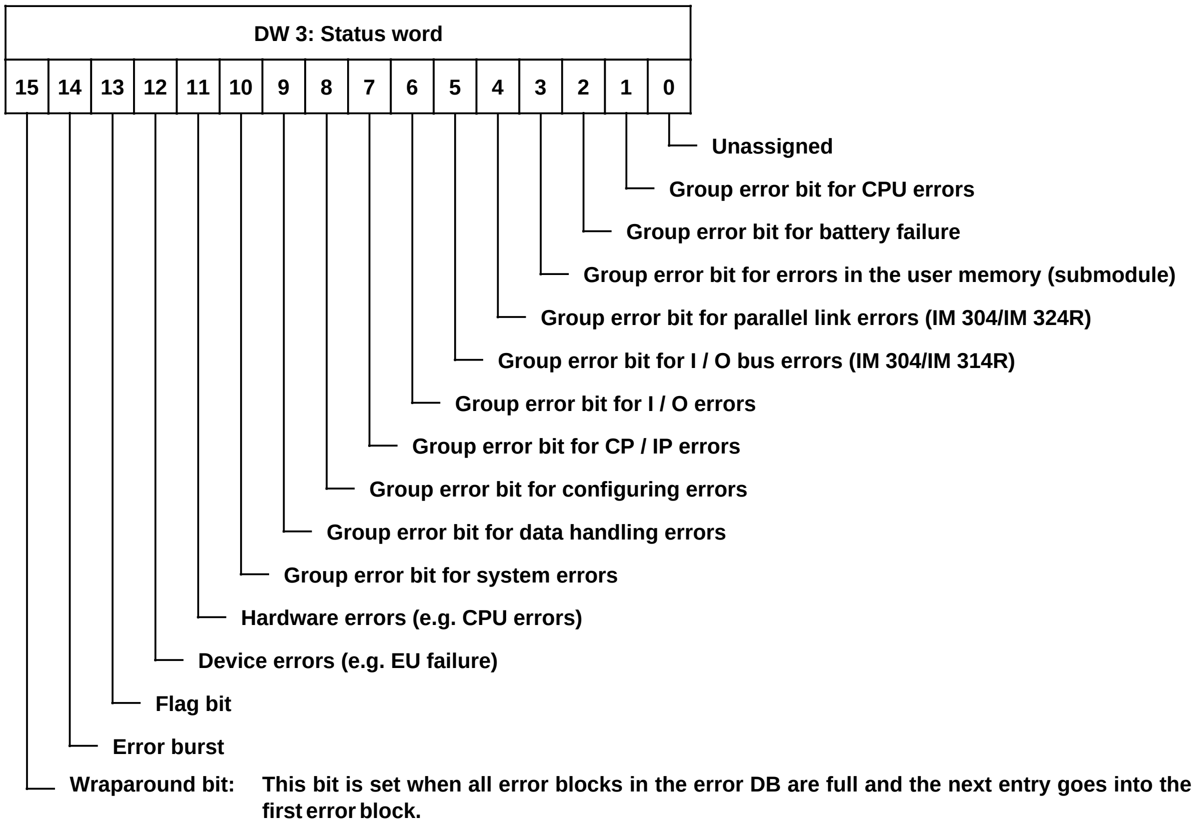


Figure 14-2. Bits in Status Word DW 3

- **DW 4: Error DB ID / Address of the 1st Error Block**

  ”115” is entered in the high-order byte of data word DW 4 as ID for the S5-115H error DB. The low-order byte of this word contains the start address of the 1st error block in the error DB; i.e. data word number 128.

- **DW 5: Unassigned**

  You can use this data word as you require.

- **DW 6 to 126: Static Error Image**

  The static error image shows which I / Os or which CP / IP interface show(s) a malfunction.

Note:

The static error image shows only the I / Os that were configured with COM 115H.

Example: Static error image of the digital inputs (DIs) allocated to subunit A

Data word	Bits															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
6	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
7	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
8	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
:																:
13	127	126	125	124	123	122	121	120	119	118	117	116	115	114	113	112

In the sample static error image shown above, bits 7 and 14 in data word DW 7 are set to ”1”, meaning that digital inputs DI 23 and DI 30 in subunit A are not functioning.

- **DW 128 to 198: Error Memory**

  The error memory begins with data word DW 128. It is a circulating buffer with space for 10 error messages. Each error message is entered in an error block. The structure of an error block is shown below.

  If the operating system detects an error during the cycle, it makes an entry in the error block. When all error blocks have been filled, the next entry goes into the first error block (which begins at data word 128), overwriting the error originally entered there, and setting the overflow identifier (bit 15 in status word DW 3).

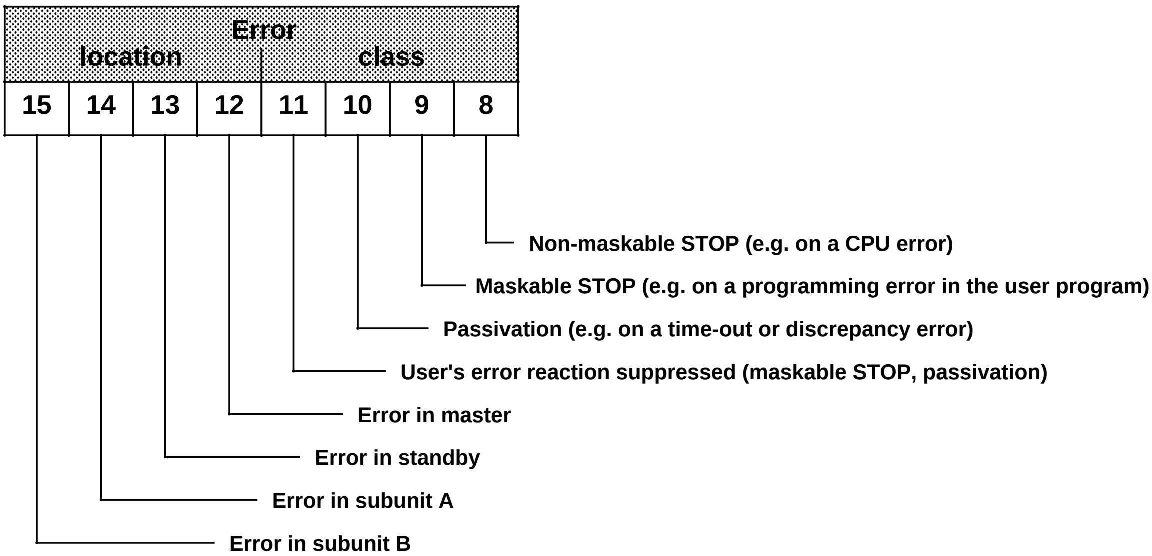
Structure of an Error Block

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Error location				Error class				Error number							
Auxiliary info 1															
Auxiliary info 2															
Auxiliary info 3															
Maintenance info															
Hour (BCD)								Minute (BCD)							
Month (BCD)								Day (BCD)							

The diagram below describes the contents of the error block in detail:

Error location and error class:

Bits 8 to 11 show the error class, bits 12 to 15 the error location.



If a programming error, for instance, has been entered in the error block, bit 9 is ”1”, as the standard response is a transition to a soft STOP.
If, for example, bits 12 and 14 are set, it is apparent that the error occured in subunit B, which is currently the master controller.

The following combinations of error location and error class are possible:

Table 14-2. Possible Combinations

"1" Bits	Description
12 / 13	Error occured in a subunit
14 / 15	
13	Error in the IM 304 / 324R parallel link
12	Error in the switched I / Os
13	Comparison error

Error Number:
The error number is a serial number between 1 and 255. A message in plaintext is allocated to each error number (e.g. CPU 942H error, CP / IP error).

Auxiliary Information:
The auxiliary information (max. 3 data words) provides as many details as possible about the error, e.g. module address, interface number.

Maintenance Information:
The maintenance information comprises one data word, and provides additional details for the maintenance personnel, such as the program that detected the error and the serial number.

Time Tag:
The current date or the time at which an error occurred is entered in these words, providing that a CP 523 system message module is available which is supported by the S5-115H operating system. An error message block (FB 48, which is part of the COM 115H standard software package), which you can invoke in OB 37, forwards the ”error information” to the CP 523. The date and time are then read back from the CP 523 over FB 48, and entered in the error DB's error block (time tag) (Section 12.3.4 under the heading ”Error Diagnosis with COM 115H”).

- **Structure of the User Message Block**
  The user message block is part of the error block, and comprises the error number and auxiliary info 1, 2 and 3. By reading out this information, you can determine exactly what caused the error and where it occurred. The associated error message is output in plaintext over COM 115H (Appendix D, ”COM 115H Error Messages”).

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
								Error number							
Auxiliary info 1															
Auxiliary info 2															
Auxiliary info 3															

14.1.2 Methods of Evaluating the Error DB

You can evaluate the error DB in the following ways:

- **Evaluating the Error DB on the Programmer with COM 115H**
  You can output the error messages in plaintext by selecting the ”H Errors” function in the COM 115H diagnostics menu, and page up and down through the error blocks.

- **Evaluating the Error DB with STEP 5**
  When the operating system has made an entry in the error DB, it automatically invokes OB 37. You can thus evaluate the contents of the error DB in the STEP 5 program that you wrote in OB 37, using, for instance, the error counter, write pointer, read pointer, status word, etc., to help you. You can then determine the response on an error-dependent basis.

- **Evaluating the Error DB on the Programmer using On-Line Functions**
  You can also evaluate the error DB as data field directly at the programmer or operator panel with some of the available On-Line functions.

- **Evaluating the Error DB over the Programmer Bus**

14.1.3 Output of Operating System Error Messages over the CP 523

This section presents an example to show you how you can use OB 37 to output operating system error messages over the CP 523.

Preparatory Procedures

- Plug the memory submodule into the programmer

- Insert the COM 115H floppy and transfer the following blocks to the memory submodule from file DB 523 DST.S5D.
  - DB 1
  - DB 194
  - DB 195
  - DB 196
  - DB 197
  - DB 198

- Insert the memory submodule into the receptacle on the CP 523

- Set the relevant module address on the CP 523 (refer to Section 5 ”Addressing” in the CP 523 manual).

Note:

Data block DB 1 contains the configuring data for the printer. The following parameters are preset as shown below:
V.24; 9600 baud; 1 stop bit; 8 data bits; 1 start bit; even parity.
If you want other configuring data, you must change these parameters in DB 1.

Output of Error Messages

The error information is forwarded to the CP 523 over an ”Error message block” (i.e. FB 48, which is part of the COM 115H standard package and is stored on file ”S5 ST5 8ST.S5D), which you invoke in OB 37. The date and time are then read back from the CP 523 over FB 48 and entered in the error block (time tag).

The following diagrams show the structure of the sample program and the STEP 5 listing of OB 37.

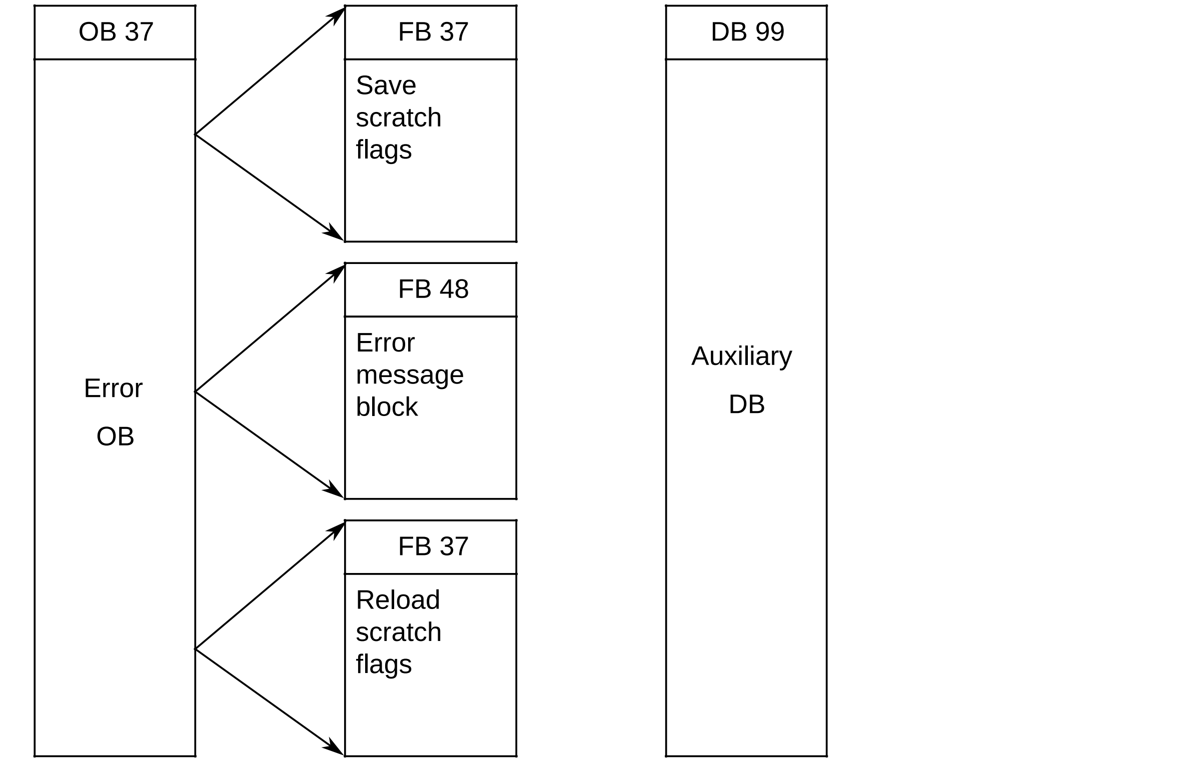


Figure 14-3. Structure of the Sample Program

Calling and Initializing OB 37.

Table 14-3. STEP 5-Listing of OB 37

STL			Description
OB 37			
	: JU	FB 37	Save scratch flags
NAME	: MERK-R/S		
H-DB	: KY	0,99	
R / S	: KS	R	
	:JU	FB 48	CP 523 standard error messages
NAME	:CP 523 STF		
BADR:	:KF	+128	
HOUR	:KS	24	
ZEIF	:KS	MI	
FEWO	:FW	195	
	:JU	FB 37	Reload scratch flags
NAME	:MERK-R/S		
H-DB	:KY	0,99	
RIS	:KC	S	
	:BE		

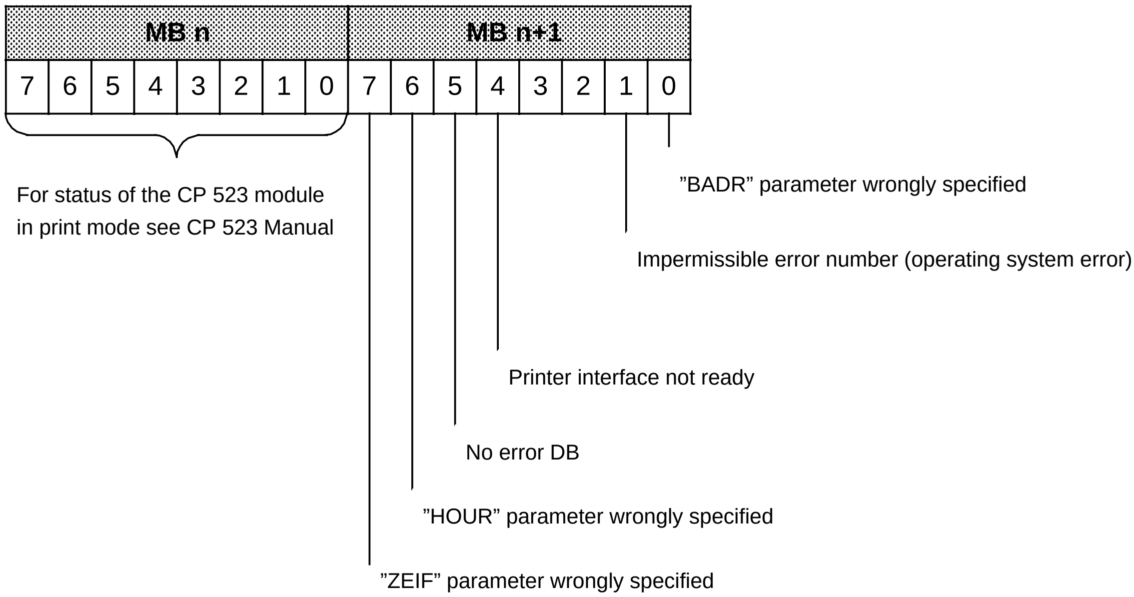
Table 14-4. Calling and Initializing FB 48

Parameter	Description	Type	Data Type	Assignment	STL

BADR	Module start address	D	KF	KF=128 to 248	`:JU`
					`NAME :CP523STF`
					`BADR :`
					`HOUR :`
					`ZEIF :`
					`FEWO :`

HOUR	Hour representation	D	KS	KC=24: 24-hour clock for COM 115H (default in the case of incorrect parameter specification) KC=12: 12-hour clock for COM 115H	
ZEIF	Time format	D	KS	KC=MI: The minute is the smallest time unit. Representation for COM 115H: Day, month, hour, minute (default in the case of incorrect parameter specification) KC=SE: The second is the smallest unit. Representation for COM 115H: Day, hour, minute, second	
FEWO	Error word for block		FW	MW=0 to 254	

Description of the FEWO in FB 48



FB 37, which is described in more detail on the next page, is not part of the COM 115H standard package. FB 37 is used to save the scratch flags in, and reload them from, an auxiliary data block.
This DB must be available, and comprise at least 30 data words.
The FB must be invoked in OB 37 before calling FB 48 and following its execution.

Calling and Initializing FB 37 "Save and Reload Scratch Flags" (not part of the COM 115H standard package).

Table 14-5. Calling and Initializing FB 37

Parameter	Description	Type	Data Type	Assignment	STL

H-DB	Number of the auxiliary DB	D	KY	3 to 255	`:JU FB 37`
					`NAME :MERK-R/S`
					`H-DB :`
					`HOUR :`
					`R/S :`

R/S	Save / reload	D	KC	KC=R: Save scratch flags KC=S: Reload scratch flags (any other values for these parameters suppress execution of the FB)	

Table 14-6. STEP 5 Listing of FB 37 "Save and Reload Scratch Flags"

STL	Description
FB 37	
NAME :MERK-R/S	
ID :A-DB I/Q/D/B/T/C: D	KM/KH/KY/KC/KF/KT/KZ/KG: KY
ID :R/S I/Q/D/B/T/C: D	KM/KH/KY/KC/KF/KT/KZ/KG: KC
: LW =R/S	
:L KC R	
:!=F	
:JC =SAVE	SAVE SCRATCH FLAGS
:TAK	
:L KC S	
:!=F	
:JC =LOAD	RELOAD SCRATCH FLAGS
:BEU	
SAVE :	SAVE SCRATCH FLAGS
:LW =H-DB	LOAD NO. OF AUX. DB
:L KH 00FF	COUNT ONLY TO 255
:AW	
:SLW 1	NO. * 2 AS MACHINE IS BYTE-ORIENTED
:L KH E400	DB ADDRESS LIST
:+F	
:LIR 0	
:L KF +55	END OF AUX. DB
:+F	
:L KH EEFF	END OF SCRATCH FLAG AREA
:TAK	
:TNB 56	
:BEU	
LOAD :	RELOAD SCRATCH FLAGS
:LW =H-DB	LOAD NO. OF AUX: DB
:L KH 00FF	
:AW	
:SLW 1	
:L KH E400	DB ADDRESS LIST
:+F	
:LIR 0	
:L KF +55	AUX. DB END ADDRESS
:+F	
:L KH EEFF	END OF SCRATCH FLAG AREA
:TNB 56	
:BE	

14.2 Interrupt Analysis

When malfunctions occur, the operating system sets various ”analysis bits” that can be scanned with the programmer using the ”ISTACK” function. LEDs on the CPU also report some malfunctions.

14.2.1 ”ISTACK” Analysis

The interrupt stack (ISTACK) is an internal CPU buffer used to flag malfunctions. When a malfunction occurs, the appropriate bit is set.
Use a programmer to read this buffer byte by byte.

Note:
You can read only part of the ISTACK when the PC is in the ”RUN” mode.

ISTACK Display on the PG 635 / PG 670 / PG 675 / PG 685 / PG 695 and PG 750 over COM 115H

Figures 14-4 and 14-5 show the ISTACK as it is displayed on CRT-based programmers. An ”X” marks the bits that have been set (e.g. REMAN, STOZUS, etc. in the example).

CONTROL BITS							
NB	PBSSCH	BSTSCH	SCHTAE	ADRBAU	SPABBR	NAUAS	QUITT
NB	NB	NB	REMAN X	NB	NB	NB	NB
STOZUS X	STOANZ X	NEUSTA	NB	BATPUF X	NB	BARB	BARBEND
NB	UAFEHL	MAFEHL	EOVH	NB	AF X	NB	NB
ASPNEP	ASPNRA	KOPFNI	PROEND	ASPNEEP	PADRFE	ASPLUE	RAMADFE
KEINAS X	SYNFEH	NINEU	NB	NB	NB	SUMF	URLAD

Figure 14-4. Control Bit Display

INTERRUPT STACK					
DEPTH: 01					
BEF-REG: BST-STP:	3204 EB0F	SAC: FB-NO.: REL-SAC:	B1D4 2 0018	DB-ADR: DB-NR.:	B238 5
ACCUM1**:**	0080	ACCUM2**:**	0000		

RESULT BITS:	CC1	CC0	OVFL	CARRY	OR	$\overline{\text{ERAB}}$ X
	STATUS	RLO				
CAUSE OF FAULT:	STOPS	NB	SUF	TRAF X	NNN	STS
	STUEB	NAU	QVZ	ZYK	PEU	BAU
	ASPFA					

Figure 14-5. Interrupt Stack Display

14.2.2 Meaning of the ISTACK Displays

Use Table 14-9 to determine the cause of a fault or an error when program scanning is interrupted. In each case, the CPU goes into the ”STOP” mode.

Table 14-7. Meaning of the ISTACK Displays

Fault / Error	Fault / Error ID	Cause	Remedy
Cold Restart is not possible	NINEU SYNFEH/ KOPFNI	Faulty block: - System start-up - Compressing has been interrupted by a power failure - Block transfer between programmer and PLC was interrupted by a power failure - Program error (TIR / TNB / DO FW)	Overall Reset Reload the program
	KOLIF	DB 1 is programmed incorrectly	Rename DB 1
	FEST	There is an error in the self-test routine of the CPU	Replace the CPU
Faulty submodule	ASPFA	The submodule ID is illegal: - S5-110S / S5-135U / S5-150U submodule	Plug in the correct submodule
Battery failure	BAU	There is no battery or the battery is low and the retentive feature has been set.	Replace the battery Perform an Overall Reset Reload the program
I / Os not ready	PEU	The I / Os are not ready: - There has been a power failure in the expansion unit, or - The connection to the expansion unit has been interrupted, or - There is no terminating connector in the central controller	- Check the power supply in the expansion unit. - Check the connection. - Install a terminator in the central controller
Program scan-ning interrupted	STOPS	The mode selector is at STOP	Set the mode selector to RUN

Table 14-7. Meaning of ISTACK Displays (continued)

Fault / Error	Fault / Error ID	Cause	Remedy
	SUF	Substitution error: A function block was called with an incorrect actual parameter	Correct the function block call
	TRAF	Transfer error: - A data block statement has been programmed with data word number greater than the data block length. - A data block statement has been programmed without opening a DB first - DB to be generated is too long for user memory (G DB operation)	Correct the program error
	STS	- Software stop by statement (STP) - STOP request from programmer - STOP request from SINEC L1 master	
	NNN	- A statement cannot be decoded - Parameter range violation	Correct the program error
	STUEB	Block stack overflow: - The maximum block call nesting depth (16) has been exceeded - The service routine for process or timed interrupts has interrupted the cyclic program during execution of an integral function block and an integral function block has also been invoked in the service routine for process or timed interrupts.	Correct the program error Disable interrupts in the cyclic program before calling integral function blocks
	NAU	There has been a power failure	
	QVZ	I / O time-out: - A peripheral byte that was not addressed has been referenced in the program, or an I / O module does not acknowledge	Correct the program error or replace the I / O module
	ZYK	Scan time exceeded: The program scan time exceeds the specified monitoring time	Check the program for continuous loops. If necessary, retrigger the watchdog timer with OB 31 or change the monitoring time.

Besides malfunction analysis, the ISTACK provides other information (Table 14-8).

Table 14-8. Mnemonics for Control Bits and ISTACK Bits

Control Bit Mnemonics	
SD	System data (from address $EA00_H$)
BSTSCH	Block shift requested
SCHTAE	Block shift active (function:COMP: PC)
ADRBAU	Construction of address lists
CA-DA	Interprocessor communication flag output address list available
CE-DE	Interprocessor communication flag input address list available
REMAN	0: all timers, counters, and flags are reset on Cold Restart 1: the second half of the timers, counters, and flags are reset on Cold Restart
STOZUS	”STOP” state (external request, for example via the programmer)
STOANZ	”STOP” bit
NEUSTA	PLC in Cold Restart
BATPUF	Battery backup okay
BARB	Program check
BARBEND	Request for end of program check
AF	Interrupt enable
ASPNEP	Memory submodule is an EPROM
ASPNRA	Memory submodule is a RAM
ASPNEEP	Memory submodule is an EEPROM
KOPFNI	Block header cannot be interpreted
KEINAS	No memory submodule
SYNFEH	Synchronization error (blocks are incorrect)
NINEU	Cold restart not possible
URLAD	Bootstrapping required

ISTACK Bit Mnemonics	
UAW	Interrupt condition code word
STOPS	Mode selector at STOP
SUF	Substitution error
TRAF	Transfer error for data block statements: data word number > data block length
NNN	Statement cannot be interpreted in the S5-115H (e.g., a 150S statement)
STS	Operation interrupted by a programmer STOP request or programmed STOP statements
STUEB	Block stack overflow: The maximum block call nesting depth of 16 has been exceeded
FEST	Error in the CPU self-test routine
NAU	Power failure
QVZ	I / O time-out: A nonexistent module has been referenced
KOLIF	Interprocessor communication flag transfer list is incorrect.
ZYK	Scan time exceeded: The maximum permissible program scan time has been exceeded.
SYSFE	Error in the SYSID block
PEU	I / Os not ready: power failure in the I / O expansion unit; connection to the I / O expansion unit interrupted No terminator in the central controller
BAU	Battery failure
ASPFA	Illegal memory submodule
CC1 / CC0	00: ACCUM1 = 0 or 0 shifted 01: ACCUM1> 0 or 1 shifted 10: ACCUM1< 0
OVF	Arithmetic Overflow (+or -)
OR	OR flag (set by ”0” operation)
STATUS	STATUS of the operand of the last binary statement executed
RLO	Resuit of the logic operation
ERAB	First scan
KE1...KE6	Nesting stack entry 1 to 6 entered for A(and O(
FKT	0 : O(1 : U(
BEF-REG	Instruction register
SAC	Step address counter
DB-ADR	Data block address
BST-STP	Block stack pointer
NR	Block number (OB, PB, FB, SB, DB)
REL-SAC	Relative step address counter

14.2.3 Error Indication via LEDs

Certain errors are indicated by LEDs on the CPU, depending on its design. Table 14-11 explains these error indications in more detail.

Table 14-9. Meaning of the Error LEDs on the CPU 942H

LED	Meaning
QVZ on	Time-out (The CPU went into ”STOP” mode.)
ZYK on	Scan time exceeded (The CPU went into ”STOP” mode.)
BASP on	Digital outputs are disabled (The CPU is in ”RESTART” or ”STOP” mode.)

14.3 Program Errors

Table 14-12 lists malfunctions caused by program errors.

Table 14-10. Program Errors

Errors	Action
All inputs are zero	Check the program
All outputs are not set	
One input is zero. An output is not set	Check program assignments (double assignment, edge generation)
Timer or counter is not running or is incorrect	
Cold Restart does not ececute correctly	Check Cold Restart blocks OB21 / 22 or insert them
Sporadic malfunctions	Check the program with STATUS

14.3.1 Determining an Error Address

The STEP address counter (SAC) in the ISTACK (bytes 25 and 26) indicates the absolute memory address of the STEP 5 statement in the PLC **before** which the CPU went into the ”STOP” mode.

You can use the ”DIR PC” programmer function to determine the appropriate block start address.

Example:
Figure 14-6 shows a program consisting of OB 1, PB 0 and PB 7. PB 7 contains an illegal statement.

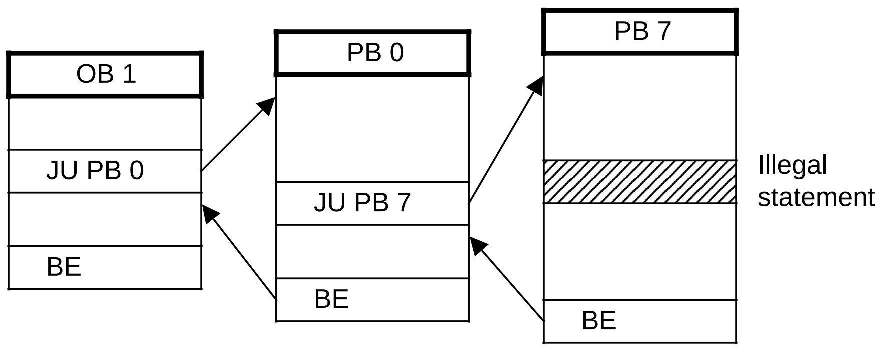
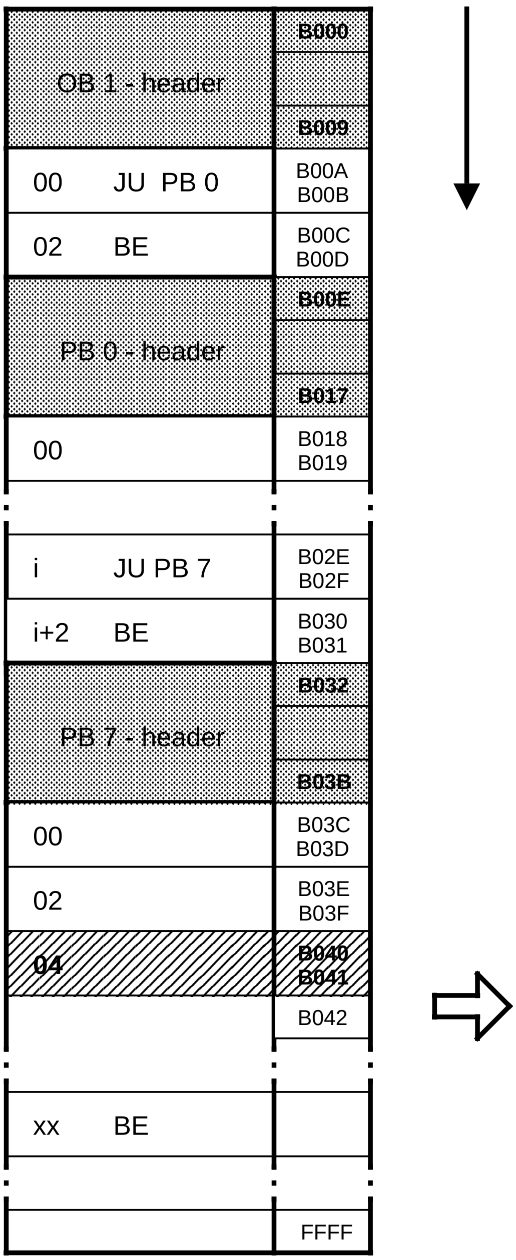


Figure 14-6. Structured Program with Illegal Statement

When the CPU reaches the illegal statement, it interrupts program scanning and goes into the ”STOP”mode with an ”NNN” error. The STEP address counter is set to the absolute address of the next, as yet unprocessed statement in the program memory.



Absolute addresses in internal RAM

It is impossible to locate a program error from the physical address of the illegal statement in RAM.
The ”DIR PC” function indicates the absolut start addresses of all programmed blocks.
You can locate a program error by comparing these two addresses.

STEP Address Counter

Byte	Contents
25	B0
26	42

Figure 14-7. Addresses in the CPU Program Memory

Display:

BLOCK ADDRESS LIST

BLOCK TYPE	NUMBER	SYMBOL	INITIAL ADDRESS IN PLC
DB	5		B238
PB	1		B128
PB	2		B148
PB	3		B174
PB	4		B19A
FB	2		B1BC

Figure 14-8. Example of a ”DIR PC” Display on a PG 750 Programmer

Address computation (necessary only when using the PG 605U programmer)

To make program corrections, you need the address of the statement that caused the error, relative to the particular block (relative address).
Determine the faulty block by comparing the STEP address counter value (SAC value) and the ”DIR PC” display.
The difference between the SAC value and the block start address gives the relative address of the error (Figure 14-5).

ISTACK-Byte	25	26
STEP Address Counter	B0	42

The absolute address B042 is greater than the start addres of PB 7. Therefore, the illegal statement is in PB 7.

DIR PC	
Block	Start Address
PB 0	B018
PB 7	B03C
OB 1	B00A

Computing the relative address: B042 - B03C = 0006

Consequently, ”0006” is the address of the statement in PB 7, **prior to which** the CPU went into the ”STOP” mode.

Figure 14-9. Computing the Relative Error Address

Display of an Illegal Statement

You can use the ”SEARCH RUN” programmer function to find specific program locations. You can use this function to look for the relative address of an error (Section 13.3).

14.3.2 Program Trace with the Block Stack ”BSTACK” Function

During program scanning, jump operations enter the following information in the block stack:

- the data block that was valid before the block was exited.
- the relative return address. This address indicates the location at which program scanning continues following the return from the called block.
- the absolute return address. This address indicates the location in the program memory at which procgram scanning continues following the return from the called block.

You can call the information listed above using the ”BSTACK” programmer function in the ”STOP” mode if the CPU has entered this mode as the result of a malfunction. ”BSTACK” shows the state of the block stack at the instant the interruption occured.

Example: Program scanning was interrupted at function block FB2. The CPU went into the ”STOP” mode with ”TRAF” because of incorrect access (i.e. DB 5 is two words long. DB 3 is ten words long).
You can use the ”BSTACK” function to determine the path used to reach FB 2 and to determine which block has passed the wrong parameter. The ”BSATCK contains the three return addresses (as marked in Figure 14-10).

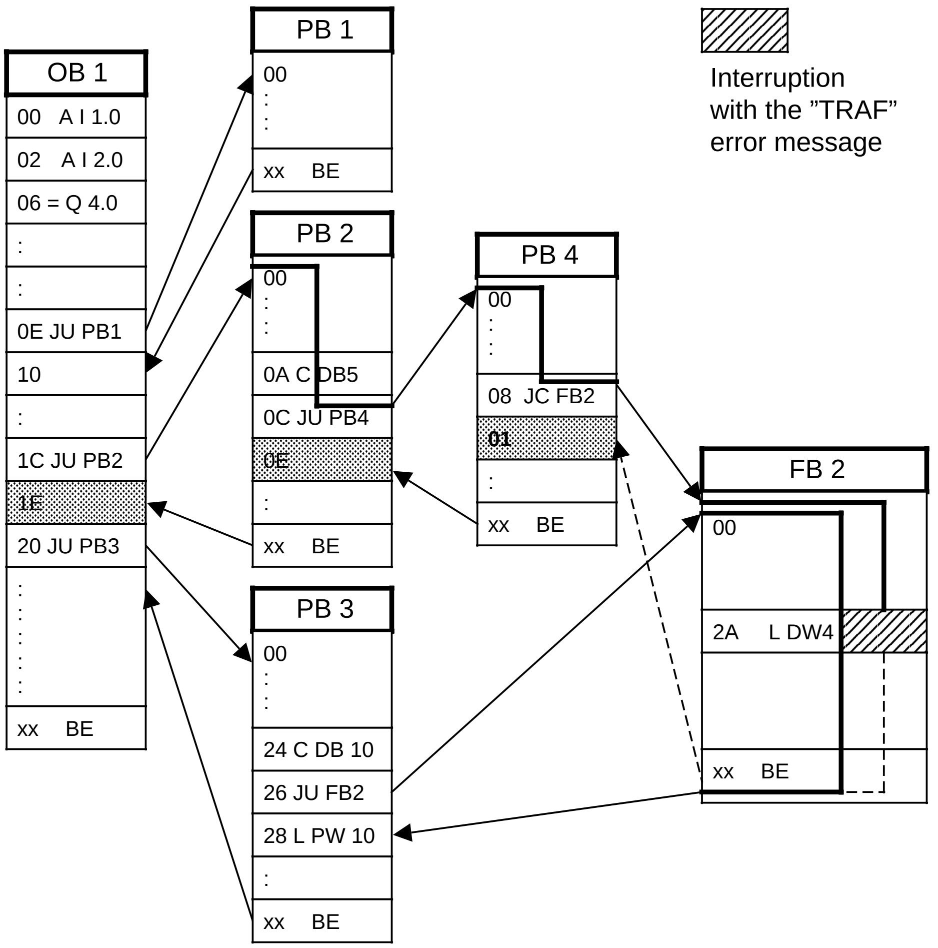


Figure 14-10. Program Trace with the ”BSTACK” Function

Display

BLOCK STACK

BLOCK NO.	BLOCK ADDR.	RETURN ADDR.	REL. ADDR.	DB NO.	DB ADDR.
PB 4	B19A	B1A4	000A DB	5	B238
PB 2	B148	B156	000E DB	5	B238
OB 1	B1E8	B208	001E		

Figure 14-11. ”BSTACK” Display on a PG 750 Programmer

The display in Figure 14-11 indicates that DB 5 was accessed incorrectly on the path
OB1 PB2 PB4.

14.4 Other Causes of Malfunction

Hardware components or improper installation can also cause mafunctions. Table 14-13 summarizes such malfunctions.

Table 14-11. Other Causes of Malfunction

Fault / Error	Action
All inputs are zero.	Check the module and the load voltage
No outputs can be set.	
One input is zero. An output is not set.	
The green LEDs on the power supply module do not light up.	Check the module and replace it if necessary.
Sporadic malfunctions.	Check the memory submodule. Check to see of the controller has been set up according to EMC guidelines.
The PLC will not go into ”RUN” mode.	Perform an Overall Reset.

Note:
If the PLC still does not operate properly after you have taken the measures recommended in Table 14-13, try to determine the faulty component by replacement.

14.5 System Parameters

Use the ”SYSPAR” programmer function to read the CPU system parameters (e. g. PLC software release).

14.6 On-Line Error Recovery

This section discusses the S5-115H's response to malfunctions and to module and expansion unit failures and the like, and recommends procedures for undertaking repairs while the PLC is on-line.

14.6.1 CPU 942H Failure and Repair Procedures

Should you have to replace a CPU 942H because of a defect, you must also replace the second CPU 942H (with the same hardware version as the first). You can check the hardware version by calling the COM function "PLC INFO". When replacing CPUs, observe the procedures described in Section 11.6 "Software Modifications".

14.6.2 IM 304 / 324R Failure and Repair Procedures

When the parallel link between subunit A and subunit B fails (e.g. because of a break in the cable or a module defect), the subunit that was the master at the time continues in solo mode. The standby CC goes to STOP.
When undertaking repairs, observe the procedures listed below with the utmost care, and only then is non-stop program scanning guaranteed.

- Switch the standby controller to "STOP" and turn off the power
- Remove the IM 304 and IM 324R interface modules, which are interconnected with a 721 cable.
- Plug a new IM 304 into the central controller that you switched off in step 1.
- Using the 721 cable, connect an operational IM 324R to the IM 304 which you inserted in step 3.
- Connect the enabling voltage (24 V) to the terminals in the frontplate of the IM 324R.
- Plug the IM 324R into the master central controller.
- Disconnect the enabling voltage (including the ground wire). The green LED on the frontplate of the IM 324R goes on.
- Switch on the power supply for the standby controller and start the controller.

After undertaking repairs and connecting the standby controller, the S5-115H once again operates as a fault-tolerant system.

Note:
The external 24 V power supply, including the ground wire, must be disconnected once it has served its purpose!

14.6.3 Expansion Unit (EU), Failure and Repair Procedures

- **Redundant EU**
  When an expansion unit fails, the associated subunit goes to STOP.

- **Switched EU**
  When the IM 304 interface module (in the master controller) or the IM 324R interface module (in the expansion unit) is interrupted, e.g. by a break in the cable (plug pulled), the 115H operating system switches to the standby controller. The controller that had been the master up to that time assumes the role of standby controller and outputs an error signal.
  The error message "EU failure", which the user can then evaluate, is output when an EU fails. The S5-115H tolerates failure of all switched EUs, i.e. both central controllers continue operating without EUs. If one of the central controllers also fails, the other continues in solo mode.

- **Single-channel EU**
  See Redundant EU

Note:
When the EU power supply fails, the relevant I / O modules, when accessed, are passivated, an error is flagged, and the error OB (OB 37) is invoked.
Once the expansion unit has been repaired, you must revoke passivation. The I / Os are then once again entered in the process image. Following completion of the link-up phase, the S5-115H once again operates a fault-tolerant system.

14.6.4 I / O Failure and Repair Procedures

The S5-115U detects failure of an I / O module when

- a time-out (QVZ) occurs or
- during the I / O test (self-test).

The failure triggers the following responses:

Table 14-12. Response to a Time-Out

QVZ	QVZ	Response
Digital input modules and analog input modules	In subunit	- Error message - Module is passivated
	In expansion unit for switched I / Os	- Error message - Module is passivated
Digital output modules and analog output modules	In subunit	- Error message - Subunit goes to STOP
	In expansion units for switched I / Os	- Error message - System continues

By switching off the power supply to the defective module you can replace the module **on-line**.

- In a centralized configuration with IM 306, you must switch off the power supply in the central controller.
- In a distributed configuration with IM 304 / 314 and a switched I / O configuration with IM 304 / 314R, you must switch off the power supply in the expansion rack.

When the I / O module has been plugged back into the subrack following **repairs**, it is not activated until passivation has been revoked. The I / O is once again entered in the process image. Following completion of the link-up phase, the S5-115H once again functions as fault-tolerant system.

14.6.5 CP / IP Failure and Repair Procedures

In the S5-115H, failure of an IP or a CP is ascertained via a time-out (QVZ). The module failure is reported. "CP / IP not configured" (error no. 82) is entered in the error DB.

Switch off the power to the module mounting rack (EU or, where applicable, the CC as well) containing the defctive CP / IP before removing the module from the rack for repairs or replacing it with an operational module!

Once the CP / IP module has been repaired or replaced, you must revoke passivation. The module is then once again addressable. Following completion of the link-up phase, the S5-115H is once again a fault-tolerant system.

The 115H operating system invokes FB "SYNCHRON" in FB 253 ("DEPASS") for CPs / IPs driven by data handling blocks; this FB synchronizes the CP / IP. IPs not driven by data handling blocks are repaired in the same way as I / O modules.

14.6.6 721 Cable Failure and Repair Procedures

In single-channel / redundant mode, you must switch off the expansion unit by linking up the IM 304 / 314 before replacing the cable.
In switched mode, the cable in configurations with IM 304 / 314R may be replaced only on the standby controller when the Im 304 / 314R is linked. If the standby controller is defect, you must not change the cable until you have switched off the expansion unit.

15 Reliability , Availability and Safety for Electronic Control Equipment

Figures

15 Reliability, Availability and Safety of Electronic Control Equipment

The terms reliability, availability, and safety of electronic control equipment are not always clear and sometimes even misinterpreted. This can be explained on the one hand by the different failure characteistics of electronic control systems compared with conventional systems. On the other hand, some of the safety regulations have been made considerably more stringent in a number of application areas in the course of the last few years. The following chapter is intended to familiarize the large number users of SIMATIC electronic control systems with the basics of this problem complex.

The information given is of a predominantly fundamental nature and applies regardless of the type of electronic control system and its manufacturer.

15.1 Reliability

Reliability is the capability of an electronic control system to satisfy, over a specified period and within the specified limits (i. e. technical data), the requirements placed upon it by its application.

Despite all the easures taken to prevent failure, there is no such thing as 100 % relaibility.

The failure rate is a measure of the reliability:

$$= \frac{n}{N_o \cdot t}$$

where n = Number of failures during time t

N_o = Initial components complement

15.1.1 Failure Characteristics of Electronic Devices

The failure-rate-versus-time curve can be broken down roughly into three time periods.

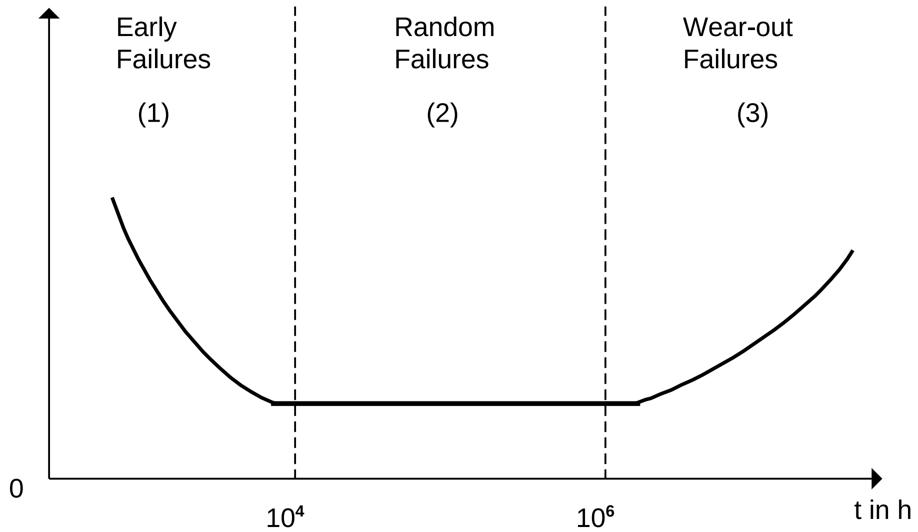


Figure 15-1. Failure Characteristics of Electronic Devices ("Bathtub Curve")

(1) Early failures are caused by material and manufacturing defects, and the failure rate falls steeply during the initial period of operation.

(2) The random failure phhase is characterized by a constant failure rate. Provided systems are used in accordance with these specifications, only random failures occur during this period.
This period covers the normal behaviour of system components and is the basis for the calculation of all reliability parameters.

(3) The failure rate increases with time. Wear-out failures become more frequent, indicating that the end of the useful life is approaching. The transition to this phase is gradual. There is no sudden increase in the failure rate.

15.1.2 Reliability of SIMATIC S5 Programmable Controllers and Components

A very high degree of reliability can be achieved by taking the following extensive and cost-intensive measures during the development and manufacture of SIMATIC S5 systems:

- The use of high-quality components;
- Worst-case design of all circuits;
- Systematic and computer-controlled testing of all components supplied by subcontractors;
- Burn-in of all LSI circuits (e. g. processors, memories etc.);
- Measures to prevent static charge building up when handling MOS ICs;
- Visual checks at different stages of manufacture ;
- In-circuit testing of all components, i. e. computer-aided testing of all components and their interaction with other components in the circuit;
- continuous heat-endurance test at elevated ambient temperature over a period of several days;
- Careful computer-controlled final testing;
- Statistical evaluation of all failures during testing to enable the immediate initiation of suitable corrective measures.

15.1.3 Failure Distribution

Despite the extensive measures described above, one must still reckon with the occurrence of failures. Experience has shown that, in installations with programmable controllers, failures can be distibuted approximately as follows:

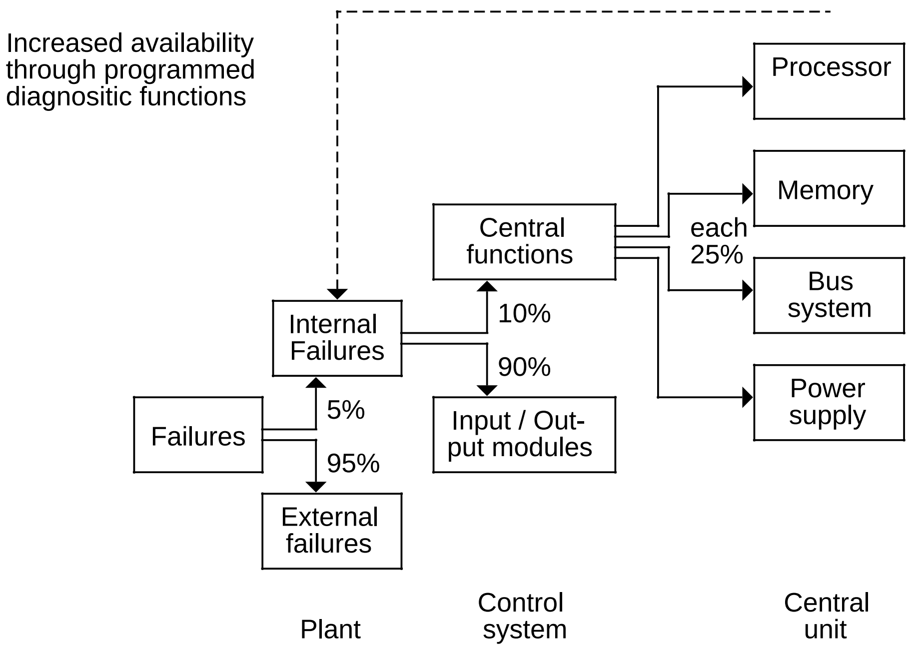


Figure 15-2. Distribution of Failure Occurrences in Installations Incorporating Programmable Controllers

Meaning of error distribution:

- Only a small number (approx. 5%) of failures occur inside the electronic control system. These can be broken down as follows:
  - CPU failures (about 10%, i. e. only 0.5% of all failures);
    these failures are evenly divided among the processor, memory, bus system, and power supply.
  - I / O module failures (about 90%, i. e. only 4.5% of all failures)

- The highest number of all failures (about 95%) occur in the sensors, actuators, drives, cabling etc.

15.2 Availability

Availability "V" is the probability of finding a system in a functional state at a specified point in time.

$$V = \frac{MTBF}{MTBF+MTTR}$$

MTBF= Meantime-Between-Failure;
MTTR= Meantime-To-Repair;

Ideal availability, i. e. V=1, can never be attained owing to the residual failure probability that always exists. A fault-tolerant system comes closest to attaining this goal.

It is possible, however, to to come near to this ideal state by using programmable controllers designed as 1-out-of-2 voter systems. The best-known controllers of this kind are the:

- S5-115H
- S5-155H

Availability can also be enhanced by reducing downtimes. Such measures include, for instance:

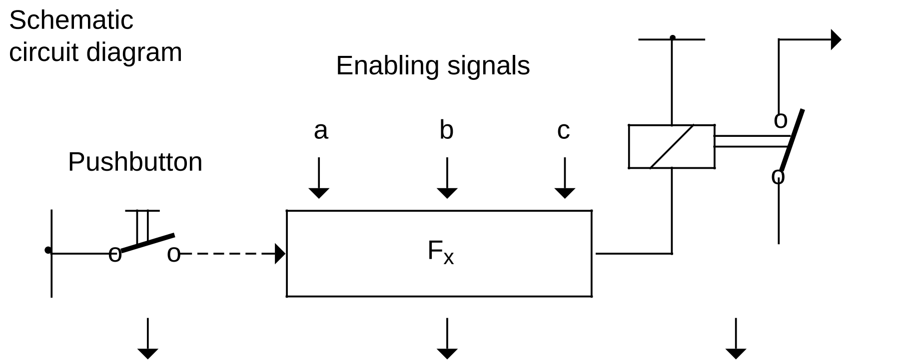
- The stocking of spare parts
- The training of operating personnel
- Fault indicators on the devices
- Higher memory and software overhead for implementing programmed diagnostic functions.

15.3 Safety

15.3.1 Types of Failures

The nature of a failure decided by the effect it has. A distinction is made between active and passive failures, as well as fatal and non-fatal failures.

Example: Control of function ”F_x”



Input	Control System	Output
0 1	No fault	No output command Output command
0 1	Active failure Passive failure	Output command No output command

Figure 15-3. Control of Function ”Fx”

Depending on the job a control system has to do, active or pasive failures can also be fatal faults.

Examples:

- In a drive control system, an active failure results in the unauthorized starting of the drive.
- In a signalling system, a passive fault can be fatal since it blocks the signalling of a dangerous operating state.

In all cases where the occurrence of failures can result in severe material damage or even injury to persons, i. e. where the failure may be dangerous or fatal, measures must be taken to enhance the safety of the control system. In this connection, the relevant regulations and specifications must be carefully observed.

15.3.2 Safety Measures

Single-Channel Configurations

In the case of single- channel programmable controllers, the means available for enhancing safety are limited:

- Programs or program sections can be stored and executed more than once.
- Outputs can be monitored per software by parallel feedback to inputs of the same device.
- Diagnostic functions within the programmable control system, which bring the output of the controller into a defined state (generally the FF state) when a failure occurs.

Failure characteristics of electromechanical and electronic control systems:

- Relays and contactors pick up only if a voltage is applied to the coil. With such a control element, therefore, active failures are less probable than passive failures.
- In electronic control systems, however, the probability of both types of failure occurring (active and passive) is approximately equal. The failing of an output transistor, for instance, may cause this transistor to become either continuously non-conducting or continuously conducting.

The safety of electronic control systems can therefore be enhanced as follows.

- All functions not relevant to the safety of the plant are controlled electronically.
- Functions that are relevant to the safety of the plant are implemented with conventional control elements.

Multi-Channel Configurations

If the measures taken to improve safety in single-channel control systems are not sufficient to satify safety requirements, elctronic control systems should be designed as redundant..

- Two-channel control systems
  In safety-oriented control systems, all components are redundant. Our most modern controller, which was prototype-tested by the Technical Inspectorate for Bavaria, is the S5-115F.
  This programmable controller consists of two subunits that are identically programmed and operate in clock synchronism. The two subunits monitor each other mutually, thus enabling them to detect problems on a reciprocal basis and initiate the appropriate safety functions.
- Multi-channel control system
  Reliable, fault-tolerant systems (e.g. on the 2-out-of.3 principle) can be implemented by adding further ”channels”.

15.4 Summary

- In electronic control systems, failures of any kind can occur at any point of the system.

- Even when the greatest efforts are made to obtain maximum reliability, the probability of such a failure occurring can never be zero.

- The following is decisive for the effects of such failures: depending on the job a control system has to do, active or passive failures may be fatal or non-fatal.

- When safety requirements are very high, fatal failures must be recognized by taking additional measures and prevented frem affecting other parts of the system.

- In the case of single-channel systems, the means available to do this are relatively limited.
  For this reason, safety-oriented functions should generally be implemented outside the electronics by interposing conventional components.

- In order to satisfy safety functions, electronic control systems should be of the multi-channel (redundant) type.

- These fundamental considerations are independent of
  - the type of the control system (hard-wired or programmable)
  - the vendor
  - the country of origin (Europe, US, etc.).

16 Application

Figures

16 Application

This section provides an example for installing an S5-115H with all three types of I / Os, i.e.:

- single-channel I / Os
- switched I / Os
- two-channel redundant I / Os

When you complete the example, you will know enough to use the S5-115H. The sample application can be extended as required.

Objectives
This section provides you with sufficient information to

- install the central controller hardware
- configure the system using COM 115H

Hardware

- Two central mounting racks (CR 700-2F)
- One expansion rack (ER 701-3LH)
- Two 942H CPUs
- Three PS 951 power supply modules
- One IM 324R interface module with adapter casing
- Three IM 304 interface modules with adapter casing
- Two IM 314R interface modules (version 2) with adapter casing and 760-0HA11 terminating connector
- One 430-7 digital input module
- Two 430-7 digital input modules
- Three 451-7 digital output modules
- Three 306 interface modules
- Three 721 connecting cables

Software
The following software is required:

- COM 115H
- STEP 5 basic software package

Procedure
First of all, you are going to put the hardware into operation. Then you will set up a system with switched I / Os. Next, you will add single-channel I / Os. Finally, you will add redundant I / Os with error locating.

16.1 Installing the Hardware

Install the hardware and put it into operation in the following order:

- Basic configuration for central controller with switched EU
- Insert the switched I / Os
- Insert the single-channel I / Os
- Install the two-channel redundant I / Os with error locating

You will then have the following system configuration.

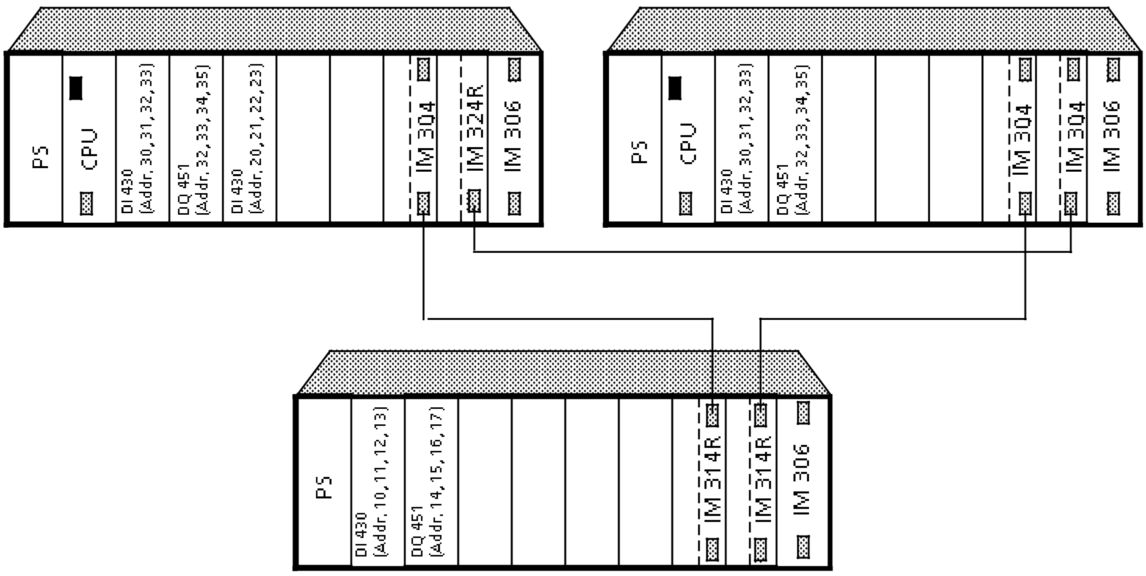


Figure 16-1. System Configuration

This configuration implements the following:

- Switched I / Os:
  24 digital inputs (3 bytes on the 430 DI in the EU)
  32 digital outputs (3 bytes on the 451 DQ in the EU)

- Single-channel I / Os:
  32 digital inputs (4 bytes on the 430 DI in subunit A)

- Two-channel redundant I / Os:
  8 digital inputs with error locating
  (1st byte on the 430 DI in subunits A and B, 2nd byte reserved for L-DI)
  16 digital inputs without error locating and readback DI
  (3rd/4th bytes on the 430 DI in subunits A and B)
  8 digital outputs with error locating
  (1st byte on the 451 DQ in subunits A and B, 2nd byte reserved for L-DQ)
  16 digital outputs without error locating and readback DI
  (3rd/4th bytes on the 451 DQ in subunits A and B)

16.1.1 Procedures for Installing the Hardware

- Set up the central and expansion racks

- Insert the
  - PS, CPU and IM 306 in subunit A, subunit B and the EU
  - PS and IM 306 in the expansion racks

- Set the IM 306 in subunit A, subunit B and the EU

- Set up the parallel link
  - Check the jumpers and switch settings on the IM 324R and IM 304.

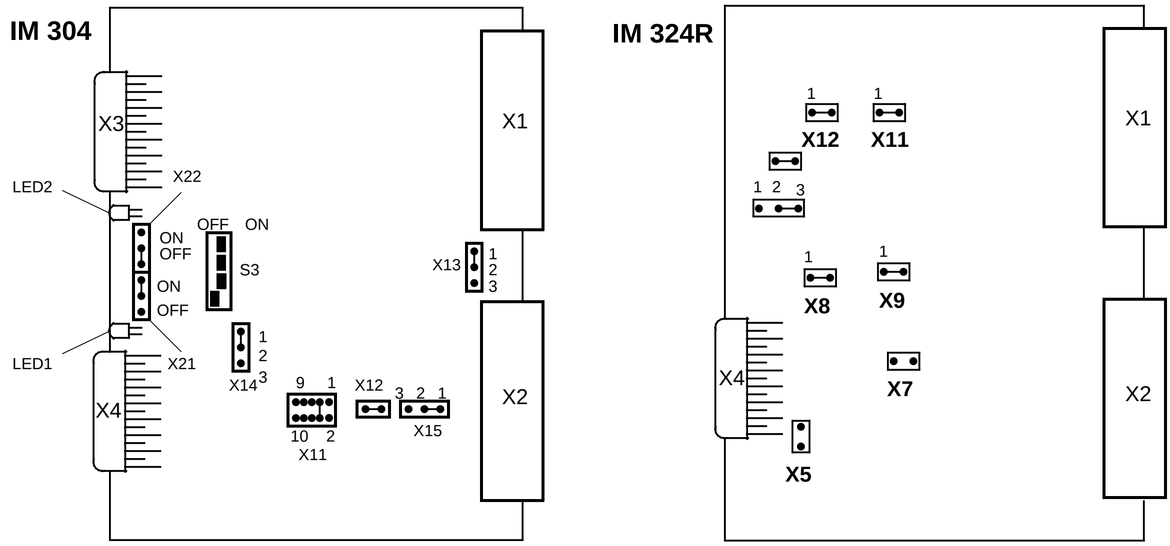


Figure 16-2. Switches and Jumper Settings for the Parallel Link

- Plug the IM 324R into slot 6 in subunit A and the IM 304 into slot 6 in subunit B.
- Take the 721 cable and connect the IM 324R interface module with the bottom connector on the IM 304.

- Connect the central mounting racks with the expansion racks for switched I / Os
  - Check the jumper and switch settings on the IM 304 interface modules in both central mounting racks (CCs).

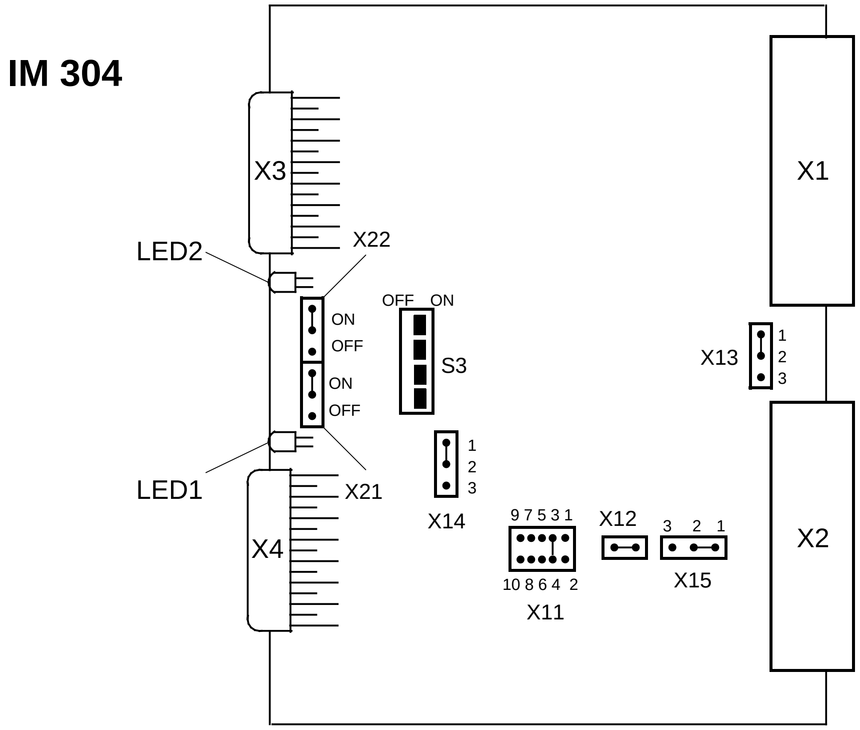


Figure 16-3. Switches and Jumper Settings for the Switched I/0 Configuration

- Plug one IM 304 into slot 5 in subunit A and the other IM 304 into slot 6 in subunit B.
- Set the two IM 314R modules as shown in the figure below. The expansion unit then has the EU number 1.

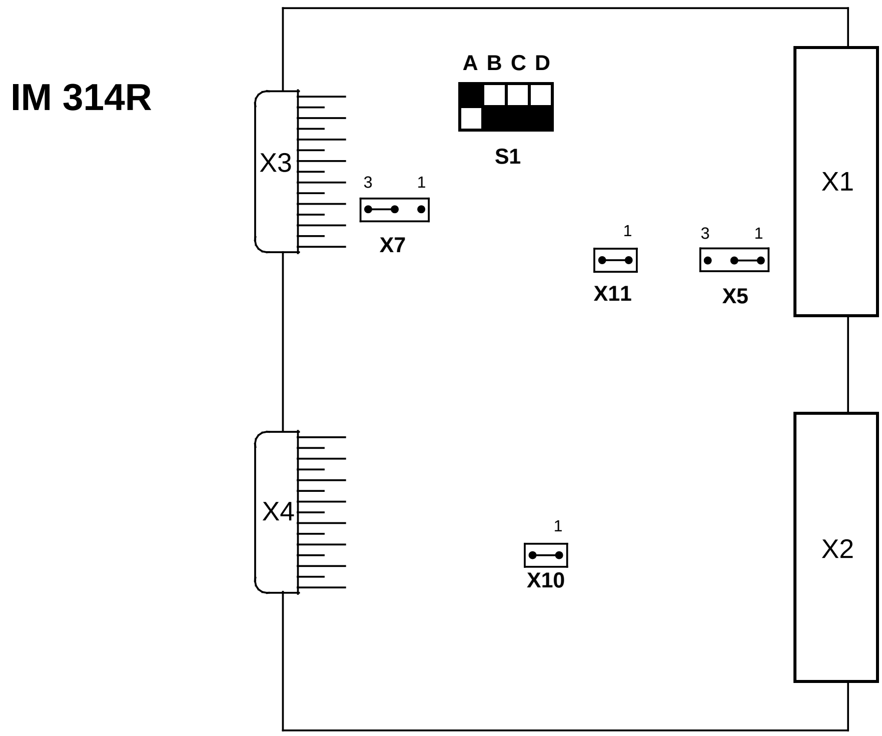


Figure 16-4. Switches and Jumper Settings for the Switched I/0 Configuration

- Plug the two IM 314R modules into slots 6 and 7 in the expansion rack.
- Using the 721 cable, interface the bottom connector on the IM 304 with the top connector on the IM 314R.
- Insert the terminating connectors in the IM 314R interfaces.

• Test the minimum system configuration
  - This procedure is illustrated by a flow diagram in Section 6.1.6, Figure 6-6.

• Install the switched I / Os
  - Plug a 430 digital input module into slot 0 in the expansion rack.
  - Plug a 451 digital output module into slot 1 in the expansion rack.

• Install the single-channel I / Os
  - Plug the 430 digital input module into slot 2 in subunit A.

• Install the two-channel redundant I / Os
  - Plug one 430 digital input module into slot 0 in subunits A and B.
  - Plug one 451 digital output module into slot 1 in subunits A and B.
  - Complete the connections shown in Figure 16-5.

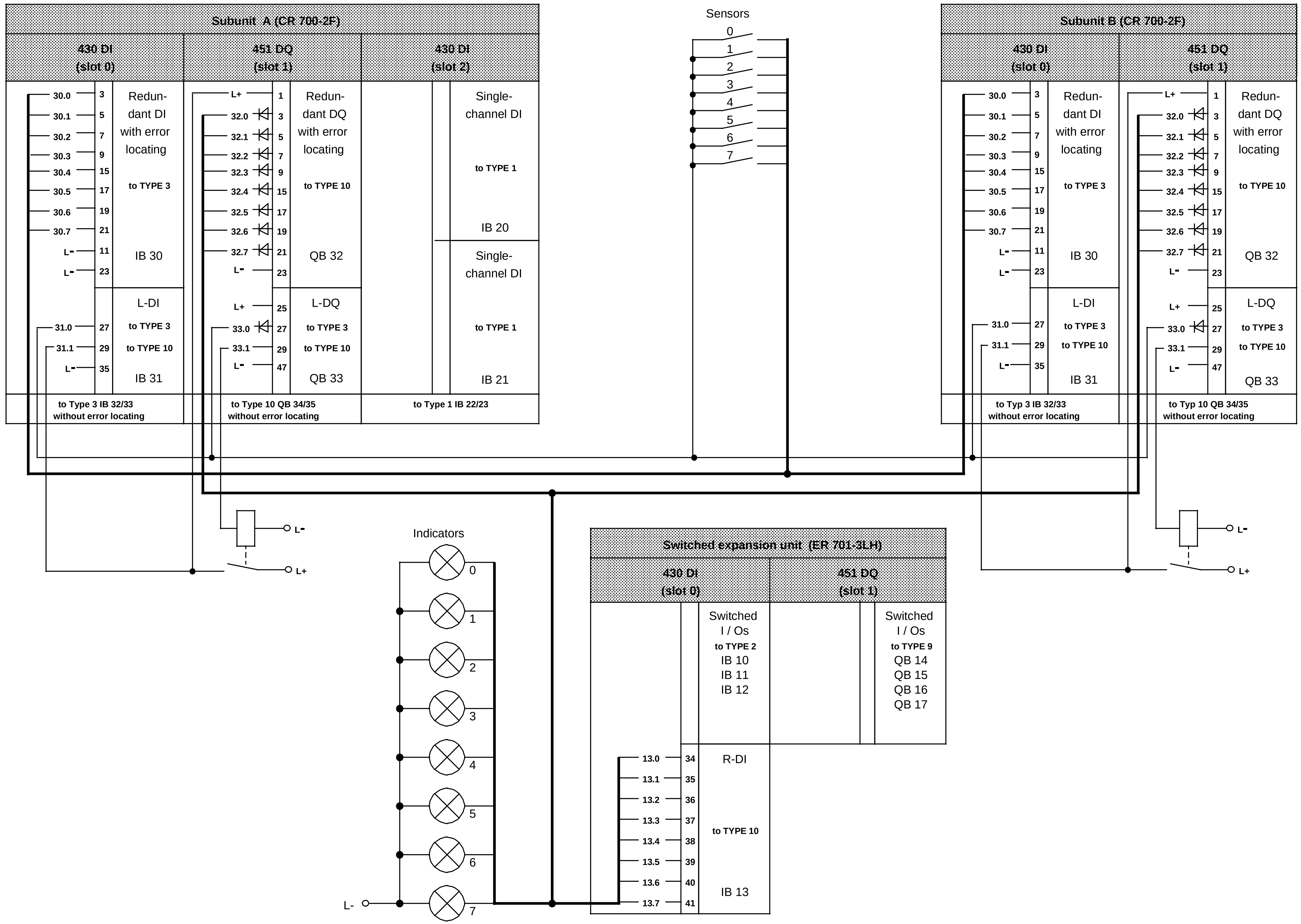


Figure 16-5. Circuit Diagram for a Redundant Structure with Error Locating Facilty

16.2 Configuring the Switched I / Os

In this section, you are going to configure three input bytes (bytes 10, 11 and 12) and four output bytes (bytes 14, 15, 16 and 17) in a switched I / O.

16.2.1 Configuring with COM 115H

To configure these bytes, screen the Package Selection form by entering "S5" on the programmer. Set the cursor to "COM 115H" and select the COM 115H software by pressing function key <F1>.
After you have entered the program file and set the OP mode to "ON" in the Defaults form, press <F6> "EXEC".
This takes you to the COM 115H ”Main Menu” form.

```
  D E F A U L T S
------------------------------------------------------------------------

                                    PROGRAM FILE : B:@@@@@@ST.S5D

SYMBOLS     : NO                    SYMBOLS FILE  :

FOOTER      : NO                    FOOTER FILE   :

PRINT WIDTH : NORMAL                PRINTER FILE  :

OP MODE     : ON

PATH NAME   :                       PATH FILE     :
```

F1	F2	F3	F4	F5	F6	F7	F8
OS	IOCONF		PLC FCT	DIAG	DEFAULTS	SYSHAN	BACK

Figure 16-6. The COM 115H Defaults Form

Press function key <F1> "OS" to screen the function key menu for "Initialize operating system".

F1	F2	F3	F4	F5	F6	F7	F8
SYSTEM	TRAFDAT	SYSID					

Figure 16-7. Function Key Menu for "Initializing Operating System"

Press function key <F1> "SYSTEM".

16.2.2 Initializing the Operating System

```
Initialize operating system
-----------------------------------------------------------------------

                    Initializing the H operating system

      No. of test slices (n*5ms)       (1....9):      1
      H error DB number                (2..255):      2
      OB13 time interval       (0.10s..600.00s):      0.10s
      Readback delay             (0.01s..1.00s):      0.01s
      H system flag word              (0...254):      0
      SINEC node no.                  (0..1023):      0
      Number of switched EUs          (0.....8):      1

      IP address areas with linear addressing
      Begin single-channel I/O subunit A      :    0000H
      Begin switched I/O                      :    0000H
```

F1	F2	F3	F4	F5	F6	F7	F8
					EXEC		BACK

Figure 16-8. Initializing the Operating System

Enter the following values in this screen form:
- H system flag word: ”0”
- Number of switched EUs: ”1”

Take over the default values for all other parameters in the screen form. Press <F6> to confirm the parameters and screen the function key menu for "Initializing the operating system". Press <F8> "BACK" to return to the "COM 115H main menu".

16.2.3 Configuring the Digital Inputs (COM 115H)

Press <F2> "IOCONF", then <F1> "DI" to screen the "Configure I / Os" form (digital inputs).

```
  COM 115H : Configure I/Os
-------------------------------------------------------------------------
=========================================================================
     I/O byte                  !    Type number
-------------------------------+-----------------------------------------
DI Byte    11                  !        2
-------------------------------+-----------------------------------------
DI Byte    12                  !        2
=========================================================================
Digital input      12
-------------------------------------------------------------------------
Type number        : 2        !
I/O channels       : 1        ! Interrupt generating   (Y / N)  : N
Availability       : enhanced !
                              !
DI in switched I/O            !
                              !
                              !
=======================================================================
Status: TYPE INPUT
```

F1	F2	F3	F4	F5	F6	F7	F8
SEARCH	COPY	TYPES	DELETE	SWAP			BACK

Figure 16-9. Configuring the Digital Inputs

Enter the type number "2" (DI in switched I/O) in bytes 10, 11 and 12 and "N" as reply to the "Interrupt generating" prompt.
Press <F8> "BACK", then <F2> "DQ" to screen the form for configuring the digital outputs.

16.2.4 Configuring the Digital Outputs (COM 115H)

```
  COM 115H : Configure I / Os
--------------------------------------------------------------------------
=========================================================================
     I/O byte                  !    Type number
-------------------------------+-----------------------------------------
DQ byte    14                  !        9
-------------------------------+-----------------------------------------
DQ byte    15                  !        9
=========================================================================
Digital output      15
-------------------------------------------------------------------------
Type number          : 9        !
I/O channels         : 1        !
Availability         : enhanced !
                                !
DQ in switched I/O              !
                                !
                                !
=======================================================================
Status: TYPE INPUT
```

F1	F2	F3	F4	F5	F6	F7	F8
SEARCH	COPY	TYPES	DELETE	SWAP			BACK

Figure 16-10. Configuring the Digital Outputs

Enter the type number "9" (DQ in switched I / O) in bytes 14, 15, 16 and 17. Press <F8> "BACK" to rescreen the function key menu for configuring the I / Os.

16.3 Configuring Single-Channel I / Os

In this section, four input bytes (bytes 20, 21, 22 and 23) are to be configured as single-channel I / Os in subunit A.

16.3.1 Configuring the Digital Inputs

<F1> "DI" screens the "Configure I / Os" form (for digital inputs).

```
COM 115H : Configure I / Os
----------------------------------------------------------------------
======================================================================
    I/O byte                    !    Type Number
-------------------------------+--------------------------------------
DQ byte    20                   !        1
-------------------------------+--------------------------------------
DQ byte    21                   !        1
======================================================================
Digital output      21
----------------------------------------------------------------------
Type number        : 1          !  SUBUNIT              (A / B): A
I/O channels       : 1          !  Interrupt generating (Y / N): N
Availability       : standard   !
                                !
DI in single-channel I/O        !
                                !
                                !
====================================================================
Status: TYPE INPUT
```

F1	F2	F3	F4	F5	F6	F7	F8
SEARCH	COPY	TYPES	DELETE	SWAP			BACK

Figure 16-11. Configuring the Digital Inputs

Enter the type number "1" in bytes 20, 21, 22 and 23; enter "A" as subunit and "N" as response to the "Interrupt generating" prompt. Press <F8> "BACK" to rescreen the function key menu for configuring the I / Os.

16.4 Configuring Two-Channel Redundant I / Os

In this section, one redundant input byte and one redundant output byte, both without error locating, as well as one redundant input byte and one redundant output byte, both with error locating, are to be configured.

16.4.1 Configuring Redundant Inputs (COM 115H)

Function key <F1> "DI" screens the "Configure I / Os" form (for digital inputs).

Redundant Inputs With Error Locating

```
  COM 115H : Configure I/Os
------------------------------------------------------------------------
========================================================================
    I/O byte                    !    Type number
-------------------------------+----------------------------------------
DI byte    30                   !        3
-------------------------------+----------------------------------------
DI byte    31                   !       LDI
========================================================================
Digital input     30
------------------------------------------------------------------------
Type number       : 3        ! Interrupt generating (Y / N) : N
I/O channels      : 2        ! Discrep. time (0.0=cycle)    : 0.05s
Availability      : high     ! (0.00s..320.00s)
                             ! L-DQ BYTE/BIT (0.0 to 127.7): 33.0
Required configuration :     ! L-DI BYTE/BIT (0.0 to 127.7) : 31.0
with / without L DI / L DQ   !
                             !
                             !
DI in redundant  I/O         !
======================================================================
Status: TYPE INPUT
```

F1	F2	F3	F4	F5	F6	F7	F8
SEARCH	COPY	TYPES	DELETE	SWAP			BACK

Figure 16-12. Configuring Redundant Inputs With Error Locating

Enter the type number "30" in byte 30. Enter the following parameters as type characteristics:

- Interrupt generating ”N”
- Discrepancy time ”0.05 s”
- L-DQ byte / bit ”33.0”
- L-DI byte / bit ”31.0”

Press <F8> "BACK" and <F2> "DQ" to screen the form for "configuring digital outputs".

Redundant Inputs Without Error Locating

```
 COM 115H : Configure I/Os
------------------------------------------------------------------------
========================================================================
     I/O byte                     !    Type number
-------------------------------+----------------------------------------
DI byte    32                     !        3
-------------------------------+----------------------------------------
DI byte    33                     !        3
========================================================================
Digital input     30
------------------------------------------------------------------------
Type number       : 3             ! Interrupt generating (Y/ N)   : N
I/O channels      : 2             ! Discrep. time (0.0=cycle)     : 0.0s
Availability      : high          ! (0.00s..320.00s)
                                  ! L DQ BYTE / BIT (0.0 to 127.7):
Required configuration:           ! L DI BYTE / BIT (0.0 to 127.7):
with / without L DI / L DQ        !
                                  !
                                  !
DI in redundant I/O               !
======================================================================
Status: TYPE INPUT
```

F1	F2	F3	F4	F5	F6	F7	F8
SEARCH	COPY	TYPES	DELETE	SWAP			BACK

Figure 16-13. Configuring Redundant Inputs Without Error Locating

Enter the type number "3" in bytes 32 and 33. Enter the following parameters as type characteristics:

- Interrupt generating ”N”
- Discrepancy time ”0.0 s” = 1 cycle

Press <F8> "BACK" and <F2> "DQ" to screen the form for "configuring digital outputs".

16.4.2 Configuring Redundant Outputs (COM 115H)

Redundant Outputs With Error Locating and Readback DI

```
  COM 115H : Configure I/Os
-------------------------------------------------------------------------
========================================================================
     I/O byte                 !    Type number
-------------------------------+----------------------------------------
DQ byte    32                 !        10
-------------------------------+----------------------------------------
DQ byte    33                 !       LDQ
========================================================================
Digital output     32
------------------------------------------------------------------------
Type number       : 10        ! L-DQ BYTE/BIT (0.0 to 127.7) : 33.1
I/O channels      :  2        ! L-DI BYTE/BIT (0.0 to 127.7) : 31.1
Availability      : high      ! R-DI BYTE         (0 to 127) : 13
                              ! R  DI in I / O               :  3
Required configuration :      !(1:SUBUNIT A, 2:SUBUNIT B, 3:switched)
without / without L DI / L DQ  !
with R DI                     !
                              !
R DQ in I/O                   !
======================================================================
Status: TYPE INPUT
   F1       F2       F3       F4       F5       F6       F7       F8
 SEARCH    COPY    TYPES    DELETE    SWAP                       BACK
```

Figure 16-14. Configuring Redundant Outputs With Error Locating and Readback DI

Enter the type number "10" in byte 32 and the following parameters as type characteristics:

- L DQ byte / bit ”33.1”
- L DI byte / bit ”31.1”
- R DI byte ”13”
- R DI in I / O "3"

Press <F8> twice in succession to return to the COM 115H main menu. Then press <F7> "SYSHAN" followed by <F3> "TRAN / LOAD".

Redundant Outputs Without Error Locating and Readback DI

```
 COM 115H : Configure I/Os
------------------------------------------------------------------------
=========================================================================
     I/O byte                     !    Type number
-------------------------------+-----------------------------------------
DQ Byte    34                     !        10
-------------------------------+-----------------------------------------
DQ Byte    35                     !        10
=========================================================================
Digital output    32
-------------------------------------------------------------------------
Type number       : 10            ! L DQ BYTE / BIT (0.0 to 127.7) :
I/O channels      :  2            ! L DI BYTE / BIT (0.0 to 127.7) :
Availability      :  high         ! R DI BYTE           (0 to 127) :
                                  ! R DI in I/O                    :
Required configuration :          ! (1:SUBUNIT A, 2:SUBUNIT B, 3:switched)
with / without L DI / L DQ        !
with R DI                         !
                                  !
DQ in redundant I/O               !
=======================================================================
Status: TYPE INPUT
```

F1	F2	F3	F4	F5	F6	F7	F8
SEARCH	COPY	TYPES	DELETE	SWAP			BACK

Figure 16-15. Configuring Redundant Outputs Without Error Locating and Readback DI

Enter type number "10" in bytes 34 and 35. Specify no type characteristics.

Press <F8> twice in succession to return to the COM 115H main menu. Then press <F7> "SYSHAN" and <F3> "TRAN / LOAD".

16.5 Transferring Configuration DB 1 (COM 115H)

You are now in the function key menu for "I / O transfer / load".

F1	F2	F3	F4	F5	F6	F7	F8
LOAD PLC	TRAN PLC	LOAD FD	TRAN FD				BACK

Figure 16-16. Function Key Menu for "I / O Transfer / Load"

You can transfer DB 1, which is currently in the programmer memory, to either the PLC (<F2> "TRAN PLC") or to the program file on floppy disk (<F4> "TRAN FD").
Transfer DB 1 to the program file first, then to the PLC. Then press <F8> twice in succession to return to the COM 115H main menu.

16.6 Listing the Configuring Data (COM 115H)

F1	F2	F3	F4	F5	F6	F7	F8
DI	DQ	AI	AQ	CP / IP	TYPES	ALL	BACK

Figure 16-17. Function Key Menu for the "Print Menu"

The following printout is generated when you press <F1> "DI":

Digital inputs:

I / O Byte	Short Symbol	Type	Sub-unit
IB 10		2	
IB 12		2	
IB 20		1	A
IB 22		1	A
IB 30		3	
IB 32		3	

I / O Byte	Short Symbol	Type	Sub-unit
IB 11		2	
IB 13		RDI	
IB 21		1	A
IB 23		1	A
IB 31		LDI	
IB 33		3	

Press <F2> "DQ" to output the digital outputs:

Digital outputs:

I / O Byte	Short Symbol	Type	Sub-unit
QB 14		9	
QB 16		9	
QB 32		10	
QB 34		10	

I / O-Byte	Short Symbol	Type	Sub-unit
QB 15		9	
QB 17		9	
QB 33		LDQ	
QB 35		10	

Press <F8> "BACK" three times in succession to exit COM 115H.

16.7 Servicing the S5-115H

The configuration DB (DB 1) is not in subunit A.

Execute a cold restart on subunit A. Upon completion of the self-test (red and green LEDs go on), the CPU goes to RUN (green LED on).

The operating system generates the configured error DB and the RAM DB automatically.

Execute an overall reset, then a cold restart on subunit B. The program is transferred from subunit A (master) to subunit B, i.e. subunit B is "activated". The red and green LEDs on subunit B flash alternately. Following completion of the self-test (red and green LEDs on), the standby controller's CPU also goes to RUN. The green LED flashes to indicate the "standby" state.

You can now generate programs as you would on the S5-115U.

On-line Functions
In redundant mode, all write functions are executed on both PLCs simultaneously.
In this mode, the Read functions are identical to those of the U system.

17 Technical Specifications

17 Technical Specifications

17.1 General Technical Specifications

Climatic
Environmental Conditions

Temperature

Operation	
- Open design air intake temperature (measured at the bottom of the modules)	0 to +55° C
- Cabinet design (Where cabinet design is concerned, the dissipatible heat loss depends on the type of construction, the ambient temperature, and the arrangement of the devices) Air intake temperature (measured at the bottom of the modules)	0 to +55° C
Storage / Shipping	- 40 to +85° C
Temperature change	
- operation	maximum 10 K / h
- storage / shipping	maximum 20 K / h

Relative humidity

- operation	95% (according to DIN 40040)
- storage / shipping	95% (noncondensing)

Atmospheric pressure

- operation	860 to 1060 hPa [1]
- storage / shipping	660 to 1060 hPa [1]

Pollutants

- SO_2	0,5 ppm, (rel. humidity 60%, noncondensing)
- H_2S	0,1 ppm, (rel. humidity 60%, noncondensing)

[1] For use under 900 hPa (=1000 m above sea level), check with the manufacturer on the cooling requirements.

Mechanical
Environmental Conditions

Vibration	according to IEC 68-2-6
- tested with	10 to 57 Hz, (const. amplitude 0.15 mm) 57 to 150 Hz, (const. acceleration 2 g)
Shock	according to IEC 68-2-27
- tested with	12 shocks (half sine 15 g / 11 ms)
Free fall	according to IEC 68-2-32
- tested at	height of fall 1 m

Electromagnetic Compatibility (EMC)
Noise Immunity

Damped oscillatory ware test	according to IEC 255-4
- AC power supply modules	2,5 kV
- DC power supply modules	1 kV
- output DC 24 V	1 kV
- input AC 115 / 230 V	2.5 kV
- digital input / output modules	2.5 kV
- analog input / output modules	1 kV
- communications interfaces	1 kV
Pulse burst test	according to IEC 65 (Sec) 87
- power supply modules	2 kV
- digital input / output modules	2 kV
- analog input / output modules	1 kV
- communications interfaces	1 kV
Electronic discharge test	according to IEC 801-2 (Discharge to all parts accessible to the operator in normal operation)
- power supply modules	5 kV
- digital input / output modules	5 kV
- analog input / output modules	5 kV
- communications interfaces	5 kV
Radiated electromagnetic field test	according to IEC 801-3
- test field strength	3 V/m
Fast transient burst test	according to IEC 801-4
- power supply modules	Class
- digital input / output modules	
- analog input / output modules	
- communications interface	

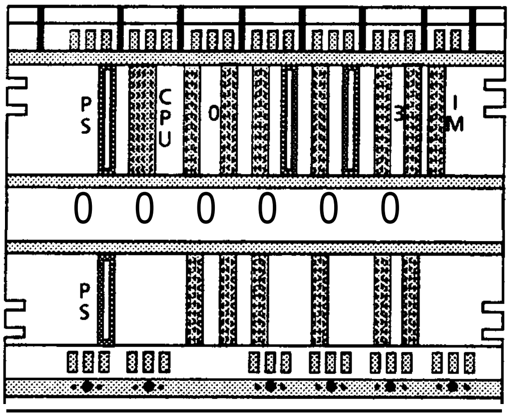
IEC / VDE
Safety Information

Degree of protection to IEC 529	
- Type	IP 20
- Class	according to IEC 536
Isolation rating	
- between electrically independent circuits **and** with circuits connected by a central grounding point	according to VDE 0160
- between all circuits **and** central grounding point (standard mounting rail)	according to VDE 0160
Test voltage for rated voltage V_e of the circuits (AC / DC)	Sine, 50 Hz
V_e= 0 to 50 V	500 V
V_e= 50 to 125 V	1250 V
V_e= 125 to 250 V	1500 V
Impulse voltage	according to IEC 255-4
for a rated voltage V_e of the circuits (AC / DC)	
U_e= 0 to 50 V	1 kV, 1.2 / 50 µs
U_e= 50 to 125 V	1 kV, 1.2 / 50 µs
U_e= 125 to 250 V	3 kV, 1.2 / 50 µs
RI specification	according to VDE 0871
- Limit class	A
Note: AC output modules are not interference suppressed!	

17.2 Module Descriptions

17.2.1 Mounting Racks (CRs, ERs)

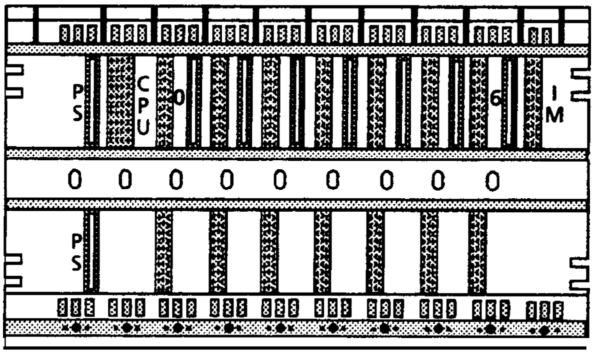
Mounting Rack CR 700-0 for Central Controller O **(6ES5700-OLB1l)**



Technical Specifications

Number of input/ ouput modules that can be plugged in	max. 6
Number of expansion units that can be connected	
- central	max. 3
- distributed up to 600 m	max. 2 x 4
Dimensions W x H x D(mm)	353 x 303 x47
Weight	4 kg (8.80 lb.)

Mounting Rack CR 700-2 for Central Controller 2 **(6ES5700-2LA12)**

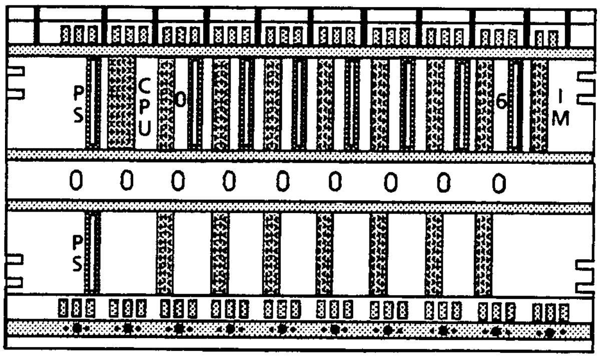


Technical Specifications

Number of input I ouput modules that can be plugged in	max. 7
Number of expansion units that can be connected	
- central	max. 3
- distributed up to 600 m	max. 2 x 4
Dimensions W x H x D (mm)	4B3 x 303 x47
Weight	5 kg (11.0 lb.)

17

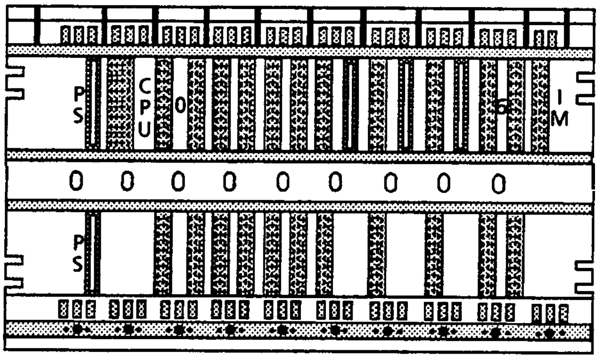
Mounting Rack CR 700-2F for Central Controller 2F (6ES5700-2LA12)



Technical Specifications

Number of input I output modules that can be plugged in	**max.** *6*
Number of expansion units that can be connected	
- central	**max.** *3*
- distributed up to 600 m	**max.** *2* **x** *4*
Dimensions W x H x D (mm)	*483* **x** *303* **X47**
Weight	**5 kg (11.0 lb.)**

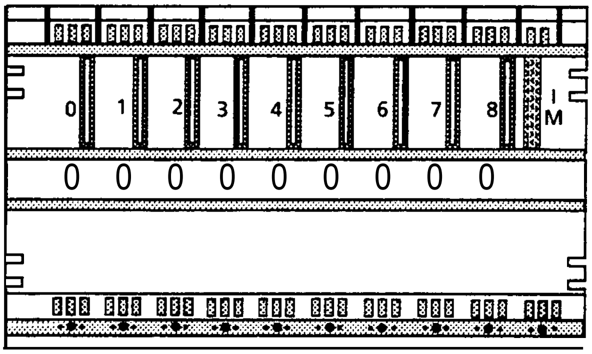
Mounting Rack CR 700-3 for Central Controller 3 (6ES5700-3LA12)



Technical Specifications

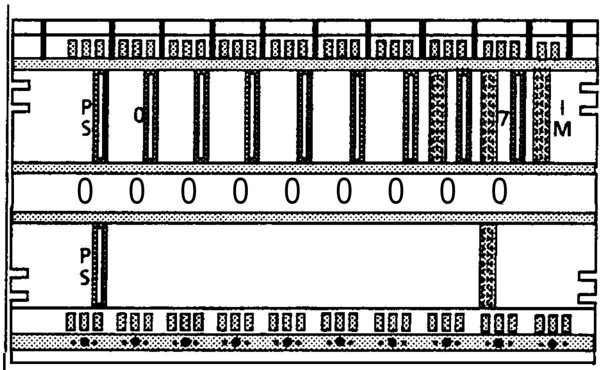
Number of input/ output modules that can be plugged in	**max. 11**
Number of expansion units that can be connected	
- central	**max. 3**
- distributed up to 600 m	**max. 2 x 4**
Dimensions W x H x D (mm)	**483 x 303 x47**
Weight	*5 kg* **(11.0 lb.)**

Mounting Rack ER 701-1 for Expansion Unit 1 (6ES5701-1LA12)



Technical Specifications	
Number of input / output es that can be plugged in	max. 9
Interface module - central connection	IM 306
Interrupt evaluation	not possible
Dimensions W x H x D (mm)	483 x 303x 47
Weight	5 kg (11.0 lb.)

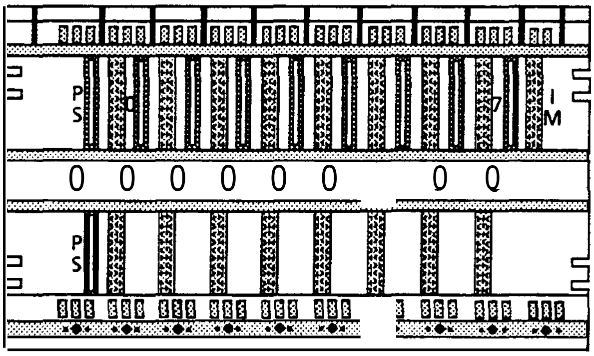
Mounting Rack ER 701-2 for Expansion Unit 2 (6ES5701-2LA12)



Technical Specifications	
Number of input/ output modules that can be plugged in	max. 7
Interface module - distributed connection	IM 306 AS 310 I IM 314
Interrupt evaluation	not possible
Dimensions W x H x D (mm)	4s3 x 303 x 47
Weight	5 kg (11.0 lb.)

17

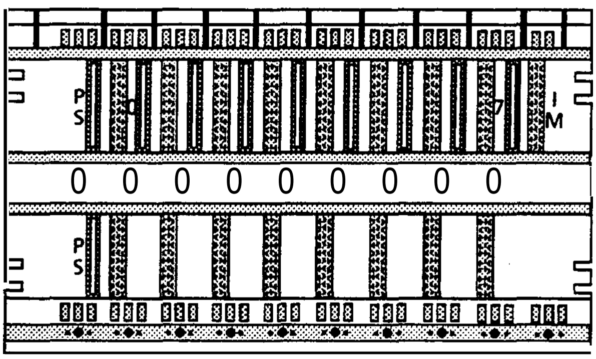
Mounting Rack ER 701-3 for Expansion Unit 3 (6ES5701-3LA13)



Technical Specifications

Number of input/ output modules that can be plugged in	**max. 7**
Interface module	
- central connection	**IM 306**
- distributed connection	**AS 310/ IM 314**
Interrupt evaluation	**not possible**
Dimensions W x H x D (mm)	**483 x 303 x47**
Weight	**5 kg (11.0 lb.)**

Mounting Rack ER 701-3 for Switched Expansion Unit (6ES5701-3LH11)

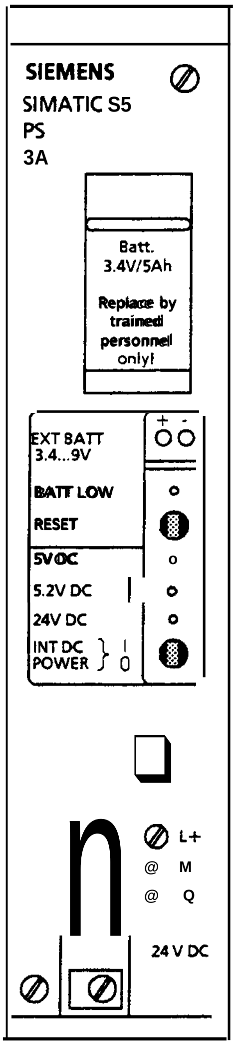


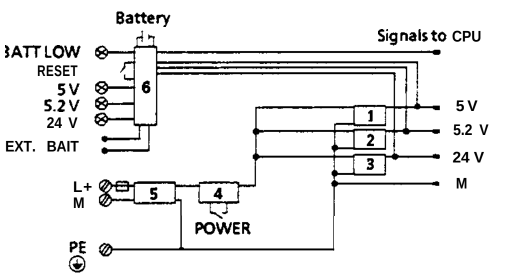
Technical Specifications

Number of input/ output modules that can be plugged in	**max. 7**
Interface module	
- switched connection	**IM 314R**
Interrupt evaluation	**not possible**
Dimensions W x H x D (mm)	**483 x 303 x47**
Weight	**5 kg (11.0 lb.)**

17.2.2 Power Supply Modules

Power Supply Module PS 951 24 V DC; 5 V, 3 A (6ES5951-7NB21)





1 Chopper controller
2 Chopper controller
3 Linear controller
4 Control electronics
5 Radio interference suppression filter
6 Monitoring electronics

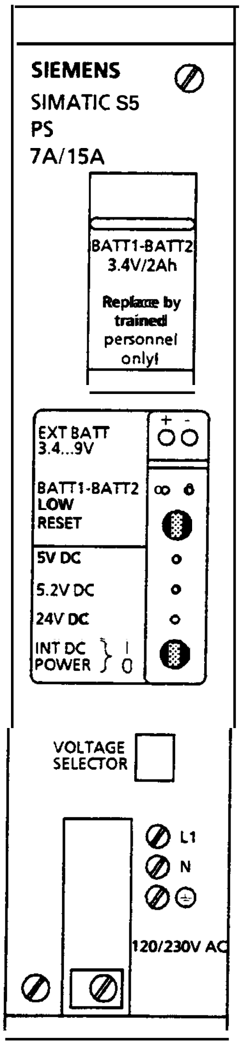
simplified schematic

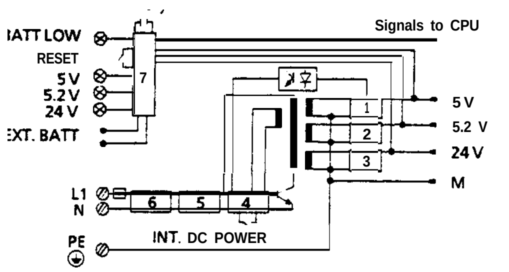
Technical Specifications

Input voltage L+		
- Rated value		24 V DC
- Permissible range		19.2 to 30 V
Input current at 24 V		
- Rated value		1.51 A
- inrush current	max.	15 x I_N
- I^2t		0.4A%
Power consumption		36.2 W
Output voltage		
- Rated value		5 V
- Tolerance		±1.5%
Output current		
- Rated value without fan		3 A
- Rated value with fan		3 A
- Permissible range		0.3to 3 A
Output voltage (PG/OP)		
- Rated value		5.2 V
- Tolerance		±1.5%
Output current		max. 1 A
Backup battery		Lithium battery, size C (3.6 V/5 Ah)
- Backup time	min.	1 year (at 0.3 mA, 25°C and uninterrupted backup)
Mains buffering (at $L+_{min}$)	min.	20 ms
Output voltage (auxiliary voltage)		
- Rated value		24 V
- Tolerance		±5%
Output current		max. 0.2 A
Short-circuit protection		Electronic
Fault indicator		No
Fuse (primary circuit)		Integral
Class of protection		class 1
Galvanic isolation		No
RI specifications		A according to VDE 0871
Power losses of the module	typ.	11.2 W
Weight	approx.	1.6 kg (3.53 lb.)

17

Power Supply Module PS 951 120/230 V AC; 5 V, 7/15 A (6ES5951-7LD21) –





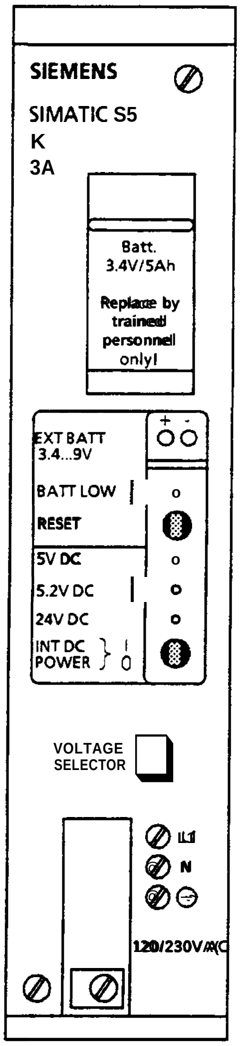
Chopper controller
Linear controller
Linear controller
4 Control electronics
5 Rectifier
6 Radio interference suppression filter
7 Monitoring electronics

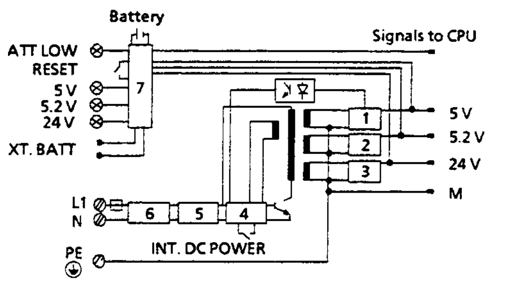
implified schematic

Technical Specifications

Input voltage L1		
- Rated value		120/230 V AC
- Permissible range		94to 132 V 187 to 264V
Line frequency		
- Rated value		50 Hz
- Permissible range		47 to 63 Hz
Input current at 120/230 V		
- Rated value		1.410.8A
- Inrush current	max.	15 x I_N
. I^2t		1.8 A^2s
Power consumption (active power)		133 w
Output voltage		
- Rated value		5 V
- Tolerance		±1.5%
Output current		
- Rated value without fan		7 A
- Rated value with fan		15 A
- Permissible range		0.3 to 15 A
Output voltage (PG/OP)		
- Rated value		5.2 V
- Tolerance		±1.5%
Output current		max. 2.5 A
Backup battery		2 lithium batteries, size AA (3.6 V/2x1.75 Ah)
- Backup time	min.	1 year (at 0.3 mA, 25°C and uninterrupted backup)
Mains buffering (at $L1_{min}$)	min.	20 ms
Output voltage (auxiliary voltage)		
- Rated value		24 V
- Tolerance		±5%
Output current		max. 0.35 A
Short-circuit protection		Electronic
Fauk indicator		No
Fuse (primary circuit)		Integral
aass of protection		Class 1
Galvanic isolation		Yes
Iselation rating		Safe electrical isolation according to VDE 0160
- Tested with		2700 V DC
Initial discharge current to VDE 0160 at 230 V AC		2.6 mA
RI specifications		A according to VDE 0871
Power losses of the module	typ.	36 W
Weight	approx.	1.9 kg (4.19 lb.)

Power Supply Module PS 951 120/230 V AC; 5 V, 3 A (6ES5951-7LB21)





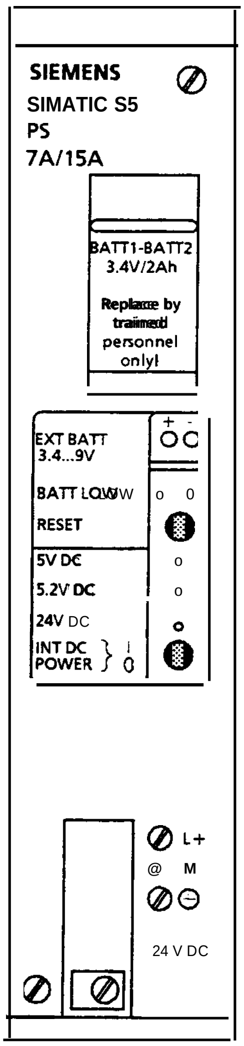
Chopper controller 4 Control electronics
Linear controller 5 Rectifier
Linear controller 6 Radio interference suppression filter
7 Monitoring electronics

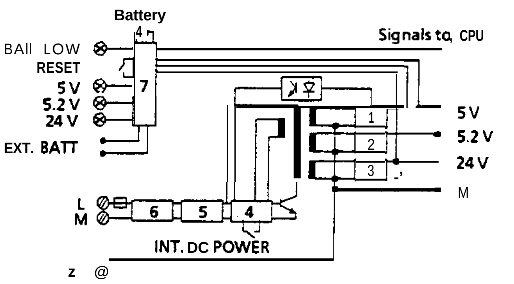
implified schematic

Technical Specifications		
Input voltage L1		
- Rated value		120/230 V AC
- Permissible range		94 to 132 V/ 187 to 264 V
Line frequency		
- Rated value		50 Hz
- Permissible range		47 to 63 Hz
Input current at 120/230 V		
- Rated value		0.55/0.33 A
- Inrush current	max.	$15 \times I_N$
- I^2t		$0.135\ A^2s$
Power consumption (active power)		44.8 W
Output voltage		
- Rated value		5 V
- Tolerance		±1.5%
Output current		
- Rated value without fan		3 A
- Rated value with fan		3 A
- Permissible range		0.3 A to 3 A
Output voltage (PG/OP)		
- Rated value		5.2 V
- Tolerance		±1.5%
Output current		max. 1 A
Output voltage (auxiliary voltage)		
- Rated value		24 V
- Tolerance		±5%
Output current		max. 0.2 A
Backup battery		Lithium battery, size C (3.6 V/5 Ah)
- Backup time	min.	1 year (at 0.3 mA, 25°C and uninterrupted backup)
Mains buffering (at $L1_{min}$)	min.	20 ms
Short-circuit protection		Electronic
Fault indicator		No
Fuse (primary circuit)		Integral
Galvanic isolation		Yes
Isolation rating		Safe electrical isolation according to VDE 0160
- Tested with		2700 V DC
Initial discharge current to VDE 0160 at 230 V AC		2.6 mA
RI specifications		A according to VDE 0871
Power losses of the module	typ.	19.8 W
Weight	approx.	1.6 kg (3.53 lb.)

17

Power Supply Module PS 95124 V DC; 5 V, 7/15 A (6ES5951-7ND41)





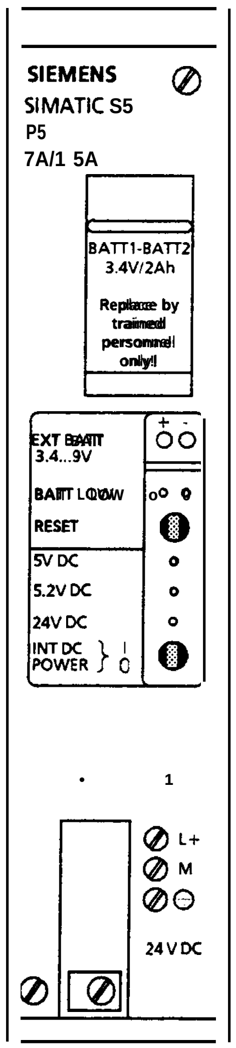
Chopper controller	4 Control electronics
Linear controller	5 Rectifier
Linear controller	6 Radio interference suppression filter
	7 Monitoring electronics

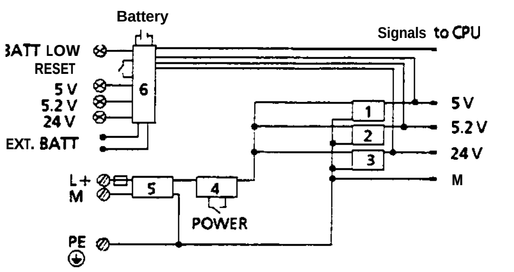
implified schematic

Technical Specifications

Input voltage L+		
- Rated value		24 V DC
- Permissible range		19.2 to 30V
Input current at 24 V		
- Rated value		5.6 A
- Inrush current	max.	15 x I_N
- I^2t		4.5 A^2s
Power consumption		134.4 W
Output voltage		
- Rated value		*5 V*
- Tolerance		±1.5%
Output current		
- Rated value without fan		7 A
- Rated value with fan		15A
- Permissible range		0.3 to 15A
Output voltage (PG/OP)		
- Rated value		5.2 V
- Tolerance		±1.5%
Output current		max. 2.5 A
Backup battery		2 lithium batteries, size AA (3.6 V/2 x 1.75 Ah)
- Backup time	min.	1 year (at 0.3 MA, " 25°C and uninterrupted backup)
Mains buffering (at L+ min)	min.	20 ms
Output voltage (auxiliary voltage)		
- Rated value		24 V
- Tolerance		±5%
Output current		max. 0.35 A
Short-circuit protection		Electronic
Fault indicator		No
Fuse (primary circuit)		Integral
Class of protection		Class 1
Galvanic isolation		Yes
Isolation rating		Safe electrical isolation according to VDE 0160
Tested with		2700 V DC
?I specifications		A according to VDE 0871
’ower losses of the module	typ.	38 W
Neight	approx.	1.7 kg (3.75 lb.)

Power Supply Module PS 951 24 V DC; 5 V, 7/15 A (6ES5951-7ND51)





Chopper controller
Chopper controller
Linear controller
4 Control electronics
5 Radio interference suppression filter
6 Monitoring electronics

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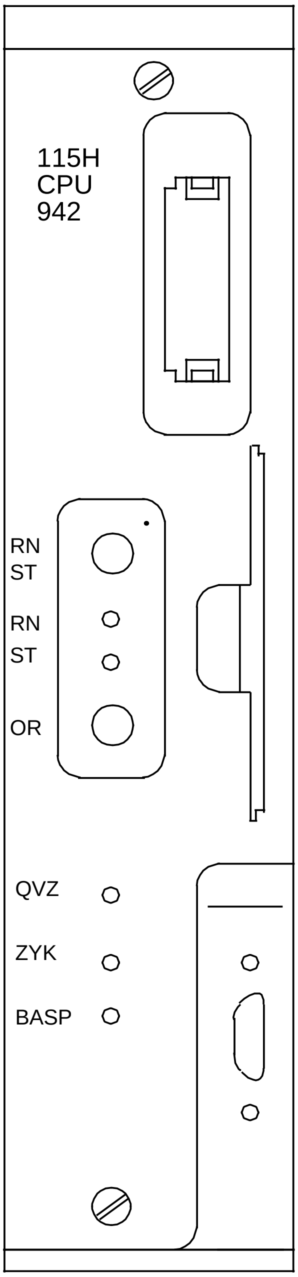
Technical Specifications

Input voltage L+		
- Rated value		24VDC
- Permissible range		19.2 to 30 V
Input current at 24 V		
- Rated value		5.04A
- Inrush current	max.	15X I_N
· I^2t		16A%
Power consumption		120.5 W
Output voltage		
- Rated value		5 V
- Tolerance		±1.5%
Output current		
- Rated value without fan		7 A
- Rated value with fan		15A
- Permissible range		0.3 to 15A
Output voltage (PG/OP)		
- Rated value		5.2 V
- Tolerance		±1.5%
Output current		max. 2.5 A
Backup battery		2 lithium batteries, size AA (3.6 V/2 x 1.75Ah)
- Backup time	min.	1 year (at 0.3 mA, 25°C and uninterrupted backup)
Mains buffering [at $L+_{min}$]	min.	*20* ms
Output voltage (auxiliary voltage)		
. Rated value		24 V
, Tolerance		±5%
Output current		max. 0.35 A
Short-circuit protection		Electronic
'auk indicator		No
ʼuse (primary circuit)		Integral
Ɔlass of protection		class 1
ʒalvanic isolation		No
ʋl specifications		A according to VDE 0671
ʼower losses of the module	typ.	24.1 W
Veight	approx.	1.7 kg (3.75 lb.)

17

17.2.3 Central Processing Unit

Central Processing Unit CPU 942H (6ES5 942-7UH11)



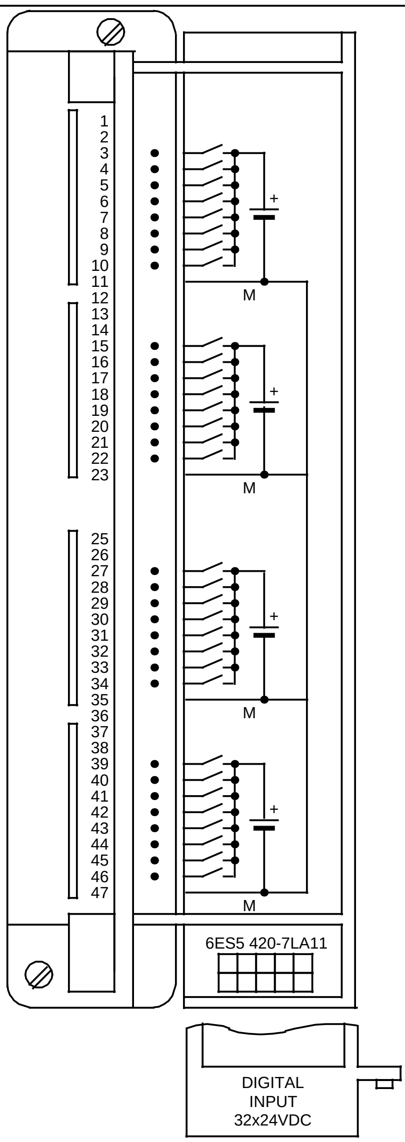
Technical Specifications

Memory capacity (total)	max.	21504 statements [1]
- internal memory	max.	5120 statements [1]
- memory submodule (RAM)	max.	16384 statements [1]
- memory submodule (EPROM)	max.	16384 statements [1]
- memory submodule (EEPROM)	max.	8192 statements [1]
Execution time		
- per binary operation	approx.	1.6 µs
- per word operation	approx.	1.6 to 200 µs
Scan time monitoring	approx.	500 msec. (can be modified)
Flags		2048; of these 1024 are optionally retentive [2]
Timers		
- number		128; of these 64 are optionally retentive [2]
- range		0.01 to 9990 sec.
Counters		
- number		128; of these 64 are optionally retentive [2]
- range		0 to 999 (count up, count down)
Digital inputs Digital outputs - total	max.	2048
Analog inputs Analog outputs - total	max.	128
Organization blocks	max.	256
Program blocks	max.	256
Function blocks	max.	256 (can be assigned parameters)
Sequence blocks	max.	256
Data blocks	max.	254
Operations set	approx.	170 operations
Current consumption		
- from 5 V (internal)		0.8 A
- from 24 V (when a PG 605 or PG 615 programmer is connected)		0.02 A
Power losses		
of the module	typ.	4 W
- with programmer	typ.	4.5 W
Weight	approx.	1.5 kg (3.3 lb.)

[1] A statement usually takes up two bytes in the program memory.
[2] Use back-up battery for retentive feature.

17.2.4 Digital Input Modules

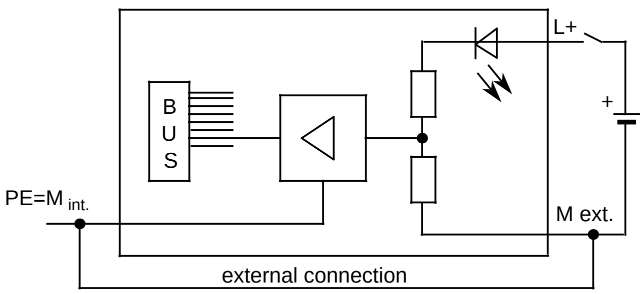
Digital Input Module 32 x 24 V DC, Nonfloating (6ES5 420-7LA11)



Terminal Assignment

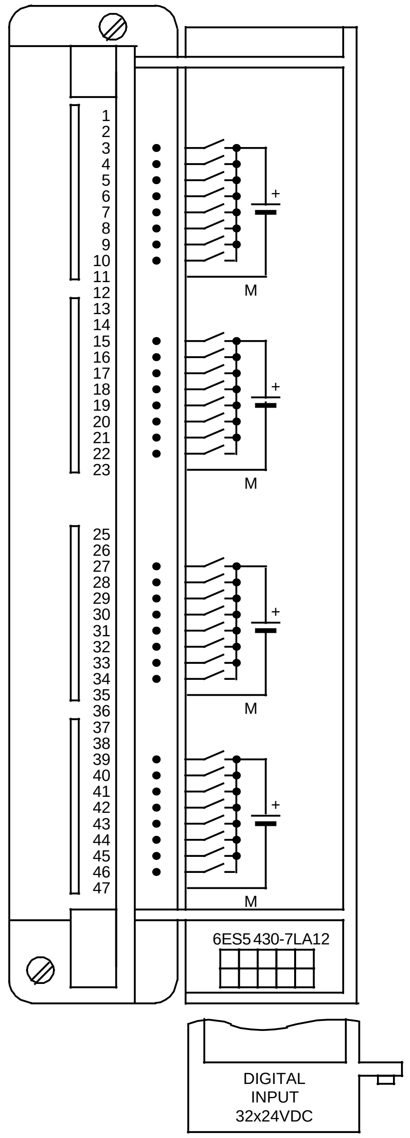
Technical Specifications

Number of inputs		**32**
Galvanic isolation		**no**
Input voltage L+		
- rated value		**24 V DC**
- for ”0” signal		**-30 to +5 V**
- for ”1” signal		**13 to 30 V**
Input current		
- for ”1” signal	**typ.**	**8.5 mA**
Delay time		
- from ”0” to ”1”		**1.4 to 5 msec.**
- from ”1” to ”0”		**1.4 to 5 msec.**
Cable length		
- shielded	**max.**	**1000 m (3281 ft.)**
- unshielded	**max.**	**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Connection of 2-wire BERO proximity switches		**possible**
- leakage (quiescent) current		**1.5 mA**
Current consumption		
- from 5 V (internal)		**5 mA**
Power losses of the module	**typ.**	**6.5 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

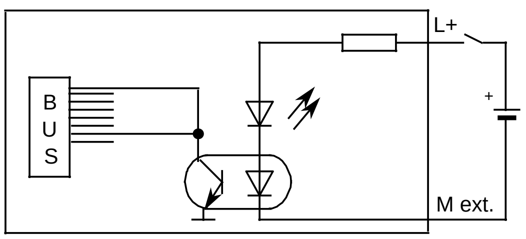


Simplified Schematic

Digital Input Module 32 x 24 V DC, Floating (6ES5 430-7LA12)



Terminal Assignment

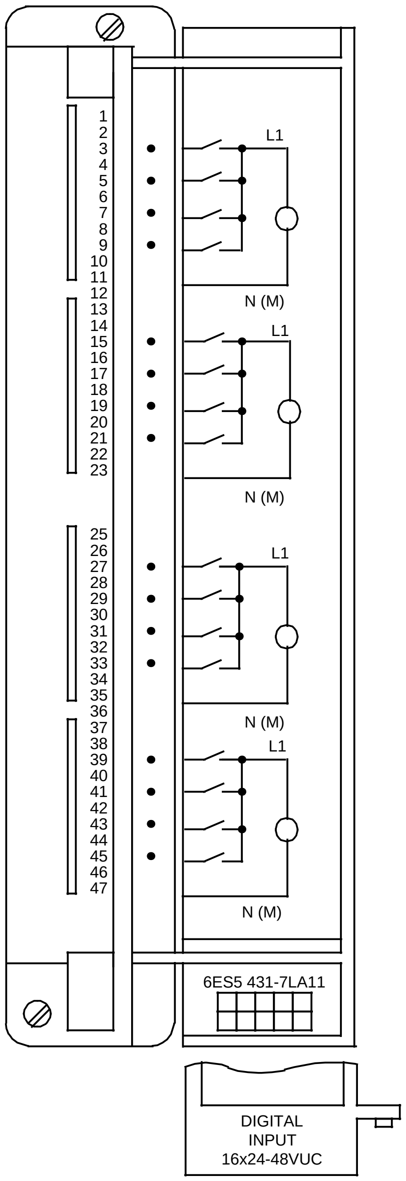


Simplified Schematic

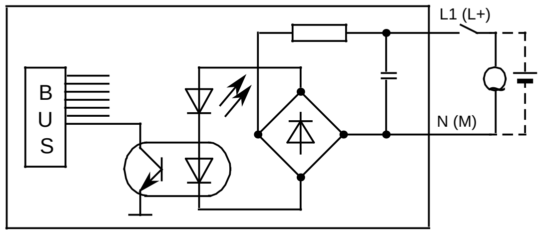
Technical Specifications

Number of inputs		**32**
Galvanic isolation		**yes (optocoupler)**
- in groups of		**8**
Input voltage L+		
- rated value		**24 V DC**
- for ”0” signal		**-30 to +5 V**
- for ”1” signal		**13 to 30 V**
Input current		
- for ”1” signal	**typ.**	**8.5 mA**
Delay time		
- from ”0” to ”1”	**typ.**	**2.2 msec.;**
	max.	**4.6 msec.**
- from ”1” to ”0”	**typ.**	**4.5 msec.;**
	max.	**12 msec.**
Cable length		
- shielded	**max.**	**1000 m (3281 ft.)**
- unshielded	**max.**	**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage		
(between groups)		**30 V**
- isolation group		**C**
- tested at		**500 V**
Rated isolation voltage		
(L+ to ⏚)		**30 V**
- isolation group		**C**
- tested at		**500 V**
Connection of 2-wire		
BERO proximity switches		**possible**
- quiescent current		**1.5 mA**
Current consumption		
- from 5 V (internal)		**5 mA**
Power losses of		
the module	**typ.**	**6.5 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

Digital Input Module 16 x 24 to 48 V UC (6ES5 431-7LA11)



Terminal Assignment



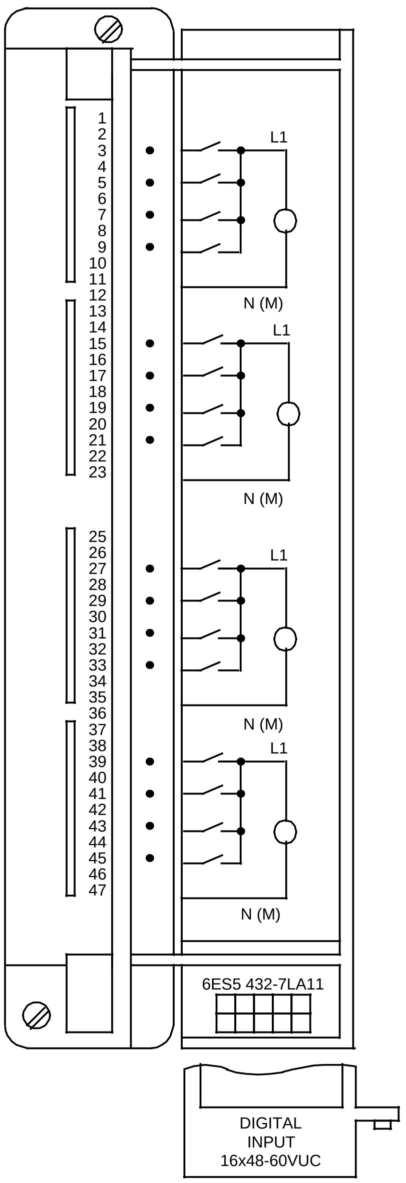
Simplified Schematic

Technical Specifications

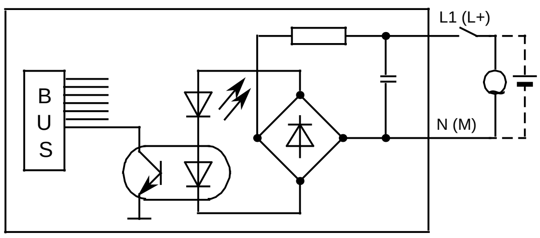
Number of inputs		**16**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**4**
Input voltage L+		
- rated value		**24 to 48 V UC**
- frequency		**0 to 63 Hz**
- for "0" signal		**0 to 5 V**
- for "1" signal		**13 to 60 V**
Input current for "1" signal		
- at 24 V AC	**typ.**	**8.5 mA**
- at 24 V DC	**typ.**	**9.0 mA**
- at 48 V AC	**typ.**	**10.5 mA**
- at 48 V DC	**typ.**	**10.5 mA**
Delay time		
- from "0" to "1"		**2 to 13 msec.**
- from "1" to "0"		**10 to 25 msec.**
Cable length		
- shielded	**max.**	**1000 m (3281 ft.)**
- unshielded	**max.**	**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage [1] (between groups)		**60V**
- isolation group		**C**
- tested at		**500 V**
Rated isolation voltage (L1 to ⏚)		**60V**
- isolation group		**C**
- tested at		**500 V**
Connection of 2-wire BERO proximity switches		**possible**
- quiescent current		**2 mA**
Current consumption		
- from 5 V (internal)		**5 mA**
Power losses of the module	**typ.**	**9 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

[1] Connection of different phases is not permissible.

Digital Input Module16 x 48 to 60 V UC, Floating (6ES5 432-7LA11)



Terminal Assignment



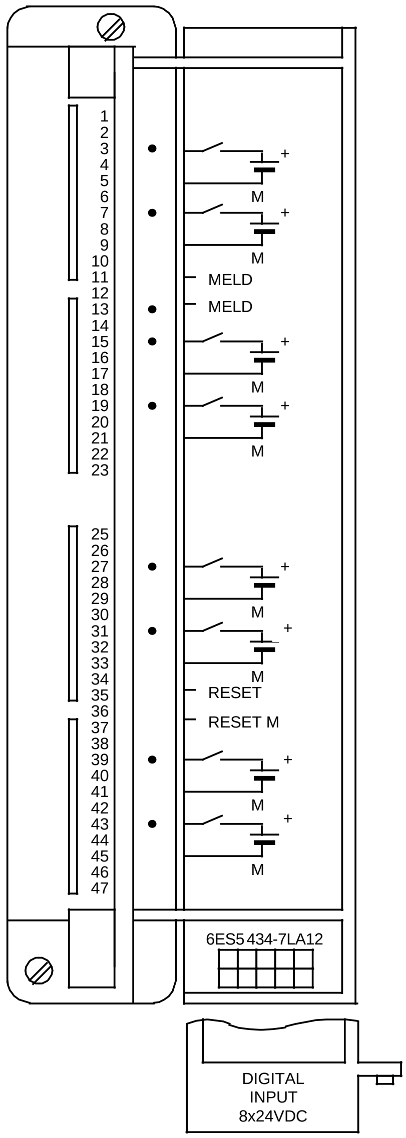
Simplified Schematic

Technical Specifications

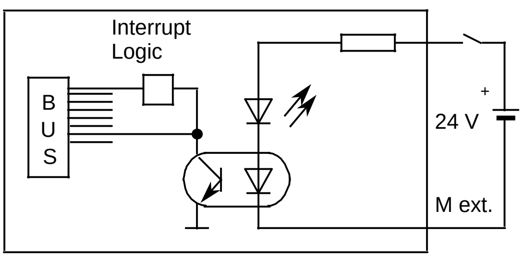
Number of inputs		**16**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**4**
Input voltage L1		
- rated value		**48 to 60 V UC**
- frequency		**0 to 63 Hz**
- for "0" signal		**0 to 10 V**
- for "1" signal		**30 to 72 V**
Input current for "1" signal		
- at 48 V AC / 50 Hz	**typ.**	**8.5 mA**
- at 48 V DC	**typ.**	**9.5 mA**
- at 60 V AC / 50 Hz	**typ.**	**9.5 mA**
- at 60 V DC	**typ.**	**10.0 mA**
Delay time		
- from "0" to "1"		**2 to 13 msec.**
- from "1" to "0"		**10 to 25 msec.**
Cable length		
- shielded	**max.**	**1000 m (3281 ft.)**
- unshielded	**max.**	**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage[1] (between groups)		**60 V**
- isolation group		**C**
- tested at		**500 V**
Rated isolation voltage (L1 to ⏚)		**60 V**
- isolation group		**C**
- tested at		**500 V**
Connection of 2-wire BERO proximity switches		**possible**
- quiescent current		**5 mA**
Current consumption		
- from 5 V (internal)		**5 mA**
Power losses of the module	**typ.**	**10 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

[1] Connection of different phases is not permissible.

Digital Input Module 8 x 24 V DC (with P Interrupt), Floating (6ES5 434-7LA12)



Terminal Assignment

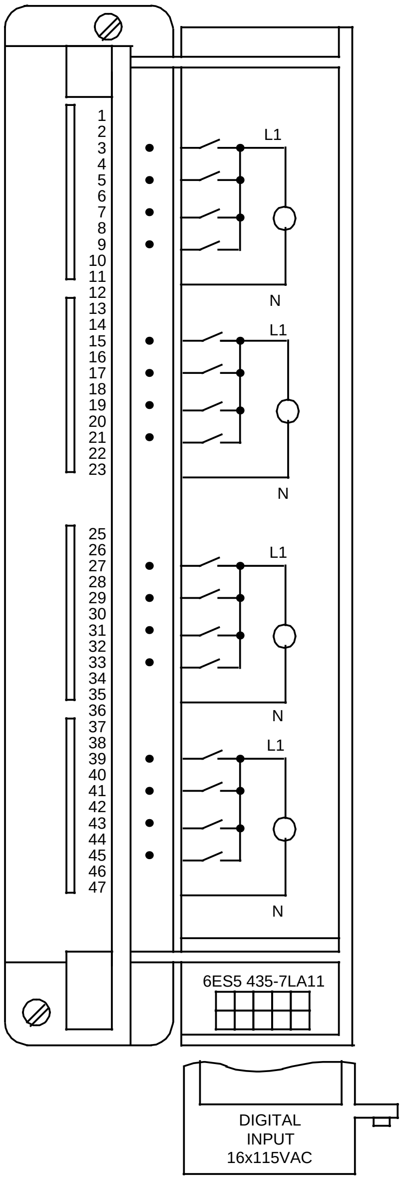


Simplified Schematic

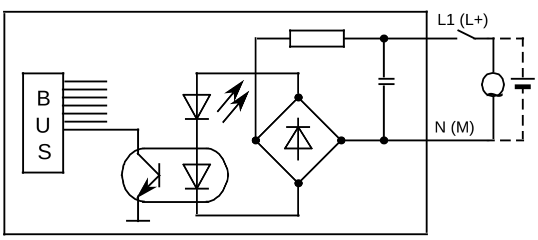
Technical Specifications

Number of inputs		**8**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**1**
Input voltage L+		
- rated value		**24 V DC**
- for "0" signal		**-30 to +5 V**
- for "1" signal		**13 to 30 V**
Input current for "1" signal		
- at 24 V DC	**typ.**	**8.5 mA**
Delay time		
- from "0" to "1"		**0.5 to 1.5 msec.**
- from "1" to "0"		**0.5 to 1.5 msec.**
Interrupt signal (external)		**latching relay contact (permissible load: max. 0.2 A 50 V DC - switching capacity max. 20 W or 35 VA)**
Interrupt signal (internal)		**via bus line PRAL-N**
Acknowledgement		**external via input reset 24 V DC**
Cable length		
- shielded	**max.**	**1000 m (3281 ft.)**
- unshielded	**max.**	**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between groups)		**30V**
- isolation group		**C**
- tested at		**500 V**
Rated isolation voltage (L+ to ⏚)		**30 V**
- isolation group		**C**
- tested at		**500 V**
Connection of 2-wire BERO proximity switches		**possible**
- quiescent current	**max.**	**1.5 mA**
Current consumption		
- from 5 V (internal)		**<70 mA**
Power losses of the module	**typ.**	**2 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

Digital Input Module 16 x 115 V AC, Floating (6ES5 435-7LA11)



Terminal Assignment



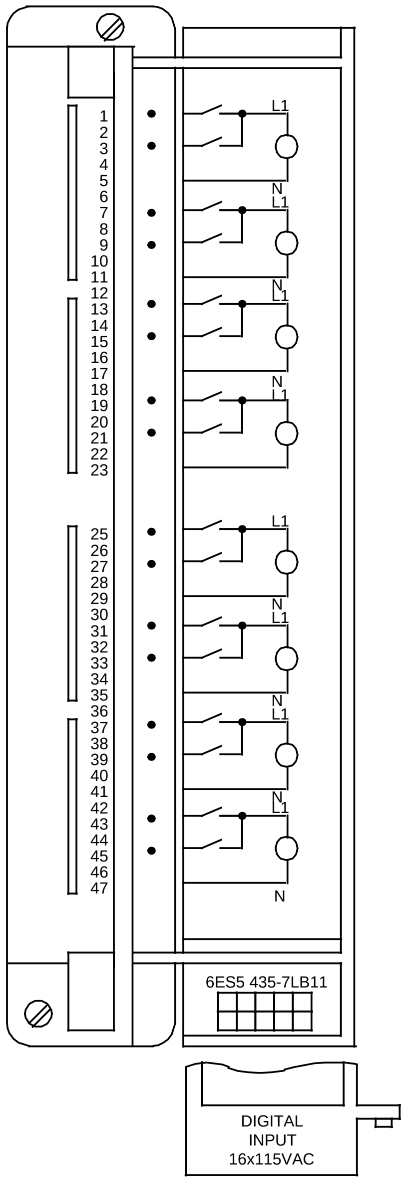
Simplified Schematic

Technical Specifications

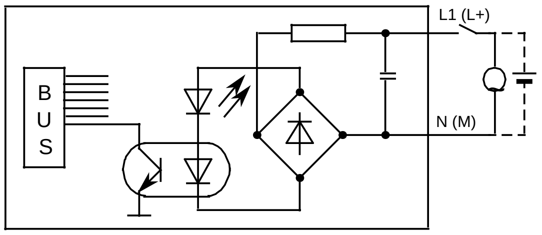
Number of inputs		**16**
Galvanic isolation		**yes (optocoupler)**
- in groups of		**4**
Input voltage L1		
- rated value		**115 V UC**
- frequency		**47 to 63 Hz**
- for ”0” signal		**0 to 40 V**
- for ”1” signal		**85 to 135 V**
Input current a for ”1” signal		
- at AC, 50 Hz	**typ.**	**15 mA**
- at DC	**typ.**	**6 mA**
Response time		
- from ”0” to ”1”		**2 to 13 msec.**
- from ”1” to ”0”		**10 to 25 msec.**
Cable length		
- shielded		**1000 m (3281 ft.)**
- unshielded		**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage [1] (between groups)		**250 V**
- isolation group		**C**
- tested at		**1500 V**
Rated isolation voltage (L1 to ⏚)		**250 V**
- isolation group		**C**
- tested at		**1500 V**
Connection of 2-wire BERO proximity switches		**possible**
- quiescent current		**5 mA**
Current consumption		
- from 5 V (internal)		**5 mA**
Simultaneity factor (per group, L1=135 V)		
- at 25°C		**100%**
- at 55°C		**75%**
Power losses of the module	**typ.**	**11 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

[1] **Connection of different phases is not permissible.**

Digital Input Module 16 x 115 V AC (6ES5 435-7LB11)



Terminal Assignment



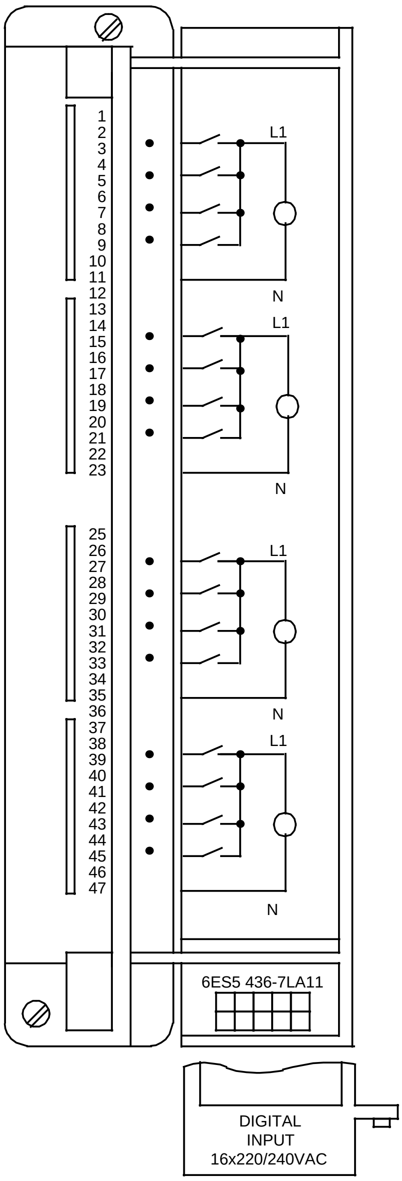
Simplified Schematic

Technical Specifications

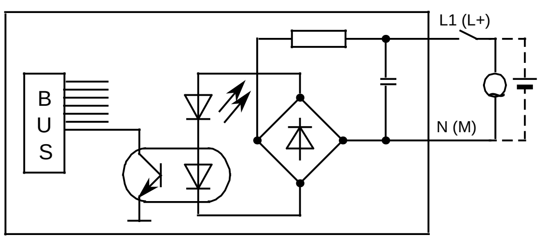
Number of inputs		**16**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**2**
Input voltage L1		
- rated value		**115 V UC**
- frequency		**47 to 63 Hz**
- for ”0” signal		**0 to 40 V**
- for ”1” signal		**85 to 135 V**
Input current for ”1” signal		
- at AC, 50 Hz	**typ.**	**10 mA**
- at DC	**typ.**	**6 mA**
Response time		
- from ”0” to ”1”		**2 to 13 msec.**
- from ”1” to ”0”		**10 to 25 msec.**
Cable length		
- shielded		**1000 m (3281 ft.)**
- unshielded		**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage [1] (between groups)		**250 V**
- isolation group		**C**
- tested at		**1500 V**
Rated isolation voltage (L1 to ⏚)		**250 V**
- isolation group		**C**
- tested at		**1500 V**
Connection of 2-wire BERO proximity switches		**possible**
- quiescent current		**5 mA**
Current consumption		
- from 5 V (internal)		**5 mA**
Simultaneity factor (per group, L1=135 V)		
- at 25°C		**100%**
- at 55°C		**75%**
Power losses of the module	**typ.**	**11 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

[1] Connection of different phases is permissible.

Digital Input Module 16 x 230 V AC, Floating (6ES5 436-7LA11)



Terminal Assignment



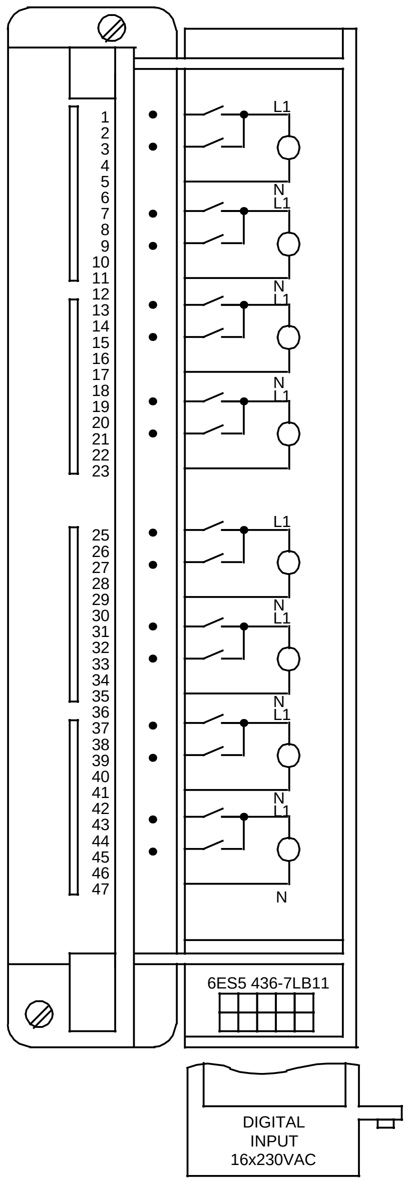
Simplified Schematic

Technical Specifications

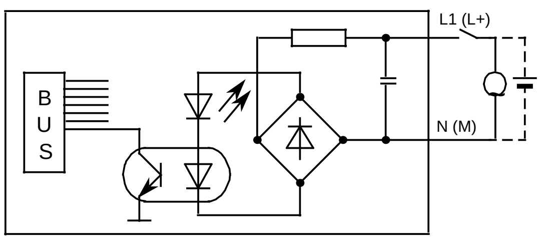
Number of inputs		**16**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**4**
Input voltage L1		
- rated value		**230 V AC**
- frequency		**47 to 63 Hz**
- for "0" signal		**0 to 70 V**
- for "1" signal		**170 to 264 V**
Input current at "1" signal		
- for AC, 50 Hz	**typ.**	**15 mA**
- for DC	**typ.**	**2.2 mA**
Response time		
- from "0" to "1"		**2 to 13 msec.**
- from "1" to "0"		**10 to 35 msec.**
Cable length		
- shielded		**1000 m (3281 ft.)**
- unshielded		**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage [1] (between groups)		**250 V**
- isolation group		**C**
- tested at		**1500 V AC**
Rated isolation voltage (L1 to ⏚)		**250 V**
- isolation group		**C**
- tested at		**1500 V AC**
Connection of 2-wire BERO proximity switches		**possible**
- quiescent current		**3 mA**
Current consumption		
- from 5 V (internal)		**5 mA**
Simultaneity factor (per group, for L1=264 V)		
- at 25°C		**100%**
- at 55°C		**75%**
Power losses of the module	**typ.**	**11 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

[1] **Connection of different phases is not permissible.**

Digital Input Module 16 x 230 V AC (6ES5 436-7LB11)



Terminal Assignment



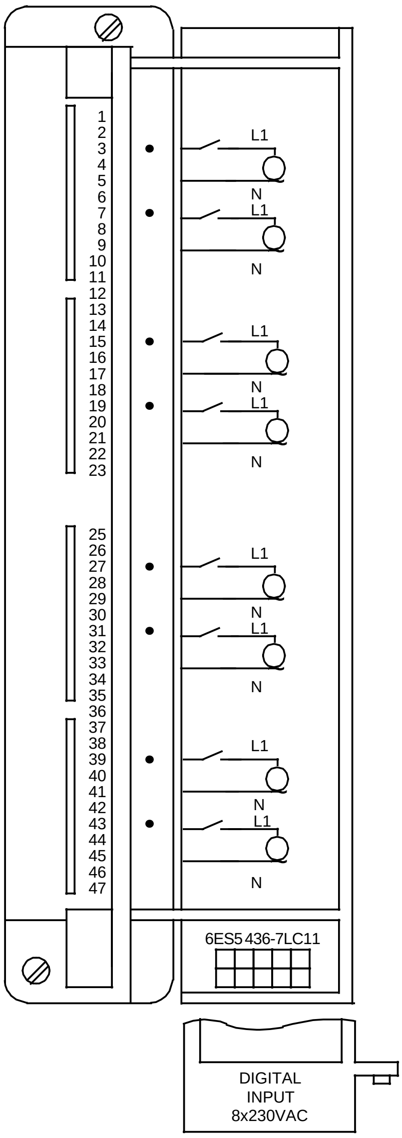
Simplified Schematic

Technical Specifications

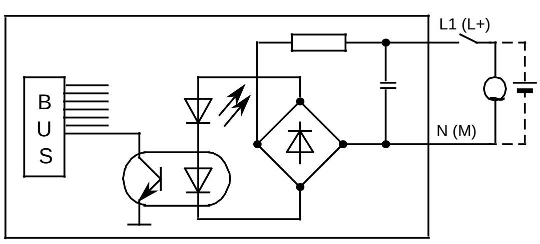
Number of inputs		**16**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**2**
Input voltage L1		
- rated value		**UC 230 V**
- frequency		**47 to 63 Hz**
- for ”0” signal		**0 to 70 V**
- for ”1” signal		**170 to 264 V**
Input current		
for ”1” signal		
- at AC, 50 Hz	**typ.**	**15 mA**
- at DC	**typ.**	**2.2 mA**
Response time		
- from ”0” to ”1”		**2 to 13 msec.**
- from ”1” to ”0”		**10 to 35 msec.**
Cable length		
- shielded		**1000 m (3281 ft.)**
- unshielded		**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage [1]		
(between groups)		**250 V**
- isolation group		**C**
- tested at		**1500 V**
Rated isolation voltage		
(L1 to ⏚)		**250 V**
- isolation group		**C**
- tested at		**1500 V**
Connection of 2-wire		
BERO proximity switches		**possible**
- quiescent current		**3 mA**
Current consumption		
- from 5 V (internal)		**5 mA**
Simultaneity factor		
(per group, for L1=264 V)		
- at 25°C		**100%**
- at 55°C		**75%**
Power losses of		
the module	**typ.**	**11 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

[1] **Connection of different phases is not permissible.**

Digital Input Module 8 x 230 V AC (6ES5 436-7LC11)



Terminal Assignment



Simplified Schematic

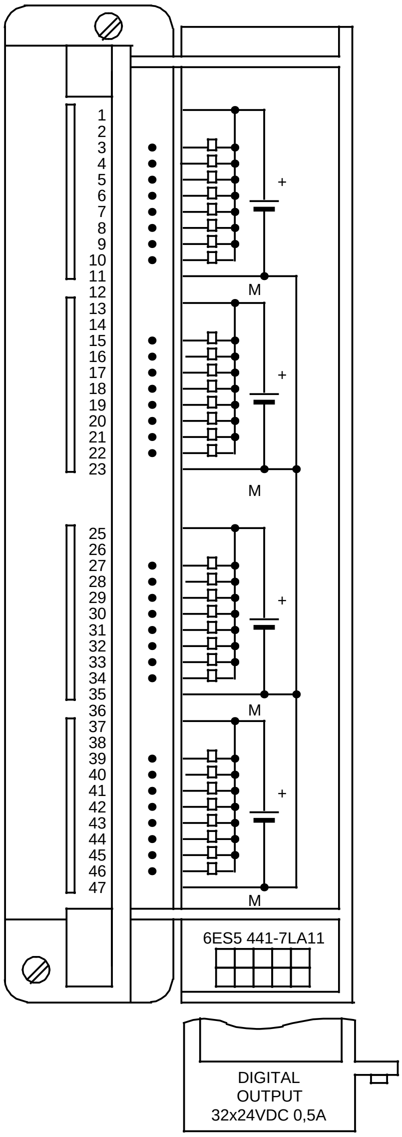
Technical Specifications

Number of inputs			**8**
Galvanically isolated			**yes (optocoupler)**
- in groups of			**1**
Input voltage L1			
- rated value			**230 V UC**
- frequency			**47 to 63 Hz**
- for "0" signal			**0 to 100 V**
- for "1" signal			**170 to 264 V**
Input current for			
"1" signal	**AC**	**typ.**	**16 mA**
	DC	**typ.**	**2.2 mA**
Response time			
- from "0" to "1"			**2 to 13 msec.**
- from "1" to "0"			**10 to 25 msec.**
Cable length			
- shielded			**1000 m (3281 ft.)**
- unshielded			**600 m (1969 ft.)**
Isolation rating			**according to VDE 0160**
Rated isolation voltage [1)]			
(between groups)			**250 V**
- isolation group			**C**
- tested at			**2700 V**
Rated isolation voltage			
(L1 to ⏚)			**250 V**
- isolation group			**C**
- tested at			**2700 V**
Connection of 2-wire			
BERO proximity switches			**possible**
- quiescent current			**5 mA**
Current consumption			
- from 5 V (internal)			**5 mA**
Power losses of			
the module		**typ.**	**5 W**
Weight		**approx.**	**0.7 kg (1.54 lb.)**

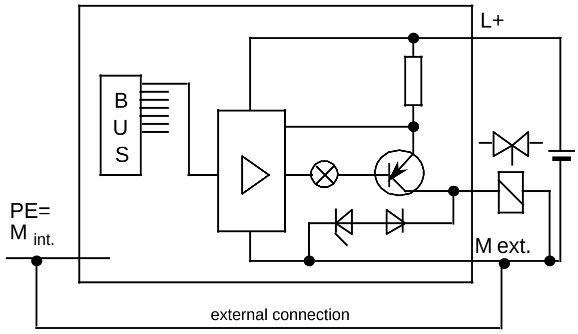
[1] **Connection of different phases is not permissible.**

17.2.5 Digital Output Modules

Digital Output Module 32 x 24 V DC; 0.5 A, Nonfloating (6ES5 441-7LA11)



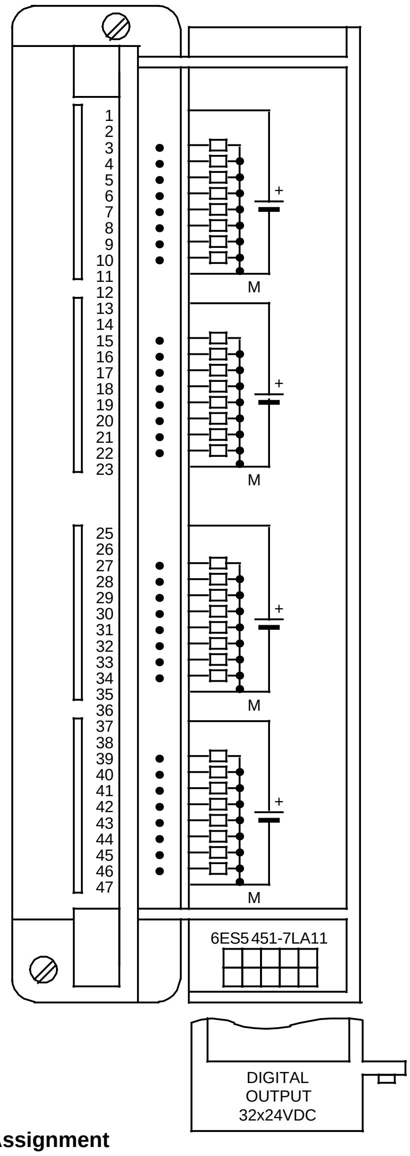
Terminal Assignment



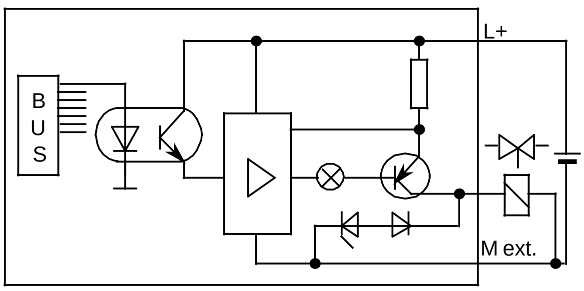
Simplified Schematic

Technical Specifications		
Number of outputs		32
Galvanically isolated		no
- in groups of		8
Load voltage L+		
- rated value		24 V DC
- permissible range		20 to 30 V
- surge voltage at t 0.5 sec.		35 V
Output voltage		
- for "1" signal	min.	L+- 2.5 V
Output current to "1" signal		
- rated value		0.5 A
- lamp load	max.	5 W
Leakage current to "0" signal	max.	1 mA
Parallel connection of outputs		not possible
Permissible total current of outputs		100% at 25°C and 50% at 55°C (related to the sum of the currents)
Short circuit protection		electronic
Limitation of the voltage induced on circuit interruption		- 15 V
Switching frequency		
- inductive load	max.	0.5 Hz
- resistive load	max.	100 Hz
Cable length		
- shielded	max.	1000 m (3281 ft.)
- unshielded	max.	600 m (1969 ft.)
Isolation rating		according to VDE 0160
Current consumption		
- from 5 V (internal)		10 mA
- from L+ (without load)		17 mA/per group
Power losses of the module	typ.	20 W
Weight	approx.	0.7 kg (1.54 lb.)

Digital Output Module 32 x 24 V DC; 0.5 A, Floating (6ES5 451-7LA11)



Terminal Assignment

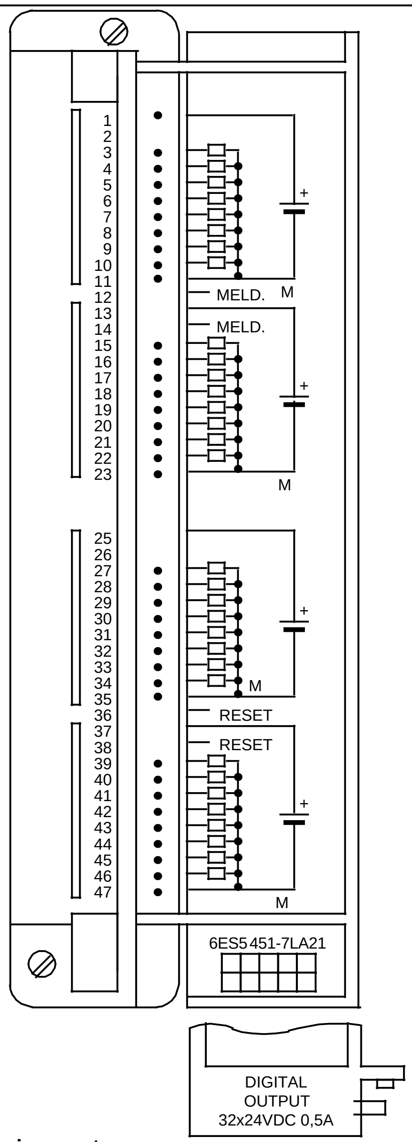


Simplified Schematic

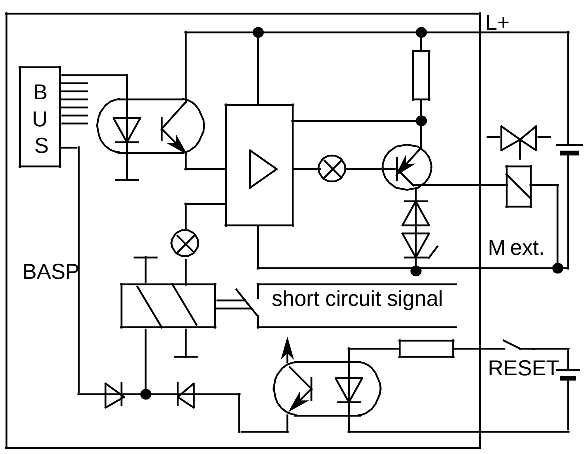
Technical Specifications

Number of outputs		**32**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**8**
Load voltage L+		
- rated value		**24 V DC**
- permissible range		**20 to 30 V**
- surge voltage at t 0.5 sec.		**35 V**
Output voltage		
- for "1" signal	**min.**	**L+ -2.5 V**
Output current for "1" signal		
- rated value		**0.5 A**
- lamp load	**max.**	**5 W**
Leakage current for "0" signal	**max.**	**1 mA**
Parallel connection of outputs		**not possible**
Permissible total current of outputs		**100% at 25°C and 50% at 55°C (related to the sum of the currents)**
Short circuit protection		**electronic**
Limitation of the voltage induced on circuit interruption		**- 15 V**
Switching frequency		
- inductive load	**max.**	**0.5 Hz**
- resistive load	**max.**	**100 Hz**
Cable length		
- shielded		**1000 m (3281 ft.)**
- unshielded		**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between groups)		**30 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Rated isolation voltage (L+ to ⏚)		**30 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Current consumption		
- from 5 V (internal)		**100 mA**
- from L+ (without load)		**17 mA / per group**
Power losses of the module	**typ.**	**20 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

Digital Output Module 32 x 24 V DC; 0.5 A, Floating (6ES5 451-7LA21)



Terminal Assignment



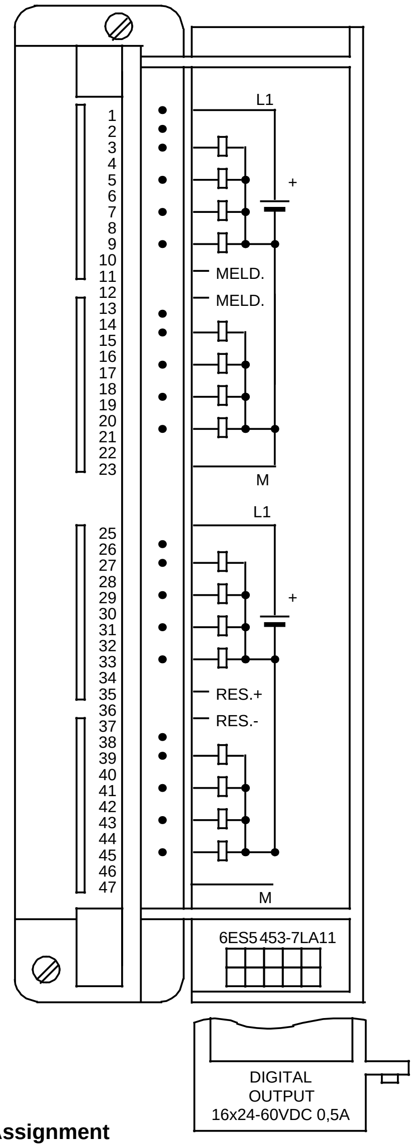
Simplified Schematic

Technical Specifications

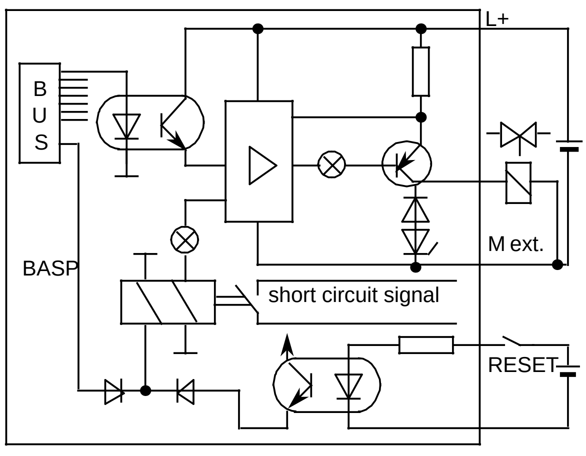
Number of outputs		**32**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**8**
Load voltage L+		
- rated value		**24 V DC**
- permissible ramge		**20 to 30 V**
- surge voltage at t 0.5 sec.		**35 V**
Output voltage		
- for "1" signal	**min.**	**L+ -2.5 V**
Output current for "1" signal		
- rated value		**0.5 A**
- lamp load	**max.**	**5 W**
Leakage current for "0" signal	**max.**	**1 mA**
Parallel connection of outputs		**not possible**
Permissible total current of outputs		**100% at 25°C and 50% at 55°C (related to the sum of the currents)**
Short circuit protection		**electronic**
Short circuit indicator		**red LED (per group)**
Short circuit signal (latching relay contact)		**latching[1]**
Type of relay		**V23042 B201 B101**
- load		**100V DC; 0.2 A**
- switching capacity		**20 W or 35 VA**
- reset input		**24V DC**
Limitation of the voltage induced on circuit interruption		**- 15 V**
Switching frequency		
- inductive load	**max.**	**0.5 Hz**
- resistive load	**max.**	**100 Hz**
Cable length		
- shielded		**1000 m (3281 ft.)**
- unshielded		**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between groups)		**30 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Rated isolation voltage (L+ to ⏚)		**30 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Current consumption		
- from 5 V (internal)		**100 mA**
- from L+ (without load)		**17 mA / per group**
Power losses of the module	**typ.**	**20 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

[1] Pickup delay: approx. 1 sec. after start of short circuit

Digital Output Module 16 x 24 to 60 V DC; 0.5 A, Floating (6ES5 453-7LA11)



Terminal Assignment



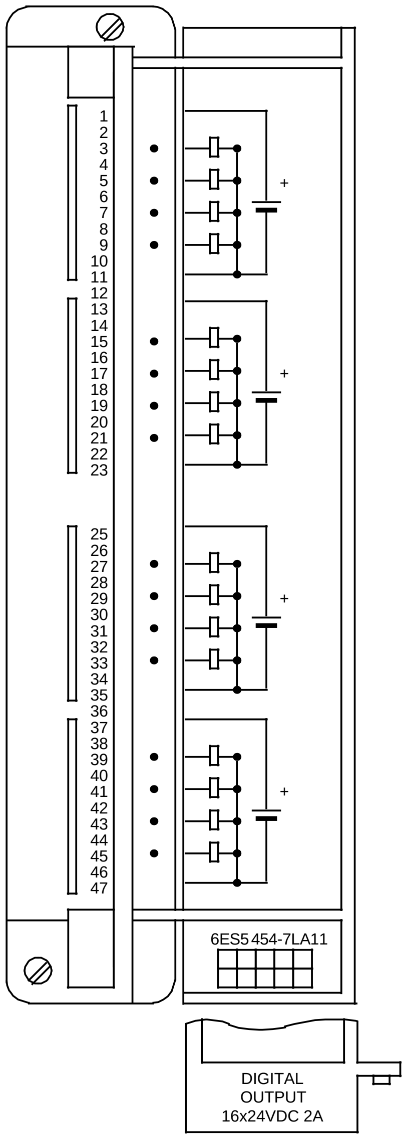
Simplified Schematic

Technical Specifications

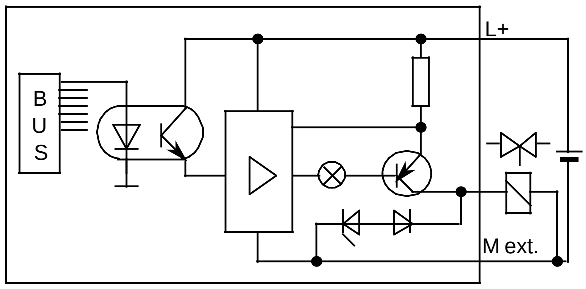
Number of outputs		**16**
Galvanic isolation		**yes (optocoupler)**
- in groups of		**8**
Load voltage L+		
- rated value		**24 to 60 V DC**
- permissible range		**20 to 75 V**
- surge voltage at t 0.5 sec.		**87 V**
Ouput voltage		
- for "1" signal	**max.**	**L+ -2.5 V**
Output current for "1" signal		
- rated value		**0.5 A**
- lamp load	**max.**	**5 W**
Leakage current for "0" signal	**max.**	**1 mA**
Parallel connection of outputs		**not possible**
Permissible total current of outputs, per group		**100%**
Short circuit protection		**electronic**
Short circuit indicator		**red LED (each group)**
Short circuit signal (latching relay contact)		**latching [1]**
Type of relay		**V23042 B201 B101**
- load		**100 V DC; 0.2 A**
- switching capacity		**20 W or 35 VA**
- reset input		**24 V DC**
Limitation of the voltage induced on circuit interruption		**- 30 V**
Switching frequency		
- inductive load	**max.**	**0.5 Hz**
- resistive load	**max.**	**100 Hz**
Cable length		
- shielded	**max.**	**1000 m (3281 ft.)**
- unshielded	**max.**	**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between groups)		**75 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Rated isolation voltage (L+ to ⏚)		**75 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Current consumption		
- from +5 V (internal)		**50 mA**
- from L+ (without load)		**50 mA / per group**
Power losses of the module	**typ.**	**14 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

[1] **Pickup delay: approx. 1 sec. after start of short circuit**

Digital Output Module 16 x 24 V DC; 2 A, Floating (6ES5 454-7LA11)



Terminal Assignment

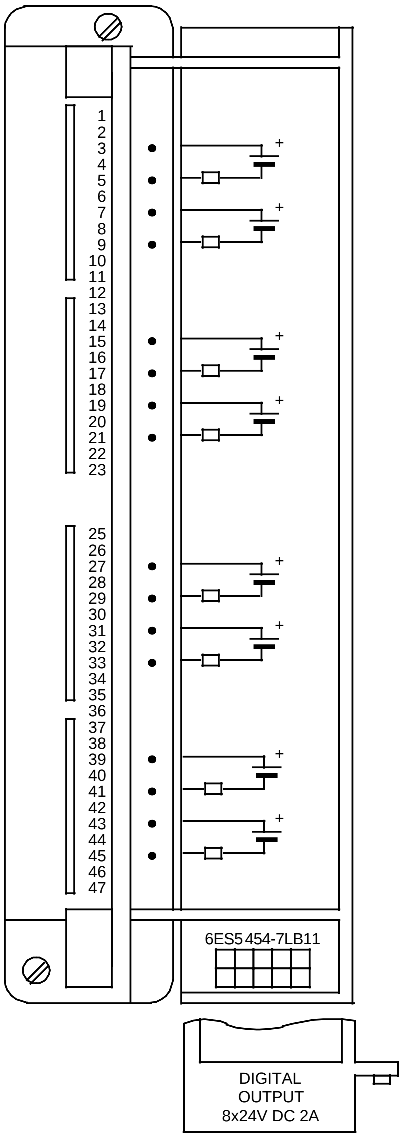


Simplified Schematic

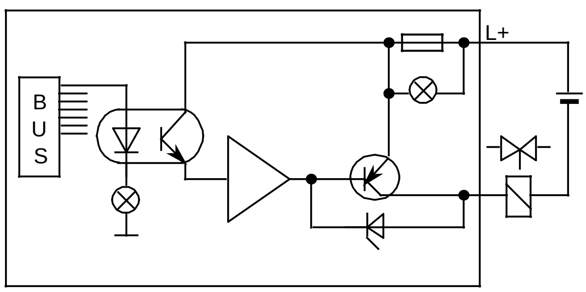
Technical Specifications

Number of outputs		**16**
Galvanic isolation		**yes (optocoupler)**
- in groups of		**4**
Load voltage L+		
- rated value		**24 V DC**
- permissible range		**20 to 30 V**
- surge voltage at t 0.5 sec.		**35 V**
Output voltage		
- for "1" signal	**min.**	**L+ - 3 V**
Output current for "1" signal		
- rated value		**2 A**
- lamp load	**max.**	**10 W**
Leakage current for "0" signal	**max.**	**1 mA**
Parallel connection of outputs		**not possible**
Permissible total current of outputs, per group		**50% (related to the sum of the currents of a group)**
Short circuit protection		**electronic**
Limitation of the voltage induced on circuit interruption		**- 15 V**
Switching frequency		
- inductive load	**max.**	**0.27 Hz**
- resistive load	**max.**	**100 Hz**
Cable length		
- shielded	**max.**	**1000 m (3281 ft.)**
- unshielded	**max.**	**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between groups)		**30 V DC**
- isolation group		**C**
- tested		**500 V AC**
Rated isolation voltage (L+ to ⏚)		**30 V DC**
- isolation group		**C**
- tested with		**500 V AC**
Current consumption		
- from 5 V (internal)		**50 mA**
- from L+ (without load)		**8.5 mA / per group**
Power losses of the module	**typ.**	**20 W**
Weight	**approx.**	**1.1 kg (2.43 lb.)**

Digital Output Module 8 x 24 V DC; 2 A, Floating (6ES5 454-7LB11)



Terminal Assignment

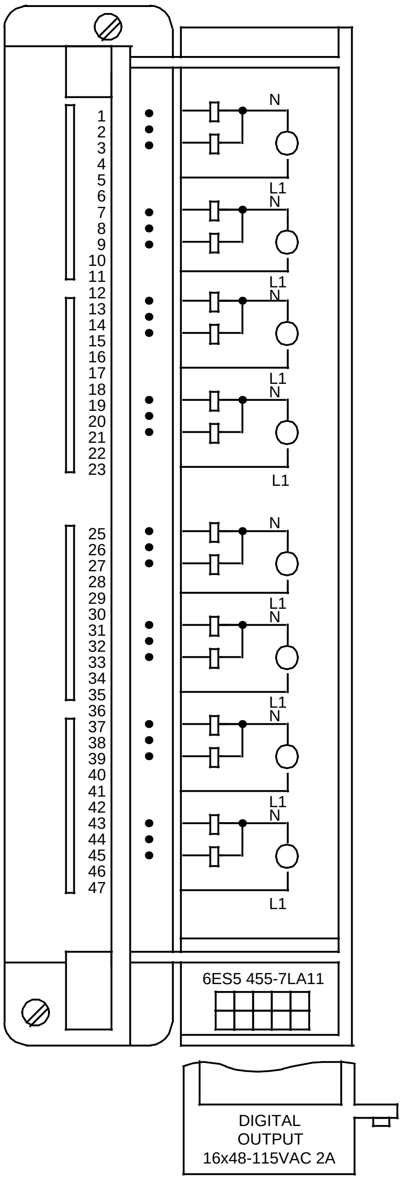


Simplified Schematic

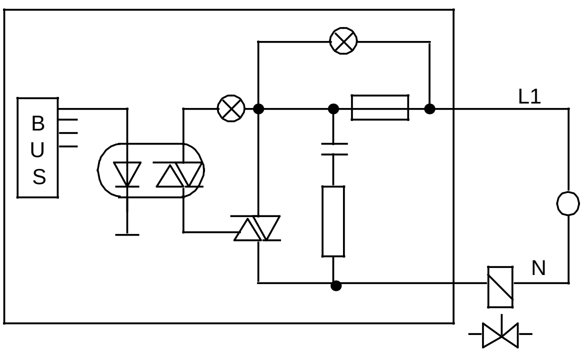
Technical Specifications

Number of outputs		**8**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**1**
Load voltage L+		
- rated value		**24 V DC**
- permissible range		**20 to 30 V**
- surge voltage at t 0.5 sec.		**35 V**
Output voltage		
- for "1" signal	**min.**	**L+- 3 V**
Output current		
- rated value		**2 A**
- lamp load	**max.**	**10 W**
Leakage current for "0" signal	**maximum**	**1 mA**
Parallel connection of outputs		**possible**
- maximum current		**1 x rated current**
Permissible total current of outputs, per group		**100% at 25°C and 50% at 55°C (related to the sum of the currents of a group)**
Short circuit protection (for each group)		**with F 2.5 A fuse (e.g. Wickmann 19340)**
Limitation of the voltage induced on circuit interruption	**typ.**	**- 21 V**
Switching frequency		
- inductive load	**maximum**	**0.27 Hz**
- resistive load	**maximum**	**100 Hz**
Cable length		
- shielded	**maximum**	**1000 m (3281 ft.)**
- unshielded	**maximum**	**600 m (1969 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between groups)		**30 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Rated isolation voltage (L+ to ⏚)		**30 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Current consumption		
- from + 5 V (internal)	**maximum**	**50 mA**
Power losses of the module	**typ.**	**20 W**
Weight	**approx.**	**0.8 kg (1.76 lb.)**

Digital Output Module 16 x 48 to 115 V AC;2 A, Floating (6ES5 455-7LA11)



Terminal Assignment

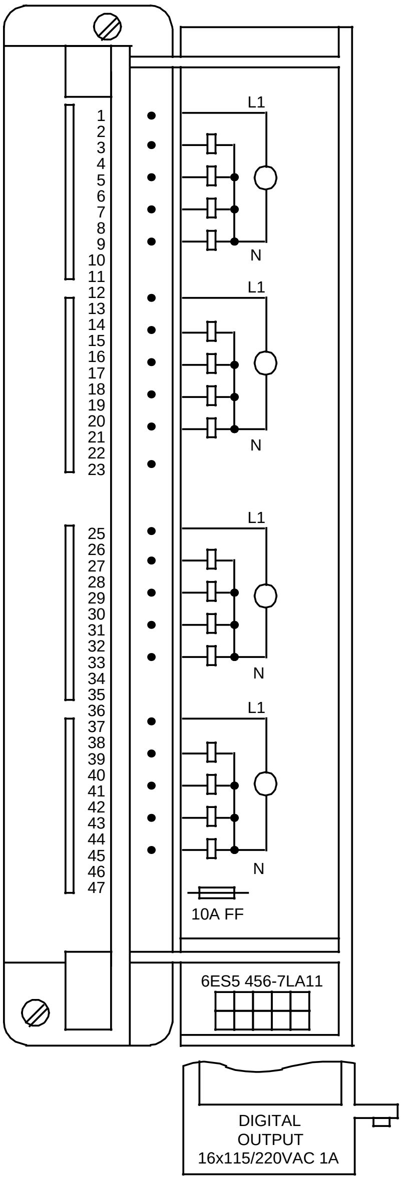


Simplified Schematic

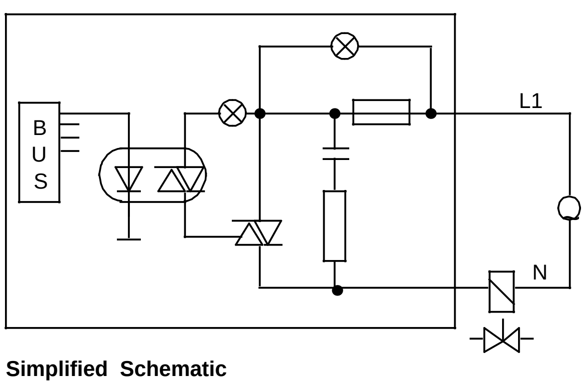
Technical Specifications

Number of outputs		**16**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**2**
Load voltage L1		
- rated value		**48 / 115 V AC**
- frequency		**47 to 63 Hz**
- permissible range		**40 to 140 V**
Output voltage		
- for "1" signal	**min.**	**L1 - 7 V**
Output current for "1" signal		
- rated value		**2 A / per group**
- permissible range		**40 mA to 2 A**
- lamp load	**max.**	**50 / 100 W / per group**
Leakage current for "0" signal	**max.**	**1/3 mA**
Parallel connection of outputs		**not possible**
Making capacity		**depends on the size of the fuse**
Permissible total current of outputs		**100%**
Short circuit protection (for each group)		**with Gould GAB4 fuse or Bussmann ABC4**
Fault indication (red LED for each group)		**defective fuse**
Switching frequency	**max.**	**10 Hz**
Cable length		
- shielded	**max.**	**1000 m (3281 ft.)**
- unshielded	**max.**	**300 m (984 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between groups)		**250 V AC**
- isolation group		**C**
- tested at		**1500 V AC**
Rated isolation voltage (L1 to ⏚)		**250 V AC**
- isolation group		**C**
- tested at		**1500 V AC**
Current consumption		
- from 5 V (internal)	**max.**	**175 mA**
Power losses of the module	**typ.**	**16 W**
Weight	**approx.**	**1.1 kg (2.43 lb.)**

Digital Output Module 16 x 115 to 230 V AC; 1 A, Floating (6ES5 456-7LA11)



Terminal Assignment



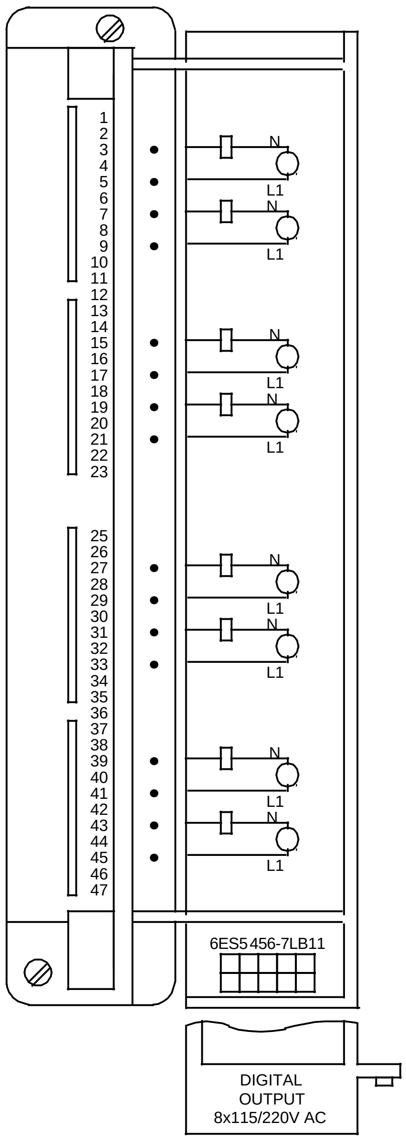
Simplified Schematic

Technical Specifications

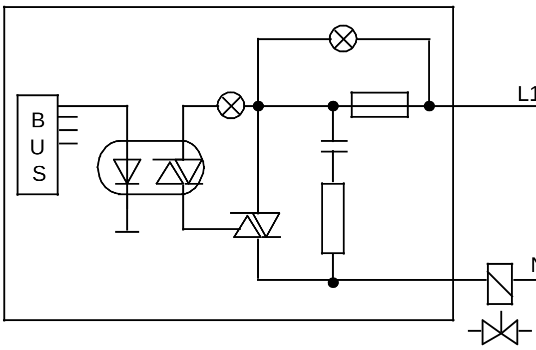
Number of outputs		**16**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**4**
Load voltage L1		
- rated value		**115 / 230 V AC**
- frequency		**47 to 63 Hz**
- permissible range		**89 to 264 V**
Output voltage		
- for "1" signal	**min.**	**L1 - 7 V**
Output current for "1" signal		
- rated value		**1 A**
- permissible range		**40 mA to 1 A**
- lamp load		**25 / 50 W**
Leakage current for "0" signal	**typ.**	**3 / 5 mA [1]**
Parallel connection of outputs		**not possible**
Making capacity		**depends on the size of the fuse**
Permissible total current of outputs		**100%**
Short circuit protection (for each group)		**fuse (10 A FF) (e.g. Wickmann 19231)**
Fault indication (red LED for each group)		**defective fuse**
Switching frequency	**max.**	**10 Hz**
Cable length		
- shielded		**1000 m (3281 ft.)**
- unshielded		**300 m (984 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between groups)		**250 V AC**
- isolation groups		**C**
- tested at		**1500 V AC**
Rated isolation voltage (L1 to ⏚)		**250 V AC**
- isolation groups		**C**
- tested at		**1500 V AC**
Current consumption		
- from 5 V (internal)	**max.**	**70 mA**
Power losses of the module	**typ.**	**16 W**
Weight	**approx.**	**1.1 kg (2.43 lb.)**

[1] **Please note the max. dropout capacity of the connected loads (contactors of the 3TJ1 to 3TJ5 series and contactors of the SIMICOMT series cannot be triggered)!**

Digital Output Module 8 x 115 to 230 V AC; 2 A (6ES5 456-7LB11)



Terminal Assignment



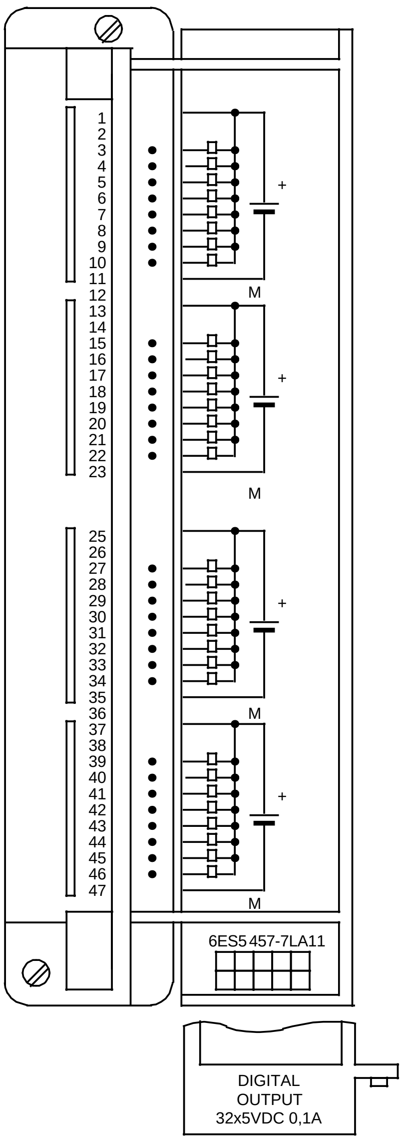
Simplified Schematic

Technical Specifications

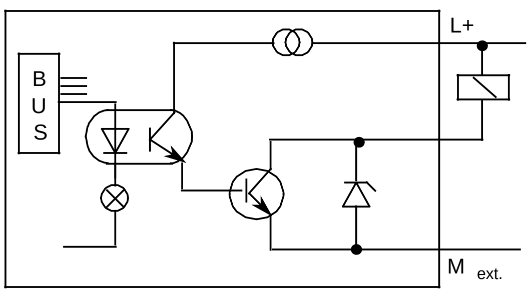
Number of outputs		**8**
Galvanically isolated		**yes (optocoupler)**
- in groups of		**1**
Load voltage L1		
- rated value		**115 / 230 V AC**
- frequency		**47 to 63 Hz**
- permissible range		**89 to 264 V**
Output voltage		
- for "1" signal	**min.**	**L1 - 7 V**
Output current for "1" signal		
- rated value		**1 A**
- permissible range		**40 mA to 2 A**
- lamp load		**25 / 50 W**
Leakage current for "0" signal	**typ.**	**3 / 5 mA [1]**
Parallel connection of outputs		**not possible**
Making capacity		**depends on the size of the fuse**
Permissible total current of outputs		**100%**
Short circuit protection (for each group)		**fuse (6.3 A FF) (e.g. Wickmann 19231)**
Fault indication (red LED for each group)		**defective fuse**
Switching frequency	**max.**	**10 Hz**
Cable length		
- shielded		**1000 m (3281 ft.)**
- unshielded		**300 m (984 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between groups)		**250 V AC**
- isolation groups		**C**
- tested at		**2700 V AC**
Rated isolation voltage (L1 to ⏚)		**250 V AC**
- isolation groups		**C**
- tested at		**2700 V AC**
Current consumption		
- from 5 V (internal)	**max.**	**35 mA**
Power losses of the module	**typ.**	**16 W**
Weight	**approx.**	**1.1 kg (2.43 lb.)**

1 Please note the max. dropout capacity of the connected loads (contactors of the 3TJ1 to 3TJ5 series and contactors of the SIMICOMT series cannot be triggered)!

Digital Output Module 32 x 5 to 24 V DC; 0.1 A, Floating (6ES5 457-7LA11)



Terminal Assignment



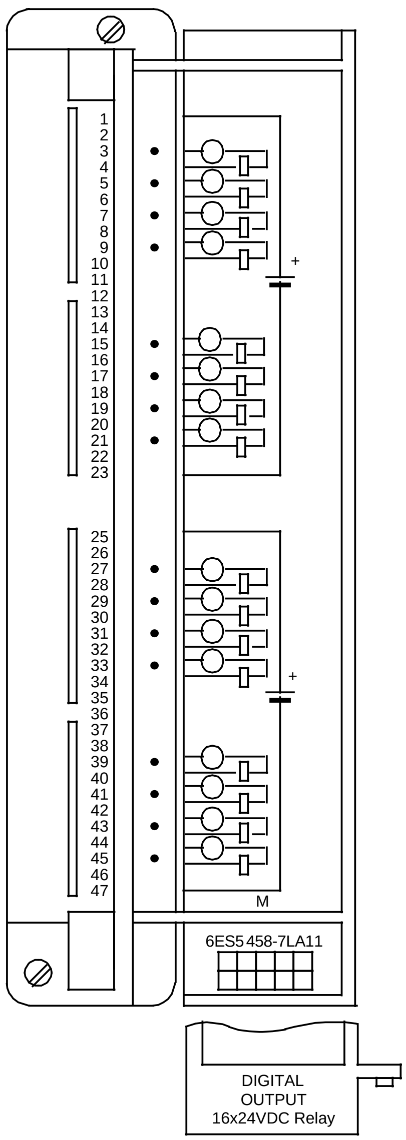
Simplified Schematic

Technical Specifications

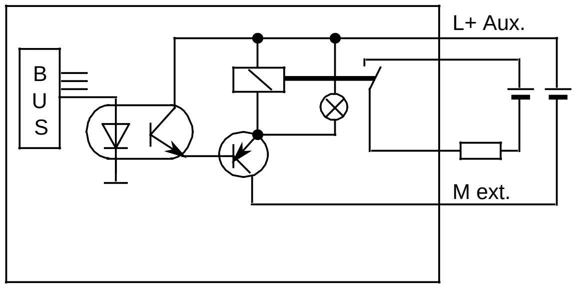
Number of outputs		**32**
Galvanic isolation		**yes (optocoupler)**
- in groups of		**8**
Load voltage L1		
- rated value		**5 / 24 V DC**
- permissible range		**4.75 to 30 V**
Output voltage [1]		**TTL compatible**
Output current for "1" signal	**max.**	**100 mA**
Parallel connection of outputs		**possible**
Permissible total current of outputs		**100%**
Short circuit protection		**no**
Limitation of the voltage induced on circuit interruption (for V_p=30 V)		**- 10 V**
Switching frequency		
- inductive load		**2 Hz**
- resistive load		**10 Hz**
Cable length		
- shielded		**1000 m (3281 ft.)**
- unshielded		**300 m (984 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between groups)		**30 V**
- isolation group		**C**
- tested at		**500 V**
Rated isolation voltage (5 V to ⏚)		**30 V**
- isolation group		**C**
- tested at		**500 V**
Current consumption		
- from 5 V (internal)	**max.**	**100 mA**
- from L1 (without load)	**max.**	**4 mA**
Power losses of the module	**typ.**	**6 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

[1] **Transistor with open collector - current sinking**

Relay Output Module for Measuring Currents 16 x 24 V DC (6ES5 458-7LA11)



Terminal Assignment

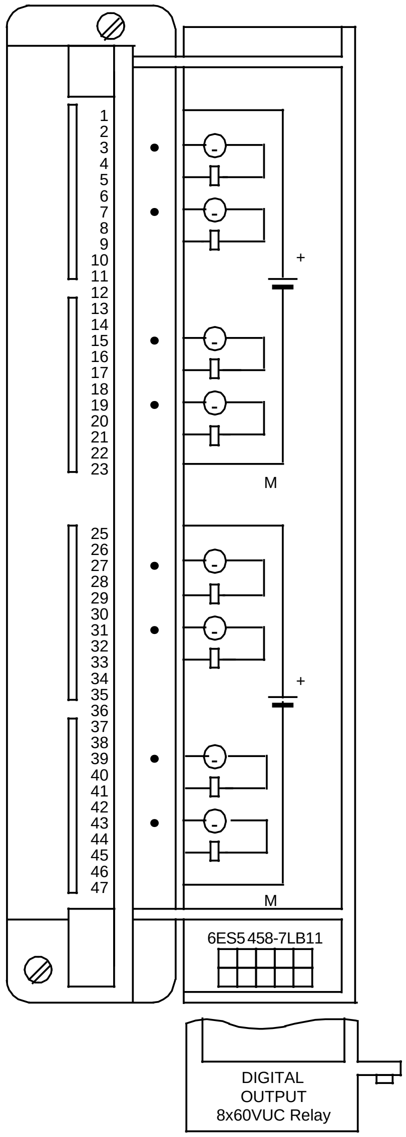


Simplified Schematic

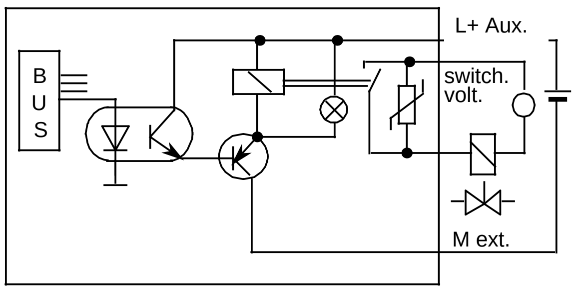
Technical Specifications

Number of outputs		**16**
- contact bridge		**no**
- galvanic isolation		**yes**
- in groups of		**1**
- relay type		**3700-2501-011 (Günther)**
Limiting continuous current per contact		**0.5 A**
Parallel connection of outputs		**possible**
Permissible total current of outputs		**100%**
Switching frequency		
- resistive load	**max.**	**60 Hz**
- inductive load		**not permissible**
Switching voltage	**max.**	**30 V DC**
Switching capacity of the contacts		
- resistive load		**10 W at 0.5 A;**
- inductive load		**not permissible**
Number of contact operating cycles according to VDE 0660, Part 200		
- DC 11		**1 x 10^9**
Supply voltage L+ (for relay)		
- rated value		**24 V DC**
- permissible range		**20 to 30 V**
- surge voltage at t<0.5 sec.		**35 V**
- ripple	**max.**	**3.6 V**
Cable length		
- shielded		**1000 m (3281 ft.)**
- unshielded		**300 m (984 ft.)**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between contacts)		**30 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Rated isolation voltage (contacts to L+)		**30 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Rated isolation voltage (contacts to ⏚)		**30 V DC**
- isolation group		**C**
- tested at		**500 V AC**
Current consumption		
- from 5 V (internal)	**max.**	**50 mA**
- fromL+ (for relay)		**240 mA**
Power losses of the module	**typ.**	**5 W**
Weight	**approx.**	**0.8 kg (1.76 lb.)**

Relay Output Module 8 x 30 V DC / 230 V AC (6ES5 458-7LB11)



Terminal Assignment

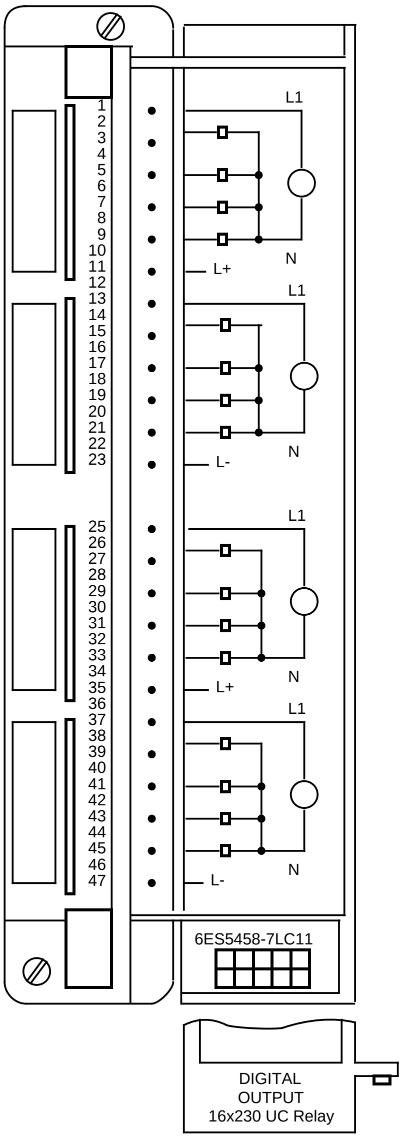


Simplified Schematic

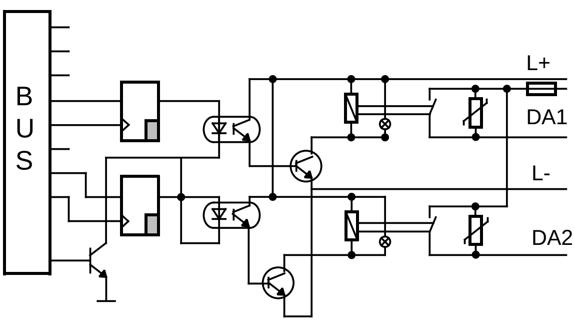
Technical Specifications

Number of outputs		**8**
- contact bridge		**varistor SIOV-S07-K275**
- galvanic isolation		**yes**
- in groups of		**1**
- relay type		**V23157-006-A402 (Siemens)**
Limiting continuous current per contact		**5 A**
Parallel connection of outputs		**possible**
Permissible total current of outputs		**100%**
Switching capacity of the contacts		
- resistive load		**5 A at 250 V AC**
		2.5 A at 30 V DC
- inductive load		**1.5 A at 250 V AC**
		0.5 A at 30 V DC
Switching frequency	**max.**	**10 Hz**
Number of contact opera-ting cycles according to VDE 0660, Part 200		
- AC 11		**1.5 x 10^6**
- DC 11		**0.5 x 10^6**
Supply voltage L+ (for relay)		
- rated value		**24 V DC**
- permissible range		**20 to 30 V**
- surge voltage at t	**0.5 sec.**	**35 V**
- ripple	**max.**	**3.6 V**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (between contacts)		**250 V AC**
- isolation group		**C**
- tested at		**1500 V AC**
Rated isolation voltage (between contacts L+)		**250 V AC**
- isolation group		**C**
- tested at		**1500 V AC**
Rated isolation voltage (between contacts ⏚)		**250 V AC**
- isolation group		**C**
- tested at		**1500 V AC**
Current consumption		
- from 5 V (internal)	**max.**	**50 mA**
- from L+ (for relay)		**200 mA**
Power losses of the module	**typ.**	**4 W**
Weight	**approx.**	**0.8 kg (1.76 lb.)**

Relay Output Module 16 x 230 V UC (6ES5 458-7LC11)



Terminal Assignment

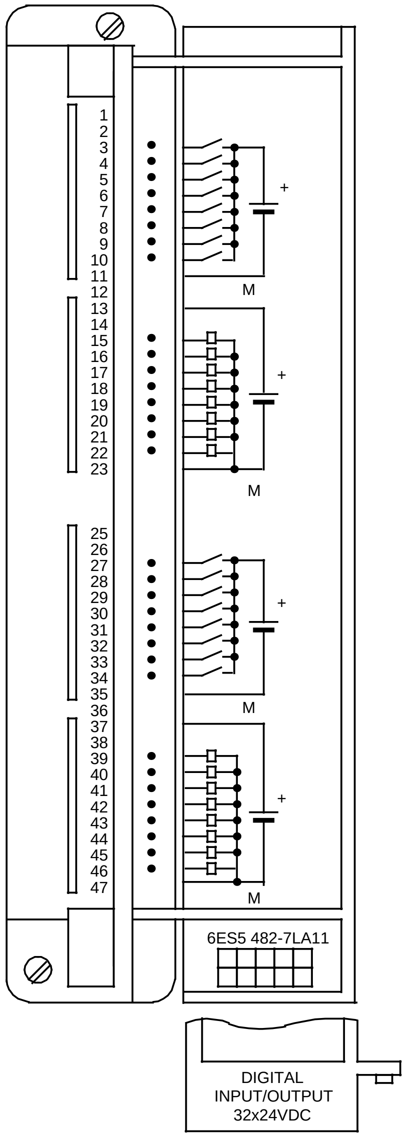


Technical Specifications

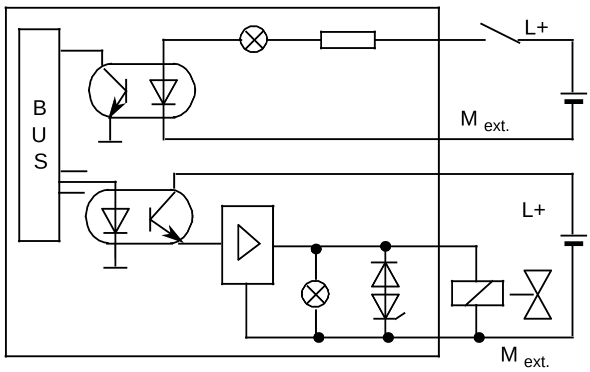
Number of outputs	**16**
- contact bridge	**Varistor SIOV-S07-K275**
- galvanic isolation	**yes**
- in groups of	**4 outputs**
- relay type	**MSR V23061-B1007-A401**
Switching capacity of the contacts	
- resistive load	**5.0 A at 250 V AC** **5.0 A at 30 V DC** **0.4 A at 110 V DC**
- inductive load	**1.5 A at 250 V AC** **1.0 A at 30 V DC** **0.08 A at 110 V DC**
Switching frequency	
- resistive load	**max. 10 Hz**
- inductive load	**2 Hz**
Permiss. current load on relay contacts	
- one relay per root	**5 A/contact**
- two relays " "	**4 A/contact**
- three " " "	**2.5 A/contact**
- four " " "	**2 A/contact**
Number of contact operating cycles according to VDE 0660, Part 200	
- 11 DC	**1.5 x 10^6 (AC)** **0.5 x 10^6 (DC)**
Supply voltage L+/L- (for relay)	
- rated value	**24 V DC**
- permissible range	**20 to 30 V**
- surge voltage at t<0.5 sec.	**35 V**
- ripple max.	**3.6 V**
Cable length	
- shielded	**1000 m (3281 ft.)**
- unshielded	**300 m (984 ft.)**
Isolation rating	**according to VDE 0160**
Rated isolation voltage (contacts to L+)	**250 V AC**
- isolation group	**C**
- tested at	**1500 V AC**
Rated isolation voltage (contacts to M)	**250 V AC**
- isolation group	**C**
- tested at	**1500 V AC**
Current consumption	
- from 5 V (internal)	**max. 50 mA(+4 mA per active channel)**
- fromL+ (for relay)	**16 mA per active channel**
Power losses of the module	**typ. 6.5 W**
Weight	**approx. 0.8 kg (1.76 lb.)**

17.2.6 Digital Input / Output Module

Digital Input / Output Module 32 x 24 V DC; 0.5 A (6ES5 482-7LA11)



Terminal Assignment



Simplified Schematic

Technical Specifications

Number of inputs		**16**
Galvanic isolation		**yes (optocoupler)**
- in groups of		**8**
Input voltage		
- rated value		**24 V DC**

The technical specifications for the inputs correspond to those for the 6ES5 430-7LA11 digital input module.

Number of outputs		**16**
Galvanic isolation		**yes (optocoupler)**
- in groups of		**8**
Output current for "1" signal		
- rated value		**0.5 A**

The technical specifications for the outputs correspond to those for the 6ES5 451-7LA11 digital output module.

Outputs	**0 to 3 and 4 to 7** **8 to 11 and 12 to 15**	**can be connected in parallel**
Parallel current		**0.8 x I_{rated}**
Permissible current of outputs		**100% at 35°C and 50% at 55°C (related to the sum of the currents of a group)**
Current consumption		
- from 5 V (internal)	**maximum**	**50 mA**
Power loss	**typically**	**18 W**
Weight	**approx.**	**0.7 kg (1.54 lb.)**

The inputs and outputs are referenced under the same address (e.g. I 0.0 to I 1.7 and Q 0.0 to Q 1.7).

17.2.7 Analog Input Modules

Analog Input Module 8 x I / V / PT 100, Floating (6ES5 460-7LA11)

Pin Assignment for the Front Connector

a	b
1	L+=24V
2	
3	M0+
4	
5	M0 -
6	
7	M1+
8	
9	M1 -
10	
11	S+
12	
13	
14	
15	M2+
16	
17	M2 -
18	
19	M3+
20	
21	M3 -
22	
23	KOMP+
25	KOMP -
26	
27	M4+
28	
29	M4 -
30	
31	M5+
32	
33	M5 -
34	
35	S -
36	
37	
38	
39	M6+
40	
41	M6 -
42	
43	M7+
44	
45	M7 -
46	
47	L -

a = Pin no.
b = Assignment

Analog Input Module 8 x I / V / PT 100, Floating (6ES5 460-7LA11)

Technical Specifications

Number of inputs		**8 voltage/current inputs or 8 inputs for PT 100**
Galvanic isolation		**yes (not for PT 100)**
Input ranges (rated values)		**±50 mV; ±500 mV; PT 100; ±1 V; ±5 V; ±10 V; ±20 mA; +4 to 20 mA (can be selected for four channels at a time using range cards)**
Input resistance		**± 50 mV: 10 M ± 500 mV: 10 M PT 100: 10 M ± 1 V: 90 k ; 2 ‰ ± 5 V: 50 k ; 2 ‰ ± 10 V: 50 k ; 2 ‰ ± 20 mA: 25 ; 1 ‰ ± 4...20 mA:31.25 ; 1 ‰**
Type of connection for sensors		**two-wire connection; four-wire connection for PT 100**
Digital representation of the input signal		**12 bits plus sign or 13 bits two's complement (2048 units= rated value)**
Measuring principle		**integrating**
Conversion principle		**voltage-time conversion (dual-slope)**
Integration time (adjustable for opt. noise suppression)		**20 msec. at 50 Hz 16.6 msec. at 60 Hz**
Coding time (Single coding for 2048 units)	**max.**	**60 msec. at 50 Hz 50 msec. at 60 Hz**
Scan time for - 8 inputs		**0.48 sec. at 50 Hz**
Permissible voltage between inputs and between inputs and central grounding point (destruction limit)	**max.**	**18 V or 75 V for max. 1 msec. and a duty factor of 1 : 20**
Permissible voltage between the reference potential of a nonfloating sensor and the central grounding point	**max.**	**75 V DC / 60 V AC**

Error indication for - range violation - wirebreak in the sensor line		**yes (exceeding 4095 units) can be specified in the range 50 mV, 500 mV and PT 100 (only measuring circuits)**
Interference suppression for f=n x (50 / 60 Hz±1%) n=1, 2, to		
- common-mode noise (V_P<1 V)	**min.**	**100 dB**
- series-mode noise (peak noise value < rated value of the range)	**min.**	**40 dB**
Basic errors		**± 50 mV : ± 2 ‰ ± 500 mV : ± 1.5 ‰ PT 100 : ± 2 ‰ ± 1 V : ± 3.5 ‰ ± 5 V : ± 3.5 ‰ ± 10 V : ± 3.5 ‰ ± 20 mA : ± 2.5 ‰ +4 to 20 mA : ± 2.5 ‰**
Operational errors (0°C to 55°C)		**± 50 mV : ± 5 ‰ ± 500 mV : ± 4.5 ‰ PT 100 : ± 5 ‰ ± 1 V : ± 7.7 ‰ ± 5 V : ± 7.7 ‰ ± 10 V : ± 7.7 ‰ ± 20 mA : ± 6.7 ‰ + 4 to 20 mA : ± 6.7 ‰**
Cable length - shielded	**max.**	**200 m (656 ft.); 50 m (164 ft.) at± 50 mV**
Front connector		**46 pins**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (channel to channel) - tested at		**500 V**
Rated isolation voltage (channel to ⏚) - tested at		**500 V**
Current consumption - rated value - ripple Vpp - permissible range (including ripple)		**24 V DC 3.6 V 20 to 30 V**
Current consumption - from 5 V (internal) - from 24 V (external)	**typ. typ.**	**0.15 A 0.1 A**
Power losses of the module	**typ.**	**3 W**
Weight	**approx.**	**0.4 kg (0.88 lb.)**

Analog Input Module 8 x I / V / PT 100, Floating (6ES5 460-7LA12)

Pin Assignments for the Front Connector

a	b
1	L+=24V
2	
3	M0+
4	
5	M0 -
6	
7	M1+
8	
9	M1 -
10	
11	S+
12	
13	
14	
15	M2+
16	
17	M2 -
18	
19	M3+
20	
21	M3 -
22	
23	KOMP+
25	KOMP -
26 ⚠	
27	M4+
28	
29	M4 -
30	
31	M5+
32	
33	M5 -
34	
35	S -
36	
37	
38	
39	M6+
40	
41	M6 -
42	
43	M7+
44	
45	M7 -
46	
47	L -

a = Pin no.
b = Assignment

Analog Input Module 8 x I / V / PT 100, Floating (6ES5 460-7LA12)

Technical Specifications

Number of inputs		8 voltage/current inputs or 8 inputs for PT 100
Galvanic isolation		yes (not for PT 100)
Input ranges (rated values)		±50 mV; ±500 mV; PT 100; ±1 V; ±5 V; ±10 V; ±20 mA; +4 to 20 mA (can be selected for four channels at a time using range cards)
Input resistance		± 50 mV: 10 M ± 500 mV: 10 M PT 100: 10 M ± 1 V: 90 k ; 2 ‰ ± 5 V: 50 k ; 2 ‰ ± 10 V: 50 k ; 2 ‰ ± 20 mA: 25 ; 1 ‰ ± 4 to 20 mA:31.25 ; 1 ‰
Type of connection for sensors		two-wire connection; four-wire connection for PT 100
Digital representation of the input signal		12 bits plus sign or 13 bits two's complement (2048 units = rated value)
Measuring principle		integrating
Conversion principle		voltage-time conversion (dual-slope)
Integration time (adjustable for opt. noise suppression)		20 msec. at 50 Hz 16.6 msec. at 60 Hz
Coding time (Single coding for 2048 units)	max.	60 msec. at 50 Hz 50 msec. at 60 Hz
Scan time for - 8 inputs		0.48 sec. at 50 Hz
Permissible voltage between inputs and between inputs and central grounding point (destruction limit)	max.	18 V or 75 V for max. 1 msec. and a duty factor 1 : 20
Permissible voltage between the reference potential of a nonfloating sensor and the central grounding point	max.	75 V DC / 60 V AC
Error indication for - range violation		yes (exceeding 4095 units)
- wirebreak in the sensor line		can be specified in the range 50 mV, 500 mV and PT 100 (only measuring circuits)

Wire-break test current (disconnectable)		configurable
Noise suppression for f=n x (50 / 60 Hz±1%) n=1, 2, to - common-mode noise (V_P<1 V)	min.	100 dB
- series-mode noise (peak noise value < rated value of the range)	min.	40 dB
Basic errors		± 50 mV : ± 2 ‰ ± 500 mV : ± 1.5 ‰ PT 100 : ± 2 ‰ ± 1 V : ± 3.5 ‰ ± 5 V : ± 3.5 ‰ ± 10 V : ± 3.5 ‰ ± 20 mA : ± 2.5 ‰ + 4 to 20 mA : ± 2.5 ‰
Operational errors (0°C to 55°C)		± 50 mV : ± 5 ‰ ± 500 mV : ± 4.5 ‰ PT 100 : ± 5 ‰ ± 1 V : ± 7.7 ‰ ± 5 V : ± 7.7 ‰ ± 10 V : ± 7.7 ‰ ± 20 mA : ± 6.7 ‰ + 4 to 20 mA : ± 6.7 ‰
Cable length - shielded	max.	200 m (656 ft.); 50 m for± 50 mV
Front connector		46 pins
Isolation rating		according to VDE 0160
Rated isolation voltage (channel to channel) - tested at		500 V
Rated isolation voltage (channel to ⏚) - tested at		500 V
Current consumption - rated value - ripple Vpp - permissible range (including ripple)		24 V DC 3.6 V 20 to 30 V
Current consumption - from 5 V (internal) - from 24 V (external)	typ. typ.	0.15 A 0.1 A
Power losses of the module	typ.	3 W
Weight	approx.	0.4 kg (0.88 lb.)

Analog Input Module 16 x I / V or 8 x PT 100, Nonfloating (6ES5 465-7LA11)

Pin assignment for the Front Connector

a	b
1	L+=24V
2	
3	M0+
4	M0 -
5	M1+
6	M1-
7	M2+
8	M2 -
9	M3+
10	M3 -
11	
12	
13	**M_{ext} ***
14	
15	M4+
16	M4 -
17	M5+
18	M5 -
19	M6+
20	M6 -
21	M7+
22	M7 -
23	KOMP+
25	KOMP -
26	
27	M8+
28	M8 -
29	M9+
30	M9 -
31	M10+
32	M10 -
33	M11+
34	M11 -
35	
36	
37	**M_{ext} ***
38	
39	M12+
40	M12 -
41	M13+
42	M13 -
43	M14+
44	M14 -
45	M15+
46	M15 -
47	

a = Pin no.
b = Assignment

(Connection options see section 10)

Analog Input Module 16 x I / V or 8 x PT 100, Nonfloating (6ES5 465-7LA11)

Technical Specifications

Number of inputs		16 voltage / current inputs or 8 inputs for PT 100
Galvanic isolation		no
Input ranges (rated values)		±50 mV; ±500 mV; PT 100; ±1 V; ±5 V; ±10 V; ±20 mA; +4 to 20 mA (can be selected for four channels at a time using range cards)
Input resistance		± 50 mV: 10 M ± 500 mV: 10 M PT 100: 10 M ± 1 V: 90 k ; 2 ‰ ± 5 V: 50 k ; 2 ‰ ± 10 V: 50 k ; 2 ‰ ± 20 mA: 25 ; 1 ‰ ± 4 to 20 mA:31.25 ;1 ‰
Type of connection for sensors		two-wire connection; for four-wire connection for PT 100
Digital representation of the input signal		12 bits plus sign or 13 bits two's complement (2048 units = rated value)
Measuring principle		integrating
Conversion principle		voltage-time conversion (dual-slope)
Integration time (adjustable for opt. noise suppression)		20 msec. at 50 Hz 16.6 msec. at 60 Hz
Coding time (single coding for 2048 units)	max.	60 msec. at 50 Hz 50 msec. at 60 Hz
Scan time for - 8 inputs - 16 inputs		 0.48 sec. at 50 Hz 0.96 sec. at 50 Hz
Permissible voltage between inputs and between inputs and central grounding point (destruction limit)	max. max.	18 V or 75 V for 1 msec. and a duty factor of 1 : 20
Permissible voltage between the reference potential of a nonfloating sensor and the central grounding point	max.	± 1 V
Error indication for - range violation - wirebreak in the sensor line		 yes (exceeding 4095 units) can be specified in the range 50 mV, 500 mV

Noise suppression for f=n x (50 / 60 Hz±1%) n=1, 2, to			
- common mode noise (V_P<1 V)	min.	86 dB	
- series-mode noise (peak noise value < rated value of the range)	min.	40 dB	
Basic errors		± 50 mV	: ± 2‰
		± 500 mV	: ± 1.5 ‰
		PT 100	: ± 2‰
		± 1 V	: ± 3.5 ‰
		± 5 V	: ± 3.5 ‰
		± 10 V	: ± 3.5 ‰
		± 20 mA	: ± 2.5 ‰
		+ 4 to 20 mA	: ± 2.5 ‰
Operational errors (0°C to 55°C)		± 50 mV	: ± 5 ‰
		± 500 mV	: ± 4.5 ‰
		PT 100	: ± 5 ‰
		± 1 V	: ± 7.7 ‰
		± 5 V	: ± 7.7 ‰
		± 10 V	: ± 7,7 ‰
		± 20 mA	: ± 6.7 ‰
		+ 4 to 20 mA	: ± 6.7 ‰
Cable length - shielded	max.	200 m; 50 m for ± 50 mV	
Front connector		46 pins	
Power supply - rated value - ripple Vpp - permissible range		 24 V DC [1] 3.6 V 20 to 30 V (including ripple)	
Current consumption - from 5 V (internal) - from 24 V	 typ. max.	 0.15 A 20 mA / transducer	
Power losses of the module	typ.	0.75 W	
Weight	approx.	0.4 kg (0.88 lb.)	

[1] only required for two-wire transducers

Analog Output Module 16 x I / V or 8 x PT 100, Nonfloating **(6ES5 465-7LA12)**

Pin Assignment for the Front Connector

a	b
1	L+=24V
2	
3	M0+
4	M0 -
5	M1+
6	M1-
7	M2+
8	M2 -
9	M3+
10	M3 -
11	
12	
13	**M_{ext} ***
14	
15	M4+
16	M4 -
17	M5+
18	M5 -
19	M6+
20	M6 -
21	M7+
22	M7 -
23	KOMP+
25	KOMP -
26 ⚠	
27	M8+
28	M8 -
29	M9+
30	M9 -
31	M10+
32	M10 -
33	M11+
34	M11 -
35	
36	
37	**M_{ext} ***
38	
39	M12+
40	M12 -
41	M13+
42	M13 -
43	M14+
44	M14 -
45	M15+
46	M15 -
47	

a = Pin no.
b = Assignment

(Connection options see section 10)

Analog Input Module 16 x I / V or 8 x PT 100, Nonfloating (6ES5 465-7LA12)

Technical Specifications

Number of inputs	**16 voltage / current inputs or 8 inputs for PT 100**
Galvanic isolation	**no**
Input ranges (rated values)	**±50 mV; ±500 mV; PT 100; ±1 V; ±5 V; ±10 V; ±20 mA; +4 to 20 mA (can be selected for four channels at a time using range cards)**
Input resistance	**± 50 mV: 10 M ± 500 mV: 10 M PT 100: 10 M ± 1 V: 90 k ; 2 ‰ ± 5 V: 50 k ; 2 ‰ ± 10 V: 50 k ; 2 ‰ ± 20 mA: 25 ; 1 ‰ ± 4 to 20 mA:31.25 ; 1‰**
Type of connection for sensors	**two-wire connection; four-wire connection for PT 100**
Digital representation of the input signal	**12 bit + sign or 13 bits two's complement (2048 units =rated value)**
Measuring principle	**integrating**
Conversion principle	**voltage-time conversion (dual-slope)**
Integration time (adjustable for optimum noise suppression)	**20 msec. at 50 Hz 16.6 msec. at 60 Hz**
Scan time max. (single coding for 2048 units)	**60 msec. at 50 Hz 50 msec. at 60 Hz**
Coding time - 8 inputs - 16 inputs	 **0.48 sec. at 50 Hz 0.96 sec. at 50 Hz**
Permissible voltage max. between inputs and between inputs and central grounding point (destruction limit)	**18 V or 75 V for max. 1 msec. and a duty factor of 1 : 20**
Permissible voltage max. between the reference potential of a nonfloating sensor and the central grounding point	**± 1 V**
Error indication for - range violation - wirebreak in the sensor line	 **yes (exceeding 4095 units) can be specified in the range 50 mV, 500mV (PT 100)**
Wirebreak test current disconnectable	**configurable**

Noise suppression for f=n x (50 / 60 Hz±1%) n=1, 2, to		
- common-mode noise (V_p<1 V)	**min.**	**86 dB**
- series-mode noise (peak noise value < rated value of the range)	**min.**	**40 dB**

Basic errors	**± 50 mV :**	**± 2‰**
	± 500 mV :	**± 1.5 ‰**
	PT 100 :	**± 2‰**
	± 1 V :	**± 3.5 ‰**
	± 5 V :	**± 3.5 ‰**
	± 10 V :	**± 3.5 ‰**
	± 20 mA :	**± 2.5 ‰**
	+ 4.. to 20 mA:	**± 2.5 ‰**
Operational errors (0°C to 55°C)	**± 50 mV :**	**± 5 ‰**
	± 500 mV :	**± 4,5 ‰**
	PT 100 :	**± 5 ‰**
	± 1 V :	**± 7.7 ‰**
	± 5 V :	**± 7.7 ‰**
	± 10 V :	**± 7.7 ‰**
	± 20 mA :	**± 6.7 ‰**
	+ 4 to 20 mA :	**± 6.7 ‰**

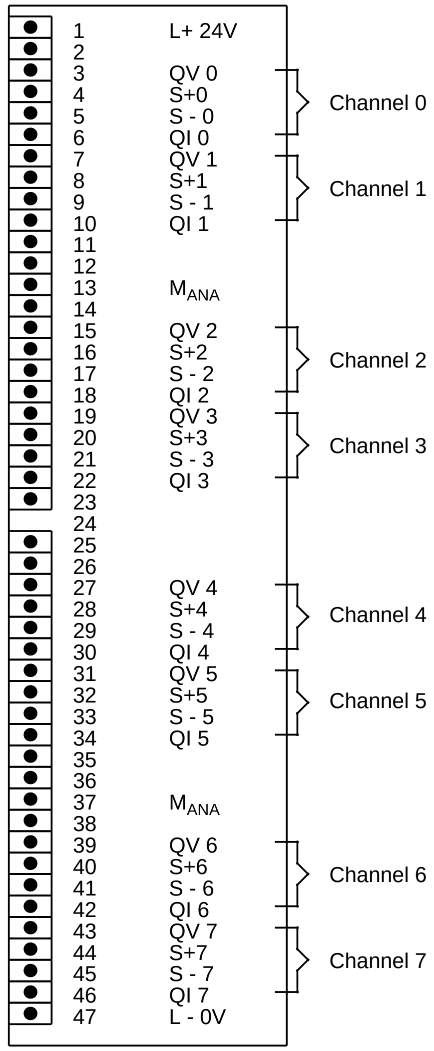
Cable length - shielded		 **max. 200 m; 50 m for ± 50 mV**
Front connector		**46 pins**
Power supply - rated value - ripple Vpp - permissible range (including ripple)		 **24 V DC [1] 3.6 V 20 to 30 V**
Current consumption - from 5 V (internal) - from 24 V	 **typically max.**	 **0.15 A 20 mA / transducer**
Power losses of the module	**typically**	**0.75 W**
Weight	**approx.**	**0.4 kg (0.88 lb.)**

[1] only required for two-wire transducers or for disconnecting the wirebreak test current

17.2.8 Analog Output Modules

Analog Output Modules 8 x± 10 V; 0 to 20 mA; Floating **(6ES5 470-7LA11)**

Pin Assignments for the Front Connectors



M_{ANA}	=	common reference point of all current and voltage channels
QV x	=	voltage output channel x
QI x	=	current output channel x
S+x	=	sensor line + channel x
S - x	=	sensor line - channel x

Analog Output Module 8 x± 10 V; 0 to 20 mA; Floating (6ES5 470-7LA11)

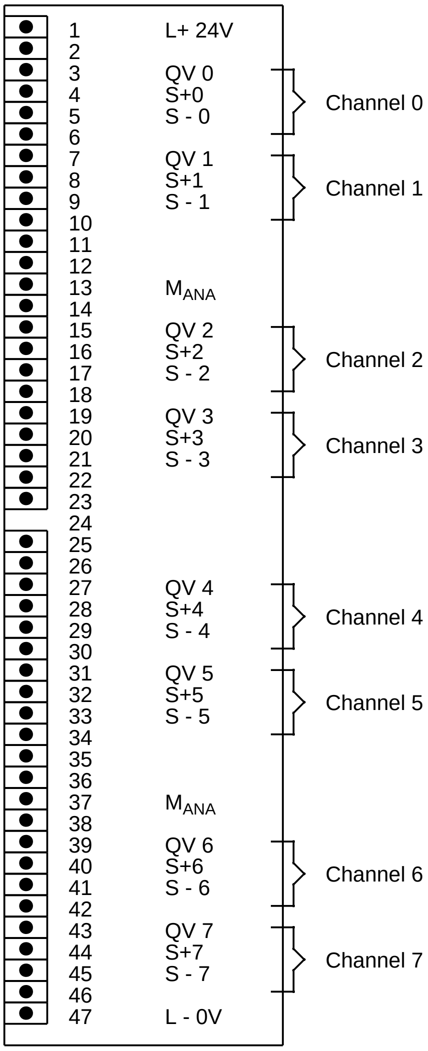
Technical Specifications

Number of outputs		**8 voltage and current outputs**
Galvanic isolation		**yes (not between the inputs)**
Output ranges (rated values)		**± 10 V; 0 to 20 mA**
Load resistance		
- for voltage outputs	**minimum**	**3.3 k**
- for current outputs	**maximum**	**300**
Load connection		**Load to M_{ANA} terminal**
Digital representation of the output signal		**11 bits plus sign (1024 units= rated value)**
Conversion time		**1 msec.**
Permissible overload capability	**approx.**	**25 % (up to 1280 units)**
Short-circuit protection		**yes**
Short-circuit current	**approx.**	**25 mA (for voltage output)**
Open-circuit voltage	**approx.**	**18 V (for current output)**
Voltage between the reference potential of the load (M_{ANA} terminal) and the housing	**maximum**	**60 V AC / 75 V DC**
Linearity in the rated range		**± 2.5 ‰ ± 3 units**
Operational errors (0°C to 55°C)		**± 6 ‰**
Cable length		
- shielded	**maximum**	**200 m (656 ft.)**
Front connector		**46 pins**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (outputs to ⏚)		
- tested at		**500 V**

Power supply		
- rated value		**24 V DC**
- ripple Vpp		**3.6 V**
- permissible range (ripple included)		**20 to 30 V**
Current consumption		
- from 5 V (internal)	**typically**	**0.25 A**
- from 24 V (external)	**typically**	**0.3 A**
Power losses of the module	**typically**	**8.5 W**
Weight	**approx.**	**0.4 kg (0.88 lb.)**

Analog Output Module 8 x ± 10 V; Floating **(6ES5 470-7LB11)**

Terminal Assignment of the Front Connector



M_{ANA}	=	common reference point of all current and voltage channels
QV x	=	voltage output channel x
S+x	=	sensor line + channel x
S - x	=	sensor line - channel x

Analog Ouptut Module 8 x ± 10 V; Floating (6ES5 470-7LB11)

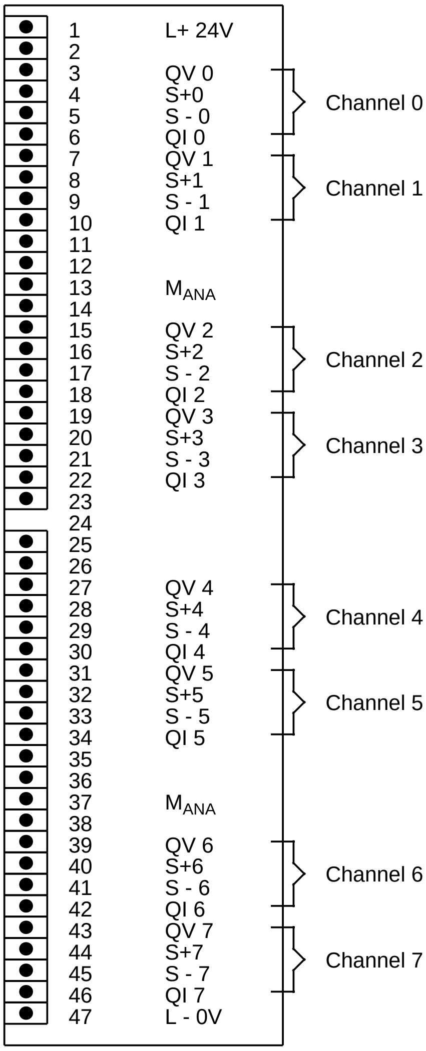
Technical Specifications

Number of outputs		**8 voltage**
Galvanic isolation		**yes (not between the inputs)**
Output ranges (rated value)		**± 10 V**
Load resistance	**minimum**	**3.3 k**
Load connection		**Load to M_{ANA}terminal**
Digital representation of the output signal		**11 bits plus sign (1024 units= rated value)**
Conversion time		**1 msec.**
Permissible overload capability	**approx.**	**25 % (up to 1280 units)**
Short-circuit protection		**yes**
Short-circuit current	**approx.**	**25 mA**
Voltage between the reference potential of the load (M_{ANA} terminal) and the housing	**maximum**	**60 V AC / 75 V DC**
Linearity in the rated range		**± 2,5 ‰ ± 3 units**
Operational errors (0°C to 55°C)		**± 6 ‰**
Cable length - shielded	**maximum**	**200 m (656 ft.)**
Front connector		**46 pins**
Isolation rating		**according to VDE 0160**
Rated isolation voltage (outputs to ⏚) - tested at		**500 V**

Power supply		
- rated value		**24 V DC**
- ripple Vpp		**3.6 V**
- permissible range (ripple included)		**20 to 30 V**
Current consumption		
- from 5 V (internal)	**typically**	**0.25 A**
- from 24 V (external)	**typically**	**0.3 A**
Power losses of the module	**typically**	**8.5 W**
Weight	**approx.**	**0.4 kg (0.88 lb.)**

Analog Output Module 8 x +1 to 5 V; +4 to 20 mA; Floating **(6ES5 470-7LC11)**

Pin Assignment for the Front Connector



M_{ANA}	=	common reference point of all current and voltage channels
QV x	=	voltage output channel x
QI x	=	current output channel x
S+x	=	sensor line + channel x
S - x	=	sensor line - channel x

Analog Output Module 8 x +1 to 5 V; +4 to 20 mA; Floating (6ES5 470-7LC11)

Technical Specifications		
Number of outputs		8 voltage and current outputs
Galvanic isolation		yes (not between the inputs)
Output ranges (rated values)		+1 to 5 V; +4 to 20 mA
Load resistance		
- for voltage outputs	min.	3,3 k
- for current outputs	max.	300
Load connection		Load to M_{ANA} terminal
Digital representation of the output signal		11 bits plus sign (1024 units=rated value)
Conversion time		1 msec.
Permissible overload	approx.	25 % (up to 1280 units)
Short-circuit protection		yes
Short-circuit current	approx.	25 mA (for voltage output)
Open-circuit voltage	approx.	18 V (for current output)
Voltage between the reference potential of the load (M_{ANA} terminal) and the housing	max.	60 V AC / 75 V DC
Linearity in the rated range		± 2.5 ‰ ± 3 units
Operational errors (0°C to 55°C)		± 6 ‰
Cable length		
- shielded	min.	200 m (656 ft.)
Front connector		46 pins
Isolation rating		according to VDE 0160
Rated isolation voltage (outputs to ⏚)		
- tested at		500 V
Power supply		
- rated value		24 V DC
- ripple Vpp		3.6 V
- permissible range (ripple included)		20 to 30 V
Current consumption		
- from 5 V (internal)	typically	0.25 A
- from 24 V (external)	typically	0.3 A
Power losses of the module	typically	8.5 W
Weight	approx.	0.4 kg (0.88 lb.)

17.2.9 Intelligent Input / Output Modules

Table 17-1 lists the intelligent input / output modules you can use with the S5-115H programmable controller.

Table 17-1. Overview of Intelligent Input / Output Modules

Intelligent Input/Output Module*	Current consumption (internally at 5V)	Fan required?	Adapter casing required?
IP 240 Counter and position decoder	0.6** A	No	Yes
IP 241 USW Ultrasonic position decoder	1.2 A	Yes	Yes
IP 242B Counter module	1.2 A	No	Yes
IP 243 Analog module	1.2 A	No	Yes
IP 246 Positioning module	1.0 A	No	Yes
IP 247-4UA11 IP 247-4UA21 Positioning module	0.8 A	Yes No	Yes
IP 252 Closed-loop control module (Direct access to IP 240 not permissible)	2.3 A	No	Yes
IP 281 Counter module	0.6 A	No	Yes
IP 288 Positioning module/ cam controller	0.8 A	No	Yes
WF 705 Position decoder	0.5 A	No	Yes
WF 706 Positioning module	0.75 A (3-channel) 1.5 A (6-channel)	No	Yes
WF 707 Cam controller	0.5 A	No	Yes
WF 721 Positioning module	1.0 A	No	Yes
WF 723 Positioning module	1.3 A	No	Yes

* See Catalog for Order Nos. of modules and manuals
** Without sensor supply

17.2.10 Communication Processors

Table 17-2 lists the communications processors that you can use with the S5-115H programmable controller.

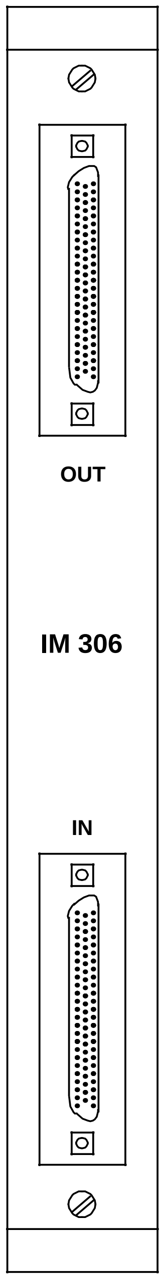
Table 17-2. Overview of Communications Processors

Communications Processor*	Current consumption (internally at 5V)	Fan required?	Adapter casing required?
CP 516 Memory module	0.8 A	No	Yes
CP 524/544 Computer link	1.5 A	Yes	Yes
CP 525 Listing / computer link	1.8 A	Yes	Yes
CP 526 Listing / computer link	2.2 A	Yes	Yes
CP 530A Configuring a SINEC L1 network (PG bus using second CP 530 not permissible)	1.0 A	Yes	Yes
CP 530 Configuring a SINEC L1 network (PG bus using second CP 530 not permissible)	1.0 A	No	No
CP 5430/5431 Configuring a SINEC L2 network	0.45 A	No[1]	Yes
CP 143-0AB.. Configuring a SINEC H1 network	2.5 A	Yes	Yes
CP 523 Serial input/output	0.13 A	No	Yes
CP 527/528 - for monochrome CRT monitors - for colour CRT monitors	1.5 A/1.8 A	No	Yes
CP 552-1 CP 552-2 Diagnostics processor	1.8 A 3.2 A	No No	Yes
CP 580 CP 581	5.5 A 1.8 A**	Yes Sometimes	Yes[3] Yes[4]

* See Catalog for Order Nos. of modules and manuals
** Basic module
1 See Chapter 3, Installation Guidelines
2 Can only be connected with adapter casing 6ES5 491-0LC11
3 Can only be connected with adapter casing 6ES5 491-0LD11
4 In some cases, can only be connected with adapter casing 6ES5 491-0LD11

17.2.11 Interface Modules

IM 306 Interface Module **(6ES5 306-7LA11)**



Technical Specifications

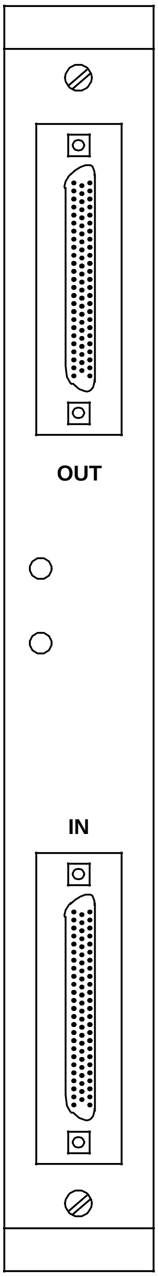
Current supplied to the EU	max.	2 A
Current consumption (5 V; own consumption)		50 mA
Weight	approx.	0.6 kg (1.3 lb.)

Accessories

705 connecting cable (see Catalog ST 52.3)	6ES5 705-0AF00 6ES5 705-0BB50

The IM 306 interface module is used for central connection of up to three expansion units (EUs) to one central controller (CC) (see also Chapter 3).

AS 301 Interface Module **(6ES5 301-3AB13)**

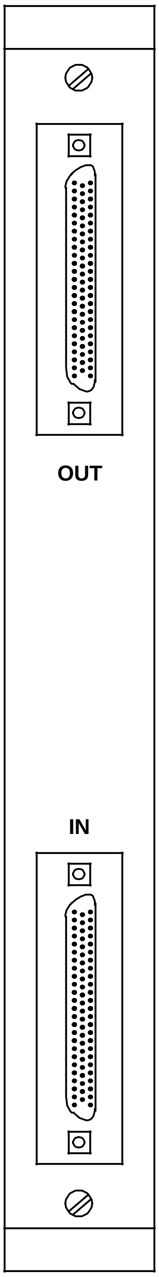


Technical Specifications

Current consumption (at 5 V)	max.	0.75 A
Weight	approx.	0.3kg (0.7 lb.)

The AS 301 interface module is used in combination with the AS 310 interface module for distributed connection (up to 200 m, or 656 ft.) of expansion units (EUs) to a central controller (CC) (see also Chapter 3).

AS 310 Interface Module **(6ES5 310-3AB11)**



Technical Specifications

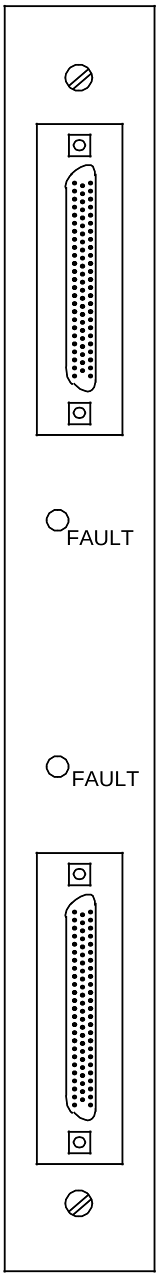
Current consumption (at 5 V)	max.	0.65 A
Weight	approx.	0.3 kg (0.7 lb.)

Accessories

Adapter casing	6ES5 491-0LA12
Terminating connector for AS 314	6ES5 760-0AA11
721 connecting cable (see Catalog ST 52.3)	

The AS 310 interface module is used in combination with the AS 301 interface module for distributed connection (up to 200 m, or 656 ft.) of expansion units (EUs) to a central controller (CC) (see also Chapter 3).

IM 304 Interface Module **(6ES5 304-3UA11)**



Technical Specifications

Current consumption (at 5 V)	max.	1.5 A
Weight	approx.	0.3 kg (0.7 lb.)

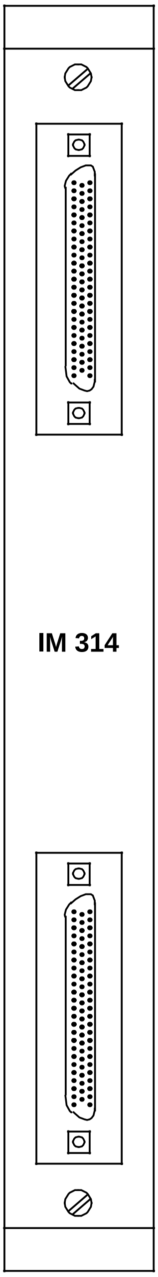
Accessories

Adapter casing	6ES5 491-0LA12
721 connecting cable (see Catalog ST 52.3)	

The IM 304 interface module is used in combination with the

- IM 314 for distributed connection (up to 600 m, or 1969 ft.) of expansion units (EUs) to a central controller (CC) (see also Chapter 3).
- IM 314R for switched connection (up to 600 m, or 1969 ft.) of expansion units (EUs) to a central controller (CC) (see also Chapter 3).
- IM 324R for parallel interfacing (up to 100 m, or 328 ft.) of the central controllers.

IM 314 Interface Module **(6ES5 314-3UA11)**



Technical Specifications

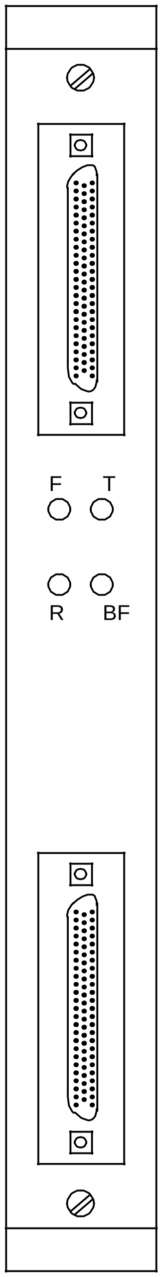
Current consumption (at 5 V)	max.	1.0 A
Weight	approx.	0.3 kg (0.7 lb.)

Accessories

Adapter casing	6ES5 491-0LA12
Terminating connector for IM 314	6ES5 760-1AA11
721 connecting cable (see Catalog ST 52.3)	

The IM 314 interface module is used in combination with the IM 304 interface module for distributed connection (up to 600 m, or 1969 ft.) of expansion units (EUs) to a central controller (CC) (see also Chapter 3).

IM 314R Interface Module **(6ES5 314-3UR11)**



Technical Specifications

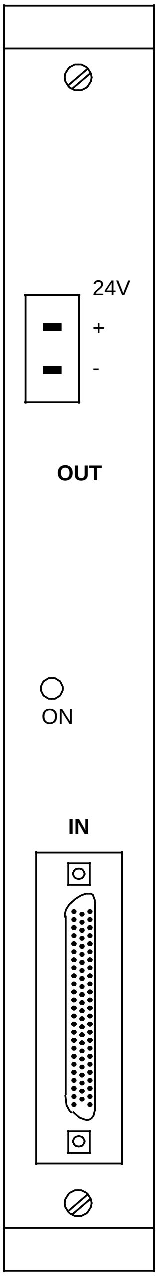
Current consumption (at 5 V)	max.	1.0 A
Weight	approx.	0.3 kg (0.7 lb.)

Accessories

Adapter casing	6ES5 491-0LA12
Terminating connector for IM 314	6ES5 760-1AA11
721 connecting cable (see Catalog ST 52.3)	

The IM 314R interface module is used in combination with the IM 304 interface module for connecting (up to 600 m, or 1969 ft.) switched expansion units (EUs) to a central controller (CC) (see also Chapter 3).

IM 324R Interface Module **(6ES5 324-3UR11)**



Technical Specifications

Current consumption (at 5 V)	max.	1.5 A
Weight	approx.	0.3 kg (0.7 lb.)

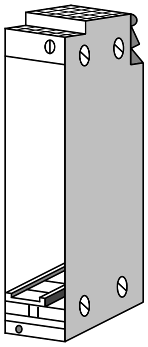
Accessoires

Adapter casing	6ES5 491-0LA12
721 Connecting cable (see Catalog ST 52.3)	

The IM 324R interface module is used in combination with the IM 304 interface module for parallel interfacing of the central controllers over a distance of no more than 100 m (328 ft.) (see also Chapter 3).

17.3 Accessories

Adapter Casing for Two Printed Circuit Boards (6ES5 491-0LB11)

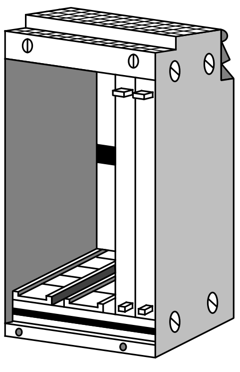


Technical Specifications

Dimensions (W×H×D) in mm		43 x 303 x 187
Weight	approx.	0.9 kg (2 lb.)

Even modules which are not of the block type can be used in the S5-115H, provided an adapter casing is available.
The adapter casing can take one module or, in the case of the CR 700-3 subrack, two modules, but only one double-width module, i.e. IP241, IP 245, IP 246 or IP 247 (self-ventilated model), IP 252, or CP 535.

Adapter Casing for CP 551 Bulk Storage Memory for up to 6 Printed Circuit Boards (6ES5 491-0LC11)



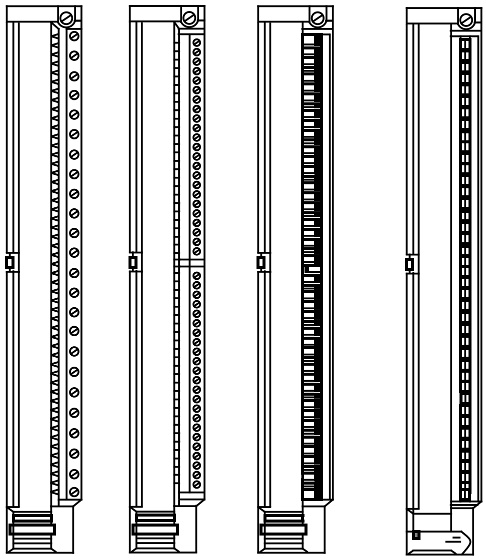
Technical Specifications

Dimensions (W×H×D) in mm		129 x 363 x 187
Weight	approx.	1.8 kg (3.97 lb.)

Even modules which are not of the block type can be used in the S5-115H, provided an adapter casing is available.
The adapter casing can take three modules; using this adapter casing, the CP 551 can also be mounted in a CR 700-3 subrack.

490 Front Connector

Screw-type connection		Crimp snap-in connection	Spring-loaded connection
24-pin	46-pin	46-pin	46-pin



Technical Specifications
see Catalog ST 52.3

490 Front Connector

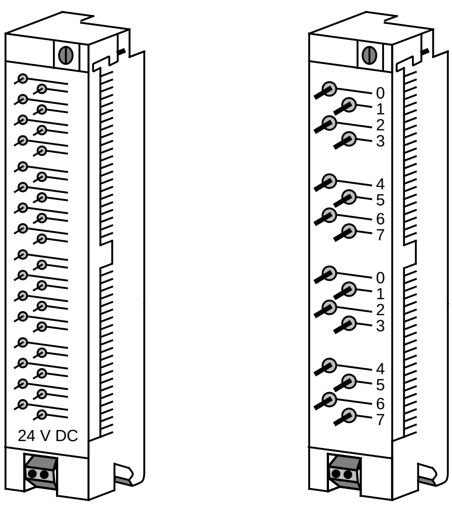
- for screw-type connection
  - 24-pin — **6ES5 490-7LB11**
  - 46-pin — **6ES5 490-7LB21**

763 jumper comb (for use in front connectors with screw-type terminals) — 6ES5 763-7LA11

- for 46-pin crimp snap-in connectors
  - without crimp contacts — **6ES5 490-7LA21**
  - with 50 crimp contacts — **6ES5 490-7LA11**

Crimp contacts (250 per package) — 6XX3 070
Crimping tool for crimping the crimp contacts — 6XX3 071
Extraction tool for crimp contacts — 6ES5 497-4UC11

Simulator



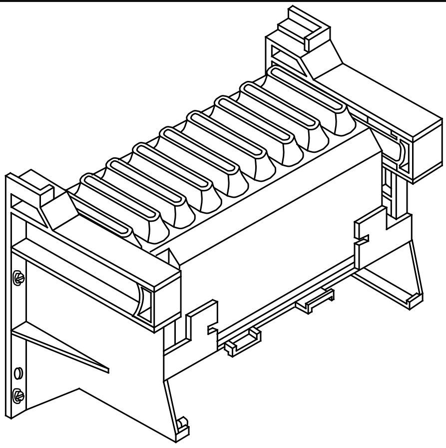
Technical Specifications
see Catalog ST 52.3

Simulator

- 32 switches / buttons — **6ES5 490-7SA11**
  24 V DC
  can be plugged into 6ES5 420-7LA11, 6ES5 430-7LA11

- 16 switches / buttons — **6ES5 490-7SA21**
  24/ 48/ 60/ 115/ 230 V AC/ DC
  can be plugged into 6ES5 431-7LA11, 6ES5 432-7LA11, 6ES5 435-7LA11, 6ES5 435-7LB12, 6ES5 436-7LA11, 6ES5 436-7LB12

Fan Subassembly



If the 6ES5 951-7LD11 or 6ES5 951-7ND11 power supply modules carry a load of more than 7 A, or if modules with a high power consumption are used, a fan subassembly is necessary.

Technical Specifications (6ES5 981-0HA11 and 6ES5 981-0HB11)

Fan	6ES5 981-0HA11	6ES5 981-0HB11
Input voltage		
- rated value	230 / 115 V AC	230 / 115 V AC
- tolerance	-10% to +10%	-10% to +10%
Network frequency		
- Rated value	50 / 60 Hz	50 / 60 Hz
Input current	typ. 420 mA	typ. 420 mA
Contact rating		
- with resistive load of	5.0 A at 230 V AC 2.5 A at 30 V DC	5.0 A at 230 V AC 2.5 A at 30 V DC
- with inductive load of	1.5 A at 230 V AC 0.5 A at 30 V DC	1.5 A at 230 V AC 0.5 A at 30 V DC
- Service life Operating cycles	$1.5 \cdot 10^6$ AC11	$1.5 \cdot 10^6$ AC11
Degree of protection	IP20 to DIN 40 050	IP20 to DIN 40 050
Interference suppression	A to VDE 0871	A to VDE 0871
Dimensions W x H x D (mm)	423 x 110 x 135 16.6 x 3.93 x 5.31 in.	294 x 110 x 135 11.5 x 3.93 x 5.31 in.
Weight	1.5 kg (3.3 lb.)	1.4 kg (3 lb.)

Accessories

Installation kits	6ES5 981-0JA11	6ES5 981-0JB11
Filter mat unit	6ES5 981-0GA11	6ES5 981-0GB11

Fan Subassembly (Continued)

Technical Specifications (6ES5 981-0HA21 and 6ES5 981-0HB21)

Fan	6ES5 981-0HA21	6ES5 981-0HB21
Input voltage		
- rated value	24 V DC	24 V DC
- permissible range (including ripple)	+20 V to+30 V	+20 V to+30 V
Input current	typ. 800 mA	typ. 800 mA
Contact rating		
- with resistive load	5.0 A at 230 V AC	5.0 A at 230 V AC
	2.5 A at 30 V DC	2.5 A at 30 V DC
- with inductive load	1.5 A at 230 V AC	1.5 A at 230 V AC
	0.5 A at 30 V DC	0.5 A at 30 V DC
- Service life		
Operating cycles	1.5·106 DC11	1.5·106 DC11
Degree of protection	IP20 to DIN 40 050	IP20 to DIN 40 050
Interference suppression	A to VDE 0871	A to VDE 0871
Dimensions		
W x H x D (mm)	423 x 110 x 135	294 x 110 x 135
Weight	1.5 kg (3.3 lb.)	1.4 kg (3 lb.)
Accessories		
Installation kit	6ES5 981-0JA11	6ES5 981-0JB11
Filter mat unit	6ES5 981-0GA11	6ES5 981-0GB11

Backup Battery **(6EW1 000-7AA)**

Technical Specifications

Lithium battery (3.4 V / 5.2 Ah)		
- backup time (at 25°C and constant backup of the CPU with memory submodule	approx.	2 years
- service life (at 25°C)	approx.	5 years
- external battery backup		3.4...9 V

Fuses

Wickmann 19231	**2.5 A FF**	**6ES5 980-3BC21**
	4 A FF	**6ES5 980-3BC51**
	10 A FF	**6ES5 980-3BC41**
Gould GAB4		
Bussmann ABC4		

Relays

Siemens V23042 B201 B101

Günther 3700-2501-011

Siemens V23157-006-A402

Appendices

A Operations List

A Operations List

A.1 General Remarks Concerning the Operations List

Abbreviation	**Description**
ACCUM 1	Accumulator 1 (When accumulator 1 is loaded, any existing contents are shifted into accumulator 2.)
ACCUM 2	Accumulator 2
CC0 / CC1	Condition code 0 / Condition code 1
CSF	STEP 5 control system flowchart method of representation
Formal operand	Expression with a maximum of 4 characters. The first character must be a letter of the alphabet.
STL	STEP 5 statement list method of representation
LAD	STEP 5 ladder diagram method of representation
OV	Overflow. This condition code bit is set if, e.g., a numerical range is exceeded during arithmetic operations.
PII	Process input image
PIQ	Process output image
RLO	Result of the logic operation
RLO dependent? Y Y N N	The statement is executed only if the RLO is ”1”. The statement is executed only on positive / negative edge change of the RLO. The statement is always executed.
RLO affected? Y / N	The RLO is affected / not affected by the operation.
RLO reloaded? Y / N	When the next binary logic operation takes place (excluding an assignment operation), the RLO is reloaded / not reloaded with the signal status of the parameter used.

Abb.	Description	Permissible operand value range for CPU 942H
Q	Output	0 to 127.7
QB	Output byte	0 to 127
QW	Output word	0 to 126 (digital) 128 to 254 (analog)
BF	Byte constant (fixed-point number)	- 128 to + 127
RS	System data area - for load operations (supplementary operations) and transfer operations (system operations) - for bit test and set operations (system operations)	 0 to 255 0.0 to 255.15
D	Data word (1 bit)	0.0 to 255.15
DB	Data block	2 to 255
DL	Data word (left byte)	0 to 255
DR	Data word (right byte)	0 to 255
DW	Data word	0 to 255
I	Input	0.0 to 127.7
IB	Input byte	0 to 127
IW	Input word	0 to 126 (digital) 128 bis 254 (analog)
FB	Function block	0 to 255
KB	Byte constant (1 byte)	0 bis 255
KC	Character constant (2 characters)	any two alphanumeric characters
KF	Fixed-point constant (2 bytes)	- 32768 to + 32767
KH	Hexadecimal constant (2 bytes)	0 to FFFF
KM	Binary constant (2 bytes)	arbitrary bit pattern (16 bits)
KT	Time (2 bytes)	0.0 to 999.3
KY	Byte constant(2 byte)	0 to 255 (per byte)
KZ	Count (2 bytes)	0 to 999

Abb.	Description	Permissible operand value range for CPU 942H
F	Flag	0.0 to 255.7
FY	Flag byte	0 to 255
FW	Flag word	0 to 254
OB[2]	Organization block	1 to 255
PB	Program block (with block call and return operations)	0 to 255
PB / PY[1]	Peripheral word	0 to 124
PW	Peripheral word	0 to 126
SB	Sequence block	0 to 255
T	Timer - for supplementary operations ”Test Bit” and ”Set”	0 to 127 0.0 to 127.7
Z	Counter - for supplementary operations ”Test Bit” and ”Set”	0 to 127 0.0 to 127.7

1 On a Programmer with S5-DOS

2 See 10.3.1 for an overview of the organization blocks and their function.

Note:

Please note that the execution times specified in A.2 to A.4 are guideline values. The actual execution times are determined by the processor architecture. The operation runs in the standard processor or in the STEP 5 coprocessor, depending on the type of CPU used.
The pure execution time is increased by a switching time when changing from direct processing in the coprocessor to interpretive processing in the standard processor. These switching times are contained in the execution times specified, based on an operation mix.

A.2 Basic Operations

☒ for organization blocks (OB)
☒ for program blocks (PB)
☒ for function blocks (FB)
☒ for sequence blocks (SB)

Ope-ration (STL)	Operands					1 RLO depend.? 2 RLO affected? 3 RLO reloaded?			Typical execution time in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Logic Operations										
A	•	•	•	•	•	N	Y	N	1,6	AND: Scan for ”1”
AN	•	•	•	•	•	N	Y	N	1,6	AND: Scan for ”0”
O	•	•	•	•	•	N	Y	N	1,6	OR: Scan for ”1”
ON	•	•	•	•	•	N	Y	N	1,6	OR: Scan for ”0”
O						N	Y	Y	1,6	ORing of AND operations
A(						N	Y	Y	1,6	ANDing of parenthesized expressions (6 nesting levels)
O(						N	Y	Y	1,6	ORing of parenthesized expressions (6 nesting levels)
)						N	Y	Y	1,6	Close parenthesis (conclusion of a parenthesized expression)
Set / Reset Operations										
S	•	•	•			Y	N	Y	1,6	Set operand to ”1”.
R	•	•	•			Y	N	Y	1,6	Reset operand to ”0”.
=	•	•	•			Y	N	Y	1,6	Assign value of RLO to operand.
Load Operations										
L	IB					N	N	N	1,6	Load an input byte from the PII into ACCUM 1.
L	QB					N	N	N	1,6	Load an output byte from the PIQ into ACCUM 1.

☒ for organization blocks (OB)
☒ for program blocks (PB)
☒ for function blocks (FB)
☒ for sequence blocks (SB)

Ope-ration (STL)	Operands					1 RLO depend.? 2 RLO affected? 3 RLO reloaded?			Typical Execution Time in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Load Operations (cont.)										
L	IW					N	N	N	1.6	Load an input word from the PII into ACCUM 1: byte n ACCUM 1 (bits 8-15); byte n+1 ACCUM 1 (bits 0-7).
L	PY					N	N	N	530 * 900**	Load an input byte from the digital / analog input modules into ACCUM 1.
L	QW					N	N	N	1.6	Load an output word from the PIQ into ACCUM 1: byte n ACCUM 1 (bits 8-15); byte n+1 ACCUM 1 (bits 0-7).
L	PW					N	N	N	1000 * 1700**	Load an input word from a digital / analog input module into ACCUM 1: byte n ACCUM 1 (bits 8-15); byte n+1 ACCUM 1
L	FY					N	N	N	1.6	Load a flag byte into ACCUM 1.
L	FW					N	N	N	1.6	Load a flag word into ACCUM 1: byte n ACCUM 1 (bits 8-15); byte n+1 ACCUM 1 (bits 0-7).
L	DL					N	N	N	69	Load a data word (left-hand byte) in the current data block into ACCUM 1.
L	DR					N	N	N	71	Load a data word (right-hand byte) in the current data block into ACCUM 1.
L	DW					N	N	N	72	Load a data word in the current data block into ACCUM 1: byte n ACCUM 1 (bits 8-15); byte n+1 ACCUM 1 (bits 0-7).
L	KB					N	N	N	51	Load a constant (1-byte number) into ACCUM 1.
L	KC					N	N	N	1.6	Load a constant (2 characters in ASCII format) into ACCUM 1.
L	KF					N	N	N	1.6	Load a constant (fixed-point number) into ACCUM .
L	KH					N	N	N	1.6	Load a constant (hexadecimal code) into ACCUM 1.
L	KM					N	N	N	1.6	Load a constant (bit pattern) into ACCUM 1.
L	KY					N	N	N	1.6	Load a constant (2-byte number) into ACCUM 1.

***** On access to single-channel and switched I / Os
****** On access to two-channel I / Os

☒ for organization blocks (OB)
☒ for program blocks (PB)
☒ for function blocks (FB)
☒ for sequence blocks (SB)

Operation (STL)	Operands					1 RLO depend? 2 RLO affected? 3 RLO reloaded?			Typical Execution Time in µs	Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Load Operations (cont.)										
L	KT					N	N	N	1,6	Load a constant (time in BCD) into ACCUM 1.
L	KZ					N	N	N	1,6	Load a constant (count in BCD) into ACCUM 1.
L				•	•	N	N	N	1,6	Load time or count (in binary code) into ACCUM 1.
LC				•		N	N	N	127	Load BCD-coded time into ACCUM 1.
LC					•	N	N	N	125	Load BCD-coded count into ACCUM 1.
Transfer Operations										
T	IB					N	N	N	1,6	Transfer the contents of ACCUM 1 to an input byte (into the PII).
T	QB					N	N	N	1,6	Transfer the contents of ACCUM 1 to an output byte (into the PIQ).
T	IW					N	N	N	1,6	Transfer the contents of ACCUM 1 to an input word (into the PII): ACCUM 1 (bits 8-15) byte n; ACCUM 1 (bits 0-7) byte n+1.
T	QW					N	N	N	1,6	Transfer the contents of ACCUM 1 to an output word (into the PIQ): ACCUM 1 (bits 8-15) byte n; ACCUM 1 (bits 0-7) byte n+1.
T	PY					N	N	N	430* 790**	Transfer the contents of ACCUM 1 to a digital or analog output module with updating of the PIQ.
T	PW					N	N	N	810* 1450**	Transfer the contents of ACCUM 1 to the digital / analog output modules, interrupt PIQ and update the PIQ.
T	FY					N	N	N	1,6	Transfer the contents of ACCUM 1 to a flag byte.
T	FW					N	N	N	1,6	Transfer the contents of ACCUM 1 to a flag word (into the PIQ): ACCUM 1 (bits 8-15) byte n; ACCUM 1 (bits 0-7) byte n+1.
T	DL					N	N	N	64	Transfer the contents of ACCUM 1 to a data word (left-hand byte).
T	DR					N	N	N	66	Transfer the contents of ACCUM 1 to a data word (right-hand byte).
T	DW					N	N	N	69	Transfer the contents of ACCUM 1 to a data word.

* On access to single-channel and switched I / Os
** On access to two-channel I / Os

☒ for organization blocks (OB)
☒ for program blocks (PB)
☒ for function blocks (FB)
☒ for sequence blocks (SB)

Ope-ration (STL)	Operands					1 RLO depend.? 2 RLO affected? 3 RLO reloaded?			Typical Execution Time in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Timer Operations										
SP				•		Y	N	Y	121	Start pulse timer (entered in ACCUM 1) (signal contraction)
SE				•		Y	N	Y	121	Start extended pulse (entered in ACCUM 1) (signal contracting and stretching)
SD				•		Y	N	Y	124	Start ON-delay timer (entered in ACCUM 1)
SS				•		Y	N	Y	124	Start latching ON-delay timer (entered in ACCUM 1)
SF				•		Y	N	Y	119	Start OFF-delay timer (entered in ACCUM 1)
R				•		Y	N	Y	81	Reset a timer
Counter Operations										
CU					•	Y	N	Y	159	Counter counts up 1
CD					•	Y	N	Y	110	Counter counts down 1
S					•	Y	N	Y	120	Set counter
R					•	Y	N	Y	133	Reset counter
Arithmetic Operations										
+F						N	N	N	1.6	Add two fixed-point numbers: ACCUM 1+ACCUM 2 Evaluate result via CC 1 / CC0 / 0V
- F						N	N	N	1.6	Subtract one fixed-point number from another: ACCUM 2 - ACCUM 1. Evaluate result via CC 1 / CC 0 / 0V

⊠ for organization blocks (OB)
⊠ for program blocks (PB)
⊠ for function blocks (FB)
⊠ for sequence blocks (SB)

Operation (STL)	Operands					1 RLO depend.? 2 RLO affected? 3 RLO reloaded			Typical Execution Times in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Comparison Operations										
!=F						N	Y	N	1.6	Compare two fixed-point numbers for "equal." If ACCUM 2 = ACCUM 1, the RLO is "1". CC 1 / CC 0 are affected.
><F						N	Y	N	1.6	Compare two fixed-point numbers for "not equal." If ACCUM 2 ACCUM 1, the RLO is "1". CC 1 / CC 0 are affected.
>F						N	Y	N	1.6	Compare two fixed-point numbers for "greater than." If ACCUM 2 > ACCUM 1, the RLO is "1". CC 1 / CC 0 are affected.
>=F						N	Y	N	1.6	Compare two fixed-point numbers for "greater than or equal to." If ACCUM 2 ACCUM 1, the RLO is "1". CC 1 / CC 0 are affected.
<F						N	Y	N	1.6	Compare two fixed-point numbers for "less than". If ACCUM 2 < ACCUM 1, the RLO is "1". CC 1 / CC 0 are affected.
<=F						N	Y	N	1.6	Compare two fixed-point numbers for "less than or equal to." If ACCUM 2 ACCUM 1, the RLO is "1". CC 1 / CC 0 are affected.
Block Call Operations										
JU	OB					N	N	Y	1100	Call an organization block unconditionally.
JU	PB					N	N	Y	1100	Jump unconditionally to a program block.
JU	FB					N	N	Y	1100	Jump unconditionally to a function block.
JU	SB					N	N	Y	1100	Jump unconditionally to a sequence block.
JC	OB					Y	Y [1]	Y	1100	Jump conditionally to a program block.
JC	PB					Y	Y [1]	Y	1100	Jump conditionally to a function block.
JC	FB					Y	Y [1]	Y	1100	Jump conditionally to a function block.
JC	SB					Y	Y [1]	Y	1100	Jump conditionally to a sequence block.

1 RLO is set to "1".

☒ for organization blocks (OB)
☒ for program blocks (PB)
☒ for function blocks (FB)
☒ for sequence blocks (SB)

Ope-ration (STL)	Operands					1 RLO depend.? 2 RLO affected 3 RLO reloaded?			Typical Execution Time in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Block Call Operations (cont.)										
C	DB					N	N	N	66	Call a data block.
G	DB					N	N	N	190	Generate a data block.
Return Operations										
BE						N	N	Y	99	Block end (termination of a block)
BEC						Y	Y[1]	Y	101	Block end, conditional
BEU						N	N	Y	99	Block end, unconditional (BEU cannot be used in organization blocks.)
"No" Operations										
NOP 0						N	N	N	1.6	No operation (all bits reset)
NOP 1						N	N	N	1.6	No operation (all bits set)
Stop Operation										
STP						N	N	N	47	Stop: scanning cycle is completed. Error ID "STS" is set in the ISTACK.
Display Generation Operations										
BLD 130						N	N	N	1.6	Display construction statement for the programmer: carriage return generates blank line.
BLD 131						N	N	N	1.6	Display construction statement for the programmer: switch over to statement list (STL)
BLD 132						N	N	N	1.6	Display construction statement for the programmer: switch over to control system flowchart (CSF)

1 RLO is set to "1."

☒ for organization blocks (OB)
☒ for program blocks (PB)
☒ for function blocks (FB)
☒ for sequence blocks (SB)

Operation (STL)	Operands					1 RLO depend.? 2 RLO affected? 3 RLO reloaded?			Typical Execution Time in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Display Generation Operations (cont.)										
BLD 133						N	N	N	1.6	Display construction statement for the programmer: switch over to ladder diagram (LAD)
BLD 255						N	N	N	1.6	Display construction statement for the programmer: segment end

A.3 Supplementary Operations

☐ for organization blocks (OB)
☐ for program blocks (PB)
☒ for function blocks (FB)
☐ for sequence blocks (SB)

Operation (STL)	Operands					1 RLO depend.? 2 RLO affected? 3 RLO reloaded?			Typical Execution Time in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Boolean Logic Operations										
A=	Formal operand •	•	•	•	•	N	Y	N	129	AND operation: scan formal operand for ”1”.
AN=	Formal operand •	•	•	•	•	N	Y	N	129	AND operation: scan formal operand for ”0”.
O=	Formaloperand •	•	•	•	•	N	Y	N	129	OR operation: scan formal operand for ”1”.
ON=	Formal operand •	•	•	•	•	N	Y	N	129	OR operation: scan formal operand for ”0”.
AW						N	N	N	1.6	Combine contents of ACCUM 2 and ACCUM 1 through logic AND (word operation). Result is stored in ACCUM 1. CC 1 / CC 0 are affected.
OW						N	N	N	1.6	Combine contents of ACCUM 2 and ACCUM 1 through logic OR (word operation). Result is stored in ACCUM 1. CC 1 / CC 0 are affected.
XOW						N	N	N	1.6	Combine contents of ACCUM 2 and ACCUM 1 through EXCLUSIVE OR (word operation). Result is stored in ACCUM 1. CC 1 / CC 0 are affected.

☐ for organization blocks (OB)
☐ for program blocks (PB)
☒ for function blocks (FB)
☐ for sequence blocks (SB)

Operation (STL)	Operands					1 RLO depend.? 2 RLO affected? 3 RLO reloaded?			Typical Execution Time in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Bit Test Operations										
TB				•	•	N	Y	N	154	Test a timer or counter word bit for ”1”.
TB	D					N	Y	N	154	Test a data word bit for ”1”.
TB	RS					N	Y	N	152	Test a data word bit in the system data range for ”1”.
TBN				•	•	N	Y	N	154	Test a timer or counter word bit for ”0”.
TBN	D					N	Y	N	154	Test a data word bit for ”0”.
TBN	RS					N	Y	N	153	Test a data word bit in the system data area for ”0”.
SU				•	•	N	N	Y	155	Set a timer or counter word bit unconditionally.
SU	D					N	N	Y	155	Set a data word bit unconditionally.
RU				•	•	N	N	Y	155	Reset a timer or counter word bit unconditionally.
RU	D					N	N	Y	155	Reset a data word bit unconditionally.
Set / Reset Operations										
S=	Formal operand: •	•	•			Y	N	Y	127	Set a formal operand (binary) (when RLO =1).
RB=	Formal operand: •	•	•			Y	N	Y	127	Reset a formal operand (binary) (when RLO =1).
RD=	Formal operand:			•	•	Y	N	Y	121	Reset a formal operand (digital) (when RLO =1).
==	Formal operand: •	•	•			Y	N	Y	127	Assign the value of the RLO (binary) to the formal operand.

☐ for organization blocks (OB)
☐ for program blocks (PB)
☒ for function blocks (FB)
☐ for sequence blocks (SB)

Operation (STL)	Operands I	Q	F	T	C	1 RLO depend.?	2 RLO affected?	3 RLO reloaded?	Typical Execution Time in µs CPU 942H	Function Description
Timer and Counter Operations										
FR				•	•	Y	N	Y	83	Enable a timer / counter for cold restart. If RLO = ”1”, - ”FR T” restarts the timer - ”FR Z” sets, decrements, or increments the counter
FR=	Formal operand			•	•	Y	N	Y	121 *	Enable formal operand (timer / counter) for cold restart (for detailed description, see ”FR” operation).
SP=	Formal operand			•		Y	N	Y	121 *	Start a pulse timer (formal operand) with the value stored in ACCUM 1.
SR=	Formal operand			•		Y	N	Y	121 *	Start an ON-delay timer (formal operand) with the value stored in ACCUM 1.
SEC=	Formal operand			•	•	Y	N	Y	121 *	Start a timer (formal operand) as extended pulse with the value stored in ACCUM 1, or set a counter (formal operand) with the specified count value.
SSU=	Formal operand			•	•	Y	N	Y	121 *	Start a latching ON-delay timer (formal operand) with the value stored in ACCUM 1, or increment a counter (formal operand).
SFD=	Formal operand			•	•	Y	N	Y	121 *	Start an OFF-delay timer (formal operand) with the value stored in ACCUM 1, or decrement a counter (formal operand).
Load and Transfer Operations										
L=	Formal operand •	•		•	•	N	N	N	127 *	Load the value of the formal operand into ACCUM 1 (parameter type: BY, W).
L	RS					N	N	N	66	Load a word from the system data area into ACCUM 1.
LD=	Formal operand			•	•	N	N	N	121 *	Load the value of the formal operand in BCD code into ACCUM 1.
LW=	Formal operand •	•	•	•	•	N	N	N	126	Load a formal operand bit pattern into ACCUM 1 (parameter type: D; Data type: KF, KH, KM; KC, KT, KZ).
T=	Formal operand •	•				N	N	N	128 *	Transfer the contents of ACCUM 1 to the formal operand (parameter type: BY, W).

***** Plus processing time of the substituted operation

☐ for organization blocks (OB)
☐ for program blocks (PB)
☒ for function blocks (FB)
☐ for sequence blocks (SB)

Ope-ration (STL)	Operands					1 RLO depend.? 2 RLO affected? 3 RLO reloaded?			Typical Execution Time in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Conversion Operations										
CFW						N	N	N	1.6	Form the one's complement of ACCUM 1.
CSW						N	N	N	1.6	Form the two's complement of ACCUM 1. CC 1 / CC 0 and OV are affected.
Shift Operations										
SLW	Parameter n=0 to 15					N	N	N	1.6	Shift the contents of ACCUM 1 to the left by the value specified in the parameter. Unassigned positions are padded with zeros. CC 1 / CC 0 are affected.
SRW	Parameter n=0 to 15					N	N	N	1.6	Shift the contents of ACCUM 1 to the right by the value specified in the parameter. Unassigned positions are padded with zeros. CC 1 / CC 0 are affected.
Jump Operations										
JU=	Symbolic address maximum 4 characters					N	N	N	1.6	Jump unconditionally to the symbolic address.
JC=	Symbolic address maximum 4 characters					Y	Y[1]	Y	1.6	Jump conditionally to the symbolic address. (If the RLO is "0", it is set to "1").
JZ=	Symbolic address maximum 4 characters					N	N	N	1.6	Jump if zero. The jump is made only if CC 1 = 0 and CC 0 = 0. The RLO is not changed.
JN=	Symbolic address maximum 4 characters					N	N	N	1.6	Jump if not zero. The jump is made only if CC 1 CC 0 . The RLO is not changed.
JP=	Symbolic address maximum 4 characters					N	N	N	1.6	Jump if the result > 0. The jump is made only if CC 1=1 and CC 0=0. The RLO is not changed.
JM=	Symbolic address maximum 4 characters					N	N	N	1.6	Jump if the result < 0. The jump is made only if CC 1=0 and CC 0=1. The RLO is not changed.
JO=	Symbolic address maximum 4 characters					N	N	N	1.6	Jump on overflow. The jump is made only if the OVERFLOW bit is set. The RLO is not changed.

1 RLO is set to "1."

☐ for organization blocks (OB)
☐ for program blocks (PB)
☒ for function blocks (FB)
☐ for sequence blocks (SB)

Operation (STL)	Operands					1 RLO depend.? 2 RLO affected? 3 RLO reloaded?			Typical Execution Time in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Other Operations										
IA						N	N	N	1000	Disable interrupt. I / O interrupt or processing of the timed interrupt OB is disabled.
RA						N	N	N	1000	Enable interrupt. This operation cancels the effect of IA.
D						N	N	N	43	Decrement the low byte (bits 0 to 7) of ACCUM 1 by the value n (n=0 to 255).
I						N	N	N	43	Increment the low byte (bits 0 to 7) of ACCUM 1 by the value n (n=0 to 255).
DO=	Formal operand •	•	•	•	•	N	N	N	122 *	Process a block. (Only C DB, JU PB, JU FB, JU SB can be substituted).
DO	DW **					N	N	N	118	Process data word. The next operation is combined through logic OR with the parameter specified in the data word and executed**.
DO	FW **					N	N	N	102	Process flag word. The next operation is combined through logic OR with the parameter specified in the flag word and executed**.

* Plus processing time of the substituted operation

** Permissible operations:

A, AN, O, ON;	L, LC, T;
S, R, =;	JU, JC, JZ, JN, JP, JM, JO, SLW, SRW;
FR T, R T, SF T,SD T, SI T, SS T, SE T;	D, I;
FR C, R C, S C, CD C, CV C;	C DB; T RS, TNB

A.4 System Operations

☐ for organization blocks (OB)
☐ for program blocks (PB)
☒ for function blocks (FB)
☐ for sequence blocks (SB)

Ope-ration (STL)	Operands					1 RLO depend.? 2 RLO affected? 3 RLO reloaded?			Typical Execution Time in µs	Function Description
	I	Q	F	T	C	1	2	3	CPU 942H	
Set Operations										
SU	RS					N	N	Y	154	Set bit in system data area unconditionally.
RU	RS					N	N	Y	154	Reset bit in system data area unconditionally.
Load and Transfer Oprations										
LIR	0 2					N	N	N	250 * 1300 ** 2000 ***	Load the contents of a memory word indirectly into the register (0: ACCUM 1; 2: ACCUM 2).
TIR	0 2					N	N	N	230 * 1100 ** 1700 ***	Transfer the register contents indirectly into the memory word (0: ACCUM 1; 2: ACCUM 2).
TNB	Parameter n=0 to 255					N	N	N	300 +16 • number of bytes * 300 +500 • number of bytes** 123 +800 • numb. of bytes***	Transfer a block byte by byte (number of bytes 0 to 255).
T	RS					N	N	N	61	Transfer a word to the system data area.
Arithmetic Operations										
ADD	BN					N	N	N	49	Add byte constant (fixed point) to ACCUM 1.
ADD	KF					N	N	N	87	Add fixed-point constant (word) to ACCUM 1.

* on transfers involving the contents of internal RAM
** on transfers involving single-channel and switched I / Os
*** on transfers involving dual-channel I / Os

☐ for organization blocks (OB)
☐ for program blocks (PB)
☒ for function blocks (FB)
☐ for sequence blocks (SB)

Ope-ration (STL)	**Operands**					**1 RLO depend.? 2 RLO affected? 3 RLO reloaded?**			**Typical Execution Time in µs**	**Function Description**
	I	**Q**	**F**	**T**	**C**	**1**	**2**	**3**	**CPU 942H**	
Other Operations										
DI	Formal operand					N	N	N	128	Process via a formal operand (indirect). The number of the formal operand is in ACCUM 1.
	•	•	•	•	•					
STS						N	N	N	47	Stop operation. Program processing is interrupted immediately after this operation.
TAK						N	N	N	47	Swap the contents of ACCUM 1 and ACCUM 2.

A.5 Evaluating CC 1 and CC 0

CC 1	CC 0	Arithmetic Operations	Digital Logic Operations	Comparison Operations	Shift Operations	Conversion Operations
0	0	Result = 0	Result = 0	ACCUM 2 = ACCUM 1	Shifted bit = 0	-
0	1	Result < 0	-	ACCUM 2 < ACCUM 1	-	Result < 0
1	0	Result > 0	Result 0	ACCUM 2 > ACCUM 1	Shifted bit = 1	Result > 0

A.6 Machine Code Listing

Machine Code								Operation	Operand
B0		B1		B2		B3			
L	R	L	R	L	R	L	R		
0	0	0	0					NOP 0	
0	1	0	0					CFW	
0	2	0_d	0_d					L	T
0	3	0_l	0_l					TNB	
0	4	0_d	0_d					FR	T
0	5	0	0					BEC	
0	6	0_c	0_c					FR=	
0	7	0_c	0_c					A=	
0	8	0	0					IA	
0	8	8	0					RA	
0	9	0	0					CSW	
0	A	0_a	0_a					L	FY
0	B	0_a	0_a					T	FY
0	C	0_d	0_d					LC	T
0	D	0_i	0_i					JO=	
0	E	0_c	0_c					LD=	
0	F	0_c	0_c					0=	
1	0	8	2					BLD	130
1	0	8	3					BLD	131
1	0	8	4					BLD	132
1	0	8	5					BLD	133
1	0	F	F					BLD	255
1	1	0_n	0_n					I	
1	2	0_a	0_a					L	FW
1	3	0_a	0_a					T	FW
1	4	0_d	0_d					SF	T
1	5	0_i	0_i					JP=	
1	6	0_c	0_c					SSFD=	
1	7	0_c	0_c					S=	
1	9	0_n	0_n					D	
1	C	0_d	0_d					SE	T
1	D	0_f	0_f					JC	FB

Machine Code								Operation	Operand
B0		B1		B2		B3			
L	R	L	R	L	R	L	R		
1	E	0_c	0_c					SEC=	
1	F	0_c	0_c					==	
2	0	0_f	0_f					C	DB
2	1	2	0					>F	
2	1	4	0					<F	
2	1	6	0					><F	
2	1	8	0					!=F	
2	1	A	0					>=F	
2	1	C	0					<=F	
2	2	0_g	0_g					L	DL
2	3	0_d	0_d					T	DL
2	4	0_c	0_c					SD	T
2	5	0_i	0_i					JM=	
2	6	0_c	0_c					SR=	
2	7	0_c	0_c					AN=	
2	8	0_e	0_e					L	KB
2	A	0_g	0_g					L	DR
2	B	0_g	0_g					T	DR
2	C	0_d	0_d					SS	T
2	D	0_i	0_i					JU=	
2	E	0_c	0_c	0_e	0_e	0_e	0_e	SSU=	
2	F	0_c	0_c	0_e	0_e	0_e	0_e	ON=	
3	0	0	1	0_e	0_e	0_e	0_e	L	KZ
3	0	0	2	0_e	0_e	0_e	0_e	L	KT
3	0	0	4	0_e	0_e	0_e	0_e	L	KF
3	0	1	0	0_e	0_e	0_e	0_e	L	KC
3	0	2	0	0_e	0_e	0_e	0_e	L	KY
3	0	4	0					L	KH
3	0	8	0					L	KM
3	2	0_g	0_g					L	DW
3	3	0_g	0_g					T	DW
3	4	0_d	0_d					SI	T

Machine Code								Opera-tion	Ope-rand
B0		B1		B2		B3			
L	R	L	R	L	R	L	R		
3	5	0_i	0_i					JN=	
3	6	0_c	0_c					SP=	
3	7	0_c	0_c					RB=	
3	C	0_d	0_d					R	T
3	D	0_f	0_f					JU	FB
3	E	0_c	0_c					RD=	
3	F	0_c	0_c					LW=	
4	0	0	0_k					LIR	
4	1	0	0					AW	
4	2	0_o	0_o					L	Z
4	4	0_o	0_o					FR	Z
4	5	0_i	0_i					JZ=	
4	6	0_c	0_c					L=	
4	8	0	0_k					TIR	
4	9	0	0					OW	
4	A	0_a	0_a					L	EB
4	A	8_a	0_a					L	AB
4	B	0_a	0_a					T	EB
4	B	8_a	0_a					T	AB
4	C	0_o	0_o					LC	Z
4	D	0_f	0_f					JC	OB
4	E	0_g	0_g					DO	MW
5	0	0_e	0_e					ADD	BF
5	1	0	0					XOW	
5	2	0_a	0_a					L	EW
5	2	8_a	0_a					L	AW
5	3	0_a	0_a					T	EW
5	3	8_a	0_a					T	AW
5	4	0_o	0_o					CD	Z
5	5	0_f	0_f					JC	PB
5	8	0	0	0_e	0_e	0_e	0_e	ADD	KF
5	9	0	0					-F	

Machine Code								Opera-tion	Ope-rand
B0		B1		B2		B3			
L	R	L	R	L	R	L	R		
5	C	0_o	0_o					S	C
5	D	0_f	0_f					JC	SB
6	1	0_h	0_h					SLW	
6	2	0_g	0_g					L	RS
6	3	0_g	0_g					T	RS
6	5	0	0					BE	
6	5	0	1					BEU	
6	6	0_c	0_c					T=	
6	9	0_h	0_h					SRW	
6	C	0_o	0_o					CU	C
6	D	0_f	0_f					JU	OB
6	E	0_g	0_g					DO	DW
7	0	0	0					STS	
7	0	0	2					TAK	
7	0	0	3					STP	
7	0	0	B	0_m	0_m	0_m	0_m	JUR	
7	0	1	5	C	0	0_o	0_o	TB	C
7	0	1	5	8	0	0_o	0_o	TBN	C
7	0	1	5	4	0	0_o	0_o	SU	C
7	0	1	5	0	0	0_o	0_o	RU	C
7	0	2	5	C	0	0_d	0_d	TB	T
7	0	2	5	8	0	0_d	0_d	TBN	T
7	0	2	5	4	0	0_d	0_d	SU	T
7	0	2	5	0	0	0_d	0_d	RU	T
7	0	4	6	C	0_b	0_g	0_g	TB	D
7	0	4	6	8	0_b	0_g	0_g	TBN	D
7	0	4	6	4	0_b	0_g	0_g	SU	D
7	0	4	6	0	0_b	0_g	0_g	RU	D
7	0	5	7	C	0_b	0_g	0_g	TB	RS
7	0	5	7	8	0_b	0_g	0_g	TBN	RS
7	0	5	7	4	0_b	0_g	0_g	SU	RS
7	0	5	7	0	0_b	0_g	0_g	RU	RS

Machine Code								Operation	Operand
B0		B1		B2		B3			
L	R	L	R	L	R	L	R		
7	2	0_d	0_d					L	PB
7	3	0_d	0_d					T	PB
7	5	0_f	0_f					JU	PB
7	6	0_c	0_c					DO=	
7	8	0	5	0	0	0_f	0_f	G	DB
7	9	0	0					+F	
7	A	0_a	0_a					L	PW
7	B	0_a	0_a					T	PW
7	C	0_o	0_o					R	C
7	D	0_f	0_f					JU	SB
7	E	0	0					DI	
8	0_b	0_a	0_a					A	F
8	8_b	0_a	0_a					O	F
9	0_b	0_a	0_a					S	F
9	8_b	0_a	0_a					=	F
A	0_b	0_a	0_a					AN	F
A	8_b	0_a	0_a					ON	F
B	0_b	0_a	0_a					R	F
B	8	0_o	0_o					A	C
B	9	0_o	0_o					O	C
B	A	0	0					A(	
B	B	0	0					O(	
B	C	0_o	0_o					AN	C

Machine Code								Operation	Operand
B0		B1		B2		B3			
L	R	L	R	L	R	L	R		
B	D	0_o	0_o					ON	C
B	F	0	0					)	
C	0_b	0_a	0_a					A	I
C	0_b	8_a	0_a					A	Q
C	8_b	0_a	0_a					O	I
C	8_b	8_a	0_a					O	Q
D	0_b	0_a	0_a					S	I
D	0_b	8_a	0_a					S	Q
D	8_b	0_a	0_a					=	I
D	8_b	8_a	0_a					=	Q
E	0_b	0_a	0_a					AN	I
E	0_b	8_a	0_a					AN	Q
E	8_b	0_a	0_a					ON	I
E	8_b	8_a	0_a					ON	Q
F	0_b	0_a	0_a					R	I
F	0_b	8_a	0_a					R	Q
F	8	0_d	0_d					A	T
F	9	0_d	0_d					O	T
F	A	0_i	0_i					JC=	
F	B	0	0					O	
F	C	0_d	0_d					AN	T
F	D	0_d	0_d					ON	T
F	F	F	F					NOP 1	

Explanation of the Indices

a + byte address
b + bit address
c + parameter address
d + timer number
e + constant
f + block number
g + word address
h + number of shifts
i + relative jump address
k + register address
l + block length in bytes
m + jump displacement (16 bits)
n + value
o + counter number

B Maintenance

Figures

B Maintenance

Proper functioning of the programmable controller can only be guaranteed if the electronic components have not been interfered with.
This appendix describes the maintenance jobs you can perform on your programmable controller.

B.1 Changing Fuses

On output modules with red LED indicators for fuse failure, you can remove the fuses with a screwdriver (maximum width 3 mm). Swing the front connectors out to gain access to the fuses. Fuse specifications are noted on the inside of the front doors.

B.2 Installing or Changing the Battery

Use a 3.4 V / 5 Ah lithium battery for backup (Order No. 6EW1 000-7AA, size C). Its service life for continuous backup is at least two years.

Note:
If you install or change a battery when the PLC is shut off and there is no external voltage supply, perform an Overall Reset on the CPU afterwards. Otherwise, the CPU cannot go into the “RUN” mode.

B.2.1 Removing the Battery

To remove the battery, proceed as described below:

1. Open the battery compartment as follows (Figure B-1)
   Press the slide down.
   Swing the battery compartment door out and down.

2. Removing the battery
   Remove the battery by pulling the end of the plastic ribbon forward. The battery slides out of its clamp and falls out.

3. Closing the battery compartment door
   Close the battery compartment door by swinging it back into place. Latch it with the slide.

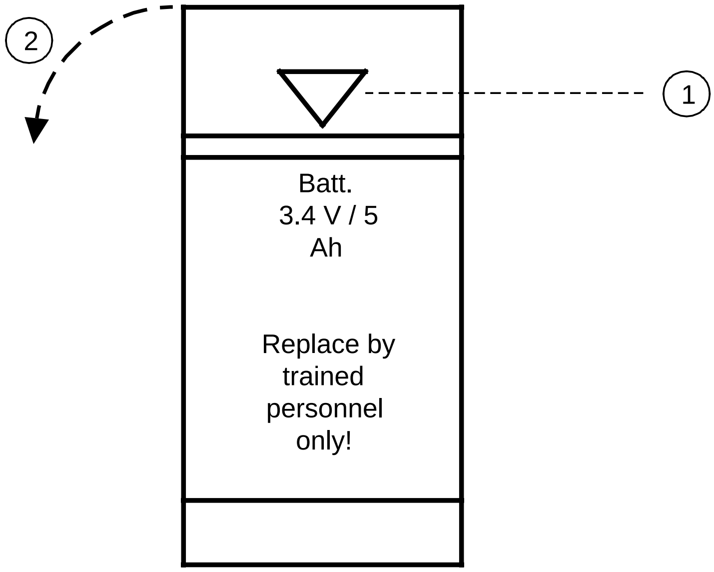


Figure B-1. Opening the Battery Compartment

B.2.2 Installing the Battery

To install a battery, proceed as described below:

1. Open the battery compartment door as described in subsection B.2.1.

2. Installing the battery
   Note the following carefully before inserting the battery:
   - The poles are indicated in the rear of the battery compartment.
   - The plastic ribbon should be to the left of the battery so that its end stays in a freely accessible position.

3. Close the battery compartment door as described in section B.2.1.

B.2.3 Battery Disposal

Used batteries contain dangerous contaminants, and their disposal requires special precautionary measures!

WARNING:

Improper handling can cause a lithium battery to catch fire and explode!
Do not recharge or disassemble a lithium battery.
Keep it away from water and open flame. Do not expose it to temperatures greater than 100° C!

B.3 Changing the Fan Filter Mat

Under the fan is a filter mat (Order No. 6ES5 981-OJA11) to keep the electronic components and the printed circuit boards in the modules clean. As preventive maintenance, change this filter regularly according to the degree of air pollution in the PLC’s environment.

To change the filter, proceed as described below (see also Figure B-2):

1. Remove the dirty filter mat using the two handles .
2. Place the new filter mat in the guide tracks and push it back .

Note :
You can change the filter while the PLC is operating.

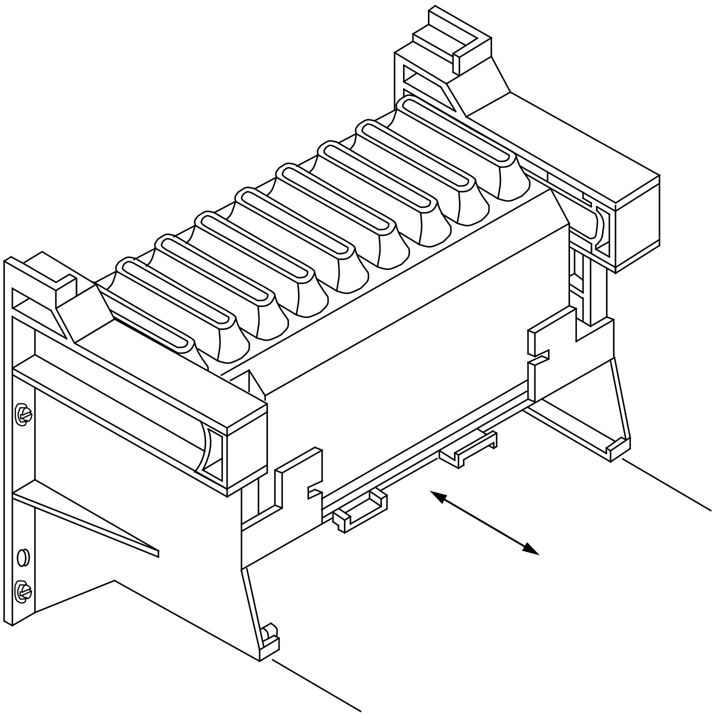


Figure B-2. Changing the Fan Filter Mat

C Module Slots

C Module Slots

C.1 Connector Pin Assignments for Power Supply Module

Pin	Upper Connector (a b)	Lower connector (only on CC 2 / 2F / 3 and EU 2 / 3) (a b)
1	M	M
2	+5V	+5V
3	+5V	+5V
4	+5V	+5V
5	+5V	+5V
6	+5V	M
7	+5V	M
8	+5.2V	M
9	M	M
10	M	$\overline{\text{NAU}}$
11	UBATT	M
12	M	$\overline{\text{BAU}}$
13	$\overline{\text{HOLD}}$*	M
14	M	$\overline{\text{RESETA}}$
15	$\overline{\text{RESETA}}$	M
16	M	$\overline{\text{PEU}}$
17	RESET	M
18	M	$\overline{\text{HOLDA3}}$*
19	$\overline{\text{BAU}}$	$\overline{\text{HOLDA2}}$*
20	M	$\overline{\text{HOLDA1}}$*
21		$\overline{\text{HOLD}}$*
22	$\overline{\text{HOLDA1}}$*	
23	$\overline{\text{NAU}}$	
24	$\overline{\text{HOLDA2}}$*	
25	$\overline{\text{PEU}}$	
26	$\overline{\text{HOLDA3}}$*	
27	$\overline{\text{DS1}}$	
28	M	
29	+24V	+24V
30	M24V	M24V
31		
32	M	M

* Only on 7 / 15 A power supply module

C.2 Connector Pin Assignments for the CPUs

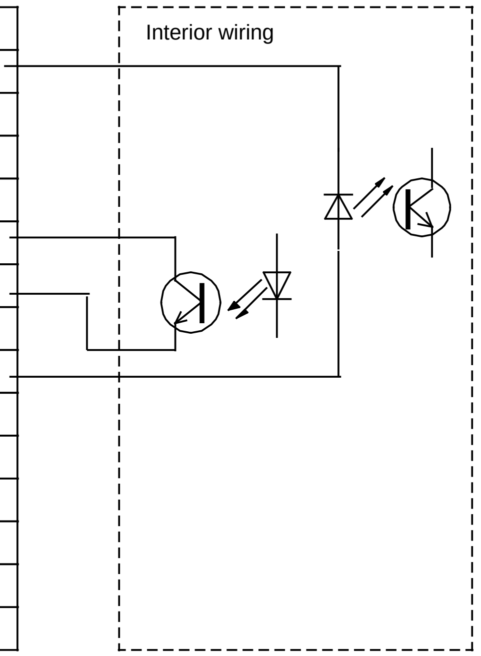
CPU slot
Upper connector

	z	b	d	f
2	+5V	M	+5.2V	+5V
4	TAKT	PESP	UBATT	$\overline{\text{F0}}$
6	RESET	ADB0	ADB12	$\overline{\text{F1}}$
8	$\overline{\text{MRD}}$	ADB1	ADB13	$\overline{\text{F2}}$
10	$\overline{\text{MWR}}$	ADB2	ADB14	$\overline{\text{F3}}$
12	$\overline{\text{RDY}}$	ADB3	ADB15	$\overline{\text{F4}}$
14	DB0	ADB4	$\overline{\text{IRA}}$	$\overline{\text{F5}}$
16	DB1	ADB5	$\overline{\text{IRB}}$	$\overline{\text{F6}}$
18	DB2	ADB6	$\overline{\text{IRC}}$	$\overline{\text{ASF}}$
20	DB3	ADB7	$\overline{\text{IRD}}$	$\overline{\text{HOLD}}$
22	DB4	ADB8	$\overline{\text{BAU}}$	$\overline{\text{HOLDA1}}$
24	DB5	ADB9	$\overline{\text{NAU}}$	$\overline{\text{HOLDA2}}$*
26	DB6	ADB10	$\overline{\text{PEU}}$	$\overline{\text{HOLDA3}}$*
28	DB7	ADB11	$\overline{\text{DSI}}$	$\overline{\text{PRAL}}$
30	M24V	BASP		+24V
32		M	$\overline{\text{DSI}}$	$\overline{\text{ASG}}$

***** Only on 7 / 15A power supply module

Interface assignments for the serial interface

1	M_{EXT}
2	TTY IN-
3	+5.2 V
4	+ 24 V
5	M
6	TTY OUT+
7	TTY OUT-
8	M_{EXT}
9	TTY IN+
10	M 24 V
11	20 mA
12	M
13	20 mA
14	+ 5.2 V
15	M



C.3 Connector Pin Assignments for CPs and Intelligent I / Os

Slots 0 to 5 (left)*****
Upper connector

	z	b	d
2	+5V	M	+5.2V
4	TAKT	PESP	UBATT
6	RESET	ADB0	ADB12
8	$\overline{\text{MRD}}$	ADB1	ADB13
10	$\overline{\text{MWR}}$	ADB2	ADB14
12	$\overline{\text{RDY}}$	ADB3	ADB15
14	DB0	ADB4	$\overline{\text{IRA}}$
16	DB1	ADB5	$\overline{\text{IRB}}$
18	DB2	ADB6	$\overline{\text{IRC}}$
20	DB3	ADB7	$\overline{\text{IRD}}$
22	DB4	ADB8	$\overline{\text{BAU}}$
24	DB5	ADB9	$\overline{\text{NAU}}$
26	DB6	ADB10	$\overline{\text{PEU}}$
28	DB7	ADB11	$\overline{\text{DSI}}$
30	M24V	BASP	+24V
32		M	

Lower connector;
only on CC 2 and EU 3

	z	b	d
2	+5V	M	
4			
6			
8			
10			
12			
14	$\overline{\text{NAU}}$		
16	$\overline{\text{BAU}}$		
18	$\overline{\text{HOLDAX}}$**		
20	$\overline{\text{HOLD}}$		
22			
24			
26			
28			
30	M+24V	M+24V	
32	+24V	M	

***** In CC 0 and CC 1 only in slot 0
In CC 2 only in slots 0 to 5
In CC 2F only in slots 0 to 5
In CC 3 only in slots 0a to 5a
0b to 2b
In EU 3 only in slots 0a to 6a

****** X= HOLDA1 Slot 0
not available in EU 3

C.4 Connector Pin Assignments for Digital and Analog Input / Output Modules

Slots 0 to 8 (right)*****

	a b
1	M
2	+5V
3	PESP
4	ADB0
5	RESET
6	ADB1
7	$\overline{\text{MRD}}$
8	ADB2
9	$\overline{\text{MWR}}$
10	ADB3
11	$\overline{\text{RDY}}$
12	ADB4
13	DB0
14	ADB5
15	DB1
16	ADB6
17	DB2
18	ADB7
19	DB3
20	ADB8
21	DB4
22	ADB9
23	DB5
24	ADB10
25	DB6
26	ADB11
27	DB7
28	BASP
29	$\overline{\text{PRAL}}$
30	M
31	$\overline{\text{ASG}}$
32	$\overline{\text{FX}}$**

*		
	Slots 0 to 3	in CC 0
	Slots 0 to 6	in CC 1
	Slots 0a to 6a	in CC 2F
	Slots 0a to 6a	in CC 2
	Slots 3a to 5	in CC 3
	Slots 0 to 8	in EU 1
	Slots 0b to 7b	in EU 2
	Slots 0b to7b	in EU 3

** Enabling lines of the individual slots (X=0 to 8)

C.5 Connector Pin Assignments for Interface Modules

C.5.1 Connector Pin Assignments for the Symmetrical and Serial EU Interface Modules

Slot 6 (left) in CC 2
Slots 5 and 6 (left) in CC 2F
Slots 6a and 6b in CC 3

Upper connector

	z	b	d
2	+5V	M	
4	TAKT	PESP	+5V
6	RESET	ADB0	ADB12
8	$\overline{\text{MRD}}$	ADB1	ADB13
10	$\overline{\text{MWR}}$	ADB2	ADB14
12	$\overline{\text{RDY}}$	ADB3	ADB15
14	DB0	ADB4	+5V
16	DB1	ADB5	+5V
18	DB2	ADB6	M
20	DB3	ADB7	M
22	DB4	ADB8	M
24	DB5	ADB9	M
26	DB6	ADB10	M
28	DB7	ADB11	M
30		BASP	M
32	M	M	$\overline{\text{DSI}}$

Lower connector

	z	b	d
2	+5V	M	
4			
6			
8			
10			
12	+5V	+5V	
14	+5V	+5V	
16	+5V	+5V	
18	$\overline{\text{RESETA}}$	$\overline{\text{PEU}}$	
20			
22	M	M	
24	M	M	
26	M	M	
28	M	M	
30	M	M	
32	M	M	

C.5.2 Connector Pin Assignments for the Symmetrical and Serial CC Interface Modules

Slot 7 (left) in EU2 / 3

Upper connector

	z	b	d
2	+5V	M	
4		PESP	+5V
6	RESET	ADB0	
8	$\overline{\text{MRD}}$	ADB1	
10	$\overline{\text{MWR}}$	ADB2	
12	$\overline{\text{RDY}}$	ADB3	
14	DB0	ADB4	+5V
16	DB1	ADB5	+5V
18	DB2	ADB6	M
20	DB3	ADB7	M
22	DB4	ADB8	M
24	DB5	ADB9	M
26	DB6	ADB10	M
28	DB7	ADB11	M
30		BASP	M
32		M	

Lower connector

	z	b	d
2	+5V	M	M
4			
6			
8			
10			
12	+5V	+5V	
14	+5V	+5V	
16	+5V	+5V	
18	$\overline{\text{RESETA}}$	$\overline{\text{NAU}}$	
20			
22	M	M	
24	M	M	
26	M	M	
28	M	M	
30	M	M	
32	M	M	

C.5.3 Connector Pin Assignments for the Asymmetrical IM 306 Interface Module

Upper connector

	z	b	d
2	+5V	M	+5V
4		PESP	+5V
6	RESET	ADB0	$\overline{\text{RESETA}}$
8	$\overline{\text{MRD}}$	ADB1	$\overline{\text{F0}}$
10	$\overline{\text{MWR}}$	ADB2	$\overline{\text{F1}}$
12	$\overline{\text{RDY}}$	ADB3	$\overline{\text{F2}}$
14	DB0	ADB4	$\overline{\text{F3}}$
16	DB1	ADB5	$\overline{\text{F4}}$
18	DB2	ADB6	$\overline{\text{F5}}$
20	DB3	ADB7	$\overline{\text{F6}}$
22	DB4	ADB8	$\overline{\text{F7}}$*
24	DB5	ADB9	$\overline{\text{F8}}$**
26	DB6	ADB10	
28	DB7	ADB11	$\overline{\text{PEU}}$
30	M	BASP	$\overline{\text{ASF}}$
32	M	M	$\overline{\text{ASG}}$

* Only in EU1, EU2 and EU3
** Only in EU1

C.6 Connector Pin Assignments for the ER 701-3LA13 Mounting Rack

Power supply

Pin	Upper connector (a b)	Lower connector (a b)
1	M	M
2	+5V	+5V
3	+5V	+5V
4	+5V	+5V
5	+5V	+5V
6	+5V	M
7	+5V	M
8	+5.2V	M
9	M	M
10	M	NAU
11	UBATT	M
12	M	BAU
13		M
14	M	$\overline{RESETA}$
15	$\overline{RESETA}$	M
16	M	
17	RESET	M
18	M	
19	$\overline{BAU}$	
20	M	
21		
22		
23	$\overline{NAU}$	
24		
25	$\overline{PEU}$	
26	M	
27	$\overline{DSI}$	
28		
29		+24V
30		M24V
31		
32	M	M

Slots 0a to 6a

Upper connector

	z	b	d
2	+5V	M	+5.2V
4	TAKT	PESP	UBATT
6	RESET	ADB0	ADB12
8	$\overline{MRD}$	ADB1	ADB13
10	$\overline{MWR}$	ADB2	ADB14
12	$\overline{RDY}$	ADB3	ADB15
14	DB0	ADB4	$\overline{IRA}$
16	DB1	ADB5	$\overline{IRB}$
18	DB2	ADB6	$\overline{IRC}$
20	DB3	ADB7	$\overline{IRD}$
22	DB4	ADB8	$\overline{BAU}$
24	DB5	ADB9	$\overline{NAU}$
26	DB6	ADB10	$\overline{PEU}$
28	DB7	ADB11	$\overline{DSI}$
30	M24V	BASP	+24V
32		M	

Lower connector

	z	b	d
2	+5V	M	
4			
6			
8			
10			
12			
14	$\overline{NAU}$		
16	$\overline{BAU}$		
18	$\overline{RESETA}$		
20			
22			
24			
26			
28			
30	M+24V	M+24V	
32	+24V	M	

Slot 7a

Upper connector

	z	b	d
2	+5V	M	
4		PESP	+5V
6	RESET	ADB0	ADB12
8	$\overline{MRD}$	ADB1	ADB13
10	$\overline{MWR}$	ADB2	ADB14
12	$\overline{RDY}$	ADB3	ADB15
14	DB0	ADB4	+5V
16	DB1	ADB5	+5V
18	DB2	ADB6	M
20	DB3	ADB7	M
22	DB4	ADB8	M
24	DB5	ADB9	M
26	DB6	ADB10	M
28	DB7	ADB11	M
30		BASP	M
32		M	

Lower connector

	z	b	d
2	+5V	M	
4			M
6			
8			
10			
12	+5V	+5V	
14	+5V	+5V	
16	+5V	+5V	
18	$\overline{RESETA}$	$\overline{NAU}$	
20			
22	M	M	
24	M	M	
26	M	M	
28	M	M	
30	M	M	
32	M	M	

Slots 0b to 7b

Upper connector

	a b
1	M
2	+5V
3	PESP
4	ADB0
5	RESET
6	ADB1
7	$\overline{MRD}$
8	ADB2
9	$\overline{MWR}$
10	ADB3
11	$\overline{RDY}$
12	ADB4
13	DB0
14	ADB5
15	DB1
16	ADB6
17	DB2
18	ADB7
19	DB3
20	ADB8
21	DB4
22	ADB9
23	DB5
24	ADB10
25	DB6
26	ADB11
27	DB7
28	BASP
29	
30	M
31	$\overline{ASG}$
32	$\overline{F_0}$ to $\overline{F_7}$

C.7 Connector Pin Assignments for the ER 701-3LH11 Mounting Rack

Power Supply Module

Upper Connector

	a	b
1	M	
2	+5V	
3	+5V	
4	+5V	
5	+5V	
6	+5V	
7	+5V	
8	+5,2V	
9	M	
10	M	
11	UBATT	
12	M	
13		
14	M	
15	$\overline{\text{RESETA}}$	
16	M	
17	RESET	
18	M	
19	$\overline{\text{BAU}}$	
20	M	
21		
22		
23	$\overline{\text{NAU}}$	
24		
25	$\overline{\text{PEU}}$	
26	M	
27	$\overline{\text{DSI}}$	
28		
29		
30		
31		
32	M	

Lower Connector

	a	b
1	M	
2	+5V	
3	+5V	
4	+5V	
5	+5V	
6	M	
7	M	
8	M	
9	M	
10	$\overline{\text{NAU}}$	
11	M	
12	$\overline{\text{BAU}}$	
13	M	
14	$\overline{\text{RESETA}}$	
15	M	
16		
17	M	
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29	+24V	
30	M24V	
31		
32	M	

Slots 0a to 5a

Upper Connector

	z	b	d
2	+5V	M	+5,2V
4	TAKT	PESP	UBATT
6	RESET	ADB0	ADB12
8	$\overline{MRD}$	ADB1	ADB13
10	$\overline{MWR}$	ADB2	ADB14
12	$\overline{RDY}$	ADB3	ADB15
14	DB0	ADB4	$\overline{IRA}$
16	DB1	ADB5	$\overline{IRB}$
18	DB2	ADB6	$\overline{IRC}$
20	DB3	ADB7	$\overline{IRD}$
22	DB4	ADB8	$\overline{BAU}$
24	DB5	ADB9	$\overline{NAU}$
26	DB6	ADB10	$\overline{PEU}$
28	DB7	ADB11	$\overline{DSI}$
30	M24V	BASP	+24V
32		M	

Lower connector

	z	b	d
2	+5V	M	
4			
6			
8			
10			
12			
14	$\overline{NAU}$		
16	$\overline{BAU}$		
18			
20			
22			
24			
26			
28			
30	M24V	M24V	
32	+24V	M	

Slot 6a

Upper Connector

	z	b	d
2	+5V	M	
4		PESP	+5V
6	RESET	ADB0	ADB12
8	$\overline{MRD}$	ADB1	ADB13
10	$\overline{MWR}$	ADB2	ADB14
12	$\overline{RDY}$	ADB3	ADB15
14	DB0	ADB4	+5V
16	DB1	ADB5	+5V
18	DB2	ADB6	M
20	DB3	ADB7	M
22	DB4	ADB8	M
24	DB5	ADB9	M
26	DB6	ADB10	M
28	DB7	ADB11	M
30		BASP	M
32		M	

Lower Connector

	z	b	d
2	+5V	M	
4	SANA 0	NASA 0	M
6	SANA 1	NASA 1	
8	SANA 2	NASA 2	
10	SANA 3	NASA 3	
12		+5V	
14	$\overline{NAU}$	+5V	
16	$\overline{BAU}$	+5V	
18	$\overline{RESETA}$	$\overline{NAU}$	
20	BASPAB	BASPBA	
22	M	M	
24			
26			
28			
30			
32	M	M	

Slot 7a

Upper Connector

	z	b	d
2	+5V	M	
4		PESP	+5V
6	RESET	ADB0	ADB12
8	$\overline{\text{MRD}}$	ADB1	ADB13
10	$\overline{\text{MWR}}$	ADB2	ADB14
12	$\overline{\text{RDY}}$	ADB3	ADB15
14	DB0	ADB4	+5V
16	DB1	ADB5	+5V
18	DB2	ADB6	M
20	DB3	ADB7	M
22	DB4	ADB8	M
24	DB5	ADB9	M
26	DB6	ADB10	M
28	DB7	ADB11	M
30		BASP	M
32		M	

Lower Connector

	z	b	d
2	+5V	M	
4	NASA 0	SANA 0	M
6	NASA 1	SANA 1	
8	NASA 2	SANA 2	
10	NASA 3	SANA 3	
12	+5V	+5V	
14	+5V	+5V	
16	+5V	+5V	
18	$\overline{\text{RESETA}}$	$\overline{\text{NAU}}$	
20	BASPAB	BASPBA	
22	M	M	
24	M	M	
26	M	M	
28	M	M	
30	M	M	
32	M	M	

Slots 0b to 7b

Upper Connector

	a	b
1	M	
2	+5V	
3	PESP	
4	ADB0	
5	RESET	
6	ADB1	
7	$\overline{MRD}$	
8	ADB2	
9	$\overline{MWR}$	
10	ADB3	
11	$\overline{RDY}$	
12	ADB4	
13	DB0	
14	ADB5	
15	DB1	
16	ADB6	
17	DB2	
18	ADB7	
19	DB3	
20	ADB8	
21	DB4	
22	ADB9	
23	DB5	
24	ADB10	
25	DB6	
26	ADB11	
27	DB7	
28	BASP	
29		
30	M	
31	$\overline{ASG}$	
32	$\overline{F_0}$ ... $\overline{F_7}$	

C.8 Legend for Connector Pin Assignments

+5V	Supply voltage for all modules
M	Ground for +5V and +5.2V
+5.2V	Supply voltage for PG 605U and PG 615 programmers
+24V	Supply voltage for 20 mA interface and programming voltage for the PG 615 programmer
M24V	Ground for +24V
U_{BATT}	3.4V battery voltage for RAM back-up
RESET	Reset pulse for all modules
$\overline{\text{RESETA}}$	Reset pulse request (initiates or extends a Reset pulse).
$\overline{\text{BAU}}$	Battery failure; signal is generated if there is no battery plugged in or if the battery is low.
$\overline{\text{NAU}}$	Powerfailure; signal is generated shortly before the supply voltage fails.
$\overline{\text{PEU}}$	I / O not ready; signal is generated when the power supply in the expansion unit fails.
$\overline{\text{DSI}}$	Data back-up; signal is generated with a delay after $\overline{\text{NAU}}$ and switches the battery-backed RAM to 'Standby' in the case of some modules (hardware-implemented).
BASP	Command output inhibit; signal is generated when the CPU stops. The signal disables the digital output modules.
$\overline{\text{MRD}}$	Memory Read; is generated on every Read access.
$\overline{\text{MWR}}$	Memory Write; is generated on every Write access.
$\overline{\text{RDY}}$	Ready; signal acknowledging $\overline{\text{MRD}}$ or $\overline{\text{MWR}}$ access.
PESP	Memory I / O Select; is generated every time I / O memory is accessed.
$\overline{\text{ASF}}$	Interface module free; the central controller is operated without an interface module. A terminating connector must be plugged in instead of the interface module.
$\overline{\text{ASG}}$	Interface module plugged in

$\overline{\text{IRA}}$, $\overline{\text{IRB}}$	Interrupt A, B; hardware interrupt signals from intelligent I / Os.
$\overline{\text{PRAL}}$	Process interrupt; hardware interrupt signal from a digital I / O module.
$\overline{\text{HOLDA1, 2, 3}}$	S5 bus enable for intelligent process control module (IPR).
$\overline{\text{HOLD}}$	S5 bus reserved by the intelligent process controller module (IPR).
F0 to 8	Enable circuit for I / Os
ADB0 to 15	Address bus
DB0 to 7	Data bus
SANA 0 to 3	Privat signals of the IM 314R interface module
NASA 0 to 3	Privat signals of the IM 314R interface module
BASPAB	Privat signals of the IM 314R interface module
BASPBA	Privat signals of the IM 314R interface module

D COM 115H Error Messages

D COM 115H Error Messages

Error Code	Error Message	Cause of Error	Recovery Procedures
1	CPU 942 error	Hardware fault on the CPU 942H	Replace CPU module
5	User submodule defective	Hardware fault on the user submodule	Replace user submodule
7	System error	Operating system detected illegal system state	Check your control program for illegal access attempts to the system data area
10	I / Os not ready	Expansion unit, connecting cable or IM 306 failure	Check or replace the connecting cable and / or the IM 306; watch for additional error messages.
11	Standby error when attempting to activate	Parallel link error	- Check IM 304 / IM 324R modules - Check connecting cable and insert properly
15	Master STOP during activation	Master CPU went to STOP during standby activation phase	Read out error messages from the master PLC and rectify problem
16	"Standby STOP" set in H flag word	H flag bit "Stop standby" was set in the control program	Check utilization of the H flag word
17	I / Os ready again	The "I / Os not ready" error (error code 10) was rectified	When this message is issued, you can log the time and date of the repair procedures (only when system is equipped with a CP 523)
23	Error search mode without result	No hardware fault detected	Error code 24 provides further details
24	Error in PIQ comparison Auxiliary info 1: PIQ byte no.	The PIQ byte is not the same in the two CPUs. Possible causes: - Access to protected memory areas - Parallel link error	- Check control program - Check IM 304, IM 324R and connecting cables and replace if necessary

Error Code	Error Message	Cause of Error	Recovery Procedures
26	Not same user submodule in subunits A + B	The CPUs in the two sub-units are equipped with different user submodules (i.e. submodules with different Order Nos.)	- Insert user submodules with identical Order Nos. in the two CPUs
28	Not same system program EPROM in subunits A + B	The CPUs in the two subunits have different version numbers	Compare CPU version numbers. Use CPUs with identical version numbers.
29	Not same user program code in subunits A + B	The contents of the user submodules are not identical	Generate EPROMs with identical contents.
30	Error in standby-master transfer	Problems with the IM 304 / IM 314R interface link	Check or replace IM 304s, IM 314Rs and connecting cables.
33	Parallel link error (IM 304 / IM 324R)	PLCs cannot communicate (e.g. due to a power failure in one of the PLCs)	Check or replace IM 304s, IM 324Rs and connecting cables. Check the power supply.
34	Synchronisation error	CPUs processed different program sections. Possible causes: - Different data in internal memory - Code-modifiable FB not configured	- Check the control program for access to protected memory areas. - Check configuration of code-modifiable FBs
35	Standby-master transfer	Master controller failed during program processing. Possible causes: - Power failure - Hardware fault	Read out subsequent error messages and rectify problem
37	Standby-master transfer due to I / O error	The first switched I / O time-out causes a switch from master to standby	Watch for subsequent error messages and evaluate the static error image. Rectify the problem and revoke passivation via the H flag word.

Error Code	Error Message	Cause of Error	Recovery Procedures
40	I / O bus error (IM 304 / IM 314R) Auxiliary info 1: EU number:(1 to 8)	EU power failure. Interface to switched EU defective.	- Check power supply - Check or replace IM 304, IM 314R and / or connecting cable
41	EU available but not configured Auxiliary info 1: EU number:(1 to 8)	A non-configured EU was detected during START-UP.	- Check configuration of switched EUs - Check settings on the IM 314R
50	Time-out on digital input byte Auxiliary info 1: DI byte no.:(0 to 127)	Bad DI module. EU or IM 306 failed.	- Check or replace DI module - Check EU - Check or replace IM 306
51	Time-out on digital output byte Auxiliary info 1: DQ byte no.:(0 to 127)	Bad DQ module. EU or IM 306 failed.	- Check or replace DI module - Check EU - Check or replace IM 306
52	Time-out on analog input word Auxiliary info 1: AI word:(128 to 254)	Bad AI module. EU or IM 306 failed.	- Check or replace DI module - Check EU - Check or replace IM 306
53	Time-out on analog output word Auxiliary info 1: AQ word:(128 to 254)	Bad AQ module. EU or IM 306 failed.	- Check or replace DI module - Check EU - Check or replace IM 306
54	Time-out when initiating selective sampling Auxiliary info 1: AI word:(128 to 254)	Selective sampling mode not set on AI module.	AI module can be set for selective sampling
55	Configured DI byte not available (time-out at start-up) Auxiliary info 1: DI byte no.:(0 to 127)	- Configuring error - Wrong address setting on the IM 306 - Module defective - EU failure	- Check configuring data - Check module addressing on the IM 306 - Replace module - Check EU interfacing and operation

Error Code	Error Message	Cause of Error	Recovery Procedures
56	Configured DQ byte not available (time-out at start-up) Auxiliary info 1: DQ byte no.:(0 to 127)	- Configuring error - Wrong address setting on the IM 306 - Module defective - EU failure	Check configuration - Check module addressing on the IM 306 - Replace module - Check EU interfacing and operation
57	Configured AI word not available (time-out at start-up) Auxiliary info 1: AQ word no.:(128 to 254)	- Configuring error - Wrong address setting on the IM 306 - Module defective - EU failure	Check configuration - Check module addressing on the IM 306 - Replace module - Check EU interfacing and operation
58	Configured AQ word not available (time-out at start-up) Auxiliary info 1: AQ word no.:(128 to 254)	- Configuring error - Wrong address setting on the IM 306 - Module defective - EU failure	Check configuration - Check module addressing on the IM 306 - Replace module - Check EU interfacing and operation
59	DQ group passivation Auxiliary info 1: DQ byte no.:(0 to 127)	Module passivated due to L-DQ failure	This error message is issued together with error messages 61, 71, 73 and 74. Rectify these errors and revoke passivation.
60	DI error (perm. ”0” or perm. ”1”) Auxiliary info 1: Byte address: Bit number:	DIs still not identical when discrepancy time expired	Check or replace DI module. Check locating facility (wiring).
61	DQ error (perm. ”0” or perm. ” 1”) Auxiliary info 1: Byte address: Bit number:	R DI module did not read anticipated value	Check locating facility (wiring). Replace module. Output of this error message for both subunits indicates an external fault.

Error Code	Error Message	Cause of Error	Recovery Procedures
62	Process interrupt discrepancy	Interrupt generated in one subunit only. Possible cause: - Wirebreak - Interrupt module defective	Check wiring. Replace interrupt module.
	Auxiliary info 1: Byte address: Bit number:		
70	Error in locating DI	Wiring fault L DI or L DQ module defective	Check wiring. Replace locating modules.
	Auxiliary info 1: LDI byte no.:(0 to 127) Bit number:(0 to 7) Auxiliary info 2: LDQ byte no.:(0 to 127) Bit number:(0 to 7)		
71	Error in locating DQ	Locating facility defective	Check wiring Replace locating modules.
	Auxiliary info 1: LDI byte no.:(0 to 127) Bit number:(0 to 7) Auxiliary info 2: LDQ byte no.:(0 to 127) Bit number:(0 to 7)		
72	Time-out on a locating DI	L DI module or EU failure	Check wiring Replace locating modules.
	Auxiliary info 1: Byte no. LDI:(0 to 127)		
73	Time-out on a locating DQ	L DQ module or EU failure	Check wiring Replace locating modules.
	Auxiliary info 1: Byte no. LDQ:(0 to 127)		
74	Perm. ”0” error of an L DQ for red. DQs	L DQ bit defective or wiring fault	Check or replace module. Check wiring
	Auxiliary info 1: Byte address Bit number		
75	Readback error	Error detected on DQ readback. Readback DI was passivated.	If a permanent "0" or permanent "1" error was also reported, check the DQ and R DI modules. Check wiring.
	Auxiliary info 1: R DI byte no.:(0 to 127)		

Error Code	Error Message	Cause of Error	Recovery Procedures
76	Time-out on readback DI	R DI module or EU defective	If a permanent "0" or permanent "1" error was also reported, check the DQ and R DI modules. Check wiring.
	Auxiliary info 1: R DI byte no.:(0 to 127)		
77	Passivation of a readback DI due to DQ error	Error on DQ readback. Readback DI was passivated.	If a permanent "0" or permanent "1" error was also reported, check the DQ and R DI modules. Check wiring.
	Auxiliary info 1: R DI byte no.:(0 to 127)		
81	CP / IP does not acknowledge (time-out)	CP / IP module or EU defective	If a permanent "0" or permanent "1" error was also reported, check the DQ and R DI modules. Check wiring.
	Auxiliary info 1: Interface no.:(0 to 255)		
82	CP / IP not configured	CP / IP module not configured. CP / IP acknowledges on several addresses.	Check configuration and address setting on the CPs / IPs.
	Auxiliary info 1: Interface no.:(0 to 255)		
90	Configured FB not stored in PLC	Code-modifiable FB was configured but is not in the master controller.	Check configuration. Transfer FB to master controller.
	Auxiliary info 1: Block no.:		
95	DI module not configured	PLC contains a module that was not configured.	Check configuration. Check address setting on the module.
	Auxiliary info 1: DI byte no.:(0 to 127)		
96	DQ module not configured	PLC contains a module that was not configured.	Check configuration. Check address setting on the module.
	Auxiliary info 1: DQ byte no.:(0 to 127)		
97	AI module not configured	PLC contains a module that was not configured.	Check configuration. Check address setting on the module.
	Auxiliary info 1: AI word no.:(128 to 254)		

Error Code	Error Message	Error Cause	Recovery Procedures
98	AQ module not configured	PLC equipped with a module that was not configured.	Check configuration. Check address setting on the module.
	Auxiliary info 1: AQ word no.:(128 to 254)		
111	Substitution error when calling the AQ FB	One or more invalid parameters in FB 251 call.	Correct the FB 251 call in the control program.
	Auxiliary info 1: AQ word no.:		
112	Substitution error when calling the AI FB	One or more invalid parameters in FB 250 or FB 252 call.	Correct the FB 250 or FB 252 call.
	Auxiliary info 1: AI word no.:		
113	Invalid AI channel number	Invalid channel number specified in FB 250 or FB 252 call.	Correct the FB 250 or FB 252 call. Channel number must be in the range from 0 to 15.
	Auxiliary info 1: AI word no.:(128 to 254)		
114	AI word not configured	Non-addressable AI word specified in FB 250 or FB 252 call.	Configure AI word with COM 115H or correct the FB 250 or FB 252 call.
	Auxiliary info 1: AI word no.:(128 to 254)		
115	Invalid AI channel type	Invalid channel type specified in FB 250 or FB 252 call.	Correct the FB 250 or FB 252 call. Channel type must be in the range from 3 to 6.
	Auxiliary info 1: DI byte no.:(128 to 254)		
116	Invalid AI module address	Invalid module address specified in FB 250 or FB 252 call.	Correct the FB 250 or FB 252 call. Module address must be in the range from 128 to 224 and divisible by 8.
	Auxiliary info 1: DQ byte no.:(128. to .254)		
127	Time interrupt discrepancy	Hardware fault on the 942H CPU.	- Replace CPUs
130	Programming error in direct access operation	Direct access to protected memory area (e.g. Write to EPROM).	Locate direct access statement with the aid of the step address counter (SAC) and correct the statement.
	Auxiliary info 1: Source or destination address		

Error Code	Error Message	Cause of Error	Recovery Procedures
131	Time-out error in direct access operation	IP module or EU failed Incorrect configuring of address range	Check module's addressing socket. Check address ranges for single-channel and switched I / Os.
	Auxiliary info 1: Source or destination address		
134	Data handling error as result of software modification	Standby controller detected - non-identical block lengths - block missing	All dynamic data transferred from master to standby controller.

E Guidelines for Handling Electrostatic Sensitive Devices (ESD)

Figures

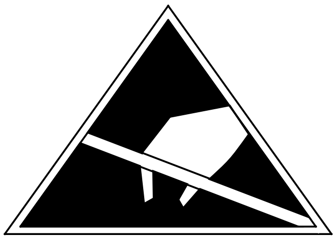
E Guidelines for Handling Electrostatic Sensitive Devices (ESD)

What is ESD?

All electronic modules are equipped with large-scale integrated ICs or components. Due to their design, these electronic elements are very sensitive to overvoltages and thus to any electrostatic discharge.

These **E**lectrostatic **S**enstive **D**evices are commonly referred to by the abbreviation **ESD.**

Electrostatic sensitive devices are labelled with the following symbol:



Caution

Electrostatic sensitive devices are subject to voltages that are far below the voltage values that can still be perceived by human beings. These voltages are present if you touch a component or module without previously being electrostatically discharged. In most cases, the damage caused by an overvoltage is not immediately noticeable and results in total damage only after a prolonged period of operation.

Electrostatic charging of objects and persons

Every object with no conductive connection to the electrical potential of its surroundings can be charged electrostatically. In this way, voltages up to 15000 V can build up whereas minor charges, i.e. up to 100 V, are not relevant.

Examples:

• Plastic covers	up to	5000 V
• Plastic cups	up to	5000 V
• Plastic-bound books and notebooks	up to	8000 V
• Desoldering device with plastic parts	up to	8000 V
• Walking on plastic flooring	up to	12000 V
• Sitting on a padded chair	up to	15000 V
• Walking on a carpet (synthetic)	up to	15000 V

Limits for perceiving electrostatic discharges

An electrostatic discharge is

- perceptible from 3500 V
- audible from 4500 V
- visible from 5000 V

A fraction of these voltages is capable of destroying or damaging electronic devices.

Carefully note and apply the protective measures described below to protect and prolong the life of your modules and components.

General protective measures against electrostatic discharge damage

- Keep plastics away from sensitive devices. Most plastic materials have a tendency to build up electrostatic charges easily.

- Make sure that the personnel, working surfaces and packaging are sufficiently grounded when handling electrostatic sensitive devices.

- If possible, avoid any contact with electrostatic sensitive devices. Hold modules without touching the pins of components or printed conductors. In this way, the discharged energy cannot affect the sensitive devices.

Additional precautions for modules without housings

Note the following measures that have to be taken for modules that are not protected against accidental contact:

- Touch electrostatical sensitive devices only
  - if you wear a wristband complying with ESD specifications or
  - if you use special ESD footwear or ground straps when walking on an ESD floor.

- Persons working on electronic devices should first discharge their bodies by touching grounded metallic parts (e.g. bare metal parts of switchgear cabinets, water pipes, etc.).

- Protect the modules against contact with chargeable and highly insulating materials, such as plastic foils, insulating table tops or clothes made of plastic fibres.

- Place electrostatic sensitive devices only on conductive surfaces:
  - Tables with ESD surface
  - Conductive ESD foam plastic (ESD foam plastic is mostly coloured black)
  - ESD bags

- Avoid direct contact of electrostatic sensitive devices with visual display units, monitors or TV sets (minimum distance to screen > 10 cm).

The following Figure once again illustrates the precautions for handling electrostatically sensitive devices.

- a Conductive flooring material
- b Table with conductive, grounded surface
- c ESD footwear
- d ESD smock
- e Grounded ESD wristband
- f Ground connection of switchgear cabinet
- g Grounded chair

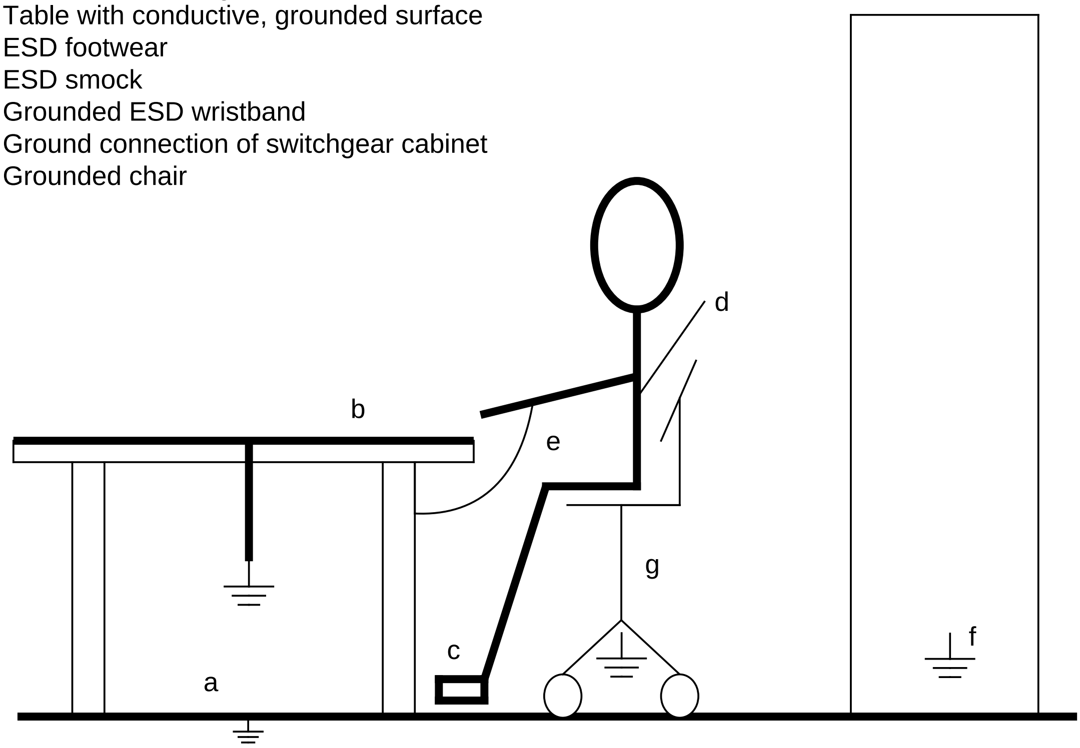


Figure E-1. ESD Measures

Taking measurements and working on ESD modules

Measurements may be taken on electrostatic sensitive devices only if

- the measuring device is grounded (e.g. via protective conductor) or
- the tip of the isolated measuring tool has previously been discharged (e.g. by briefly touching grounded metal parts).

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