

SIMATIC S5

**ET 100U
Distributed I/Os**

Manual

EWA 4NEB 812 6040-02a

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Preface

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Preface

The ET 100U Electronic Terminator for distributed I/O is the modular process-oriented and machine-oriented I/O level for the S5-115U, S5-135U, S5-150U and S5-155U programmable controllers. The ET 100U enables you on the one hand to digitize physical sensor signals in the vicinity of the process and to transfer them to the central controller, and, on the other hand, to send digital output information to the ET 100U and convert it into control currents or voltages for the actuators in the process.

The performance capability of the ET 100U has been constantly increasing. This has made it necessary to revise the manual. At the same time, we have attempted to meet demands for higher quality in technical documentation, which means:

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

However, the applications are so numerous that not all the problems which might occur can be dealt with in one manual. Should any problems arise that are not handled in this manual, please ask your Siemens representative for advice or send us the correction and suggestions form which you will find at the end of the manual.

Introduction

The following pages contain information which will help you to use this manual.

Description of Contents

The contents of the manual can be divided into blocks according to topic:

- Description
(System Overview, Technical Specifications)
- Module Range
(Overview/Order Numbers, General Technical Specifications, Description of the Modules)
- Installation and Operation
(Hardware Installation, Start-Up, Addressing)
- Error Diagnostics
- Special Capabilities
(Analog Value Processing, Function Modules)
- Reliability, Availability and Safety of Electronic Control Equipment

At the end of the book you will find correction forms. Please enter any suggestions you may have in the way of improvements or corrections in this form and return it to us. Your comments will help us to improve the next edition.

Courses

SIEMENS provide SIMATIC S5 users with extensive opportunities for training.

For more information, please contact your Siemens representatives.

Reference Literature

This manual is a comprehensive description of the ET 100U. Topics not specific to the ET 100U, however, have only been briefly dealt with. You will find more detailed information in the following literature:

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

Hans Berger
Siemens AG, Berlin and Munich 1989

Contents:

- STEP 5 Programming language
- Program scanning
- Integral program blocks
- Interfaces to the I/O

Order No.: ISBN 3-8009-1530-8

- **Automatisieren mit SIMATIC S5-135U**
SIMATIC S5 Programmable Controllers

Hans Berger
Siemens AG, Berlin and Munich 1987

Contents:

- STEP 5 - Language scope for CPU 921/922/928
- Parallel operation of central processors

Order No.: ISBN 3-8009-1522-7

Always refer to the manuals for any given central controller.

The following catalogs contain information on the range of controllers and programmers available:

- ST 52.1 "S5-90U, S5-95U, S5-100U, S5-95F Programmable Controllers"
- ST 52.3 "S5-115U/H/F Programmable Controller"
- ST 54.1 "S5-135U, S5-155U/H Programmable Controllers"
- ST 54.2 "ET 200/ET 100U Distributed I/O Systems"
- ST 59 "Programmers"
- MP 11 "Thermocouples, Compensating Boxes"

Conventions

In order to improve the readability on the manual, a menu-style 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 preceded by a breakdown of its subject matter. The individual chapters are subdivided into sections and subsections. **Bold-face type** is used for further subdivisions.
- Pages, 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 at the bottom left of the page.
- Cross-references are shown as follows:
"(7.3.2)" refers to subsection 7.3.2.
No references are made to individual pages.
- All dimensions in drawings etc. are given in millimeters (mm) and inches (in.).
- Information of particular importance is framed in grey-bordered rectangles.

Manuals can only describe the current version of the controller. 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".

1 System Overview

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1 System Description

The modular ET 100U electronic terminator for distributed I/O extends the I/O range of compact programmable controllers.

The extra-discrete modularity of the ET 100U makes it the ideal solution for plants and machines where sensors and actuators are distributed over a large area.

Input and output modules for all commonly used (digital) signal levels and for all the usual (analog) signal ranges can be used. With 1, 2, 4 or 8 channels, these modules can be combined up to the maximum configuration (32 bytes) in any mix. The modules exchange information with the relevant 318-8 interface module via a modular bus consisting of bus units.

The ET 100U stations (maximum of 31 stations) exchange information with the higher-level central controller via a shielded two-wire cable and the 308-3 and 318-8 interface modules. The baud rate can be anything up to 375,000 bps. The 308-3 interface module is the master and controls message traffic.

A dual-port RAM is available as a buffer for data traffic between the SIMATIC S5 processor and the 308-3 interface module. The dual-port RAM has 2K bytes - 1K byte each for inputs and outputs. The central processor accesses the ET 100U using the STEP 5 load and transfer operations. The central processor and the 308-3 interface module operate asynchronously and therefore do not interfere with each other.

The I/O modules have no address setters. The relevant module addresses are stored in an EPROM in the 308-3 interface module and transferred to the individual ET 100Us at every start-up or restart.

The corresponding address lists are generated on the programmer with the help of the COM ET 100 software.

Diagnostics capabilities simplify operation and troubleshooting in the system. In addition to the error and fault displays on the modules, all error and fault information is stored according to error type in diagnostics bytes and can be read out via the programmer, displayed on output modules or on screen via a standard interface, or printed out.

The outstanding features of the ET 100U are:

- Low cabling and installation costs
- Extra-discrete modularity
- Clear system design
- Direct two-wire connection of sensors and actuators without intermediate terminals
- Two-wire cable between the central controller and the ET 100U which can be connected using screw-type terminals on the front connector
- 9 V serial, noiseproof bus
- Fast and reliable error detection
- Modules can be replaced without danger of mix-ups and without disturbing the fixed I/O wiring.

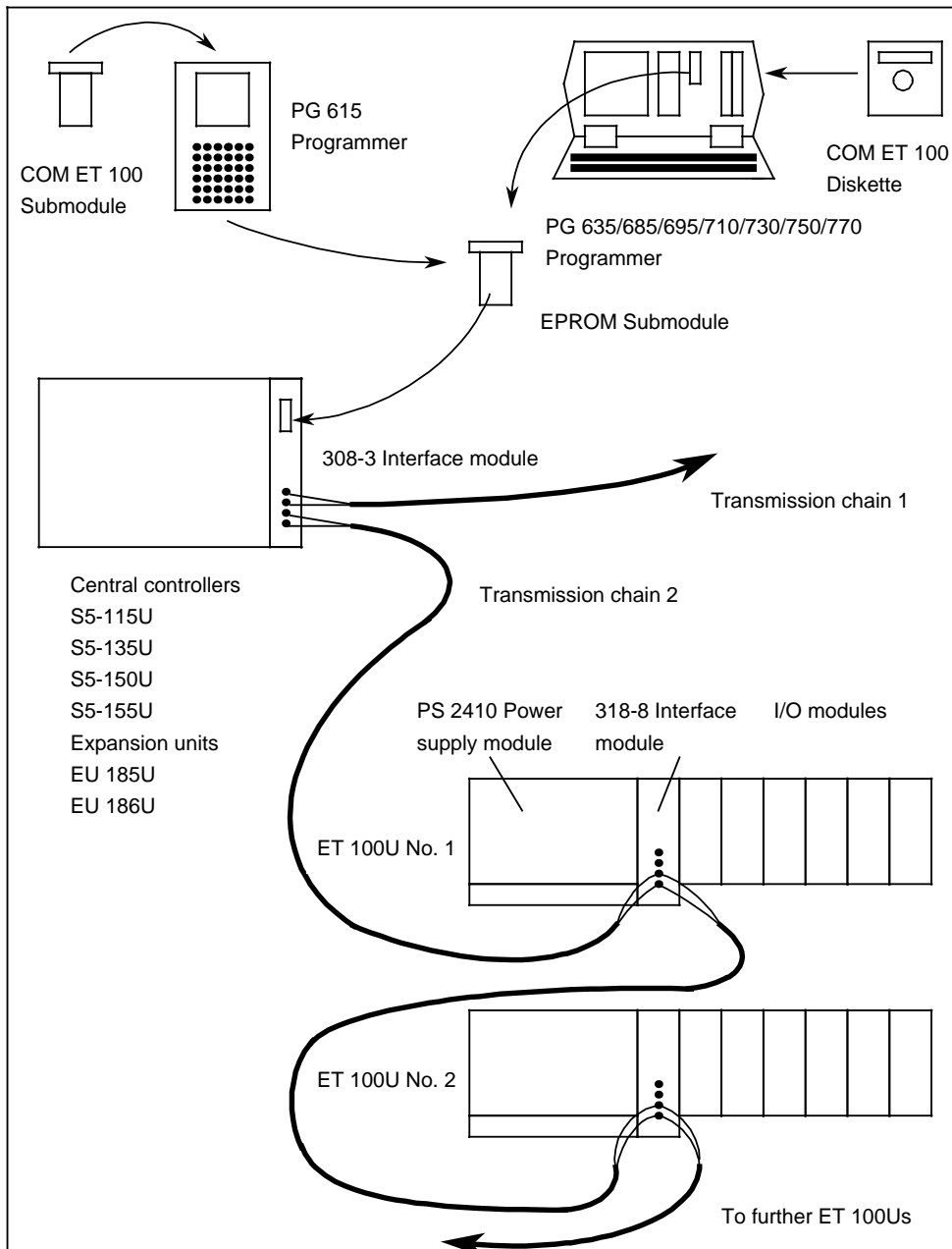


Figure 1-1 Hardware Configuration

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2 Module Range and Accessories

2.1 Overview/Order Numbers

	Order Nos.
35 mm Standard Sectional Rail (Mounting Rack)	
for 19" cabinets, length 483 mm (19 in.)	6ES5 710-8MA11
for 600 mm (24 in.) cabinets, length 530 mm (20.1 in.)	6ES5 710-8MA21
for 900 mm (36 in.) cabinets, length 830 mm (32.7 in.)	6ES5 710-8MA31
Length 2000 mm (80 in.), blank	6ES5 710-8MA41
Ground Terminal for Transmission Cable	
10 per package	6ES5 728-8MA11
Power Supply Modules	
PS 930 power supply module 115/230V AC; 24 V DC ; 1 A	6ES5 930-8MD11
PS 931 power supply module 115/230V AC; 24 V DC ; 2 A (with electronic protection)	6ES5 931-8MD11
PS 2410 power supply module 120/230 V AC (with voltage selection); 24 V DC; 10 A	6EW1 380-4AB01
Bus Units	
Bus unit with SIGUT screw-type terminals	6ES5 700-8MA11
Bus unit with crimp snap-in connections	6ES5 700-8MA21
Accessories	
Extracting tool for crimp snap-in connections	6ES5 497-8MA11
Crimp snap-in contacts, 250	6XX3070
Crimping tool for attaching the crimp contacts	6XX3071

		Order Nos.
Interface Modules		
308-3 interface module (in the central controller)		6ES5 308-3UA12
- 376 memory submodule (EPROM)		6ES5 376-0AA11
- 376 memory submodule (EPROM)		6ES5 376-1AA11
318-8 interface module (ET 100U)		6ES5 318-8MA12
IM 315 interface module		6ES5 315-8MA11
IM 316 interface module		6ES5 316-8MA12
- Connecting cable (0.5 m/1.6 ft.)		6ES5 712-8AF00
- Connecting cable (2.5 m/8.2 ft.)		6ES5 712-8BC50
- Connecting cable (5.0 m/16.5 ft.)		6ES5 712-8BF00
- Connecting cable (10 m/33 ft.)		6ES5 712-8CB00
 Digital Input Modules		
4 x 24 V DC	non-floating	6ES5 420-8MA11
8 x 24 V DC	non-floating	6ES5 421-8MA12
16x 24 V DC	non-floating	6ES5 422-8MA11
4 x DC 24 to 60 V DC	floating	6ES5 430-8MB11
4 x 115 V AC	floating	6ES5 430-8MC11
4 x 230 V AC	floating	6ES5 430-8MD11
8 x 24 V DC	floating	6ES5 431-8MA11
8 x 115 V AC	floating	6ES5 431-8MC11
8 x 230 V AC	floating	6ES5 431-8MD11
8 x 5 to 24 V DC	floating	6ES5 433-8MA11
 Digital Output Modules		
4 x 24 V DC/0.5 A	non-floating	6ES5 440-8MA11
4 x 24 V DC/2 A	non-floating	6ES5 440-8MA21
8 x 24 V DC/0.5 A	non-floating	6ES5 441-8MA11
4 x 24 to 60 V DC/0.5 A	floating	6ES5 450-8MB11
4 x AC 115 to 230 V AC/1 A	floating*	6ES5 450-8MD11
8 x 24 V DC/1 A	floating	6ES5 451-8MA11
8 x 115 to 230 V AC/0.5 A	floating*	6ES5 451-8MD11
8 x 5 to 24 V DC/0.1A	floating	6ES5 453-8MA11
8 x relays		
- 30 V DC/230 V AC	floating	6ES5 451-8MR12
4 x relays		
- 30 V DC/230 V AC	floating	6ES5 452-8MR11
 * Replacement fuse (10 A extra-fast)		 6ES5 980-3BC11

		Order Nos.
Digital Input/Output Modules		
16 x 24 V DC/ 16 x 24 V DC/0.5 A	non-floating	6ES5 482-8MA13
Analog Input Modules		
4 x ±50 mV	floating	6ES5 464-8MA11
4 x ±50 mV	floating	6ES5 464-8MA21
4 x ±1 V	floating	6ES5 464-8MB11
4 x ±10 V	floating	6ES5 464-8MC11
4 x ±20 mA	floating	6ES5 464-8MD11
4 x ±4 to 20 mA	floating	6ES5 464-8ME11
2 x PT 100/ ±500 mV	floating	6ES5 464-8MF11
2 x PT 100/±500 mV	floating	6ES5 464-8MF21
4 x + 0 to10 V	non-floating	6ES5 466-8MC11
Analog Output Modules		
2 x ± 10 V	floating	6ES5 470-8MA12
2 x ± 20 mA	floating	6ES5 470-8MB12
2 x 4 to 20 mA	floating	6ES5 470-8MC12
2 x 1 to 5 V	floating	6ES5 470-8MD12
Function Modules		
Comparator module 2 x 0.5 to 20 mA / 0.5 to 10 V		6ES5 461-8MA11
Timer module 2 x 0.3 to 300 s		6ES5 380-8MA11
Counter module 2 x 0 to 500 Hz		6ES5 385-8MA11
Counter module 1 x 25/500 KHz		6ES5 385-8MB11
Simulator (digital input/output signals)		6ES5 788-8MA11
Diagnostic module (for troubleshooting on the I/O bus of the ET 100U; not for normal operation!)		6ES5 330-8MA11
COM ET 100 Software Package		
for PG 615		6ES5 815-8MA01
for PG 635		6ES5 835-3SC12
for PG 685/695/7x0		6ES5 895-3SC12

2.3 Power Supply Modules

Power Supply Module PS 931 115/230 V AC; 24 V DC/2A

(6ES5 931-8MD11)

Technical Specifications

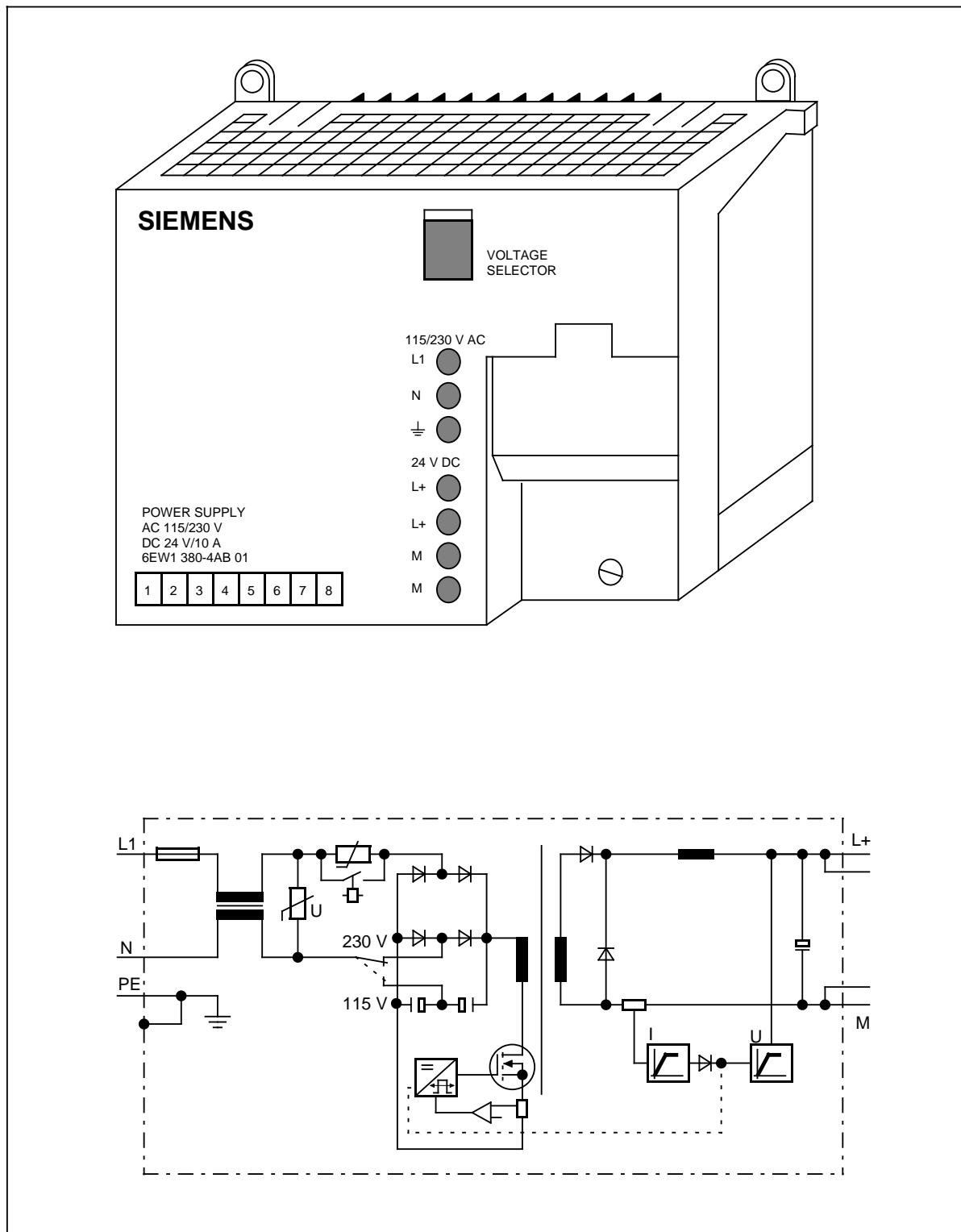
Input voltage		115/230 V AC
- rated value		86 to 150 V/
- permiss. range		187 to 253 V
Line frequency		50/60 Hz
- rated value		47 to 63 Hz
Input current at 115/230 V		
- rated value		0.9/0.6 A
Efficiency	approx.	85%
Power consumption	approx.	58 W
Output voltage		24 V DC
- rated value		22.8 to 25.2 V
- permiss. range		yes
- open-circuit voltage		
Output current		2 A
- rated value		
Buffering of line voltage dips		
- duration of voltage dips		20 ms at 187 V/2 A
- repetition rate		1 s
Short-circuit protection		power limiting, electronic cutoff, non-latching
Fault LED		no
Protection class		1
Galvanic isolation		yes
Conductor cross-sectional area		
- stranded*		2x0.5 to 1.5 mm ²
- solid		2x0.5 to 2.5 mm ²
Insulation rating		VDE 0160 and VDE 0805 (transformer)
Rated insulation voltage (+24 V to L1)		250 V AC
- insulation group		2xB
- tested with		230 V AC
Dimensions WxHxD in mm		45.4x135x120
Power loss of the module	typ.	10 W
Weight	approx.	500 g (1.1 lbs.)

* with core end sleeves

When interference-susceptible loads are connected, the use of a mains filter on the 24 V side is recommended (e.g. No. B84114-D-B20 from Siemens).

Power Supply Module PS 2410

(6EW1 380-4AB01)



Power Supply Modules PS 2410 (continued)

(6EW1 380-4AB01)

Technical specifications

Input voltage V_{input}		120 V/230 V AC (selectable)
- Permissible range (continuously)		93 V to 132 V AC, 187 V to 264 AC
- Frequency		47 Hz to 63 Hz
- Inrush current		< 24 A
Efficiency under rated conditions		82 %
Output voltage V_{output}		24 V DC
- Rated output voltage		24 V DC
- Tolerance range		$\pm 5 \%$
- Residual ripple		100 mV _{pp}
- Switching surges (at 30 MHz)		500 mV _{pp}
Output current I_{output}		10 A
- Rated output current		10 A
Short-circuit protection		Electronic
Current limiting		
- Threshold value	approx.	1.1 I_{output} (rated)
Overvoltage protection		-
Voltage response		
- dynamic at load change (10 to 90 %)		5 %
- Correction time		3 ms
Bridging of line voltage drops		10 ms (at 230 V)
Permissible ambient temperature		
- Self-ventilation during operation		0 °C to 60 °C
- During storage/shipping		-25 °C to 85 °C
Humidity class to DIN 40 040		F
Safety class		I
Degree of protection (DIN 40050, IEC 144)		IP 20
Insulation rating		to VDE 0160, VDE 0805
- Test voltage, primary/secondary		3.75 kV AC (eff.)
		UL 508, File E 143289
RI specification to VDE 0871		Class A
Design		Snap-on housing
Dimensions (W x H x D) mm		190 x 126 x 135
Connection		Via screw-type terminals
- Cross-section		1.5 mm ² , stranded
		2.5 mm ² , solid
Sensor line		No
Powerfail signal		No
Weight	approx.	2.5 kg (5.5 lbs.)

Note:

The performance data specified are referred to vertical installation of the module. Horizontal installation is possible for ambient temperatures < 40°C and if the power output is reduced to 24 V/6 A.

2.4 Bus Units

Bus Unit (SIGUT)

(6ES5 700-8MA11)

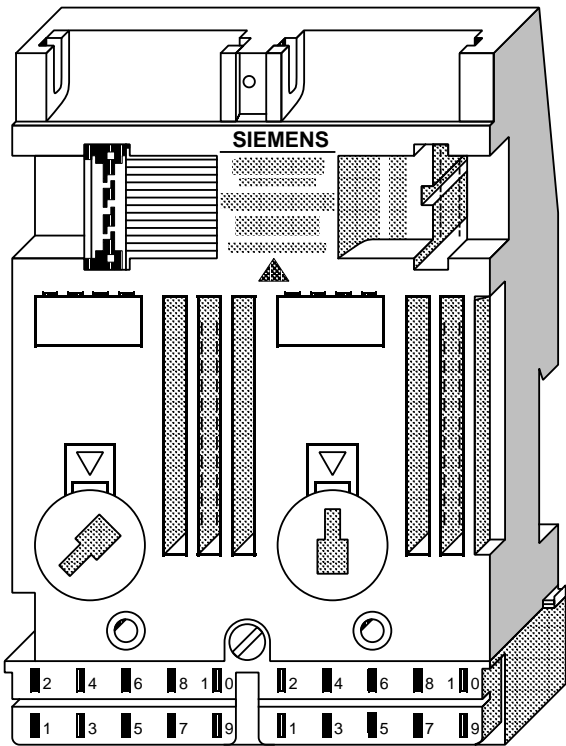
Technical Specifications

Type of connection		SIGUT screw-type terminals
Number of plug-in modules		2
Number of bus units per programmable controller	max.	16
Connection between two bus units		flat ribbon
Number of terminals		10 per slot
Rated insulation voltage (+9 V to \perp)		12 V AC
- insulation group		1xB
- tested with		500 V AC
Conductor cross sectional area		
- stranded*		2x0.5 to 1.5 mm ²
- solid		2x0.5 to 2.5 mm ²
Current consumption - from +9 V (CPU)	typ.	1 mA
Dimensions WxHxD (in mm)		91.5x162x39
Weight	approx.	300 g (10.6 oz.)

* with core end sleeves

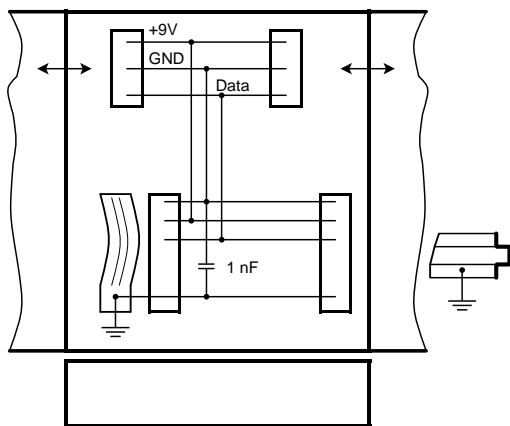
Bus Unit (Crimp-Snap-In Connections)

(6ES5 700-8MA21)



Technical Specifications

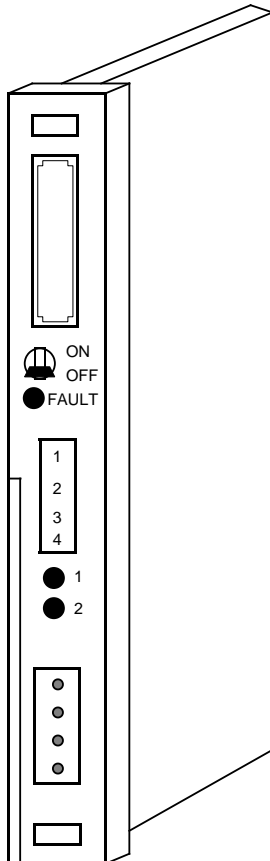
Type of connection	Crimp snap-in
Number of plug-in modules	2
Number of bus units per programmable controller	max. 16
Connection between two bus units	flat ribbon
Number of terminals	10 per slot
Conductor cross sectional area - stranded	0.5 to 1.5 mm ²
Rated insulation voltage (+9 V to \rightarrow - insulation group - tested with)	12 V AC 1xB 500 V AC
Current consumption - from +9 V (CPU)	typ. 1 mA
Dimensions WxHxD (in mm)	91.5x135x39
Weight	approx. 250 g (8.8 oz.)



2.5 Interface Modules

308-3 Interface Module

(6ES5 308-3UA12)



Technical Specifications

Can be plugged into	S5-135U, S5-150U, S5-155U; S5-115U with adapter casing; EG 185U, EG 186U
No. of nodes per interface	max. 63 EGs, ETs or ICMs
Current consumption from the controller	0.5 A
Dimensions (WxHxD in mm)	20x245x190
Weight	approx. 400 g/14 oz.

Serial interface

Number of interfaces	1 with 2 electrically isolated connections (floating, parallel)
No. of modules per interface	max. 32 ETs or EUs
Design	similar to EIA-RS-485 standard
Transmission method	serial, party-line
Synchronisation procedure	asynchronous, half-duplex
Baud rate	375,000/187,500/62,500/31,250 bps, switch-selectable
Data security at - 375,000 bps	1 check byte per 18 data bytes = Hamming distance 3
- Other baud rates	2 check bytes per 18 data bytes = Hamming distance 5
Noise immunity at low baud rates	Enhanced by a low-pass filter (62,500/31,250 bps)
Input voltage for receiving	max. 5 V, symmetrical
Output voltage for transmitting	max. 5 V, symmetrical
Max. cable length for - 375,000 baud	0.5 km/0.3 miles per interface chain
- 187,500 baud	1.0 km/0.6 miles per interface chain
- 62,50 baud	1.0 km/0.6 miles per interface chain
- 31,250 baud	3.0 km/1.8 miles per interface chain
Conductor cross-section	0.5 to 1.5 mm ² (20 to 15 AWG), stranded
Transmission cable	Shielded; twisted pair (Cable types A, B, or D) to VDE 0160
Insulation rating (S/S. interface to N)	
- Isolation group tested with	500 V AC

Interface Module 318-8

(6ES5 318-8MA12)

Technical Specifications

Configuration	max.	16 Bus units (32 modules)
Expansion capability		IM 316 interface module (for connecting up to 32 modules)
Address volume per ET 100U	max.	32 bytes
Supply voltage, L+/M		24 V DC (20 to 30 V), polarized
Current consumption		80 to 350 mA
Output current (9 V Bus)		- at 40 °C ambient: 900 mA - at 60 °C ambient: 700 mA
Dimensions		WxHxD in mm (in.): 45x160x135 (1.7x6.2x5.3)
Weight	approx.	400 g

Alarm output

Supply voltage L+		20 ... 30 V DC
Switching current	max.	15 mA
Output voltage	min.	L+-2,5 V
Polarization		yes
Short-circuit		yes
Type of switch		Floating Transistor galvanically isolated

Rated insulation voltage (Switch to \perp)

- Insulation group
- Tested with

500 V AC

Serial port

Supply voltage, internal		5 V, floating
Output voltage (Send)	max.	5 V, symmetrical
Input voltage (receive)	max.	5 V, symmetrical

Baud rate (selectable)

- 375,000 bps
- 187,500 bps
- 62,500 bps
- 31,250 bps

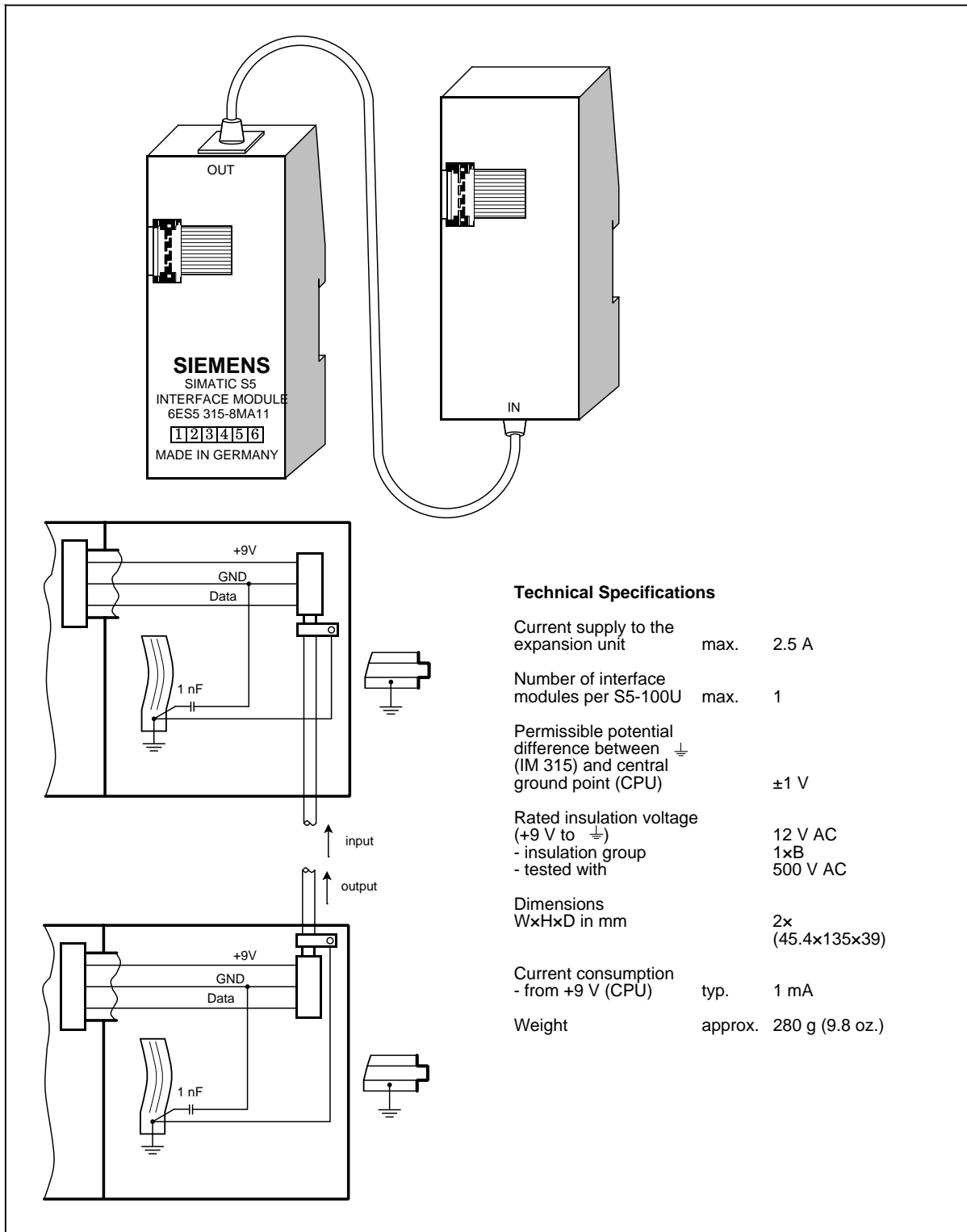
Insulation rating (S/S interface to \perp)

- Insulation group
- Test voltage

500 V AC

Interface Module IM 315

(6ES5 315-8MA11)



Technical Specifications

Current supply to the expansion unit	max.	2.5 A
Number of interface modules per S5-100U	max.	1
Permissible potential difference between \perp (IM 315) and central ground point (CPU)		± 1 V
Rated insulation voltage (+9 V to \perp)		12 V AC
- insulation group		1xB
- tested with		500 V AC
Dimensions WxHxD in mm	2x	(45.4x135x39)
Current consumption - from +9 V (CPU)	typ.	1 mA
Weight	approx.	280 g (9.8 oz.)

Interface Module IM 316

(6ES5 316-8MA12)

Technical Specifications

Current supply to the expansion unit	max.	2.5 A
Number of interface modules per PLC	max.	4

Cable connectors for the IM 316

- cable connector (0.5 m/1.6 ft.) 6ES5 712-8AF00
- cable connector (2.5 m/8.2 ft.) 6ES5 712-8BC50
- cable connector (5.0 m/16.4 ft.) 6ES5 712-8BF00
- cable connector (10 m/33 ft.) 6ES5 712-8CB00

Cable insulation in ducts	permissible	
Permissible potential difference between \perp (IM 316) and central ground point (CPU)	± 1 V	
Rated insulation voltage (+9 V to \perp)	12 V AC	
- insulation group	1xB	
Dimensions WxHxD in mm	45.4x135x39	
Current consumption - from +9 V (CPU)	typ.	27 mA
Weight	approx.	120 g (4.2 oz.)

2.6 I/O Modules

2.6.1 Digital Input Modules

Digital Input Module 4x24 V DC

(6ES5 420-8MA11)

Technical Specifications

Address designation (for ET 100U only)	4DI
Number of inputs	4
Galvanic isolation - in groups of	no 4
Input voltage L+ - rated value	24 V DC
- "0" signal	0 to 5 V
- "1" signal	13 to 33 V
Input current at "1" signal	typ. 7 mA (at 24 V)
Inherent delay - from "0" to "1"	typ. 2.5 ms*
- from "1" to "0"	typ. 5 ms*
Length of cable - unshielded	max. 100 m (330 ft.)
Rated insulation voltage** (+9 V to \perp) - insulation group	12 V AC 1xB
Fault LED (red)	no input voltage L+
Connection of 2-wire BERO proximity switches - residual current	possible 1.5 mA
Current consumption - from +9 V (CPU)	typ. 16 mA
Power loss of the module	typ. 0.8 W
Weight	approx. 205 g (7.2 oz.)

* Times depend on voltage
 ** Relevant only for isolated assembly in the ET 100U/200U

Digital Input Module 8x24 V DC

(6ES5 421-8MA12)

Technical Specifications

Address designation (for ET 100U only)	8DI
Number of inputs	8
Galvanic isolation - in groups of	no 8
Input voltage L+ - rated value	24 V DC
- "0" signal	0 to 5 V
- "1" signal	13 to 33 V
Input current at "1" signal	typ. 7 mA (at 24 V)
Inherent delay - from "0" to "1"	typ. 2.3 ms*
- from "1" to "0"	typ. 4.5 ms*
Length of cable - unshielded	max. 100 m (330 ft.)
Rated insulation voltage** (+9 V to \perp) - insulation group	12 V AC 1xB
Fault LED (red)	no input voltage L+/M
Connection of 2-wire BERO proximity switches - residual current	possible 1.5 mA
Current consumption from +9 V (CPU)	typ. 34 mA
Power loss of the module	typ. 1.6 W
Weight	approx. 190 g (6.7 oz.)

* Times depend on voltage
** Relevant only for isolated assembly in the ET 100U/200U

Digital Input Module 16x24 V DC

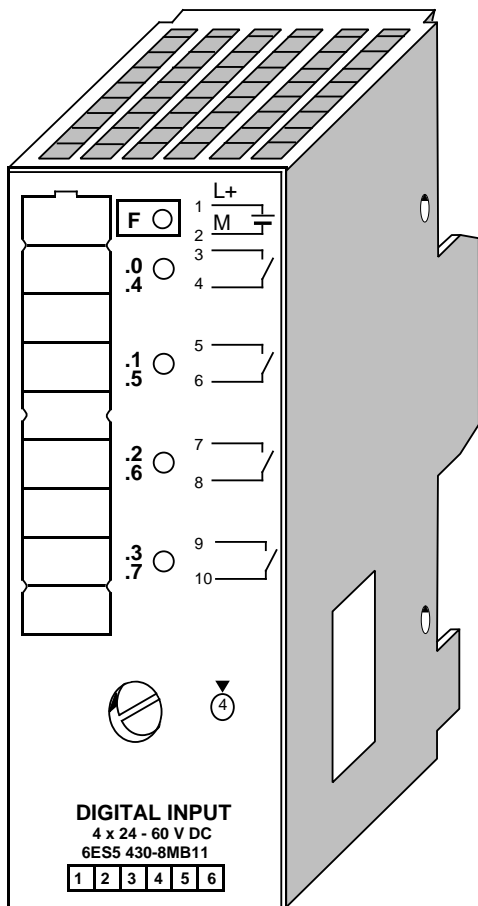
**(6ES5 422-8MA11)
(6ES5 490-8MA12)
(6ES5 490-8MB11)**

Technical Specifications

Address designation (for ET 100U only)	1AX
Number of inputs	16
Galvanic isolation	no
Input voltage L+	
- rated value	24 V DC
- "0" signal	0 to 5 V
- "1" signal	13 to 30 V
Input protection	
- against polarity reversal	no, fuse trips
- against overvoltage	up to 33 V
Input current at "1" signal	typ. 4.5 mA
Inherent delay	
- from "0" to "1"	typ. 4 ms
- from "1" to "0"	typ. 3 ms
Length of cable	
- unshielded	100 m
Rated insulation voltage (+9 V to \perp)	12 V AC
- insulation group	1xB
EMC/noise immunity to VDE 801-4, severity level 3	2 kV
Fault LED (red)	on L+/M interruption
Connection of 2-wire BERO proximity switches	possible
- residual current	1.5 mA
Current consumption	
- from +9 V (CPU)	typ. 50 mA
Power loss of the module	typ. 4.5 W
Weight	ca. 190 g (6.7 oz.)

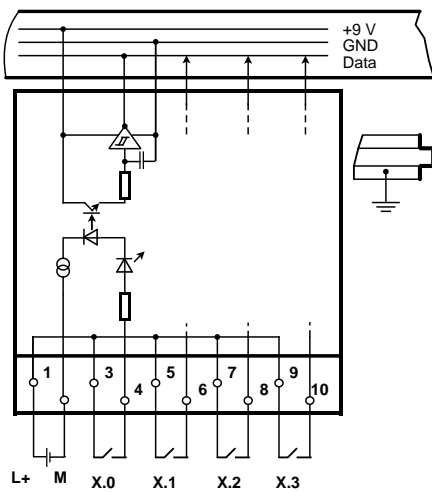
Digital Input Module 4x24 to 60 V DC

(6ES5 430-8MB11)



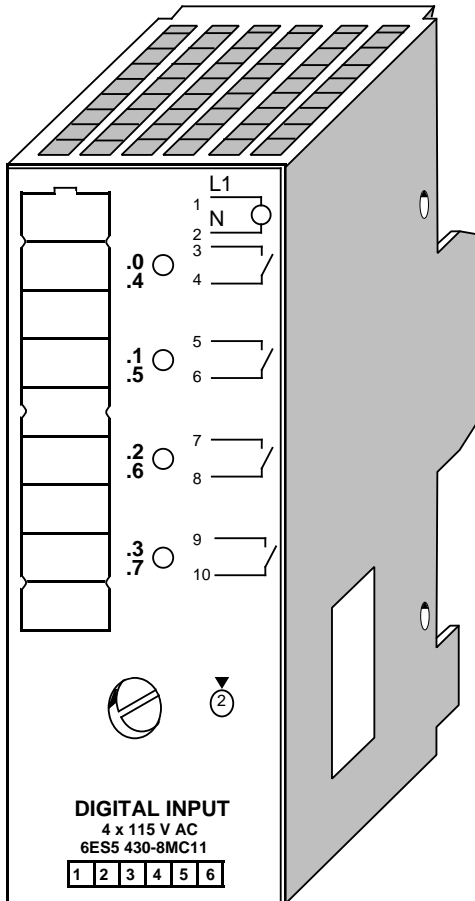
Technical Specifications

Address designation (for ET 100U only)		4DI
Number of inputs		4
Galvanic isolation		yes (optocoupler)
- in groups of		4
Input voltage L+		
- rated value		24 to 60 V DC
- "0" signal		- 33 to 8 V
- "1" signal		13 to 72 V
Input current at "1" signal	typ.	4.5 to 7.5 mA
Inherent delay		
- from "0" to "1"	typ.	3 ms (1.4 to 5 ms)
- from "1" to "0"	typ.	3 ms (1.4 to 5 ms)
Length of cable		
- unshielded	max.	100 m (330 ft.)
Rated insulation voltage (+9 V to \downarrow)		12 V AC
- insulation group		1xB
- tested with		500 V AC
Rated insulation voltage (+9 V to L+)		60 V AC
- insulation group		2xB
- tested with		1250 V AC
Fault LED (red)		no input voltage L+
Connection of 2-wire BERO proximity switches		possible
- residual current		1.5 mA
Current consumption		
- from +9 V (CPU)		5 mA
- from L+	max.	35 mA
Power loss of the module	max.	2 W
Weight	approx.	200 g (7 oz.)



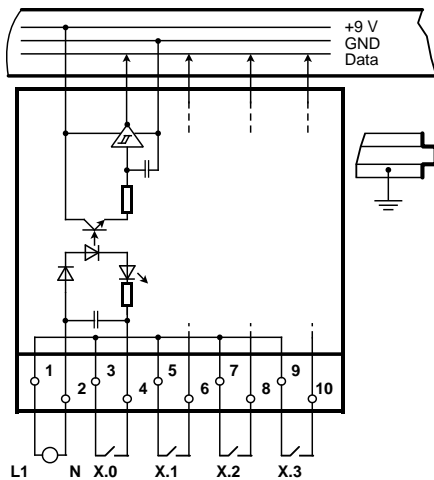
Digital Input Module 4x115 V AC

(6ES5 430-8MC11)



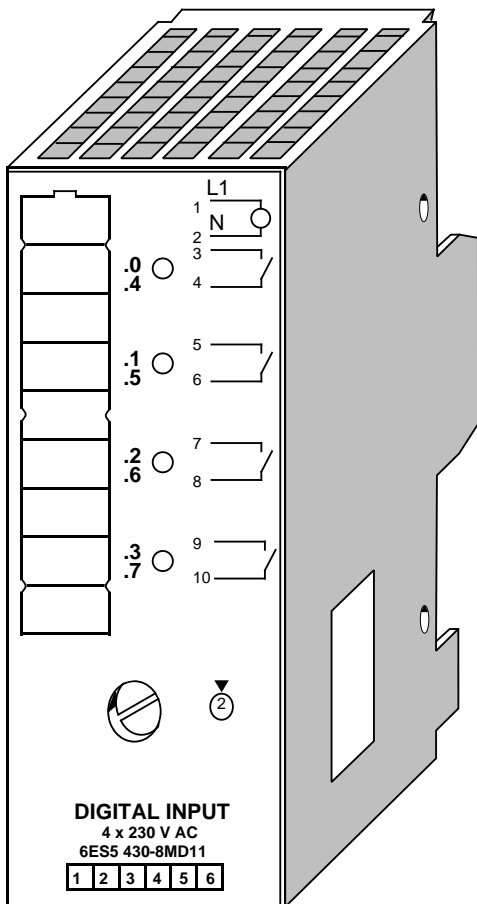
Technical Specifications

Address designation (for ET 100U only)		4DI
Number of inputs		4
Galvanic isolation		yes (optocoupler)
- in groups of		4
Input voltage L1		
- rated value		115 V AC/DC
- "0" signal		0 to 40 V
- "1" signal		85 to 135 V
- frequency		47 to 63 Hz
Input current at "1" signal	typ.	14 mA at 115 V AC
	typ.	6 mA at 115 V DC
Inherent delay		
- from "0" to "1"	typ.	10 ms
- from "1" to "0"	typ.	20 ms
Length of cable		
- unshielded	max.	100 m (330 ft.)
Rated insulation voltage (+9 V to L1)		125 V AC
- insulation group		2xB
- tested with		1250 V AC
Rated insulation voltage (+9 V to \downarrow)		12 V AC
- insulation group		1xB
- tested with		500 V AC
Connection of 2-wire BERO proximity switches		possible
- residual current		5 mA
Current consumption		
- from +9 V (CPU)	typ.	16 mA
Power loss of the module	typ.	2.8 W
Weight	approx.	210 g (7.4 oz.)



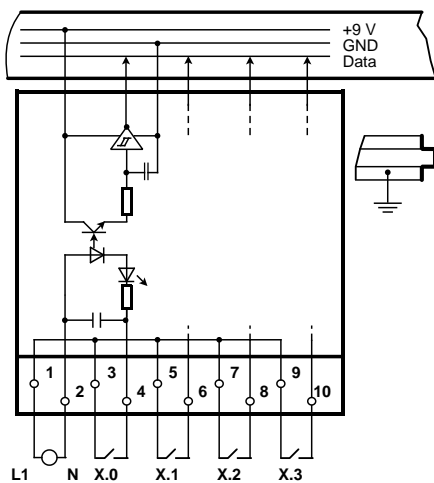
Digital Input Module 4x230 V AC

(6ES5 430-8MD11)



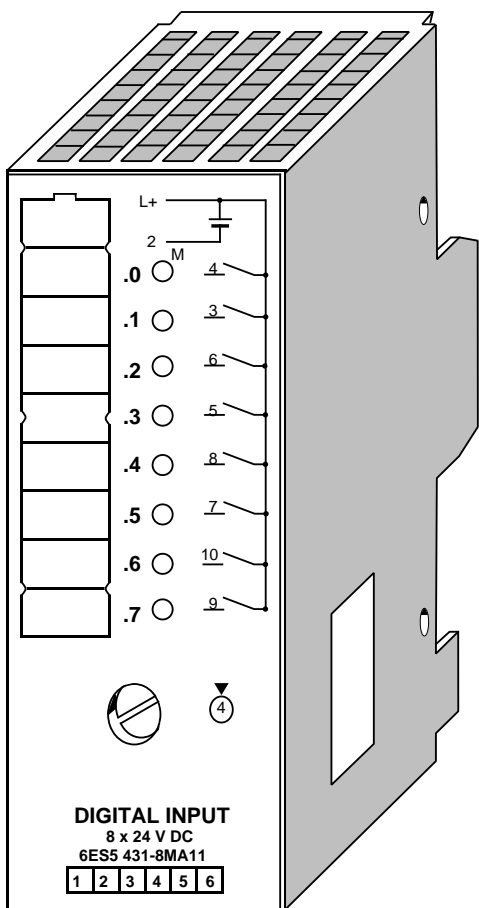
Technical specifications

Address designation (for ET 100U only)		4DI
Number of inputs		4
Galvanic isolation		yes (optocoupler)
- in groups of		4
Input voltage L1		
- rated value		230 V AC/DC
- "0" signal		0 to 70 V
- "1" signal		170 to 264 V
- frequency		47 to 63 Hz
Input current at "1" signal	typ.	16 mA at 230 V AC
	typ.	2.5 mA at 230 V DC
Inherent delay		
- from "0" to "1"	typ.	10 ms
- from "1" to "0"	typ.	20 ms
Length of cable		
- unshielded	max.	100 m (330 ft.)
Rated insulation voltage (+9 V to L1)		250 V AC
- insulation group		2xB
- tested with		1500 V AC
Rated insulation voltage (+9 V to \downarrow)		12 V AC
- insulation group		1xB
- tested with		500 V AC
Connection of 2-wire BERO proximity switches		possible
- residual current		5 mA
Current consumption		
- from +9 V (CPU)	typ.	16 mA
Power loss of the module	typ.	2.5 W
Weight	approx.	210 g (7.4 oz.)



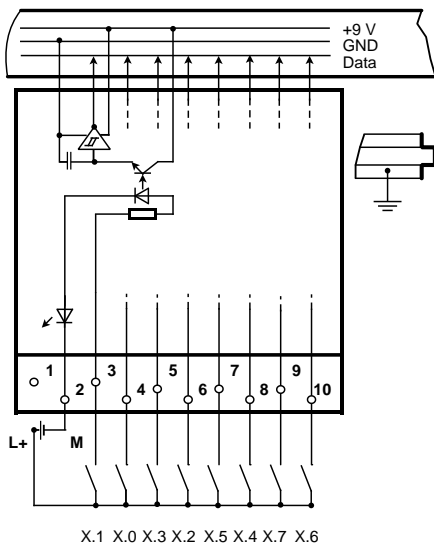
Digital Input Module 8 x 24 V DC

(6ES5 431-8MA11)



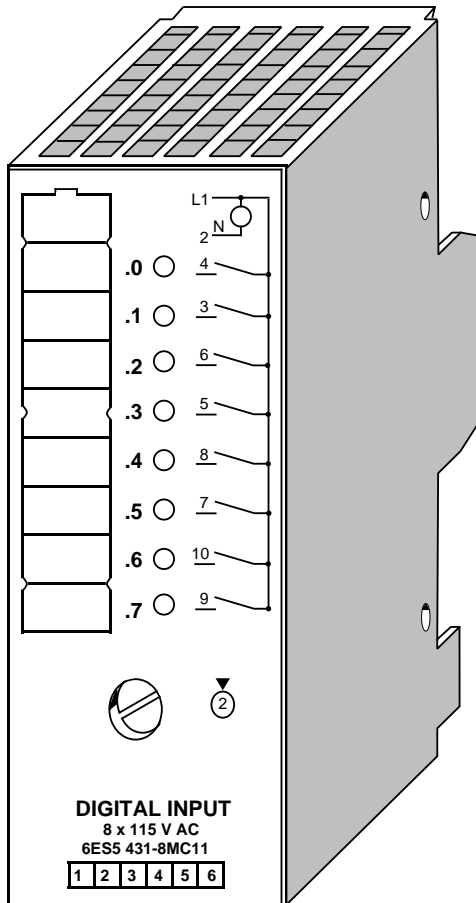
Technical Specifications

Address designation (for ET 100U only)		8DI
Number of inputs		8
Galvanic isolation		yes (optocoupler)
- in groups of		8
Input voltage L+		
- rated value		24 V DC
- "0" signal		0 to 5 V
- "1" signal		13 to 33 V
Input current at "1" signal	typ.	8.7 mA (at 24 V)
Inherent delay		
- from "0" to "1"	typ.	5.5 ms
- from "1" to "0"	typ.	4 ms
Length of cable		
- unshielded	max.	100 m (330 ft.)
Rated insulation voltage (+ 9 V to \downarrow)		12 V AC
- insulation group		2xB
- tested with		500 V AC
Rated insulation voltage (+ 9 V to L+)		30 V AC
- insulation group		2xB
- tested with		500 V AC
Connection of 2-wire BERO proximity switches		possible
- residual current		1.5 mA
Current consumption - from + 9 V (CPU)	typ.	32 mA
Power loss of the module	typ.	2 W
Weight	approx.	190 g (6.7 oz.)



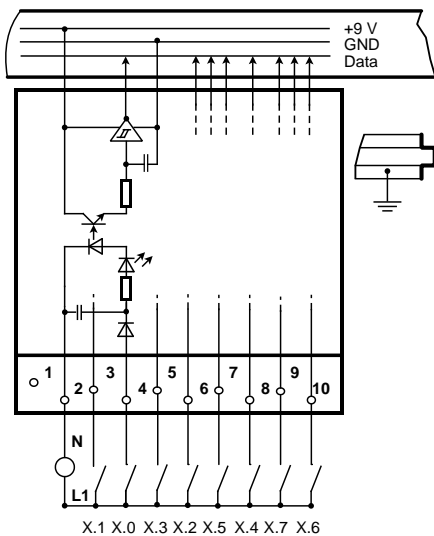
Digital Input Module 8x115 V AC

(6ES5 431-8MC11)



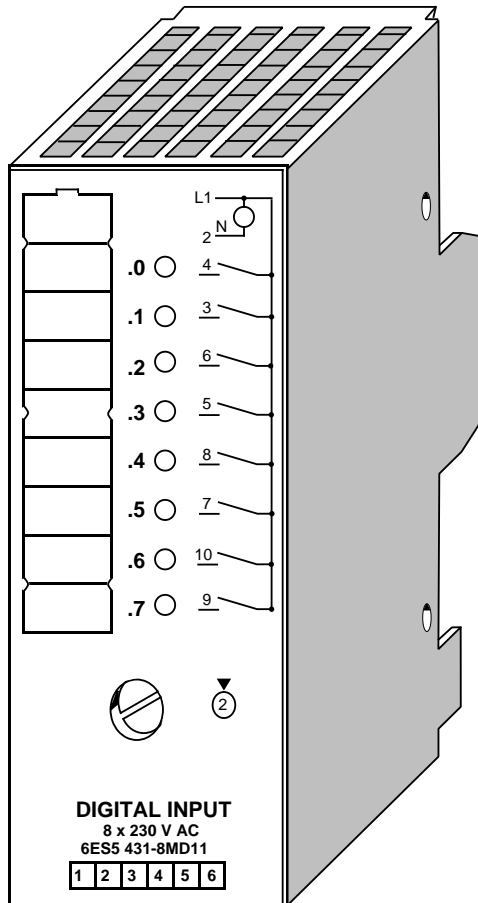
Technical Specifications

Address designation (for ET 100U only)		8DI
Number of inputs		8
Galvanic isolation		yes (optocoupler)
- in groups of		8
Input voltage L1		115 V AC/DC
- rated value		0 to 40 V
- "0" signal		85 to 135 V
- "1" signal		47 to 63 Hz
- frequency		
Input current at "1" signal	typ.	12 mA at 115 V AC
	typ.	2.5 mA at 115 V DC
Inherent delay		
- from "0" to "1"	typ.	10 ms
- from "1" to "0"	typ.	20 ms
Length of cable		
- unshielded	max.	100 m (330 ft.)
Rated insulation voltage (+9 V to L1)		125 V AC
- insulation group		2xB
- tested with		1250 V AC
Rated insulation voltage (+9 V to \perp)		12 V AC
- insulation group		1xB
- tested with		500 V AC
Connection of 2-wire BERO proximity switches		possible
- residual current		4 mA
Current consumption		
- from +9 V (CPU)	typ.	32 mA
Power loss of the module	typ.	2.5 W
Weight	approx.	260 g (9 oz.)



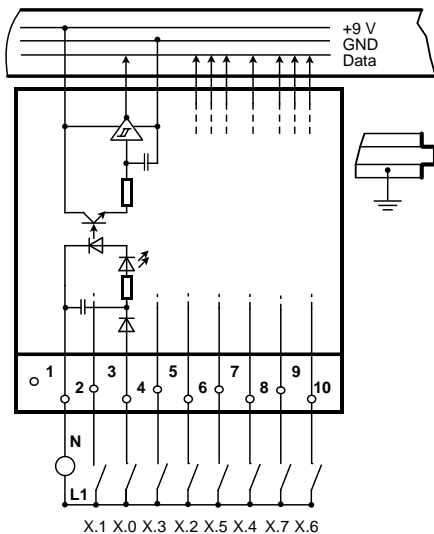
Digital Input Module 8 x 230 V AC

(6ES5 431-8MD11)



Technical specifications

Address designation (for ET 100U only)		8DI
Number of inputs		8
Galvanic isolation		yes (optocoupler)
- in groups of		8
Input voltage L1		230 V AC/DC
- rated value		0 to 95 V
- "0" signal		195 to 253 V
- "1" signal		47 to 63 Hz
- frequency		
Input current at "1" signal	typ.	16 mA at 230 V AC
	typ.	1.8 mA at 230 V DC
Inherent delay		
- from "0" to "1"	typ.	10 ms
- from "1" to "0"	typ.	20 ms
Length of cable		
- unshielded	max.	100 m (330 ft.)
Rated insulation voltage (+9 V to L1)		250 V AC
- insulation group		2xB
- tested with		1500 V AC
Rated insulation voltage (+9 V to GND)		12 V AC
- insulation group		1xB
- tested with		500 V AC
Connection of 2-wire BERO proximity switches		possible
- residual current		5 mA
Current consumption		
- from +9 V (CPU)	typ.	32 mA
Power loss of the module	typ.	3.6 W
Weight	approx.	260 g (9 oz.)



Digital Input Module 8 x DC 5 ... 24 V

(6ES5 433-8MA11)

Technical Specifications

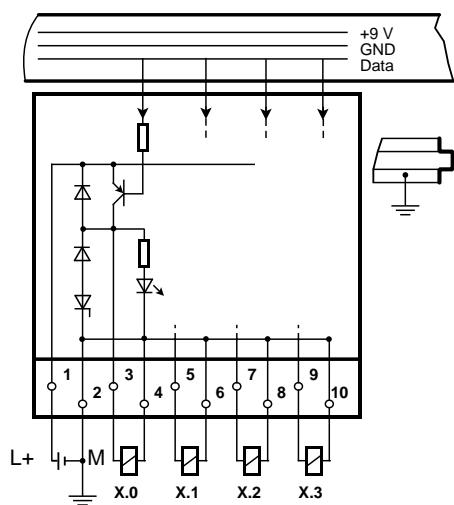
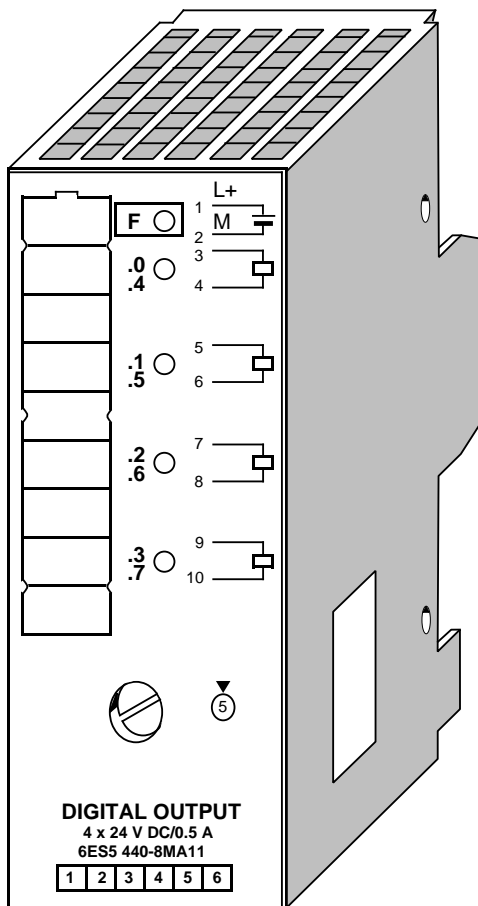
Address designation (for ET 100U only)	8DI
Number of inputs	8
Galvanic isolation - in groups of	yes (optocoupler) 8
Input voltage L+ - rated value	5 to 24 V DC
- "0" signal	Vin approx. 25% L+
- "1" signal	Vin approx. 45% L+
Permissible range	4.5 to 30 V
Input resistance	4.7 k to L+ or M; reversible on the back of the module*
The LED displays the evaluated signal	
Inherent delay	approx. 1 ms or 10 ms; reversible on the back of the module*
Length of cable - unshielded	max. 100 m (330 ft.)
Rated insulation voltage (+ 9 V to L+)	30 V AC
- insulation group	2 x B
- tested with	500 V AC
Rated insulation voltage (+ 9 V to \perp)	12 V AC
- insulation group	2 x B
- tested with	500 V AC
Current consumption - from + 9 V (CPU)	typ. 6 mA
- from L+	typ. 60 mA
Power loss of the module	typ. 2.4 W
Weight	approx. 225 g (8 oz.)

* reversible in groups of 8

2.6.2 Digital Output Modules

Digital Output Module 4x24 V DC/0.5 A

(6ES5 440-8MA11)



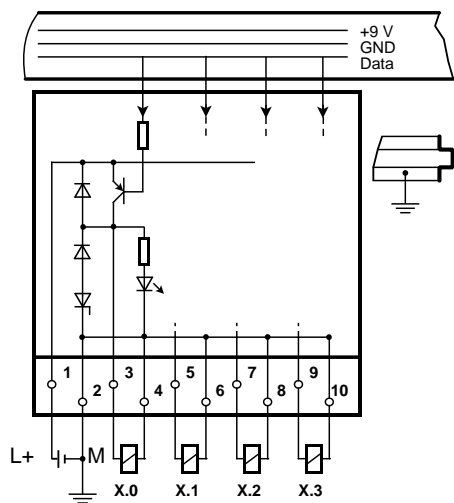
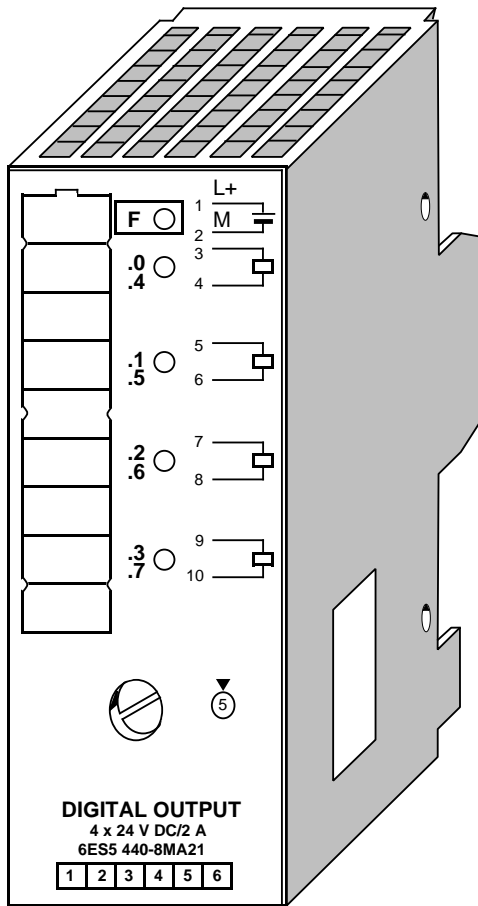
Technical Specifications

Address designation (for ET 100U only)		4DQ
Number of outputs		4
Galvanic isolation		no
- in groups of		4
Load voltage L+		
- rated value		24 V DC
- permissible range (including ripple)		20 to 30 V
- value at $t < 0.5$ s		35 V
Output current for "1" signal		
- rated value		0.5 A
- permissible range		5 to 500 mA
- lamp load	max.	5 W
Residual current at "0" signal	max.	0.5 mA
Output voltage - "1" signal	max.	L+ (- 1.2 V)
Short-circuit protection		short-circuit protected output with autom. switch on when the short- circuit does not exist any more
Fault LED (red)		short-circuit/no load voltage L+
Error diagnostics		possible
Voltage induced on circuit interruption (internal) limited to		- 15 V
Switching frequency		
- resistive load	max.	100 Hz
- inductive load	max.	2 Hz
Total permissible current of outputs		2 A
Driving of digital input		possible
Paralleling of outputs		possible
- maximum current		0.8 A
Length of cable		
- unshielded	max.	100 m (330 ft.)
Rated insulation voltage*		12 V AC
(+9 V to \perp)		
- insulation group		1xB
Current consumption		
- from +9 V (CPU)	typ.	15 mA
- from L+(without load)	typ.	25 mA
Power loss of the module	typ.	3 W
Weight	approx.	200 g (7 oz.)

* Relevant only for isolated assembly in the ET 100U/200U

Digital Output Module 4 x 24 V DC/2 A

(6ES5 440-8MA21)



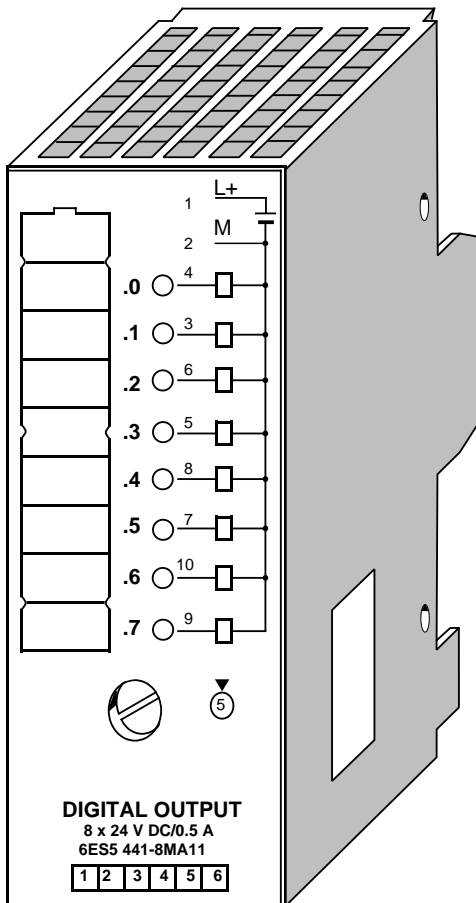
Technical Specifications

Address designation (for ET 100U only)	4DQ
Number of outputs	4
Galvanic isolation	no
- in groups of	4
Load voltage L+	
- rated value	24 V DC
- permissible range (including ripple)	20 to 30 V
- value at t < 0.5 s	35 V
Output current for "1" signal	
- rated value	2 A
- permissible range	5 mA to 2 A
- lamp load	max. 10 W
Residual current at "0" signal	max. 1 mA
Output voltage - "1" signal	max. L+ (- 1.5 V)
Short-circuit protection	short-circuit protected output with autom. switch on when the short-circuit does not exist any more
Fault LED (red)	short-circuit/no load voltage L+
Error diagnostics	possible
Voltage induced on circuit interruption (internal) limited to	- 15 V
Switching frequency	
- resistive load	max. 100 Hz
- inductive load	max. 2 Hz
Total permissible current of outputs	4 A
Driving of digital input	possible
Paralleling of outputs	possible
- maximum current	3.2 A
Length of cable	
- unshielded	max. 100 m (330 ft.)
Rated insulation voltage* (+9 V to GND)	12 V AC
- insulation group	1xB
Current consumption	
- from +9 V (CPU)	typ. 15 mA
- from L+ (without load)	typ. 25 mA
Power loss of the module	typ. 4.8 W
Weight	approx. 200 g (7 oz.)

* Relevant only for isolated assembly in the ET 100U/200U

Digital Output Module 8x24 V DC/0.5 A

(6ES5 441-8MA11)



Technical Specifications

Address designation (for ET 100U only)	8DQ
Number of outputs	8
Galvanic isolation	no
- in groups of	8
Load voltage L+	
- rated value	24 V DC
- permissible range (including ripple)	20 to 30 V
- value at $t < 0.5$ s	35 V

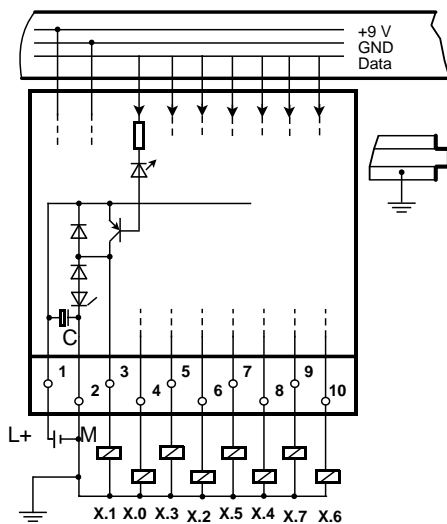
Warning

Capacitor C remains loaded after switch off of L+

Output current for "1" signal		
- rated value		0.5 A at 60 °C (140 °F) 1 A at 30 °C (86 °F) 5 mA to 1 A
- permissible range		
- lamp load	max.	5 W
Residual current at "0" signal	max.	1.0 mA
Output voltage		
- "1" signal	max.	L+ (- 1.2 V)
Short-circuit protection		no
Voltage induced on circuit interruption (internal) limited to		- 15 V
Switching frequency		
- resistive load	max.	100 Hz
- inductive load	max.	2 Hz
Total permissible current of outputs		4 A

Driving of digital input		possible
Paralleling of 2 outputs		possible
- maximum current		0.8 A
Length of cable		
- unshielded	max.	100 m (330 ft.)
Rated insulation voltage*		
(+9 V to \perp)		12 V AC
- insulation group		1xB
Current consumption		
- from +9 V (CPU)	typ.	14 mA
- from L+(without load)	typ.	15 mA
Power loss of the module	typ.	3.5 W
Weight	approx.	220 g (7.7 oz.)

* Relevant only for isolated assembly in the ET 100U/200 U



Digital Output Module 4x24 to 60 V DC/0.5 A

(6ES5 450-8MB11)

Technical Specifications

Address designation (for ET 100U only)	4DQ
Number of outputs	4
Galvanic isolation	yes (optocoupler)
- in groups of	4
Load voltage L+	
- rated value	24 to 60 V DC
- permissible range	20 to 72 V
Output current for "1" signal	
- rated value	0.5 A
- permissible range	5 mA to 0.5 A
- lamp load	max. 5 to 12 W
Residual current at "0" signal	max. 1 mA
Short-circuit protection	short-circuit protected output with autom. switch on when the short-circuit does not exist any more
Fault LED (red)	short circuit/ no load voltage L+
Error diagnostics	possible
Voltage induced on circuit interruption (internal) limited to	- 30 V
Switching frequency	
- resistive load	max. 100 Hz
- inductive load	max. 2 Hz
Total permissible current of outputs	2 A
Driving of digital input	possible
Paralleling of 2 outputs	possible
- maximum current	2x0.4 A
Length of cable	
- unshielded	max. 100 m (330 ft.)
Rated insulation voltage	
- (+9 V to L+)	60 V AC
- insulation group	2xB
- tested with	500 V AC
Rated insulation voltage (+9 V to \perp)	12 V AC
- insulation group	1xB
- tested with	500 V AC
Current consumption	
- from +9 V (CPU)	typ. 15 mA
- from L+ (without load)	typ. 30 mA (at 60 V)
Power loss of the module	typ. 5 W
Weight	approx. 200 g (7 oz.)

Digital Output Module 4x115 to 230 V AC/1 A

(6ES5 450-8MD11)

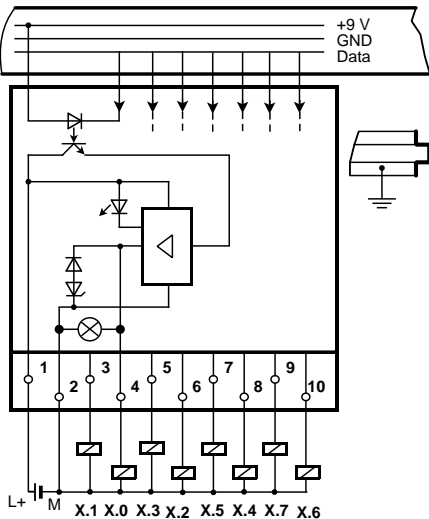
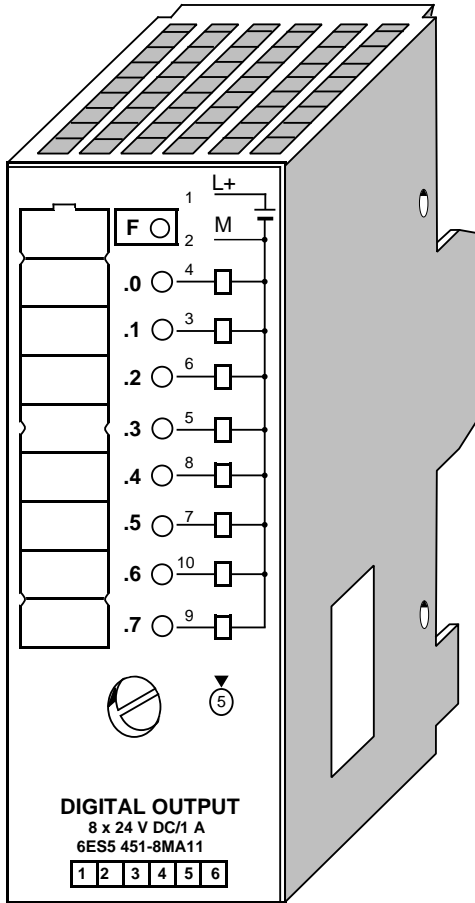
Technical Specifications

Address designation (for ET 100U only)		4DQ
Number of outputs		4
Galvanic isolation		yes
- in groups of		4
Load voltage L1		115 to 230 V AC
- rated value		
- frequency	max.	47 to 63 Hz
- permissible range		85 to 264 V
Output current for "1" signal		1 A
- rated value		
- permissible range	max.	50 mA to 1 A
- lamp load		25/50 W
Contact current closing rating		determined by the size of the fuse
Residual current at "0" signal	max.	3/5 mA
Output voltage - "1" signal	max.	L1 (- 7 V)
Signal status display (green LEDs)		only with load connected
Short-circuit protection		fuse (10 A extra fast) (Wickmann No. 19231, or 6ES5 980-3BC41)
Fault LED (red)		fuse blown*
Switching frequency	max.	10 Hz
Permissible current of all outputs		4 A
Driving of digital input		possible
Paralleling of outputs		not possible
Length of cable - unshielded	max.	100 m (330 ft.)
Rated insulation voltage (+9 V to L1)		250 V AC
- insulation group		2xB
- tested with		1500 V AC
Rated insulation voltage (+9 V to GND)		12 V AC
- insulation group		1xB
- tested with		500 V AC
Current consumption - from +9 V (CPU)	typ.	14 mA
Power loss of the module	typ.	3.5 W
Weight	approx.	315 g (11 oz.)

* Indication only given if load voltage is applied and at least one load is connected

Digital Output Module 8 x 24 V DC/1 A

(6ES5 451-8MA11)

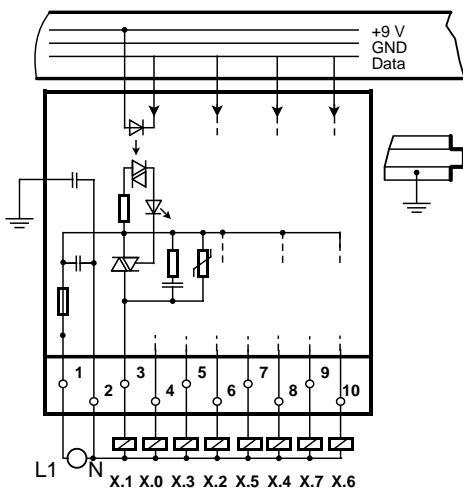
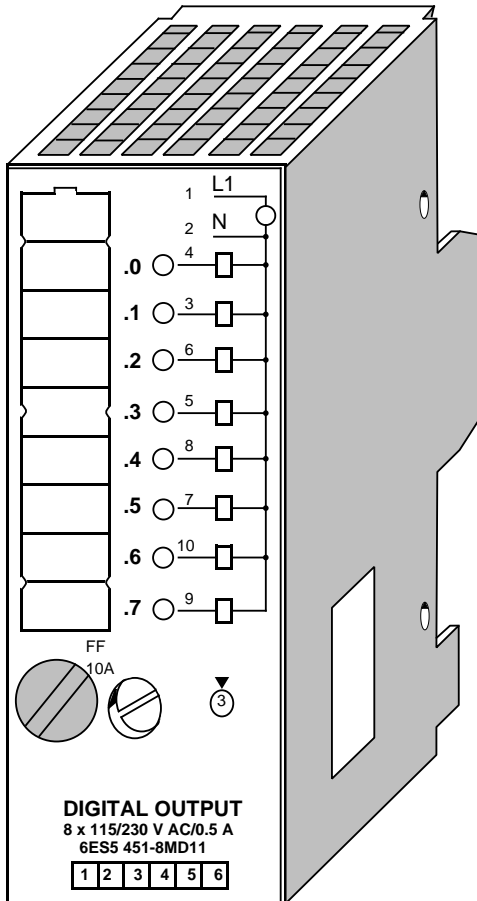


Technical Specifications

Address designation (for ET 100U only)	8DQ
Number of outputs	8
Galvanic isolation - in groups of	yes (optocoupler) 8
Load voltage L+ - rated value	24 V DC
- permissible range (including ripple)	20 to 30 V
- value at t<0.5 s	35 V
Output current for "1" signal - rated value	1 A
- permissible range	5 mA to 1A
- lamp load	max. 10 W
Residual current at "0" signal	max. 0.5 mA
Output voltage - at "1" signal	max. L+ (- 0.6 V)
Short-circuit protection	short-circuit protected output with autom. switch on when the short-circuit does not exist any more
Fault LED (red)	short-circuit
Voltage induced on circuit interruption (internal) limited to	-15 V
Switching frequency - resistive load	max. 100 Hz
- inductive load	max. 2 Hz
Permissible current of all outputs	6 A
Driving of digital input	possible
Paralleling of 2 outputs - maximum current	possible in pairs 1.8 A
Length of cable - unshielded	max. 100 m (330 ft.)
Rated insulation voltage (+ 9 V to L+)	24 V AC
- insulation group - tested with	2xB 500 V AC
Rated insulation voltage (+ 9 V to M)	12 V AC
- insulation group - tested with	1xB 500 V AC
Current consumption - from +9 V (CPU)	typ. 35 mA
- from L+ (without load)	typ. 50 mA
Power loss of the module	typ. 3 W
Weight	approx. 230 g (8 oz.)

Digital Output Module 8x115 to 230 V AC/0.5 A

(6ES5 451-8MD11)

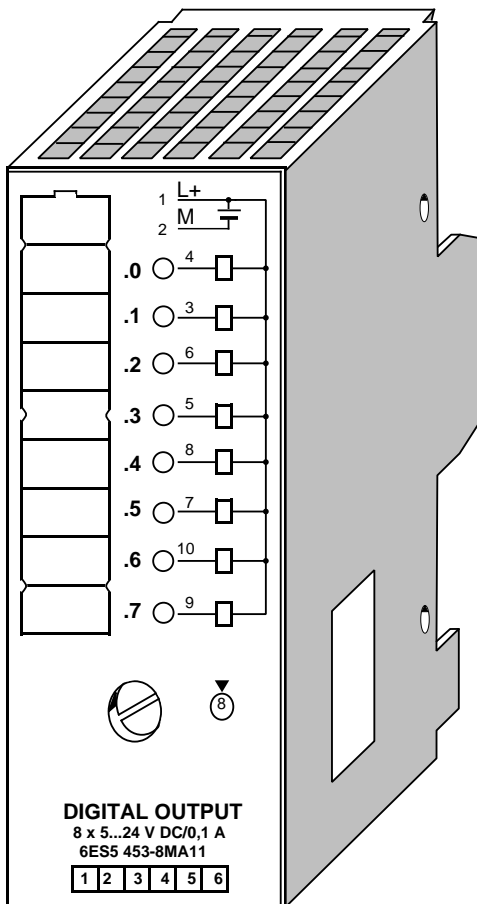


Technical Specifications

Address designation (for ET 100U only)		8DQ
Number of outputs		8
Galvanic isolation		yes (optocoupler)
- in groups of		8
Load voltage L1		
- rated value		115 to 230 V AC
- frequency	max.	47 to 63 Hz
- permissible range		85 to 264 V
Output current for "1" signal		
- rated value		0.5 A
- permissible range	max.	50 mA to 0.5 A
- lamp load		25/50 W
Contact current closing rating:		determined by the size of the fuse
Residual current at "0" signal	max.	3/5 mA
Output voltage - at "1" signal	max.	L1 (-7 V)
Signal Status Display (green LEDs)		only with load connected
Short-circuit protection		fuse (10 A extra fast) (Wickmann No. 19231, or 6ES5 980-3BC41)
Switching frequency	max.	10 Hz
Permissible current of all outputs		4 A
Driving of digital input		possible
Paralleling of outputs		not possible
Length of cable - unshielded	max.	100 m (330 ft.)
Rated insulation voltage (+9 V to L1)		250 V AC
- insulation group		2xB
- tested with		1500 V AC
Rated insulation voltage (+9 V to GND)		12 V AC
- insulation group		1xB
- tested with		500 V AC
Current consumption - from +9 V (CPU)	typ.	25 mA
Power loss of the module	typ.	3.5 W
Weight	approx.	270 g (9 oz.)

Digital Output Module 8x5 to 24 V DC/0.1 A

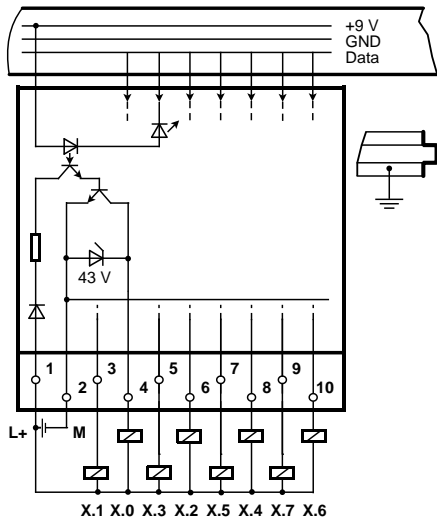
(6ES5 453-8MA11)



Technical Specifications

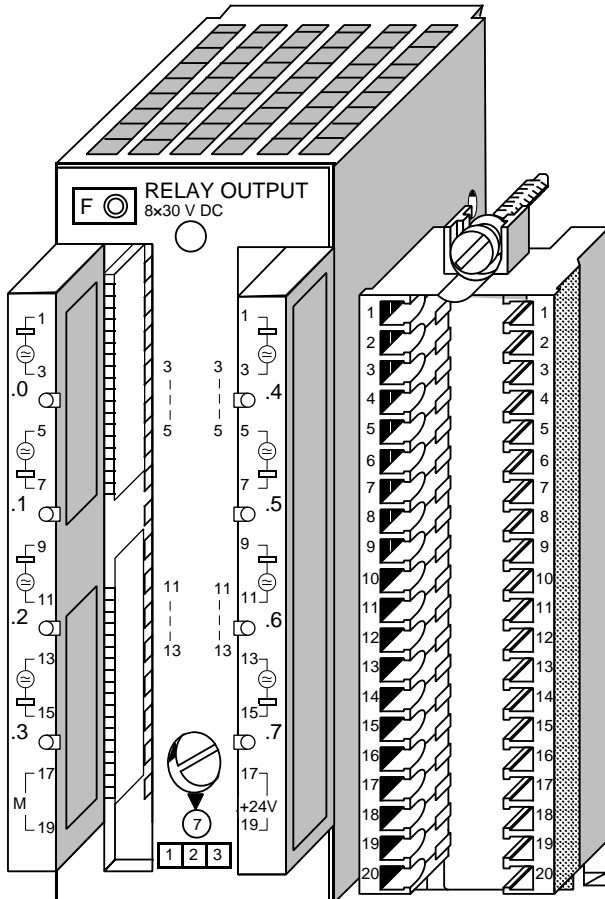
Address designation (for ET 100U only)	8DQ
Number of outputs	8
Galvanic isolation	yes
- in groups of	8
Load voltage L+	
- rated value	5 to 24 V DC
- permissible range (including ripple)	4.75 to 30 V
- value at $t < 0.5$ s	35 V
Output current for "1" signal	
- rated value	100 mA
Output voltage	TTL-compatible*
Short-circuit protection	no
Voltage induced on circuit interruption (internal) limited to	- 19 V (at 24 V)
Switching frequency	
- resistive load	max. 100 Hz
- inductive load	max. 2 Hz
Paralleling of outputs	possible
- maximum current	($0.8 \times I_{\text{rated}}$)
Length of cable	
- unshielded	max. 100 m (330 ft.)
Rated insulation voltage (+9 V to \downarrow)	12 V AC
- insulation group	1xB
- tested with	500 V AC
Current consumption	
- from +9 V (CPU)	typ. 20 mA
- from L+ (without load)	typ. 28 mA
Power loss of the module	typ. 1 W
Weight	approx. 220 g (8 oz.)

* transistor with open collector, switching to M potential



Relay Output Module 8 x 30 V DC/230 V AC
Crimp Snap-in Connector, 40-pin
Screw Plug Connector, 20-pin
Screw Plug Connector, 40-pin

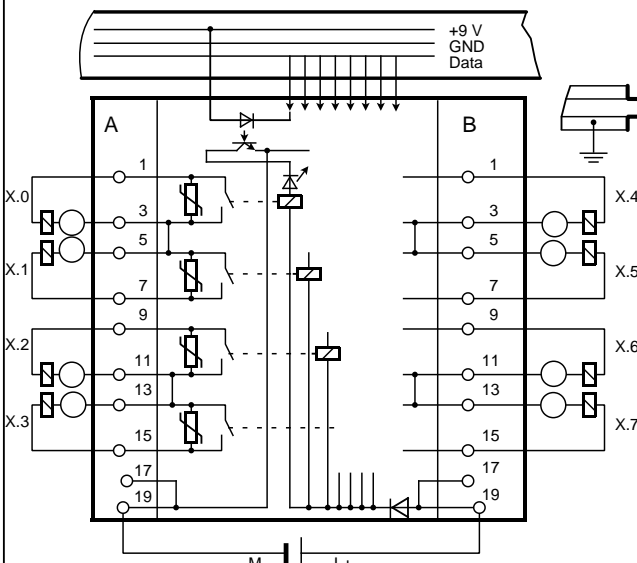
(6ES5 451-8MR12)
(6ES5 490-8MA12/-8MA02)
(6ES5 490-8MB21)
(6ES5 490-8MB11)



RELAY OUTPUT
8x30 V DC

Technical Specifications

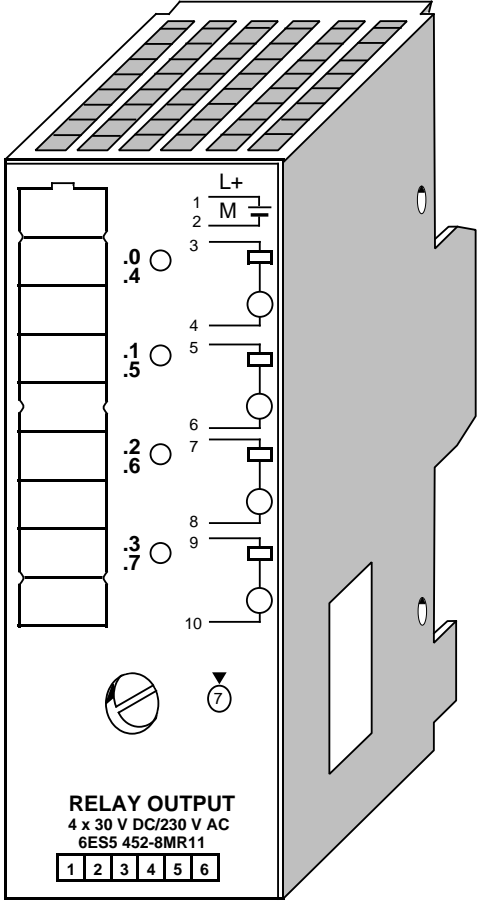
Address designation (for ET 100U only)	8DQ
Outputs	8 relay outputs, contact switching varistor
Galvanic isolation - in groups of	yes 2 with signal status display
Continuous current I_{th}	3 A
Fault LED (red)	no input voltage
Length of cable - unshielded	max. 100 m (330 ft.)
Rated insulation voltage (+ 9 V to L 1) - insulation group - tested with	250 V AC 2xB 1500 V AC
Rated insulation voltage (+ 9 V to \downarrow) - insulation group - tested with	12 V AC 1xB 500 V AC
Current consumption - from + 9 V (CPU) - from L+	typ. 30 mA typ. 70 mA
Power loss of the module	typ. 1.6 W
Weight	approx. 300 g (11 oz.)
Switching capacity of the contacts - resistive load	max. 3 A at 250 V AC 1.5 A at 30 V DC
- inductive load	max. 0.5 A at 250 V AC 0.5 A at 30 V DC
Operating cycles of the contacts according to VDE 0660, part 200 - AC-11 - DC-11	1x10 ⁶ 0.5x10 ⁶
Switching frequency	max. 10 Hz
Rated insulation voltage (between contacts) - insulation group - tested with	250 V AC 2xB 1500 V AC
Supply voltage L+ (for the relays) - rated value - ripple V_{pp} - permissible range (ripple included) - value at $t < 0.5$ s	max. 24 V DC 3.6 V 20 to 30 V 35 V



The schematic diagram shows the internal circuitry of the relay output module. It features two main sections, A and B, each containing four relays. The relays are connected to a common supply voltage L+ and ground M. The output terminals are labeled X.0 through X.7. The diagram also shows the connection of the module to the ET 100U system, including the +9 V, GND, and Data lines.

Relay Output Module 4 x 30 V DC/ 230 V AC

(6ES5 452-8MR11)

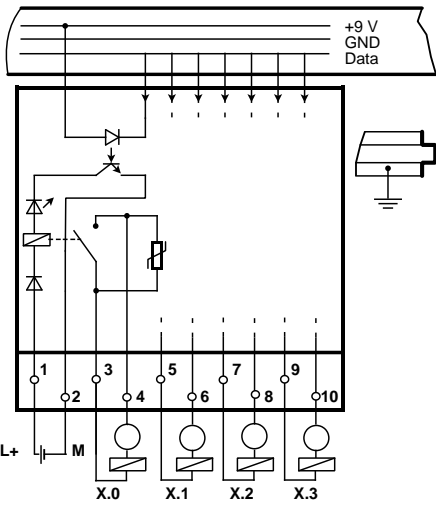


RELAY OUTPUT
4 x 30 V DC/230 V AC
6ES5 452-8MR11

1 2 3 4 5 6

Technical Specifications

Address designation (for ET 100U only)	4DQ
Outputs	4 relay outputs, contact switching varistor
Galvanic isolation - in groups of	yes (optocoupler) 1
Continuous current I_{th}	5 A
Length of cable - unshielded	max. 100 m (330 ft.)
Rated insulation voltage (+ 9 V to L 1)	250 V AC
- insulation group	2xB
- tested with	1500 V AC
Rated insulation voltage (+ 9 V to \perp)	12 V AC
- insulation group	1xB
- tested with	500 V AC
Current consumption - from + 9 V (CPU)	typ. 14 mA
- from L+	typ. 100 mA
Power loss of the module	typ. 2 W
Weight	approx. 240 g (11 oz.)
Switching capacity of the contacts - resistive load	max. 5 A at 250 V AC 2.5 A at 30 V DC
- inductive load	max. 1.5 A at 250 V AC 0.5 A at 30 V DC
Operating cycles of the contacts according to VDE 0660, part 200 - AC-11	1.5x10 ⁶
- DC-11	0.5x10 ⁶
Switching frequency	max. 10 Hz
Rated insulation voltage (between contacts) - insulation group	250 V AC 2xB
- tested with	1500 V AC
Supply voltage L+ (for the relays) - rated value	max. 24 V DC
- ripple V_{PP}	3.6 V
- permissible range (ripple included)	20 to 30 V
- value at $t < 0.5$ s	35 V



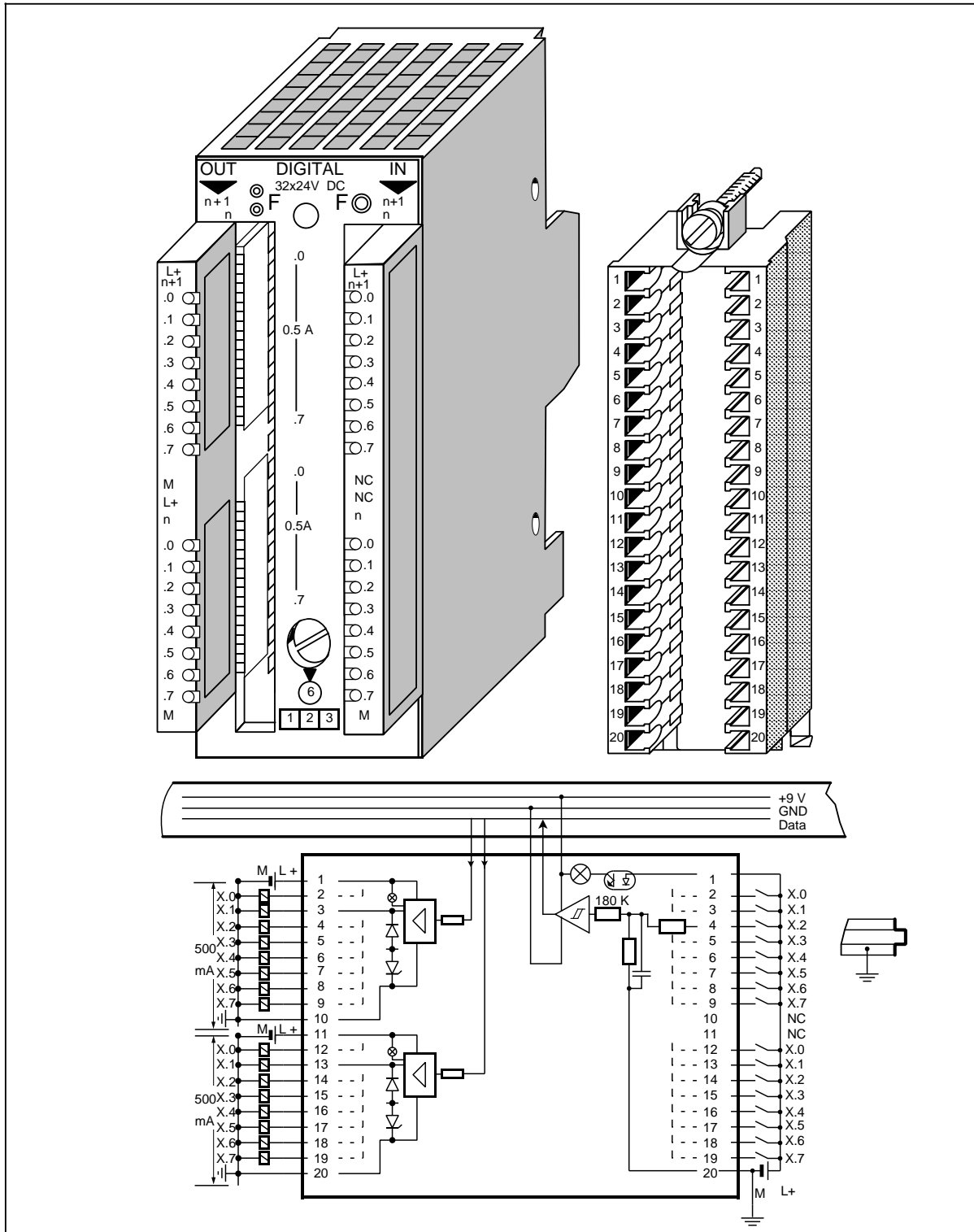
+9 V
GND
Data

L+ M

X.0 X.1 X.2 X.3

Digital Input/Output Module with LED Display
Crimp Snap-in Connector, 40-pin
Screw Plug Connector, 40-pin

(6ES5 482-8MA13)
 (6ES5 490-8MA12/8MA02)
 (6ES5 490-8MB11)



Digital Input/Output Module with LED Display (Continued)

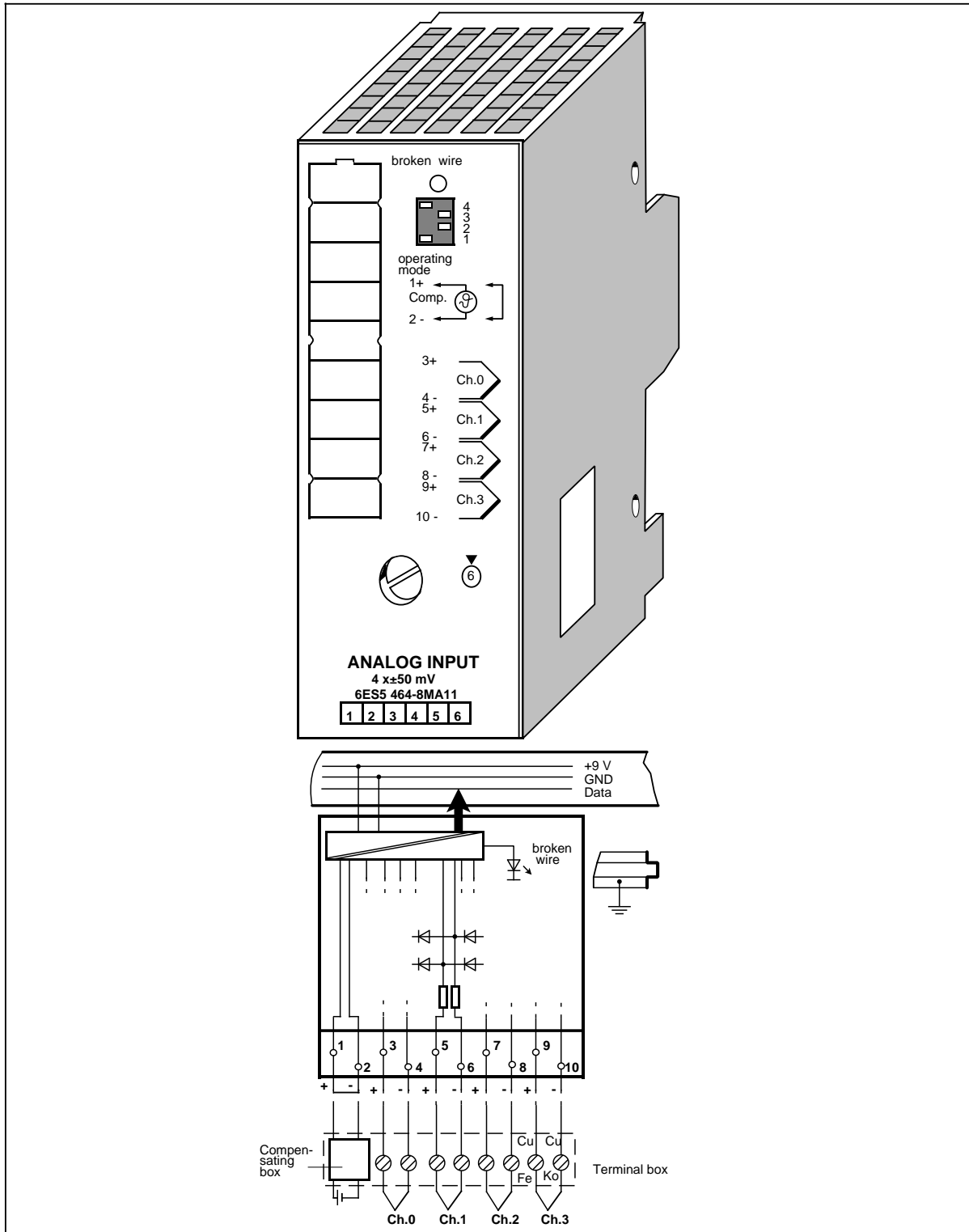
(6ES5 482-8MA13)

Technical Specifications		Output side	
Address designation (for ET 100U only)	1AX	Number of outputs	16
Cable length - unshielded	100 m (330 ft.)	Galvanic isolation - in groups of	no 8
Rated insulation voltage (+9 V to \perp) - insulation group	12 V AC 1xB	Load voltage L+ - rated value	24 V DC
Power loss of the module	typ. 4.5 W	- permissible range (ripple included)	20 to 30 V
Weight	approx. 190 g (7 oz.)	- value at $t < 0.5$ s	35 V
Input side		Output current I_N for "1" signal	
Number of inputs	16	- rated value	500 mA
Galvanic isolation - in groups of	no 16	- permissible range	5 to 500 mA
Input voltage L+ - rated value	24 V DC	Residual current for "0" signal	max. 0.5 mA
- for "0" signal	0 to 5 V	Short-circuit protection	yes
- for "1" signal	13 to 30 V	Short-circuit indication	red LED
Input current for "1" signal	typ. 4.5 mA	Output voltage for "1" signal	L+(- 0.6 V)
Inherent delay - from "0" to "1"	typ. 4 ms	Voltage induced on circuit interruption (internal) limited to	- 15 V
- from "1" to "0"	typ. 3 ms	Switching frequency with - resistive load	100 Hz
Fault LED (red)	indicates interruption of L+/M supply	- inductive load	2 Hz
Connection of two-wire BERO proximity switches	possible	Permissible total current of the outputs	6 A
- residual current	1.5 mA	Driving of a digital input	possible
Current consumption - from +9 V (CPU)	typ. 50 mA	Paralleling of outputs - maximum current	possible in pairs ($0.8 \times I_N$)
		Current consumption - from +9 V (CPU)	typ. 10 mA
		- from L+ (without load)	typ. 100 mA
		Lamp load	max. 5 W

2.6.3 Analog Input Module

Analog Input Module 4 x±50 mV

(6ES5 464-8MA11)



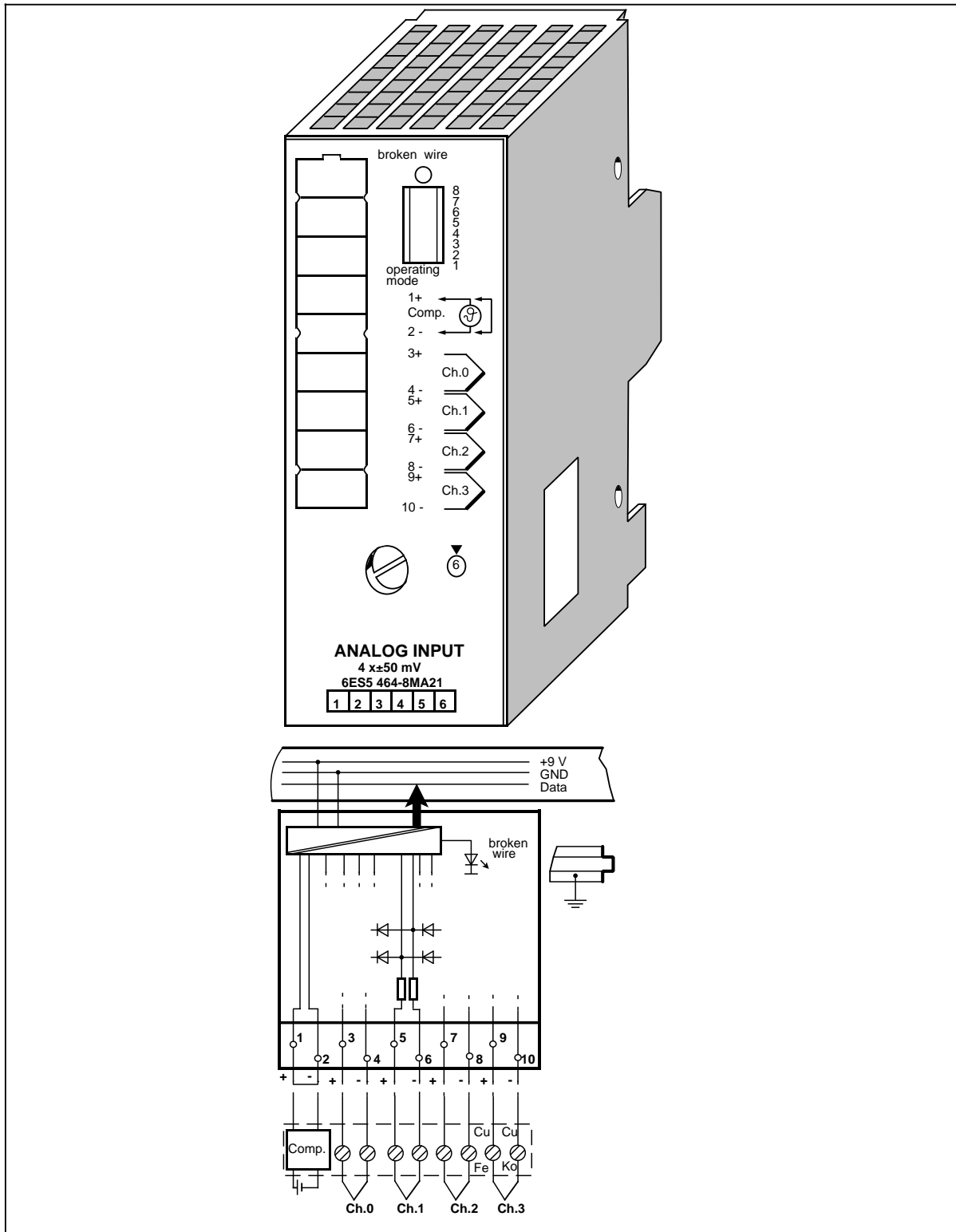
Analog Input Module 4 x±50 mV (continued)

(6ES5 464-8MA11)

Technical Specifications			
Address designation (for ET 100U only)	4AI	Noise suppression for f=nx (50/60 Hz±1%); n=1, 2, ...	
Input range (rated value)	±50 mV	- common-mode rejection (V _{pp} =1 V)	min. 86 dB
Number of inputs	1, 2 or 4 (selectable)	- series-mode rejection (peak value of noise <rated value of input range)	min. 40 dB
Galvanic isolation	yes (inputs to grounding point; not between inputs)	Basic error limits (=operational error limits at 25°C, referred to input ranges of the module)	±0.15 %
Input resistance	10 M	Operational error limits (0 to 60 °C) (32 to 140°F) (referred to input ranges of the module)	±0.4 %
Connection method of sensors	two-wire connection	Length of cable - shielded	max. 50 m (164 ft.)
Digital representation of input signal	12 bits+sign (2048 units = rated value)	Supply voltage L+	none
Measured value representation	two's complement (left-justified)	Connection of com- pensating box	possible
Measuring principle	integrating	Rated insulation voltage (+9 V to \bar{U}) - insulation group - tested with	12 V AC 1xB 500 V AC
Conversion principle	voltage-time conversion (dual slope)	Rated insulation voltage (inputs to+9 V) - insulation group - tested with	60 V AC 1xB 500 V AC
Integration time (adjustable for optimum noise suppression)	20 ms at 50 Hz 16.6 ms at 60 Hz	Current consumption - from+9 V (CPU)	typ. 70 mA
Encoding time per input - for 2048 units	max. 60 ms at 50 Hz max. 50 ms at 60 Hz	Power loss of the module	typ. 0.7 W
- for 4095 units	max. 80 ms at 50 Hz max. 66.6 ms at 60 Hz	Weight	approx. 230 g (8 oz.)
Permissible voltage difference - between inputs	max. ±1 V		
- between inputs and central ground point	max. 75 V DC/60 V AC		
Permissible input voltage (destruction limit)	max. 24 V DC		
Fault indication for - range exceeded	yes (more than 4095 units)		
- sensor wire break	yes (selectable), via test pulse		
- general indication of wire break	red LED		

Analog Input Module 4 x ± 50 mV

(6ES5 464-8MA21)



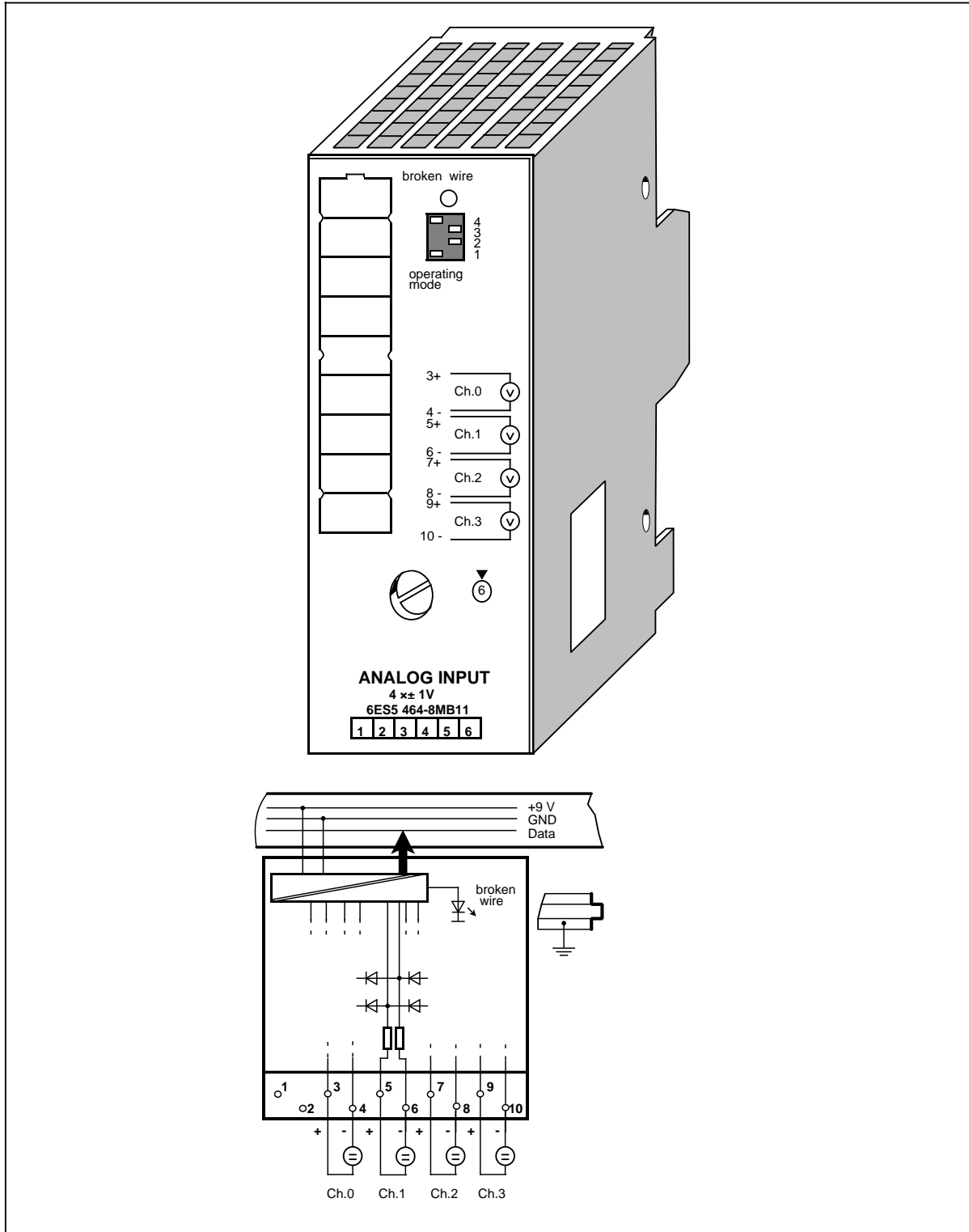
Analog Input Module 4 x±50 mV (continued)

(6ES5 464-8MA21)

Technical Specifications			
Address designation (for ET 100U only)		4AI	Noise suppression for $f = nx$ (50/60 Hz±1%) $n = 1, 2, \dots$
Input range (rated value)		± 50 mV	- common mode rejection ($V_{pp} = 1$ V) min. 86 dB
Number of inputs		1, 2 or 4 (selectable)	- series mode rejection (peak value of noise < rated value of input range) min. 40 dB
Galvanic isolation		yes (inputs to grounding point; not between inputs)	Basic error limits (operating error limits at 25°C, referred to input ranges of module) ±0.15%
Input resistance		10 M	Operating error limits (0 to 60 °C, referred to input range of module (32 to 140°F) ±0.4%
Connection method of sensors		two-wire connection	Linearization exactness for rated range (for types J, K, L) ±1 °C (1.8 °F)
Digital representation of input signal		12 bits + sign (2048 units = rated value)	Characteristic lineari- zation for the following thermoelements - nickel-chromium/ nickel-aluminium (type K) - iron/copper-nickel (type J) - iron/copper-nickel (type L)
Measured value representation		two's complement (left-justified)	IEC 584 IEC 584 DIN 43710
Measuring principle		integrating	Length of cable - shielded max. 50 m (164 ft.)
Conversion principle		voltage-time conversion (dual slope)	Supply voltage L+ none
Integration time (adjustable for optimum noise suppression)		20 ms at 50 Hz 16.6 ms at 60 Hz	Internal temperature compensation possible
Encoding time per input			Connection of compensating box possible
- for 2048 units	max.	60 ms at 50 Hz	Rated insulation voltage (+9 V to \downarrow) 12 V AC
- for 4095 units	max.	50 ms at 60 Hz	- insulation group 1xB
	max.	80 ms at 50 Hz	- tested with 500 V DC
	max.	66.6 ms at 60 Hz	Rated insulation voltage (inputs to + 9 V) 60 V AC
Permissible voltage difference			- insulation group 1xB
- between inputs	max.	±1 V	- tested with 500 V DC
- between inputs and central ground point	max.	75 V DC/60 V AC	Current consumption - from + 9 V (CPU) typ. 100 mA
Permissible input voltage (destruction limit)	max.	24 V DC	Power loss of the module typ. 0.7 W
Fault indication for - range exceeded		yes (more than 4095 units)	Weight approx. 230 g (8 oz.)
- sensor wire break		yes (selectable), via test pulse	
- general indication of wire break		red LED	

Analog Input Module 4 x ± 1 V

(6ES5 464-8MB11)



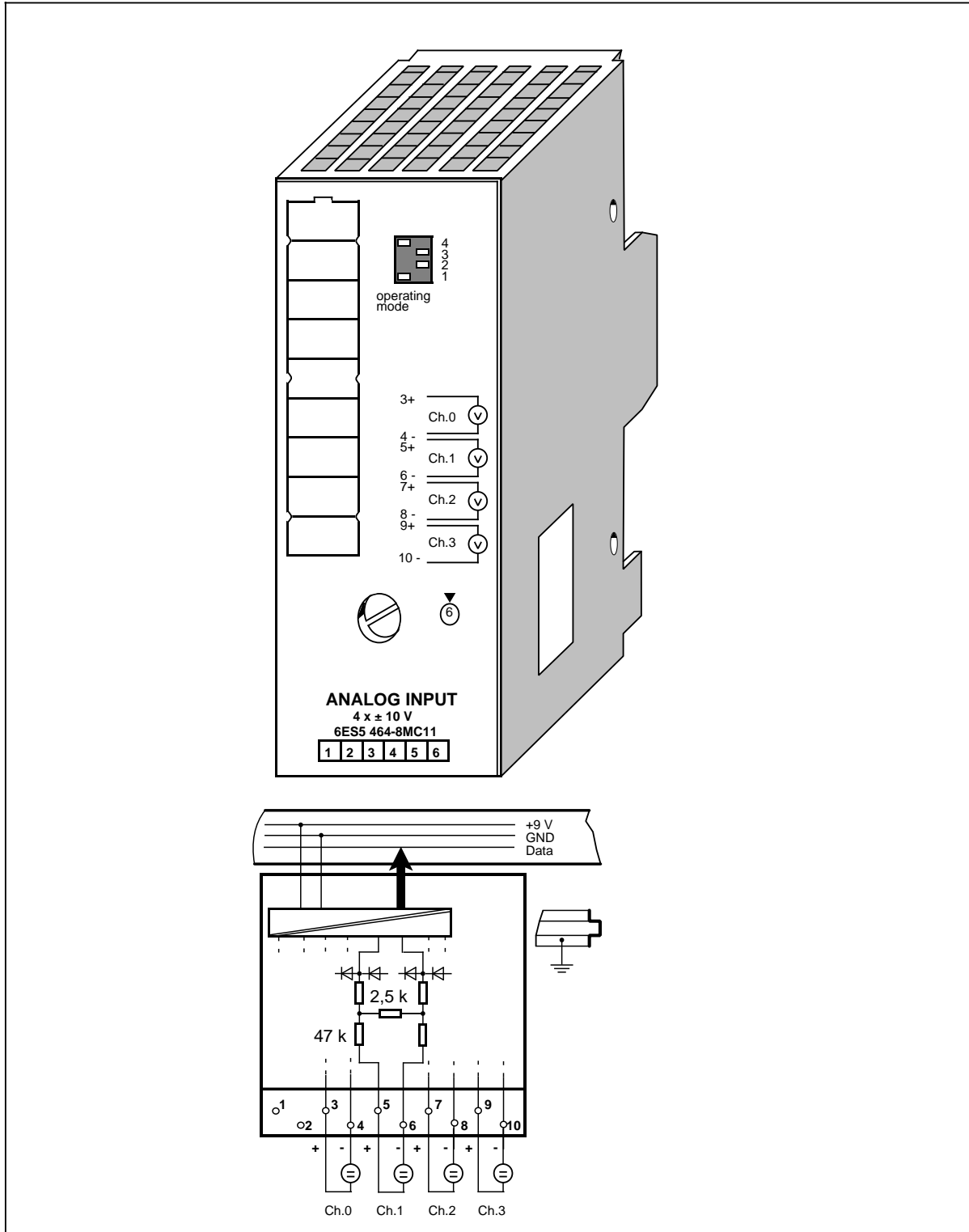
Analog Input Module 4 x ± 1 V (continued)

(6ES5 464-8MB11)

Technical Specifications			
Address designation (for ET 100U only)		4AI	Noise suppression for $f=nx$ (50/60 Hz±1%); $n=1, 2, \dots$
Input range (rated value)		± 1 V	- common-mode rejection ($V_{pp}=1$ V) min. 86 dB
Number of inputs		1, 2 or 4 (selectable)	- series-mode rejection min. 40 dB (peak value of noise < rated value of input range)
Galvanic isolation		yes (inputs to grounding point; not between inputs)	Basic error limits (operational error limits at 25°C, referred to input ranges of the module) ±0.1 %
Input resistance		10 M	
Connection method of sensors		two-wire connection	Operational error limits (0 to 60 °C, referred to input range of the module) (32 to 140°F) ±0.35 %
Digital representation of input signal		12 bits+sign (2048 units = rated value)	
Measured value representation		two's complement (left-justified)	Length of cable - shielded max. 200 m (660 ft.)
Measuring principle		integrating	Supply voltage L+ none
Conversion principle		voltage-time conversion (dual slope)	Rated insulation voltage (+9 V to \downarrow) 12 V AC - insulation group 1xB - tested with 500 V AC
Integration time (adjustable for optimum noise suppression)		20 ms at 50 Hz 16.6 ms at 60 Hz	Rated insulation voltage (inputs to +9 V) 60 V AC - insulation group 1xB - tested with 500 V AC
Encoding time per input			Current consumption - from +9 V (CPU) typ. 70 mA
- for 2048 units	max.	60 ms at 50 Hz	
	max.	50 ms at 60 Hz	
- for 4095 units	max.	80 ms at 50 Hz	Power loss of the module typ. 0.7 W
	max.	66.6 ms at 60 Hz	
Permissible voltage difference			Weight approx. 230 g (8 oz.)
- between inputs	max.	± 1V	
- between inputs and central ground point	max.	75 V DC/60 V AC	
Permissible input voltage (destruction limit)	max.	24 V DC	
Fault indication for - range exceeded		yes (more than 4095 units)	
- sensor wire break		yes (selectable), via test pulse	
- general indication of wire break		red LED	

Analog Input Module 4 x ± 10 V

(6ES5 464-8MC11)



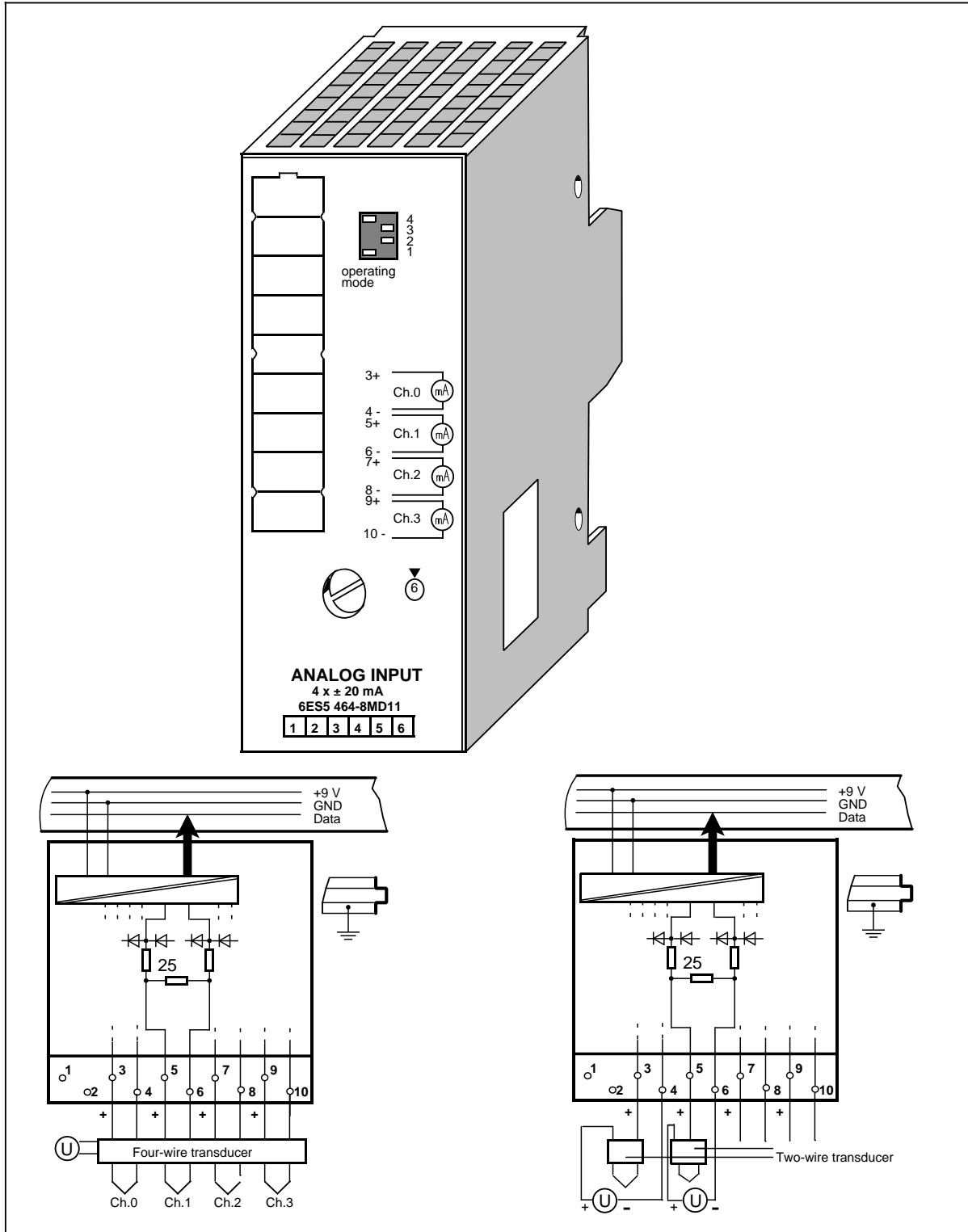
Analog Input Module 4 x±10 V (continued)

(6ES5 464-8MC11)

Technical Specifications			
Address designation (for ET 100U only)	4AI	Noise suppression for $f=nx$ (50/60 Hz±1%); $n=1,2, \dots$	
Input range (rated value)	±10 V	- common-mode rejection ($V_{pp}=1$ V)	min. 86 dB
Number of inputs	1, 2 or 4 (selectable)	- series-mode rejection (peak value of noise < rated value of input range)	min. 40 dB
Galvanic isolation	yes (inputs to grounding point; not between inputs)	Basic error limits (operational error limits at 25°C, referred to the input ranges of the module)	±0.2 %
Input resistance	50 k	Operational error limits (0 to 60 °C, referred to the input ranges of the module) (32 to 140°F)	±0.45 %
Connection method of sensors	two-wire connection	Length of cable - shielded	max. 200 m (660 ft.)
Digital representation of input signal	12 bits+sign (2048 units =rated value)	Supply voltage L+	none
Measured value representation	two's complement (left-justified)	Rated insulation voltage (+9 V to \perp)	12 V AC 1xB 500 V AC
Measuring principle	integrating	- insulation group	
Conversion principle	voltage-time conversion (dual slope)	- tested with	
Integration time (adjustable for optimum noise suppression)	20 ms at 50 Hz 16.6 ms at 60 Hz	Rated insulation voltage (inputs to +9 V)	60 V AC 1xB 500 V AC
Encoding time per input		- insulation group	
- for 2048 units	max. 60 ms at 50 Hz	- tested with	
- for 4095 units	max. 50 ms at 60 Hz max. 80 ms at 50 Hz max. 66.6 ms at 60 Hz	Current consumption - from +9 V (CPU)	typ. 70 mA
Permissible voltage difference		Power loss of the module	typ. 0.7 W
- between inputs	max. ±1 V	Weight	approx. 230 g (8 oz.)
- between inputs and central ground point	max. 75 V DC/60 V AC		
Permissible input voltage (destruction limit)	max. 50 V DC		
Fault indication for - range exceeded	yes (more than 4095 units)		
- sensor wire break	no		
- general indication of wire break	no		

Analog Input Module 4 x ±20 mA

(6ES5 464-8MD11)



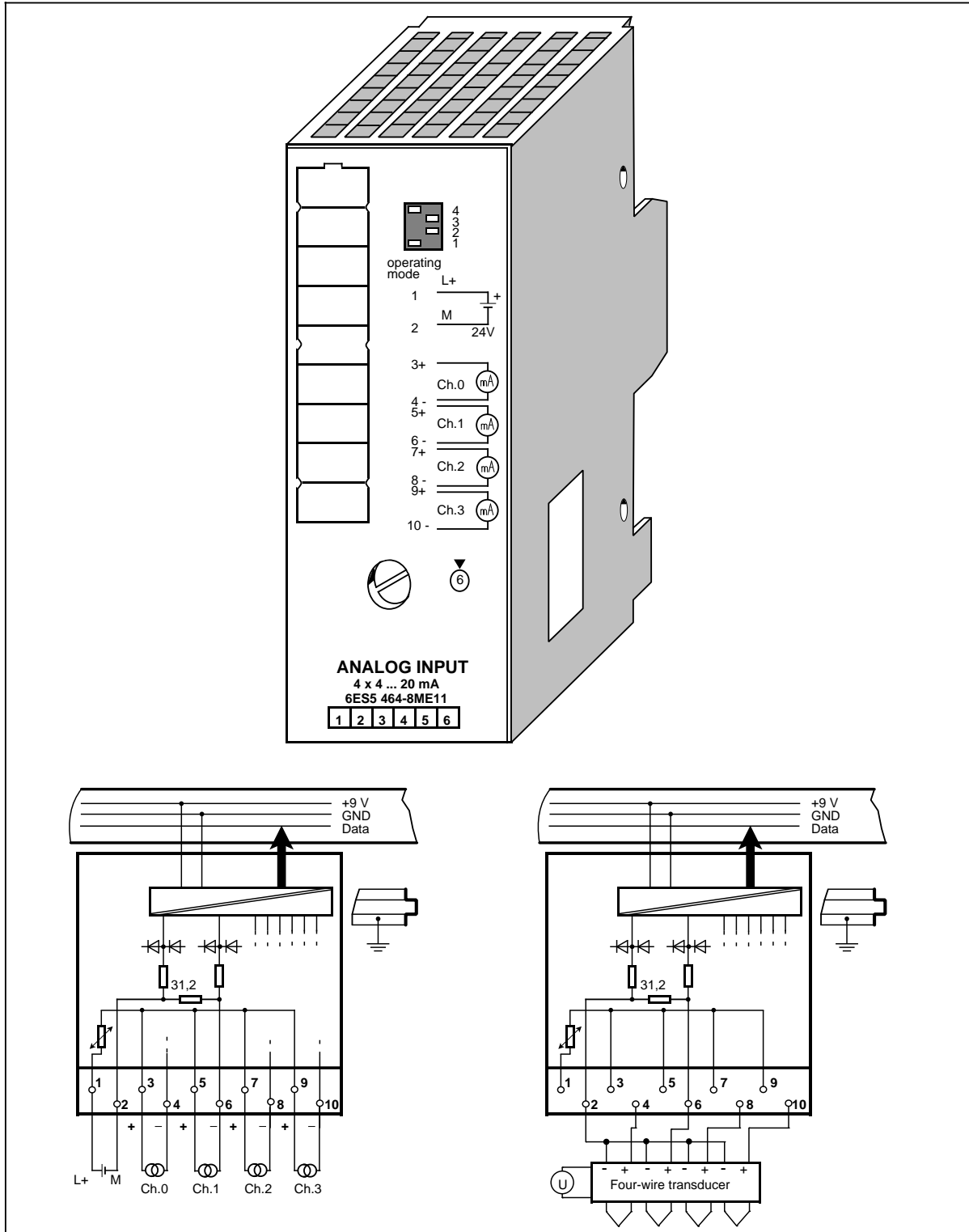
Analog Input Module 4 x ± 20 mA (continued)

(6ES5 464-8MD11)

Technical Specifications			
Address designation (for ET 100U only)	4AI	Noise suppression for $f=nx$ (50/60 Hz \pm 1%); $n=1,2, \dots$	
Input range (rated value)	± 20 V	- common-mode rejection ($V_{pp}=1$ V)	min. 86 dB
Number of inputs	1, 2 or 4 (selectable)	- series-mode rejection (peak value of noise < rated value of input range)	min. 40 dB
Galvanic isolation	yes (inputs to grounding point; not between inputs)	Basic error limits (operational error limits at 25°C, referred to the input ranges of the module)	± 0.2 %
Input resistance	25	Operational error limits (0 to 60 °C, referred to the input ranges of the module) (32 to 140°F)	± 0.45 %
Connection method of sensors	two-wire connection	Length of cable - shielded	max. 200 m (660 ft.)
Digital representation of input signal	12 bits+sign (2048 units =rated value)	Supply voltage L+	none
Measured value representation	two's complement (left-justified)	Rated insulation voltage (+9 V to \pm) - insulation group - tested with	12 V AC 1xB 500 V AC
Measuring principle	integrating	Rated insulation voltage (inputs to +9 V) - insulation group - tested with	60 V AC 1xB 500 V AC
Conversion principle	voltage-time conversion (dual slope)	Current consumption - from +9 V (CPU)	typ. 70 mA
Integration time (adjustable for optimum noise suppression)	20 ms at 50 Hz 16.6 ms at 60 Hz	Power loss of the module	typ. 0.7 W
Encoding time per input		Weight	approx. 230 g (8 oz.)
- for 2048 units	max. 60 ms at 50 Hz		
- for 4095 units	max. 50 ms at 60 Hz max. 80 ms at 50 Hz max. 66.6 ms at 60 Hz		
Permissible voltage difference			
- between inputs	max. ± 1 V		
- between inputs and central ground point	max. 75 V DC/60 V AC		
Permissible input voltage (destruction limit)	max. 80 mA		
Fault indication for - range exceeded	yes (more than 4095 units)		
- sensor wire break	no		
- general indication of wire break	no		

Analog Input Module 4 x ± 4 to 20 mA

(6ES5 464-8ME11)



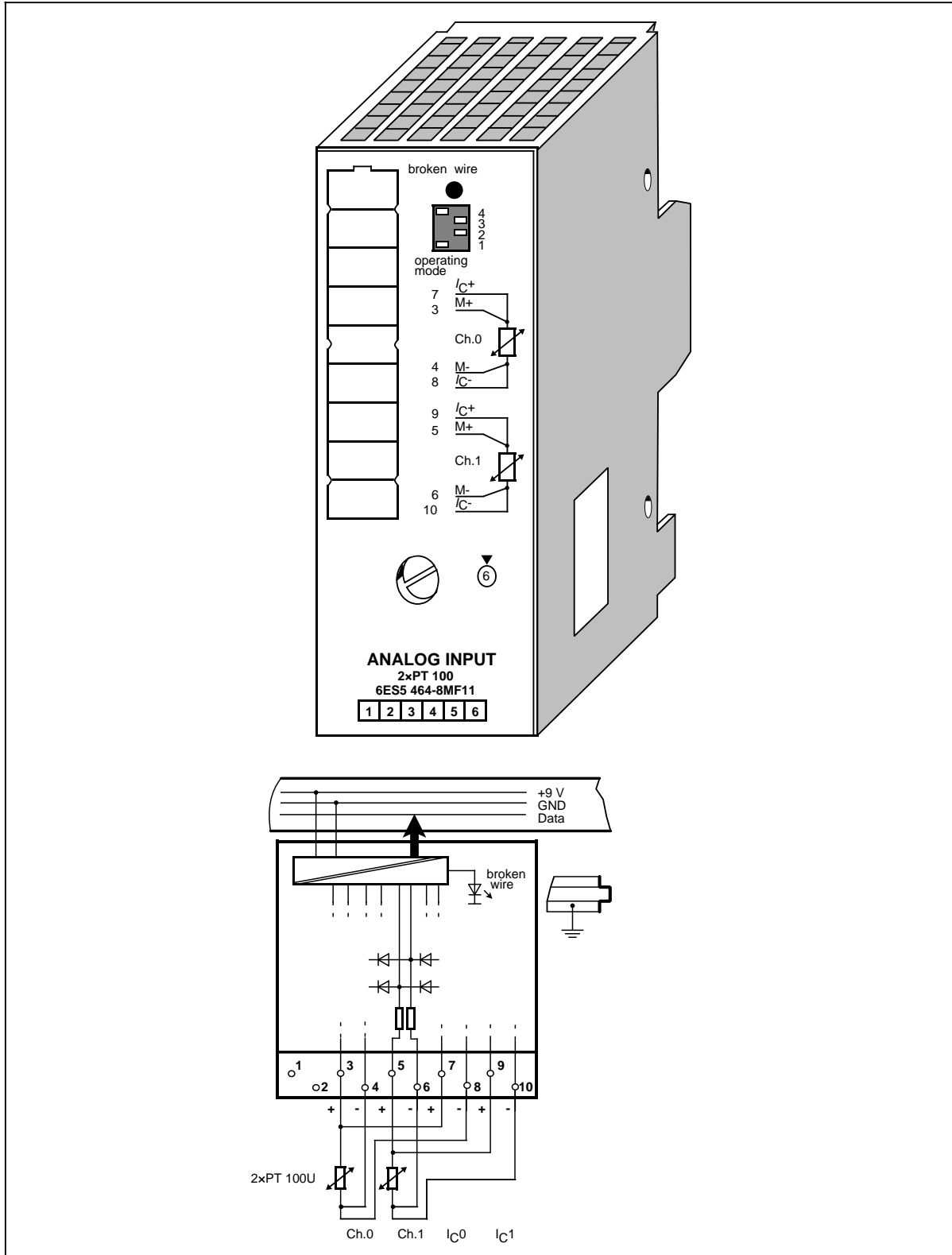
Analog Input Module 4 x ± 4 to 20 mA (continued)

(6ES5 464-8ME11)

Technical Specifications			
Address designation (for ET 100U only)		4AI	Noise suppression for f=nx (50/60 Hz±1%); n=1, 2, ...
Input range (rated value)		4 to 20 mA	- common-mode rejection (V _{pp} =1 V) min. 86 dB
Number of inputs		1, 2 or 4 (selectable)	- series-mode rejection min. 40 dB (peak value of noise < rated value of input range)
Galvanic isolation		yes (inputs to grounding point; not between inputs)	Basic error limits ±0.15 % (operational error limits at 25°C, referred to input ranges of the module)
Input resistance		31.25	Operational error limits ±0.4 % (0 to 60 °C, referred to the input ranges of the module) (32 to 140°F)
Connection method of sensors		two-wire connection for 2/4 wire transducers	Length of cable - shielded max. 200 m (660 ft.)
Digital representation of input signal		12 bits+sign (2048 units =rated value)	Supply voltage L+ for 2-wire transducers
Measured value representation		two's complement (left-justified)	- rated value 24 V DC
Measuring principle		integrating	- ripple V _{pp} 3.6 V
Conversion principle		voltage-time conversion (dual slope)	- permissible range 20 to 30 V
Integration time (adjustable for optimum noise suppression)		20 ms at 50 Hz 16.6 ms at 60 Hz	Rated insulation voltage (+9 V to $\bar{0}$) 12 V AC
Encoding time per input			- insulation group 1xB
- for 2048 units	max.	60 ms at 50 Hz	- tested with 500 V AC
- for 4095 units	max.	50 ms at 60 Hz	
	max.	80 ms at 50 Hz	
	max.	66.6 ms at 60 Hz	
Permissible voltage difference			Rated insulation voltage (inputs to +9 V)
- between inputs	max.	±1 V	- insulation group 60 V AC
- between inputs and central ground point	max.	75 V DC/60 V AC	- tested with 500 V AC
Permissible input voltage (destruction limit)	max.	80 mA	Current consumption
			- from +9 V (CPU) typ. 70 mA
			- from L+ typ. 80 mA
Fault indication for - range exceeded		yes (more than 4095 units)	Power loss of the module
- sensor wire break		no	- for 2-wire transducers typ. 1.0 W
- general indication of wire break		no	- for 4-wire transducers typ. 0.7 W
			Weight approx. 230 g (8 oz.)

Analog Input Module 2 x PT 100/± 500 mV

(6ES5 464-8MF11)



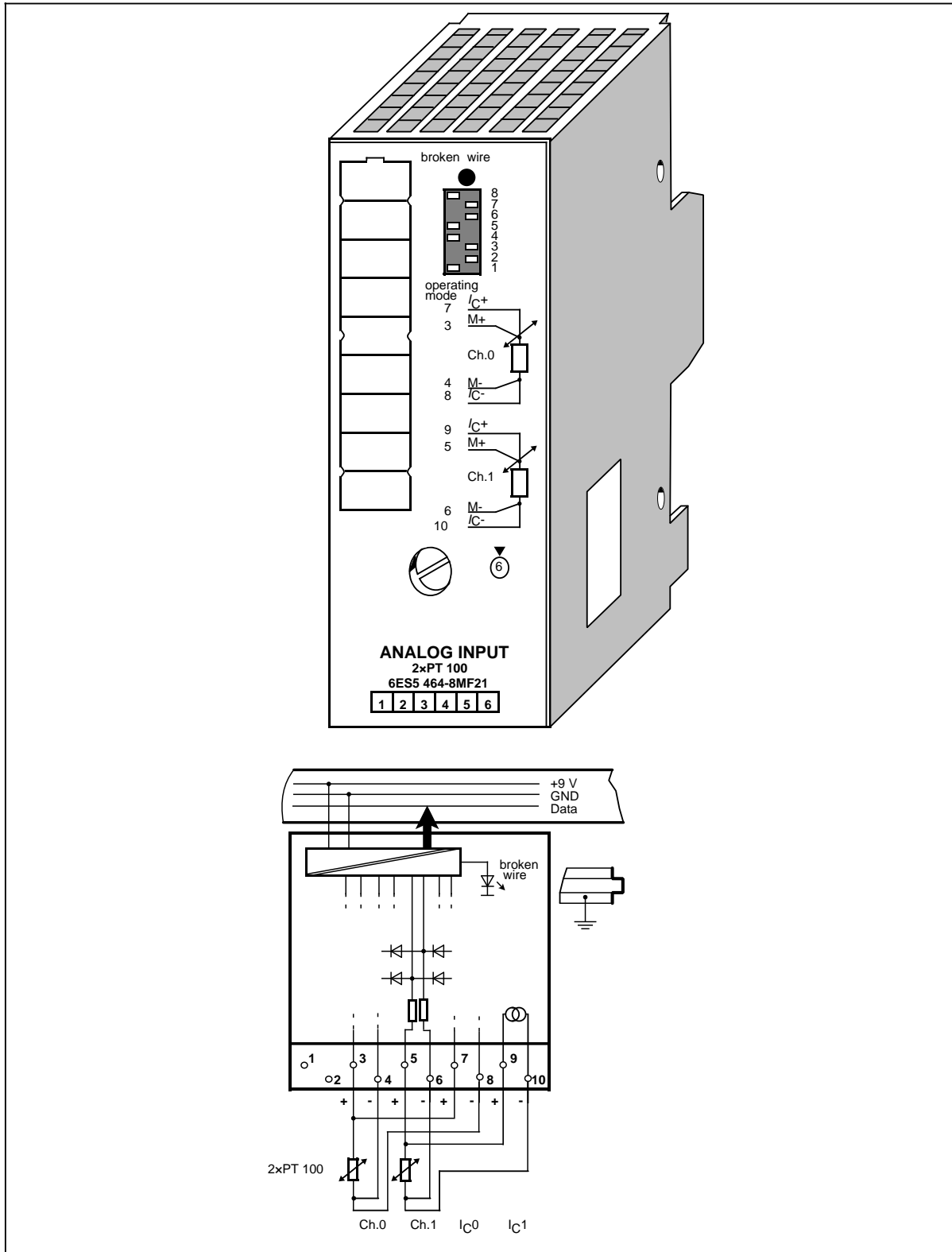
Analog Input Module 2 x PT 100/±500 mV (continued)

(6ES5 464-8MF11)

Technical Specifications			
Address designation (for ET 100U only)	2AI	Noise suppression for $f=nx$ (50/60 Hz±1%); $n=1, 2, \dots$	
Input ranges (rated values)		- common mode rejection ($V_p=1$ V)	min. 86 dB
- Resistance encoder (PT 100)	0 to 200 (max. 400)	- series mode rejection (peak value of noise <rated value of input range)	min. 40 dB
- Voltage sources	±500 mV		
Number of inputs	1 or 2 (selectable)		
Galvanic isolation	yes (inputs to grounding point; not between inputs)	Basic error limits (operating error limits at 25 °C, referred to input range ±500 mV)	±0.15%
Input resistance	10 M	Operating error limits (0 to 60 °C, referred to input range ±500 mV (32 to 140°F))	±0.4%
Connection method of sensors	two-wire or four-wire connection		
Digital representation of input signal	12 bits+sign (2048 units=rated value)	Length of cable - shielded	max. 200 m (660 ft.)
Measured value representation	two's complement (left-justified)	Supply voltage L+	none
Measuring principle	integrating	Auxiliary current for PT 100	2.5 mA
Conversion principle	voltage-time conversion (dual slope)	Auxiliary current single error - tolerance	±0.05 %
		- temperature error	±0.006 %/K
		- influence of load variation	±0.02 %/100
Integration time (adjustable for optimum noise suppression)	20 ms at 50 Hz 16.6 ms at 60 Hz	Internal temperature compensation	possible
Encoding time per input		Rated insulation voltage (+9 V to \pm)	12 V AC
- for 2048 units	max. 60 ms at 50 Hz	- insulation group	1 x B
	max. 50 ms at 60 Hz	- tested with	500 V AC
- for 4095 units	max. 80 ms at 50 Hz		
	max. 66.6 ms at 60 Hz	Rated insulation voltage (inputs to + 9 V)	60 V AC
		- insulation group	1 x B
		- tested with	500 V AC
Permissible voltage difference		Current consumption - from +9 V (CPU)	typ. 70 mA
- between inputs	max. ±1 V	Power loss of the module	typ. 0.9 W
- between inputs and central ground point	max. 75 V DC/60 V AC	Weight	approx. 230 g (8 oz.)
Permissible input voltage (destruction limit)	max. 24 V DC		
Fault indication for - range exceeded	yes (more than 4095 units)		
- sensor wire break	yes (selectable), via test pulse		
- general indication of wire break	red LED		

Analog Input Module 2 x PT 100/±500 mV

(6ES5 464-8MF21)



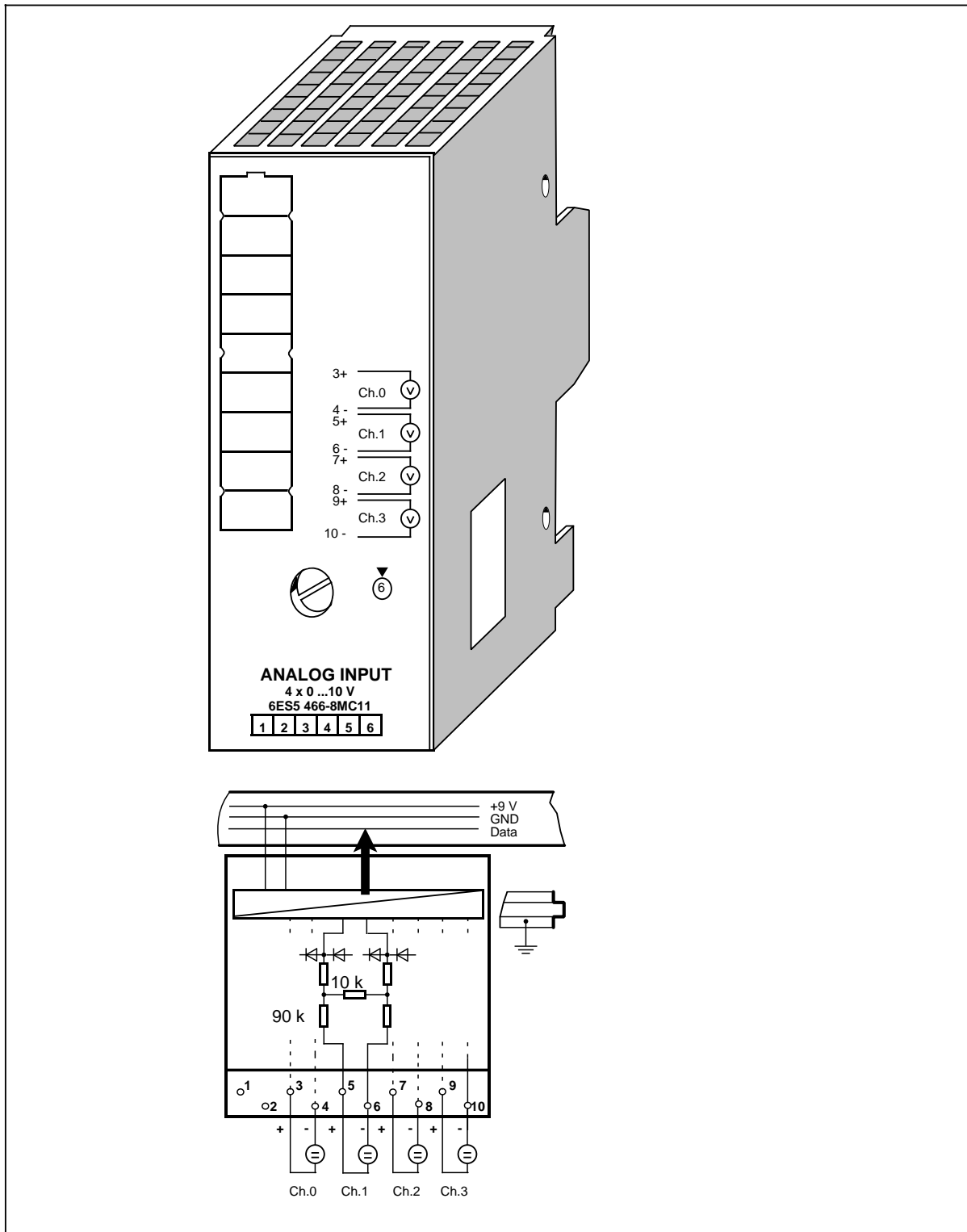
Analog Input Module 2xPT 100/±500 mV (continued)

(6ES5 464-8MF21)

Technical Specifications			
Address designation (for ET 100U only)	2AI	- sensor wire break	yes (selectable), via test pulse
Input range (rated values)		- general indication of wire break	red LED
- resistance sensor (PT 100)	0 to 200 (max. 400) ± 500 mV	Noise suppression for f=nx (50/60 Hz±1 %); n=1, 2, ...	
- voltage sources		- common-mode rejection (V _{pp} =1 V)	min. 86 dB
Number of inputs	1 or 2 (selectable)	- series-mode rejection (peak value of noise < rated value of input range)	min. 40 dB
Galvanic isolation	yes (inputs to grounding point; not between inputs)	Basic error limits (operational error limits at 25 °C, referred to input range ±500 mV)	±0.15 %
Input resistance	10 M	Operational error limits (0 to 60 °C, referred to input range ±500 mV) (32 to 140°F)	±0.4 %
Connection method of sensors	two- or four-wire connection	Linearization exactness in rated range	±0.5 °C (0.9 °F)
Digital representation of input signal	12 bits+sign (2048 units=rated value)	Characteristic linearization of PT 100-characteristic curve	DIN IEC 751
Measured value representation	two's complement (left-justified)	Length of cable - shielded	max. 200 m (660 ft.)
Measuring principle	integrating	Supply voltage L+	none
Conversion principle	voltage-time conversion (dual slope)	Auxiliary current for PT 100	2.5 mA
Integration time (adjustable for optimum noise suppression)	20 ms at 50 Hz 16.6 ms at 60 Hz	Auxiliary current single error - tolerance	± 0.05%
Encoding time per input		- temperature error	±0.006%/K
- for 2048 units	max. 60 ms at 50 Hz	- influence of load variation	±0.02%/100
- for 4095 units	max. 50 ms at 60 Hz max. 80 ms at 50 Hz max. 66.6 ms at 60 Hz	Rated insulation voltage (+9 V to $\underline{\underline{0}}$)	12 V AC
Permissible voltage difference		- insulation group	1xB
- between inputs	max. ± 1 V	- tested with	500 V AC
- between inputs and central ground point	max. 75 V DC/60 V AC	Rated insulation voltage (inputs to +9 V)	60 V AC
Permissible input voltage (destruction limit)	max. 24 V DC	- insulation group	1xB
		- tested with	500 V AC
Fault indication for - range exceeded	yes (more than 4095 units)	Current consumption - from +9 V (CPU)	typ. 100 mA
		Power loss of the module	typ. 0.9 W
		Weight	approx. 230 g (8 oz.)

Analog Input Module 4 x 0 to 10 V

(6ES5 466-8MC11)



Analog Input Module 4 x+0 to 10 V (continued)

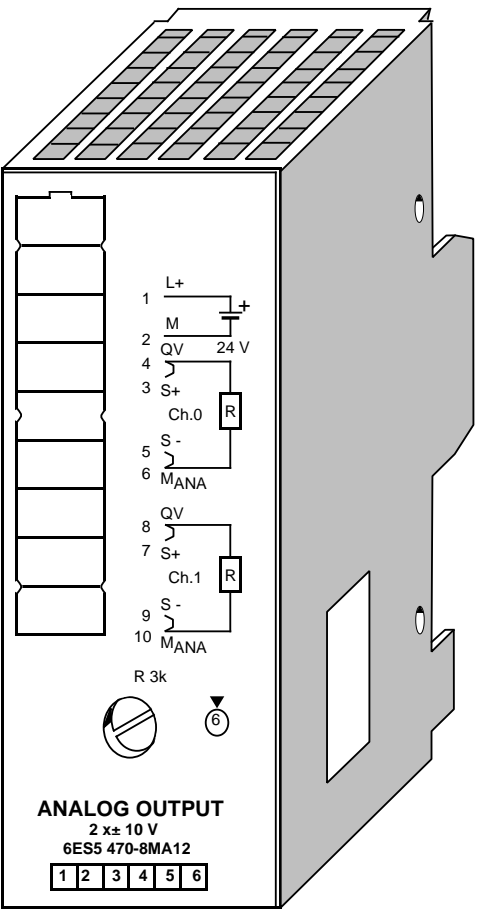
(6ES5 466-8MC11)

Technical Specifications			
Address designation (for ET 100U only)	2AI	Noise suppression - common mode interference ($V_{PP}=1\text{ V}$) min.	86 dB
Input range (rated value)	+0 to 10 V	Basic error limits (operational error limits at 25 °C, referred to input ranges of the module)	±0.4 %
Number of inputs	4		
Galvanic isolation	no	Operational error limits (0 to 60 °C, referred to the input ranges of the module) (32 to 140°F)	±0.6 %
Input resistance	100 k		
Connection method of sensors	two-wire connection	Length of cable - shielded	max. 200 m (660 ft.)
Digital representation of input signal	8 bits (256 units =rated value)		
Representation of the measured value	binary	Supply voltage L+	none
Measuring principle	successive approximation	Current consumption - from +9 V (CPU) typ.	100 mA
Conversion time	100 µs	Power loss of the module typ.	0.9 W
Encoding time per input	5 ms	Weight	approx. 270 g (7 oz.)
Permissible voltage difference - between inputs	max. ±1 V		
Permissible input voltage (destruction limit)	max. 60 V DC		
Fault indication for - range exceeded - sensor wire break - general indication of wire break	no no no		

2.6.4 Analog Output Module

Analog Output Module 2 x±10 V

(6ES5 470-8MA12)



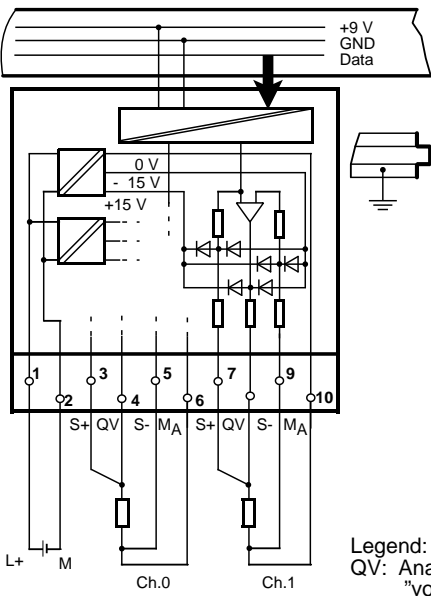
ANALOG OUTPUT
2 x±10 V
6ES5 470-8MA12

1 L+
2 M
3 QV 24 V
4 S+
5 Ch.0
6 S-
7 M_A
8 QV
9 S+
10 Ch.1
11 S-
12 M_A

R 3k

Technical Specifications

Address designation (for ET 100U only)	2AQ
Output range (rated values)	±10 V
Number of outputs	2
Galvanic isolation	yes (outputs to grounding point and between outputs)
Input resistance	3.3 k
Capacitive load incl. cable capacitance	<100 nF
Connection method	two- or four-wire connection
Digital representation of output signal	11 bits+sign (1024 units = rated value)
Measured value representation	two's complement (left-justified)
Conversion time (0 to 100 %)	max. 0.15 ms
Permissible overload	25 %
Short-circuit protection	yes
Short-circuit current	±30 mA
Permissible voltage difference to ground and between outputs	max. 75 V DC/60 V AC
Basic error limits (operational error limits at 25 °C, referred to output range of the module)	±0.3%
Operational error limits (0 to 60 °C, referred to output range) (32 to 140°F)	±0.6%
Length of cable - shielded	max. 200 m (660 ft.)
Supply voltage L+ (peripheral)	24 V DC
- rated value	3.6 V
- ripple V _{PP}	20 to 30 V
- permissible range (ripple included)	
Rated insulation voltage (+9 V to ↕)	12 V AC
- insulation group	1 x B
- tested with	500 V AC
Rated insulation voltage (Output to L+, between outputs, output to+9V)	60 V AC
- insulation group	1 x B
- tested with	500 V AC
Current consumption - from+9 V (CPU)	typ. 80 mA
- from L+	typ. 100 mA
Power loss of the module	typ. 3.1 W
Weight	approx. 290 g (10 oz.)



Legend:
QV: Analog output "voltage"

Analog Output Module 2 x±20 mA

(6ES5 470-8MB12)

ANALOG OUTPUT
2 x± 20 mA
6ES5 470-8MB12

1 2 3 4 5 6

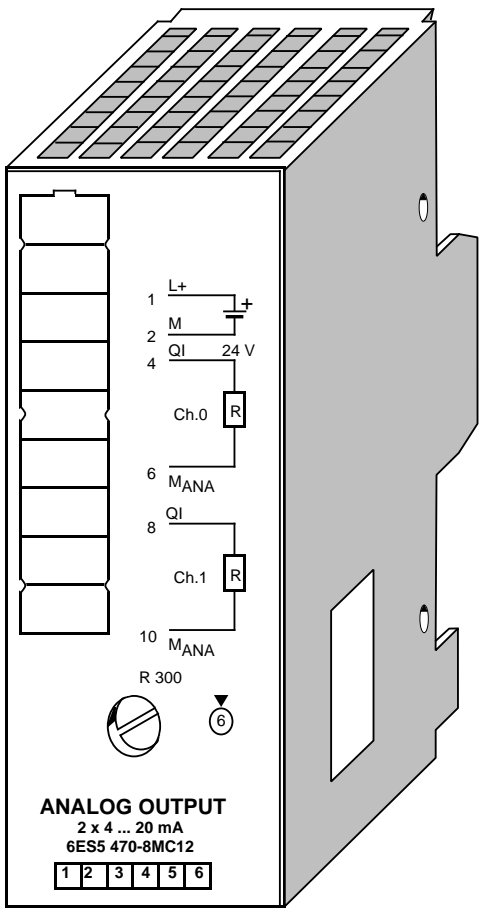
Technical Specifications

Address designation (for ET 100U only)	2AQ
Output range (rated value)	±20 mA
Number of outputs	2
Galvanic isolation	yes (outputs to grounding point and between outputs)
Load resistance	300
Connection method	two-wire connection
Digital representation of output signal	11 bits + sign (1024 units = rated value)
Measured value representation	two's complement (left-justified)
Conversion time (0 to 100%)	max. 0.15 ms
Permissible overload	25%
Open-circuit voltage	±15 V
Permissible voltage difference to ground and between outputs	max. 75 V DC/60 V AC
Basic error limits (operational error limits at 25°C, referred to output range)	±0.3%
Operational error limits (0 to 60 °C, referred to output range) (5" to 140°F)	±0.6%
Length of cable - shielded	max. 200 m (660 ft.)
Supply voltage L+ - rated value	24 V DC
- ripple V _{PP}	3.6 V
- permissible range (ripple included)	20 to 30 V
Rated insulation voltage (+9 V to ⚡)	12 V AC
- insulation group	1xB
- tested with	500 V AC
Rated insulation voltage (Output to L+, between outputs, output to + 9V)	60 V AC
- insulation group	1xB
- tested with	500 V AC
Current consumption - from +9 V (CPU)	typ. 170 mA
- from L+	typ. 130 mA
Power loss of the module	typ. 3.8 W
Weight	approx. 290 g (10 oz.)

Legend:
QI: Analog output "current"

Analog Output Module 2 x 4 to 20 mA

(6ES5 470-8MC12)

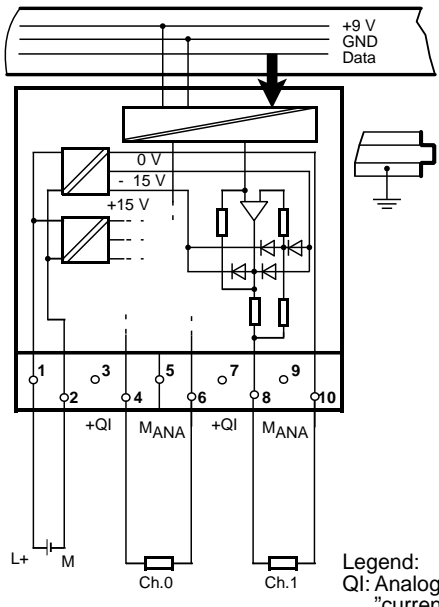


ANALOG OUTPUT
2 x 4 ... 20 mA
6ES5 470-8MC12

1 L+
2 M
4 QI 24 V
Ch.0 R
6 MANA
8 QI
Ch.1 R
10 MANA
R 300

Technical specifications

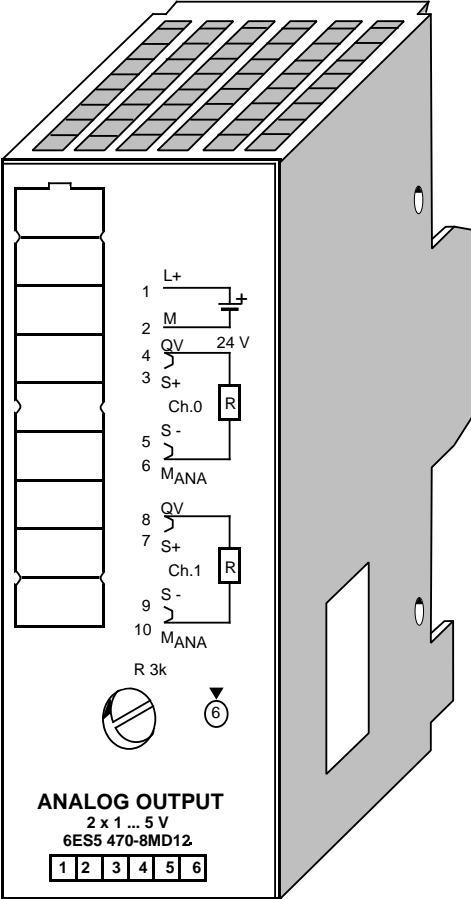
Address designation (For EWT 100U only)	2AQ
Output range (rated value)	4 to 20 mA
Number of outputs	2
Galvanic isolation	yes (outputs to grounding point and between outputs)
Load resistance	300
Capacitive load incl. cable capacitance	< 100 nF
Connection method	two-wire connection
Digital representation of output signal	11 bits+sign (1024 units rated value)
Measured value representation	two's complement (left-justified)
Conversion time (0 to 100%)	max. 0.15 ms
Permissible overload	25%
Open-circuit voltage	± 15 V
Permissible voltage difference to central ground point and between outputs	max. 75 V DC/60 V AC
Basic error limits (operational error limits at 25 °C, referred to output range)	±0.2%
Operating error limits (0 to 60 °C, referred to output range) (32 to 140°F)	±0.6%
Length of cable - shielded	max. 200 m (660 ft.)
Supply voltage L+ - rated value	24 V DC
- ripple V_{PP}	3.6 V
- permissible range (ripple included)	20 to 30 V
Rated insulation voltage (+9 V to \pm)	12 V AC
- insulation group	1xB
- tested with	500 V AC
Rated insulation voltage (outputs to L+, between outputs, output to+9 V)	60 V AC
- insulation group	1xB
- tested with	500 V AC
Current consumption - from+9 V (CPU)	typ. 170 mA
- from L+	typ. 130 mA
Power loss of the module	typ. 3.8 W
Weight	approx. 290 g (10 oz.)



Legend:
QI: Analog output "current"

Analog Output Module 2 x 1 to 5 V

(6ES5 470-8MD12)

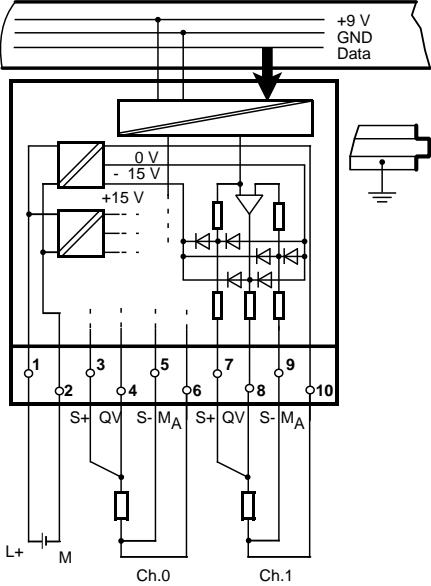


ANALOG OUTPUT
2 x 1 ... 5 V
6ES5 470-8MD12

Terminal labels: 1 L+, 2 M, 3 QV, 4 S+, 5 S-, 6 M_A, 7 QV, 8 S+, 9 S-, 10 M_A. Includes a 3k resistor and a 24V source.

Technical Specifications

Address designation (for ET 100U only)	2AQ
Output range (rated value)	1 to 5 V
Number of outputs	2
Galvanic isolation	yes (outputs to grounding point and between outputs)
Load resistance	min. 3.3 k
Connection method	two- or four-wire connection
Digital representation of output signal	11 bits+sign (1024 units=rated value)
Measured value representation	two's complement (left-justified)
Conversion time (0 to 100%)	max. 0.15 ms
Permissible overload	25%
Short-circuit protection	yes
Short-circuit current	±30 mA
Permissible voltage difference to central ground point and between outputs	max. 75 V DC/60 V AC
Basic error limits (operational error limits at 25 °C, referred to output range)	±0.2%
Operating error limits (0 to 60 °C, referred to output range) (32 to 140°F)	±0.6%
Length of cable - shielded	max. 200 m (660 ft.)
Supply voltage L+ - rated value	24 V DC
- ripple V _{PP}	3.6 V
- permissible range (ripple included)	20 to 30 V
Insulation rating	VDE 0160
Rated insulation voltage (+9 V to ⊥)	12 V AC
- insulation group	1xB
- tested with	500 V AC
Rated insulation voltage (outputs to L+, between outputs, output to +9 V)	60 V AC
- insulation group	1xB
- tested with	500 V AC
Current consumption - from +9 V (CPU)	typ. 170 mA
- from L+	typ. 100 mA
Power loss of the module	typ. 3.1 W
Weight	approx. 290 g (10 oz.)

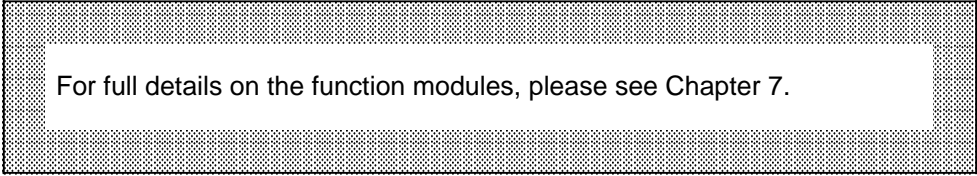


Internal circuit diagram showing power supply rails (+9V, GND, Data, 0V, -15V, +15V), operational amplifiers, and output drivers connected to terminals 1-10. Labels include L+, M, Ch.0, Ch.1, S+, QV, S-, M_A.

2.6.5 Function Modules

These are all modules provided with special functions, such as:

- Comparator module
- Timer module
- Counter module
- Fast counter/position decoder module
- Input/output simulator for digital modules
- Diagnostic module
- Printer output module



For full details on the function modules, please see Chapter 7.

That chapter will also be updated with modules that were not yet available when this manual was published.

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3 Hardware Installation

3.1 Mechanical Assembly

The power supply module, the 318-8 interface module and the bus units are mounted on the standard sectional rail or mounting rack (DIN EN 50022-35x15) and the I/O modules are plugged into the bus units.

Attach the rail to a metal plate with a thickness of at least 2 mm (0.07 in.), so that a good reference potential is available for grounding the power cables.

Bus units with SIGUT terminals or crimp snap-in connections have different heights.

3.1.1 Assembling a Tier

The following parts are required for assembling an ET 100U :

- Power supply module
- 318-8 interface module
- Bus units
- Input/output modules.

A power supply module is only required if you do not have a 24 V DC supply.

Mount the first module at the extreme left of the standard sectional rail and add the other modules to the right.

Mounting the PS 931 Power Supply Module

The design of the backplane enables simple attachment to the standard sectional rail.

- Hook the power supply module onto the top of the rail.
- Swing it down in the direction of the arrow (+ Figure 3-1).
- Press it down firmly until it snaps onto the rail.

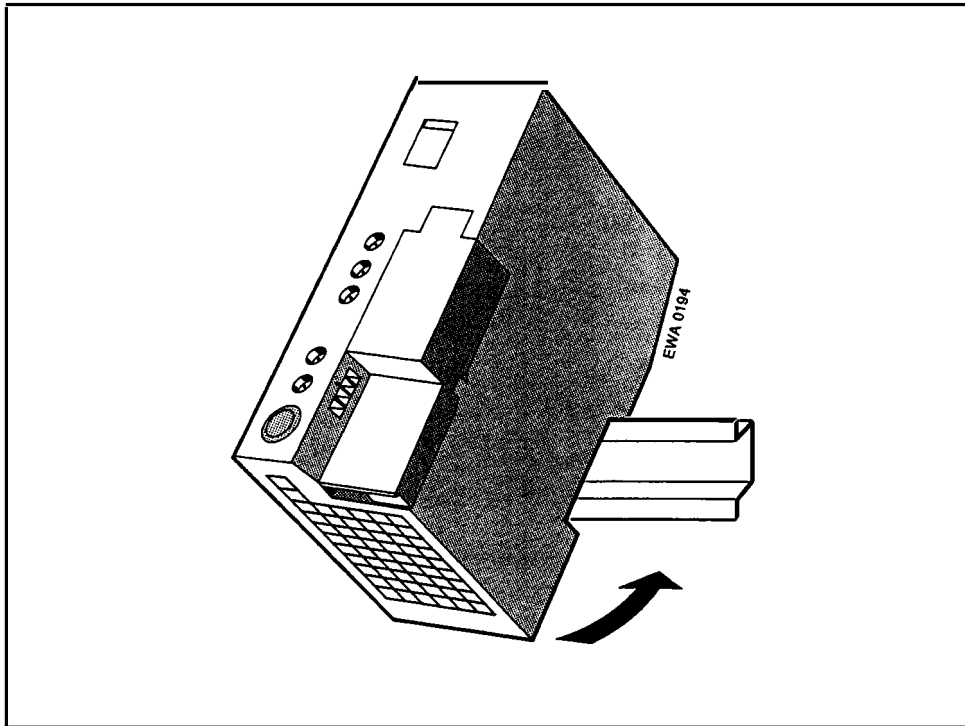


Figure 3-1 Mounting the PS 931 Power Supply Module

Mounting the PS 2410 Power Supply Module

Proceed as for the PS 931 power supply module

- Hook the PS 2410 onto the top of the rail.
- Swing it down in the direction of the arrow (Figure 3-1).

Mounting the 318 Interface Module

Proceed in the same way as for the power supply modules.

Mounting the Bus Unit

Hook on and swing down in the same way as the power supply module and the 318-8 interface module.

There are small hooks on the side of the bus units to interlock them mechanically with each other and with the 318-8 interface module.

Connecting Bus Units Electrically to the 318-8 Interface Module or to Each Other

- Pull the ribbon cable (top left on the bus unit) out of its holder
- Plug it into the receptacle on the right of the right side of the 318-8 interface module or into the socket of the bus unit to the left (→ Figure 3-2).

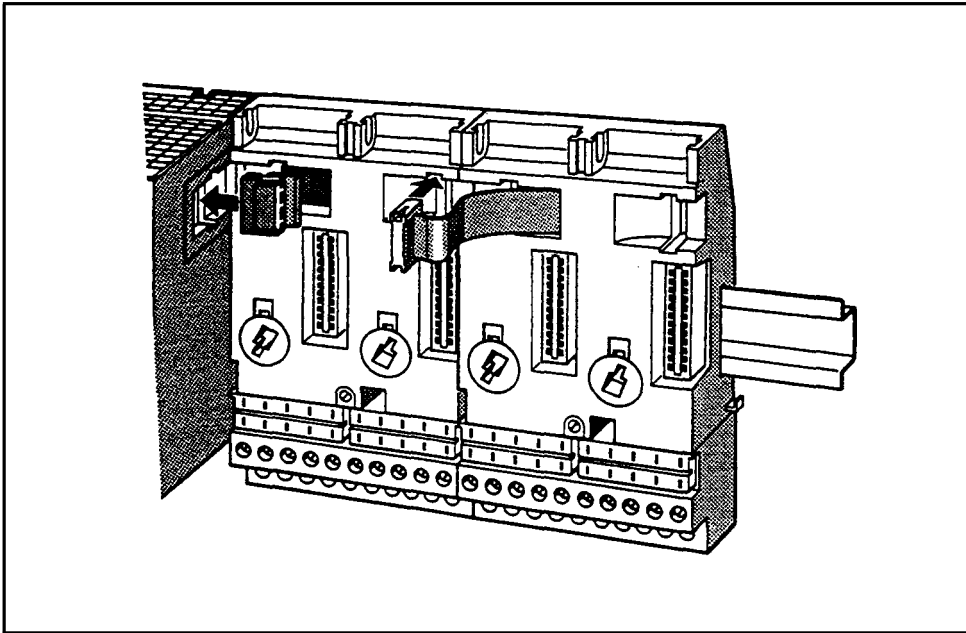


Figure 3-2 Electrical Connection of Bus Units

Plugging Input and Output Modules into the Bus Units

Before mounting an input or output module, the coding element on the bus unit must be set to the module type. This mechanical coding prevents wrong module types from being plugged in.

Setting the coding element:

An identifying number is printed on the frontplate of every input/output module. A number between 2 and 8 is used, depending on the particular module type. There is a white mechanical coding key on the rear of each input or output module. The position of the coding key depends on the module type and cannot be changed. The bus unit has a mating piece for each key, a white rotating coding element or "lock" (→ Figure 3-3). Use a screwdriver to set the "lock" on the bus unit to the corresponding module identification number.

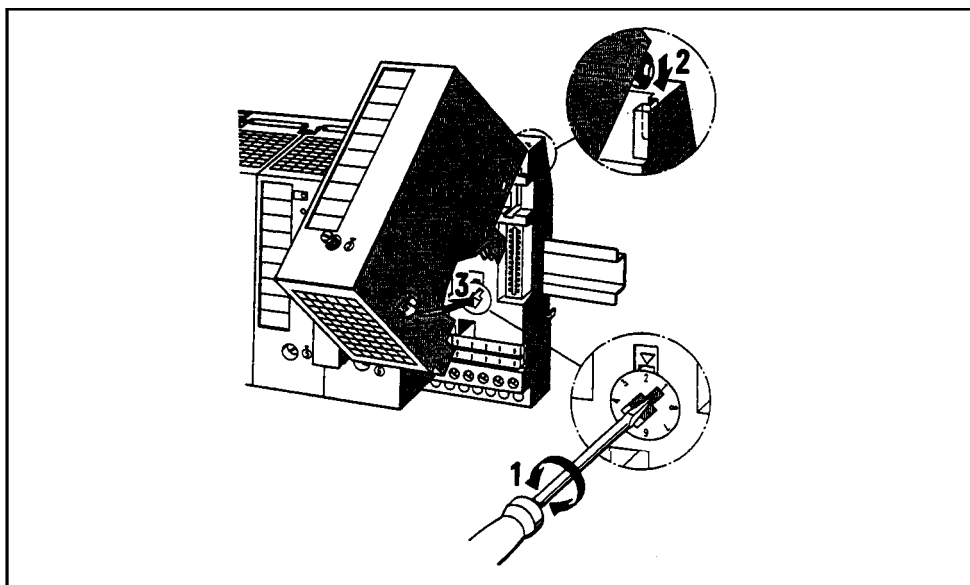
3

Figure 3-3 Coding System to Prevent the Plugging in of Wrong Modules

The 6ES5 788-8MA11 simulator module has no coding key. It can therefore be connected in place of all digital modules.

Attaching the module:

- Hook the module onto the top of the bus unit.
- Swing it down onto the bus unit.
- Press it firmly down.
- Secure the module in position by tightening the screw on the front.

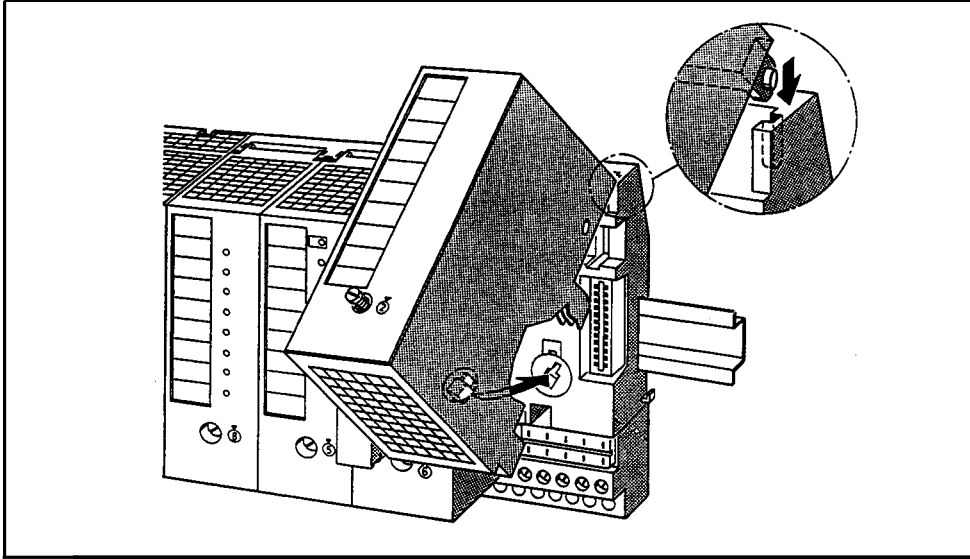


Figure 3-4 Hooking an Input/Output Module onto the Bus Unit

Labeling

Enter the module addresses and codes of the modules and the bus units in the labeling strip (→ Figure 3-5).

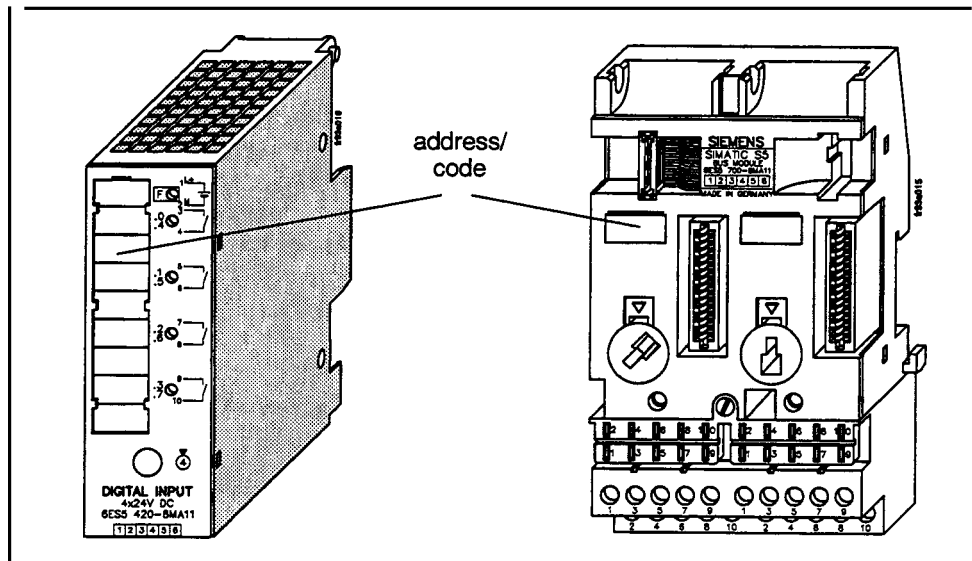


Figure 3-5 Module and Bus Unit Labels

3.1.2 Multi-Tier Expansion

If all modules cannot be accommodated on one tier, the configuration can be expanded to up to four tiers. A maximum of 16 bus units may be used. The number of units mounted in one tier is irrelevant. One interface module is required per tier for interconnecting the individual tiers.

Assembly is as with bus units. The interface module must then be connected back to the last bus unit via the ribbon cable.

Use the IM 315 interface module for two-tier configurations. This consists of two modules which are permanently connected via a 0.5 m (20 in.) long cable.

Use the IM 316 interface modules for multi-tier configurations. These modules are connected via cables with attached connectors. The cable is connected to the "out" socket in the ET 100U tier and to the "in" socket in the expansion tier. Each of the connectors is secured with two screws (as protection against inadvertently unplugging the connector and for establishing contact with the shield).

A common ground potential is required for the standard sectional rails in configurations using more than one cabinet.

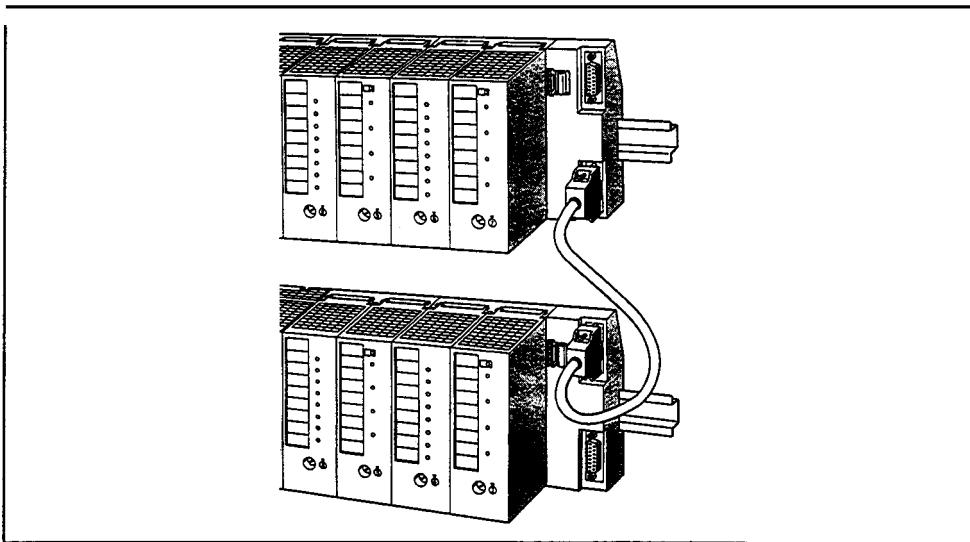


Figure 3-6 Interconnecting Tiers with interface Modules (6ES5 316-8MA12)

Numbering in Multi-Tier Configurations

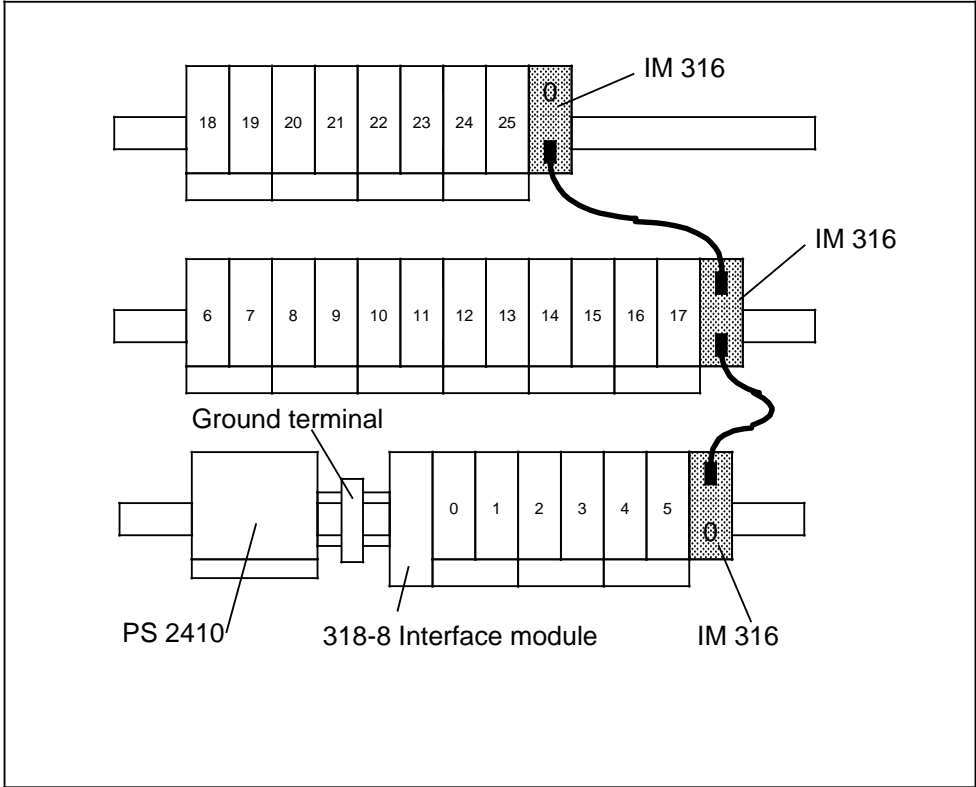


Figure 3-7 Numbering in Multi-Tier Configurations

3.1.3 Open Mounting and Cabinet Mounting

Open Mounting

The ET 100U fulfills the requirements of degree of protection IP 20. It is protected against ingress of medium-sized solid foreign bodies of diameters greater than 12 mm (0.5 in.) and against contact with live or moving parts inside the enclosure by fingers.

It is not protected against water.

The components are cooled by natural convection (max. amb. temp. = 60 °C). The ET 100U is therefore suitable for open mounting in industrial environments with normal pollution.

Cabinet Mounting

Where there is a danger that the terminals, for example, could be accidentally touched, or the possibility of water splashing or dripping onto it, the ET 100U must be mounted in a cabinet with the relevant degree of protection. In environments with harmful gases and condensates or heavy deposits of dust (especially conductive dust), mounting in a housing with a heat exchanger is recommended.

For reasons of noise immunity, the ET 100U should be mounted on a metal plate. If this is not possible, the minimum requirement is that all standard sectional rails be connected to each other through a low resistance. Mounting plates of the 8LW or 8LX systems can also be used (Catalog NV 21).

There must be a clearance of at least 210 mm (8.3 in.) between individual standard sectional rails. See Figures 3-8 and 3-9.

Because of the heat generated by the ET 100U, the power supply unit and the 318-8 interface module should always be in the bottommost tier.

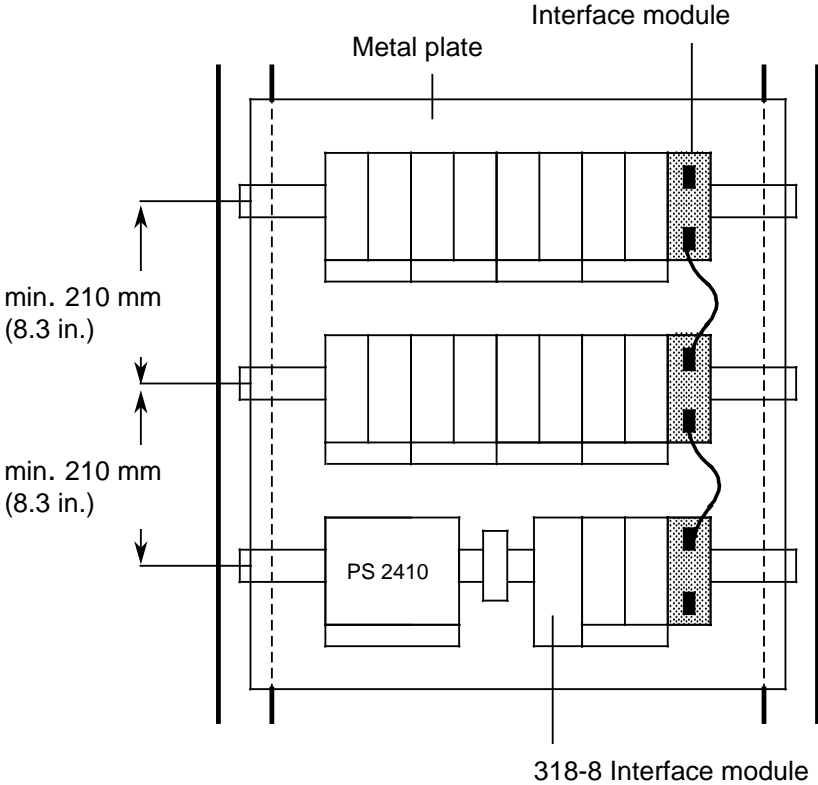


Figure 3-8 Multi-Tier Configuration in a Cabinet with the IM 316 Interface Module (6ES5 316-8MA12)

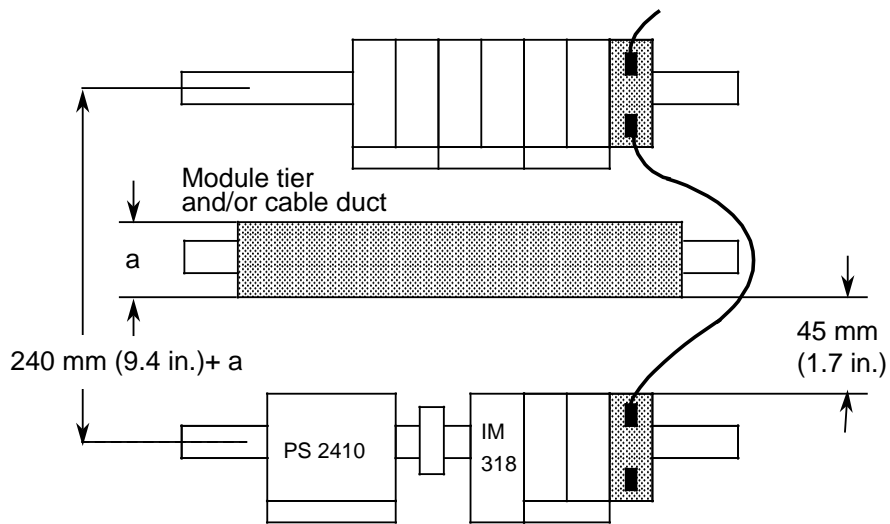


Figure 3-9 Control Cabinet Mounting with Module Tier

3.1.4 Vertical Mounting

The standard sectional rail can also be mounted vertically so that the modules are assembled one on top of the other. Heat dissipation by convection is less effective in this case and the permissible ambient temperature is reduced to a maximum of 40°C.

With multi-tier configurations, the same minimum clearances must be observed as in horizontal configurations.

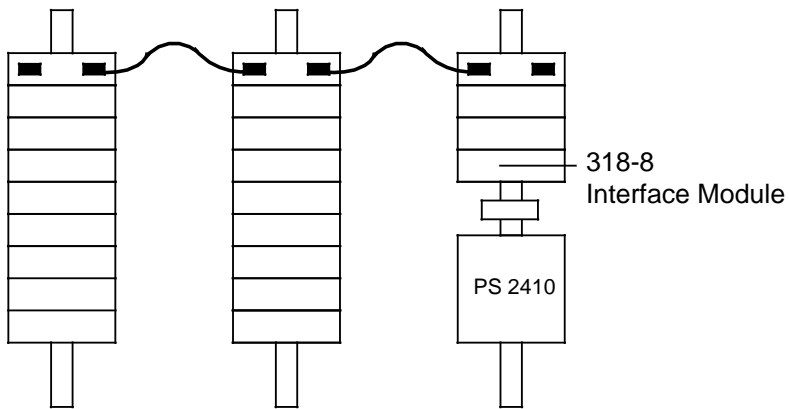


Figure 3-10 Vertical Mounting of the ET 100U

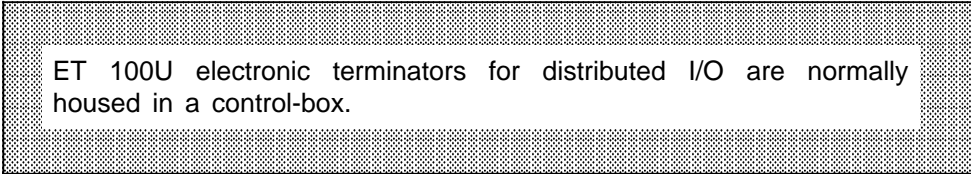
3.1.5 Power Dissipation in the Modules

If the ET 100U is mounted in a cabinet or other type of enclosure (e.g. distribution box), the dissipatable heat loss is an important limiting parameter. The sum of all heat losses of the modules must never exceed the specified value. You will find details on module power dissipation in the technical specifications. Also in this respect, please note the permissible total current of all outputs (only in the case of digital output modules). The permissible total current of all outputs must not be exceeded even when all outputs are set, since this would result in an excessive heat build-up.

Please also ensure that no excessive heat builds up in the event of a fault. This can usually be avoided by resetting the outputs if the PC stops and also by switching off the power supply.

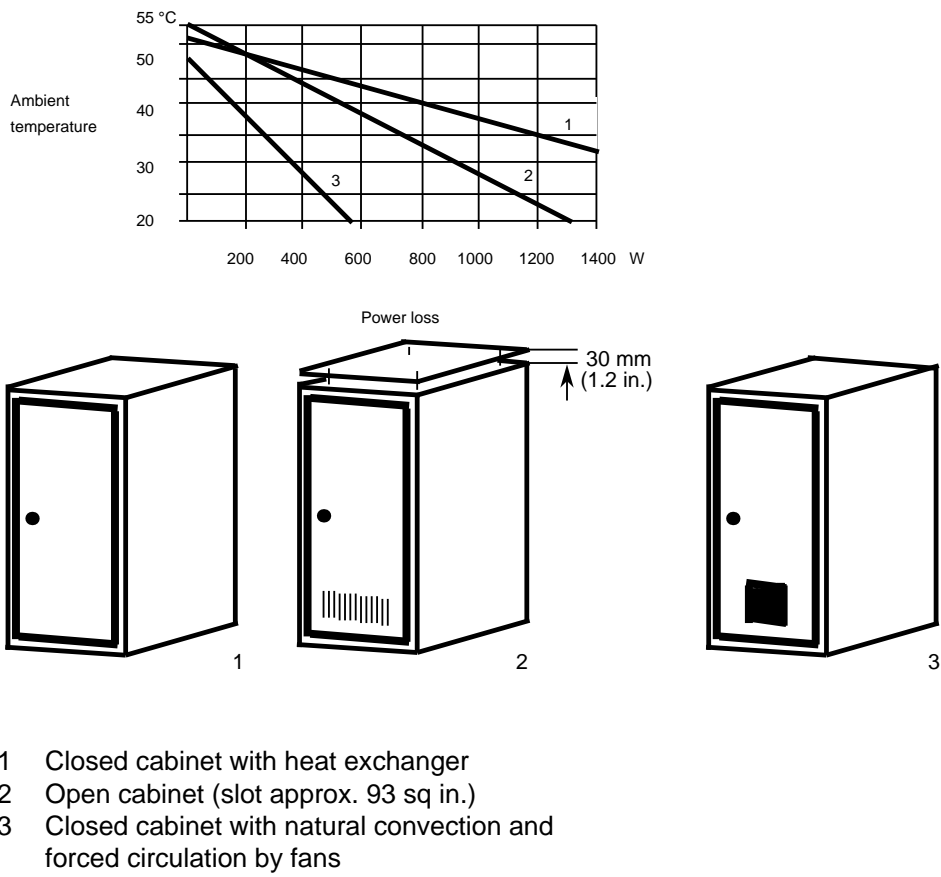
Heat Loss from a Cabinet

The dissipatable heat loss in a cabinet depends on the design of the cabinet, its ambient temperature and the arrangement of modules within the cabinet. .



ET 100U electronic terminators for distributed I/O are normally housed in a control-box.

Should installation in a cabinet prove unavoidable, which is unlikely but possible, you can consult the diagram on the following page for guidelines concerning the maximum permissible ambient temperature of a cabinet with the dimensions 600 mm x 600 mm x 2000 mm (24 in. x 24 in. x 80 in.), depending on the power loss of the installed modules. These values are only valid if the modules are arranged as described in 3.1.3.



- 1 Closed cabinet with heat exchanger
- 2 Open cabinet (slot approx. 93 sq in.)
- 3 Closed cabinet with natural convection and forced circulation by fans

Figure 3-11 Maximum Permissible Ambient Temperature of a Cabinet Depending on the Modules Installed

Heat Loss from a Distribution Box

The difference between the maximum ambient temperature and the average internal temperature of a distribution box determines the maximum heat losses that can be dissipated from the box.

Assuming an average internal temperature of 60°C, a maximum ambient temperature of 30°C will result in a temperature difference T of 30°K. Consult the following table for some maximum dissipatable heat loss values. These values are valid for the 8HP insulation-enclosed distribution system. You will find further configuration notes in Catalog NV 11, Part 2 Low-Voltage Distribution Boards (Order.No.E86010-K1911-A111-A1).

Table 3-1 Dissipatable Heat Losses from 8HP Insulation-Enclosed

8 HP Insulation-Enclosed Distribution Boxes W x H x D (mm/in.)	Maximum Dissipatable Heat Losses (W)	
	T=20°K	T=30°K
Size 2: 307x307x167/ 12 x 12 x 6.5 in.	39	58
Size 3: 614x307x167/ 24 x 12 x 6.5 in.	48	75
Size 4: 614x307x167/ 24 x 12 x 6.5 in.	61	110

3.1.6 Dismantling the ET 100U

Before dismantling parts of the ET 100U, make sure that the ET 100U and the input/output modules are disconnected from the power supply.

Detaching Input and Output Modules

Undo the securing screw and swing the module up on its hinge out of the bus unit.

Dismantling the Interface Module

- **IM 316 only:** Undo the securing screws on the plug and remove the connecting cable.
Undo the connection (ribbon cable) to the adjacent bus unit.
- Use a screw driver to press the catch at the bottom of the interface module down (→ Figure 3-12).
- Swing the module up off the rail.

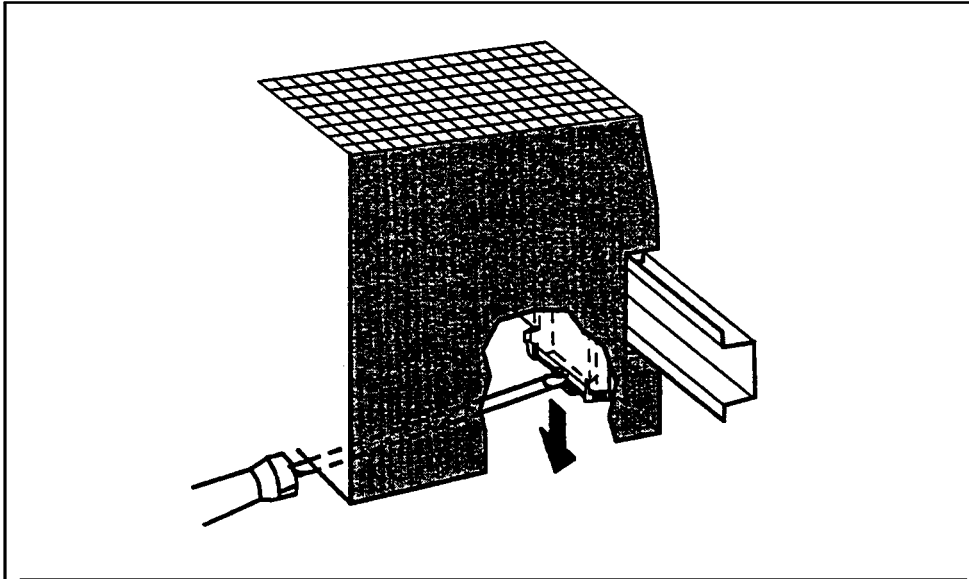
**3**

Figure 3-12 Dismantling an Interface Module

Detaching Bus Units

- Undo the connections to the adjacent bus units or to the 318-8 interface module.
- Use a screwdriver to press the catch down (→Figure 3-13).
- Swing the module up out of the rail.

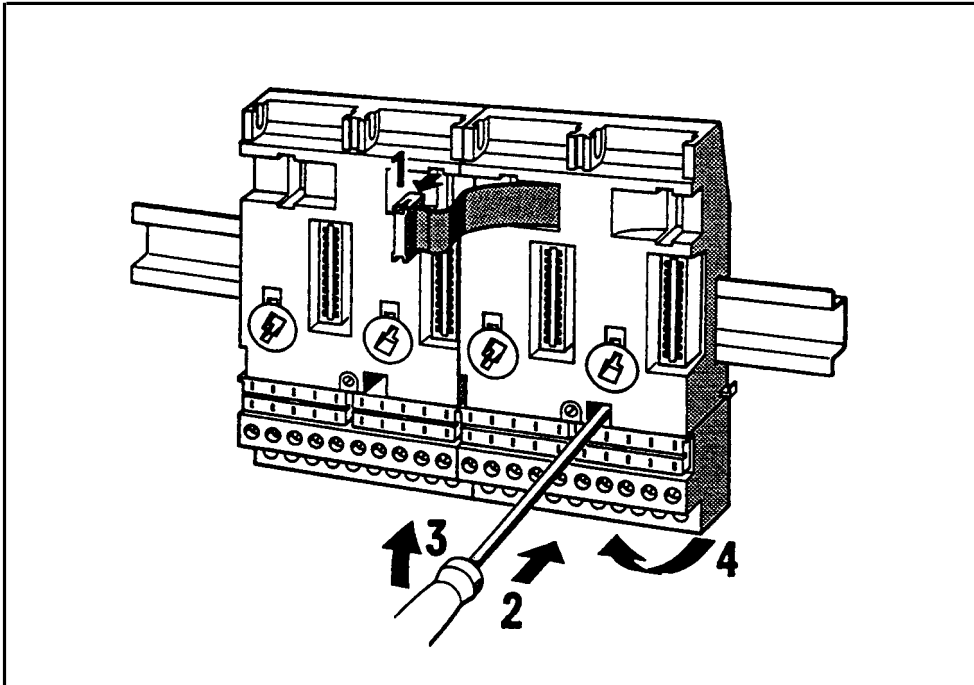


Figure 3-13 Detaching a Bus Unit from the Standard Sectional Rail

Detaching the 318-8 Interface Module and the Power Supply Module

- Remove the I/O module in slot "0".
- Undo the connection (ribbon cable) between the 318-8 interface module and the first bus unit.
- Undo the connections between the 318-8 interface module and the power supply module.
- Use a screwdriver to press the catch at the bottom of the relevant module down.
- Swing the module up off the rail.

3.1.7 Replacing I/O Modules

Please note the following when replacing I/O modules:

I/O modules may be plugged in or withdrawn when connected to the load power supply if the following requirements are met:

- The IM 318-8 must be in the STOP state.
- **All** bus units installed in slave stations must be of revision level 4 and higher.
- Only digital or analog modules may be removed or installed while connected to the load power supply.

3.1.8 Dimension Drawings

Dimensions are indicated in millimeters. The approximate equivalent in inches is indicated in parentheses. (1 mm=0.039 in. rounded off to the nearest tenth or hundredth of an inch)

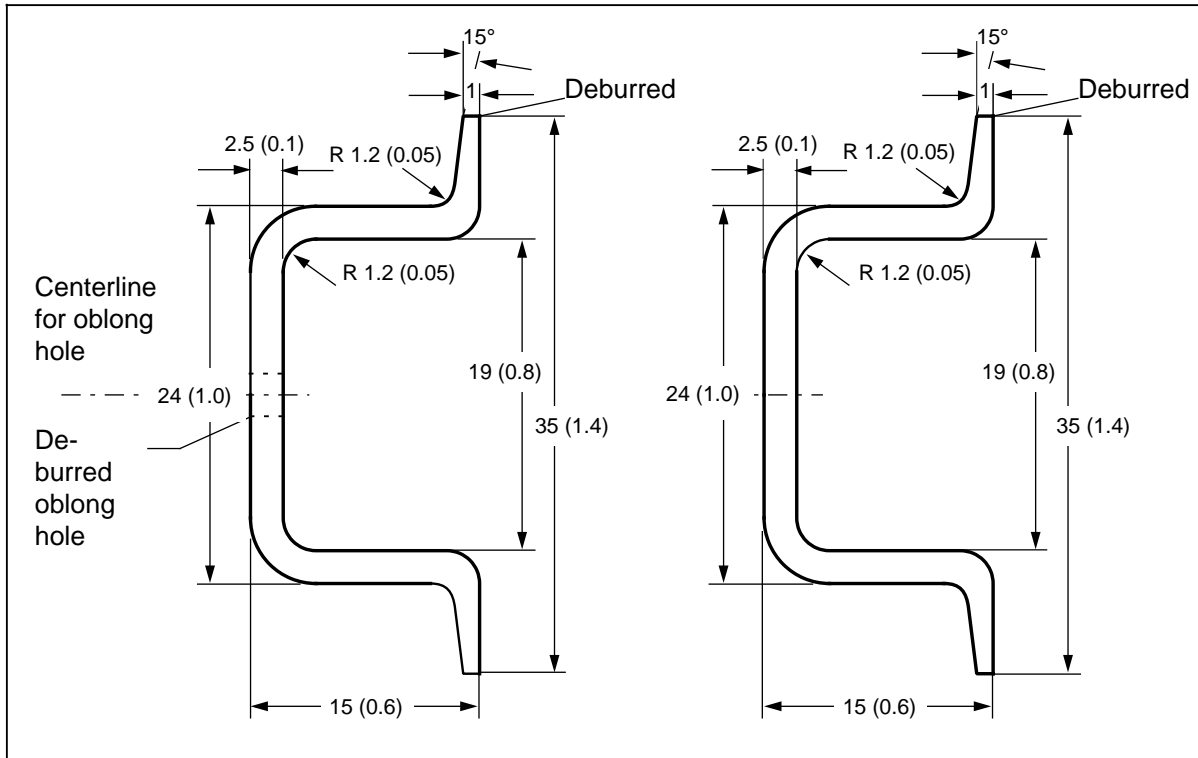


Figure 3-14 Cross Sections of Standard Mounting Rails

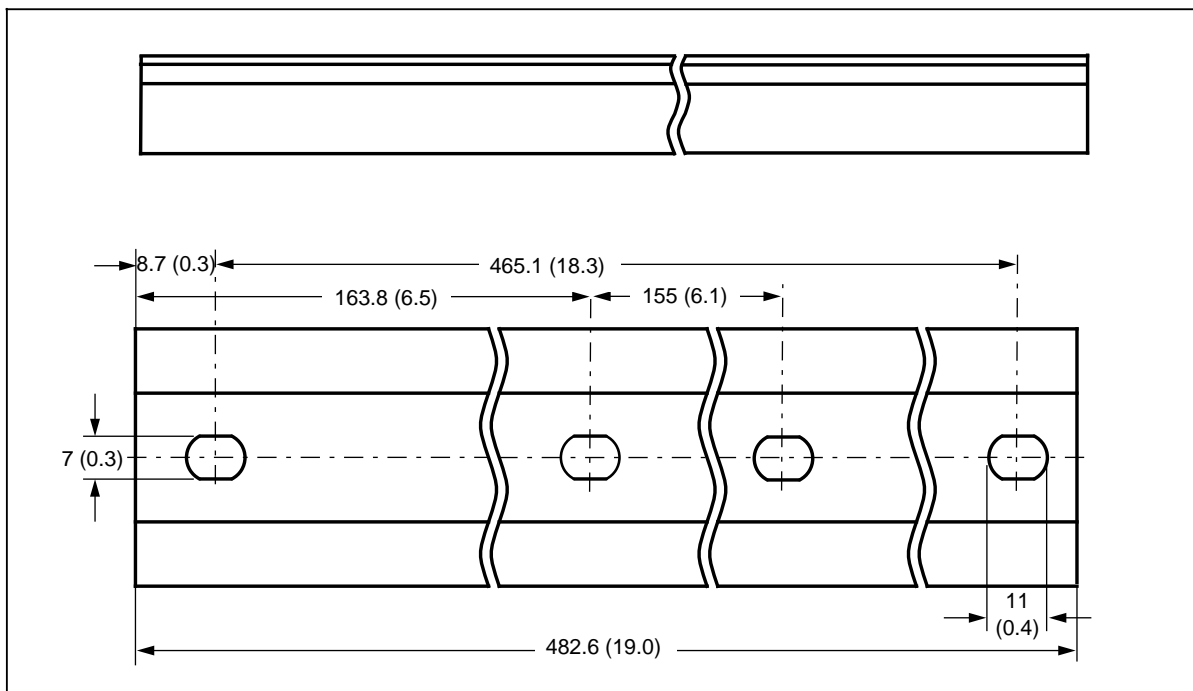


Figure 3-15 Dimension Drawing of the 483-mm (19-in.) Standard Mounting Rail

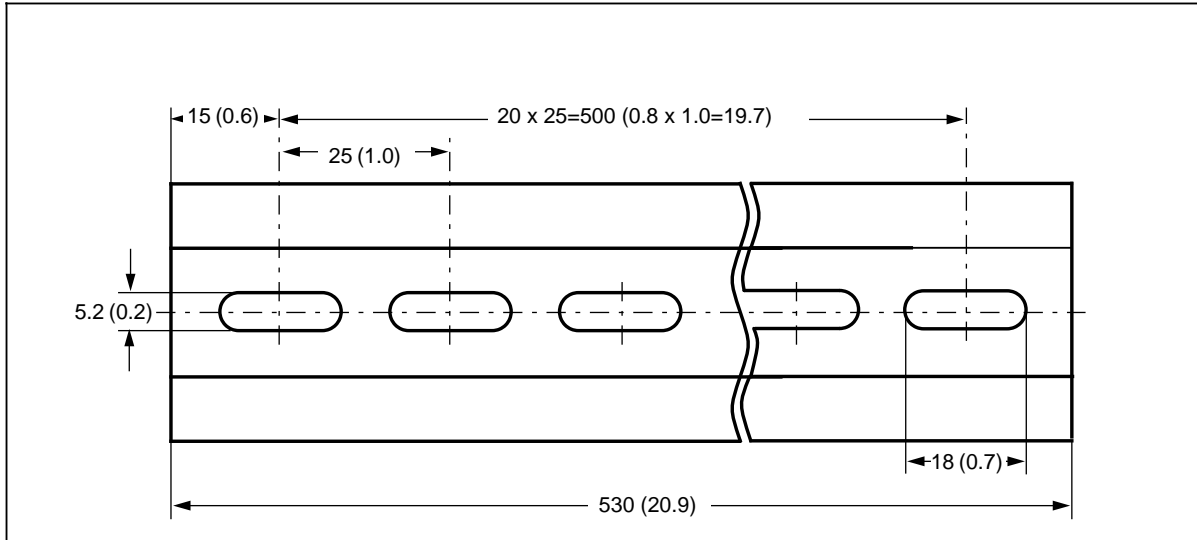


Figure 3-16 Dimension Drawing of the 530-mm (20.9-in.) Standard Mounting Rail

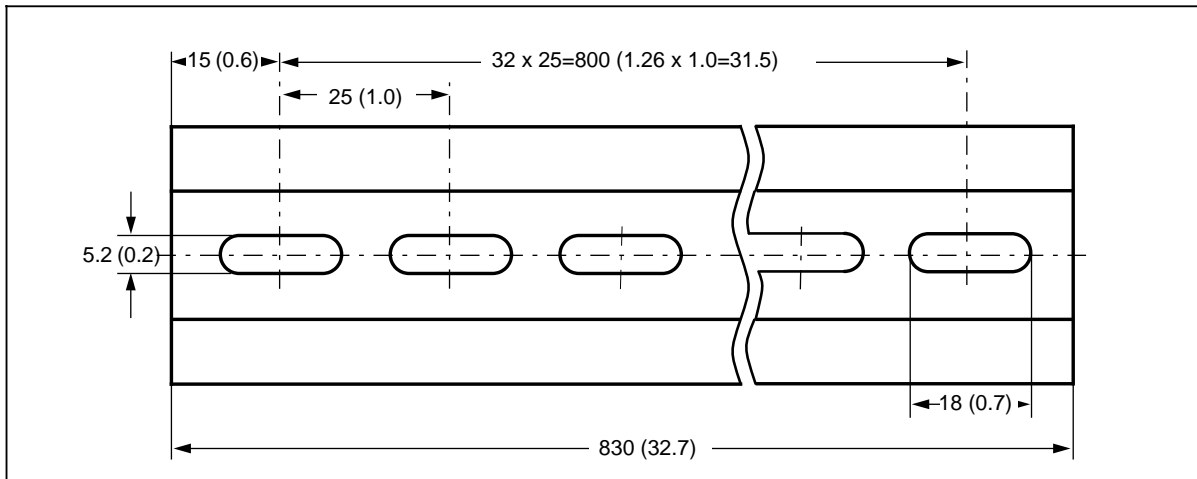


Figure 3-17 Dimension Drawing of the 830-mm (32.7-in.) Standard Mounting Rail

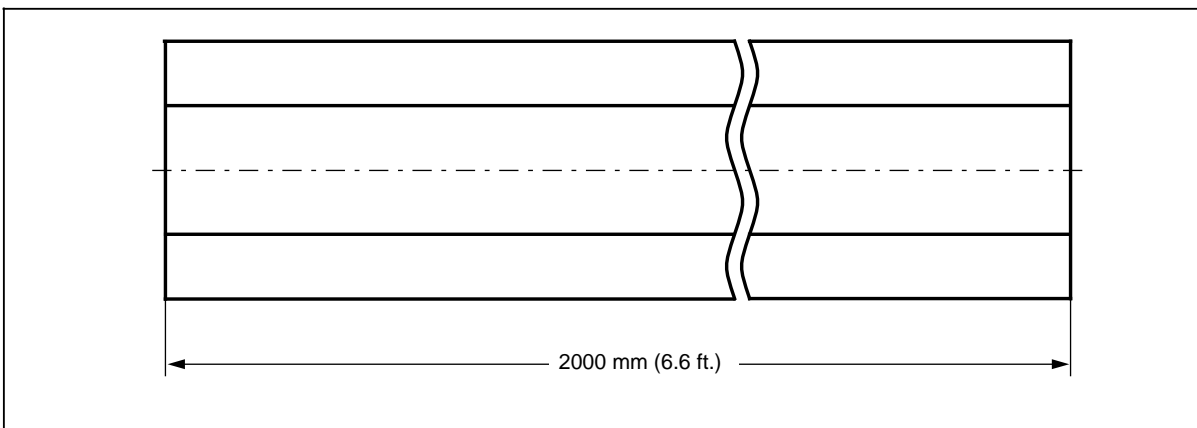


Figure 3-18 Dimension Drawing of the 2-m (6.6-ft.) Standard Mounting Rail

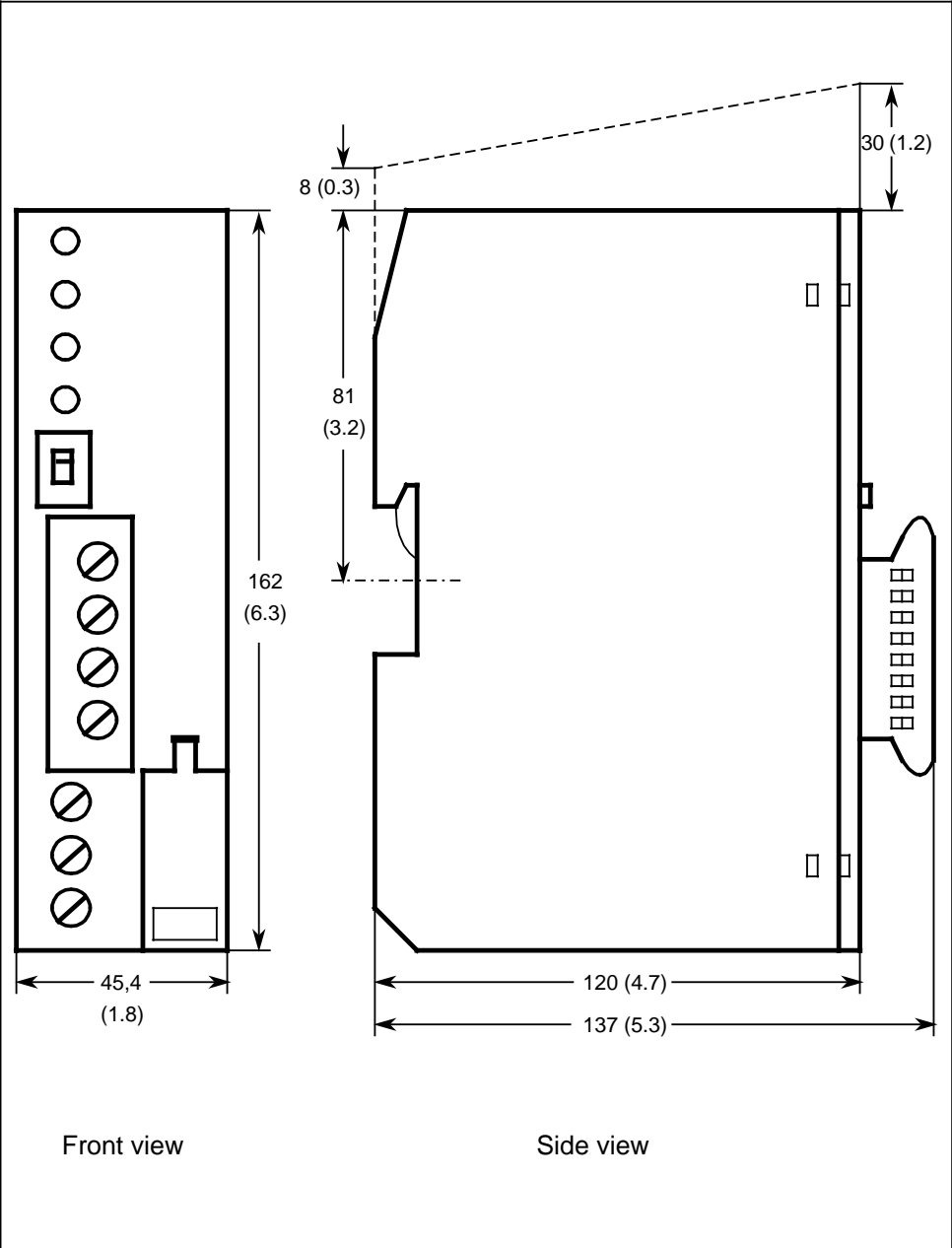


Figure 3-19 Dimensional Drawing of the 318-8 Interface Module

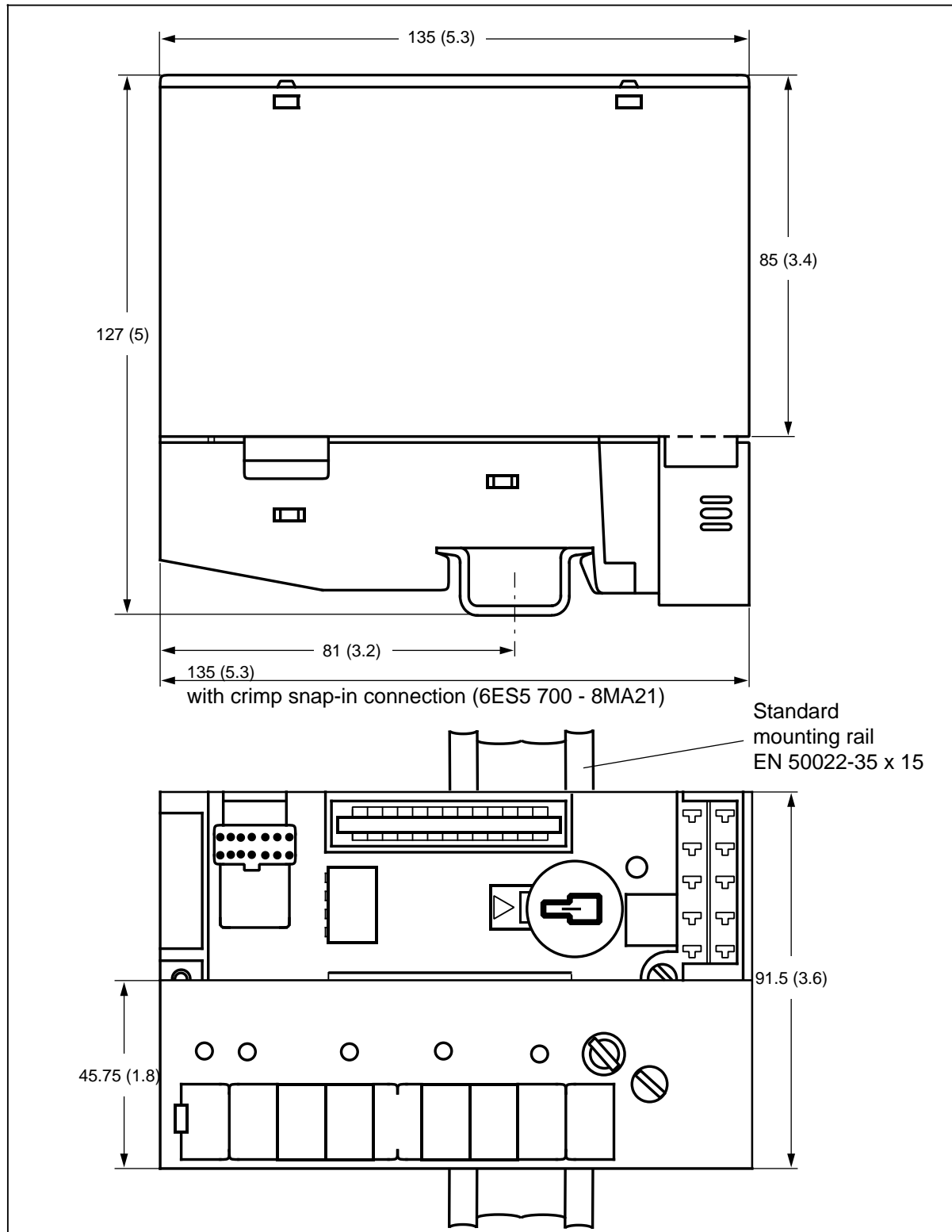


Figure 3-20 Dimension Drawing of the Bus Unit (Crimp Snap-in Connections) with I/O Module

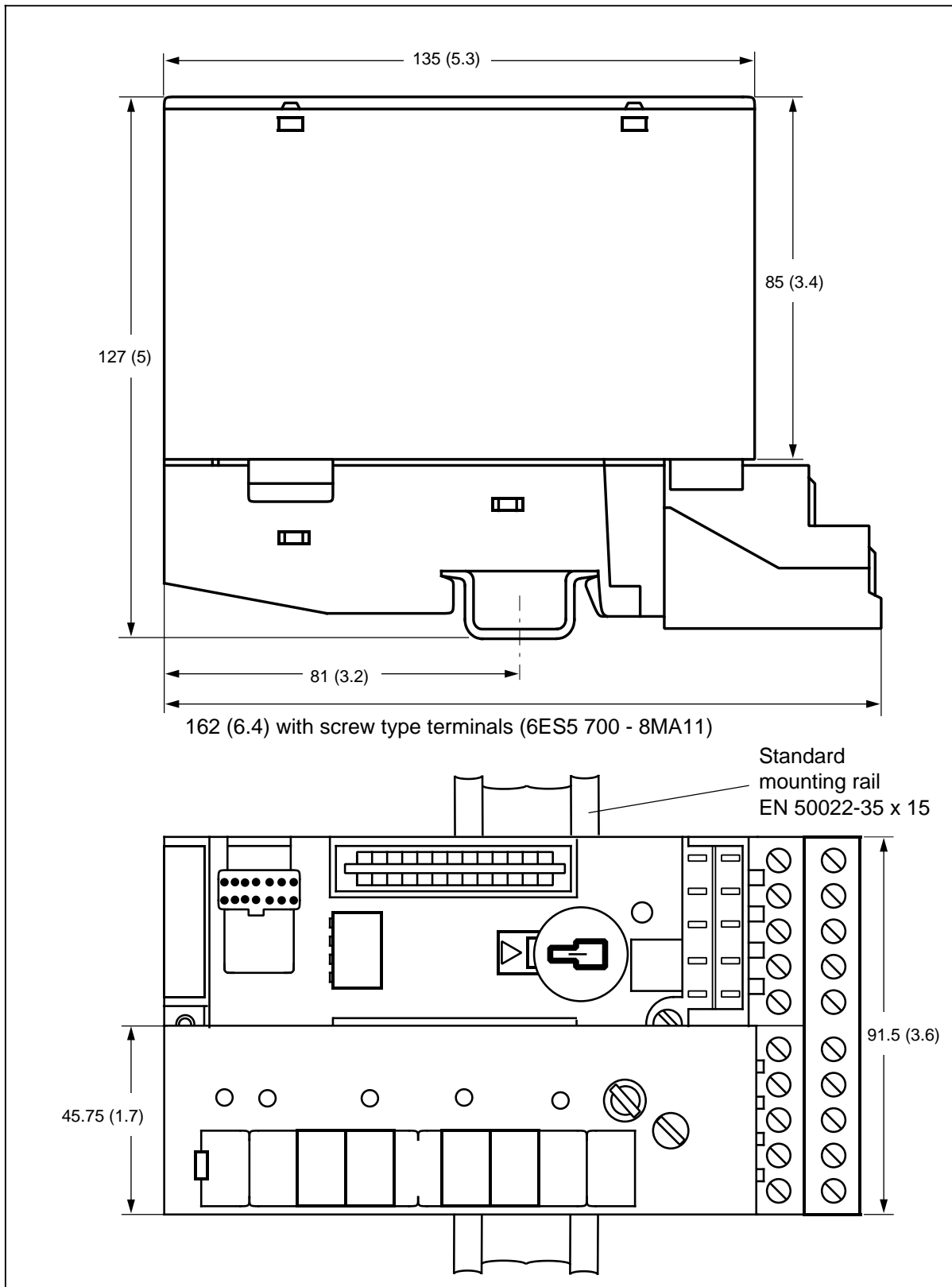


Figure 3-21 Dimension Drawing of the Bus Unit (SIGUT Screw-type Terminals) with I/O Module

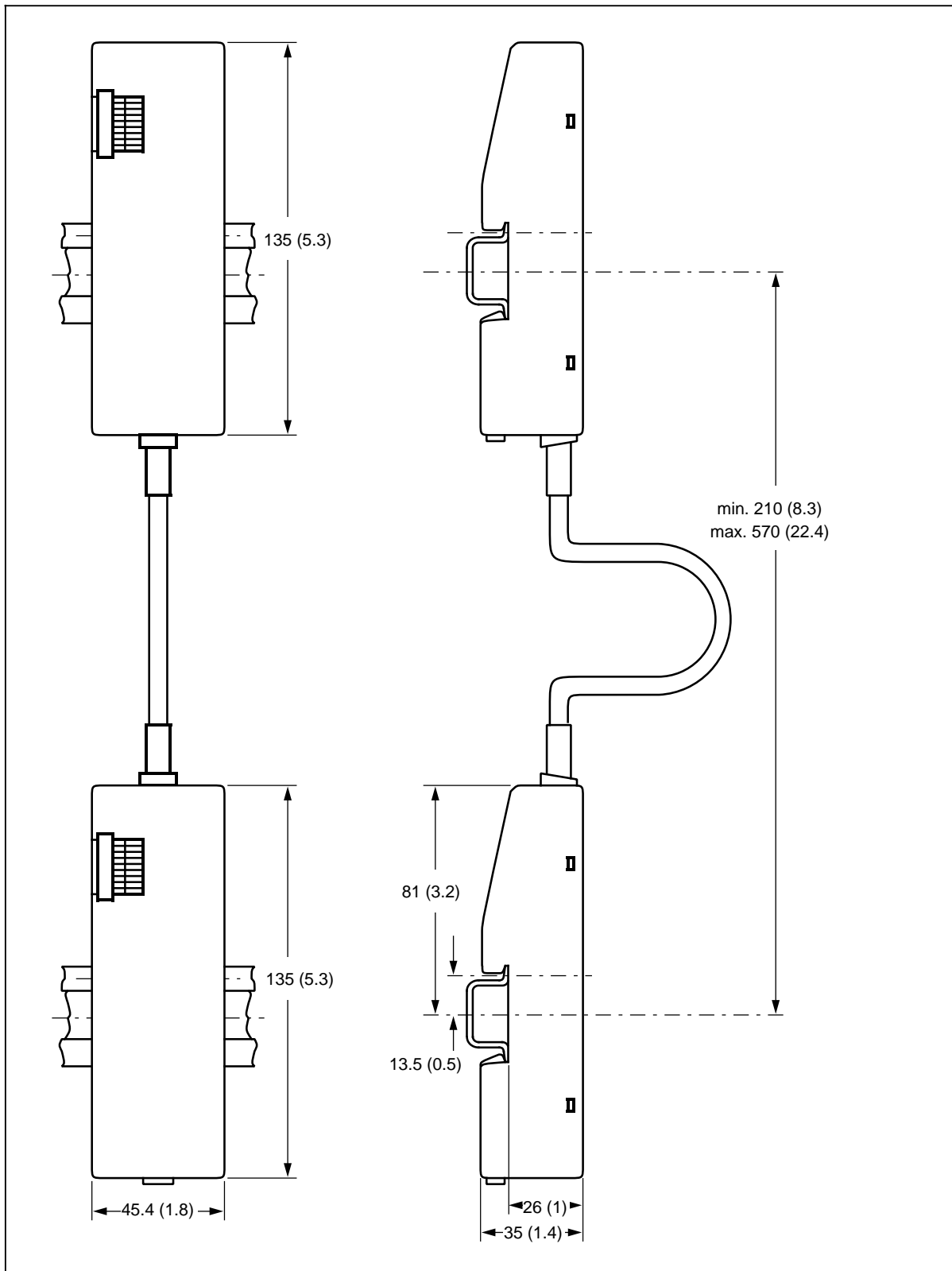


Figure 3-22 Dimension Drawing of the IM 315 Interface Module

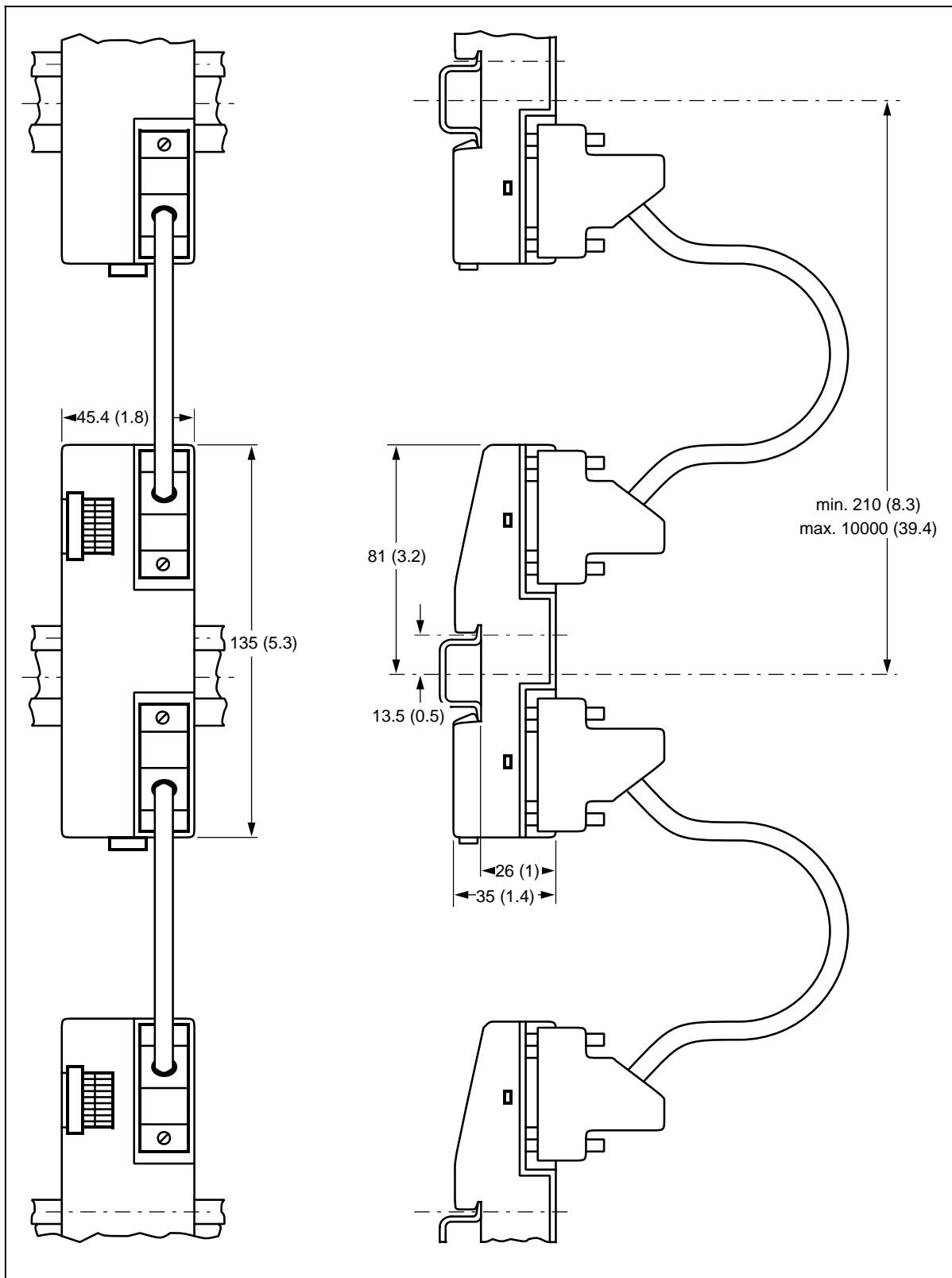


Figure 3-23 Dimension Drawing of the IM 316 Interface Module

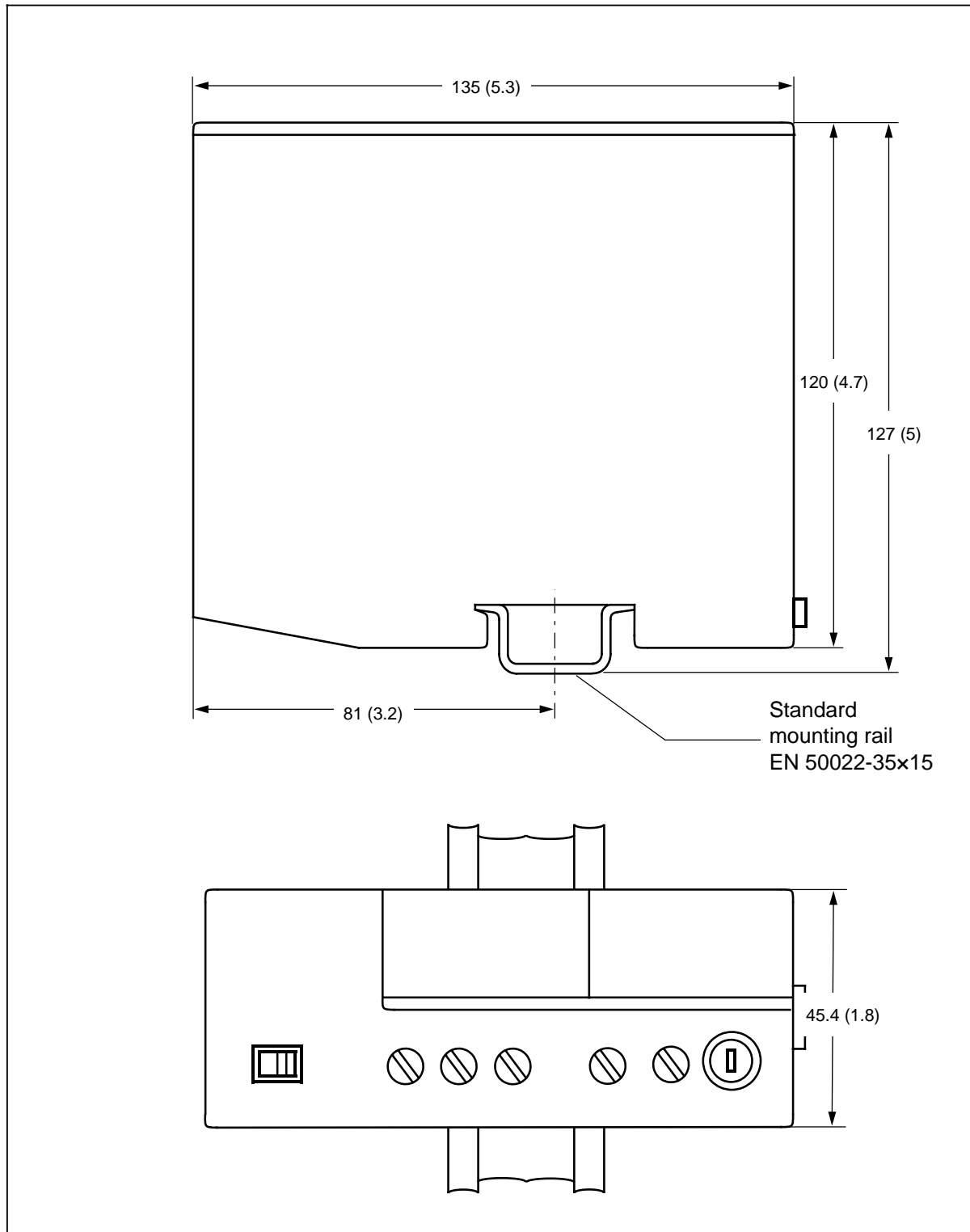


Figure 3-24 Dimension Drawing of the PS 931 Power Supply Module

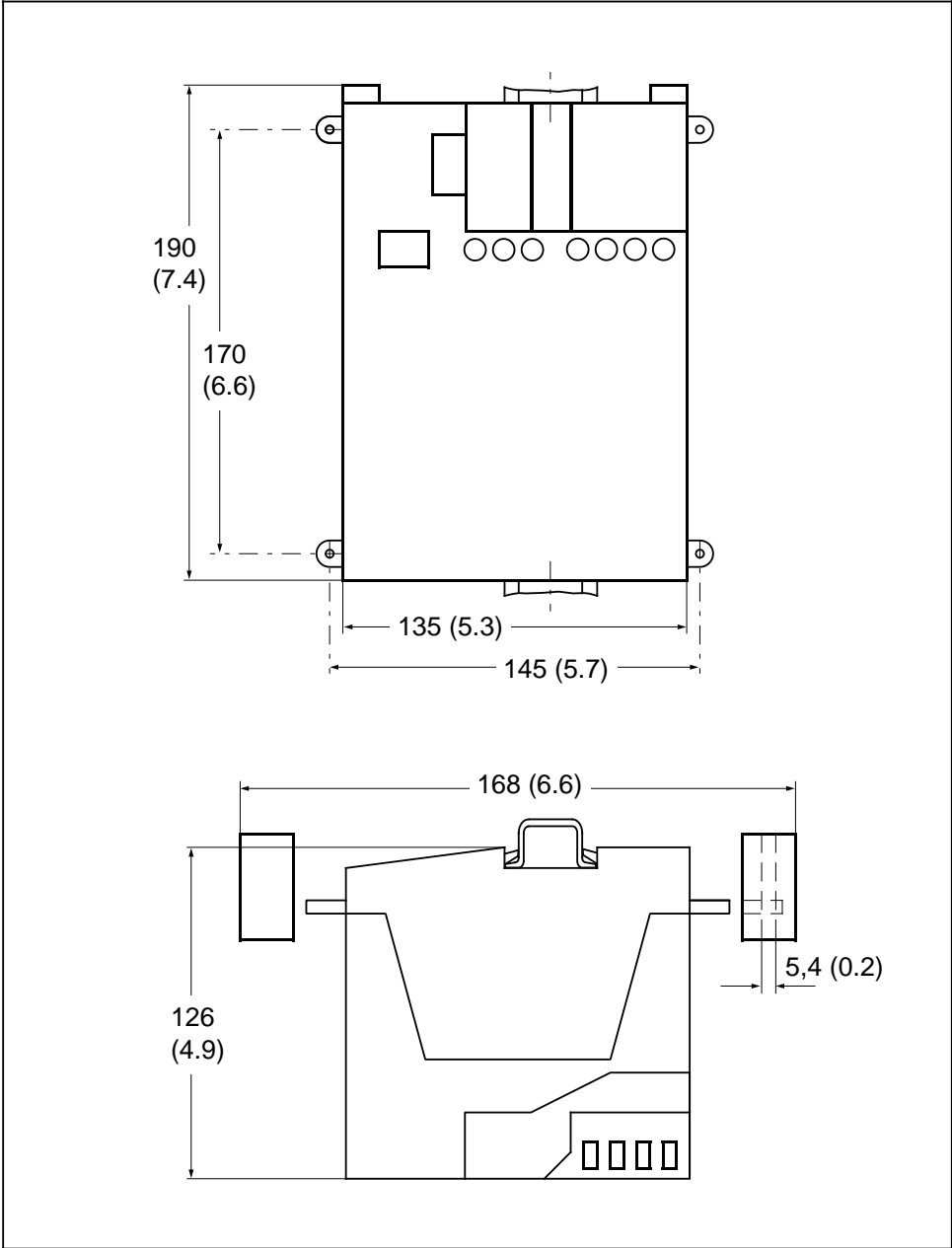


Figure 3-25 Dimensional Drawing of the PS 2410 Power Supply Module

3.2 Electrical Connections

The permanent wiring allows I/O modules to be replaced without undoing process signal cables.

3.2.1 SIGUT/Crimp Snap-in Connections

SIGUT Screw-Type Terminals

Two leads can be terminated with this type of connection. The screws are best tightened using a 5 mm (0.2 in.) screwdriver.

Permissible conductor cross-sections:

- Stranded conductor with core end sleeves: 2 x 0.5 to 1.5 mm² (20 to 15 AWG)
- Solid conductor: 2 x 0.5 to 2.5 mm² (20 to 13 AWG)

The PS 2410 is an exception (3.2.2).

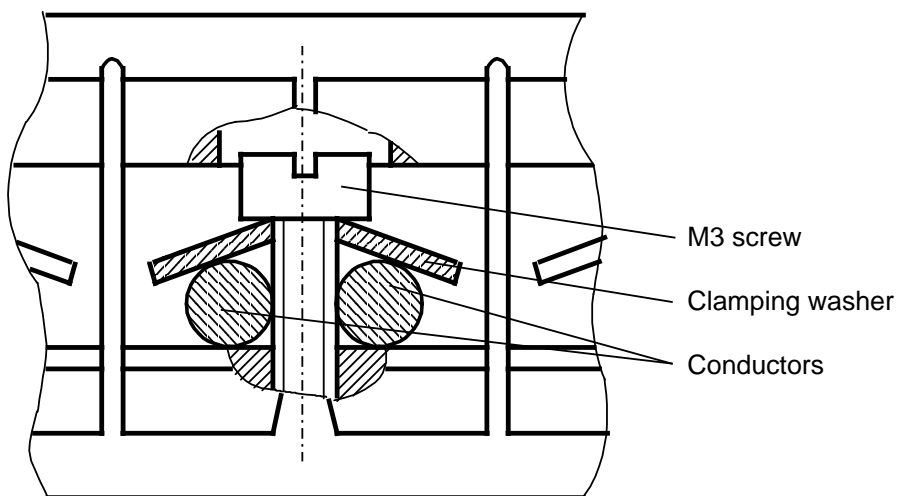


Figure 3-26 SIGUT Screw-Type Terminals

Crimp-Snap-in-Connections

Bus units with crimp snap-in connections have exactly the same height as the central processing unit.

Stranded cables with a cross-section of between 0.5 and 1.5 mm² (20 and 15 AWG) can be attached to these terminals.

Mounting the Terminal in the Terminal Block (→ Figure 3-27)

- Remove the module plugged into the bus unit.
- Use a screwdriver to lever the terminal block out of the bus unit (1).
- Swing it out to reveal the rear side (2).
- Push the terminal into the receptacle until the locating spring engages.
N. B.: The spring must point into the slot (3) !
- Make sure that the terminal has engaged properly by briefly pulling on the cable.
- Swing the terminal block back up into its original position and press firmly until it snaps into position.

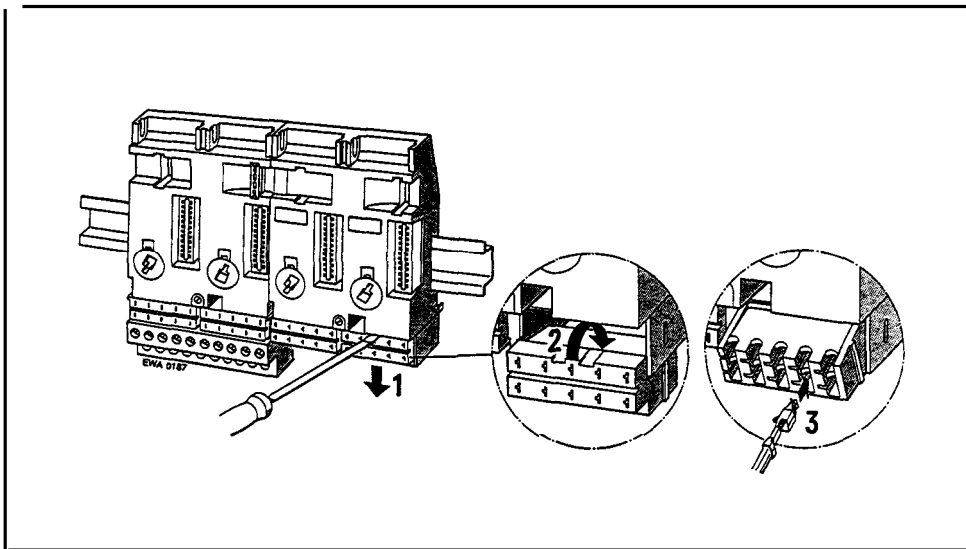


Figure 3-27 Crimp Snap-In Terminals

Undoing Crimp Snap-In Connections

- Put the terminal block into the position as shown in Figure 3-28.
- Insert the extraction tool into the slot beside the terminal to compress the barb (1).
- Locate the cable in the groove on the extraction tool and pull out the tool together with the cable (2).
- Before using the terminal again, the deformed barb must be realigned.

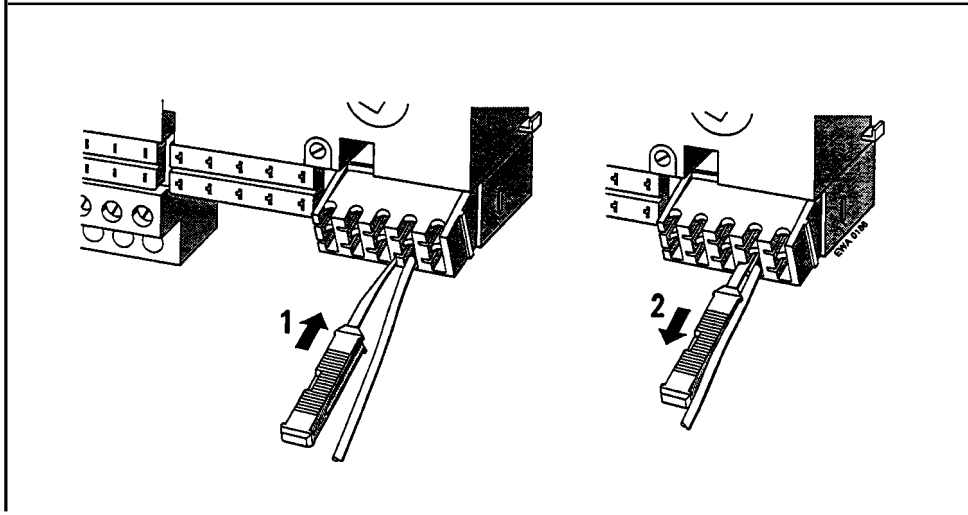


Figure 3-28 Undoing a Crimp Snap-In Connection

3.2.2 Connecting the Power Supply Module

However, in most cases it is advisable for the ET 100U to have its own power supply.

The following then applies to the supply voltage:

- If you are using nonfloating I/O modules, you must connect the M terminal to the cabinet housing in the immediate vicinity of the external power supply. The connection must be as short as possible using at least 6 mm² (9 AWG) copper wire.
- If you are using floating modules, you can ground the M terminal or not as you choose.

If you use an ungrounded supply voltage, you must provide an insulation monitor (VDE 0113 and VDE 0100, §60).

You will find further information under Equipotential Bonding and Galvanic Isolation (3.4).

If you locate the ET 100U in the immediate vicinity of the central controller or expansion unit, you can power the ET 100U and the central controller or expansion unit from the same external power supply.

In this case, you must connect the M terminal to ground as described above.

PS 931 Power Supply Module

This module can be used to power the ET 100U and as load power supply for sensors and actuators. The module offers the following functions

- 115V /230 V AC input voltages
- Floating 24V DC /2A output
- Safe electrical isolation

Proceed as follows to connect the power supply module (Figure 3-29):

- Set the voltage selector to the line voltage.

- Swing up the protective cover and connect the supply cable to the L1, N and M terminals. First make sure that the supply cable is not live. Use the strain-relief clamp provided.
- Loop the L+ and M terminals to the adjacent 318-8 interface module and to the bus units (L+ to terminal 1, M to terminal 2).
- If a grounded configuration is used, connect "M" on the power supply module or on the interface module to the standard sectional rail.
- Close the protective cover of the power supply module.

3

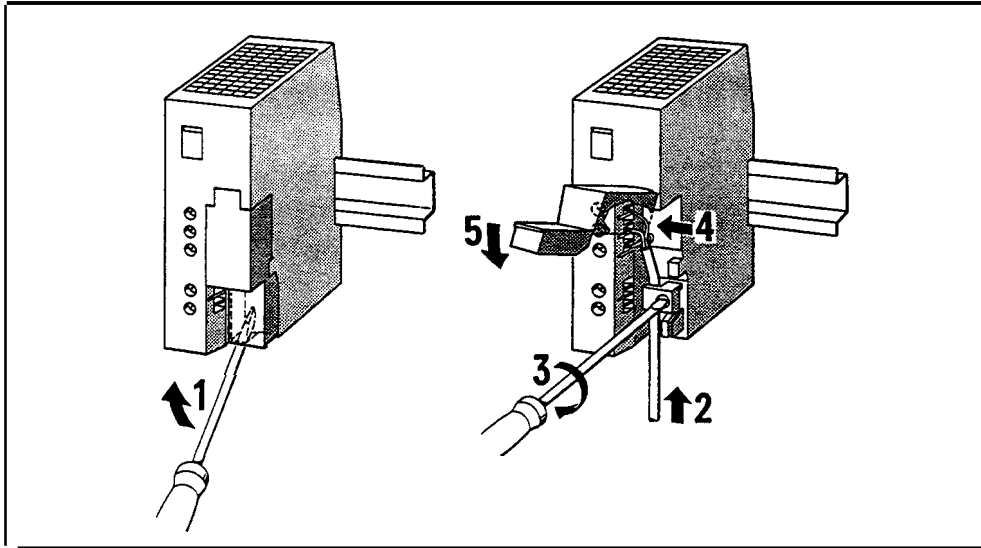


Figure 3-29 Connecting the **PS 931** Power Supply Module

PS 2410 Power Supply Module

The module can be used as power supply unit for the ET 100U and as load power supply for sensors and actuators. It offers the following:

- Input voltages of 120 V/230 V AC (selectable)
- Floating 24 V/10 A DC output
- Safe electrical isolation
- Short-circuit protection for no-load and continuous operation (electronic).

The PS 2410 power supply module is mounted on the standard mounting rail. It is set to 230 V on delivery. Proceed as follows for changing the setting to 115 V AC:

- Remove the cover labeled "Voltage Selector".
- Set the voltage selector switch to 115 V AC.
- Attach the cover.

How to connect the PS 2410 power supply module (Figure 3-30):

Do not connect any cables with cross-sections smaller than 1.5 mm² to the PS 2410 power supply module.

- Connect the supply cable to terminals L1, N and \perp . First make sure that the supply cable is dead. Use the clamp provided on the module as a cable grip.
- Connect L+ and M of the power supply unit to L+ and M of the adjacent 318-8 interface module and of the relevant bus units.
- Connect the M terminal of the power supply unit or interface module to the standard mounting rail in grounded configurations.

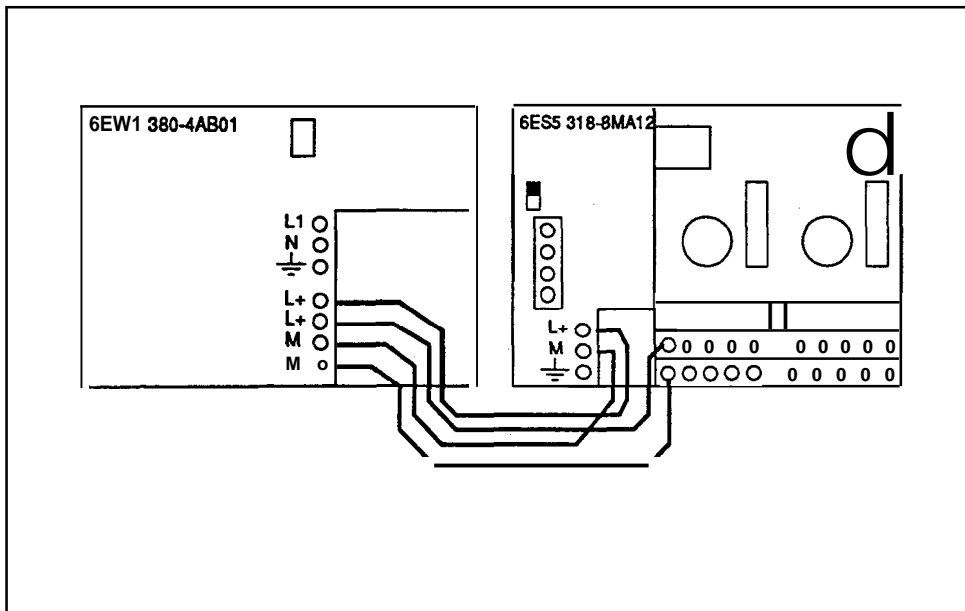


Figure 3-30 Connecting the PS 2410 Power Supply Module

3

3.2.3 Connecting the Interrupt Output

The H+ /H- interrupt outputs on the 318-8 interface module provide a simple means of disconnecting the load in the event of a fault. If a fatal fault occurs, it is either repped or the power supply is disconnected. The following are examples of fatal faults:

- I/O bus interrupted or short-circuited
- Module plugged in is not the module specified in COM ET 100 (for safety reasons, modules for 115/230 V AC are mechanically interlocked with modules for 24 to 60 V DC).

The H+ /H- interrupt output of the 318 interface module incorporates a floating transistor switch, which opens in the event of a fault. A maximum of three interrupt outputs may be connected in series.

Monitoring with Universal Load Power Supply Modules

The monitoring capabilities of commercial power supply modules are not suitable for the ET 100U. Using the following circuit arrangement (Figure 3-31), however, you can disconnect the power supply in the event of fatal faults or errors.

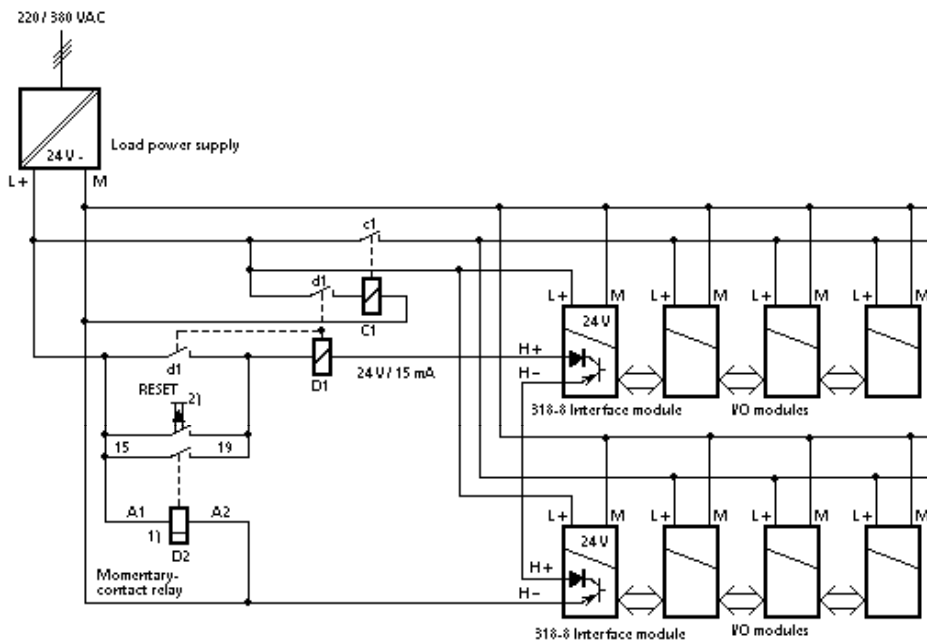


Figure 3-31 Monitoring with Universal External Power Supply Modules

C1 24 V DC relay for switching the power supply on and off. Select the size according to the maximum switching current.

D1 24 V / 15 mA relay. If several interrupt outputs are connected in series, make allowance for the voltage drop across the transistor switch (2.5 V for 15 mA). If necessary, use a 12 V relais.

A defined reset pulse is generated by the 24 V momentary-contact relay D2 when the external power supply is switched on. This guarantees startup of the ET 100U.

In the event of a fault, the H+/H- interrupt output is opened and the load voltage is disconnected via relay D1 and contactor C1.

After you have removed the fault, press the Reset button to switch the power supply back on.

3.2.4 318-8 Interface Module

The 318-8 module receives the data transmitted to the ET 100U from the 308-3 interface module in the central controller via the S / S-N* serial interface. The data received is stored in an internal buffer and transferred via the I/O bus to the output modules.

In the other direction, the input data of the input modules is transferred via the I/O bus to the 318-8 interface module. The interface module buffers the input data and then transfers the data to the serial interface, from where it is transmitted to the 308-3 interface module in the controller.

The exchange of input/output data in the serial interface and on the I/O bus is carried out within one cycle**, but is time-independent thanks to buffering.

In addition, the 318-8 interface module evaluates diagnostics information arriving from the I/O modules and supplies the CPU in the central controller with the data for the diagnostics bytes.

The four fault LEDs on the frontplate of the 318-8 provide information on the operating status of the ET 100U (6.2).

The 318-8 interface module supplies the internal voltage of 9 V for the whole ET 100U. This voltage is derived from the 24 V supply terminals (L+ and M) but not insulated from them.

* -N = Negated signal

** Cycle refers here to the referencing of all ET 100Us connected to one 308-3 module (not to be confused with the PC scanning cycle!)

Serial Interface S /S-N*



The transmission cable is connected to terminals 3 and 4 of the front connector, the incoming and outgoing cores in each case being connected together via the screw terminal. This prevents the transmission line to the other nodes from being interrupted when you remove the front connector from the module. Up to 32 nodes can be connected in one chain. The bus must be terminated at the last node of a chain with a 120-ohm terminating resistor. Connect the terminating resistor between terminals 3 and 4 of the front connector.

The terminating resistor is supplied with the 308-3 interface module.

H+ / H- Interrupt Outputs

The H+/H- interrupt outputs allow you to respond selectively to fatal faults. This is an excellent means of monitoring the ET 100U (3.3.3).

L+, M Power Supply Terminals

Connect a 24 V supply to the L+ and M terminals. M and  are connected together on the module. If a grounded configuration is used, connect  to the standard sectional rail or one of the cabinet uprights via a low resistance (3.3.2).

Connection to the I/O Bus

The connection to the I/O bus is made via the 14-pin plug connector on the side of the interface module and the ribbon cable of the first bus unit.

The ribbon cable connector must only be plugged in or unplugged when the power is off.

* -N = Negated signal

Switches

- Mode selector
In the OFF position, this switch has the same effect on the interface module as cutting off the power supply.
The switch must be at the ON position when operating the ET 100U.
- Switch block for ET numbers and baud rate.
All ET 100Us within the bus system of a 308-3 interface module must be numbered for addressing purposes.
Also, the baud rate of the serial interface must be set to the same value as the 308-3 interface.
Please use a ball-point pen or similar pointed object to set the switch blocks and not a pencil.
Figure 3-32 shows a typical setting. The symbol • indicates the ON position.

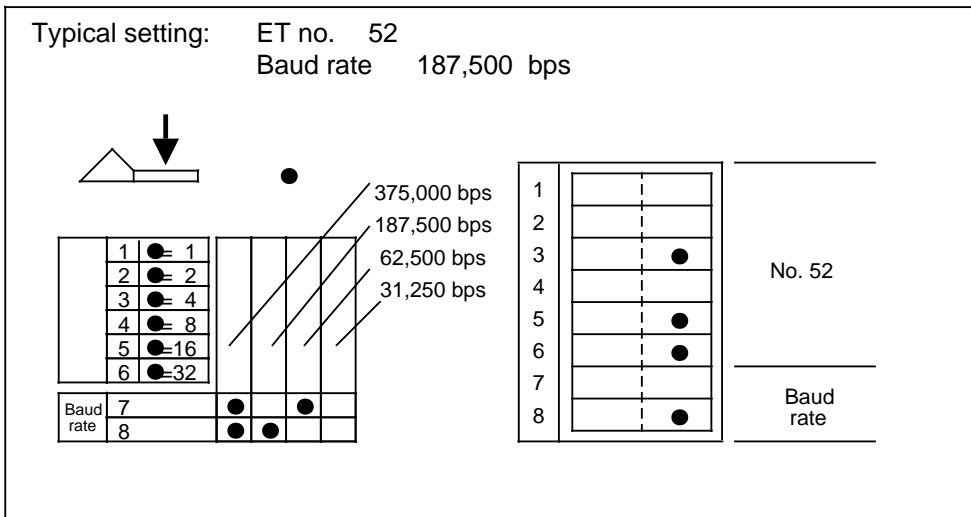


Figure 3-32 Setting the ET 100U

The 308-3 interface module is supplied with a set of labels with number stickers. There are two stickers for each number, namely, a setting sticker and a number sticker.

Affix the relevant sticker in the position indicated (Figure 3-33).

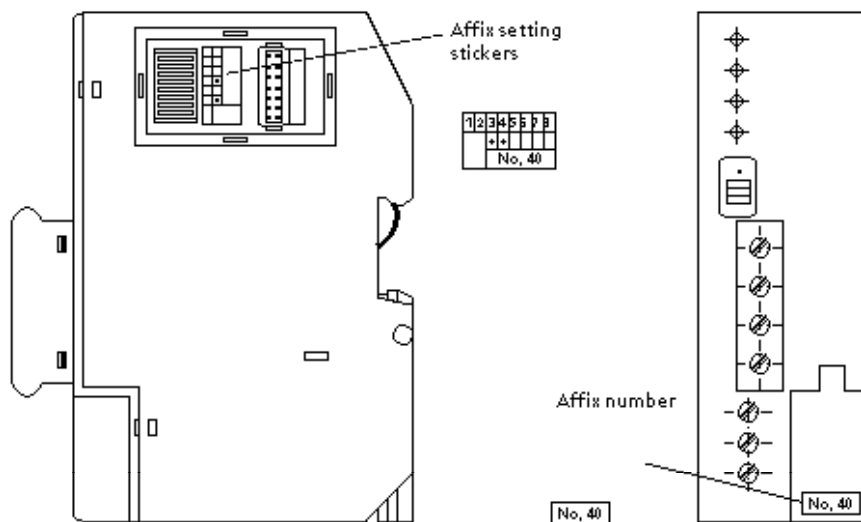


Figure 3-33 Affixing ET Numbers

3.2.5 Transmission Cable

Signal connections

Connect the S terminal (terminal 3 of the front connector) to the transmission cable core which is also connected to the S terminal of the 308-3 interface module. Proceed in the same way with the S-N* terminal (terminal 4 of the front connector). If you wish to extend the transmission cable to a further node, loop the incoming and the outgoing transmission cables through in parallel on the front connector.

If you should mix up the cores of one or several interface modules, the modules will not be accessible. However, the 308-3 module does not detect interface errors.

* -N = Negated signal

Terminating Resistor

You must terminate each line at the last node with a standard 120 ohm, 0.25 W carbon-layer resistor (supplied with the 308-3 interface module). Simply clamp the resistor between terminal 3 and 4 of the front connector.

Make sure that good contact is made. If necessary, you can press the resistor wires with the flexible transmission line into the same core end sleeve. A better solution is to solder core end sleeves to the resistor connecting wires and then clamp the resistor into position.

Connecting the Shielding

In the central controller, you must ground the transmission cable shielding as close as possible to the programmable controller using a ground clamp or at the distribution box using a shield bar. The shielding must then be continued right up to the front connector of the 308-3 interface module.

Clamp the shield of the transmission cable to the standard sectional rail in the ET 100U using a 6ES5 728-8MA11 ground terminal, and continue the shielding right up to the front connector of the 318-8 interface module. This applies to both incoming and outgoing transmission lines .

Laying the Transmission Cable

Please note the following guidelines:

Table 3-2 Laying the Transmission Cable

	Cable laid as follows	
	Baud rate up to 62,500 bps	Baud rate greater than 62,500 bps
Parallel to signal cables up to 60 V	In the same cable duct	In separate cable ducts
Parallel to power cables from 380 V	More than 10 cm / 4 in. apart, or in separate ducts or racks	More than 20 cm / 8 in. apart, or in separate ducts or racks

Selecting the Cable Type

Use a shielded, twisted-pair cable. The type selected depends on the required cable length and baud rate. Some possible cable types are listed below.

Table 3-3 Cable Types Available

Type of cable	Baud rate over a distance of		
	500 m 1640 ft	1000 m 3280 ft	3000 m 10000 ft
SIEMENS control cable, type A ¹⁾ (6XV 1830-0AH10)	375 Kbaud	187.5 Kbaud	---
SIEMENS control cable, type B ²⁾ (V45551-F21-B5)	187.5 Kbaud	62.5 Kbaud	31.25 Kbaud

You will find details of the physical characteristics required of other cable types in the Manual of the 308-3/318-3 interface modules.
(Order No.: 6ES5 998-2DP21).

- 1) Supplied by the meter: specify length in ... m ; minimum order quantity 20 m
- 2) Maximum length delivered 1000 m; greater lengths on request

3.2.6 Baud Rates

By selecting the lowest possible baud rate, you will achieve the greatest possible noise immunity on your data transmission link. However, the required response speed of the process drops in proportion to the baud rate, and should be taken into account.

Set the same baud rate for all nodes as you have set for the 308-3 interface module.

3.2.7 Connecting the Digital Input and Output Modules

All input and output modules are plugged into bus units. The signal leads are connected to the terminal blocks of the bus units. The following description involves connections to screw terminals (SIGUT method).

Crimp snap-in connections can also be used (3.2.1). In both cases, the terminal numbers are marked on the terminal blocks.

The following assignments always apply for the connection of the load voltage:

Table 3-4 Connecting the Load Voltage

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

Connecting Four-Channel Digital Modules

All these modules have two terminals for each connection. You can therefore wire them directly to the sensor or actuator. An external distribution block is not required.

All four-channel digital I/O modules for 24 V DC have a red "F" (fault) LED. This LED signals any load voltage failure. It also indicates short-circuits to M (0 V reference potential) in sensor lines in the case of input modules, and output faults in the case of output modules.

115 / 230 V AC input modules have no fault indicator. 115 / 230 V AC output modules have a fault indicator for "defective fuse". The four channels of a module are numbered from .0 to .3 or .4 to .7, depending on what addresses were assigned with COM ET 100 (Chapter 5). Each channel is allocated a pair of terminals on the terminal block.

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

Four-channel output modules generate a fault message in the event of output circuit shorts. This fault message can be evaluated via the I/O bus as a diagnostics message (Chapter 6).

Four-Channel Input Modules

Example: Connecting a sensor to channel 2 (address I 24.6) of the input module with initial address 24.4 (Figure 3-34). If the module had the initial address 24.0, you would have to program address I 24.2 for channel 2.

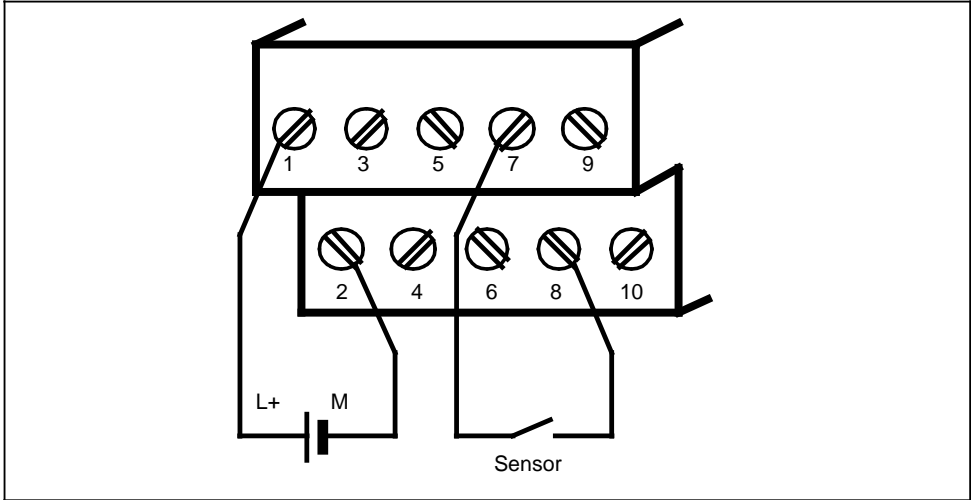


Figure 3-34 Two-Wire Connection of a Sensor to Channel 2

Four-Channel Output Modules

Example: Connecting a lamp to channel 2 (address Q 20.2) of the output module with initial address 20.0 (Figure 3-35). If the module had the initial address 20.4, you would have to program address Q 20.6 for channel 2.

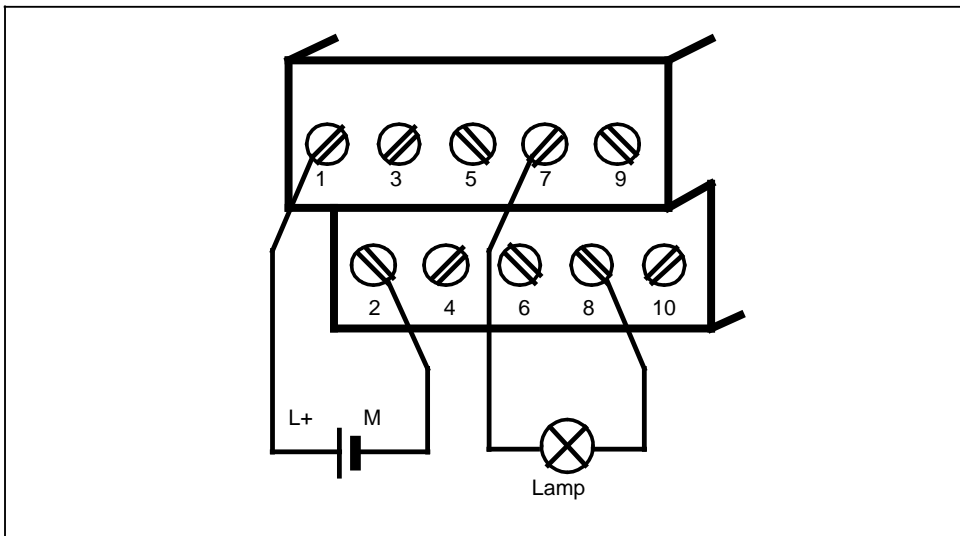


Figure 3-35 Two-Wire Connection of a Lamp to Channel 2

Connecting Eight-Channel Digital Modules

These modules do not have two terminals for each connection. An external distribution block is therefore required.

Eight-channel digital modules have no fault indicator.

The eight channels of a module are numbered from .0 to .7. Each channel is assigned to a terminal on the terminal block. The terminal assignments and the connection diagram are printed on the front of the module.

Please note that the bit address and the channel number may be different when assigning addresses with COM ET 100.

Example: If the initial address of your module is 18.4, this is the address of channel 0 and channel 1 would have the address 18.5 etc. up to channel 7 (address 19.3).

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 22.4) of the input module with initial address 22.0 (Figure 3-36). If the module had the initial address 22.4, you would have to program address I 23.0 for channel 4.

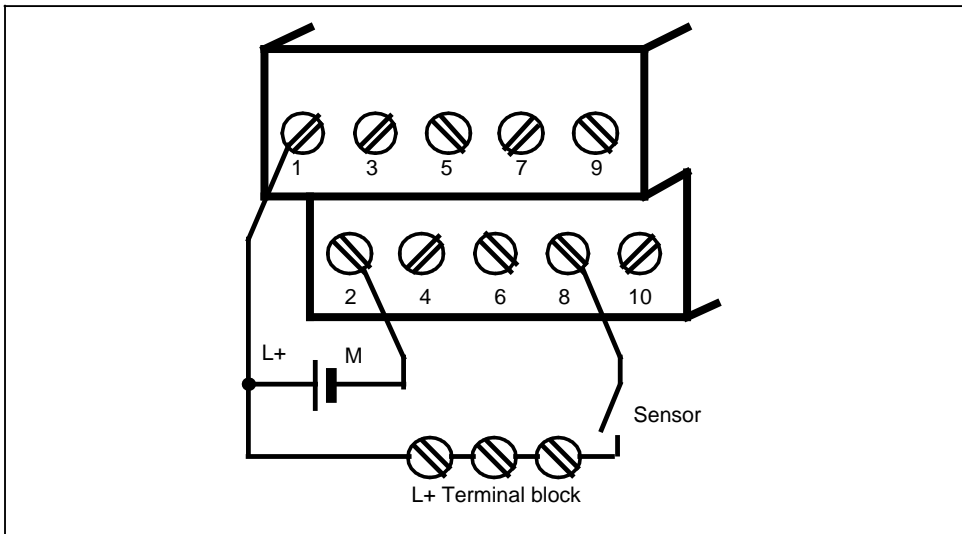


Figure 3-36 Connecting a Sensor to Channel 4

Eight-Channel Output Modules

The actuators must be connected to terminal 2 via the M terminal block.

Example: Connecting a lamp to channel 4 (address Q 22.0) of the output module with initial address 21.4 (Figure 3-37). If the module had the initial address 21.0, you would have to program address Q 21.4 for channel 4.

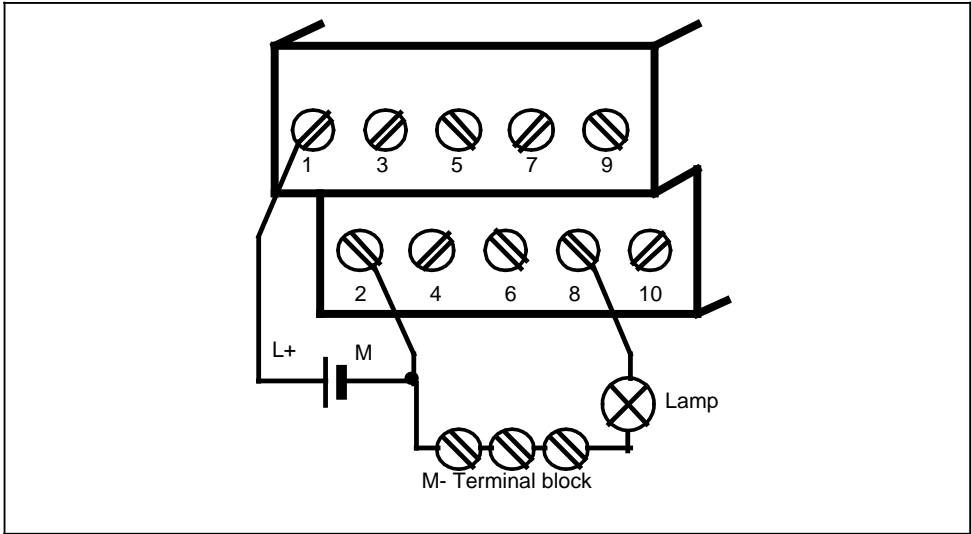


Figure 3-37 Connecting a Lamp to Channel 4

3.2.8 Connecting the Analog Modules















As with digital modules, both types of connections (SIGUT / Crimp snap-in) can be used.

Presetting Analog Input Modules

Analog input modules must be preset for a given operating mode. The following modes can be preset with the coding switches at the top of the module (Figure 3-38 and Figure 3-39).

4	<input type="checkbox"/> 50 Hz <input type="checkbox"/> 60 Hz		} Line frequency		
3	1 Channel <input type="checkbox"/>	2 Channels <input type="checkbox"/>		4 Channels <input type="checkbox"/>	6ES5 464-8MA11 ±50 mV
2	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	6ES5 464-8MB11 ±1 V
1	<input type="checkbox"/> without <input type="checkbox"/> with		} broken wire signal		
4	<input type="checkbox"/> 50 Hz <input type="checkbox"/> 60 Hz		} Line frequency		
3	1 Channel <input type="checkbox"/>	2 Channels <input type="checkbox"/>		4 Channels <input type="checkbox"/>	6ES5 464-8MC11 ±10 V
2	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	6ES5 464-8MD11 ±20 mA
1	Irrelevant			6ES5 464-8ME11 4 to 20 mA	
4	<input type="checkbox"/> 50 Hz <input type="checkbox"/> 60 Hz		} Line frequency		
3	1 Channel <input type="checkbox"/>	2 Channels <input type="checkbox"/>			
2	<input type="checkbox"/>	<input type="checkbox"/>			
1	<input type="checkbox"/> without <input type="checkbox"/> with		} broken wire signal		
				6ES5 464-8MF11 PT100/±500 mV	

Figure 3-38 Presetting the 4-Way Coding Switches

8	 50 Hz  60 Hz	Line frequency		6ES5 464-8MA21 ±50 mV
7 6	1 Channel 	2 Channels 	4 Channels 	
5	 without  with	broken wire signal		
Linearization				
4 3	without 	Type K 	Type J 	Type L 
Temperature compensation				
2 1		Type K 	Type J / L 	









8	 50 Hz  60 Hz	Line frequency		6ES5 464-8MF21 ±500 mV/Pt 100
7 6	1 Channel 	2 Channels 		
5	 without  with	broken wire signal		
Linearization				
4 3	without 	Type PT 100 		
2 1	Irrelevant			

Figure 3-39 Presetting the 8-Way Coding Switches

- **Line frequency:** Set the switch to the available line frequency to select the A/D converter integrating time for optimal noise suppression.
Line frequency 50 Hz Averaging time 20 msec
Line frequency 60 Hz Averaging time 16 msec
- **Number of channels:** Set the number of channels to be assigned in the analog input module. This allows a smaller address area in the case of four channels or less, and measured values are then updated faster.
- **Wire break signal:** If you activate the wire break signal, the red LED above the coding switch will light up in the event of a break in one of the lines to the sensor (thermocouple or PT 100) or in the sensor itself. The wire break error bit F (bit 1, byte 1) for the particular channel is set simultaneously.
- **Linearization:** This function can be used for curve linearization of thermocouples of types J, K and L or of the PT 100 resistance thermometer.
In the case of the 464-8MA21 module, the linearization function must always be activated together with the relevant compensation of the reference junction temperature.

Curve linearization applies to the following temperature ranges:

PT 100: -100 to + 850 °C in steps
of
0.5 °C each

Thermocouples:

Type J: - 200 to + 200 °C in steps
Type K: - 200 to + 1369 °C of
Type L: - 199 to + 900 °C 1 °C each

- Temperature compensation: You can take the reference junction temperature for thermocouples of types J, K and L into account. Internal module circuitry enables a voltage that is dependent on the type of thermocouple and on the temperature of the reference junction to be gated with the input signal. When the thermocouples are connected directly, this voltage ensures that 0° C at the measuring point is indicated correctly on the digital display regardless of the temperature at the reference junction.

Connecting Analog Input Modules

Please note the following before connecting:

- Set the coding switches as shown in Figure 3-38 or Figure 3-39. The modes selected apply to all channels of this module.
- In multi-channel operation, the channels should be assigned in ascending order (shorter data cycle 4.3.2).
- There must be no load voltage at terminals 1 and 2 (Exception : 24 V DC in the case of the 6ES5 464-8ME11 2-wire transducer).
- If floating sensors are connected (e.g. insulated thermocouples), the permissible potential difference V_{CM} between the inputs and the potential of the standard sectional rail must not be exceeded. To prevent this, the negative potential of the sensor must be connected to the central ground point.
- The permissible potential difference between the inputs may not exceed ± 1 V.
- The terminals of unused inputs must be shorted.
- A complete description of analog value processing is given in Chapter 7.

Analog input modules convert voltages or currents to digital values. The modules may be plugged in or unplugged during operation of the ET 100U.

The current measuring ranges work with built-in shunt resistances and the Voltage dividers are provided at the input for the ranges ± 5 volts and ± 10 volts.

A field-effect multiplexer selects the individual channels cyclically and switches them through to the analog-digital converter. The A/D converter operates on the dual-slope principle with an integrating time of 20 ms (16 ms) for optimal suppression of system noise at 50 Hz (60 Hz). The total encoding time including offset compensation and "down" integrating time is 60 ms for the full scale value.

Resolution in the nominal range is ± 2048 units. A measuring range of up to ± 4095 units is possible if it is guaranteed that this range will not be exceeded. The overflow bit "1" (byte 1, bit 0) is set in the event of overrange. All data bits are set to "1". The analog value is represented left-justified as the two's complement.

Analog Input Module 4 x ± 50 mV (6ES5 464-8MA11)

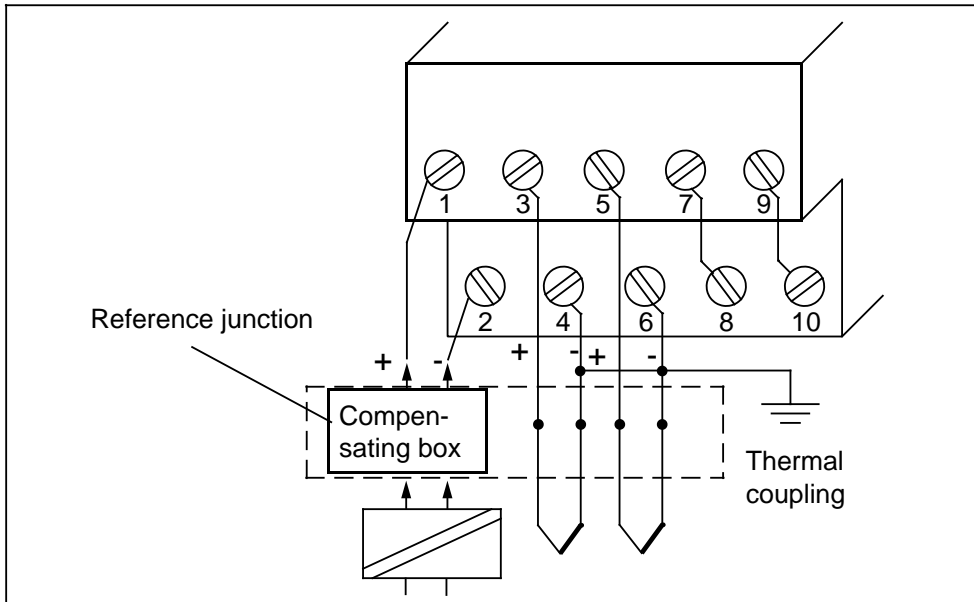


Figure 3-40 Voltage Measurements with Non-Floating Thermocouples (for the 464-8MA11 Analog Input Module)

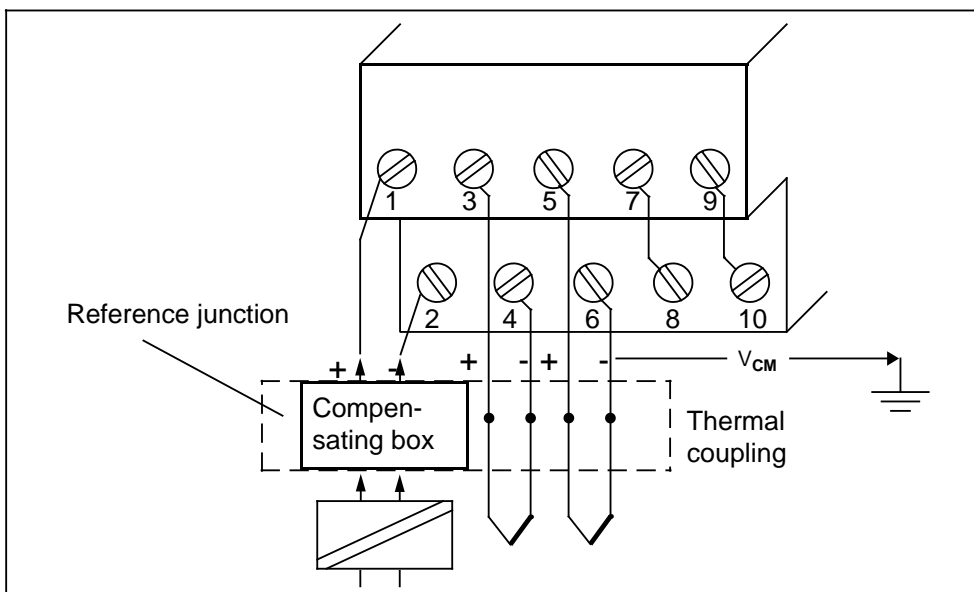
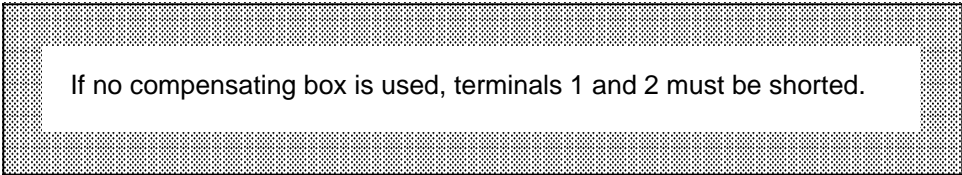


Figure 3-41 Voltage Measurements with Floating Thermocouples (464-8MA11 Analog Input Module)

In both cases, the effect of temperature on the reference junction (e.g. in the terminal box) can be neutralized with a compensating box.

Compensating Box for the 6ES5 464-8MA11 Analog Input Module

- The compensating box must have an isolated or floating supply.
- The power supply must have a grounded shielding winding.
- The box is connected to terminals 1 and 2 of the terminal block.



If no compensating box is used, terminals 1 and 2 must be shorted.

Thermocouples and compensating boxes are described in Catalog MP 11.

Analog Input Module 4 x ± 50 mV with Temperature Compensation and Linearization (6ES5 464-8MA21)

Set the linearization and the temperature compensation for the thermocouple on the coding switch. The reference temperature is 0° C, i.e. when the temperature at the measuring point is 0° C, the value 0 is displayed.

Use thermocouples of the same type on all four channels of the module. If, for any reason, you use different types or thermocouples other than J, K or L, you must not then activate linearization and temperature compensation. Compensation is then not even possible with a compensating box, because the compensating box is designed only for a specific type of thermocouple.

A terminal box with a thermostat would be feasible in this case as long as account is taken of the thermostat temperature in the program.

If you choose the mode **without** linearization and **without** temperature compensation, the module will perform like a 464-8MA11.

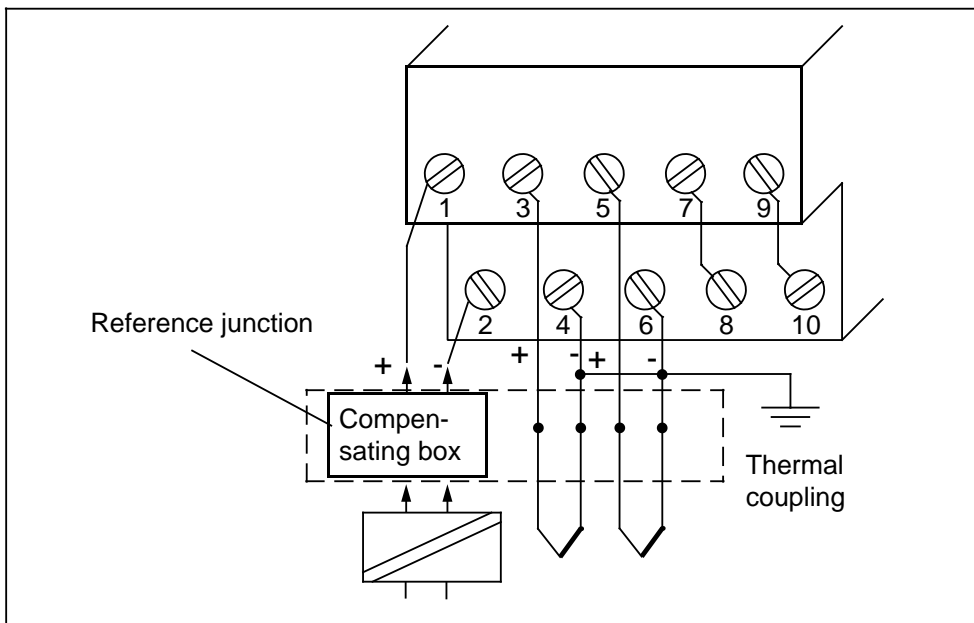


Figure 3-42 Voltage Measurements with Nonfloating Thermocouples (for the 464-8MA21 Analog Input Module)

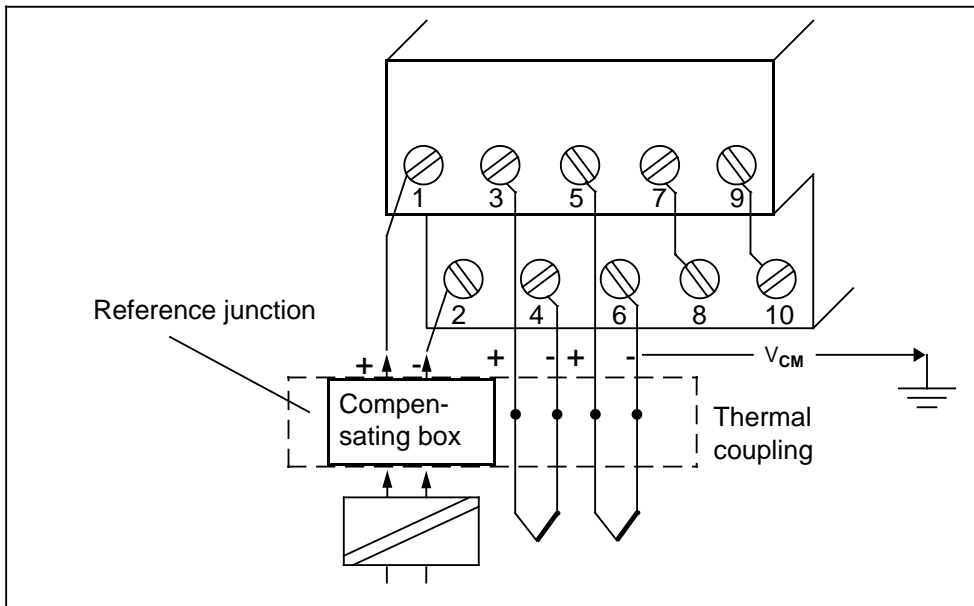


Figure 3-43 Voltage Measurements with Floating Thermocouples (for the 464-8MA21 Analog Input Module)

Analog Input Modules **4 x ± 1 V (6ES5 464-8MB11)**
 4 x ± 10V (6ES5 464-8MC11)

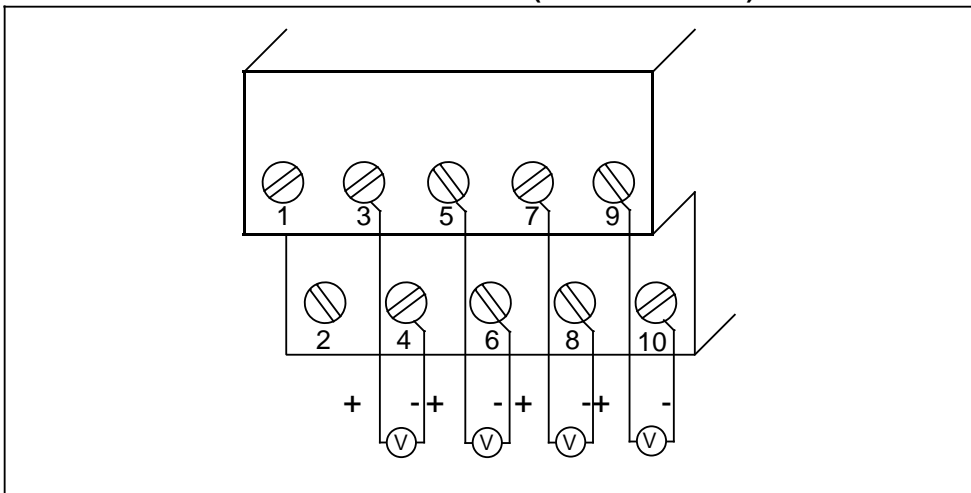


Figure 3-44 Two-Wire Connection of Voltage Sensors

Analog Input Module **4 x ± 20 mA (6ES5 464-8MD11)**

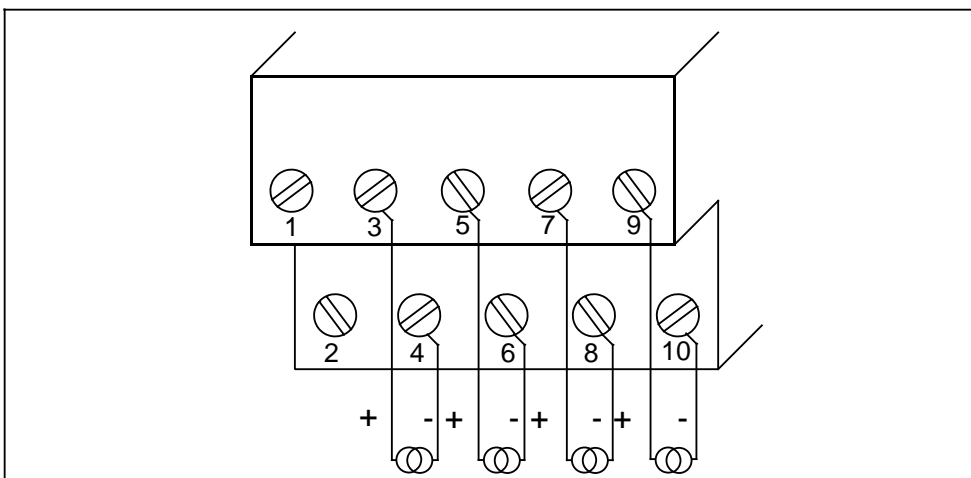


Figure 3-45 Two-Wire Connection of Current Sensors

Analog Input Module 4 x + 4 to 20 mA (6ES5 464-8ME11)

Module inputs 4, 6, 8 and 10 are connected together via the ground terminals of internal shunt resistors.
No wire break signal is possible because of the internal shunt resistors.

- Connecting two-wire transducers
The two-wire transducers are powered by the analog module with current limiting. For this purpose, connect terminals 1 and 2 with the L+ and M terminals. The transducers convert the input voltage into a current between 4 and 20 mA. This current causes a voltage drop across internal shunt resistors.

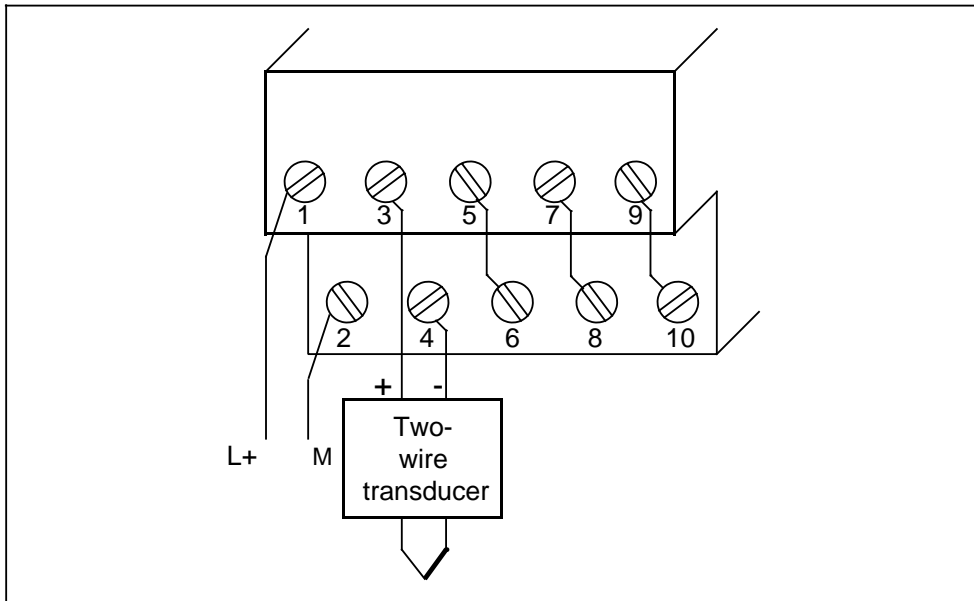


Figure 3-46 Connecting Two-Wire Transducers

- Connecting four-wire transducers
 Four-wire transducers have their own voltage source. They generate a current of between 4 and 20 mA at the output depending on the measured variable (input voltage). This current causes a voltage drop across the internal shunt resistor of the analog input.

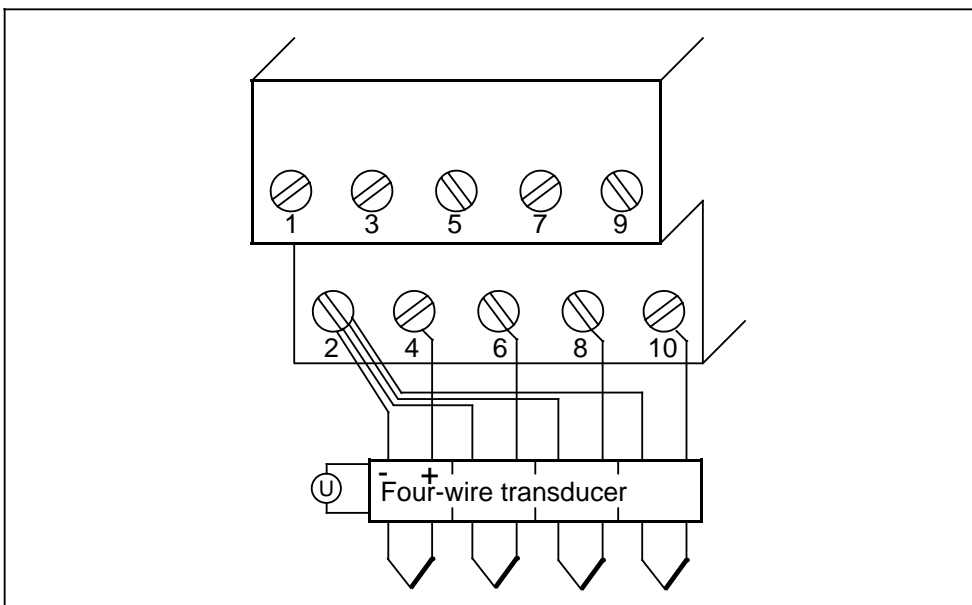


Figure 3-47 Connecting Four-Wire Transducers

Analog Input Module 2 x ± 500 mV / PT 100

(6ES5 464-8MF11)

- Voltage measurement (2 x ±500 mV)
 If a channel is not required for PT100 measurement, it can be used for voltage measurement in the range ±500 mV.
 Signal connection is via the M+/M- terminals. The I_c+ and I_c- terminals must be short-circuited.

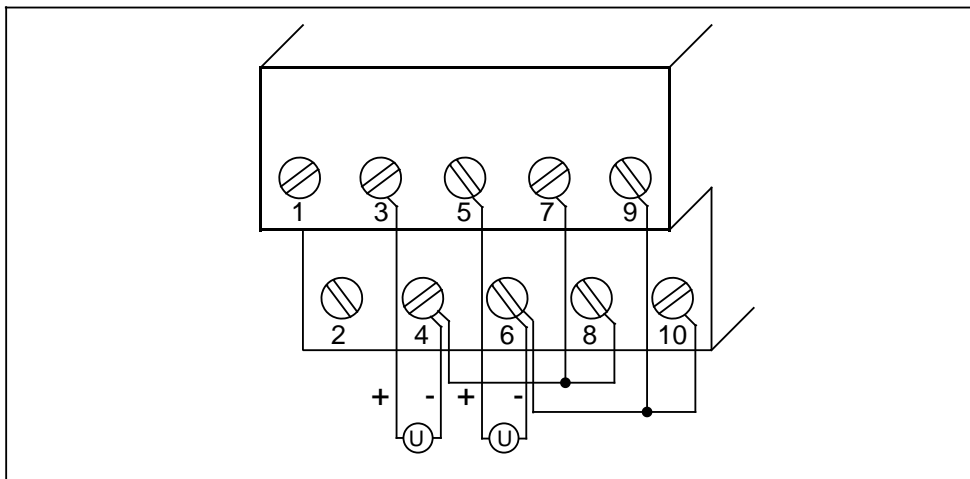


Figure 3-48 Typical Input Module Connections

- Connecting resistance thermometers (e.g. PT 100)

The resistance of the PT 100 is measured in a four-wire circuit. The constant current leads J_c 0/1 must be kept separate from the measuring leads M 0/1. The current leads and measuring leads must only be connected direct at the resistor so that voltage drops on the constant current lines do not falsify the measurement. Since the measuring inputs have a high resistance, there are practically no voltage drops on these lines.

It is also possible to measure resistance in a two-wire or three-wire circuit although a four-wire circuit is used.

If only one channel is used for a PT 100, the other can be used for voltage measurement (± 500 mV).

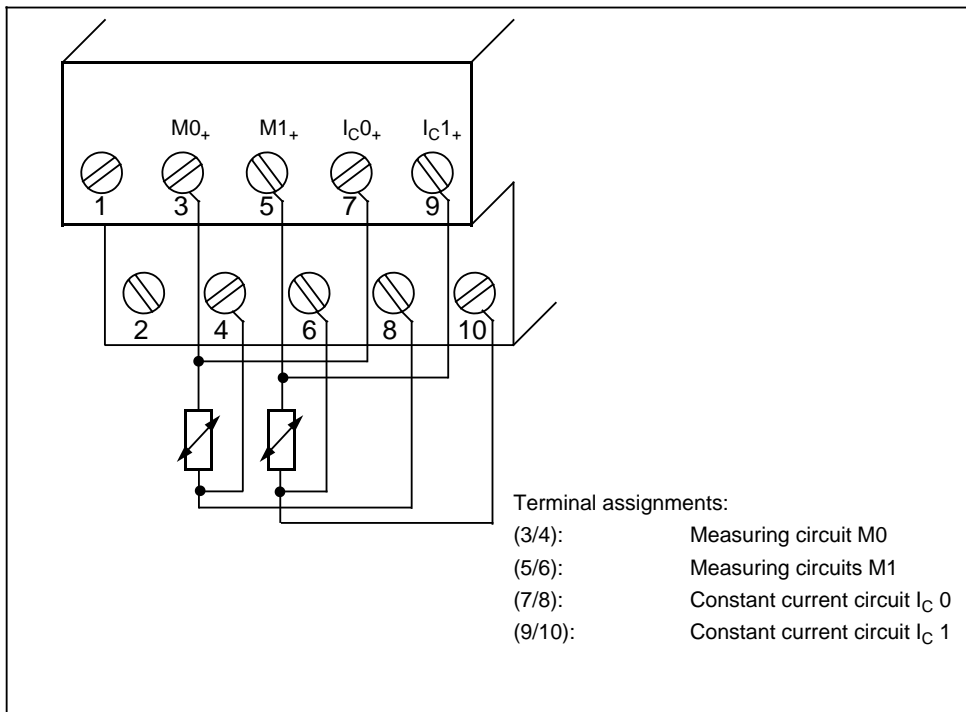


Figure 3-49 Connections for the PT 100

Analog Input Module 2 x±500 mV / PT 100 with Linearization (6ES5 464-8MF21)

The only difference between this module and the analog input module is the additional curve linearization facility. If you activate this function using the function selector switch, you will obtain a resolution of 0.5 °C per unit, where 0 °C corresponds to 0 units. The linearization applies to both channels. If you do not activate linearization, the module will operate like a 464-8MF11. The wiring schematic corresponds to that of the 464-8MF11 (Figure 3-49).

Connection of Analog Output Modules

Please note the following before connecting the modules:

- There are no coding switches on the frontplate
- The 24 V DC load voltage must be connected to terminals 1 and 2.
- Permissible potential difference between outputs: 60 V AC.
- Unused outputs are left open.
- A complete description of analog value processing is given in Chapter 7.

The analog output modules convert the bit patterns from the CPU into analog output voltages. The modules may be plugged in and unplugged during operation of the ET 100U.

The digital value is written via the I/O bus into a shift register of the analog output module and output for both channels via optocouplers in inverted two's complement form. Resolution is ± 1024 units in the nominal range for an overrange of approximately $\pm 25\%$.

Two separate DA converters generate the analog signal from the digital value. The maximum resolution of the DA converter is ± 2048 units, with the nominal range extending to ± 1024 units and the overrange reserve to approximately ± 1270 units. A linear amplifier amplifies the output signal of both DA converters to ± 10 V, ± 20 mA, +4 to +20 mA or +1 to +5 V depending on the version. The outputs are proof against open-circuit and overload .

If the CPU in the central controller or expansion unit outputs the BASP signal, e.g. in Stop mode, the 318-8 interface module will set the outputs of the analog output modules in the ET 100U to "0". The same will happen if the 318-8 interface module detects a load voltage error or if the "I/O disabled" LED lights up. The 318-8 interface module will then signal BASP autonomously.

Analog Output Modules **2 x ±10 V** **(6ES5 470-8MA12)**
 2 x +1 to 5 V **(6ES5 470-8MD12)**

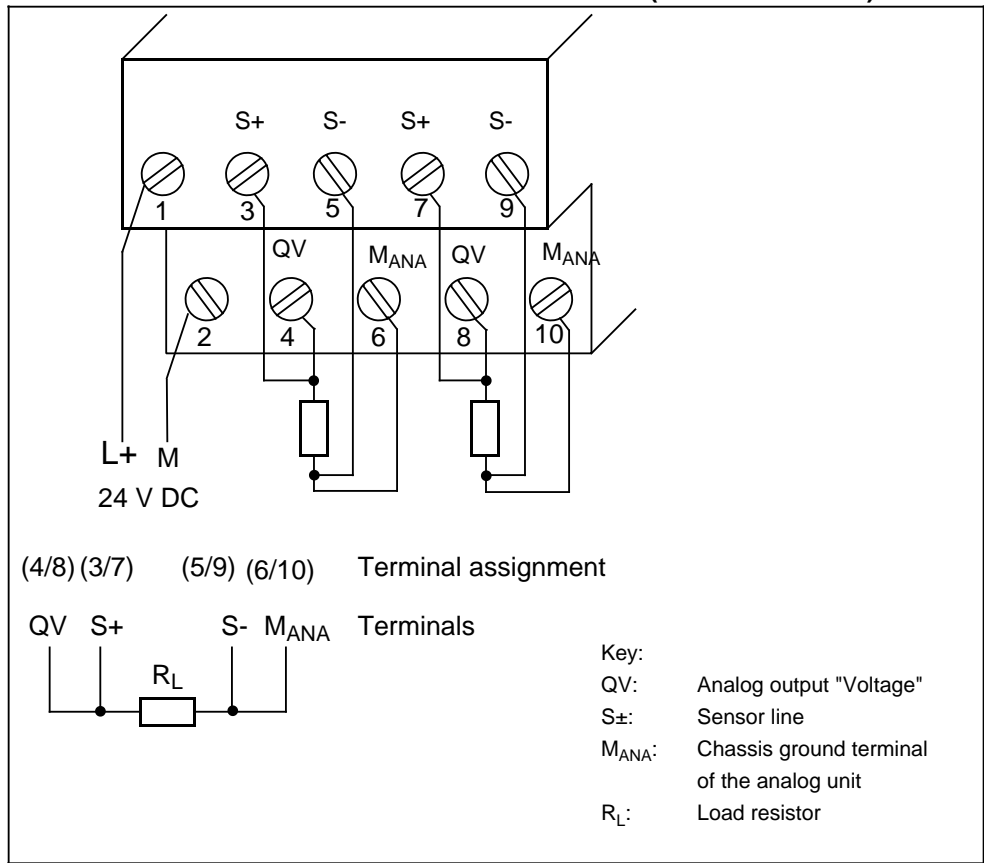


Figure 3-50 Connecting a Load via a Four-Wire Circuit

The sensor lines (S+, S -) must be connected direct to the load so that the voltage can be measured and regulated direct at the load. In this way, voltage drops of up to 3 V per line can be compensated.

Sensor lines S+ and S - can be omitted if the resistances of the QV and M lines are negligible compared with the load resistance. In this case, S+ must be connected to QV and S- to M_{ANA}.

Analog Output Modules 2 x ±20 mA (6ES5 470-8MB12)
 2 x +4 to 20 mA (6ES5 470-8MC12)

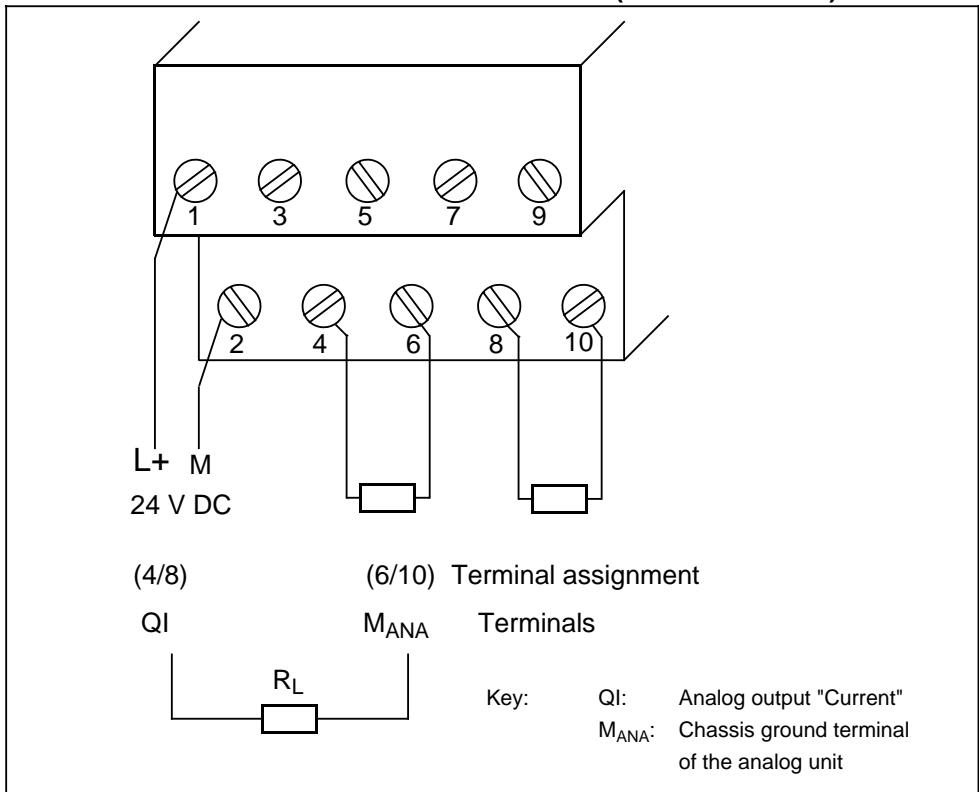


Figure 3-51 Connecting via a Two-Wire Circuit

3.3 General Configuration

3.3.1 Power Supply

The completely assembled ET 100U consists of two separate circuits:

- The control circuit for the ET 100U
- The load circuit for sensors and actuators (24 / 60 V DC or 115 / 230 V AC).

In the ET 100U, the control circuit and load circuit usually share the same power supply. This is only possible, however, in the case of DC load circuits.

Control Circuit:

The control circuit powers the 318-8 interface module, the bus units and the input/output modules. At 24 V DC / 2 A via the PS 931 power supply module, 9 V are available for the internal supply of the input and output modules.

Load Circuit:

It is recommended that you use one of the following power supplies for the 24 V DC power supply.

- The PS 931 (6ES5 931-8MD11) power supply module or
- the PS 2410 (6EW1 380-4AB01) power supply module.

If you are using load power supplies other than those recommended, make sure that the output voltage of the power supplies ranges between 20 V and 30 V (including ripple).

3.3.2 Electrical Configuration of Distributed Field Devices

Please note the following when configuring the ET 100U. The figures in the text below appear in Figures 3-52 to 3-54.

Main switch and fusing

- Provide a main switch (1) to DIN VDE 0113, part 1 or a disconnecting device to DIN VDE 0100, part 460 for the ET 100U, sensors and actuators. These devices are not required if the configuration forms part of a larger system and if the relevant devices are provided centrally.
- The sensor and actuator circuits can be grouped and provided with short-circuit and/or overload protection (2). Single-pole fusing is required by the DIN VDE 0100 standard, part 725. DIN VDE 0113, part 1, stipulates grounding of the secondary side for single-pole fusing. In all other cases, all-pole fusing is required.
- In non-floating input and output modules, terminal M of the load power supply unit must be connected to the PE conductor of the power supply.

Load power supply

- 24 V DC load circuits require a load power supply unit (3) with safe electrical isolation.
- Nonstabilized load power supplies require a backup capacitor (4) (rating: 200 uF per 1 A of load current). Connect the capacitor in parallel with the output terminals of the load power supply.
- For control systems with more than five electromagnetic devices, electrical isolation by means of a transformer is required in accordance with DIN VDE 0113, part 1; this is recommended by DIN VDE 0100, part 725.
- In the case of non-floating input and output modules, terminal M of the load power supply unit must be connected to the PE conductor of the control power supply.

Grounding

- Load circuits should always be grounded, if possible (5). For testing purposes, provide a detachable connection to the protective earth conductor at the secondary side of the load power supply unit (L- or M terminal) or the isolating transformer.
- As a rule, the ET 100U is installed in a grounded configuration:
 - For this purpose, the reference potential of the controller (M terminal of the IM 308) is to be connected to the standard mounting rail and
 - the standard mounting rail is to be connected to the protective earth conductor.

The copper conductors used should be as short and wide as possible (cross-sections of 10 mm² and more).

- For installing the ET 100U with an ungrounded reference potential only (mining and chemical industry):
 - Mount the standard mounting rail on racks that are electrically isolated
 - Connect the M terminal of the IM 308 to the standard mounting rail
 - Connect the standard mounting rail to the protective earth conductor via an RC circuit (6) (discharge of high-frequency noise).

The copper conductors used should be as short and wide as possible (cross-sections of 10 mm² and more).



Warning

Provide isolation monitoring for ungrounded circuits if

- Dangerous operating conditions might result from phase-earth-phase faults or double faults to frame,
- No safe (electrical) isolation is provided,
- The circuits are operated at voltages > 120 V DC,
- The circuits are operated at voltages > 50 V AC.

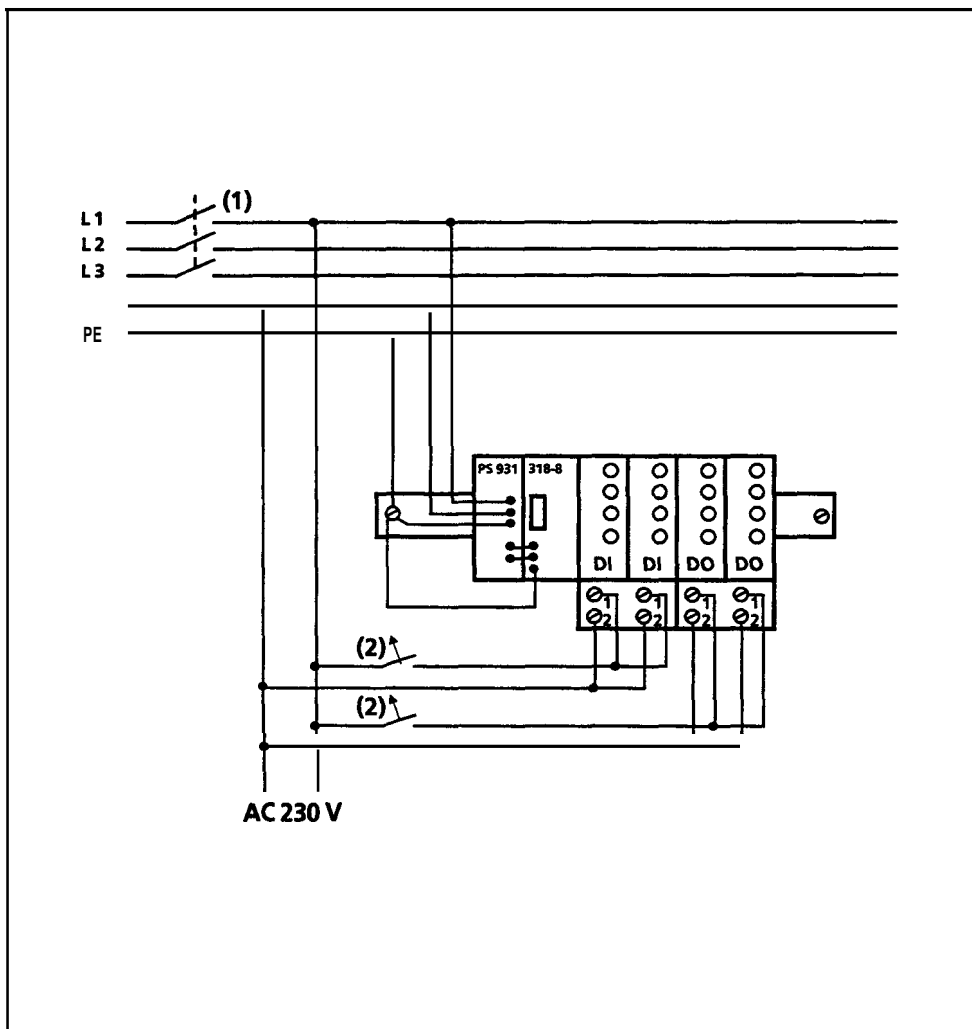


Figure 3-52 Grounded Configuration with 115/230 V AC Power Supply for ET 100U, Sensors and Actuators

3

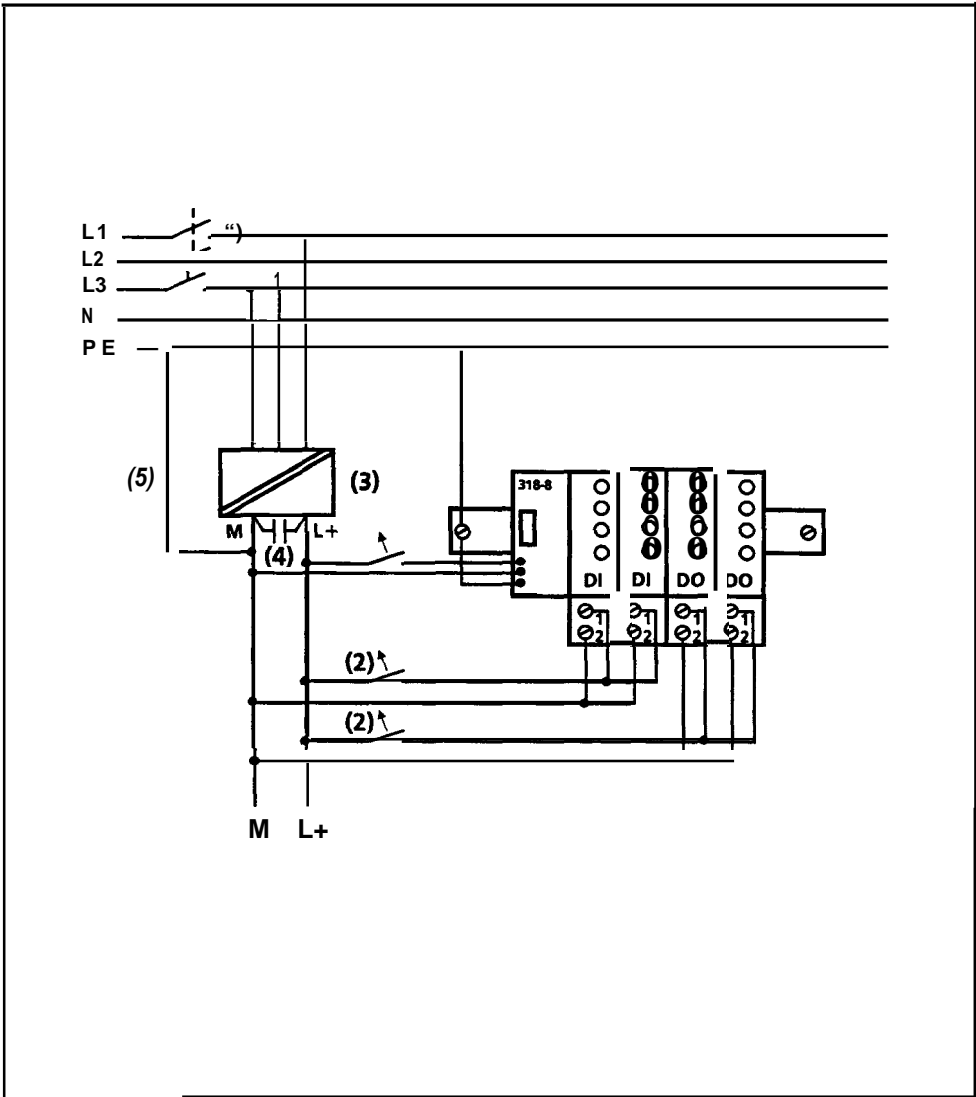


Figure 3-53 Configuration with 24V DC for ET 100U, Sensors and Actuators

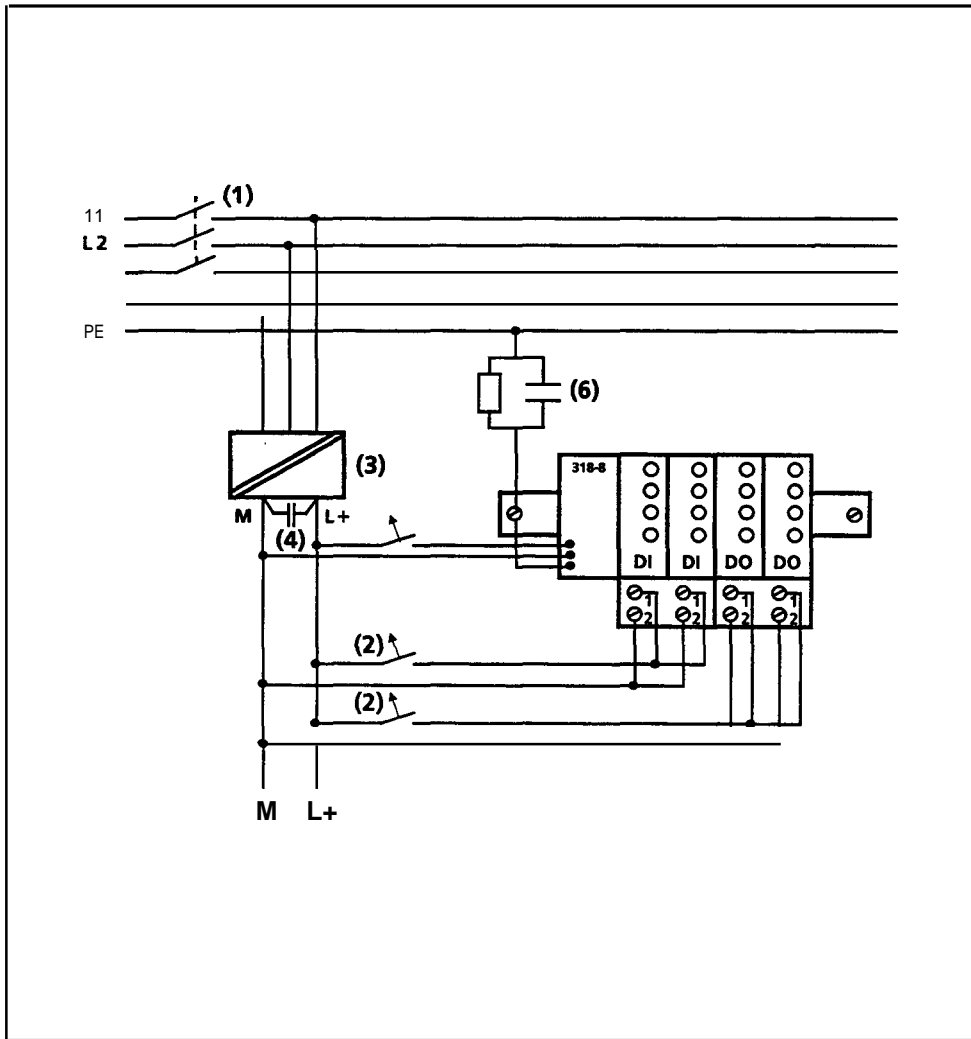


Figure 3-54 Nongrounded Operation; 24 VDC Power Supply with Safety Electrical Isolation to VDE 0160 for ET 100U, Sensors and Actuators.
 Interference voltages are discharged to the ground conductor (PE) via a capacitor.

3.3.3 Wiring Arrangement and Shielding

Please note the following with regard to wiring and shielding to keep the degree of interference to a minimum.

Running Cables Inside and Outside Cabinets

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, 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 AC voltage >400 V
- Group D: Lines for SINECH1

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

Table 3-5 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.

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.

Shielding Cables

Shielding is a measure to weaken (attenuate) magnetic, electric or electro-magnetic 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 3-55).
- 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.

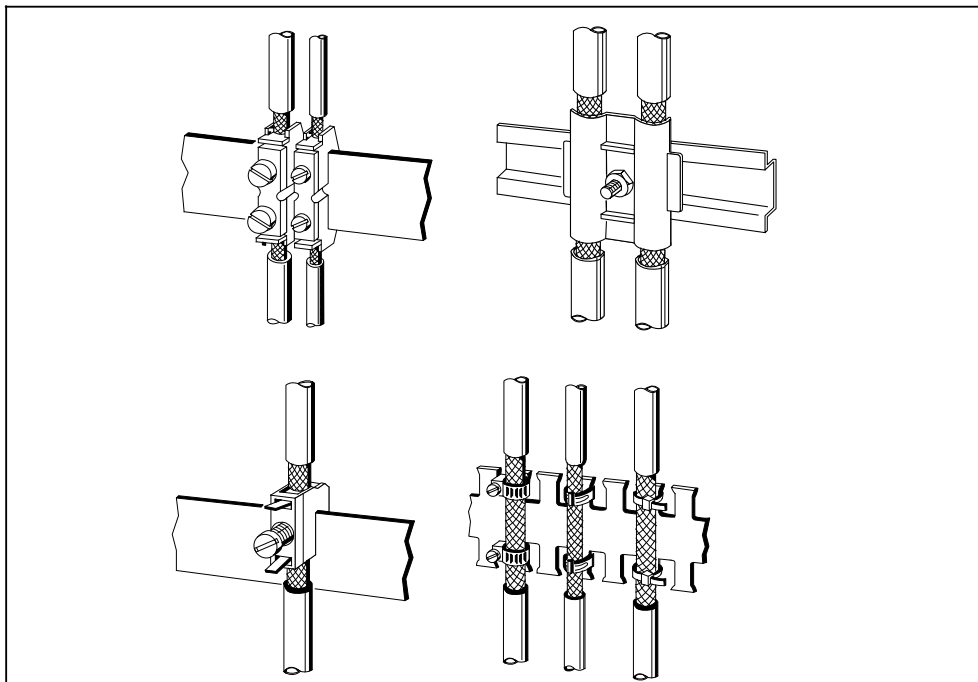


Figure 3-55 Fixing Shielded Cables with Various Types of Cable Clamps

3.3.4 Special Measures for the Prevention of Interference Voltages

Arc Suppressing 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 suppressing elements for inductive circuits in the following cases:

- If SIMATIC S5 output circuits can be switched off by additionally 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.

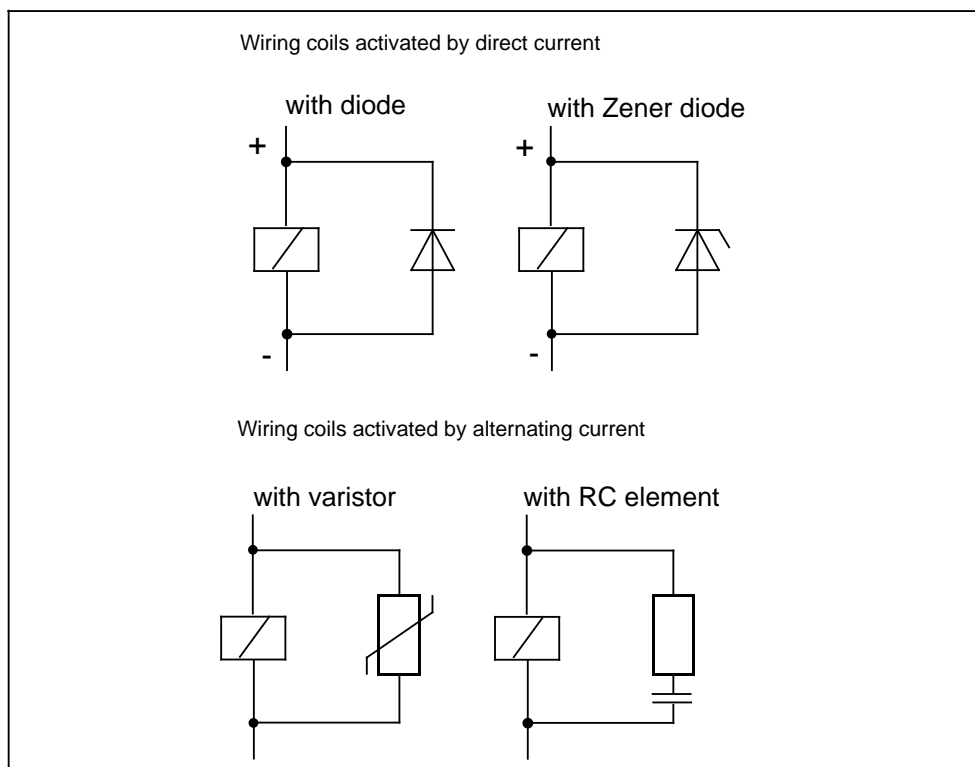


Figure 3-56 Wiring Coils

3.3.5 Protection Against Accidental Contact

Accessible parts must not become hazardous even in the case of a malfunction. Protective measures are therefore necessary to prevent excessive touch voltages.

To meet these requirements, connect all accessible metal parts, (e.g. mounting rack, cabinet uprights and the cabinet itself) to the protective ground conductor (maximum resistance between ground conductor connection in the cabinet and accessible part to be protected may not exceed 0.5 ohms).

3.3.6 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

We recommend you to use the BLITZDUCTOR® ARE, 8 V, as a protective element for the transmission cable to the ET 100U station (Figure 3.57).

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

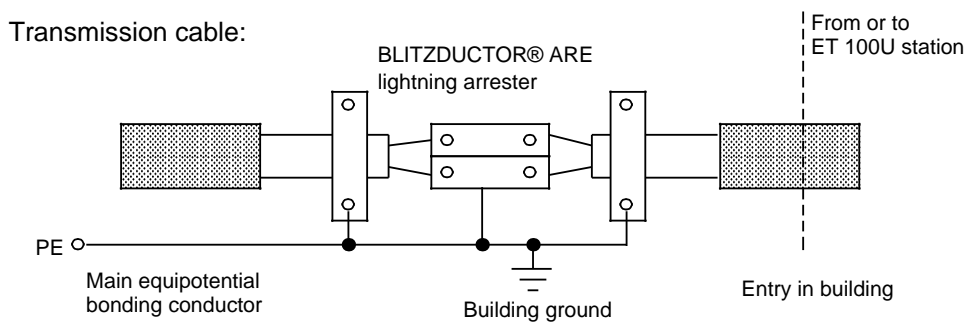


Figure 3-57 Lightning Protection

3.4 Potential Bonding and Galvanic Isolation

Serial transmission permits the use of ET 100Us for distributed I/O in plants extending over wide geographical areas. However, it also offers advantages to the user of compact machines and battery-operated plant sections.

This chapter contains everything you need to know about the equipotential bonding or galvanic isolation of the ET 100U.

3.4.1 Measures for the ET 100U Components

318-8 Interface Module

The transmission link between the 308-3 interface module and the 318-8 interface module is floating at both ends (see test voltage) and has its own supply section. Potential differences are permissible between the transmission link and ground as well as with regard to devices rated up to 75 V DC or 60 V AC. The 318-8 interface module is supplied with 24 V DC via L+/M. An internal non-floating control IC reduces the supply voltage to 9 V DC and supplies it to the I/O bus.

The M and \perp terminals are shorted via a reactor (25 μ H) on the interface module.

Connecting the \perp terminal to a central earthing point (standard mounting rail, protective earth) automatically grounds the I/O bus in the ET 100U.

PS 2410 Power Supply Module

The 24 V DC output of the PS 2410 module (L+/M) is provided with safe electrical isolation and floating. The M and \perp terminals on the 318-8 module are shorted. This means that connecting the \perp terminal of the 318-8 module to a central earthing point (standard mounting rail, protective earth) automatically grounds the connected circuits, e.g. even the PS 2410 and the I/O bus.

PS 931 Power Supply Module

The 24 V DC output on the module (L+ /M) is floating and has electrically safe isolation. The M and \perp terminals are **not** shorted on this module. This means that connecting the \perp terminal with a central grounding point (standard sectional rail, ground conductor PE) **does not** automatically ground the connected circuits. If you want to ground these circuits, you must in this case connect the \perp terminal of the 318-8 interface module to a central grounding point.

I/O Modules

There are nonisolated modules and isolated modules. You will find a relevant note in the Technical Specifications. I/O modules for 115/230 V AC are always isolated.

- Nonisolated modules

Nonisolated modules can be used where the load circuit and the control circuit have the same ground. This is the case if they share the same power supply (3.3.1). In the case of nonisolated input modules, the GND line (control circuit ground) on the I/O bus is the reference potential. A voltage drop V_1 on line affects the input signal level V_I (Figure 3-58).

In the case of nonisolated output modules, terminal 2 (M) of the terminal block is the reference potential. A voltage drop of V_2 on line raises the ground potential of the output driver and thus reduces the resulting control voltage V_{CTRL} (Figure 3-58).

Make sure that voltage drops on lines and do not exceed 1 V, otherwise the reference potentials may change, causing malfunctioning of the modules.

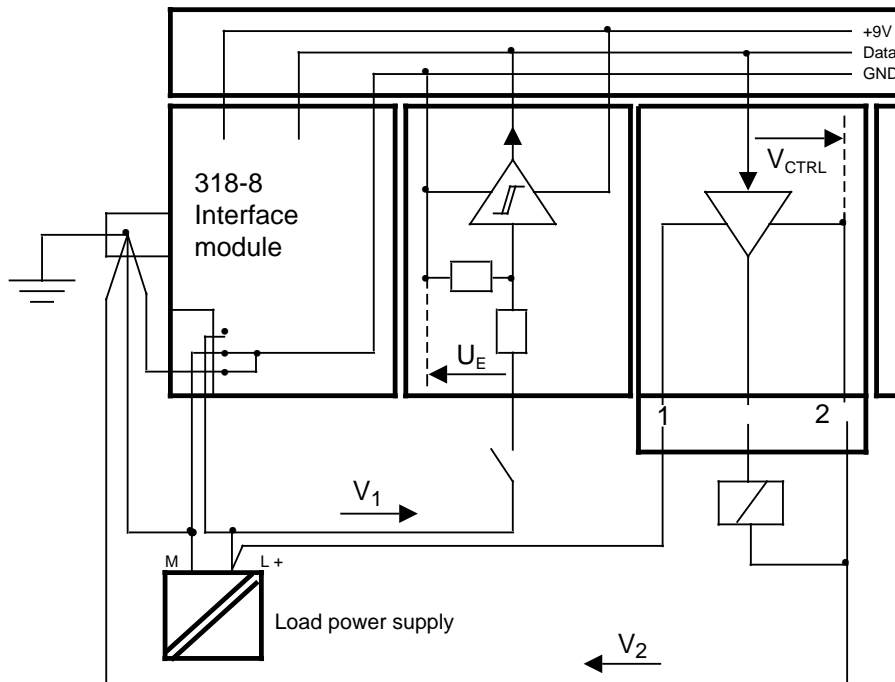


Figure 3-58 Simplified Description of Nonisolated Modules

- Isolated modules
 All modules for 115/230 V AC are isolated or floating. You must also use isolated modules where the control circuit and the load circuit have different potentials. Increased noise immunity in 24 V DC load circuits is a further advantage. Figure 3-59 shows a basic circuit diagram for isolated digital modules.

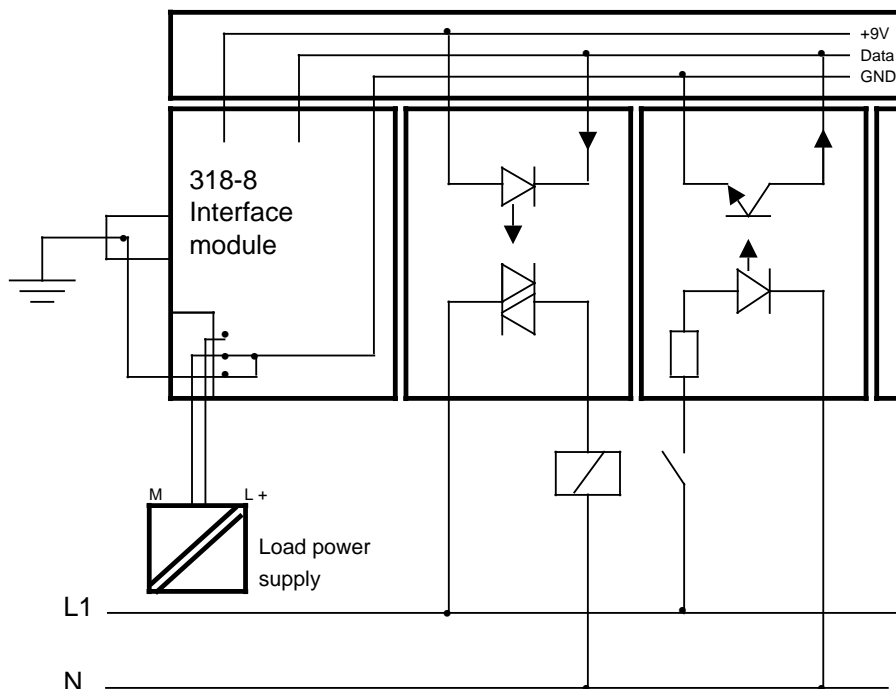


Figure 3-59 Simplified Description of Isolated Modules

3.4.2 Grounded and Ungrounded Configurations of the ET 100U

Grounding of the PS 2410 load power supply automatically grounds the 318-8 module and the I/O bus.

Use relatively large contact areas for grounding, i.e.

- Provide a conductive connection between the standard mounting rail and the vertical members in the cabinet.
- Ground all machine parts.
- Use conductors with a minimum cross-section of 10 mm² for equipotential bonding conductors and ground connections.

Non-floating modules are not automatically grounded. For grounding, the M terminal of the load power supply, the M terminal of the 318-8 interface module and the M terminals of the terminal blocks for the I/O modules must be shorted via jumpers.

Isolated modules can be connected to a floating power supply provided by an isolated load power supply unit or 115 V/230 V AC supply. They can be grounded by interconnecting the M terminals (only for DC or supply via isolating transformer).

In non-grounded configurations, the ground terminal and, consequently, M of the load power supply is to be connected to the standard mounting rail via a capacitor (1 μ F/500 V).

The M terminal of isolated load power supplies must not be grounded.

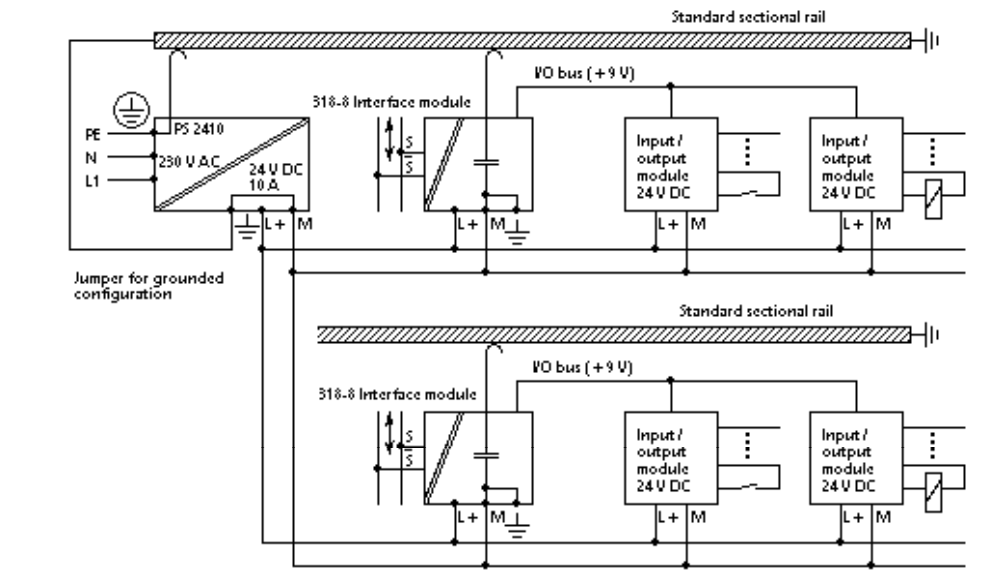


Figure 3-60 Grounded/Ungrounded Configuration

3.4.3 Non-Floating/Floating Configurations

Non-Floating Configuration

There must not be any potential difference between the various modules and the load power supply in non-floating configurations.

Floating Configuration

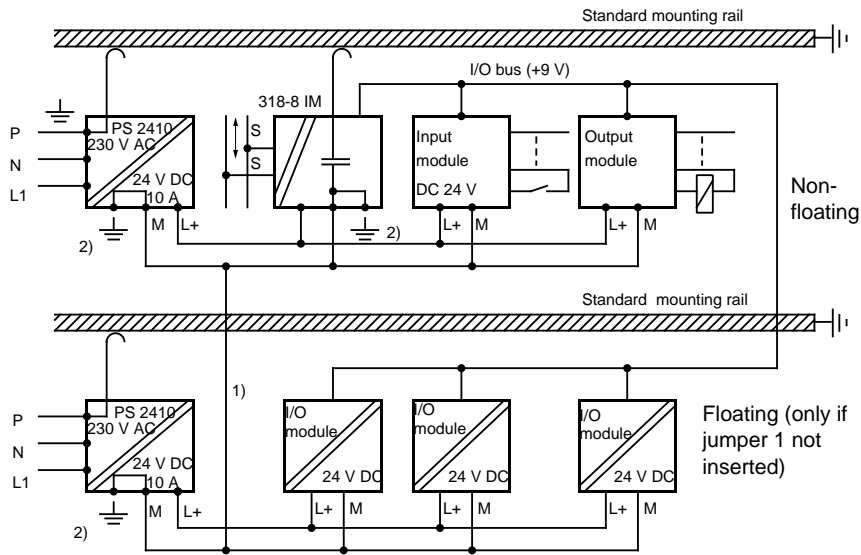
Floating configurations are recommendable if the sensors have different reference voltages.

Floating configurations also ensure increased interference immunity.

Any potential differences (U) between individual system sections do not result in compensating currents. Equipotential bonding conductors need not be provided between the individual tiers or stations.

In floating sections, high-frequency interference currents are discharged directly via by-pass capacitors (connected to ground) on the modules.

In floating configurations, dangerous contact voltages with respect to ground must be avoided, e.g. by grounding specific system sections or by using isolation monitoring with voltage limitation.



- 1) In the event of a fault, isolated circuits can generate dangerous contact voltages. Central grounding or an insulation monitoring facility are recommended.
- 2) The \perp terminal must not be connected to the standard sectional rail.

Figure 3-61 Non-Floating/Floating Configuration

If the two M terminals of the load power supply are shorted¹⁾, the floating modules are connected as in a non-floating configuration.

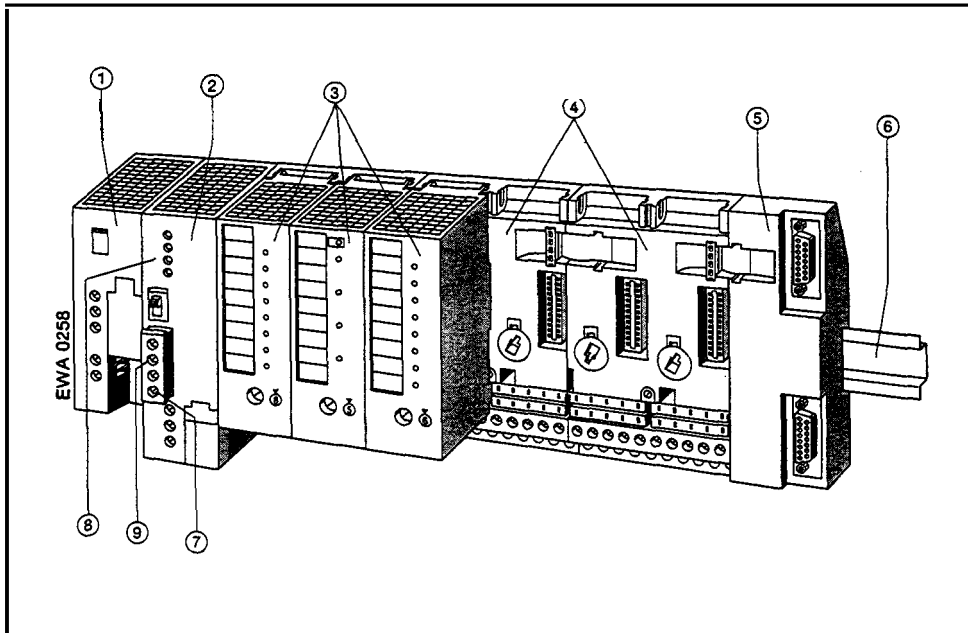
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4 Start-Up of the ET 100U

4.1 Modular Design

The ET 100U electronic terminator for distributed I/O constitutes a modular process-oriented and machine-oriented I/O level for programmable controllers of the SIMATIC S5 range. The ET 100U consists of a number of functional units (modules), which you can combine to suit your task.



4

Figure 4-1 ETIOOU Electronic Terminator for Distributed I/O

(1) Power supply module (e.g. PS931)

This module is required if there is no 24 V DC supply available.

(2) 318-8 interface module

The 318-8 interface module is the link between the distributed input/output modules and the central controller or expansion unit. Data transfer is via the serial interface (7).

LEDs on the frontplate (8) inform the user of the operating status of the ET 100U.

Fatal failures trigger the H +/H - interrupt output (9).

(3) Input/output modules

These convey information between the CPU in the central controller and the process peripherals (sensors, actuators, transducers etc.) via the 318-8 interface module and the paired-wire bus.

- Digital input and output modules (4-channel and 8-channel)
These are suitable for simple control tasks involving only the signal states "0" and "1".
- Analog input and output modules
These can be used for generating and acquiring such variable quantities as currents and voltages.
- Timer module
Various times can be set by this module (without changing the program).
- Counter module
Preprocessing of counting pulses up to 500 Hz.
- High-speed counter/position decoder module
The high-speed counter can be used for collecting high-frequency pulse trains and for simple positioning tasks.
- Comparator module
This module monitors a preset comparison value (current and voltage).
- Simulator module
Can be used to generate digital input signals or to display output signals.
- Diagnostic module
Can be used to check functions on the I/O bus.

(4) Bus units with terminal blocks (crimp snap-in or SIGUT screw-type terminals)

These units connect the 318-8 interface module to the I/O modules. Two input or output modules can be plugged into each bus unit.

(5) Interface modules

These are required for ET 100U configurations involving several tiers.

(6) Standard sectional rail or mounting rack

The ET 100U is mounted on this rack.

4.2 Data Transmission Structure

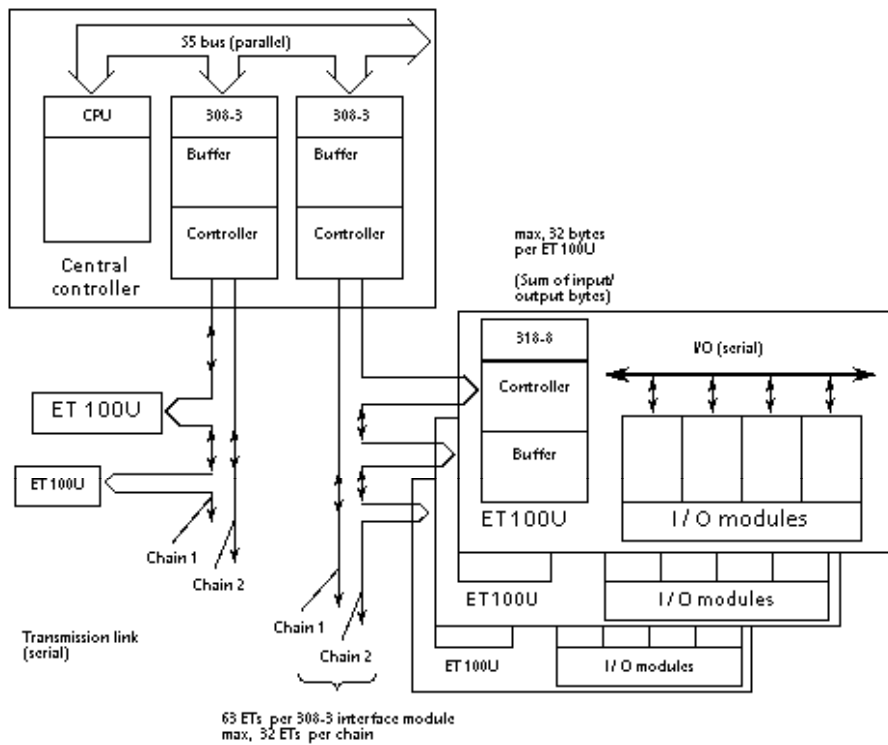


Figure 4-2 Data Transmission Structure

Data transmission between the CPU and the distributed I/O modules is synchronized by the buffers in the 308-3 and 318-8 interface modules. Serial transmission on the transmission path is not synchronized with traffic on the I/O bus and is independent of CPU accesses.

4.2.1 Data Exchange Between the ET 100U and the Central Controller or Expansion Unit

I/O data is exchanged in half-duplex mode between the 308-3 interface module and the ET 100U using a serial transmission procedure. A maximum of 63 ET 100Us can be connected. Both interface chains operate in parallel and cannot be interrupted even when the interface connector is pulled out (party line). The interfaces are isolated and similar to the EIA (Electronic Industries Association) RS 485 standard. A terminating resistor (120 ohms, 0.25 W) is required at the end of each chain.

Data is transmitted in block mode.

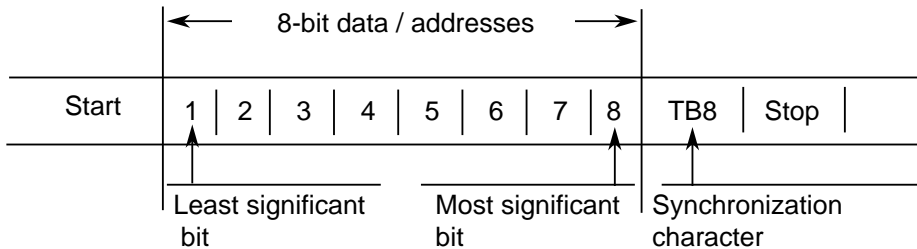
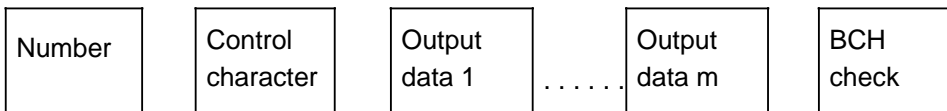


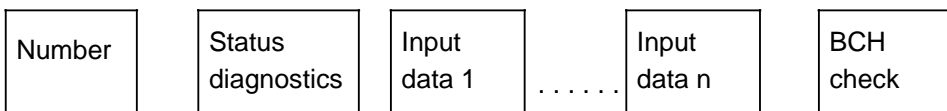
Figure 4-3 Block-Mode Data Transmission

Operating as master, the 308-3 interface module sends a message with output data, and receives a message with input data as acknowledgement.

Message to ET 100U



Message from ET 100U



The number of input and output blocks is set in the program for the EPROM memory submodule of the 308-3 interface module.

A missing I/O module is indicated (LED) and a bit is set in a diagnostics byte. The missing module is taken into account during every cycle.

Breaks in the transmission link are reported and displayed.

Data Integrity

You can monitor the data transmitted with the cyclic BCH code by inserting one or two check bytes at intervals of up to 18 data blocks.

Noise immunity can be improved for slower data transmission rates by using a filter.

Baud rate	Number of check bytes	Filter
375,000 bps	1	no
187,500 bps	2	no
62,500 bps	2	yes
31,250 bps	2	yes

After a fault has been detected, the message is repeated twice before an error bit is set in the diagnostics byte and the 318-8 interface module's LED lights up.

Parasitic signals are detected as faults and cause automatic resetting of the outputs (BASP on the 318-8 interface module). Erroneous messages are not accepted.

After a cold restart following a fault, the 318-8 interface module waits for reconfiguration by the 308-3 interface module. The programmable controller then restarts automatically.

Please note the following when configuring:

- If you expect severe interference, you should use one of the two lowest baud rates.
- If, for reasons of speed, you have to select a high baud rate, you should pay strict attention to the guidelines for connecting and laying the transmission cable.

4.2.2 I/O Bus of the ET 100U

The I/O bus of the ET 100U is a ring of shift registers (SRs). The bus also contains four control lines (CLEAR, CLOCK, LATCH and IDENT). Each 5-bit shift register consists of four data bits and a true bit.

In the case of multi-tier configurations, the bus can be expanded using the IM 315 or IM 316 interface modules. A maximum of 16 bus units can be used within one ET 100U.

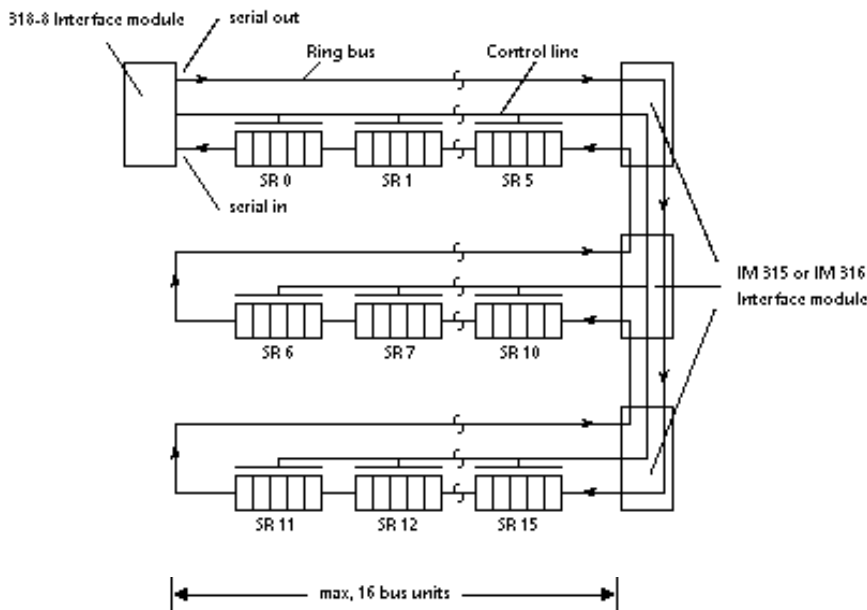


Figure 4-4 I/O Bus of the ET 100U

A shift register with five bits is assigned to each I/O module. This register is replaced by a larger shift register in the case of modules with eight inputs or outputs and also in the case of analog and function modules with two or more bytes of address area. A final true bit verifies the data as valid and can be used for self-monitoring.

The data is transferred in parallel from the shift registers to the I/O module.

The codes of the modules are read in an identification run when the ET 100U is powered up or when a module is plugged in or unplugged. The codes define the direction of transfer (input or output) and identify the module type. This information is used in the 318-8 interface module buffer to generate a process I/O image. This image is then compared with the contents of the memory submodule in the 308-3 interface module when the central controller is powered up.

Whenever the modules in the ET 100U are changed and the memory submodule in the 308-3 interface module is replaced, a reconfiguration run must be initiated by switching on the power supply voltage of the central controller. This results in a cold restart of the 308-3 interface module and CPU.

4.3 Response Time to I/O Requests

I/O modules with parallel interfaces in the central controller or in the expansion units are accessed direct, for example, by the LPY (Load Peripheral Byte) or TPY (Transfer Peripheral Byte) operations.

Response times at the I/O interface are determined as follows:

<u>Module type</u>	<u>Response time determined by</u>
Digital output	Optocoupler, circuit-breaker (approx. 100 μ s)
Digital input	Input delays (approx. 3 ms at 24 V DC)
Analog output	Settling times of the digital-analog converter (approx. 0.1 ms)
Analog input	Coding time and cycle time of the multiplexer (approx. 60 ms per channel)

Response times are increased by the serial transmission procedure of the ET 100U.

The specific transmission time for the ET 100U is a combination of the transmission times of:

- the **serial transmission link** t_{A+B}
- the **I/O bus** t_c

$t_{trans} = t_{A+B} + t_c$

4.3.1 Transmission Time on the Serial Link

Specific transmission times are required in order to update the buffer contents of the 308-3 interface module (input data) and of the 318-8 interface module (output data). These transmission times depend on the individual device configuration and the baud rate set.

You will find the relevant values in the following table.

Table 4-1 Transmission Time t_{A+B} Between the 308-3 and 318-8 Interface Modules

Baud rate	Transmission time $t_{(A+B)_{max}}$
375,000 baud	$a \times 0.7 \text{ ms} / \text{ET} + b \times 0.04 \text{ ms} / \text{byte}$
187,500 baud	$a \times 1.0 \text{ ms} / \text{ET} + b \times 0.07 \text{ ms} / \text{byte}$
62,500 baud	$a \times 2.0 \text{ ms} / \text{ET} + b \times 0.19 \text{ ms} / \text{byte}$
31,250 baud	$a \times 3.4 \text{ ms} / \text{ET} + b \times 0.36 \text{ ms} / \text{byte}$
Baud rate	Transmission time $t_{(A+B)_{min}}$
375,000 baud	$0.7 \text{ ms} + c \times 0.04 \text{ ms} / \text{byte}$
187,500 baud	$1.0 \text{ ms} + c \times 0.07 \text{ ms} / \text{byte}$
62,500 baud	$2.0 \text{ ms} + c \times 0.19 \text{ ms} / \text{byte}$
31,250 baud	$3.4 \text{ ms} + c \times 0.36 \text{ ms} / \text{byte}$

Parameters a, b and c are defined as follows:

- a = Number of all ET 100Us connected to one 308-3 interface module (both chains)
- b = The sum of all input and output bytes of all ET 100Us
- c = The sum of all input and output bytes in any one ET 100U.

Transmission cycles on the line run asynchronously with the read-in and read-out operations of the 308-3 interface module buffer.

The minimum transmission time for any one ET 100U is obtained as follows:

- For input modules
If the input data in the 308-3 interface module buffer are read out immediately after they have been received and stored via the transmission link.
- For output modules
If the ET 100U in question is accessed direct via the transmission link after output to the buffer of the 308-3 interface module.

Example for Calculating the Transmission Time t_{A+B}

The calculation is based on the following configuration.
 A baud rate of 187.500 bps was set.

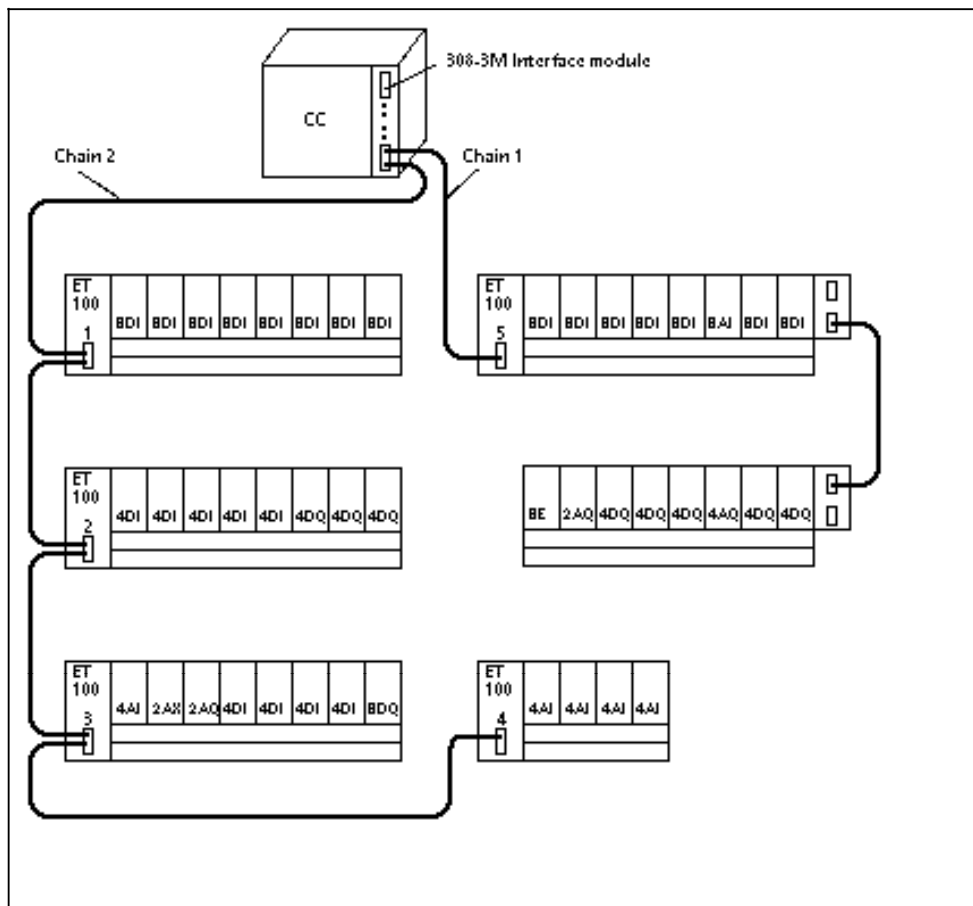


Figure 4-5 Configuration for Calculating the Transmission Time

Five ET 100Us (a=5) are connected to the 308-3 interface module illustrated.

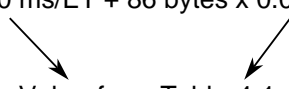
Data capacities of the individual ET 100Us are as follows:

ET No. 1 :c = 8 bytes			
No. 2 :c = 5 bytes	—————>	Incomplete half-bytes within an ET 100U are padded to form full bytes, in this case:	
No. 3 :c = 19 bytes		2 bytes DI	3 bytes
No. 4 :c = 32 bytes		1 bytes DQ	2 bytes
No. 5 :c = 22 bytes			
Total b = 86 bytes		Total	5 bytes

This defines all the variables required for the calculation:

The maximum transmission time is obtained as follows:

$$\begin{aligned}
 t_{(A+B)\max} &= a \times 1.0 \text{ ms/ET} + b \times 0.07 \text{ ms/byte} = \\
 &= 5\text{ET} \times 1.0 \text{ ms/ET} + 86 \text{ bytes} \times 0.07 \text{ ms/byte} \quad \underline{\underline{11 \text{ ms}}}
 \end{aligned}$$



 Value from Table 4-1

The minimum transmission time of the individual ET 100s is obtained as follows:

$$\begin{aligned}
 t_{(A+B)\min} &= 1.0 \text{ ms} + b \times 0.07 \text{ ms/byte} = \\
 &= 1.0 \text{ ms} + 8 \text{ bytes} \times 0.07 \text{ ms/byte} = \underline{\underline{1.56 \text{ ms}}} \text{ for ET 100U No. 1} \\
 &= 1.0 \text{ ms} + 5 \text{ bytes} \times 0.07 \text{ ms/byte} = \underline{\underline{1.35 \text{ ms}}} \text{ for ET 100U No. 2} \\
 &= 1.0 \text{ ms} + 19 \text{ bytes} \times 0.07 \text{ ms/byte} = \underline{\underline{2.33 \text{ ms}}} \text{ for ET 100U No. 3} \\
 &= 1.0 \text{ ms} + 32 \text{ bytes} \times 0.07 \text{ ms/byte} = \underline{\underline{3.24 \text{ ms}}} \text{ for ET 100U No. 4} \\
 &= 1.0 \text{ ms} + 22 \text{ bytes} \times 0.07 \text{ ms/byte} = \underline{\underline{2.54 \text{ ms}}} \text{ for ET 100U No. 5}
 \end{aligned}$$

4.3.2 Transmission Time of the I/O Bus

The controller of the 318-8 interface module supplies the I/O bus continuously with output data from the buffer and reads in the input data. The typical cycle time t_c for updating the output byte and reading in the input byte is

$$t_c = c \times 1 \text{ ms/byte}$$

c = The sum of all input and output bytes in any given ET 100U.

This I/O bus cycle is briefly interrupted for the purpose of accepting data from the transmission link. If only a few ET 100Us are connected to a shared 308-3 interface module, each ET 100U will be supplied with data more frequently, which means that the I/O bus cycle will be interrupted more often. This leads to a minimal increase in the cycle time.

Note:

308-3 interface modules of revision level 308-3UA12 and higher have minimum scan times depending on the individual baud rates selected:

375 Kbit/s	3 ms
187.5 Kbit/s	5 ms
62.5 Kbit/s	12 ms
31.25 Kbit/s	40 ms

The following applies when assembling the I/O bus:

- Input and output modules can be plugged into any slot of the ET 100U.
- Any combination of digital and analog I/O modules is permissible.

Due to the serial transmission structure of the I/O bus, we recommend that you observe the following configuration measures in the case of **time-critical applications** (e.g. if you require high-speed transmission times):

- If possible, use different ET 100Us for analog and digital I/O modules.
- Do not connect any unused bus units since even an empty bus unit takes up a byte of data.
- Do not switch off unused analog channels in order to shorten bus times.
- Position input modules directly adjacent to the 318-8 interface module; then plug in the output modules.

In order to explain the last measure in more detail, we will now look again at the method of operation of the I/O bus:

The I/O bus consists of a number of concatenated shift registers. Output data is read byte by byte from the 318-8 interface module buffer and transferred bit by bit to the output modules with a shift pulse through the shift register chain.

As soon as the data is in the shift register of the relevant output module, a LATCH pulse transfers all the output information of the shift register simultaneously into the output memory of the output modules. The same latch pulse transfers the input data into the relevant shift register.

The shift pulse now shifts the new data from the shift register bus, and simultaneously delivers new output data from the output buffer.

The output data in the buffer is refreshed several times during one I/O cycle by the 308-3 interface module via the transmission line. This, together with the direction of shift of the I/O bus, results in different updates of the output data at the slots.

Similarly, data from input modules located right next to the 318-8 interface module enters the input buffer earlier than data from input modules located further away.

Figure 4-6 illustrates this graphically.

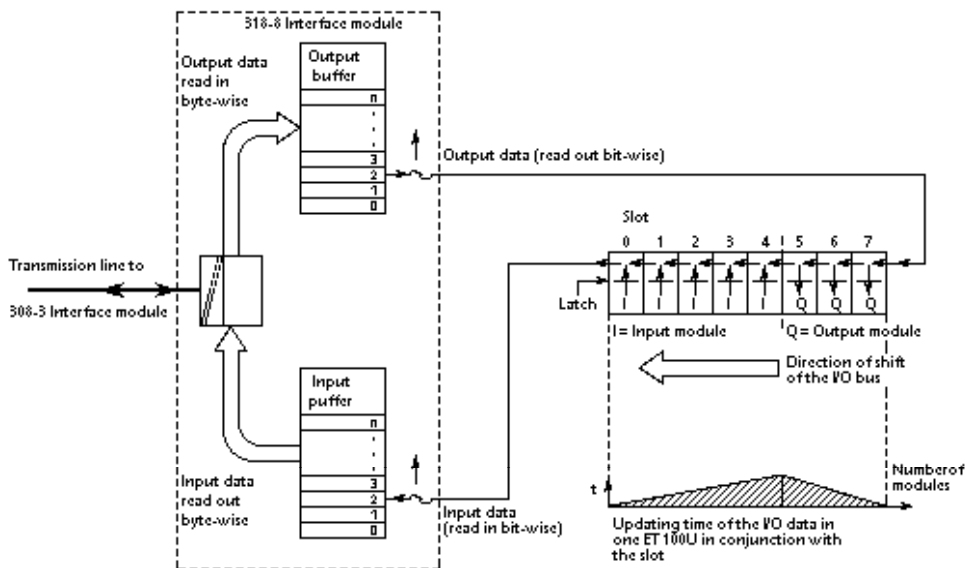


Figure 4-6 Data Transmission on the I/O Bus

This results in the following:

- Data from input modules right next to the 318-8 interface module is more up to date than data from input modules located further away.
- Data from output modules at the end of the I/O bus is more up to date than data from output modules located closer to the 318-8 interface module.

The updating time for input/output data of a module can vary from:

$$t_c \text{ to } t_c + t_c$$

where: $t_c = d \times 1 \text{ ms /byte}$ for input modules

$t_c = e \times 1 \text{ ms/byte}$ for output modules

Parameters d and e are defined as follows:

d = Number of I/O bytes including the byte of the input module in question, **counted against the direction of shift** (from the 318-8 interface module to the input module in question)

e = Number of I/O bytes including the byte of the output module in question, **counted in the direction of shift** (from the end of the ET 100U to the output module in question).

At the end of counting, incomplete half-bytes are padded to full bytes.

Example for calculating the transmission time t_c :

The calculation is based on the following ET 100U configuration.
 (Corresponds to the ET 100U configuration in Figure 4-5; 4.3.1).

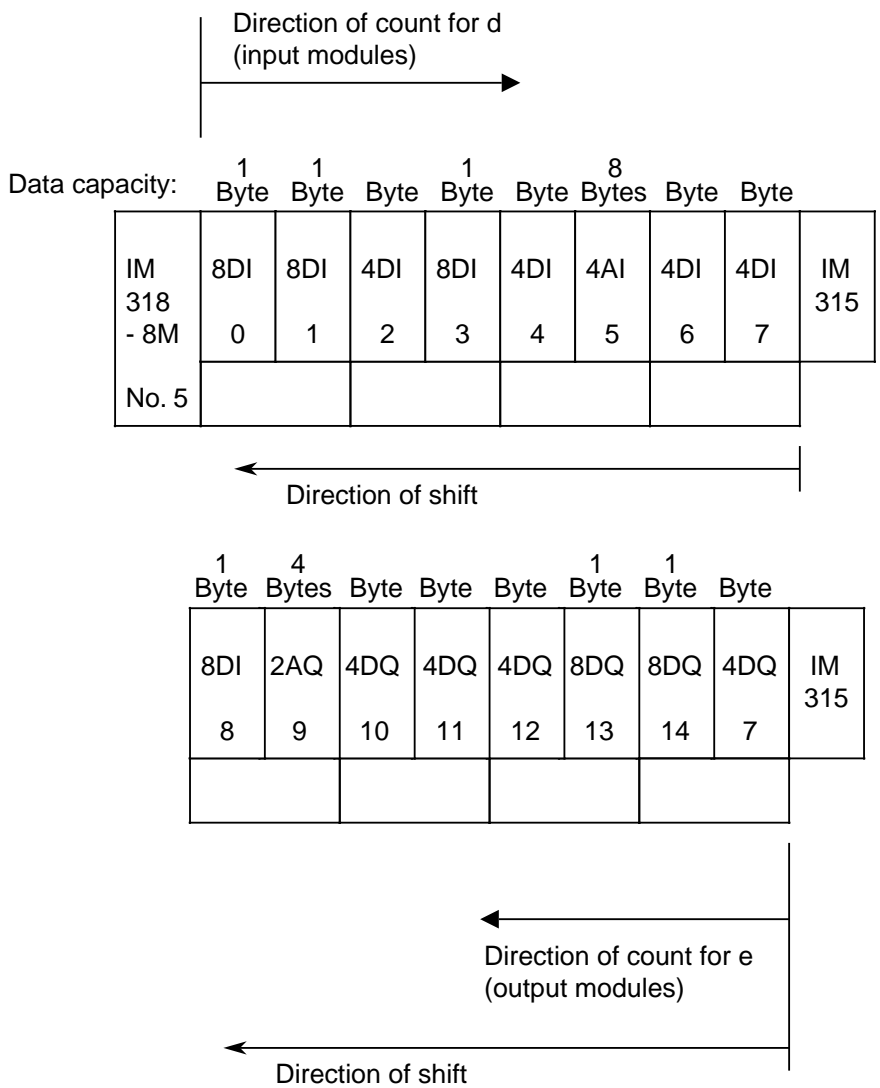


Figure 4-7 ET 100U Configuration for Calculating the Transmission Time

- Calculation of transmission time t_c on the I/O bus for the digital input module in slot 2 of the ET 100U.

Sum of all bytes in the ET 100U: $c=22$ bytes
 Calculation of value d: Sum of all I/O bytes, beginning with the 318-8 interface module and up to and including the module in question
 $d=3$ bytes

This results in:

$$t_c = c \times 1 \text{ ms/byte}$$

$$= 22 \text{ bytes} \times 1 \text{ ms/byte} = \underline{\underline{22 \text{ ms}}}$$

$$t_c = d \times 1 \text{ ms/byte}$$

$$= 3 \text{ bytes} \times 1 \text{ ms/byte} = \underline{\underline{3 \text{ ms}}}$$

The transmission time can vary from

$$t_c \text{ to } t_c + t_c$$

i.e. from: $3 \text{ ms to } 22 \text{ ms} + 3 \text{ ms} = \underline{\underline{3 \text{ ms ... 25 ms}}}$

The large variation results from configuring the analog input/output modules (2 bytes per channel) along with digital modules in the same ET 100U. In the case of time-critical applications, therefore, analog and digital modules should be plugged into different ET 100Us if possible.

- Calculation of transmission time t_c on the I/O bus for the analog output module in slot 9 of the ET 100U.

Sum of all bytes in the ET 100U: $c = 22$ bytes
 Calculation of the value e: Sum of all I/O bytes beginning at the end of the ET 100U up to and including the module in question.
 $e = 8$ bytes

This results in:

$$t_c = c \times 1 \text{ ms/byte}$$

$$= 22 \text{ bytes} \times 1 \text{ ms/byte} = \underline{\underline{22 \text{ ms}}}$$

$$t_c = e \times 1 \text{ ms/byte}$$

$$= 8 \text{ bytes} \times 1 \text{ ms/byte} = \underline{\underline{8 \text{ ms}}}$$

The transmission time can vary from

$$t_c \text{ and } t_c + t_c$$

i.e. from: $8 \text{ ms to } 22 \text{ ms} + 8 \text{ ms} = \underline{\underline{8 \text{ ms to 30 ms}}}$

4.3.3 Total Transmission Time

The total transmission time t_t consists of the transmission time of the transmission link t_{A+B} (4.3.1) and the transmission time of the I/O bus t_c (4.3.2).

The total transmission time t_t varies between :

$$t_{t \text{ min}} = t_{(A+B) \text{ min}} + t_c$$

and:

$$t_{t \text{ max}} = t_{(A+B) \text{ max}} + t_c + t_c$$

- Example for calculating total transmission time t_t :

The example is based on the examples in subsections 4.3.1 and 4.3.2. (ET 100U No. 5, digital input in slot 2).

The following values have been taken from these examples:

$t_{(A+B) \text{ min}}$	=	2.54	ms
$t_{(A+B) \text{ max}}$	=	11	ms
t_c	=	22	ms
t_c	=	3	ms

This results in the following total transmission time

$t_{t \text{ min}}$	=	$t_{(A+B) \text{ min}} + t_c$	=	$2.54 \text{ ms} + 3 \text{ ms}$	=	<u>5.5 ms</u>
$t_{t \text{ max}}$	=	$t_{(A+B) \text{ max}} + t_c + t_c$	=	$11 \text{ ms} + 22 \text{ ms} + 3 \text{ ms}$	=	<u>36 ms</u>

The total transmission time t_t varies between 5.5 and 36 ms.

The **total response time** between sending a signal and its being processed in the CPU or between the output of CPU data and its arrival at the I/O module is increased by the response times at the I/O interface (4.3).

4.4 Checklist of Essentials Before Powering Up

Recheck the following list before powering up your system.

Assembly Check

- Have you connected all necessary sensor and actuator lines?
- Are all bus units connected together or to the 318-8 interface module?
- Are all interface modules and modules plugged in?
- Have you connected the load supply?
- Have grounding measures been executed correctly?
- Have you connected the transmission cable and plugged in the front connector?
- Are terminating resistors plugged in at the ends of chains?

Settings

- Have you set the ET No. on the 318-8 interface module?
- Has the same baud rate been set correctly for all nodes?
- Is the mode selector at "ON" on the 318-8 and on all 318-8 interface modules ?
- Have you set the interface switch and the QVZ mode switch on the 308-8 interface module?
- Is the adress of the diagnostic byte on the 308-3 interface module correctly set?
- Is there a correctly programmed memory submodule in the submodule receptacle of the 308-3 interface module?

If all these conditions have been met, you can switch on the power (4.5).

4.5 Switching On the Power Supply

Do you have separate supply voltages?

Please note the power-up sequence:

1. Switch on the 318-8 interface module supply
2. Switch on the load supply (can also be switched on together with 1.)
3. Switch on the supply of the higher level central controller or expansion unit.

Observe the sequence 3-2-1 when powering down, otherwise a timeout (QVZ) can occur in the higher-level central controller or expansion unit (Chapter 5).

Do you have a central power switch?

After switching on, the higher-level central controller or expansion unit will start up with the ET 100U.

During ET 100U start-up, the "FAULT" LED on the 308-3 interface module will flash for approx. 5 to 20 s.

4.6 Status of the ET 100U after Powering Up

The following displays may light up during normal operation:

<p>308-3 Interface module</p> <p>FAULT</p> <p>● 1*</p> <p>2*</p>	<p>318-8 Interface module</p> <p>● ON</p> <p>I/O DISABLED</p> <p>I/O FAILURE</p> <p>ALARM OUTPUT</p>	<p>I/O modules</p> <p>FAULT</p> <p>I/O**</p> <p>I/O**</p> <p>I/O**</p> <p>I/O**</p>
--	--	---

If a red error LED lights up, carry out an error search (Chapter 5).

LED Statuses

- LED off
- LED bright

* The relevant LEDs light up depending on whether one or both interfaces are connected

** The relevant LEDs light up depending on the status of the I/O signals in the I/O modules.

5 Error Diagnostics			
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5 Error Diagnostics

There can be various causes for a fault in the ET 100U electronic terminator for distributed I/O. This chapter is designed to help you to detect errors and eliminate them.

5.1 Error Messages to the Central Controller

5.1.1 Errors are Reported to the Central Controller as Follows

A diagnostics byte for every ET 100U is stored in the 308-3 interface module plugged into the controller or expansion unit under the number of the relevant ET 100U. The diagnostics bytes for all the ET 100Us are stored in the 308-3 interface module buffer and are accessed using load and transfer operations. You must set the address of the diagnostics byte on the 308-3 interface module. Each ET 100U has its own diagnostics byte (data byte). However, all the ET 100Us connected to one 308-3 interface module share the same diagnostics address (address byte). Up to 63 diagnostics bytes (data) can be read via the diagnostics address using the ET No.

Access to the diagnostics byte:

```
L KB n      n=1 to 63 (Number of the ET 100U)
T PY (2) m  m=128 to 255 (Diagnostics address)
L PY (2) m
```

If you have the STUDOS (SO=;S1) operating system (older version) in the programmer, you must use the T PB m and L PB m operations in place of the TP Y (2) and L PY (2) m operations.

This enables you to respond to specific error statuses using bit comparisons. In order to prevent an error in the ET 100U leading to a timeout resulting in the CPU stopping, it is necessary to program the relevant organization block (QVZ-OB). This is possible in the S5 115U programmable controller only from CPU 943 onwards. You will find further notes in the programmable controller manual.

5.1.2 The Following Errors are Reported to the Central Controller

You can tell whether errors have occurred in the ET 100U and what type of error is involved from the bit pattern of the diagnostics byte. The relevant bit will then be "1".

Bit	7	6	5	4	3	2	1	0
	BASP	0	0	F4	F3	F2	F1	F0

- F 0:
 - ET 100U can no longer be accessed:
e.g. no power supply to the 318-8 interface modules, interface connector has been unplugged, 318-8 interface module has been disconnected, line interrupt.
 - Frequent interference on the transmission line:
Messages are repeated twice; if data received is then still invalid (BCH-check), the ET 100U can no longer be referenced.
- F 1:
 - No load voltage or output short-circuit to M potential:
A module with readback capability (e.g.: 6ES5 440-8MA...) signals missing load voltage, or at least one output is short-circuited to M.
- F 2:
 - I/O modules unplugged :
One or more I/O modules configured with COM ET 100 are not plugged in. The missing modules are flagged additionally by a time-out (QVZ) if the QVZ mode is activated in the 308-3 interface module. The time-out affects all used addresses of the ET 100U in question.
- F 3:
 - I/O bus error or wrong bus units connected:
Fault in the shift register bus of the ET 100U,
Maximum configuration exceeded,
ET 100U configuration does not agree with COM ET 100 configuration.

F 4: • Output wrongly activated:
The output of a readback module (e.g.: 6ES5 440-8MA...) is "1" despite being driven with signal "0" .
Process wiring short-circuited to the L+ terminal.
Power section of the module is defective.

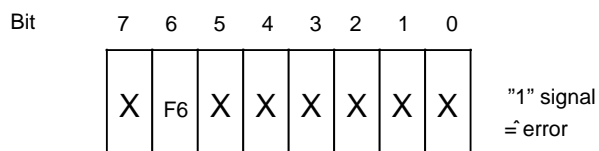
BASP:• Command output disable activated

0: • Bits meaningless

Special points:

- Diagnostics bits can also be combined.
- Errors are scanned cyclically. This can mean that errors occurring for a brief period are not captured and that the relevant diagnostics bits are therefore not set.
- Error messages are not stored.
Exception: Diagnostics bits which were present before generation of F0 (318-8 interface module failure) are retained.
- In the case of errors which result in the 318-8 interface module power supply being switched off (3.2.3) or in the case of a process wiring short-circuit to L+, either a combination of the messages F0, F1, F4 and BASP or simply the message F0 may be generated.
This is not possible if the 318-8 interface module has a separate supply.

Diagnostics Byte No. 0 for High-Level Messages



- F 6: - Serial transmission fault, e.g.:
 Mode selector of the 308-3 interface module is at OFF
 308-3 interface module has been unplugged
 Missing terminating resistor
 Loop resistance of the transmission cable is too large.
- X: - Bits meaningless when using the ET 100U in connection with SIMATIC central controllers.

5.2 Error Messages Direct at the ET 100U

The LEDs on the frontplates of the ET 100U modules inform the user about controller status or system status:

- Operating display: green LEDs
- Error display: red LEDs

The user can exert a certain amount of influence on these statuses using the operator controls (switches and keys).

Representation of the LEDs

- | | | |
|----------------|---|---|
| LED bright | ● | Operation/error |
| LED off | | No operation/supply voltage missing |
| LED flashing | ⊗ | Active/temporary error (flashing frequency approx. 2 to 3 Hz) |
| LED flickering | ⊗ | Fault (flashing frequency approx. 8 Hz) |

5.2.1 318-8 Interface Module

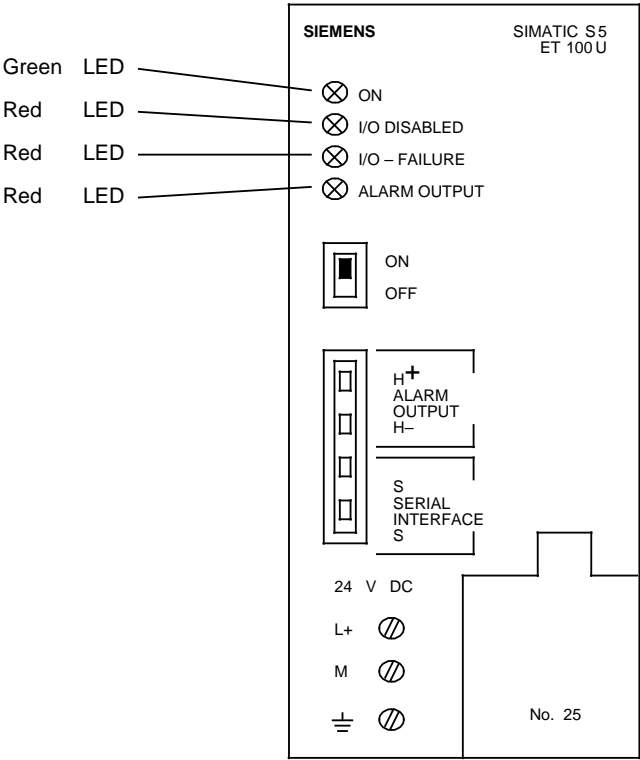


Figure 5-1 Displays on the 318-8 Interface Module

Table 5-1 Error Diagnostics in the 318-8 Interface Module

LED Status	Meaning
ON I/O DISABLED I/O-FAILURE ALARM OUTPUT	No 24 V DC supply voltage
●	Fault-free operation of the 318-8 interface module
● ●	Supply voltage below 18 V DC Output module disabled (CPU: BASP)
● ⊗	Data transfer disturbed (wire break, connector removed) 308-3 interface module not switched on
ON I/O DISABLED I/O-FAILURE ALARM OUTPUT ●	Mode selector at "OFF"
● ● ○ ●	I/O bus interrupted Wrong module plugged in (fatal failure, alarm output opening)
● ○ ● ○	Load voltage down Diagnostic module short-circuited to M potential
● ○ ● ●	Diagnostic module short-circuited to L+ potential (fatal failure, alarm output opens)

If an ET 100U fails to restart automatically after a fault is eliminated, switch the 318-8 interface module off and back on again.

If the 318-8 interface module is operated with the same supply voltage as the I/O module, the alarm output will switch off the supply voltage in the event of fatal failures provided it is configured for this purpose.

Press the RESET button of the power supply module briefly after error correction.

5.2.2 I/O Modules

The red "FAULT" LED lights up in the event of an error or fault. It indicates the following in the modules listed below:

Digital input modules: • No sensor supply, but power supply of the 318-8 interface module on

Digital output modules: • No load voltage, but power supply of the 318-8 interface module on
 • Short-circuit of one or more outputs to M potential

Analog input modules: • Wire break in one or more input lines

Analog output modules have no error/fault display.

The LED displays go off after error/fault correction.

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6 Analog Value Processing

6.1 Number Systems

In digital technology, variables are represented by numbers. A number consists of several digits.

The number $a_4a_3a_2a_1a_0$ stands for :

$$N = a_4b^4 + a_3b^3 + a_2b^2 + a_1b^1 + a_0b^0 = \sum_{i=0}^4 a_i b^i \quad \text{with } i \in [0;4]$$

"b" is the radix of the respective number system (e.g. "10" in the decimal system).

Each system therefore has b different digits.

Numbers less than 1 are expressed by negative exponents.

Table 6-1 Examples of Different Number Systems

	Radix	Digits	Representation of a Number
Decimal system	b = 10	0;1;2;...9	$357_{10} = 3 \times 10^2 + 5 \times 10^1 + 7 \times 10^0$
Binary system	b = 2	0;1	$1011_2 = 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$
Hexadecimal system	b = 16	0;1;2...9; A;B;C;D;E;F	$3BD_H = 3 \times 16^2 + 11 \times 16^1 + 13 \times 16^0$

6.2 BCD (Binary Coded Decimal)

Binary code represents numbers by two characters or elements, "0" and "1". At least four binary positions are required to represent sixteen different digits ($16=2^4$).

In the case of BCD code, each of the decimal digits are represented by four bits. The decimal value is then obtained as the cross sum of the valid binary digits.

Table 6-2 BCD

Digits in the Decimal System	Binary Code	Example
1	0001	Representation of the number 27 in the decimal system: 27 in the binary system: 11011 in BCD: 0010 0111
2	0010	
3	0011	
4	0100	
5	0101	
6	0110	
7	0111	
8	1000	
9	1001	

6.3 Conversions Involving the Individual Number Systems

6.3.1 Conversion to the Decimal System

Write the binary or hexadecimal number as a sum of the individual digits and calculate their value.

- Examples:
- $10100_2 = 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0 = 2^4 + 2^2 = 20$
 - $A29_H = 10 \times 16^2 + 2 \times 16^1 + 9 \times 16^0 = 2560 + 32 + 9 = 2601$

6.3.2 Conversion from Decimal to Binary or Hexadecimal Numbers

As already mentioned, each number "N" can be represented as a sum of the individual digits:

$$N = \sum a_i b^i \quad \text{where "i" stands for an integer.}$$

When making the conversions, we look for the coefficients a_i for the corresponding radix values "b". These coefficients are obtained as the remainders resulting from the repeated division by the radix value.

Examples: • Converting the decimal number 53 into binary code:

53 : 2 = 26	Remainder 1	$a_0 = 1$	↑
26 : 2 = 13	Remainder 0	$a_1 = 0$	
13 : 2 = 6	Remainder 1	$a_2 = 1$	
6 : 2 = 3	Remainder 0	$a_3 = 0$	
3 : 2 = 1	Remainder 1	$a_4 = 1$	
1 : 2 = 0	Remainder 1	$a_5 = 1$	

The number 53 in binary code is 110101.

• Converting the decimal number 197 into hexadecimal code:

197 : 16 = 12	Remainder 5	$a_0 = 5$	↑
12 : 16 = 0	Remainder 12	$a_1 = C$	

The number 197 in hexadecimal code is C5.

6.3.3 Converting Binary to Hexadecimal and Vice Versa

A hexadecimal digit is represented by four binary digits and every four binary digits by a hexadecimal digit.

- Examples: • Converting the binary number 110101 into a hexadecimal number:

$$\begin{array}{r}
 110101 \qquad 0011 \ 0101 \\
 a_0 = 0x2^3 + 1x2^2 + 0x2^1 + 1x2^0 = 5 \\
 a_1 = 0x2^3 + 0x2^2 + 1x2^1 + 1x2^0 = 3
 \end{array}
 \begin{array}{c}
 \uparrow \\
 \uparrow
 \end{array}$$

The number 110101 is 35 in the hexadecimal system.

- Converting the hexadecimal number C5 into a binary number:

$$\begin{array}{r}
 5 = 0x2^3 + 1x2^2 + 0x2^1 + 1x2^0 \qquad a_0 = 0101 \\
 C = 1x2^3 + 1x2^2 + 0x2^1 + 0x2^0 \qquad a_1 = 1100
 \end{array}
 \begin{array}{c}
 \uparrow \\
 \uparrow
 \end{array}$$

The number C5 in binary code 11000101.

6.4 Addition

The values of the digits in the same position are added. This result is the corresponding digit of the sum. If this value is greater than the radix, check how often the radix goes into this value.

This factor is then added as a carry at the next digit position. The remainder is the digit of the sum.

Decimal system	Binary system	Hexadecimal system
$\begin{array}{r} 857 \\ + 371 \\ \hline 11 \\ \hline 1228 \end{array}$	$\begin{array}{r} 1011 \\ + 10011 \\ \hline 11 \\ \hline 11110 \end{array}$	$\begin{array}{r} A8 \\ + 2C \\ \hline 1 \\ \hline D4 \end{array}$

Figure 6-1 Addition in Various Number Systems

6.5 Subtraction

Subtraction can be regarded as the addition of a negative number. Consequently, the numbers must be assigned their complements.

This can be done in two ways.

6.5.1 Representing Negative Numbers as the One's Complement

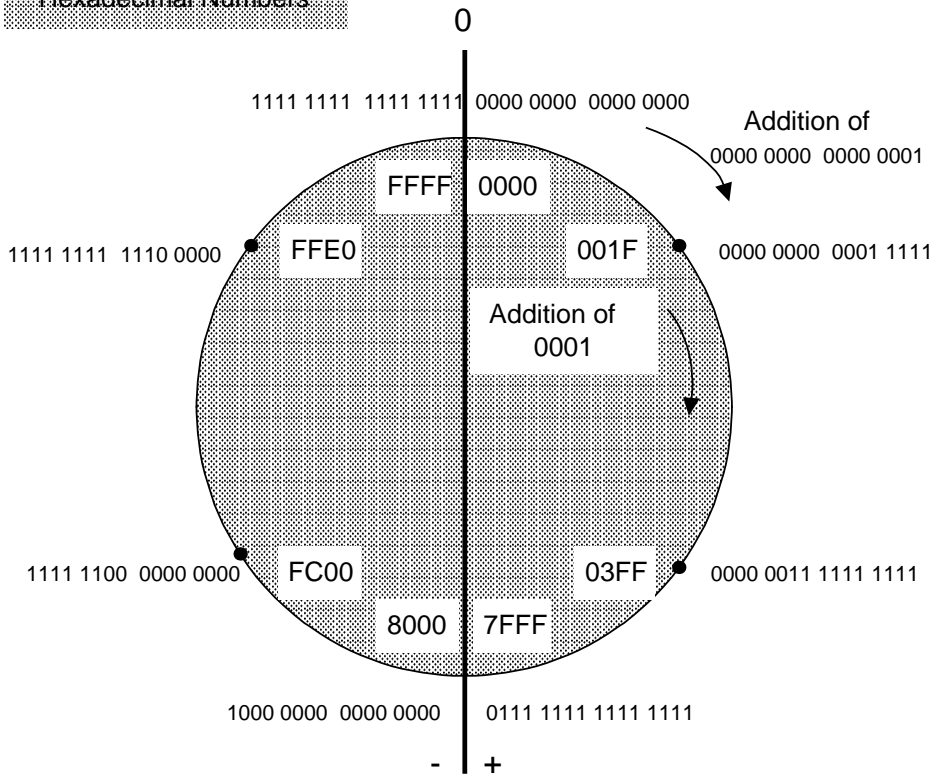
Table 6-3 Negative Numbers as One's Complement

	Binary Numbers	Hexadecimal Numbers
Forming the sign, using the most significant digit	0 for "+"; 1 for "-"	0 to 7 for "+"; 8 to F for "-"
Forming the complement	All zeros are replaced by one's and vice versa	All digits are replaced by their 16's complement; e.g. A by B; 3 by C
Example	01101 (+13 ₁₀) 10010 (-13 ₁₀)	003A (+58 ₁₀) FFC5 (-58 ₁₀)

Representation in the Number Circle

Binary Numbers

Hexadecimal Numbers



Arbitrary sign change; the "1" in bit 15 is defined as the negative sign.

In the negative range, the numbers are represented by their two's complement.

6.5.4 Subtracting One Hexadecimal Number from Another

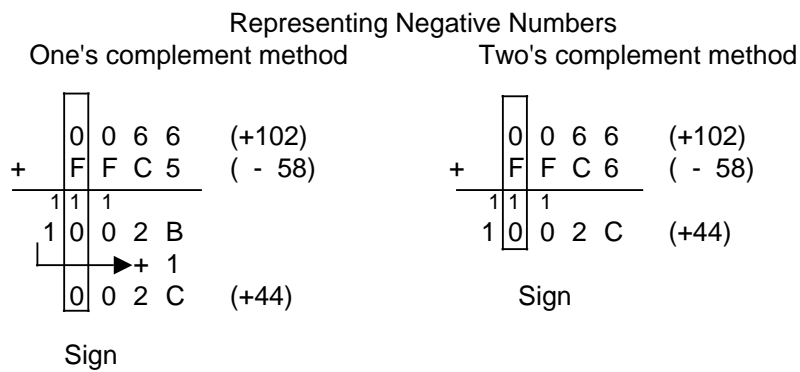


Figure 6-3 Subtracting One Hexadecimal Number from Another

6.6 Representing Analog Measured Values

6.6.1 The Significance of the Individual Data Bits

Each analog process signal must be brought into digital form to enable it to be stored in the process input image (PII). For this purpose, the analog input value is converted into a two-byte binary number. The powers of two have fixed positions in the bit patterns. The data words are then padded with zeros to fill all 16 bits.

Negative values are expressed by their two's complement (6.5.2). The information from the process output image (PIQ) is converted back into analog form for the analog output module.

Table 6-5 Representing an Analog Value as a Bit Pattern

	High Byte								Low Byte							
Bit number	7	6	5	4	3	2	1	7	6	5	4	3	2	1	0	
Analog input value	S	$\frac{1}{2}$	$\frac{10}{2}$	$\frac{9}{2}$	$\frac{8}{2}$	$\frac{7}{2}$	$\frac{6}{2}$	$\frac{5}{2}$	$\frac{4}{2}$	$\frac{3}{2}$	$\frac{2}{2}$	$\frac{1}{2}$	$\frac{0}{2}$	X	F	Ü
Analog output value	S	$\frac{10}{2}$	$\frac{9}{2}$	$\frac{8}{2}$	$\frac{7}{2}$	$\frac{6}{2}$	$\frac{5}{2}$	$\frac{4}{2}$	$\frac{3}{2}$	$\frac{2}{2}$	$\frac{1}{2}$	$\frac{0}{2}$	X	X	X	X

Legend: S Sign bit: 0 = "+" ; 1 = "-"
 X Irrelevant bits
 F Error bit: 0 = no wire break ; 1 = wire break
 Ü Carry bit: 0 = Measured value 4095 units at the most
 1 = Measured value greater than or equal to 4096 units

6.6.2 Analog Value Calculations

The tables on the following pages indicate the relationship between the contents of the data words in the process input/output images and the measured values. Further conversions can be made by selecting the relevant unit. In addition, the type of analog value representation is indicated. This indication is necessary for programming FB 250 and FB 251.

Table 6-6 Analog Input/Output Modules (Bipolar Fixed-Point Number)

Units	Measured Values in						High Byte	Low Byte	
	mV	mV	mV	V	mA				
>4095	100.0	1000.0	2000.0	20.000	40.0		0 1 1 1 1 1 1 1	1 1 1 1 1 0 0 1	Overflow
4095	99.976	999.75	1999.5	19.995	39.9902		0 1 1 1 1 1 1 1	1 1 1 1 1 0 0 0	Overrange
2049	50.024	500.24	1000.48	10.0048	20.0098		0 1 0 0 0 0 0 0	0 0 0 0 1 0 0 0	
2048	50.0	500.0	1000.0	10.000	20.0		0 1 0 0 0 0 0 0	0 0 0 0 0 0 0 0	
1024	25.0	250.0	500.0	5.000	10.0		0 0 1 0 0 0 0 0	0 0 0 0 0 0 0 0	
1	0.024	0.24	0.48	0.0048	0.0098		0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	
0	0.0	0.0	0.0	0.000	0.0		0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	
-1	-0.024	-0.24	-0.48	-0.0048	-0.0098		1 1 1 1 1 1 1 1	1 1 1 1 1 0 0 0	Nominal range
-1024	-25.0	-250.0	-500.0	-500.0	-10.0		1 1 1 0 0 0 0 0	0 0 0 0 0 0 0 0	
-2048	-50.0	-500.0	-1000.0	-1000.0	-20.0		1 1 0 0 0 0 0 0	0 0 0 0 0 0 0 0	
-2049	-50.024	-500.24	-1000.48	-10.0048	-20.0098		1 0 1 1 1 1 1 1	1 1 1 1 1 0 0 0	Overrange
-4095	-99.976	-999.75	-1999.5	-19.995	-39.9902		1 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	
<-4095	-100.0	-1000.0	-2000.0	-20.000	-40.0		1 0 0 0 0 0 0 0	0 0 0 0 1 0 0 1	Overflow

Analog Input Modules

4x ±50 mV 6ES5 464-8MA11
 4x ±1 V 6ES5 464-8MB11
 ±20 mA 6ES5 464-8MD11

Analog value representation: bipolar fixed-point number

2x ±500 mV 6ES5 464-8MF11
 4x ±10 V 6ES5 464 8MC11

Analog Input Module 4x +4 to 20 mA (6ES5 464-8ME11)

For two-wire and four-wire transducers

The inputs are interconnected via shunts R_s (common reference potential). No wire break indication is therefore possible.

Analog value representation: Absolute (unsigned) value (4 to 20 mA)

Table 6-7 Analog Input Module (Absolute Representation)

Units	Measured Value in mA	High Byte	Low Byte	
>4095	> 32.769	0 1 1 1 1 1 1 1	1 1 1 1 1 0 0 1	Overflow
4095	31.992	0 1 1 1 1 1 1 1	1 1 1 1 1 0 0 0	Overrange
2561	20.008	0 1 0 1 0 0 0 0	0 0 0 0 1 0 0 0	
2560	20.0	0 1 0 1 0 0 0 0	0 0 0 0 0 0 0 0	Nominal range
2048	16.0	0 1 0 0 0 0 0 0	0 0 0 0 0 0 0 0	
512	4.0	0 0 0 1 0 0 0 0	0 0 0 0 0 0 0 0	
511	3.992	0 0 0 0 1 1 1 1	1 1 1 1 1 0 0 0	Transducer faulted?
384	3.0	0 0 0 0 1 1 0 0	0 0 0 0 0 0 0 0	
0	0.0*	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	
-1	-0.008	1 1 1 1 1 1 1 1	1 1 1 1 1 0 0 0	
< - 4095	< - 32.769	1 0 0 0 0 0 0 0	0 0 0 0 1 0 0 1	

* Due to the tolerances for the components used in the module, the converted value can also be in the negative range (e.g. FFF8_H Unit: - 1).

Analog Input Module 2x PT 100 (6ES5 464-8MF11)

Analog value representation: Unipolar

Table 6-8 Analog Input Module (Unipolar)

Units	Resistance in	High Byte	Low Byte	
>4095	400.0	0 1 1 1 1 1 1 1	1 1 1 1 1 0 0 1	Overflow
4095	39.90	0 1 1 1 1 1 1 1	1 1 1 1 1 0 0 0	Overrange
2049	200.98	0 1 0 0 0 0 0 0	0 0 0 0 1 0 0 0	
2048	200.0	0 1 0 0 0 0 0 0	0 0 0 0 0 0 0 0	Nominal range
1024	100.0	0 0 1 0 0 0 0 0	0 0 0 0 0 0 0 0	
1	0.098	0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	
0	0.0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	

Analog Input Module 2 x PT 100 with Linearization (6ES5 464-8MF21)

Resolution of 0.5 °C per unit

Analog value representation: Bipolar fixed-point number (DIN IEC 751)

Table 6-9 Analog Input Module with Linearization (Bipolar)

Units	Temperature in °C	High Byte	Low Byte	
>1766	< 883	0 0 1 1 0 1 1 1	0 0 1 1 0 0 0 1	Overflow
1766	883	0 0 1 1 0 1 1 1	0 0 1 1 0 0 0 1	Overrange *
1702	851	0 0 1 1 0 1 0 1	0 0 1 1 0 0 0 1	
1700	850	0 0 1 1 0 1 0 1	0 0 1 0 0 0 0 0	Nominal range
1400	700	0 0 1 0 1 0 1 1	1 1 0 0 0 0 0 0	
1000	500	0 0 0 1 1 1 1 1	0 1 0 0 0 0 0 0	
600	300	0 0 0 1 0 0 1 0	1 1 0 0 0 0 0 0	
300	150	0 0 0 0 1 0 0 1	0 1 1 0 0 0 0 0	
200	100	0 0 0 0 0 1 1 0	0 1 0 0 0 0 0 0	
2	1	0 0 0 0 0 0 0 0	0 0 0 1 0 0 0 0	
0	0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	
- 40	- 20	1 1 1 1 1 1 1 0	1 1 0 0 0 0 0 0	
- 80	- 40	1 1 1 1 1 1 0 1	1 0 0 0 0 0 0 0	
- 200	- 100	1 1 1 1 1 0 0 1	1 1 0 0 0 0 0 0	
- 202	- 101	1 1 1 1 1 0 0 1	1 0 1 1 0 0 0 1	Overrange *
- 494	- 247	1 1 1 1 0 0 0 0	1 0 0 1 0 0 0 1	Overflow

* The rise in the curve present on leaving the linearized nominal area is retained in the overrange area.

Analog Input Module 2 x PT 100 without Linearization (6ES5 464-8MF21)

Resolution of approximately °C per unit (1 ohm = 10 units)
 Analog value representation: unipolar

Table 6-10 Analog Input Module without Linearization (Unipolar)

Units	Resistance in	High-Byte	Low-Byte	
>4095	>400	0 1 1 1 1 1 1 1	1 1 1 1 1 0 0 1	Overflow
4095 2049	399.90 200.098	0 1 1 1 1 1 1 1 0 1 0 0 0 0 0 0	1 1 1 1 1 0 0 0 0 0 0 0 1 0 0 0	Overrange *
2048 1024 1 0	200 100.00 0.098 0.0**	0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0	Nominal range

* The rise in the curve present on leaving the linearized nominal area is retained in the overrange area
 ** Due to the tolerances for the components used in the module, the converted value can also be in the negative range (e.g. FFF8_H Unit: - 1)

Analog Input Module 4 x Type K Thermocouple with Temperature Compensation and Linearization (6ES5 464-8MA21)

Type K: Nickel-chromium / nickel-aluminium to DIN IEC 584
 Analog value representation: Bipolar fixed-point number

Table 6-11 Analog Input Module with Type K Thermocouple (Bipolar)

Units	Temperature in °C	High-Byte	Low-Byte	
>2359		0 1 0 0 1 0 0 1	1 1 1 1 1 0 0 1	Overflow
1370	1370	0 0 1 0 1 0 1 0	1 1 0 1 0 0 0 1	Overrange *
1369	1369	0 0 1 0 1 0 1 0	1 1 0 0 1 0 0 0	Nominal range
1000	1000	0 0 0 1 1 1 1 1	0 1 0 0 0 0 0 0	
500	500	0 0 0 0 1 1 1 1	1 0 1 0 0 0 0 0	
150	150	0 0 0 0 0 1 0 0	1 0 1 1 0 0 0 0	
100	100	0 0 0 0 0 0 1 1	0 0 1 0 0 0 0 0	
1	1	0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	
0	0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	
-1	-1	1 1 1 1 1 1 1 1	1 1 1 1 1 0 0 0	
-100	-100	1 1 1 1 1 1 0 0	1 1 1 0 0 0 0 0	Accuracy 2 K
-101	-101	1 1 1 1 1 1 0 0	1 1 0 1 1 0 0 0	
-150	-150	1 1 1 1 1 0 1 1	0 1 0 1 0 0 0 0	
-200	-200	1 1 1 1 1 0 0 1	1 1 0 0 0 0 0 0	
-201	-201	1 1 1 1 1 0 0 1	1 0 1 1 1 0 0 1	Overrange *
-273		1 1 1 1 0 0 0 0	1 0 0 1 0 0 0 1	Overflow
X	X	X X X X X X X X	X X X X 0 1 0	Wire break

* The rise in the curve present on leaving the linearized nominal area is retained in the overrange area.

Analog Input Module 4 x Type J Thermocouple with Temperature Compensation and Linearization (6ES5 464-8MA21)

Type J: Iron/copper-nickel (constantan) to DIN IEC 584
 Analog value representation: Bipolar fixed-point number

Table 6-12 Analog Input Module with Type J Thermocouple (Bipolar)

Thermal voltage in mV *	Units	Temperature in °C	High-Byte	Low-Byte	
	1485		0 0 1 0 1 1 1 0	0 1 1 0 1 0 0 1	Overflow
	1201	1201	0 0 1 0 0 1 0 1	1 0 0 0 1 0 0 1	Overrange **
69.536	1200	1200	0 0 1 0 0 1 0 1	1 0 0 0 0 0 0 0	Nominal range
57.942	1000	1000	0 0 0 1 1 1 1 1	0 1 0 0 0 0 0 0	
27.388	500	500	0 0 0 0 1 1 1 1	1 0 1 0 0 0 0 0	
5.268	100	100	0 0 0 0 0 0 1 1	0 0 1 0 0 0 0 0	
0.05	1	1	0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	
0	0	0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	
-0.05	-1	-1	1 1 1 1 1 1 1 1	1 1 1 1 1 0 0 0	
-4.632	-100	-100	1 1 1 1 1 1 0 0	1 1 1 0 0 0 0 0	
-6.499	-150	-150	1 1 1 1 1 0 1 1	0 1 0 1 0 0 0 0	
-7.868	-199	-199	1 1 1 1 1 0 0 1	1 1 0 0 1 0 0 0	
-7.890	-200	-200	1 1 1 1 1 0 0 1	1 1 0 0 0 0 0 0	
	-201	-201	1 1 1 1 1 0 0 1	1 0 1 1 1 0 0 1	Overrange **
	-273		1 1 1 1 0 1 1 1	0 1 1 1 1 0 0 1	Overflow
	X	X	X X X X X X X X	X X X X 0 F 0	Wire break

* for a reference temperature of 0°C

** The rise in the curve present on leaving the linearized nominal area is retained in the over-range area.

Analog Input Module 4 x Type L Thermocouple with Temperature Compensation and Linearization (6ES5 466-8MC11)

Type L: Iron/copper-nickel (constantan) to DIN 43710
 Analog value representation: Bipolar fixed-point number

Table 6-13 Analog Input Module with Type L Thermocouple (Bipolar)

Thermal voltage in mV *	Units	Temperature in °C	High-Byte	Low-Byte	
	1361		0 0 1 0 1 0 1 0	1 0 0 0 1 0 0 1	Overflow
	901	901	0 0 1 0 1 0 0 1	0 0 1 0 1 0 0 1	Overrange **
53.14	900	900	0 0 0 1 1 1 0 0	0 0 1 0 0 0 0 0	Nominal range
27.85	500	500	0 0 0 0 1 1 1 1	1 0 1 0 0 0 0 0	
13.75	250	250	0 0 0 0 0 1 1 1	1 1 0 1 0 0 0 0	
+5.37	100	100	0 0 0 0 0 0 1 1	0 0 1 0 0 0 0 0	
0.05	1	1	0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	
0	0	0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	
-0.05	-1	-1	1 1 1 1 1 1 1 1	1 1 1 1 1 0 0 0	
-4.75	-100	-100	1 1 1 1 1 1 0 0	1 1 1 0 0 0 0 0	
-6.60	-150	-150	1 1 1 1 1 0 1 1	0 1 0 1 0 0 0 0	
-7.86	-190	-190	1 1 1 1 1 0 1 0	0 0 0 1 0 0 0 0	
-8.12	-199	-199	1 1 1 1 1 0 0 1	1 1 0 0 1 0 0 0	
	-200	-200	1 1 1 1 1 0 0 1	1 1 0 0 0 0 0 1	Overrange **
	-273		1 1 1 1 0 1 1 1	0 1 1 1 1 0 0 1	Overrange
	X	X	X X X X X X X X	X X X X 0 1 0	Wire break

* for a reference temperature of 0°C

** The rise in the curve present on leaving the linearized nominal area is retained in the over-range area

Analog Input Module (6ES5 466-8MC11)

The 6ES5 466-8MC11 module is suitable for the connection of voltage sensors.

Please refer to the block diagram (Section 2.6.3) for the wiring arrangement (two-wire connection).

Analog Value Representation

The analog input module enters the analog values in one byte each. In this respect, it differs from other analog input modules which store analog values in one word each.

Table 6-14 Analog Input Module 466-8MC11, 4 x 0 ... 10 V

Units	Input voltage in V	Byte
255	9.961	1 1 1 1 1 1 1 1
254	9.922	1 1 1 1 1 1 1 0
192	7.500	1 1 0 0 0 0 0 0
191	7.461	1 0 1 1 1 1 1 1
128	5.000	1 0 0 0 0 0 0 0
127	4.961	0 1 1 1 1 1 1 1
64	2.500	0 1 0 0 0 0 0 0
63	2.461	0 0 1 1 1 1 1 1
1	0.039	0 0 0 0 0 0 0 1
0	0.000	0 0 0 0 0 0 0 0

FB 250 (Reading in analog value) cannot be used.

Analog Output Modules

Analog value representation: Bipolar fixed-point number

Table 6-15 Analog Output Modules (Bipolar)

Units	Output Values		High Byte	Low Byte	
	in V	in mA			
1280	12.5	25.0	0 1 0 1 0 0 0 0	0 0 0 0 x x x x	Overrange
1025	10.0098	20.0195	0 1 0 0 0 0 0 0	0 0 0 0 x x x x	
1024	10.0	20.0	0 1 0 0 0 0 0 0	0 0 0 0 x x x x	Nominal range
512	5.0	10.0	0 0 1 0 0 0 0 0	0 0 0 0 x x x x	
1	0.0098	0.0195	0 0 0 0 0 0 0 0	0 0 0 0 x x x x	
0	0.0	0.0	0 0 0 0 0 0 0 0	0 0 0 0 x x x x	
-1	-0.0098	-0.0195	1 1 1 1 1 1 1 1	1 1 1 1 x x x x	
-512	-5.0	-10.0	1 1 1 0 0 0 0 0	0 0 0 0 x x x x	
-1024	-10.0	-20.0	1 1 0 0 0 0 0 0	0 0 0 0 x x x x	
-1025	-10.0098	-20.0195	1 0 1 1 1 1 1 1	1 1 1 1 x x x x	Overrange
-1280	-12.5	-25.0	1 0 1 1 0 0 0 0	0 0 0 0 x x x x	

2x ± 10 V 6ES5 470-8MA12

2x ± 20 mA 6ES5 470-8MB12

Analog value representation: unipolar representation

Table 6-16 Analog Output Modules (Unipolar)

Units	Output Values		High Byte	Low Byte	
	in V	in mA			
1280	6.0	24.0	0 1 0 1 0 0 0 0	0 0 0 0 x x x x	Overrange
1025	5.004	20.016	0 1 0 0 0 0 0 0	0 0 0 1 x x x x	
1024	5.0	20.0	0 1 0 0 0 0 0 0	0 0 0 0 x x x x	Nominal range
512	3.0	12.0	0 0 1 0 0 0 0 0	0 0 0 0 x x x x	
1	1.004	4.016	0 0 0 0 0 0 0 0	0 0 0 1 x x x x	
0	1.0	4.0	0 0 0 0 0 0 0 0	0 0 0 0 x x x x	
-1	0.996	3.984	1 1 1 1 1 1 1 1	1 1 1 1 x x x x	Overrange
-256	0.0	0.0	1 1 1 1 0 0 0 0	0 0 0 0 x x x x	
-512	-1.0	-4.0	1 1 0 0 0 0 0 0	0 0 0 0 x x x x	
-1024	-3.0	-12.0	1 1 0 0 0 0 0 0	0 0 0 0 x x x x	
-1280	-4.0	-16.0	1 0 1 1 0 0 0 0	0 0 0 0 x x x x	

2x 1 to 5 V 6ES5 470-8MD12

2x 4 to 20 mA 6ES5 470-8MC12

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7 Function Modules

7.1 Comparator Module 2x0.5 to 20 mA/0.5 to 10 V (6ES5 461-8MA11)

Technical Specifications

Address designation (for ET 100U only)	4DI
Channels	2
Galvanic isolation	yes
Current or voltage measurement	switch-selectable
Switch position "0"	no measuring
Display	green LED for actual value setpoint
Setpoint adjustment	with potentiometer
Setting error	±10 %
Reproducibility	±2 %
Hysteresis	10 %
"V" measuring range	0.5 to 10 V DC
Input resistance	47 k
Inherent delay	typ. 5 ms
Input voltage	max. 100 V DC (0.5 s)
"I" measuring range	0.5 to 20 mA
Input resistance	500
Overload capability	100 %
Rated insulation voltage (+9 V to measuring circuit and between measuring circuits) - insulation - tested with	30 V AC 2xB 500 V AC
Rated insulation voltage (+9 V to \perp) - insulation group - tested with	12 V AC 1xB 500 V AC
Length of cable - shielded - unshielded	200 m (660 ft.) 100 m (330 ft.)
Current consumption - from +9 V (CPU)	typ. 35 mA
Power losses of the module	typ. 0.3 W
Weight	approx. 200 g (7oz.)

Function

The module has two isolated comparators for voltage or current measurement (selector switch with positions V/I). When the preset value is reached, the LED of the respective channel lights up and sends a "1" signal to the CPU.

The module must be withdrawn or the measuring circuit disconnected before selecting the function.

In switch position "0", the comparator is switched off; if scanned, a "0" signal results.

The response threshold of the comparator is set by a selector on the frontplate. The selector has scale divisions to simplify adjustment.

Installation

The comparator module is mounted on a bus unit like any other input or output module (3.1.1).

Wiring

See schematic diagram. Unused inputs can be left open.

Addressing

The comparator module is addressed in the same way as a four-channel digital input module, (identifier: 4 D/I), but only two channels are assigned (channel "0" or "1").

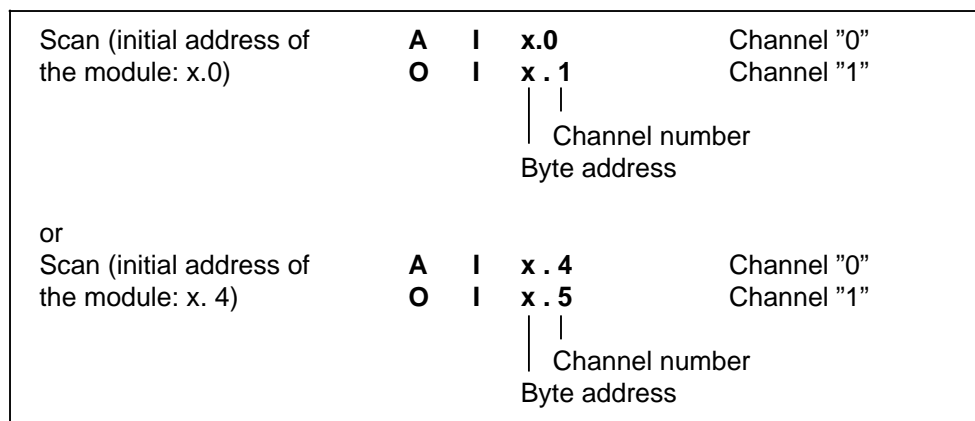


Figure 7-1 Scanning the Comparator Module

Typical Application

Connecting a current source to channel 1 (address 17.1) of the comparator module with the initial address 17.0. If the Schmitt trigger 1 detects that the current has exceeded the preset value (approximately 16 mA in this case), a switch (output 5.1) is to be operated.
 If the initial address of the module were 17.4, you would have to assign address 17.5 to channel 1.

Terminal Connections		
STL	Explanation	
A I 17.1 = Q 5.1	As soon as the limit is reached or exceeded, input 17.1 (or 17.5) becomes "1"; this sets output 5.1 to "1".	
or A I 17.5 = Q 5.1		

16.2 Timer Module 2x0.3 to 300 s

(6ES5 380-8MA11)

Technical Specifications

Address designation (for ET 100U only)	4DX
Number of timers	2
Time setting	0.3 to 3 s
Range extension factor	x10, x100
Function display	green LED
Setting error	±10 %
Reproducibility	±3%
Temperature influence	+1 %/10° C (50° F) from set time
Rated insulation voltage (+ 9V to \perp)	12 V AC
- insulation group	1xB
- tested with	500 V AC
Current consumption - from +9 V (CPU)	typ. 10 mA
Weight	approx. 200 g (7 oz.)

Function

The module contains two pulse timers. As long as the timer is running, the LED of the respective channel is bright; the relevant input is "1".

The pulse duration is preselected with the time range selector "x 0.3s/x3s/x30s" in a definite range and then set to the exact value by means of a potentiometer on the frontplate. This selector has scale divisions to simplify setting (time value = time range x scale value).

Example: Time range: x 3s
 Scale value: 7
 Set time: 7 x 3s = 21s

Installation

The counter is plugged into a bus unit like any other input or output module (3.1.1)

Wiring

No wiring is required.

Addressing

A timer module is addressed in the same way as a four-channel digital module (identifier: 4DQ) but only two channels are assigned (channel "0" or "1").

The timer module is referenced like a digital output module for starting, resetting or interrupting the pulse. The signal status is scanned in the same way as a digital input module.

It is therefore necessary that, when assigning addresses for the timer module using COM ET 100, you reserve addresses both for digital inputs and outputs. This can frequently produce different initial addresses for inputs and outputs (Figure 7-2).

Typical Application as On-Delay Timer

Mounting a timer module in an ET 100U. Since this module has both digital inputs and outputs, you have reserved the relevant I/O addresses using COM ET 100.

This has resulted in initial address 19.4 for the digital inputs and initial address 21.0 for the digital outputs.

A time of 270 s is set on channel "0" (address 21.2) of this module by means of the time-range selector and the potentiometer. The timer is started when input 12.7 is "1". A lamp is to light up (output 13.0) when the timer has run down.

STL	Explanation
A I 12.7	The timer must not be scanned in the program scan cycle in which it was enabled since the CPU would not receive the acknowledgement that the counter had started until one program scan later. If flag 65.0 is "1" and the timer has run down (AN I 19.4), output 13.0 is set to "1". If the "Timer started" message has been sent to the CPU, the flag is set. If I 12.7 is "0", the lamp is switched off. The timer is started if I 12.7 is "1".
AN I 19.4	
A F 65.0	
S Q 13.0	
A I 19.4	
= F 65.0	
AN I 12.7	
R Q 13.0	
A I 12.7	
= Q 21.2	

7.3 Simulator Module

(6ES5 788-8MA11)

Technical Specifications

Address designation (for ET 100U only)

- input simulator	8DI
- output simulator	8DQ

Function selection

- simulation of 8 input signals	selected by switch on rear of module
- display of 8 output signals	

Function display

yellow LED	
------------	--

"0"/"1" input signals

switch-selectable	
-------------------	--

Rated insulation voltage (+9 V to \rightarrow)

- insulation group	12 V AC
- tested with	1xB
	500 V AC

Signal status display for input/output

green LEDs	
------------	--

Current consumption - from +9 V (CPU)

30 mA	
-------	--

Power loss of the module

typ. 0.3 W	
------------	--

Weight

190 g (6.7 oz.)	
-----------------	--

Function

Simulator modules are eight-channel modules with which digital input signals can be simulated and output signals displayed.

The type of module to be simulated (input or output) is selected by means of a switch on the rear of the module and indicated by two LEDs on the frontplate.

Installation

The simulator module is plugged into a bus unit like any other input or output module (3.1.1). The module does not have a coding key and can therefore be plugged in in place of any digital module. The coding element on the bus unit does not have to be readjusted.

Wiring

There is no electrical connection between the module and the terminal block. It can therefore be plugged into slots that have already been wired and connected to the power supply.

Addressing

A simulator module is addressed in the same way as an eight-channel digital module (identifier: 8DI or 8DQ) (channels 0 to 7).

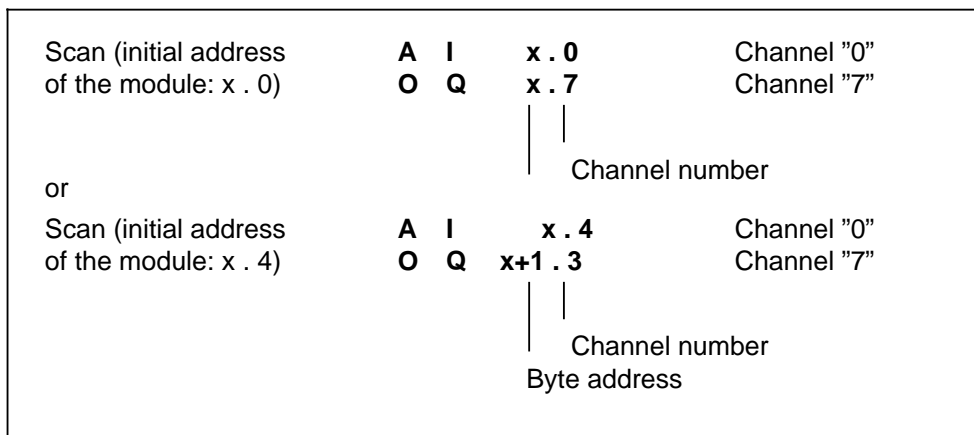


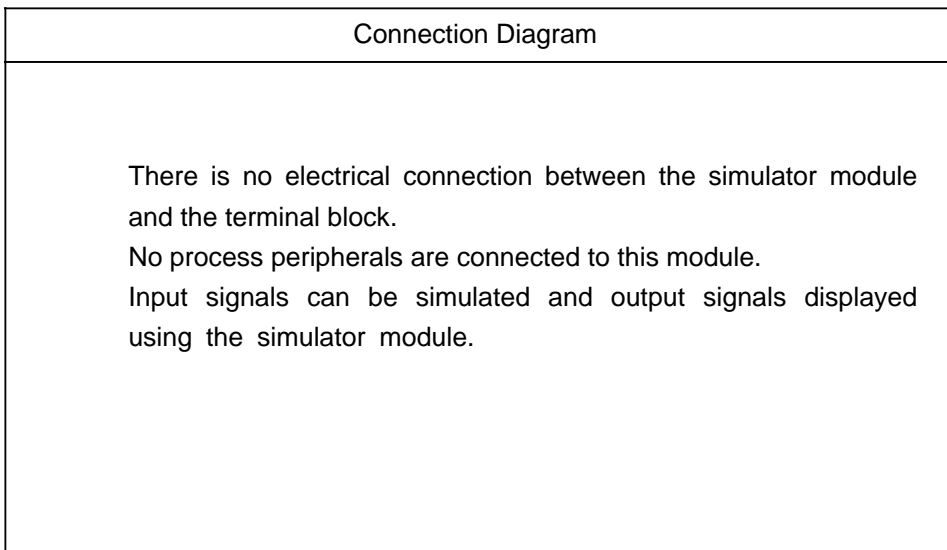
Figure 7-3 Scanning the Simulator Module

Typical Application

The CPU in the central controller or expansion unit is in the "RUN" mode; the green LED is bright but the PC is malfunctioning. You have also discovered that the fault must be in a particular I/O module. If the module has no fault indicator, check:

- whether the power supply is connected
- and whether the bus connections and interface modules are in order.

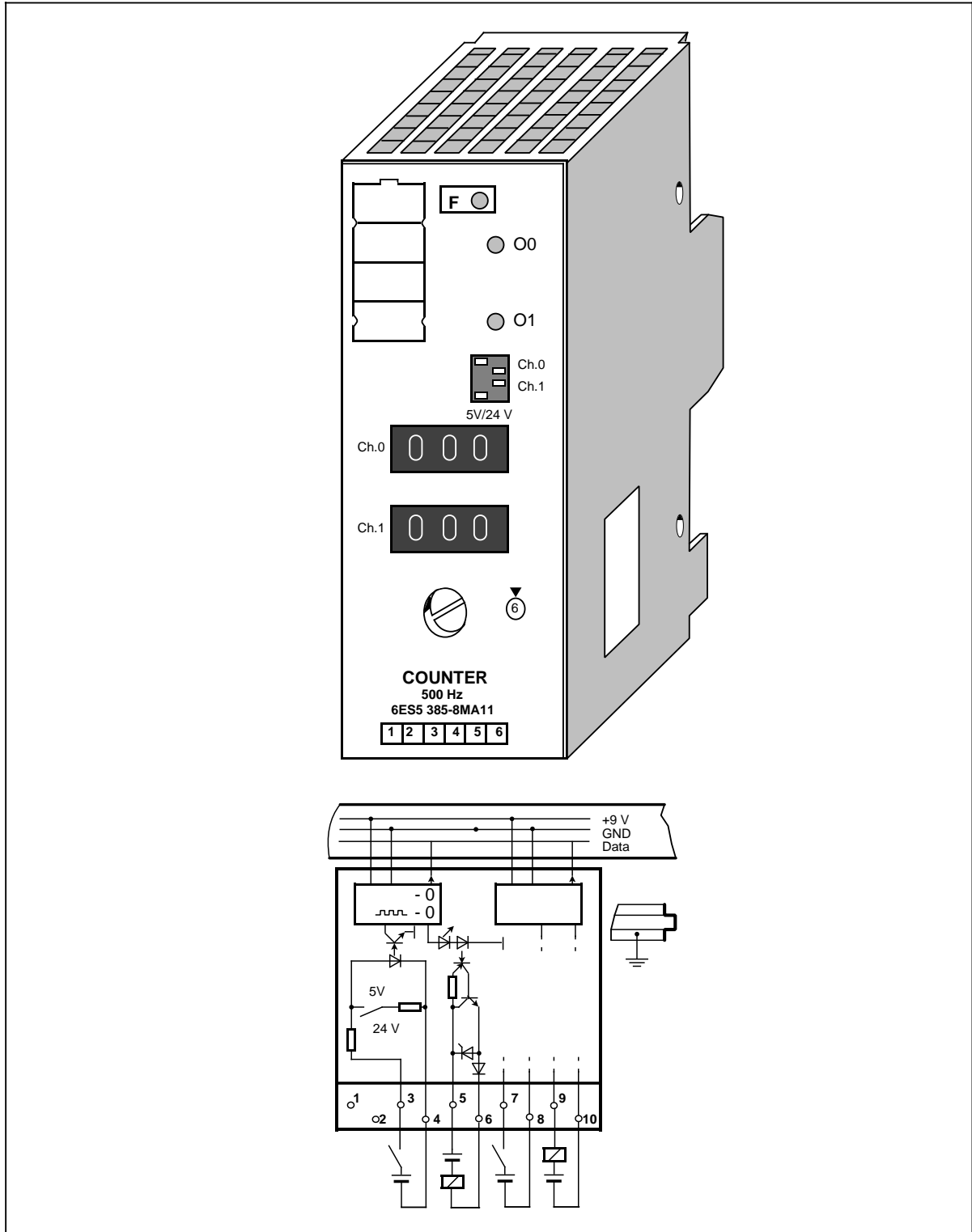
Then try to reference the module via the process image ("STATUS" or "STATUS VAR"). If this is not successful, replace the module with the simulator module. Carry out a second check with the "STATUS" or "STATUS VAR" function. If the simulator can be referenced in this way, the input/output module you have replaced is defective.



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7.4 Counter Module 2x0 to 500 Hz

(6ES5 385-8MA11)



Technical Specifications			
Address designation (for ET 100U only)	4DX	Total permissible current of outputs	1 A
Number of Inputs	2	Driving a digital input	possible
Galvanic isolation	yes	Paralleling of outputs - max. current	possible 0.5 A
Input voltage - rated value - for "0" signal - for "1" signal	5 V/24 V DC 0 to 0.8/-33 to 5 V 3 to 5 V/13 to 33 V	Length of cable - unshielded	max. 100 m (330 ft.)
Input current for "1" signal	typ. 1.5/8.5 mA	Rated insulation voltage (inputs and outputs to each other and to \perp ; input to +9 V) - insulation group - tested with	60 V AC 1xB 1250 V AC
Inherent delay	typ. 180 μ s	Current consumption - from +9 V (CPU)	typ. 20 mA
Input frequency	max. 500 Hz	Power loss of the module	typ. 2.5 W
Connection of 2-wire BERO proximity switches (24 V DC) - quiescent current	possible 1.5 mA	Weight	approx. 200 g (7 oz.)
Length of cable - unshielded	max. 30/50 m (99ft./165 ft.)		
Number of Outputs	2		
Galvanic isolation	yes		
Supply voltage L+ (for load) - rated value - permissible range (including ripple)	24 V DC 20 to 30 V		
Output current for "1" signal - rated value - permissible range - lamp load	0.5 A 0.5 to 500 mA max. 5 W		
Residual current at "0" signal	max. 1 mA		
Output voltage - for "0" signal - for "1" signal	max. 3 V max. L+-2.5 V		
Short-circuit protection	electronic		
Fault indication (red LED)	short-circuit		
Voltage induced on circuit interruption (internal) limited to	L+-47 V		
Switching frequency - resistive load - inductive load	max. 100 Hz max. 2 Hz		

Function

The module consists of two independent down counters with isolated inputs and outputs. It counts input signals up to a frequency of 500 Hz from a set value down to the value "0". When zero is reached, the 24 V DC output of the module is energized.

At the same time, a green LED on the module lights up and the input signal (I x.0 or I x.1) is set to "1".

The setpoint (0 to 999) can be entered via three decade switches on the front plate of the module.

The input voltage ranges can be set for 5 V DC or 24 V DC on toggle switches on the front plate.

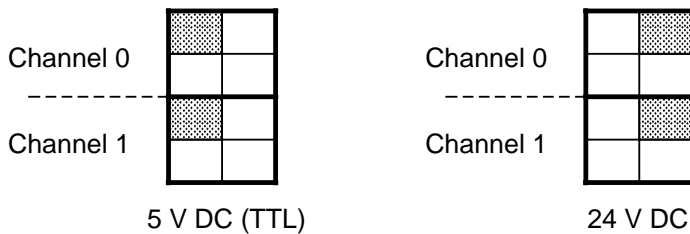


Figure 7-4 Setting the Input Voltage Range on the Counter Module (500 Hz)

Installation

The counter module is plugged into a bus unit in the same way as any other module (3.1.1).

Wiring

See schematic diagram.

Timing Diagram

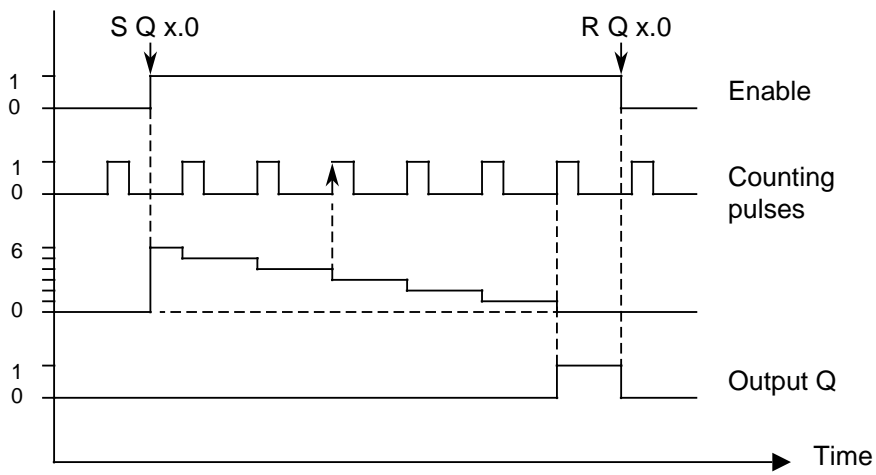


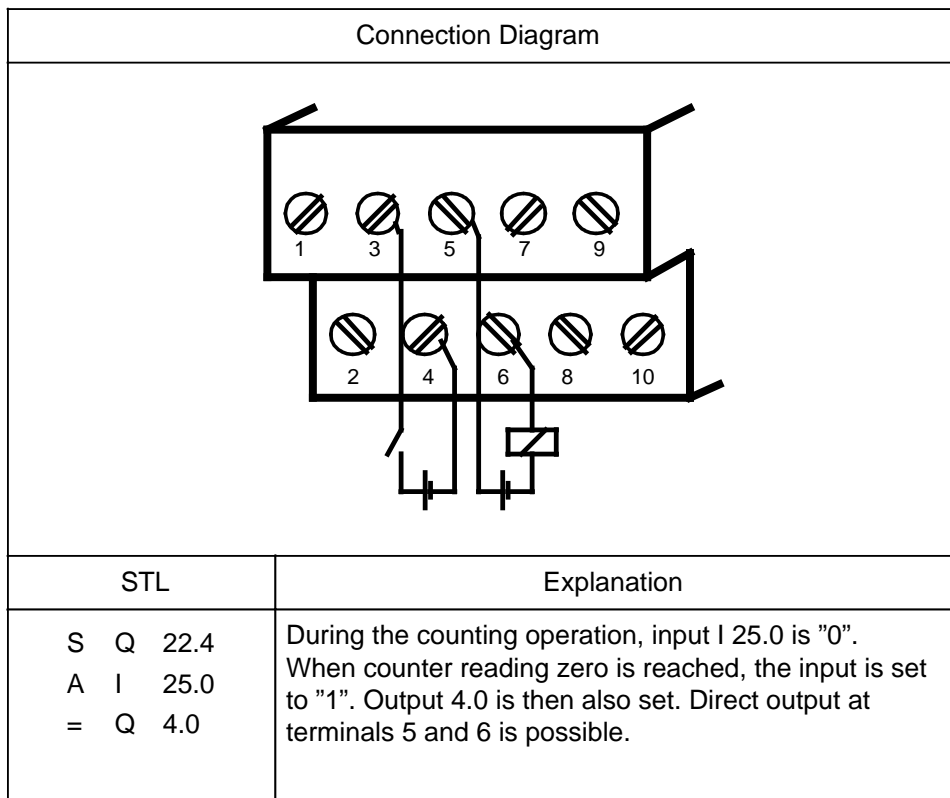
Figure 7-6 Timing Diagram: Setting and Resetting an Output of the Counter Module (500 Hz)

Typical Application

Mounting a timer module (500 Hz) in an ET 100U. Since this module has both digital inputs and outputs, you have reserved the relevant I/O addresses using COM ET 100.

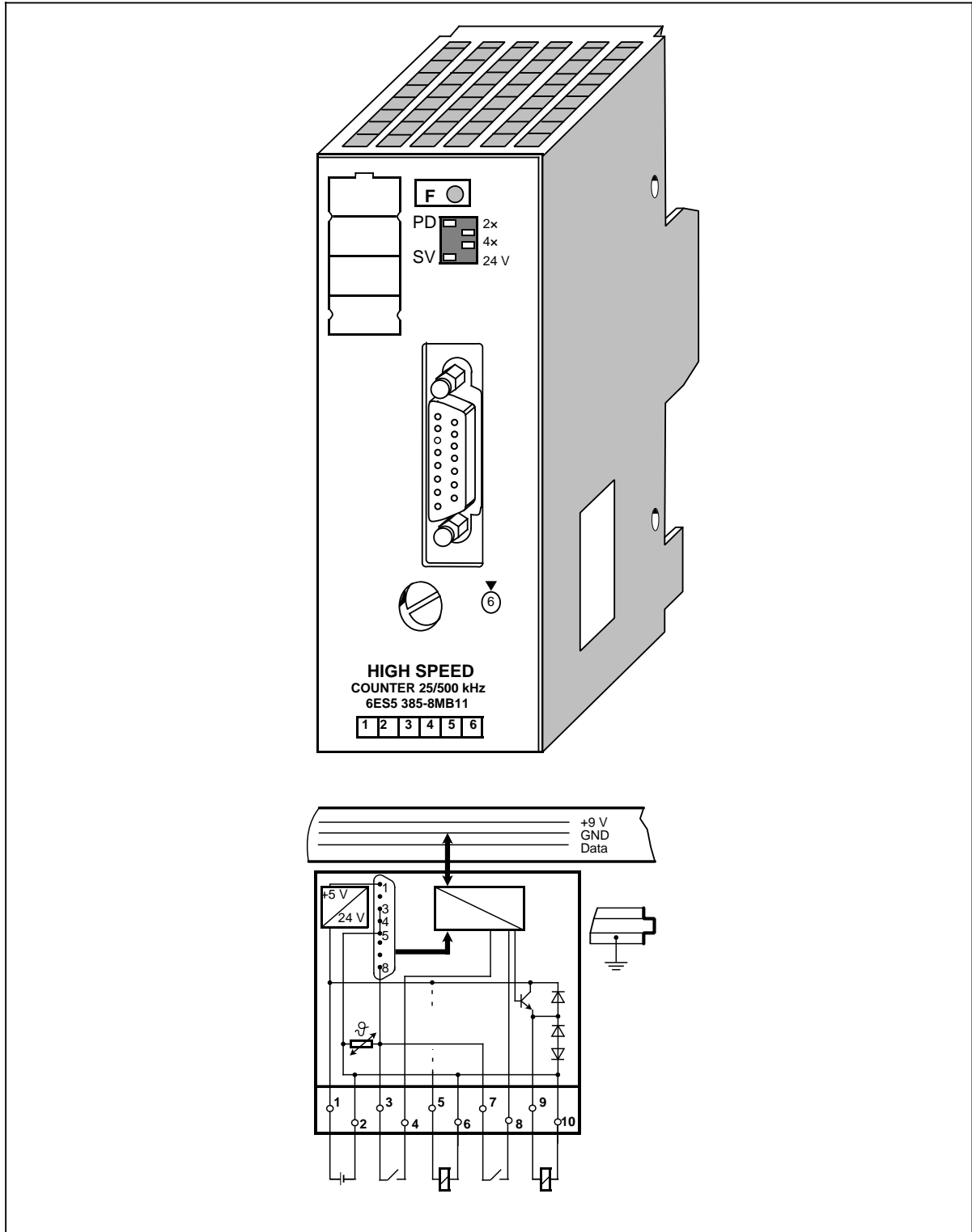
This has resulted in initial address 25.0 for the digital inputs and initial address 22.4 for the digital outputs.

A value of 100 is set on channel "0" of this module via the three numerical setters. The incoming pulses are counted once the counter has been enabled by the control program. As soon as 100 pulses have been counted, a signal (output 4.0) is to be given.



7.5 Counter Module 25/500 kHz

(6ES5 385-8MB11)



Counter Module 25/500 kHz

Technical Specifications			
Address designation (for ET 100U only)	2AX	Power supply for decoder	24 V from L+ (PTC thermistor)
Operating mode (switch-selectable)		Output current	max. 300 mA, short-circuit-proof
- position decoder	PD	Digital Inputs	reference and enabling
- counter	C	Rated input voltage	24 V DC
Decoder inputs	1 decoder 5 V (differential input) or 1 decoder 24 V DC	Input voltage	
Digital inputs	2; reference and enabling	- "0" signal	- 33 to +5 V DC
Digital outputs	2; setpoints reached 1 and 2	- "1" signal	+13 to 33 V DC
Galvanic isolation	no	Rated input current for "1" signal and at 24 V	typ. 8.5 mA
Counting range		Input frequency	max. 100 Hz
Operating mode		Inherent delay	typ. 3 ms (1.4 to 5 ms)
- position decoder	two's complement (KF) - 32768 to +32767	Cable length (unshielded)	max. 100 m (330 ft.)
- counter	unipolar representation (KH) 0 to 65535	Short-circuit protection (cable impedance up to 15)	
Counting mode		Digital Outputs	setpoints 1 and 2
- position decoder	forwards/backwards	Output current (resistive, inductive load)	5 mA to 0.5 A
- counter	up	Residual current for "0" signal	max. 0.5 mA
Setpoint input	via program	Switching current for lamps	0.22 A (5 W)
5-V Decoder Input	15-pin Cannon sub-miniature D connector	Limitation of inductive interrupting voltage	to -15 V
Input signals	differential signals to RS 422	Output voltage	
- position decoder	A A-N, B B-N, R R-N	- "1" signal	min. L+ - 2.2 V
- counter	A A-N	- "0" signal	max. 3 V
Counting frequency	max. 500 kHz	Cable length (unshielded)	max. 100 m (330 ft.)
Cable length (shielded)	max. 50 m (165 ft.)	Short-circuit protection (cable impedance up to 15)	electronic
Power supply for decoder	5 V from L+ via voltage transformer	Short-circuit indication (short-circuit to M)	red LED
Output current	max. 300 mA, short-circuit-proof	Supply voltage L+	
24-V Decoder Input	15-pin Cannon sub-miniature D connector	- rated value	24 V DC
Rated input voltage	24 V DC	- ripple V_{pp}	max. 3.6 V
Input signals		- permissible range (including ripple)	20 to 30 V DC
- position decoder	A, B, R	Fuse (internal)	T 5 A
- counter	A	Current consumption	
Input voltage		- from L+ without decoder supply	30 mA
- "0" signal	- 33 to 5 V DC	without load	
- "1" signal	+13 to 33 V DC	- internal (+9 V)	70 mA
Rated input current for "1" signal	typ. 8.5 mA	Power consumption of the module	typ. 1.9 W + total output current (I_A) × 1.1 V
Counting frequency	max. 25 kHz	Weight	approx. 250 g (9 oz.)
Cable length (shielded)	max. 100 m (330 ft.)		

Function

The counter module contains a counter and can be used as an upcounter or as an up / down counter for position decoding.

- The sensor is connected to the module by means of the 15-pin Cannon subminiature D connector.
- Pulses can be counted as 5V difference voltages to RS 422 up to 500 kHz or as 24 V DC signals up to 25 kHz.
- The module has an Enable input and a Reference input (24V).
- The control program can transfer two setpoints to the module.
- The current count, the diagnostic byte and any changes in the setpoints can be examined by the control program during operation.
- When a setpoint is reached, the associated output on the 24 V DC terminal block (Q 0 or Q 1) is routed through and the status flagged into the diagnostic byte.

The outputs can be used, for example, for positioning operations in order to change over from rapid traverse to creep speed and stop.

The mode, position resolution and input voltage range of the sensors are set on the Mode selector.

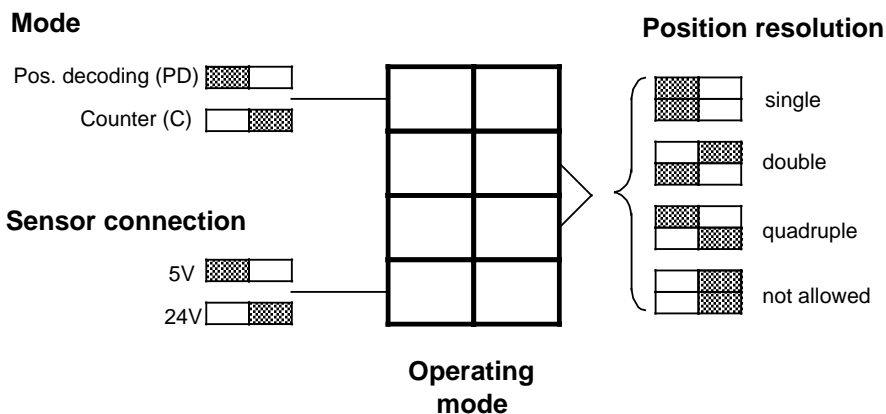


Figure 7-7 Settings on the "Mode" Selector

Please refer to 7.5.2 for a detailed functional description.

7.5.1 Installation Guidelines

Installation

- The counter module is plugged into a bus unit like any other input or output module (3.1.1).
- The module has a mechanical coding key. The coding "lock" on the bus unit should be set to number 6.

Wiring

See basic circuit diagram (7.5)

Assignment of Inputs on the Terminal Block

Two-wire BERO proximity limit switches can be connected to the reference input. The enable input can also be driven by a 24 V DC digital output module.

Outputs on the Terminal Block

There are two current-limited 24 V DC digital outputs on the terminal block.

Short-circuit Indication

A shorted output is indicated by the red LED on the frontplate.

Connection of Pulse and Position Sensors

These sensors should be connected on the frontplate by means of a 15-pin Cannon subminiature D connector. The connecting cables can be seen from the list of accessories. The module can power the sensors (5 V or 24 V) in this way. Basically, all sensors conforming to the requirements of the system signals and supply voltage can be connected. Sensors with OPEN-COLLECTOR outputs cannot be connected to the module.

The shield terminal of the sensors must be in contact with the metallic front collector cover.

P switches (contacts, two-wire BERO proximity limit switches) can be connected to the inputs on the terminal block.

Pin Assignments of the 15-pin Cannon Subminiature D Connector

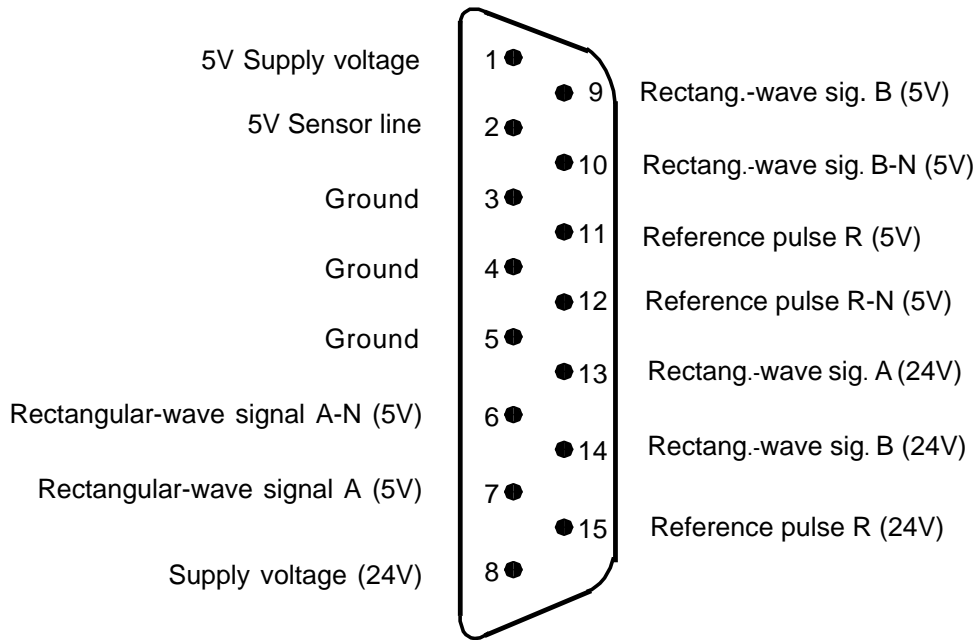


Figure 7-8 Pin Assignments of the 15-pin Cannon Subminiature D Connector

Terminal Assignments of the Terminal Block

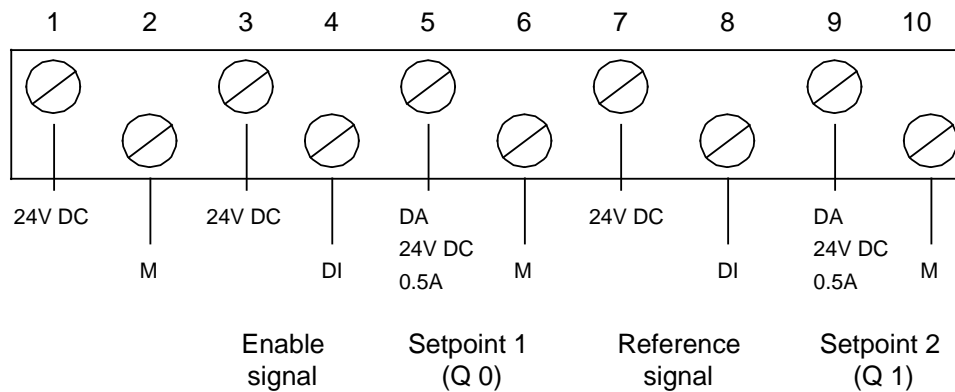


Figure 7-9 Terminal Assignments on the Terminal Block

Connecting Counting Pulse Sensors for 5V Differential Signal to RS 422

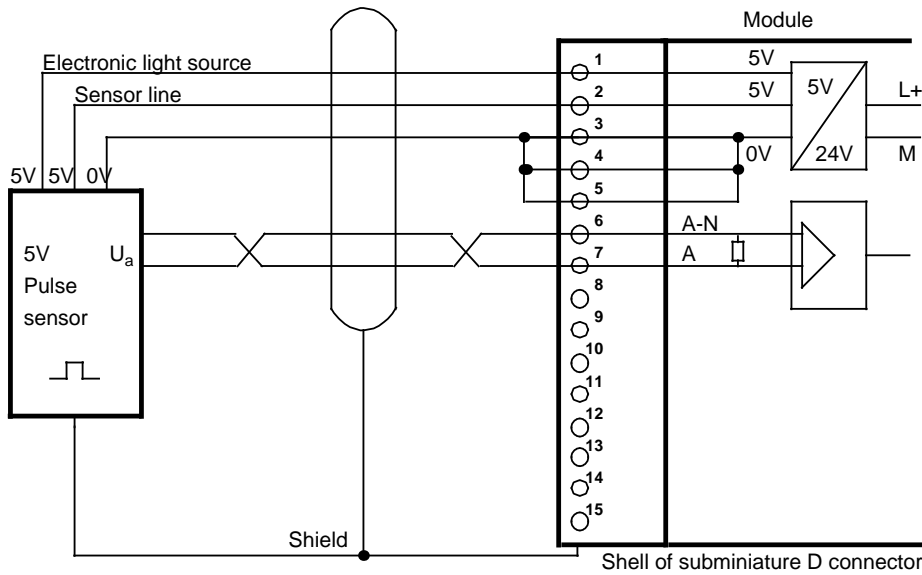


Figure 7-10 Connecting a Counting Pulse Sensor for 5V Differential Signal to RS 422

Connecting a Counting Pulse Sensor for 24V DC

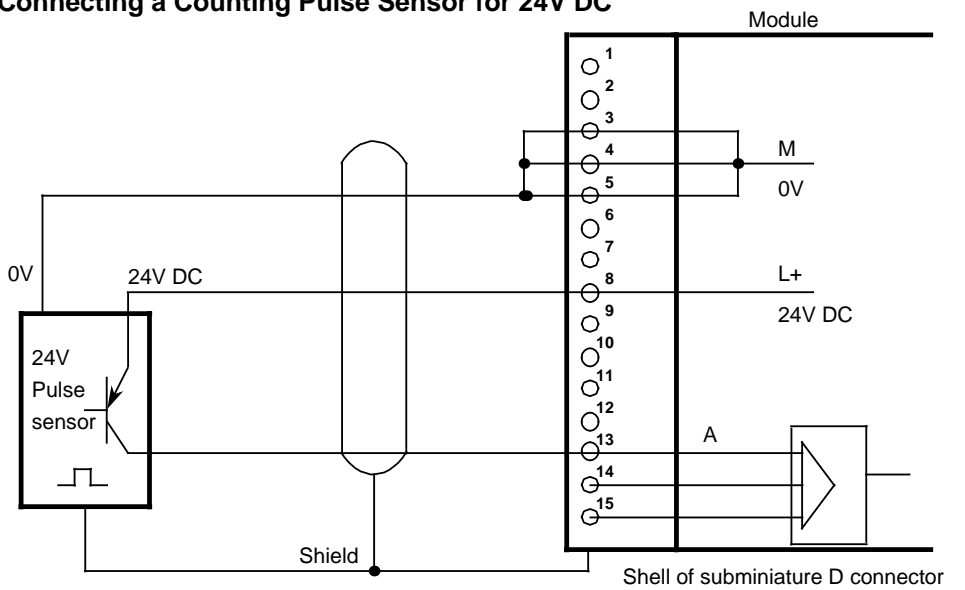


Figure 7-11 Connecting a Counting Pulse Sensor for 24 V DC

Connecting a 5V Position Sensor to RS 422

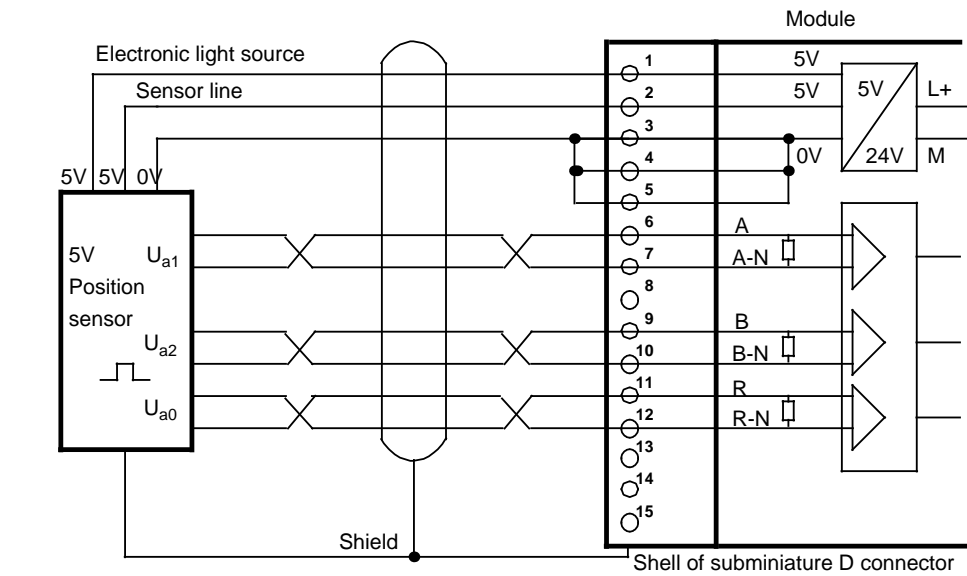


Figure 7-12 Connecting a 5V Position Sensor to RS 422

Connecting a 24V DC Position Sensor

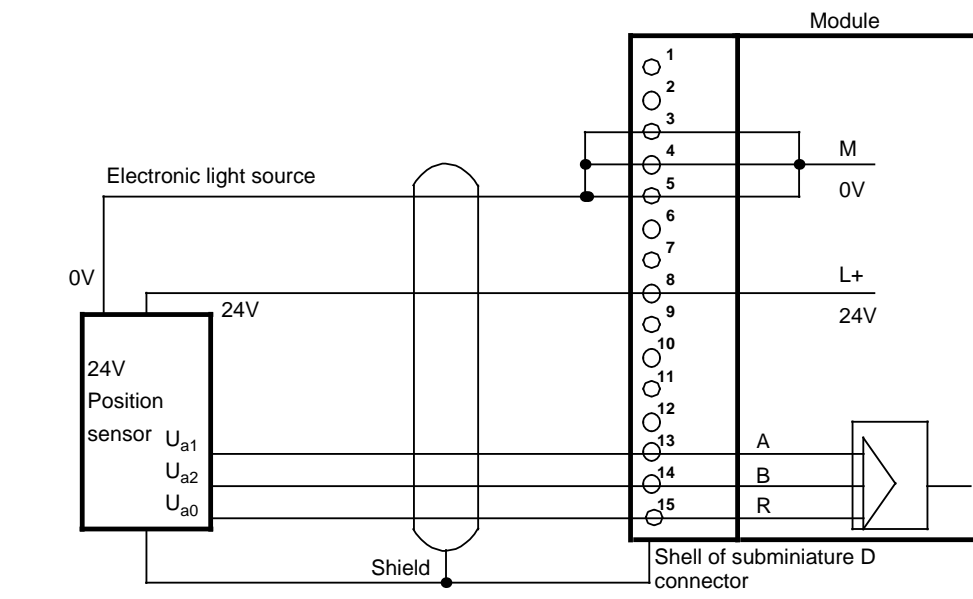


Figure 7-13 Connecting a 24V DC Position Sensor

7.5.2 Practical Notes

The load voltage and the 318-8 interface module must be disconnected before withdrawing or plugging in the module or the 15-pin Cannon subminiature D connector.

"Counter" Mode

- Default settings

The following settings are made on the Mode selector:

- "Counter" (C) mode and
- 5V or 24V counting pulse signal level.

The position of the switches for position resolution is irrelevant.

- Type of counting pulses

The counting pulses can be made available as 5V differential signals to RS 422 (up to 500 kHz) or as 24V signals (up to 25 kHz).

- Enabling/setting and disabling the counter

The counter is set to zero and the outputs reset by a positive pulse edge at the enable input. The counter is enabled.

A negative pulse edge at the enable input disables the counter. The outputs and counter are not reset. It is possible to continue to read the current counter contents.

- Counting

The counter counts the positive-going edges of the pulses.

It functions as an upcounter.

- Loading setpoints

The program can transfer two setpoints to the module (7.5.4). These setpoints must lie between 0 and 65535.

The "Setpoint 1 (setpoint 2) reached" bit in the diagnostic byte must be set if the module is to accept these setpoints.

If this bit is not set (existing setpoint not reached or exceeded), the new setpoint is immediately taken over and is valid from that point on.

If the bit is set (the existing setpoint has been reached or exceeded), the new setpoint is not accepted until a positive edge occurs at the enable input.

- Reaching the setpoints (setting the outputs)

When setpoint 1 has been reached, output Q 0 switches and when setpoint 2 is reached output Q 1 switches.

Note: If there is no setpoint loaded, the value "0" applies. The associated output then switches accordingly at counter reading "0".

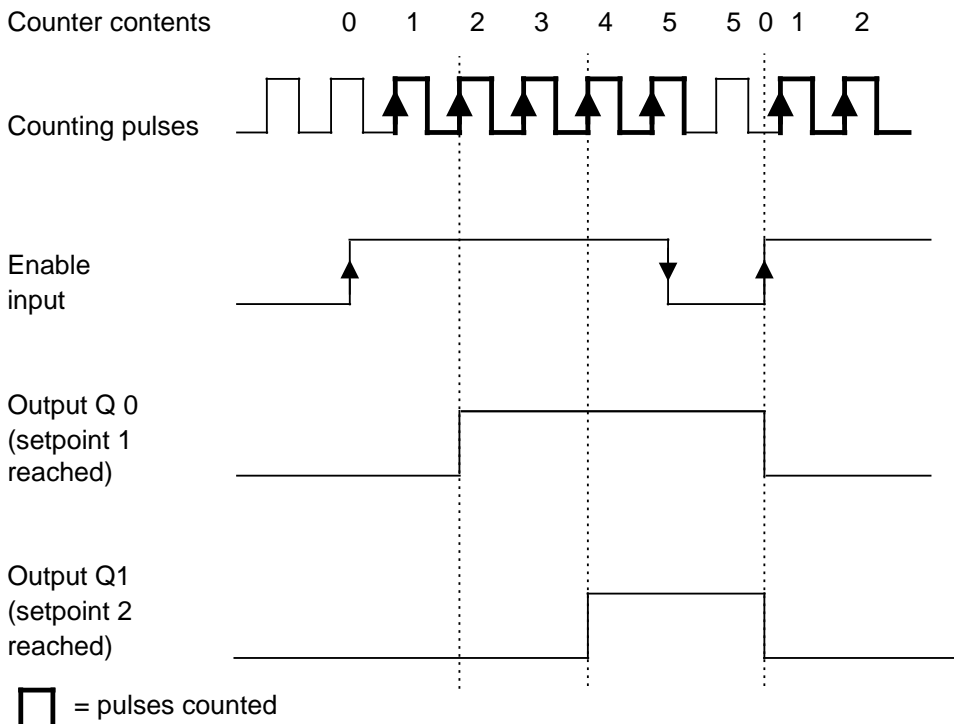


Figure 7-14 Timing Diagram for the "Counter" Mode

"Position Decoding" Mode

- Default settings

The following settings are made on the Mode switch:

- "Position decoding" (PD) mode,
- the desired position resolution, single, double or quadruple, and
- the signal level of the counting pulses (5V or 24V).

- Reference approach

A reference approach is always mandatory

- after the power supply has been switched on or restored
- after a counter overflow.

Please refer to 7.5.3 for a functional description of the reference approach.

- Type of counting pulses

The following are required:

- two counting pulses displaced by 90 degrees and
- a reference pulse of an incremental position encoder

The counting pulses and reference pulse can be made available as 5V differential signals to RS 422 (up to 500 kHz) or as 24V DC signals.

- Starting the counter

The counter is reset and started by setting the synchronizing bit in the diagnostic byte during the reference approach (7.5.3).

The counter counts both up and down.

- Loading setpoints

The control program can transfer two setpoints to the module (7.5.4). These setpoints must lie between - 32768 and +32767.

The "Setpoint 1 (setpoint 2) reached" bit in the diagnostic byte must be set in order for the module to accept the setpoints.

If this bit is not set (existing setpoint not reached or exceeded), the new setpoint is immediately taken over and is valid from that point on.

If the bit is set (the existing setpoint has been reached or exceeded), the new setpoint is not accepted until a positive-going edge occurs at the enable input.

- Reaching setpoints (setting the outputs)
 The outputs are enabled by a "1" signal at the enable input and disabled by a "0" signal at that input.

Outputs may only be enabled after a reference approach has been carried out.

When setpoint 1 has been reached, output Q 0 switches and when setpoint 2 is reached output Q 1 switches.

Note: If there is no setpoint loaded, the value "0" applies.
 The associated output then switches accordingly at counter reading "0".

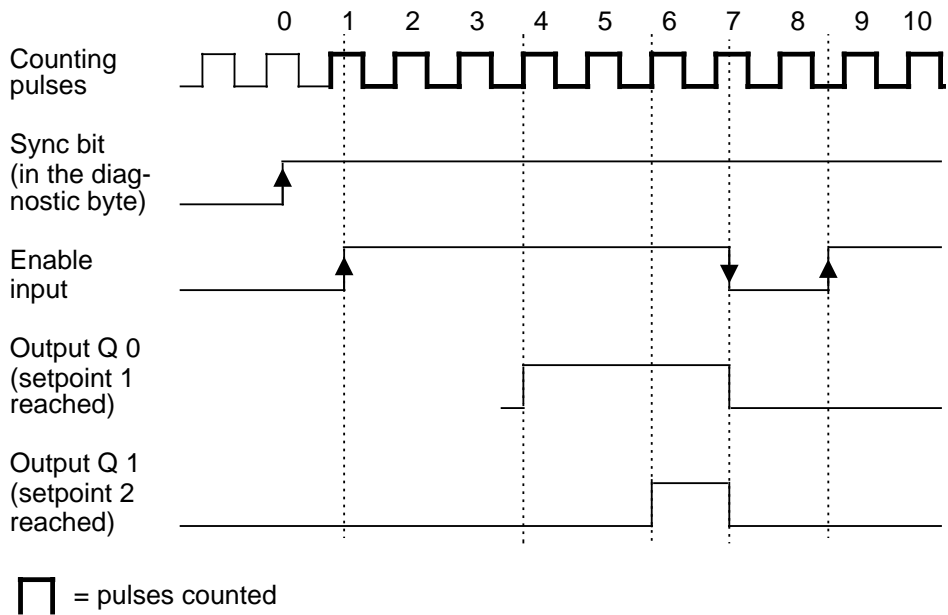


Figure 7-15 Setting and Resetting the Outputs in the "Position Decoding" Mode

7.5.3 Functional Description

Data Transfer Between the CPU and the Counter Module

The data is transmitted via the I/O bus to the 318-8 interface module and from there via the serial bus and the 308-3 interface module to the CPU in the higher-level central controller. Four bytes are used. Examples of data transfer are shown in 7.5.4.

- Data from the counter module to the CPU (PII)
The counter module sends the diagnostic byte and the current count. This data can be loaded by means of load operations in the control program and then evaluated.

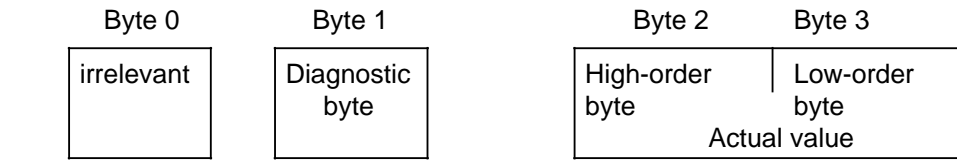


Figure 7-16 Transmitting Data from the Counter Module to the CPU

- Data from the CPU to the counter module (PIQ)
The control program transfers two setpoints to the counter module by means of transfer operations.

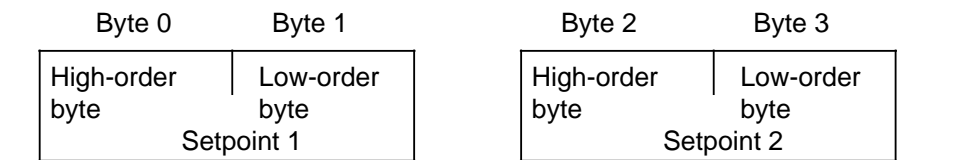
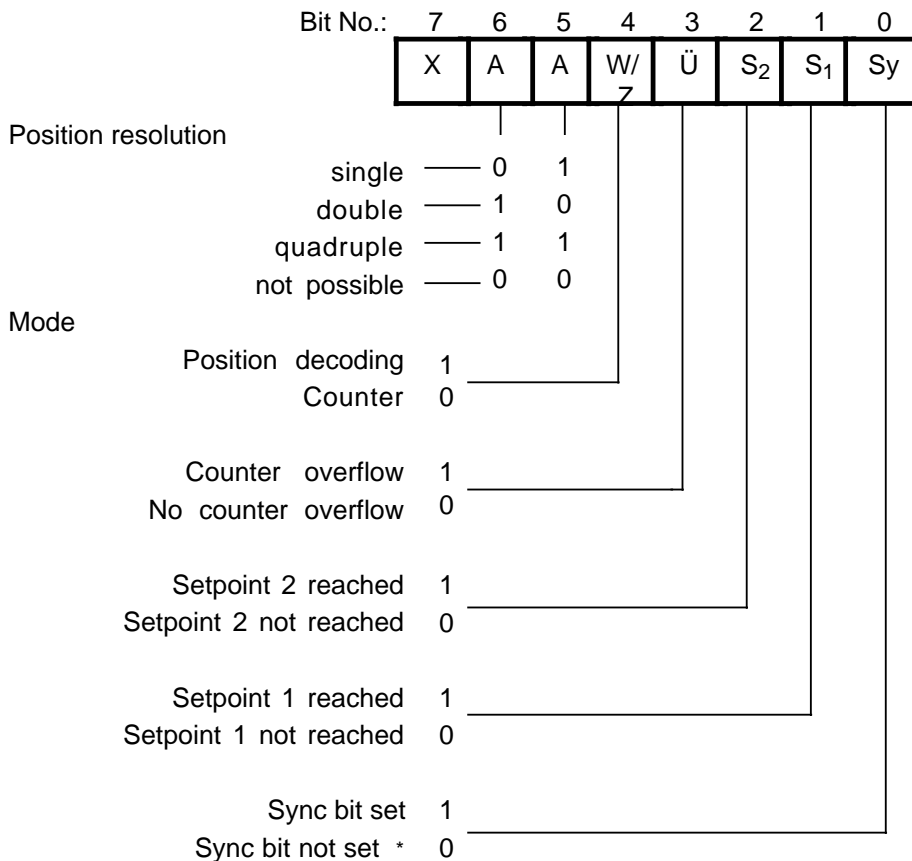


Figure 7-17 Sending Data from the CPU to the Counter Module

Diagnostic Byte

The diagnostic byte is byte 1 of the first input word. Byte 0 has no significance. The diagnostic byte provides information on the following:

- Preset position resolution
- Preset mode
- The reaching of setpoints
- Signal status of the sync bit for position decoding



X = irrelevant

* If the sync bit is not set, a reference approach must be implemented before operation can continue in the "Position decoding" mode.

Figure 7-18 Diagnostic Byte

Reference Approach (necessary only for the "Position Decoding" Mode)

- Function

The reference approach defines a position reference point for calibration purposes.

- Prerequisites

In addition to the counting pulses, the position encoder must also supply a reference pulse. An incremental position encoder, for example, supplies a reference pulse after every 500 counting pulses.

In addition to this, you also require the reference signal of a reference encoder. This may be, for example, a two-wire BERO proximity switch in the traversing path.

- Implementation

1. Connect the position encoder to the module, using the 15-pin Cannon subminiature D connector.
2. Connect the reference encoder to the reference input on the terminal block.
3. Move or rotate the position encoder in the counting-up direction until a reference pulse is produced following a reference signal (positive-going edge) of the reference encoder.
4. The position sensing system is now synchronized and the counter can be set to zero and started.

Scanning the synchro bit in the control program tells you whether the reference approach has been carried out (successfully) or not.

Outputs may not be enabled until a reference approach has been successfully carried out. (Sync bit in the diagnostic byte = "1")

Example: Transporting objects from point A to point B on a conveyor belt.
 A rotary position encoder is used, together with a BERO proximity switch as reference transmitter. The conveyor belt is marked at a definite point. As soon as this mark comes within the range of the BERO, the latter produces a reference signal.
 Following the reference point approach, the enable input is set via a digital output module.

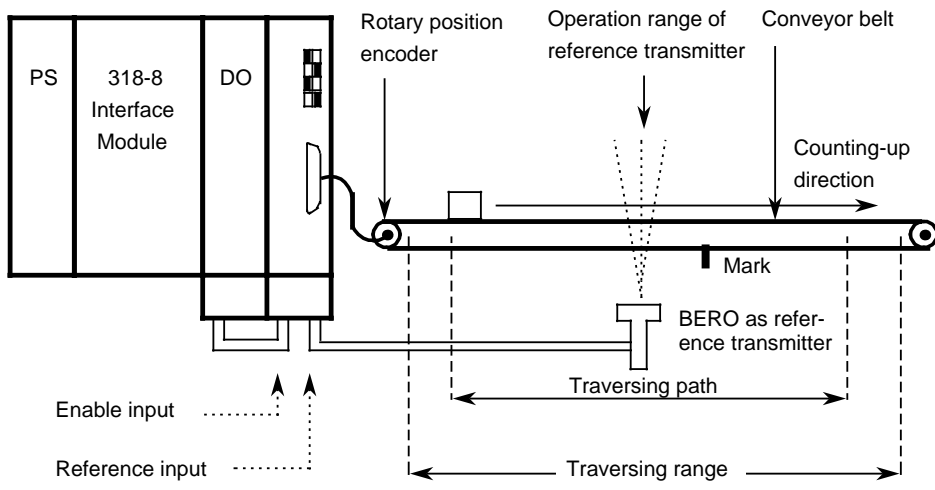
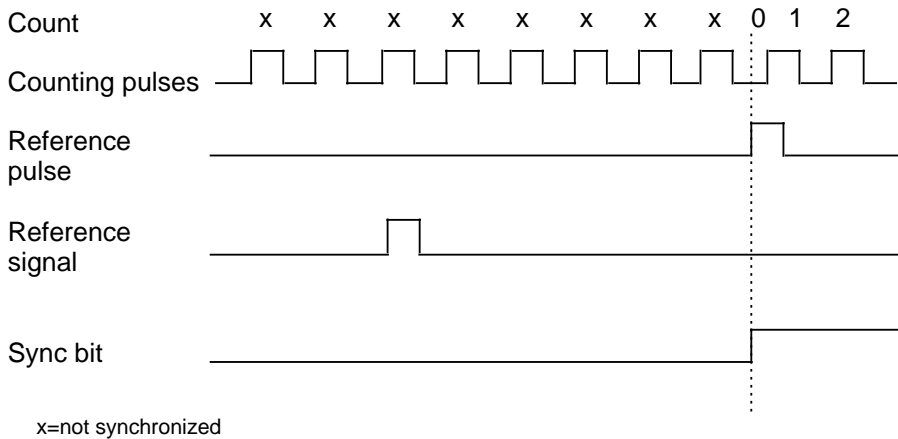


Figure 7-19 Schematic of a Reference Point Approach Operation



x=not synchronized

Figure 7-20 Timing Diagram of a Reference Point Approach Operation

Pulse Evaluation (for "Position Decoding" Mode only)

- Counter capacity

The 16-bit up-down counter permits a resolution of 65536 units between -32768 and +32767. The traversing range depends on the resolution of the position encoders.

- Pulse evaluation

The counting pulses, which are displaced by 90 degrees, can be subjected to single, double or quadruple evaluation. The necessary setting is made on the Mode switch (7.5).

Depending on whether double or quadruple pulse evaluation is used, the accuracy of the traversing path increases. However, the traversing range then available is reduced by the factor 2 or 4.

Table 7-1 Pulse Evaluation

	Single evaluation	Double evaluation	Quadruple evaluation
Counting pulse A Counting pulse B			
Count	0 1	0 1 2	0 1 2 3 4

Example:

A rotary incremental position encoder produces 1000 pulses per revolution. The spindle has a pitch of 50 mm/revolution. The position encoder therefore produces 1000 pulses for a traversing path of 50 mm (1 revolution). The revolution of the encoder is therefore 50 mm/1000 pulses.

The counter can handle up to 65536 pulses. With the above resolution, the following traversing ranges are obtained:

Table 7-2 Example for a Traversing Range

Pulse evaluation	Single	Double	Quadruple
Traversing range	3.25 m	1.625 m	0.81 m
Distance travelled/ pulse	50 µm	25 µm	12.5 µm

Representation of Setpoints and Actual Values

- "Counter" mode
Analog value representation: unipolar

Table 7-3 Analog Value Representation in "Counter" Mode

Setpoint/ actual value	Byte 0 (High)								Byte 1 (Low)							
	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
	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
>65535 *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
65535	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32768	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32767	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4096	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
4095	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
256	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
255	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

X = Bit can assume the value 0 or 1. The counter continues to count.

* The overflow bit in the diagnostic byte is set to "1".

- "Position decoding" mode
 Analog value representation: Bipolar fixed-point number

Table 7-4 Analog Value Representation in the "Position Decoding" Mode

Setpoint/ Actual Value	Byte 0 (High)								Byte 1 (Low)							
	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
	S	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
>32767 *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
32767	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4096	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
4095	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
256	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
255	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
-255	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1
-256	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
-4095	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
-4096	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
-32767	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
-32768	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<-32768 *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

X = Bit can assume the value 0 or 1 (counter continues to count).

S = Sign

* The overflow bit in the diagnostic byte is set to "1". Outputs Q 0 and Q 1 are disabled.

7.5.4 Addressing

The 25/500 kHz counter module can be addressed in the same way as a two-channel analog input or output module (code: 2 AX). When assigning setpoints 1 and 2, the module is referenced in the same way as an analog output module. The diagnostic and actual value bytes are scanned in the same way as an analog input module.

It is therefore necessary that, when assigning addresses for the counter module using COM ET 100, you reserve addresses both for analog inputs and outputs. This can frequently produce different initial addresses for inputs and outputs (Figure 7-21).

The counter module is referenced with load and transfer operations byte-wise or word-wise.

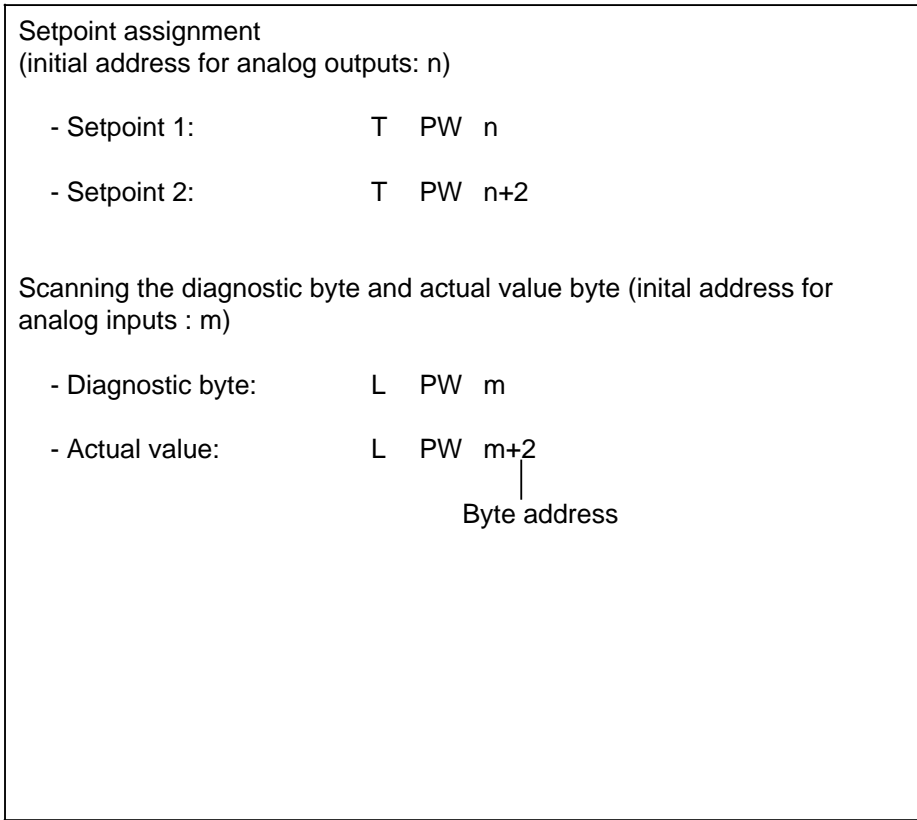


Figure 7-21 Scanning the Counter Module (25 / 500 kHz)

Examples for Data Interchange between the CPU and the Counter Module

- 1) The counter module (25/500 kHz) is mounted in an ET 100U. Address assignment using COM ET 100 has resulted in the initial address 136 for the analog inputs.

If you now wish to check whether your system for position decoding has been synchronized by a reference point approach, you must scan the sync bit in the diagnostic byte (bit 0). If this bit is set, a branch is to be made to FB 20. The position decoding operation is started in FB 20.

STL	Explanation
<pre> ... A I 137.0 JC FB 20 ... </pre>	<p>Read in bit 0 of the diagnostic byte (sync bit). If this bit is set, a branch is made to FB 20. If the bit is not set, program scanning is continued with the statement following the block call.</p>

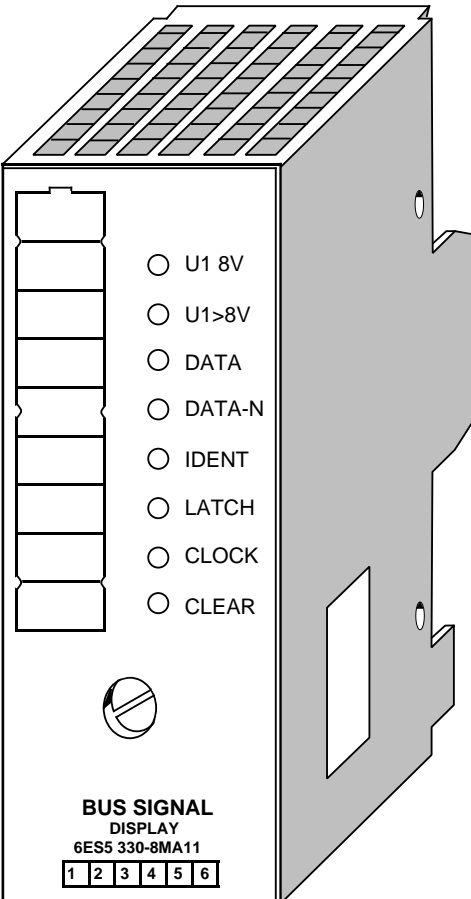
- 2) The counter module (25/500 kHz) is mounted in an ET 100U. When assigning addresses with COM ET 100, you have reserved addresses for both analog inputs and outputs. This has resulted in an initial address of 132 for the analog inputs and 138 for the analog outputs.

The setpoints stored in flag words 0 and 2 are to be transferred to the counter module (25/500 kHz). The module has only to accept the setpoints when the old setpoints have been reached or exceeded (setpoint 1(2) reached bit 1 (2) in diagnostic bit set).

STL		Description
...		
	AN I 133.1	If setpoint 1 has not yet been reached (bit 1=0), a branch is made to label 1. Read in setpoint 1 and transfer it to the counter module
	JC= M001	
	L FW 0	
	T QW 138	
M001	AN I 133.2	If setpoint 2 has not yet been reached (bit 2=0), a branch is made to label 2. Read in setpoint 2 and transfer it to the counter module
	JC= M002	
	L FW 2	
	T QW 140	
M002	BE	Block end
...		

7.6 Diagnostic Module

(6ES5 330-8MA11)

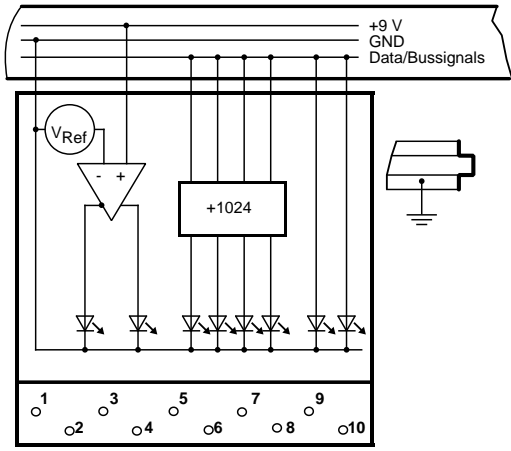


U1 8V
 U1>8V
 DATA
 DATA-N
 IDENT
 LATCH
 CLOCK
 CLEAR

BUS SIGNAL DISPLAY
6ES5 330-8MA11
1 2 3 4 5 6

Technical Specifications

Rated insulation voltage (+9 V to $\bar{\text{E}}$)	12 V AC
- insulation group	1xB
- tested with	500 V AC
Voltage monitor	
- undervoltage	red LED
- voltage ok	green LED
Signal status display for control signals	
	yellow LEDs
Current consumption	
- from +9 V (CPU)	25 mA
Power loss of the module	
typ.	0.3 W
Weight	approx. 175 g (6.1 oz.)



+9 V
GND
Data/Bussignals

+1024

V_{Ref}

1 2 3 4 5 6 7 8 9 10

Function

The diagnostic module is used for monitoring the S5-100U I/O bus. LEDs on the frontplate display the signal states of the control lines and the supply voltage for the I/O bus.

- IDENT

The programmable controller executes an IDENT run after each change from STOP to RUN mode and after any changes in the configuration in order to determine the current configuration of the programmable controller. The "IDENT" LED lights up briefly.

If the LED lights up in the "RUN" mode, this indicates that a faulty I/O module has been plugged in.

- CLEAR

The CLEAR signal line is only "1" in the "STOP" mode in normal operation.

The outputs of the output modules are disabled.

If CLEAR is "1" in the "RUN" mode, the control line itself may be defective (no contact).

- LATCH/CLOCK

These two control lines control data interchange between the CPU, the I/O bus and the I/O modules.

In normal operation, both LEDs must flash (programmable controller in RUN mode).

The flashing frequency provides information on the speed of the serial bus. In the case of the CPU 102, the LEDs flash much more slowly in Test mode than in Normal mode.

If both LEDs show a steady light in the RUN mode, the bus unit into which the diagnostic module is plugged is defective.

- DATA/DATA-N

The alternate lighting up of the DATA and DATA-N LEDs indicates data flow on the I/O bus.

If these two LEDs show a steady light (as in the case of the LATCH and CLOCK LEDs), this indicates that the bus unit into which the diagnostic module is plugged is defective.

- $U_1 < 8V$

If the supply voltage of a slot remains at a value $U_1 < 8V$, proper functioning of the I/O modules is no longer guaranteed. The low supply voltage can be explained by an excessively high bus load ($> 1 A$).

If this LED flickers, noise pulses are superimposed on the supply voltage U_1 (e.g. by the coupling of noise pulses).

The LED lights up briefly if the 318-8 interface module is switched on or off.

- $U_1 > 8V$

The supply voltage of the I/O bus is O.K.

Installation

The diagnostic module is plugged into a bus unit like any other input or output module (3.1.1). The module has no mechanical coding and the coding element on the bus unit need not be reset.

The module can be plugged in and withdrawn regardless of the operating status of the programmable controller.

Wiring

No wiring is required. Existing wiring need not be removed.

Addressing

There is no addressing since the module cannot be referenced from the 318-8 interface module.

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8 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 characteristics 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 of 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.

8.1 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 measures taken to prevent failures, there is no such thing as 100% reliability.

The failure rate is a measure of the reliability:

$$= \frac{1}{N_0} \cdot \frac{dn}{dt} \quad \text{and} \quad \begin{array}{l} n = \text{Number of failures during time } t \\ N_0 = \text{Remaining components} \end{array}$$

8.1.1 Failure Characteristics of Electronic Devices

The failure-rate-versus-time curve can be broken down roughly into three periods of time.

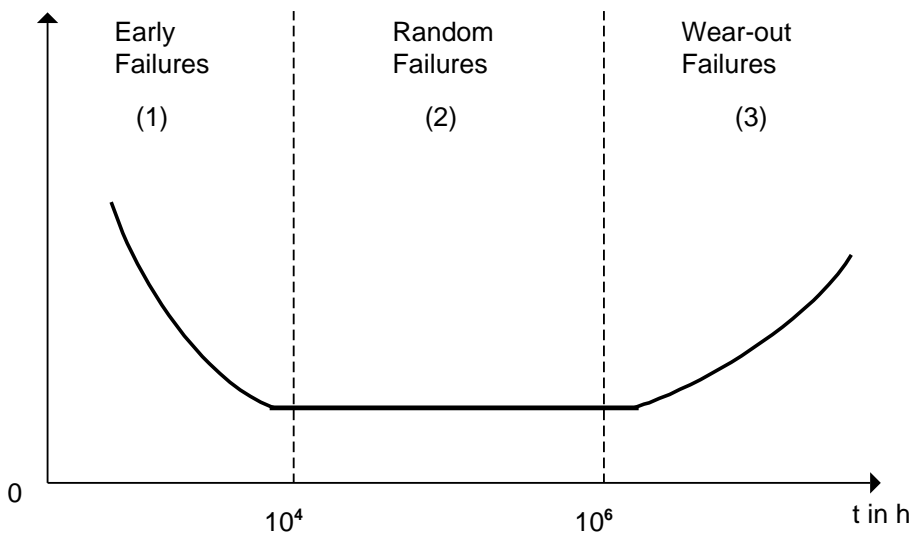


Figure 8-1 Failure Characteristics of Electronic Devices ("Bathtub" Curve)

- (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 phase is characterized by a constant failure rate. Provided the systems are used in accordance with the 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.

8.1.2 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-run 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.

8.1.3 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 distributed approximately as follows:

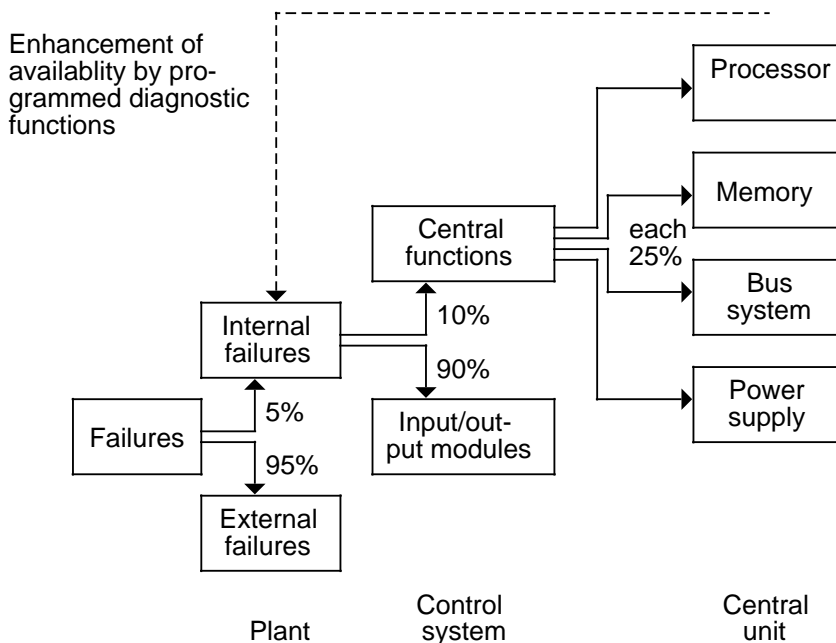


Figure 8-2 Distribution of Failure Occurrences in Installations Incorporating Programmable Controllers

- 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.

8.2 Availability

Availability "V" is the probability of finding a system in a functional state at a specified point in time.

$$V = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

MTBF= Mean Time Between Failures;
 MTTR= Mean Time To Repair;

Ideal availability, i.e. $V=1$, can never be attained owing to the residual failure probability that always exists.

However, it is possible to get near this ideal state by using, for example, voter systems. Such systems include the following.:

- Standby systems
- 2-out-of-3 voter systems
- Multi-channel voter systems with mutual check functions (for maximum safety requirements).

Availability can also be enhanced by reducing the mean time to repair. 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.

8.3 Safety

8.3.1 Types of Failure

The nature of a failure is 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"

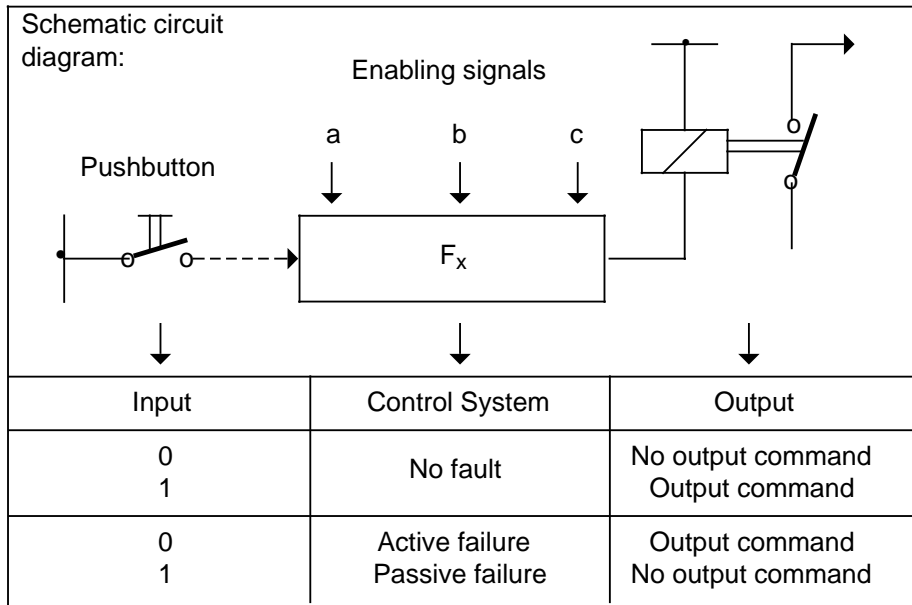


Figure 8-3 Control of Function "F_x"

Depending on the job a control system has to do, active or passive failures can also be fatal faults.

Examples:

- In a drive control system, an active failure results in the unauthorized starting of the drive.
- In an indicating system, a passive fault can be fatal since it blocks the indication 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 failures 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 observed.

8.3.2 Safety Measures

Single-Channel Configurations

In the case of single-channel programmable controllers, the means available for enhancing safety are limited:

- Programs or parts of programs can be stored and executed more than once.
- Outputs can be monitored per software by a 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 satisfy safety requirements, electronic control systems should be designed as redundant, i.e. multi-channel, systems .

- Two-channel control systems
Both "channels" monitor each other mutually and the output commands are evaluated on a "1-out-of-2" or "2-out-of-2" basis.
Suitable SIMATIC PLCs: S5-95F, S5-115F.
These PLCs consist of two subunits processing identical programs synchronously; two comparator modules monitor the operation of the PLC. Any faults are indicated and trigger the relevant safety-related functions.
- Multi-channel control systems
Further voter systems (e.g. on the 2-out-of-3 principle) can be implemented by adding further "channels".

8.4 Summary

- In electronic control systems, failures of any kind can occur at any point in 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 from 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 control system (hard-wired or programmable)
 - the vendor
 - the country of origin (Europe,US, etc.).

9

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