SIMATIC S5

S5-100U
Programmable Controller

System Manual

CPU 100/102/103

EWA 4NEB 812 6120-02b

Edition 04

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How to Use This System Manual

The S5-100U is a programmable controller for lower and intermediate performance ranges. It meets all the requirements for a modern programmable controller. To use this controller optimally, you need detailed information.

In this system manual we have attempted to present this information as completely and as well organized as possible. Certain information is repeated in various chapters so that you do not have to leaf through the manual to find what you need.

This How to Use This System Manual section gives you information that will make it easier for you to find what you need. This section explains how the manual is organized.

Contents of This System Manual

- Hardware Description (Chapters 1, 2, and 3)
  These chapters describe the controllers: how they fit into the SIMATIC® S5 family of programmable controllers, how they function, and how you install them.
- Start-Up Information (Chapters 4, 5, and 6)
  These chapters summarize the information you need to start up your programmable controller. These chapters describe how the hardware and software influence each other.
- The Programming Language of the Programmable Controllers (Chapters 7, 8, and 9)
  These chapters describe the structure, operations, and structuring aids of the STEP® 5 programming language.
- Functions of the Programmable Controllers (Chapters 10, 11, 12, 13)
  Each of these chapters contains a complete description of a particular function, from wiring to programming. Subjects include analog value processing, counter and interrupt inputs, integral clock, and the programmable controller as a SINEC® L1 slave.
- Module Spectrum (Chapters 14 and 15)
  These chapters contain information about all the currently available S5-100U modules that you can use to expand your controller. Chapter 15, Function Modules, includes the modules that require an extensive description (i. e., more than just technical specifications).
- Overviews (Appendices)
  In these chapters you will find not only a complete list of operations but also dimension drawings, a description of errors that may occur during operation of the programmable controller, maintenance and repair procedures, a list of accessories, and reference literature about programmable controllers.

You will find correction pages at the end of the system manual. Use them to indicate any corrections, additions, or suggestions for improvement you might have. Send these suggestions to us. They will help us to improve the next edition of this system manual.

Conventions

This system manual is organized in menu form to make it easier for you to find information. This means the following:

- Each chapter is marked with printed tabs.
- At the front of the system manual is an overview page that lists the title of each chapter. Following this page, you will find a table of contents.
- At the beginning of each chapter is a table of contents for that chapter. Each chapter has three level headings that are numbered. The fourth level heading is not numbered but appears in **boldface type**.
- Pages, figures, and tables are numbered separately for each chapter. On the back of the table of contents for each chapter you will find a list of the figures and tables that appear in that chapter.

This system manual employs the following specific structuring devices:

- Specific terms have characteristic abbreviations (e. g., programmer is PG). Appendix A contains a list of abbreviations.
- Footnotes are marked with a raised number (e. g., "[1]") or a raised asterisk (" * "). You will find the corresponding explanations in the lower margin of the page or under a figure or table if the footnote appears in one of these.
- Lists are designated with bullets (• as in this particular listing) or with hyphens (-).
- Cross references are indicated as follows: (see section 7.3.2). There are no references to specific page numbers.
- Dimensions in drawings are indicated in millimeters and inches.
- Value ranges are indicated as follows: 17 to 21 or 17-21.
- Especially important information appears in framed boxes such as the following:

Warning

You will find definitions for the terms "Warning," "Danger," "Caution," and "Note" in the Safety-Related Guidelines for the User at the end of the introduction.

Changes Made to the Second Edition of the S5-100U System Manual (Order Number: 6ES5 998-0UB22)

S5-100U System Manual (Order Number 6ES5 998-0UB23) has been completely revised:

- The format was adapted to the other system manuals in the SIMATIC S5 family.
- The contents were updated and reorganized.

Some of the functions of CPU 103 have been expanded:

- The default settings (default parameters) for DB1 have been integrated into CPU 103 version 8MA03. This feature makes it easier for you to use the internal CPU functions. The following chapters were included or completely revised in the system manual:
  - Chapter 9 “Integrated Blocks and Their Functions”
  - Chapter 12 “Integral Real-Time Clock, for CPU 103 Version 8MA02 and Higher”
  - Chapter 13 “Connecting the S5-100U to SINEC L1, for CPU 102 and Higher”
- The execution times of some operations have been reduced considerably, compared to the “old” CPU 103. For the new execution times refer to the list of operations in Appendix A.

The S5-100U system has been expanded to include an additional module:

- The “Communications Module CP 521 BASIC” is described in section 15.10.2.

Changes Made to the Third Edition of the S5-100U System Manual (Order Number: 6ES5 998-0UB23)

The contents were updated.

Training

Siemens offers a wide range of training courses for SIMATIC S5 users. Contact your Siemens representative for more information.

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 The SIMATIC S5 System Family

Figures

1 The SIMATIC S5 System Family

The programmable controllers (PLCs) in the SIMATIC S5 family offer economical solutions to simple control tasks and to complex computer functions.

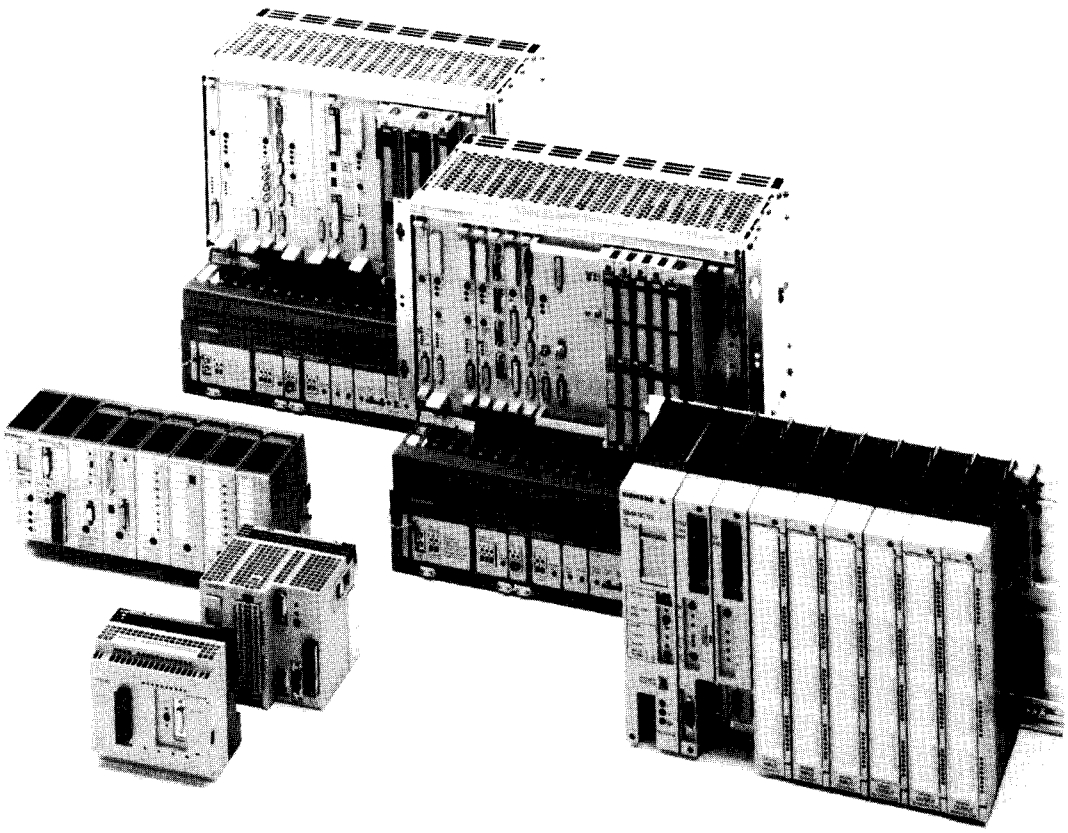

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Figure 1-1. Members of the SIMATIC S5 System Family

The S5-100U programmable controller is one of the smallest and most economical of the programmable controllers in the SIMATIC S5 family. The S5-100U is especially suited for small automation tasks. It is economical to use these programmable controllers if you want to replace more than five control relays.

The S5-100U has the following features:

- Modular Design

  Depending on the CPU you use, the S5-100U allows you to have a maximum of 448 digital inputs and outputs. It is suitable for machine control and for process automation and monitoring on a medium scale. The S5-100U allows a broad expansion capability with various types of modules to adapt optimally to a control task.

- Rugged, Lightweight Design

  All of the modules you can use with the S5-100U are block-type modules that are small, rugged, and easy to use. The modules operate without fans. None of these modules has electro-magnetically sensitive electronics. The modules are plugged into bus units and screwed tightly so that they are vibration-proof.

  The bus units snap onto a standard mounting rail. You can configure the S5-100U in one or more tiers and configure it vertically or horizontally. The S5-100U offers such a wide range of configuration possibilities that you can use it in rough and difficult operating conditions.

- Simple Programming

  The programming language is STEP 5 and its comprehensive operations set. It provides three different methods of representation, - four, if you have a CPU 103 or higher.

  You can use any of the U series programmers to program your S5-100U, or you can load programs from memory submodules.

2 Technical Description

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2 Technical Description

This chapter describes the design and principle of operation for the S5-100U programmable controller and its accessories.

2.1 Programmable Controller Design

The S5-100U belongs to the SIMATIC S5 range of programmable controllers. The S5-100U consists of various functional units (modules) that you can combine according to the task you want to perform.

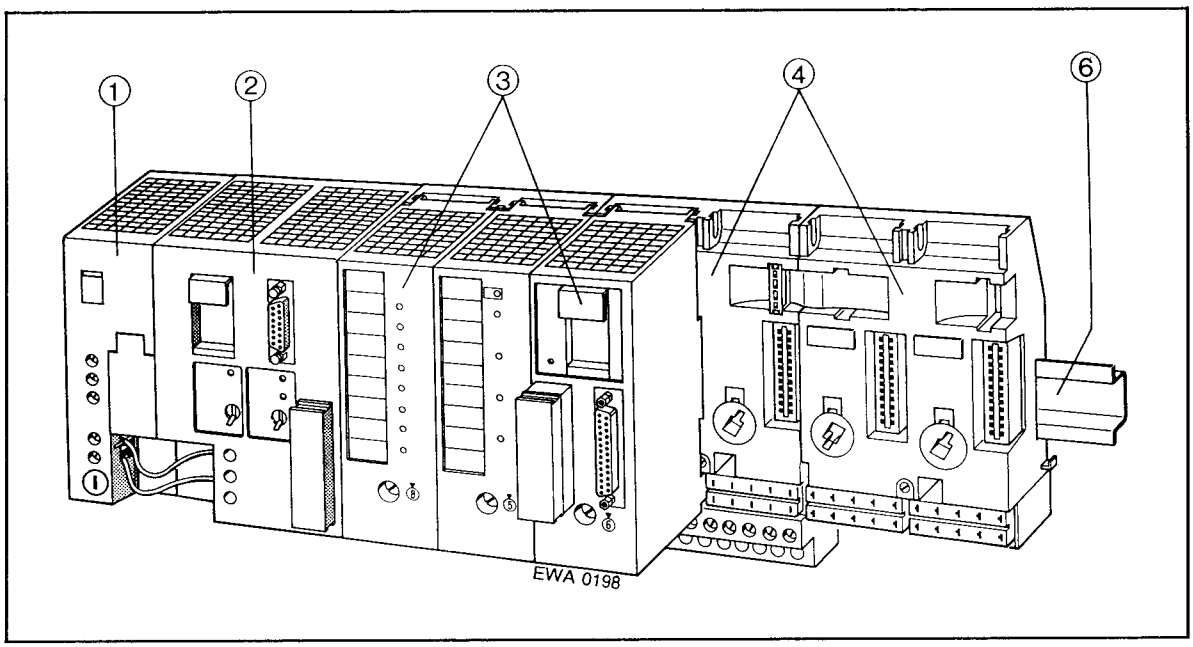


Figure 2-1. The S5-100U

① **Power supply module (PS 930)**

This module is required if 24 V DC is not available for the CPU.

② **Central processing unit (CPU)**

The CPU scans the control program. In the event of a power failure, a backup battery located in the battery compartment saves the memory contents (9).
The control program can be stored in a memory submodule.
The CPU has a serial port, and you can connect a programmer, an operator panel, or a SINEC L1 bus to it.

Input/output modules

Input/output modules transfer information between the CPU and such process peripherals as sensors, actuators, and transducers. You can use the following types of input/output modules with your S5-100U:

- Digital input modules and digital output modules (4, 8, and 16/16 channel)
  - Use these modules for simple control tasks involving signal states “0” and “1” only.
- Analog input modules and analog output modules
  - Use these modules to record and generate such variable quantities as currents and voltages.
- Timer module
  - Use this module to set various times without having to change the program.
- Counter module
  - Use this module to count pulses up to 500 Hz. You can input comparison values without having to change the program.
- High-speed counter/position detection module
  - Use the high-speed counter to record high-speed counter pulses of 25/500 kHz. You can use this module for position detection in a positioning task.
- Comparator module
  - This module makes it possible for you to monitor preset comparison values, such as for current and voltage.
- Simulator module
  - Use this module to generate digital input signals or to display digital output signals.
- Diagnostic module
  - Use this module to check the function of the I/O bus.
- Communications module (CP)
  - Use this module to output message texts with the date and clock time to a connected printer. You can also use this module to connect to external systems.
- Intelligent I/O module (IP)
  - Use these intelligent input/output modules for such special tasks as temperature control and positioning tasks.

Bus units with terminal blocks (Crimp-snap-in or SIGUT, screw type)

Use bus units to connect the CPU to input/output modules. You can plug two input/output modules into a single bus unit.

Interface modules (IM)

Use these modules to assemble your S5-100U in a multi-tier configuration.

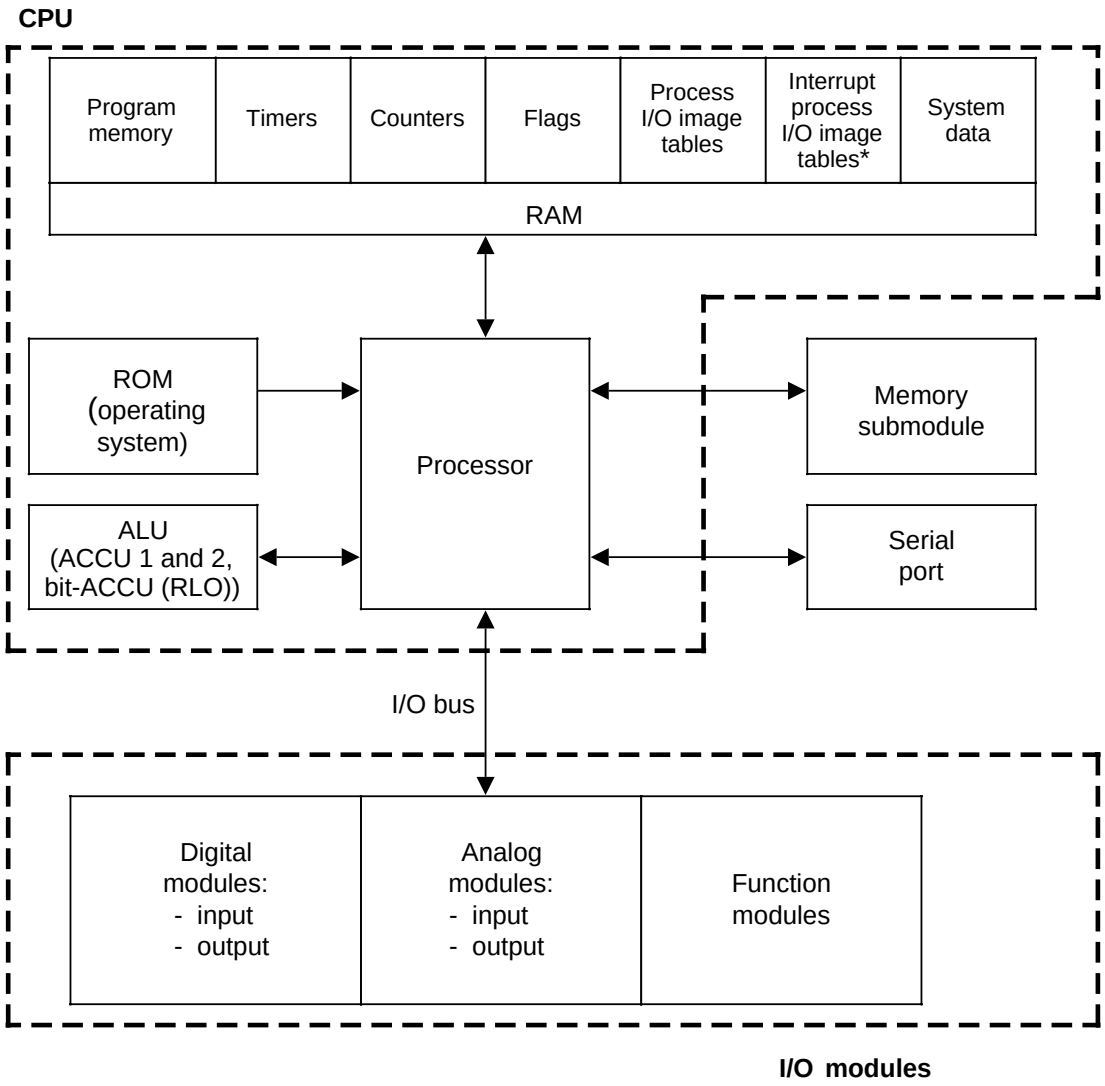
Standard mounting rail

Mount your programmable controller on the standard mounting rail.

2.2 Principle of Operation for the Programmable Controller

The remainder of this chapter explains how your S5-100U processes your program.

2.2.1 Functional Units



* Beginning with CPU 103, version 8MA02

Figure 2-2. Functional Units of the S5-100U

Program Memory (EPROM/EEPROM)

In order to safely store the control program outside of your S5-100U, you must store it on an EPROM or EEPROM memory submodule (see section 4.4).
Programs that are available on a memory submodule (EPROM or EEPROM) can be copied to the internal program memory (see section 4.3). This internal program memory is a reserved area of the CPU's internal RAM memory.

The internal RAM memory has the following characteristics:

- The memory contents can be changed quickly.
- Memory contents are lost when there is a supply voltage failure and there is no battery backup.

Operating System (ROM)

The operating system contains system programs that determine how the user program is executed, how inputs and outputs are managed, how the memory is divided, and how data is managed.
The operating system is fixed and cannot be changed.

Process Image Tables (PII, PIQ)

Signal states of input and output modules are stored in the CPU in “process image tables”. Process image tables are reserved areas in the RAM of the CPU.

Input and output modules have the following separate image tables:

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

Serial Interface

You can connect programmers, operator panels, and monitors to the serial port (cable connector). You can use the serial port to connect your S5-100U as a slave to the SINEC L1 local area network.

Timers, Counters, Flags

The CPU has timers, counters, and flags available internally that the control program can use.
The program can set, delete, start, and stop the timers and counters. The time and count values are stored in reserved areas of the RAM memory.

There is another area in the RAM memory where information such as intermediate results can be stored as flags. You can address the flags by bits, bytes, or words.

If battery backup is available, then some of the flags and counters remain in the internal RAM memory even if the supply voltage fails or your S5-100U is switched off. These flags and counters are retentive.

Table 2-1 gives information about the number and retentive characteristics (the internal memory contents are retained/are not retained) of these timers, counters, and flags.

Table 2-1. Retentive and Non-Retentive Operands

Operand	Retentive	Non-Retentive		
	CPU 100 to 103	CPU 100	CPU 102	CPU 103
Flags	0.0 to 63.7	64.0 to 127.7	64.0 to 127.7	64.0 to 255.7
Counters	0 to 7	8 to 15	8 to 31	8 to 127
Timers	____	0 to 15	0 to 31	0 to 127

Arithmetic Unit

The arithmetic unit (ALU) consists of two accumulators, ACCU 1 and 2. The accumulators can process byte and word operations.

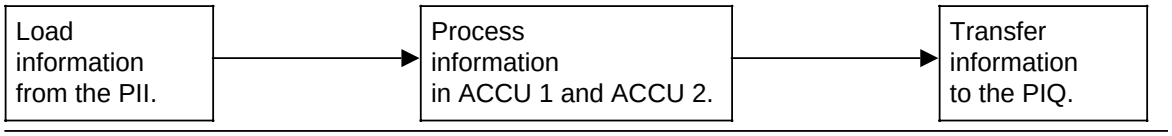


Figure 2-3. Example of an Arithmetic Logic Unit's Mode of Operation

Accumulator Design

Figure 2-4. Accumulator Design

Processor

According to the control program, the processor calls statements in the program memory in sequence and executes them. 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.

External I/O Bus

The I/O bus is the electrical connection for all signals that are exchanged between the CPU and the S5-100U modules in a programmable controller.

2.2.2 Mode of Operation for the External I/O Bus

The S5-100U has a serial bus for the transfer of data between the CPU and the I/O modules. This serial bus has the following characteristics:

- The modular design permits optimal adaptation to the particular control task.
- No addresses have to be set on the I/O modules.
- A terminating resistor connector is not required.
- Direct access to individual modules is not possible.

A number of shift registers moves the data (Figure 2-5).

Four data bits and one check bit for bus monitoring are assigned to each slot in the bus unit. All modules requiring more than four data bits have their own shift register and therefore do not have to use the shift register of the particular slot.

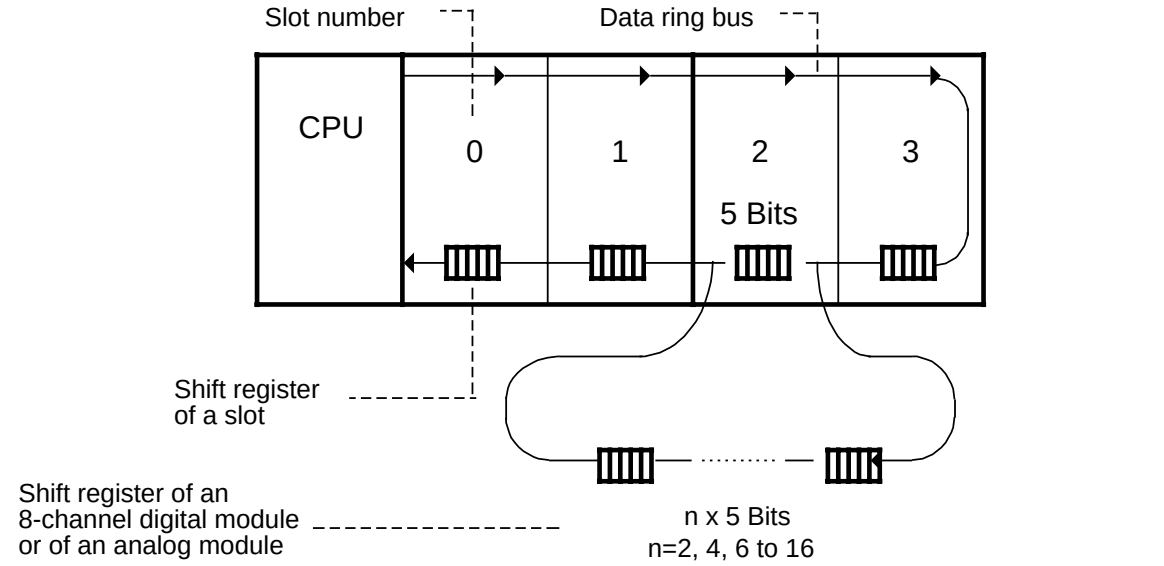


Figure 2-5. Structure of the External I/O Bus

Data Cycle

Prior to a program scan, the external I/O bus transfers current information from the input modules to the process image input table (PII). At the same time, information contained in the process image output table (PIQ) is transferred to the output modules.

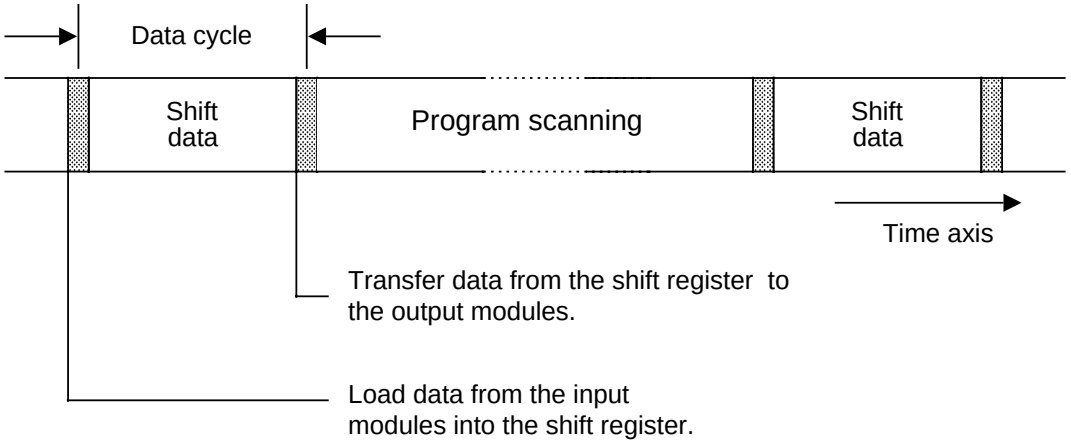


Figure 2-6. Data Cycle

Interrupt Data Cycle, for CPU 103 version 8MA02 and higher

There is an interrupt input data cycle prior to each time-controlled or interrupt-driven program scan.

Before a time-controlled program scan, current information about the input modules is read into the interrupt PII. Before an interrupt-driven program scan, interrupt inputs on slots 0 and 1 only are read into the interrupt PII.

Following a time-controlled program scan, there is not an interrupt output data cycle until data has been moved into the interrupt PIQ via a transfer operation (see section 6.6.2).
Information is output from the interrupt PIQ to the output modules during an interrupt output data cycle. The PIQ is updated.

Length of the Shift Register

The total length of the shift register is obtained from the sum of the data bits of all plugged-in modules and of the empty slots. The check bit is not counted.
You must know the length of the shift register to be able to determine the data cycle time. Data cycle time is 25 µs x number of data bits.

Table 2-2. Number of Bits per Module in the Shift Register

Plugged-in Module	Number of Data Bits
Diagnostic module or vacant slot	4
4-channel digital input and output modules	4
500 Hz comparator module, 500 Hz timer module, 500 Hz counter module	4
25 KHz counter module	32
8-channel digital input and output modules	8
Digital input and output module, 16 inputs/16 outputs	16
Simulator module	8
Analog modules for each activated channel	16*
CP 521, IP 262, IP 266, IP 267	64
Refer to the individual manuals for information on other modules.	

* This does not apply to the 466-8MC11 analog input module (8 data bits).

The CPU specifies the maximum length of the shift register in a particular configuration.

- CPU 100: 256 data bits, 128 (max.) of these from analog modules
- CPU 102: 480 data bits, 256 (max.) of these from analog modules
- CPU 103: 704 data bits, 512 (max.) of these from analog modules

Note

If the maximum expansion allowed is exceeded, the S5-100U goes into the STOP mode. The “PEU” bit (I/O not ready) is set in the ISTACK.

Examples:

a) CPU 100: This CPU lets you operate six digital modules (8-channel) and two analog modules (4-channel):

[6 x 8+2 x (4 x 16)]=48+128<256

b) CPU 100: This CPU **does not** let you use three digital modules (8-channel) with three analog modules (4-channel) because the maximum permissible number of analog data bits would be exceeded:

[3 x 8+3 x (4 x 16)]=24+192<256

c) CPU 102: This CPU lets you operate seven digital modules (8-channel) and four analog modules (4-channel):

[7 x 8+4 x (4 x 16)]=56+256<480

d) CPU 102: This CPU **does not** let you use 20 digital modules (8-channel) with 5 analog modules (4-channel) because the maximum permissible number of analog data bits would be exceeded:

[20 x 8+5 x (4 x 16)]=160+320=480

e) CPU 103: This CPU lets you operate 24 digital modules (8-channel) and eight analog modules (4-channel):

[24 x 8+8 x (4 x 16)]=192+512=704

f) CPU 103: This CPU **does not** let you use 31 digital modules (8-channel) with four analog modules (2-channel) because the maximum permissible number of slots would be exceeded:

[31 x 8+4 x (2 x 16)]=248+128<704

3 Installation Guidelines

Figures

Tables

3 Installation Guidelines

3.1 Installing S5-100U Components

Except for the I/O module, all of the S5-100U components are mounted on standard mounting rails in accordance with DIN EN 50022-35x15. Mount the rails on a metal plate to obtain the same reference potential.
Bus units with a SIGUT/screw-type, or crimp snap-in connection method have different heights.

If you install, remove, or change any parts of your S5-100U system, your system must be in the state indicated in Table 3-1.

Table 3-1. Installing, Removing, and Changing S5-100U Components

Installing, Removing, and Changing:	S5-100U Power Status	S5-100U Operating Mode	Load Voltage
I/O modules	X	STOP	OFF
Bus units Interface modules	Power OFF	X	X
CPU power supply	Power supply voltage OFF	X	X

X=not relevant

3.1.1 Assembling a Tier

You need the following components to configure the S5-100U:

- Power supply module
- Central processing unit
- Bus units
- I/O modules

If you do not have a 24 V DC power supply, you must have a power supply module.

Mount the first module on the extreme left end of the standard mounting rail. Add other modules to the right of the first module.

Mounting the PS 930 Power Supply Module

The backplane design makes it easy to attach this module to the standard mounting rail.

1. Hook the module onto the standard mounting rail.
2. Swing the module back until the slide snaps into place (see Figure 3-1).

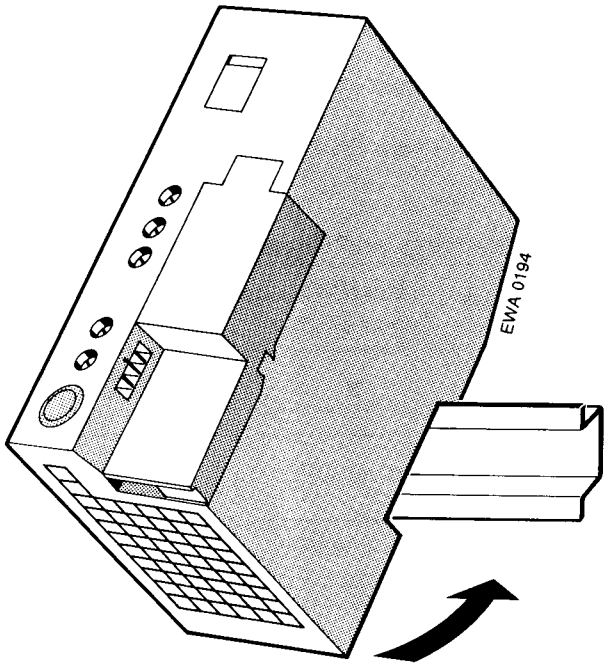


Figure 3-1. Mounting the PS 930 Power Supply Module

Removing the PS 930 Power Supply Module

1. Turn off the 115 V/230 V AC power supply.
2. Remove the connections between the CPU and the power supply module.
3. Use a screwdriver to press down on the slide on the bottom of the module.
4. Swing the module up and out of the standard mounting rail.

Mounting the Central Processing Unit

Follow the same procedure you used to mount the PS 930 power supply module (see Figure 3-1).

1. Hook the CPU onto the rail and to the right of the power supply module.
2. Swing the CPU back until the slide snaps into place.

Removing the CPU

1. Remove the I/O module located at slot "0".
2. Pull the connection (ribbon cable) between the CPU and the first bus unit.
3. Pull the connections between the CPU and the power supply module.
4. Use a screwdriver to press down on the slide on the bottom of the module.
5. Swing the module up and out of the standard mounting rail.

Mounting Bus Units

Use the same procedures to mount the bus unit that you used to mount both the power supply module and the CPU. Hooks are located on the sides of each bus unit. These hooks are used to connect bus units to each other and to connect bus units to the CPU.

Connecting Bus Units to Each Other or to the CPU

1. Pull the ribbon cable connector located on the top left of the bus unit out of its holder.
2. Plug the connector either into the receptacle located on the right side of the CPU or into the receptacle of the adjacent bus unit located on the left (see Figure 3-2).

Removing Bus Units

1. Pull the connections to the neighboring bus units or to the CPU.
2. Use a screwdriver to press down on the slide.
3. Swing the module up and out of the standard mounting rail.

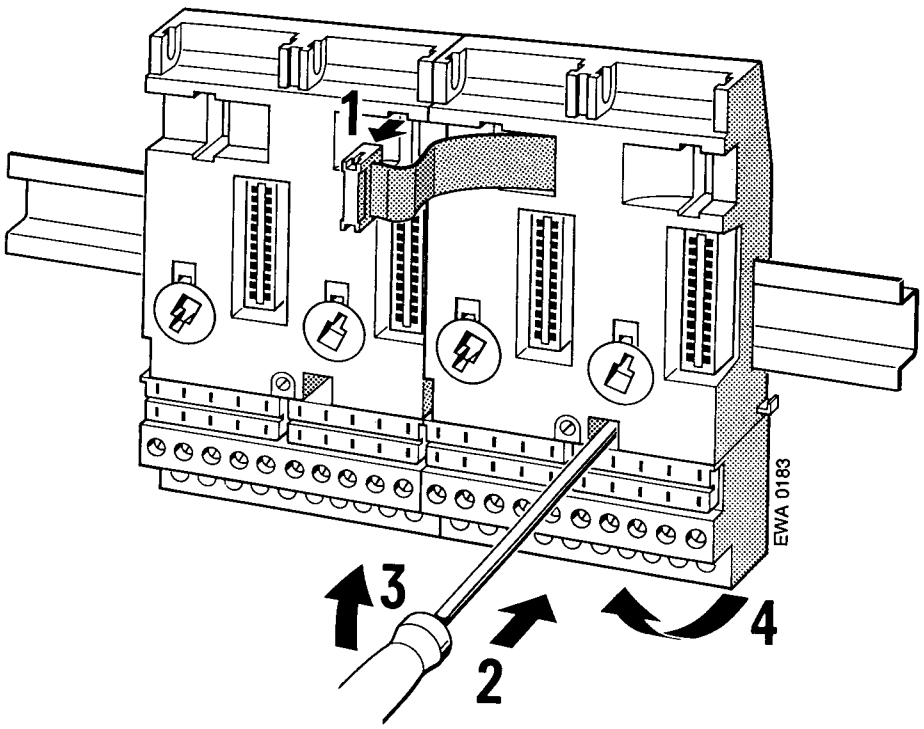


Figure 3-2. Removing Bus Units

Plugging Input and Output Modules into the Bus Units

Before you plug in an input or output module, you must set the bus unit's coding element to match the module type.

Setting the Coding Element

An identification number is printed on the front plate of every I/O module. Depending on the particular module type, the number is between two and eight. There is a white mechanical coding key located on the back of each module. The position of the coding key is determined by the module type and cannot be changed. The bus unit has a mating component for each key, a white rotating coding element or "lock" (see Figure 3-3).

Use a screwdriver to set the "lock" on the bus unit to the corresponding I/O module code number.

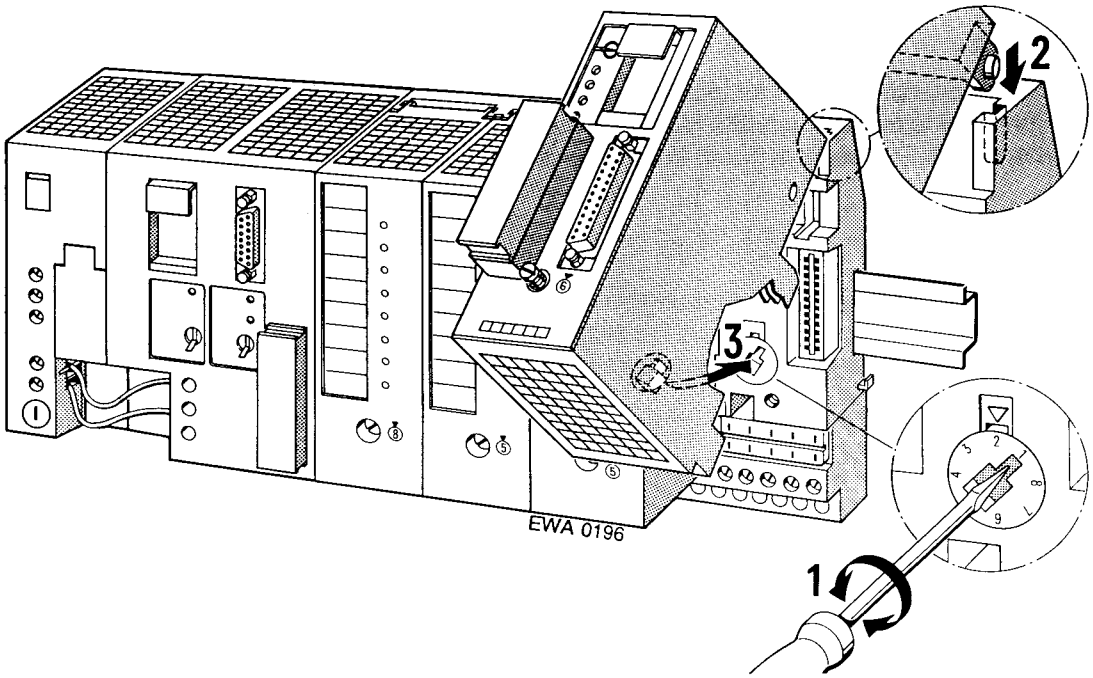


Figure 3-3. Coding System to Prevent an Inadvertent Interchange of Modules

The 6ES5 788-8MA11 simulator module does not have a coding key. You can plug in this simulator module in place of any module.

Attaching I/O Modules

1. Hook the module onto the top of the bus unit.
2. Swing the module down onto the bus unit.
3. Press the module down firmly.
4. Tighten the hold-down screw on the front of the module to attach the module to the bus unit.

Removing I/O Modules

Remove the hold-down screw and swing the module up and out of the bus unit.

3.1.2 Multi-Tier Expansion

If it is not possible to have all of the modules located on one tier, you can expand the configuration up to four tiers. You may use a maximum of 16 bus units. It does not matter how many bus units are mounted on a tier. You need one interface module per tier to interconnect the tiers.

Install an interface module as you would install a bus unit. You must connect each interface module to the last bus unit via the ribbon cable.

Use the IM 315 interface module for two-tier configurations. The IM 315 consists of two modules permanently connected to each other via a 0.5-m (20-in.) cable.

Use the IM 316 interface modules for multi-tier configurations. Use the 712-8 connecting cable to connect the IM 316 interface modules (Order No. 6ES5 712-8...).

The standard mounting rails must have a common reference potential if they are mounted in different cabinets.

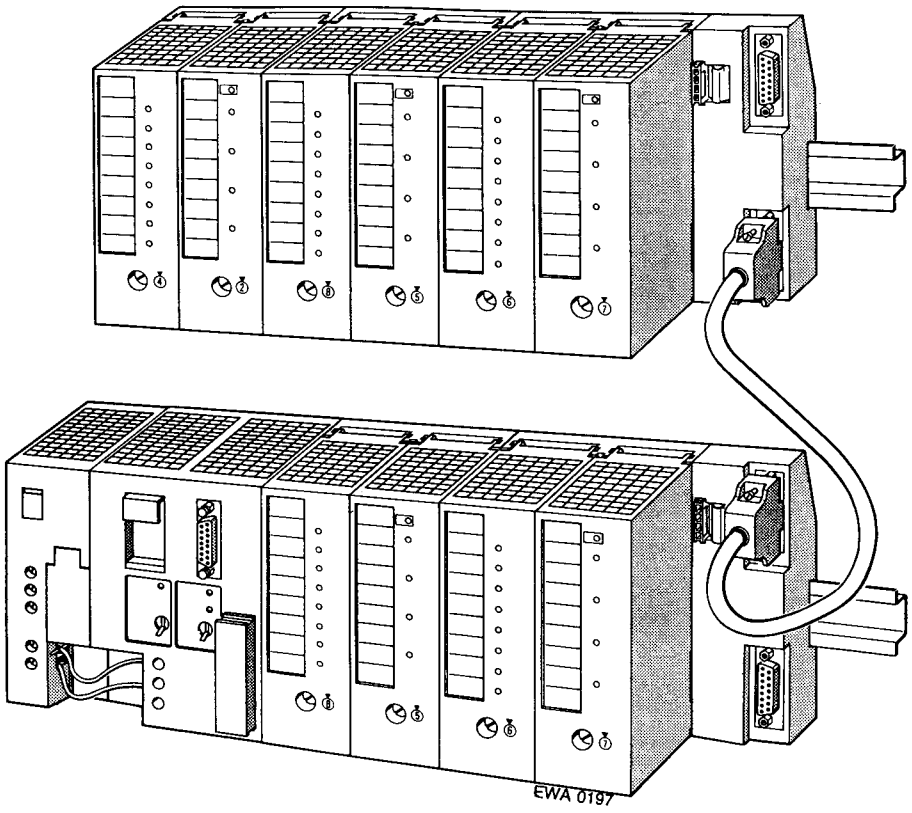


Figure 3-4. Interconnecting Tiers with Interface Modules (6ES5 316-8MA12)

Installing an Interface Module

1. Hook the interface module to the standard mounting rail.
2. Swing the interface module back until the slide on the bottom snaps into place on the rail.
3. Use the ribbon cable to connect the module to the last bus unit.
4. Use connecting cable 712-8 to join the two interface modules.
5. Connect the cable to the “out” socket on the programmable controller tier and to the “in” socket on the expansion tier.
6. Securely screw the connecting cable plugs in place. Use two screws for each connecting cable plug.

Removing an Interface Module

1. Only for the IM 316: Remove the hold-down screws from the plugs and remove the connecting cable.
2. Remove the connecting ribbon cable from the adjacent bus unit.
3. Use a screwdriver to press down on the slide located on the bottom of the interface module.
4. Swing the module up and out of the standard mounting rail.

3.1.3 Cabinet Mounting

Make sure that the S5-100U, the power supply, and all modules are well grounded. Mount the S5-100U on a metal plate to help prevent noise. There should be electrical continuity between the grounded enclosure and the mounting rails. Make sure that the system is bonded to earth.

You can use the 8LW system or the 8LX system mounting plates (see Catalog NV 21).

Adequate ventilation and heat dissipation are important to the proper operation of the system. You must have at least 210 mm (8.3 in.) between each mounting rail (see Figures in Appendix B) for proper ventilation.

Always locate the power supply and the CPU on the lowest tier to ensure better heat dissipation. To measure cabinet ventilation, define the total heat loss by calculating the sum of all typical heat losses (see Catalog ST 52.1).

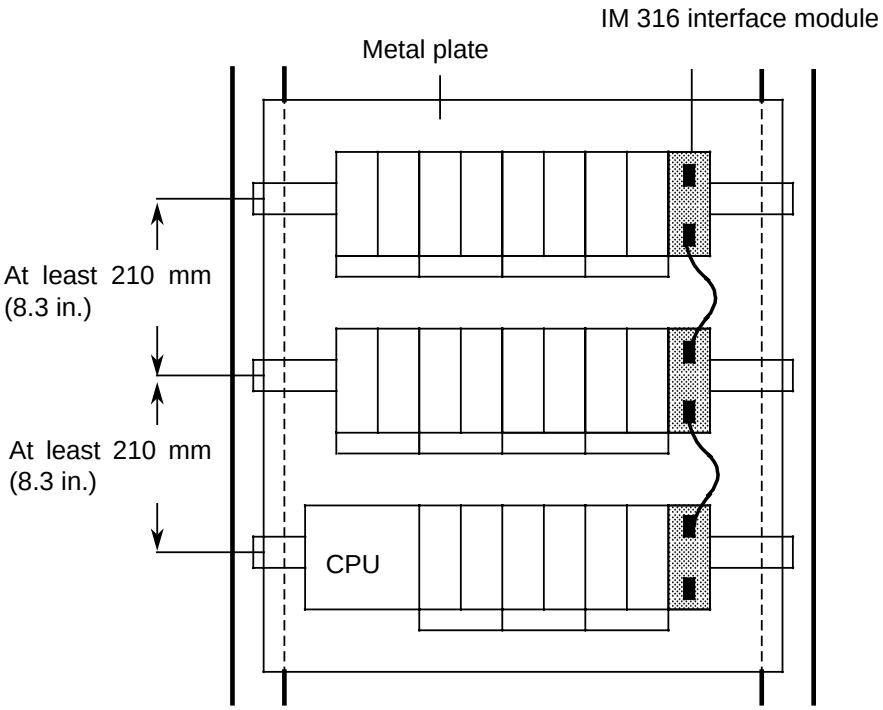


Figure 3-5. Multi-Tier Configuration in a Cabinet with the IM 316 Interface Module (6ES5 316-8MA12)

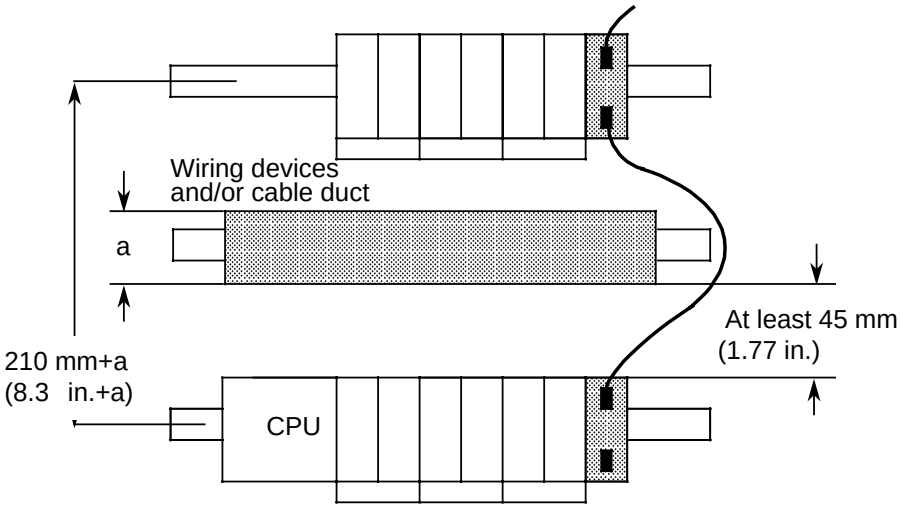


Figure 3-6. Cabinet Mounting with a Series of Devices

3.1.4 Vertical Mounting

You can also mount the standard mounting rails vertically and then attach the modules one over the other. Because heat dissipation by convection is less effective in this case, the maximum ambient temperature allowed is 40 °C (104 °F).

Use the same minimum clearances for a vertical configuration as for a horizontal configuration.

You must install a clamp (see Catalog SA 2) on the lower end of the programmable controller tier to hold the modules mechanically in position.

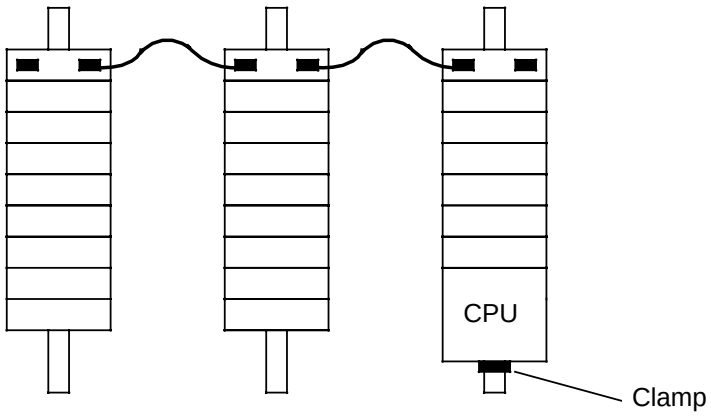


Figure 3-7. Vertically Mounting a Programmable Controller

3.2 Wiring

3.2.1 Connection Methods: Screw-Type Terminals and Crimp Snap-in

SIGUT Screw-Type Terminal

When using screw-type terminals, you can clamp two cables per terminal. It is best to use a 3.5-mm screwdriver to tighten the screws.

Permissible cable cross-sections are:

- A stranded conductor with a core end sleeve: 2 x 0.5 to 1.5 mm^2
- A solid conductor: 2 x 0.5 to 2.5 mm^2

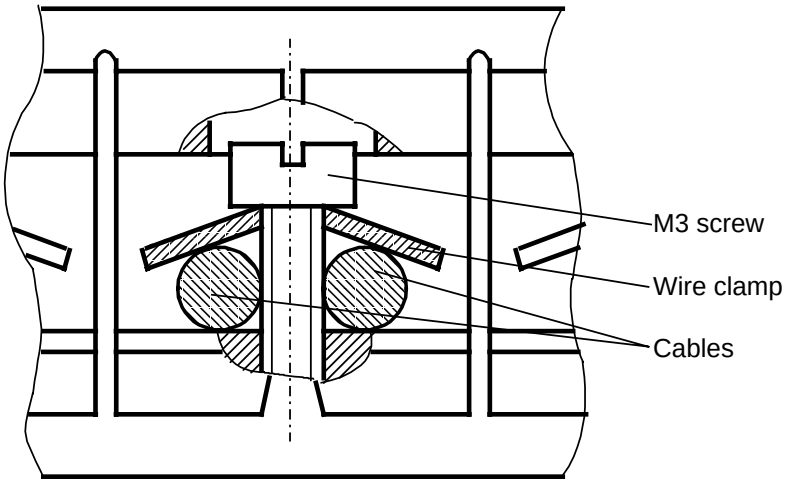


Figure 3-8. SIGUT/Screw-Type Connection Method

Crimp Snap-in Terminals

Bus units using the crimp snap-in connection method have the same height as the CPU.

You can connect stranded conductors with a cross-section of 0.5 to 1.5-mm^2 to these terminals.

Connecting the Contact to the Terminal Block

Refer to Figure 3-9 and perform the following steps to connect the contact to the terminal block.

1. Remove the module that is plugged into the bus unit.
2. Use a screwdriver to press down on the terminal block (1).
3. Swing the terminal block up. The rear side is now visible (2).
4. Push the contact into the desired opening until the locating spring engages.
   - Caution: The spring must point into the slot.
5. Pull lightly on the cable to make certain that the contact is properly engaged.
6. Swing the terminal block back into its original position.
7. Press up on the terminal block until it snaps into position.

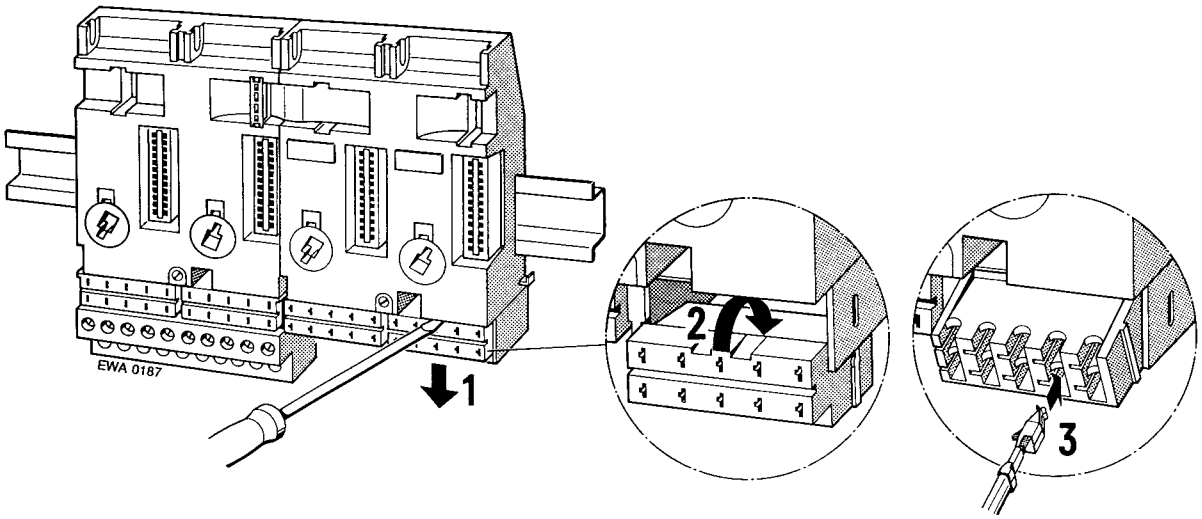


Figure 3-9. Mounting the Crimp Snap-In Terminal

Disconnecting a Terminal

1. Position the terminal block as is shown in Figure 3-10.
2. Insert the extraction tool into the slot beside the terminal so that you can compress the barb.
3. Position the cable in the groove on the extraction tool and pull out both the tool and the cable.
4. Realign the deformed barb so that you can use the terminal again.

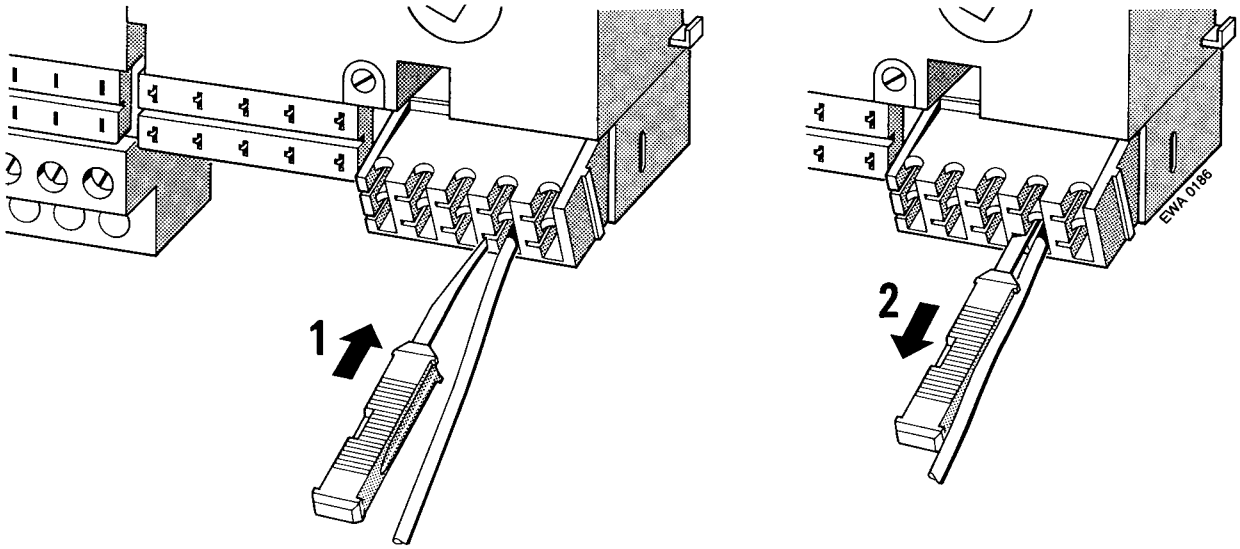


Figure 3-10. Disconnecting a Terminal

3.2.2 Connecting the Power Supply to the S5-100U

Power Supply Module

1. Set the voltage selector to the supply voltage you are using.
2. Swing up the protective cover.
3. Connect the supply cable to terminals L1, N and ⏚ (see Figure 3-11).
4. Close the protective cover.

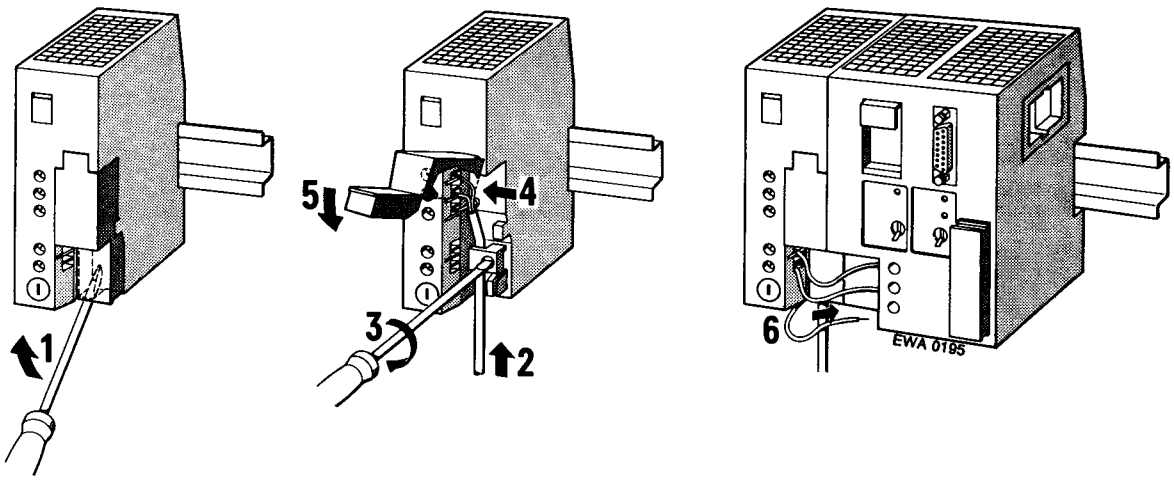


Figure 3-11. Connecting a Power Supply Module and a CPU

115/230 V AC power supply modules can be operated with a load voltage of 120/230 V AC.

CPU

1. Connect the L+ and M terminals of the PS 931 power supply module to the corresponding terminals on the CPU (see Figure 3-23).
2. Connect the ⏚ terminal of the CPU to the standard mounting rail.

3.2.3 Connecting Digital Modules

All I/O modules are plugged into bus units. Connect the I/O modules to the terminal blocks of the bus units. The connections illustrated in this section are of the screw terminal type (SIGUT connection method).

You can also use the crimp snap-in connection method described in section 3.2.1. In both cases, the terminal assignments are marked on the terminal blocks.

The assignments listed in Table 3-2 always apply for connecting the load voltage.

Table 3-2. Connecting the Load Voltage

Load Voltage	Terminal 1	Terminal 2
24 V DC	L+	M
115/230 V AC	L1	N

* 115/230 V AC digital modules can be operated with a load voltage of 120/230 V AC.

Note

For digital outputs, energy is temporarily stored in an internal capacitor for about 100 ms after the L+ supply is switched off.
Please note that this energy may be sufficient to activate low-rating loads (e.g., pulse valves) for a triggered output.

Connecting Four-Channel Digital Modules

All of these modules are designed for a two-wire connection. You can therefore wire directly to the sensor or output field device. An external distribution block is not required.

The four channels of a module are numbered from .0 through .3. (Numbers .4 through .7 are only significant for the ET 100 distributed I/O system.) Each channel has a pair of terminals on the terminal block.

The terminal assignments and the connection diagram are printed on the front plate of the module.

Connecting Four-Channel Input Modules

Example: Connecting a sensor to channel 2 (address I 3.2) on the input module in slot 3 (see Figure 3-12)

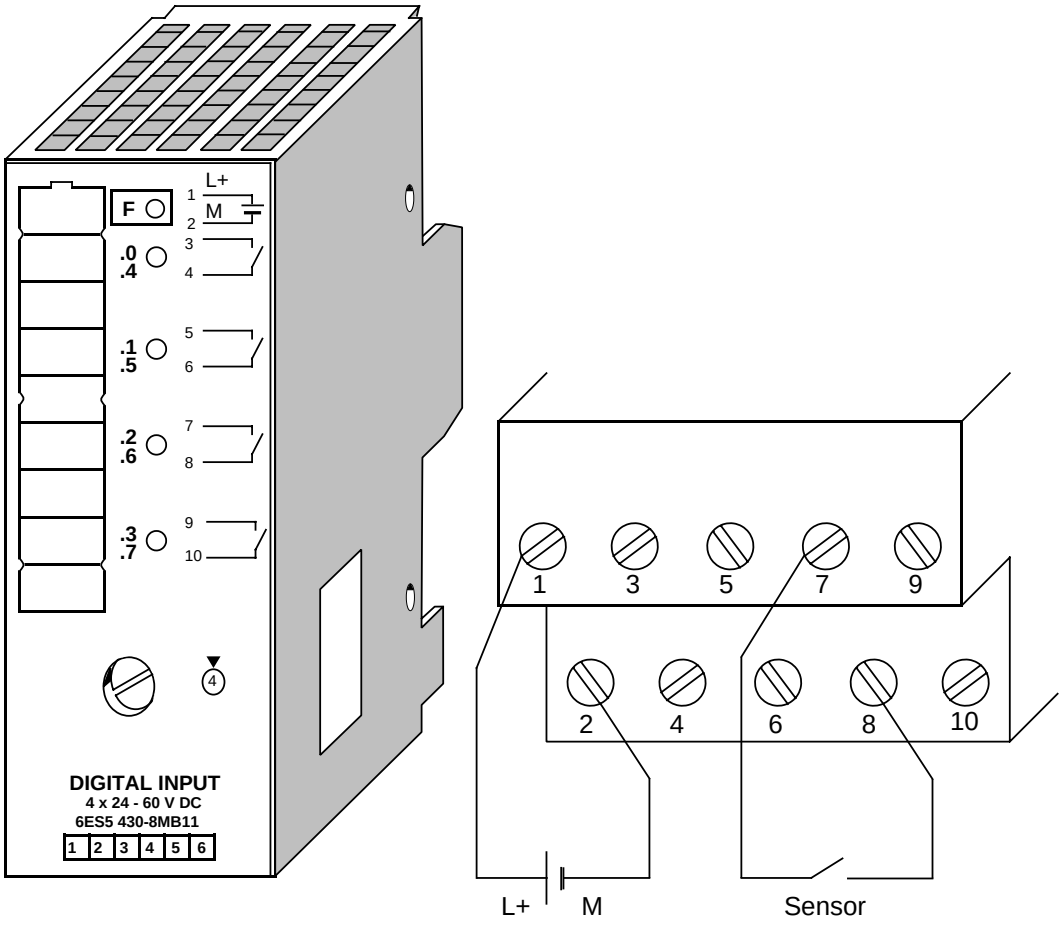


Figure 3-12. Two-Wire Connection of a Sensor to Channel 2

Connecting Four-Channel Output Modules

Example: Connecting a lamp to channel 3 (address Q 1.3) on the output module in slot 1 (see Figure 3-13)

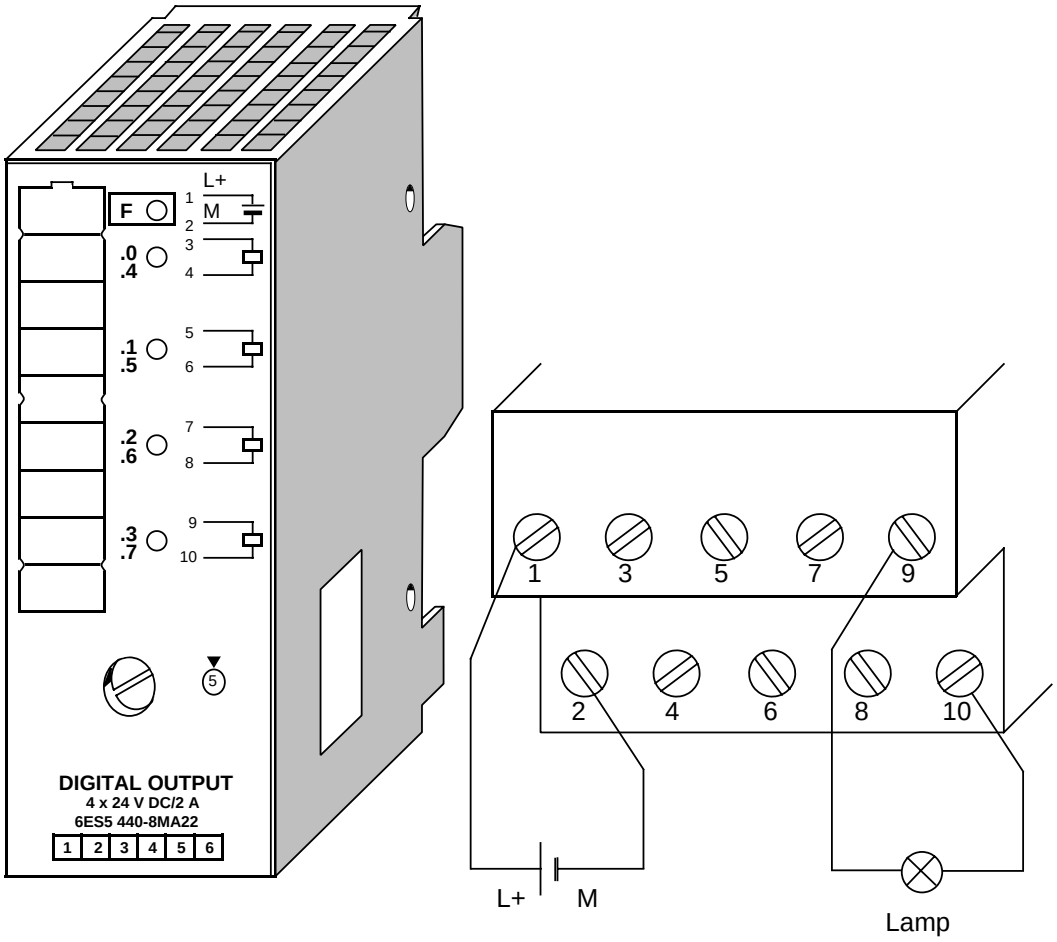


Figure 3-13. Two-Wire Connection of a Lamp to Channel 3

Connecting Eight-Channel Digital Modules

These modules do not have a two-wire connection. You therefore need an external distribution block.

The eight channels of a module are numbered from .0 through .7. One terminal on the terminal block is assigned to each channel. The terminal assignment and the connection diagram are printed on the front plate of the module.

Connecting Eight-Channel Input Modules

The sensors must be connected to terminal 1 via the L+ terminal block.

Example: Connecting a sensor to channel 4 (address I 3.4) on an input module in slot 3 (see Figure 3-14)

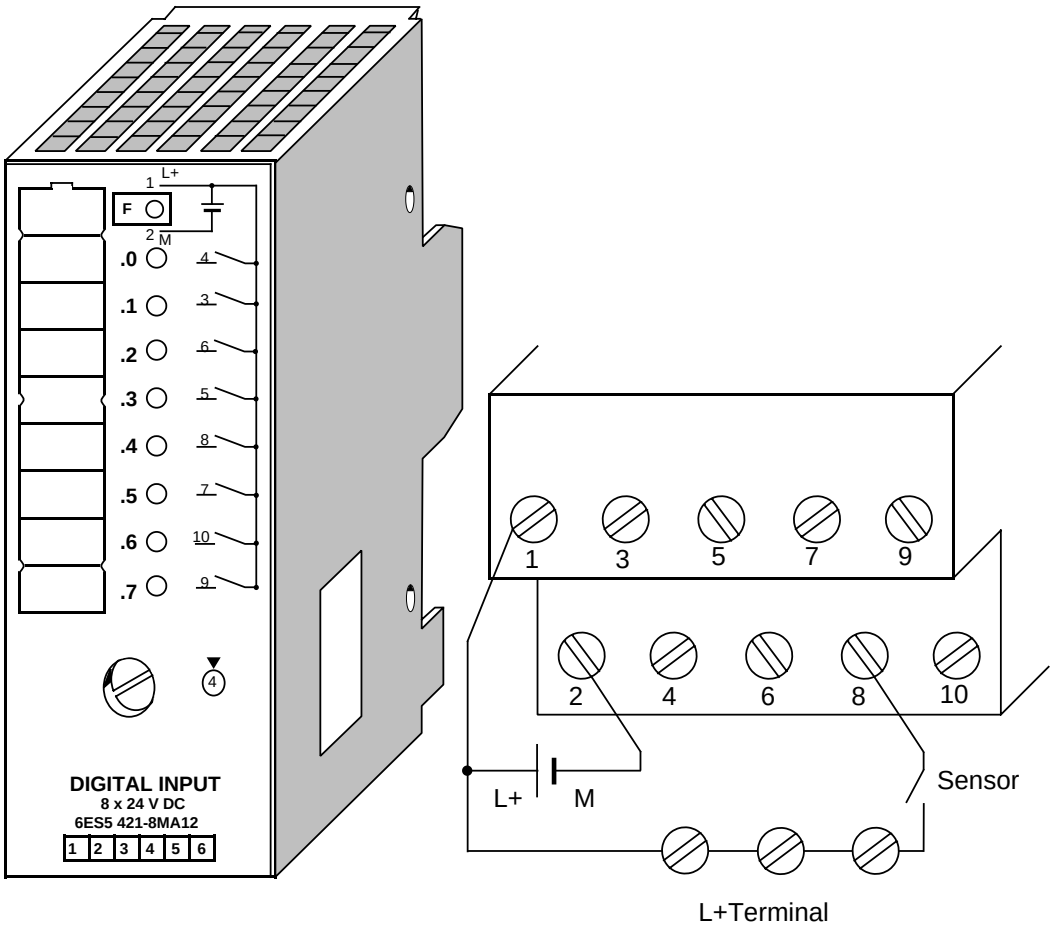


Figure 3-14. Connecting a Sensor to Channel 4

Connecting Eight-Channel Output Modules

The actuators must be connected to terminal 2 via the M (negative) terminal block. This does not apply to the digital output module 8× 5 to 24 V DC/0.1 A (see section 14.6.2).

Example: Connecting a lamp to channel 6 (address output Q 5.6) on an output module in slot 5 (see Figure 3-15)

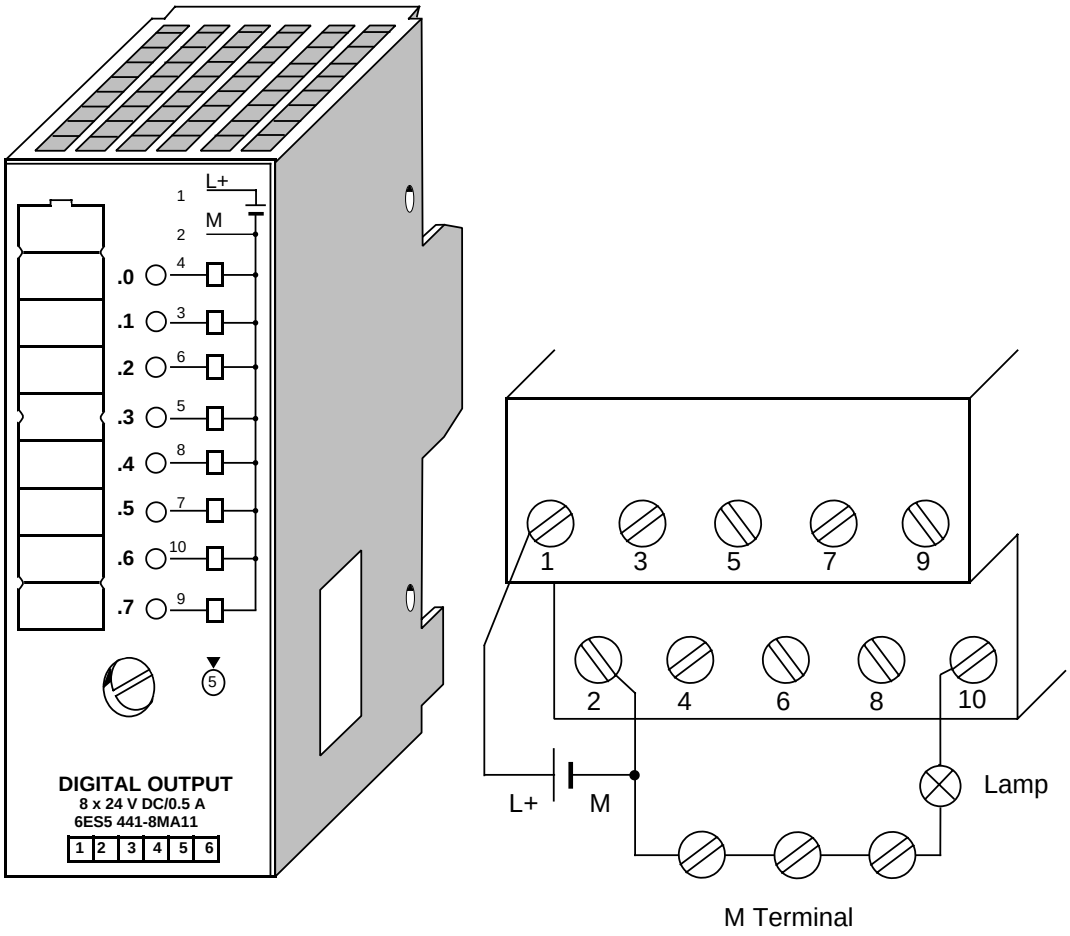


Figure 3-15. Connecting a Lamp to Channel 6

3.2.4 Connecting the Digital Input/Output Module

Use only slots 0 through 7 when you plug the module into the bus unit. Use a 40-pin cable connector with a screw-type connection or crimp snap-in connection for wiring. The module does not have a two-wire connection. You must therefore use an external distribution block.

Every channel is assigned a terminal on the 40-pin connector. The channel numbers are printed on the front plate.

The 16 channels on the input side (IN) are numbered from n.0 through n.7 and from n+1.0 through n+1.7. The 16 channels on the output side (OUT) are numbered from n.0 through n.7 and from n+1.0 through n+1.7. "n" is the start address of the slot. Slot 0, for example, has the start address of n=64 (see chapter 6).

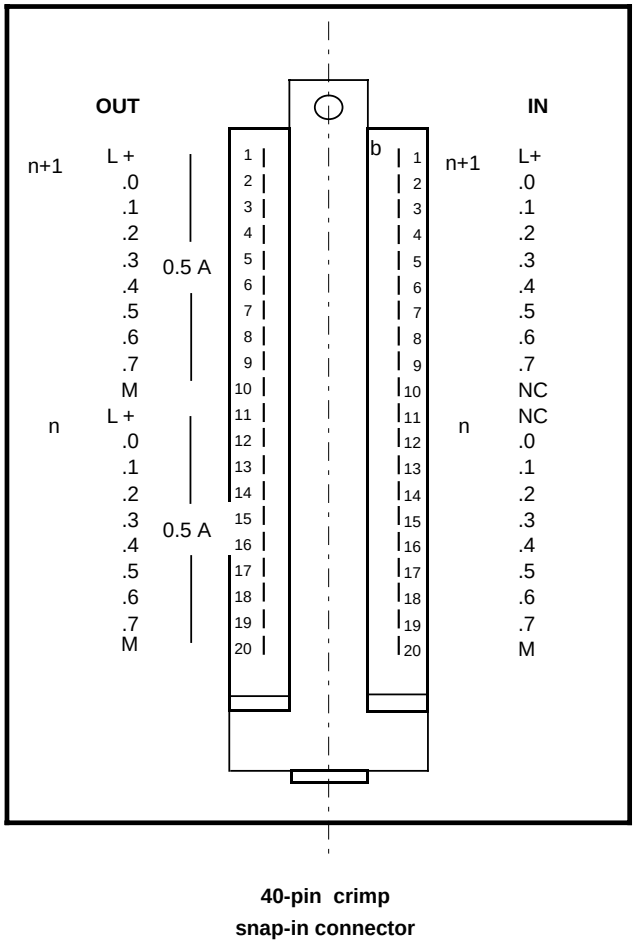


Figure 3-16. Front View of the Digital I/O Module with a Crimp Snap-In Connector (simplified view and not true to scale)

Example: The start address for the modules is 65.3. Inputs and outputs have the same address. A sensor is to be connected to input I 64.4 and a lamp to output Q 7.3. Figure 3-17 illustrates the wiring on the front connector.

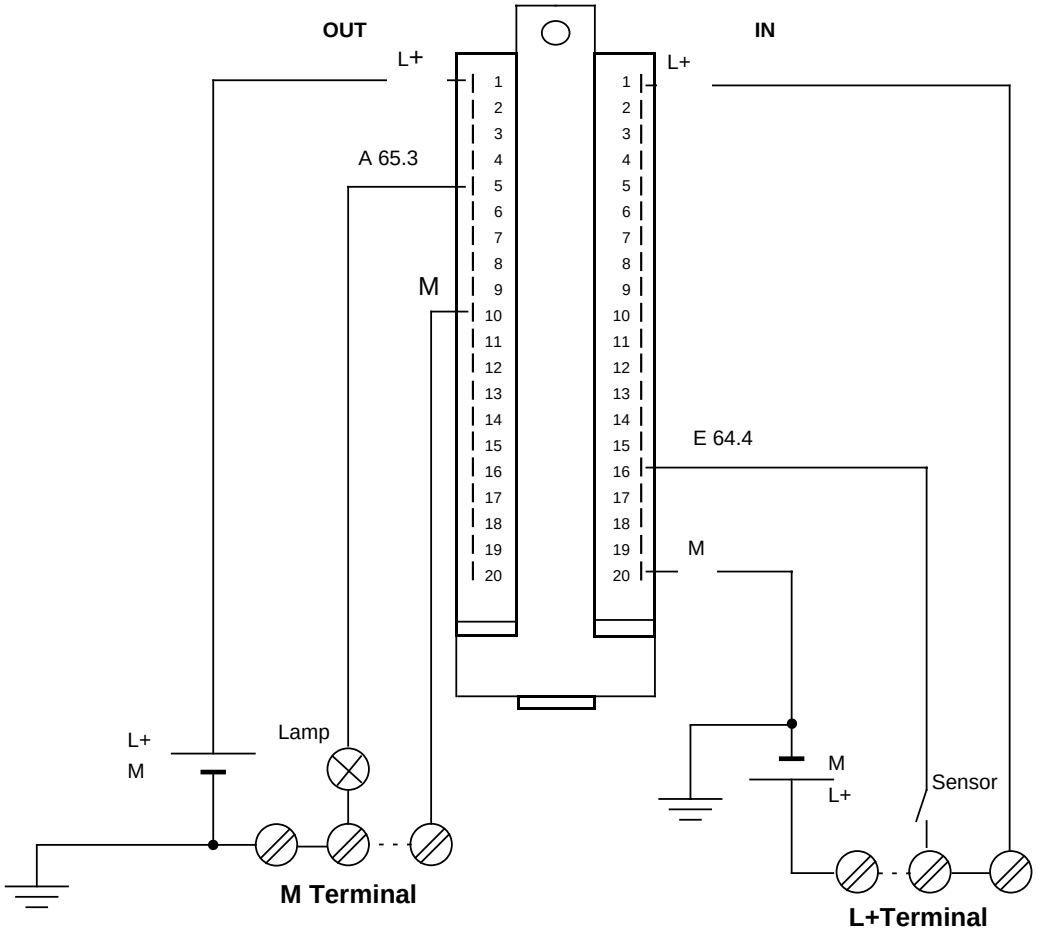


Figure 3-17. Connecting a Sensor and a Load to Digital Input/Output Module 482

Note

Chapter 11 describes how to connect analog modules.

3.3 Electrical Configuration

3.3.1 Electrical Configuration for the S5-100U

Power Supply

The entire control for the S5-100U consists of the following separate electrical circuits:

- Control circuit for the S5-100U (24 V DC)
- Control circuit for the sensors (24 V DC)
- Load circuit for the actuators (24 V DC or 115/230 V AC)

Control Circuit

The power source for the control circuit supplies the CPU, the bus units, the programmer interface, and the internal control circuits for the I/O modules. When the incoming supply is 24 V DC/1 A, the PS 931 power supply module provides an internal supply of +9 V up to a total of 1 A current input to the I/O modules. The grounding spring on the CPU forces the control circuit to be connected to the standard mounting rail. The grounding spring must also be protected from interference. The grounding spring must be grounded.

Load Circuit

The power source for the load circuit supplies the actuators of the process peripherals.

It is suggested that you use one of the following for a 24 V DC power supply:

- The PS 931 power supply module (see Chapter 14)
- A Siemens load power supply from the 6EV1 series (see Appendix D)

If you use load power supplies other than the recommended ones, make certain that the load voltage is in the range of 20 to 30 V (including ripple).

Note

If you use a switched-mode power supply unit to supply floating analog modules and BEROs, then this supply must be filtered through a network.

You can connect several mutually independent load circuits adjacent to each other on a single programmable controller. These connections can either be non-floating or floating (see section 3.3.3).

3.3.2 Electrical Configuration with External I/Os

Figures 3-18, 3-19, and 3-20 display different configuration possibilities. Pay attention to the following points when you design your configuration. The numbers appearing in parentheses in the following points refer to the numbers in Figures 3-18 to 3-20.

- You must have a main switch (**1**) in accordance with VDE 0100 for your S5-100U, the sensors, and the actuators.
- You do not need an additional fuse (**2**) to connect your S5-100U and the load circuit to power if your radial lines are a maximum of 3 meters (9.84 feet) long and are inherently earth-fault proof and short-circuit proof.
- You need a load power supply (**3**) for 24 V DC load circuits.
  - You need a back-up capacitor (rating: 200 μF per 1 A of load current) if you have non-stabilized load power supplies.
- If you have AC load circuits, galvanic isolation via a transformer (**4**) is recommended.
- You should ground the load circuit at one end. Provide a removable connection (**5**) to the ground conductor on the load power supply (terminal M) or on the isolating transformer.
  - You must provide earth-fault monitoring for any non-grounded load circuits.
- You must separately fuse (**6** and **7**) the load voltage for sensor circuits and for actuator circuits.
- You must connect the standard mounting rail of the S5-100U to the ground conductor through a capacitor (**8**, to suppress high-frequency noise) for a non-grounded configuration.
- You must have a low-resistance connection between the standard mounting rail and the cabinet's chassis ground (**10**) for a grounded configuration.
- You need a power fuse (**9**) to protect against a short-circuit occurring in the power supply.

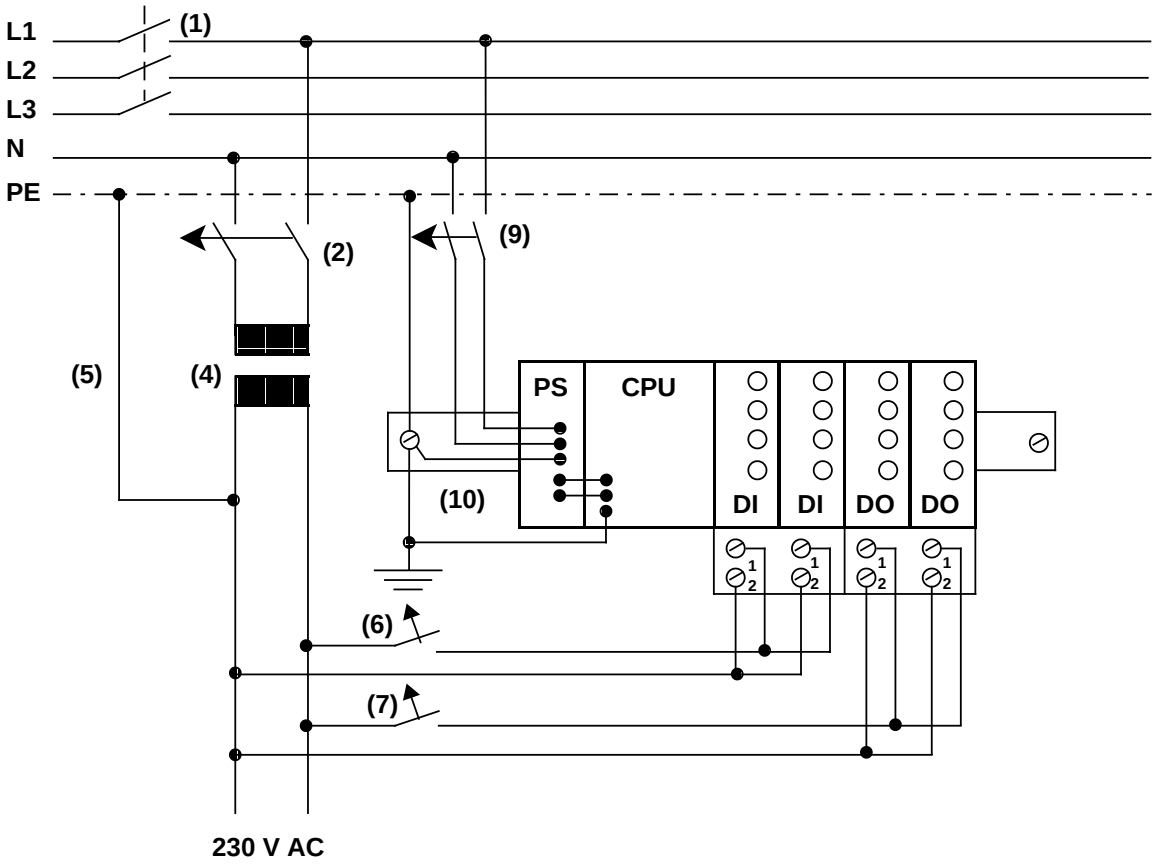


Figure 3-18. Configuration Possibility: S5-100U with 115/230 V AC Power Supply for Programmable Controller, Sensors, and Actuators

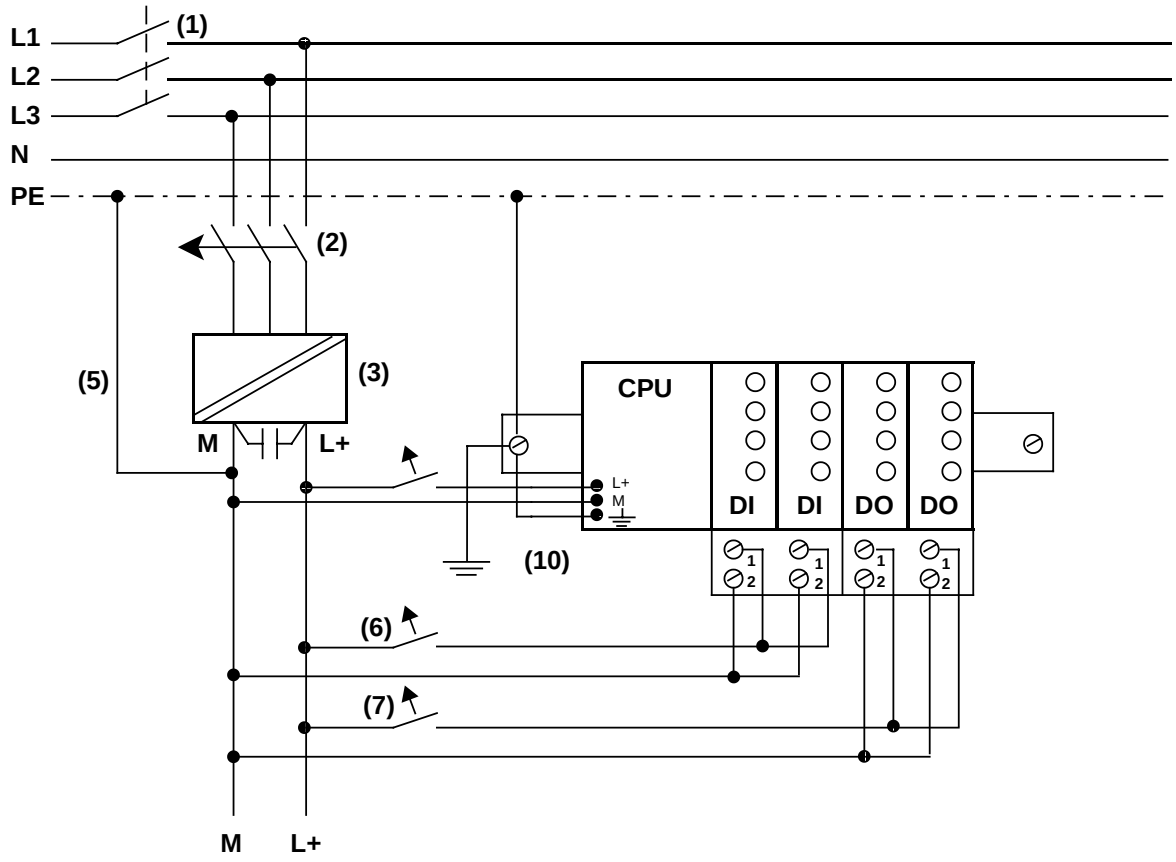


Figure 3.19 Configuration Possibility: S5-100U with 24 V DC Power Supply (with Safe Electrical Isolation According to DIN VDE 0160) for Programmable Controller, Sensors, and Actuators

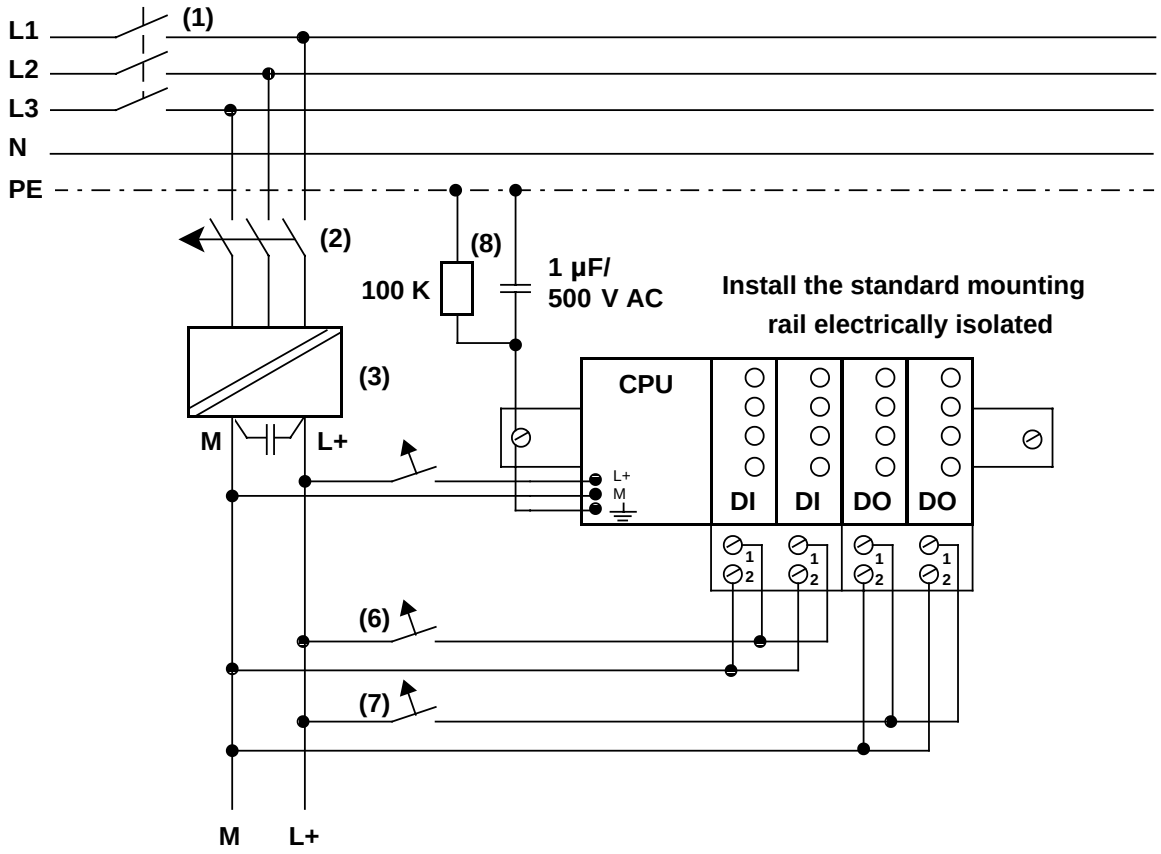


Figure 3-20. Non-Grounded Operation; 24 V DC Power Supply (with Safe Electrical Isolation According to DIN VDE 0160) for Programmable Controller and I/Os

Interference voltages are discharged to the ground conductor (PE) via a capacitor. You can prevent static charges by connecting a high-ohmic resistor (approx. 100 k / W) parallel to the capacitor.

3.3.3 Non-Floating and Floating Configurations

The S5-100U is powered by its own control circuit. The I/Os are powered by the load circuit.

The circuits can either be connected to the same grounding point (non-floating) or galvanically isolated (floating).

Example of a Non-Floating Connection of Digital Modules

A 24 V DC load circuit has the same chassis grounding as the control circuit of the CPU.

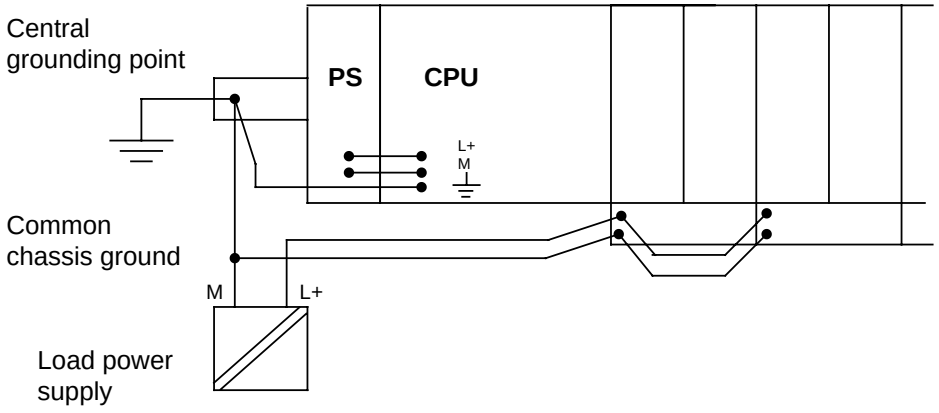


Figure 3-21. Example: Non-Floating Connection of I/Os to the S5-100U

The common chassis grounding connection makes it possible for you to use reasonably priced non-floating I/Os. These modules function according to the following principles.

- Input modules
  - The ground line, line M (control circuit chassis) is the reference potential. A voltage drop V_1 on line affects the input signal level V_I.
- Output modules
  - Terminal 2 (M) of the terminal block is the reference potential. A voltage drop V_2 on the line raises the chassis potential of the output driver and thus reduces the resulting control voltage V_{CV}.

Figure 3-22 shows a simplified connection of the S5-100U with a non-floating external I/O.

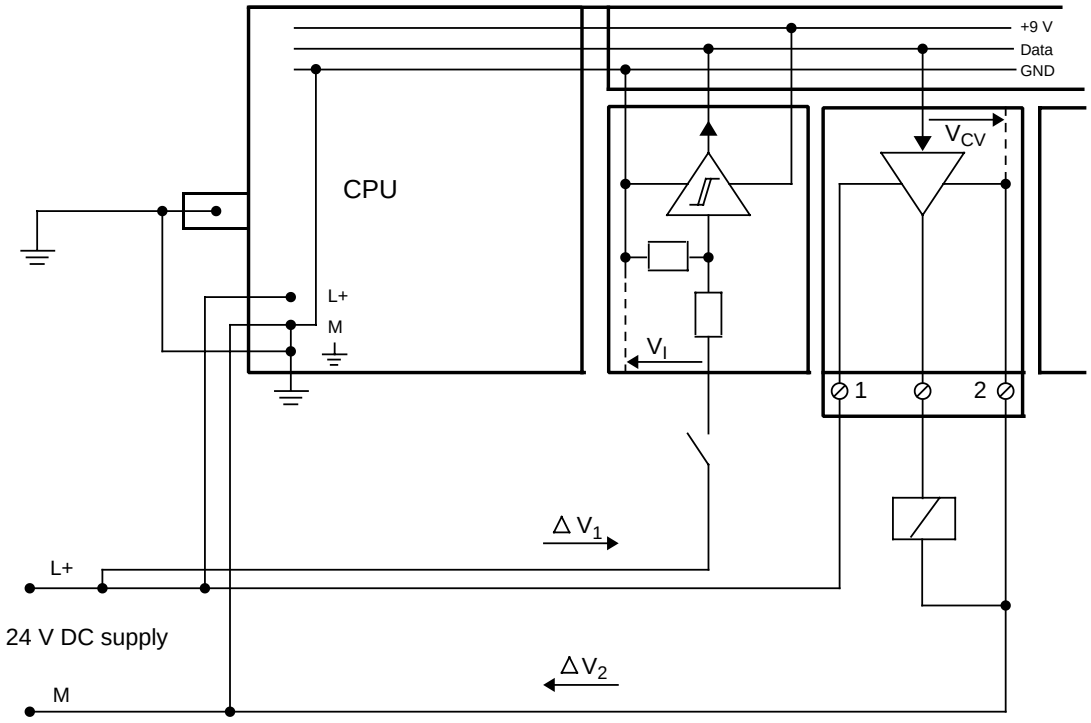


Figure 3-22. Simplified Representation of a Non-Floating I/O Connection

When you have a non-floating configuration, you must make certain that the voltage drop on cables and does not exceed 1 V. If 1 V is exceeded, the reference potentials could change and the modules could malfunction.

Warning

If you use non-floating I/O modules, you must provide an external connection between the chassis ground of the non-floating I/O module and the chassis ground of the CPU.

Example of a Floating Configuration with Digital Modules

Floating configuration is required in the following situations.

- When you need to increase interference immunity in the load circuits
- When load circuits cannot be interconnected
- When you have AC load circuits

If you have a floating configuration, the PLC's control circuit and the load circuit must be galvanically isolated.

Figure 3-23 shows a simplified connection of galvanically isolated I/Os.

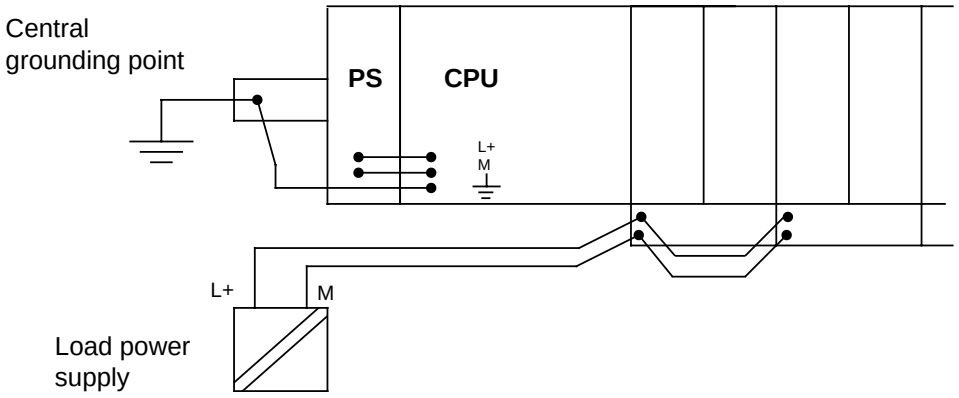


Figure 3-23. Simplified Representation of a Galvanically Isolated Connection of the I/Os to the S5-100U

Figure 3-24 shows a simplified schematic for the connection of floating I/O modules.

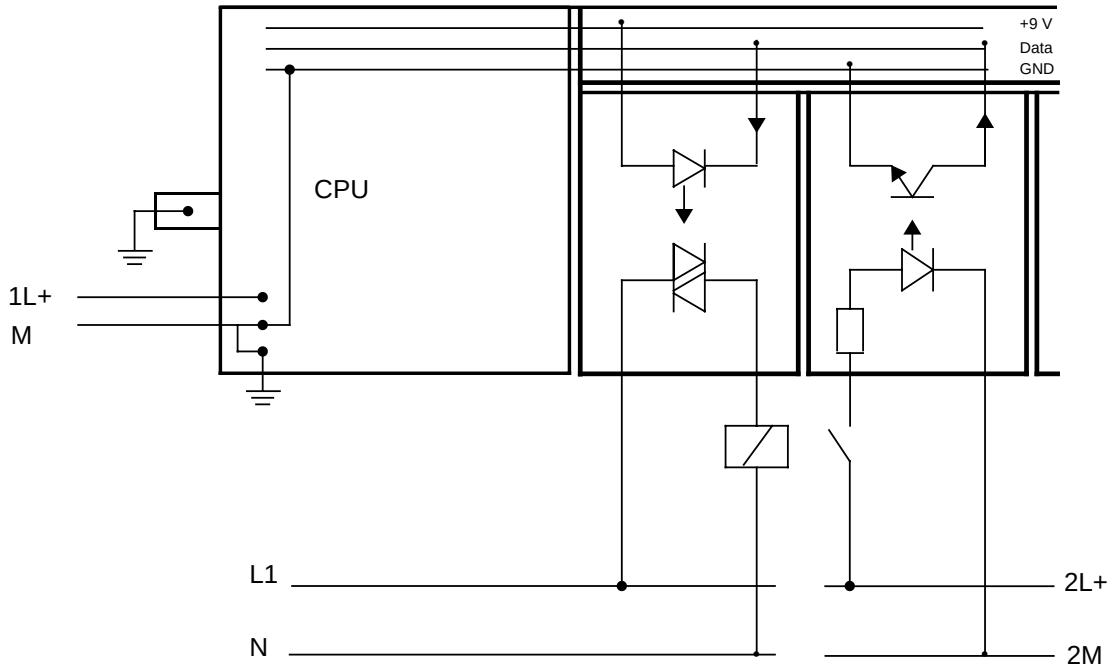


Figure 3-24. A Simplified Representation of a Floating I/O Connection

3.4 Wiring Arrangement, Shielding and Measures against Electromagnetic Interference

This section describes the wiring arrangements for bus cables, signal cables, and power supply cables that guarantee the **e**lectro**m**agnetic **c**ompatibility (EMC) of your installation.

3.4.1 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 programmer, OP, printer, SINEC L1, Profibus, Industrial Ethernet, 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 AC voltage > 400 V

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

Table 3-3. Rules for Common Running of Lines

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

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.

3.4.2 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.

3.4.3 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 conductor makes 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 mm² copper wire for equipotential bonding line up to 200 m (656.2 ft).
  - 25 mm² 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 3-25).

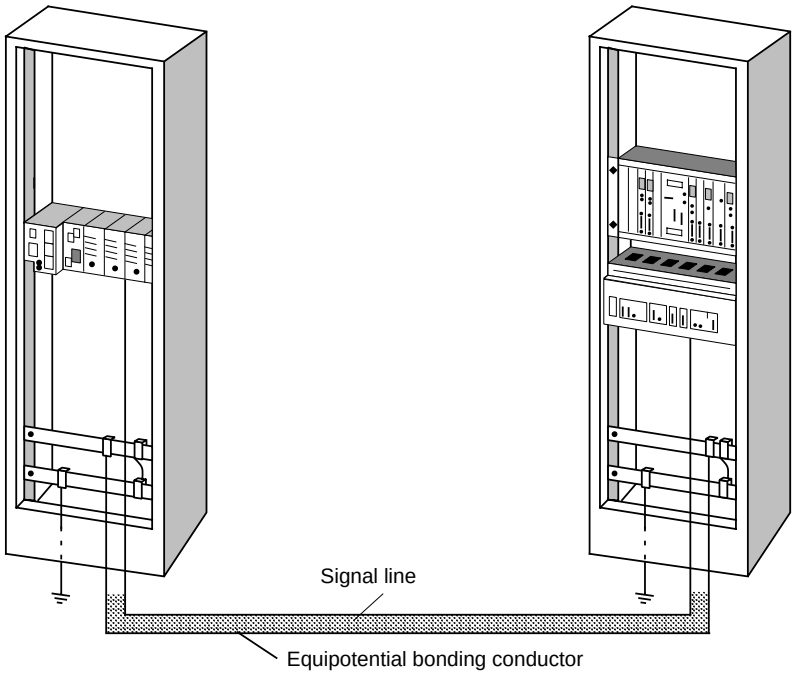


Figure 3-25. Laying Equipotential Bonding Conductor and Signal Cable

3.4.4 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 interrupt 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.

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 3-26).
- 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.

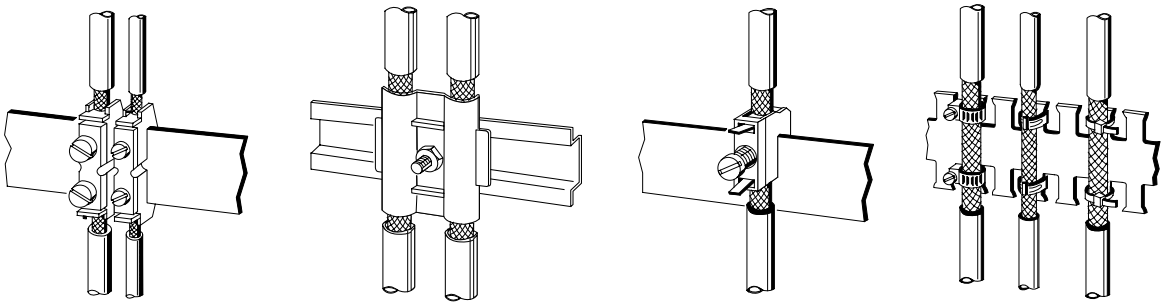


Figure 3-26. Fixing Shielded Cables with Various Types of Cable Clamps

3.4.5 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.

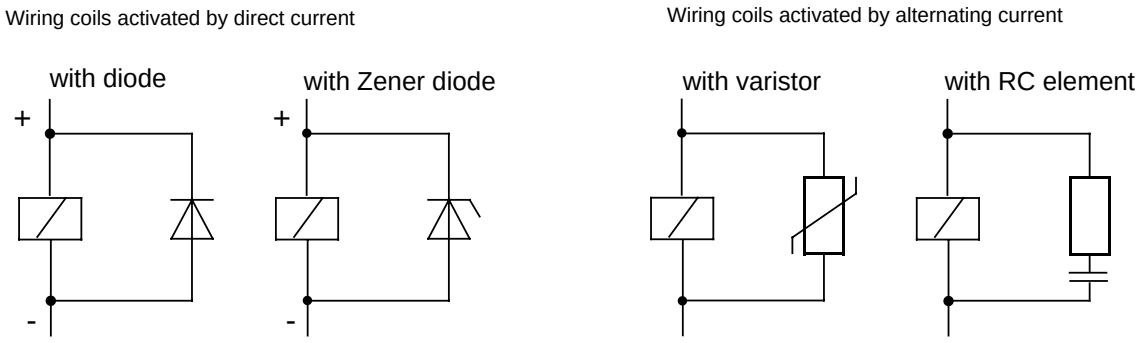


Figure 3-27. Wiring Coils