ABB

SYSTEM MANUAL

PLC Automation

Automation Builder, programmable logic controllers, control panels

Automation Builder, AC500 V3, AC500-eCo V3, AC500-XC V3, AC500-S, CP600, CP600-eCo, CP600-Pro

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1 Preface

1.1 Documentation guide

Where to find the latest information about:

- PLC system
    - Overall manual for PLC Automation

      Online help, *PDF*
    - System manual

      Online help, *PDF*
    - Getting started: First steps with the platform and creation of your first program

      Online help, *PDF*
    - Starter kit: Introduction to PLC programming and visualization, including all needed hardware components

      PDF
    - Safety user manual for safety PLCs

      PDF
- Devices
    - Data sheets

      PDF
    - Installation instructions

      PDF
    - PLC hardware descriptions

      Online help, *PDF*
    - Safety user manual for safety PLCs

      PDF
    - Control panels

      PDF
- Software and programming
    - Configuration and programming

      Online help, *PDF*
    - Programming examples available for download

      PDF
    - Programming examples available in the engineering suite: Open Automation Builder menu *"Help ➔ Project examples"*
    - Application descriptions for specific features and use cases

      PDF
    - Release notes for the latest version of the engineering suite Automation Builder

      PDF

1.2 Do I use AC500 V2 or AC500 V3?

This document describes AC500 V3 products.

We offer different ranges of the processor modules (V2, V3). You can easily find out which ones are used in your system. Either have a look at your used modules or your configuration.

Fig. 1: Hardware: Processor modules

Written type on the module	Example	Range	Relevant manual
Processor module type PM + **3 digits**	PM595	V2	*AC500 V2*
Processor module type PM + **4 digits**	PM5670	V3	AC500 V3 (this manual)
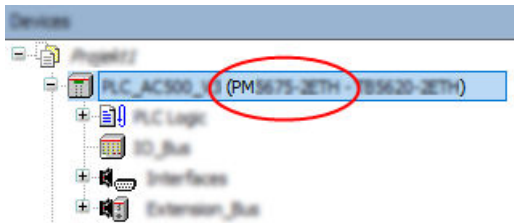
Fig. 2: Software: Configuration in engineering software Automation Builder

Written type in brackets	Example	Range	Relevant manual
Processor module type PM + **3 digits**	PM595	V2	*AC500 V2*
Processor module type PM + **4 digits**	PM5670	V3	AC500 V3 (this manual)

1.3 Regulations

Planning and installation of the electrical system

The planning and installation of the electrical system must be carried out in compliance with the applicable regulations and standards. Hazards due to malfunctions must be prevented by taking appropriate measures.

The suitability of the products for the respective application is proven by declarations of conformity and certificates.

The PLC Automation catalog contains an *overview of the available declarations of conformity and certificates*.

Qualified personnel

Both the AC500 control system and other components in the vicinity are operated with dangerous touch voltages. Touching live components can lead to serious health implications or even death.

To avoid such risks and the occurrence of property damage, persons involved in the installation, commissioning and maintenance must have relevant knowledge about the following:

- Automation technology
- Handling of hazardous voltages
- Application of relevant standards and regulations, accident prevention regulations and regulations on special environmental conditions (e.g., hazardous areas due to explosive substances, heavy soiling or corrosive influences).

1.4 Older revisions of this document

You can always find all revisions of our documents on our website.

System manual

Revisions	Select any of the revisions
Latest revision	Get a link to the latest revision
This revision	Get a direct link to the selected revision

1.5 Use the "magic button" to display your current position in the table of contents

☑ Documentation is opened in a PDF reader. PDF readers often provide a button to synchronize with the table of contents. Usually, you can find the "magic button" in the bookmarks tab. For example, it looks like this: 🔖 / 🔖

▷ Select the "magic button".

⇨ Your current position will be highlighted in the bookmark tab.

1.6 Structure of safety notices

Throughout the documentation we use the following types of safety and information notices. They make you aware of safety considerations or give advice on AC500 products usage.
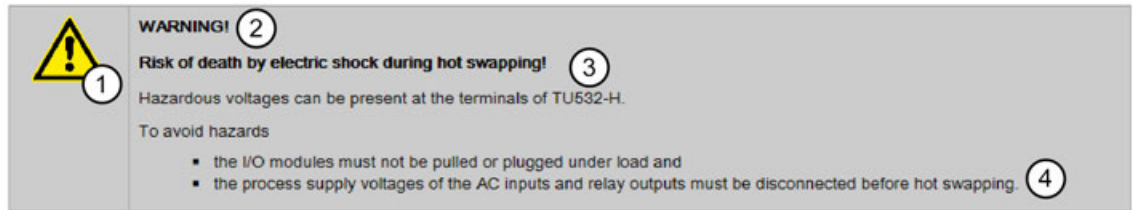
1   **Safety alert symbol** indicates the danger.
2   **Signal word** classifies the danger.
3   **Type and source of the risk** are mentioned and **possible consequences** are described.
4   **Measures to avoid these consequences** (enumerations).

Signal words

DANGER!

DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

Ensure to take measures to prevent the described impending danger.

WARNING!

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

Ensure to take measures to prevent the described dangerous situation.

CAUTION!

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

Ensure to take measures to prevent the described dangerous situation.

NOTICE!
NOTICE is used to address practices not related to physical injury but might lead to property damage for example damage of the product.

Ensure to take measures to prevent the described dangerous situation.

NOTE provides additional information on the product, e.g., advices for configuration or best practice scenarios.

2 Safety instructions

Relevant standards and regulations, accident prevention regulations and regulations on special environmental conditions must be observed (e.g., hazardous areas due to explosive substances, heavy soiling or corrosive influences).

The devices must be handled and operated within the specified technical data and system data.

The devices contain no serviceable parts and must not be opened.

Removable covers must be closed during operation unless otherwise specified.

Any liability for the consequences of incorrect use or unauthorized repairs is rejected.

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- Automation technology
- Handling of hazardous voltages
- Application of relevant standards and regulations, accident prevention regulations and regulations on special environmental conditions (e.g., hazardous areas due to explosive substances, heavy soiling or corrosive influences).

Functional safety

The AC500-S safety user manual must be read and understood before using the safety configuration and programming tools of Automation Builder/PS501 Control Builder Plus. Only qualified personnel are permitted to work with AC500-S safety PLCs.

AC500-S safety user manual

General information

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variants and requirements associated with any particular installation, ABB cannot assume responsibility or liability for actual use based on the examples and diagrams.

The PLC was developed according to the relevant standards. Any module-specific measures are described in the individual descriptions of the modules.

PLC-specific safety notices

> *The product family AC500 control system is designed according to the EN 61131-2 and IEC 61131-2 standards. Any data that differs from IEC 61131-2, is due to the higher requirements of Maritime Services. Other differences are described in the technical data description of the devices.*

> **!**
>
> **NOTICE!**
>
> **Avoidance of electrostatic charging**
>
> PLC devices and equipment are sensitive to electrostatic discharge, which can cause internal damage and affect normal operation.
>
> Observe the following rules when handling the system:
>
> – Touch a grounded object to discharge potential static.
> – Wear an approved grounding wrist strap.
> – Do not touch connectors or pins on component boards.
> – Do not touch circuit components inside the equipment.
> – If available, use a static-safe workstation.
> – When not in use, store the equipment in appropriate static-safe packaging.

> **!**
>
> **NOTICE!**
>
> **Use of suitable enclosure**
>
> The devices must be mounted in a control cabinet that ensures compliance with the specified environmental conditions.

> **i**
>
> *Cleaning instructions*
>
> *Do not use cleaning agent for cleaning the device.*
>
> *Use a damp cloth instead.*

Connection plans and a user program must be created so that no dangerous situations can occur during normal operation or failure.

The application must be tested to ensure that no dangerous situations can occur during operation.

> **i**
>
> *Do not operate devices outside of the specified, technical data!*
>
> *Trouble-free functioning cannot be ensured outside of the specified data.*

> **!**
>
> **NOTICE!**
>
> **PLC damage due to missing grounding**
>
> – Make sure to ground the devices.
> – The grounding (switch cabinet grounding) is supplied both by the mains connection (or 24 V supply voltage) and via the DIN rail. The DIN rail must be connected to ground before power is supplied to the device. The grounding may be removed only if it is certain that no more power is being supplied to the control system.
> – In case of screw mounting, use metal screws for grounding.

> **⚠**
>
> **CAUTION!**
>
> **Do not obstruct the ventilation for cooling!**
>
> The ventilation slots on the upper and lower sides of the devices must not be covered.

> **CAUTION!**
>
> **Run signal and power wiring separately!**
>
> Signal and supply lines (power cables) must be laid out so that no malfunctions due to capacitive and inductive interference can occur (EMC).

> **WARNING!**
>
> **Warning sign on the module!**
>
> This indicates that dangerous voltages may be present or that surfaces may have dangerous temperatures.

> **WARNING!**
>
> **Splaying of strands can cause hazards!**
>
> Avoid splayed strands when wiring terminals with stranded conductors.
>
> – Ferrules can be used to prevent splaying.

> **WARNING!**
>
> **Removal/Insertion under power**
>
> Removal or insertion under power is permissible only if all conditions for hot swapping are fullfilled.
>
> ✋ *Chapter 11.3 "Replace an I/O module with hot swap" on page 99*
>
> The devices are not designed for removal or insertion under power when the conditions for hot swap do not apply. Because of unforeseeable consequences, it is not allowed to plug in or unplug devices with the power being ON.
>
> Make sure that all voltage sources (supply and process voltage) are switched off before doing any of the following actions:
>
> – Connect or disconnect any signal or terminal block.
> – Remove, mount or replace a module.
>
> Disconnecting any powered devices while they are energized in a hazardous location could result in an electric arc, which could create an ignition source resulting in fire or explosion.
>
> Prior to proceeding, make sure that power is been disconnected and that the area has been thoroughly checked to ensure that flammable materials are not present.
>
> The devices must not be opened when in operation. The same applies to the network interfaces.

Information on batteries

> **CAUTION!**
>
> **Use only ABB approved lithium battery modules!**
>
> At the end of the battery's lifetime, always replace it only with a genuine battery module.

> **CAUTION!**
> **Risk of explosion!**
>
> Do not open, re-charge or disassemble lithium batteries. Attempting to charge lithium batteries will lead to overheating and can cause explosions.
>
> Protect them from heat and fire and store them in a dry place.
>
> Never short-circuit or operate lithium batteries with the polarities reversed. The batteries are likely to overheat and explode. Avoid unintentional short circuiting do not store batteries in metal containers and do not place them on metallic surfaces. Escaping lithium is a health hazard.

> *Environment considerations*
>
> *Recycle exhausted batteries. Dispose of batteries in an environmentally conscious manner in accordance with regulations issued by the local authorities.*

3 System overview

3.1 AC500 PLC product family

AC500 programmable logic controllers (PLCs) The AC500 (Standard), AC500-eCo, AC500-S and AC500-XC scalable PLC ranges provide solutions for small, medium and high-end applications. Our AC500 platform offers different performance levels and is the ideal choice for high availability, extreme environments or safety solutions. Our AC500 PLC platform offers interoperability and compatibility in hardware and software from compact PLCs up to high-end and safety PLCs.

Due to the flexible combinations of AC500 devices and components, AC500 PLCs can be used for controlling a wide variety of applications to fulfill your automation needs.

Features of AC500 PLCs

● Scalable and consistently expandable system
● Different performance classes of processor modules (CPUs) available
● Several fieldbusses available
● Parallel connection to several fieldbusses which can be combined arbitrarily

The AC500 product family consists of the following product groups:

● AC500 (Standard):
  AC500 standard PLCs offer a wide range of performance levels and scalability. The PLCs are highly capable of communication and extension for flexible application.
● AC500-eCo:
  AC500-eCo PLCs are cost-effective, high-performance compact PLCs that offer total interoperability with the core AC500 range and provide battery-free buffering of remanent data. All I/O modules can be freely connected in a simple, stable and reliable manner.
● AC500-S:
  AC500-S PLCs are designed for safety applications in factory, process or machine automation.
● AC500-XC:
  AC500 (Standard) and AC500-S provide devices with -XC extension as a product variant.
  These variants operate according to their product group and can, in addition, be operated under extreme conditions. AC500-XC PLCs can be used at high altitudes, extended operating temperature and in humid conditions. The devices also provids a high level of resistance to vibration and corrosive gases. The AC500-XC series is consistent with standard devices concerning the overall dimensions, the control function and the software compatibility.

The AC500 product family is characterized by functional modularity. As the complete AC500 product family shares the same hardware platform and programming software tool, the devices of the AC500 product groups can be flexibly combined.

S500 devices represent the I/O modules of the product group AC500 (Standard), whereas S500-eCo devices represent the I/O modules of the product group AC500-eCo. Both S500 and S500-eCo devices can be flexibly combined with devices of the AC500 product family.

3.2 AC500/S500 system structure

The AC500 product family provides a variety of modules and pluggable components for expanding the capabilities of the processor module with additional I/Os or other communication protocols. Depending on the features and functions of the processor module (CPU) compatible components can be added to a complete AC500 PLC system.

Centralized I/O extension
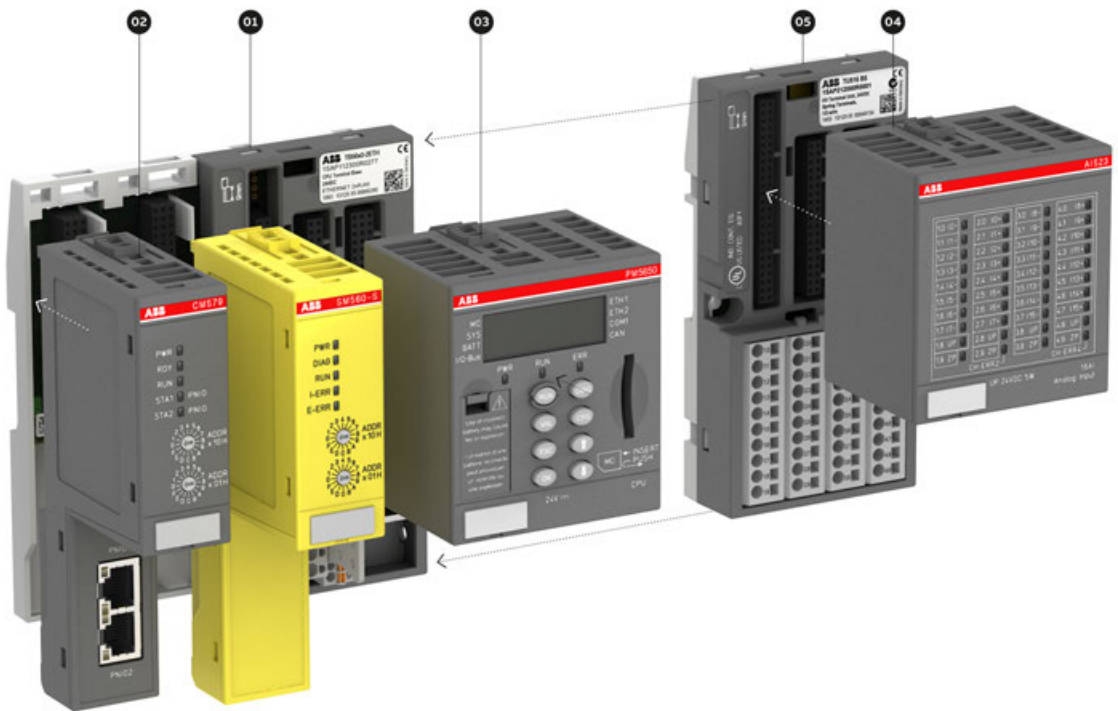
01 Terminal base for processor module and 0 to 6 communication modules, with serial and Ethernet interfaces
02 Communication module for, e.g., PROFIBUS, EtherCAT, and for support of safety solution
03 Processor module with integrated communication
04 I/O module, up to 10 I/O modules can be connected
05 Terminal unit for I/O modules, also for decentralized extension

**Decentralized
I/O extension**
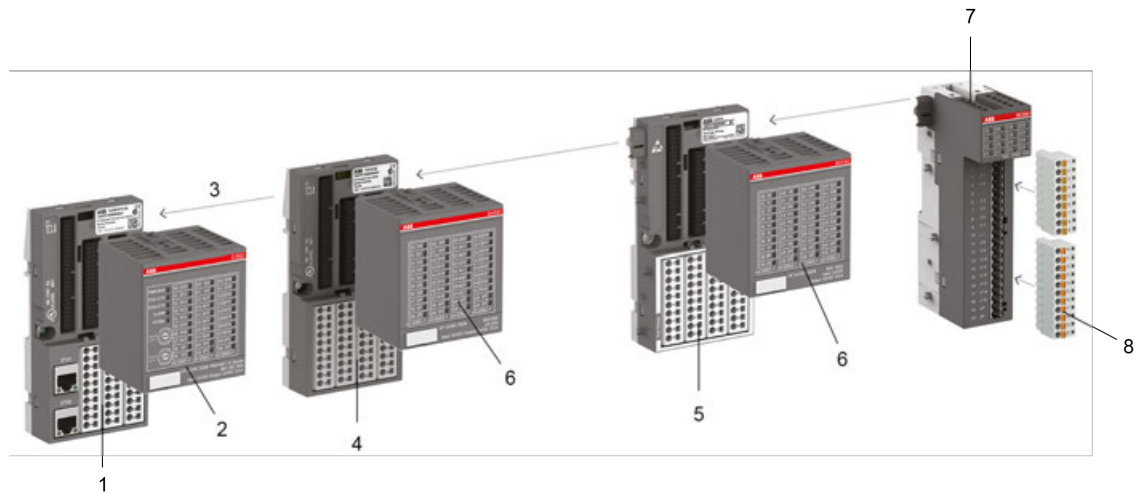
1 Terminal unit for communication interface modules
2 Communication interface module with up to 24 integrated I/Os
3 I/O bus
4 Terminal unit for I/O modules, with screw or spring connection
5 Terminal unit for hot swap of I/O modules to exchange of I/O modules while the system is running
6 S500 I/O modules with up to 32 channels for analog and/or digital signals
7 Compact S500-eCo I/O modules with up to 16 channels for analog and/or digital signals
8 Removable terminal blocks

3.3 AC500-eCo/S500-eCo system structure

AC500-eCo/S500-eCo series is compatible with AC500/S500.

The compact AC500-eCo processor module can be used for small applications with the integrated I/O channels.

The functionality of the processor modules can be extended with option boards, e.g., for additional I/O channels.

For larger applications, I/O modules can be connected centralized or decentralized.
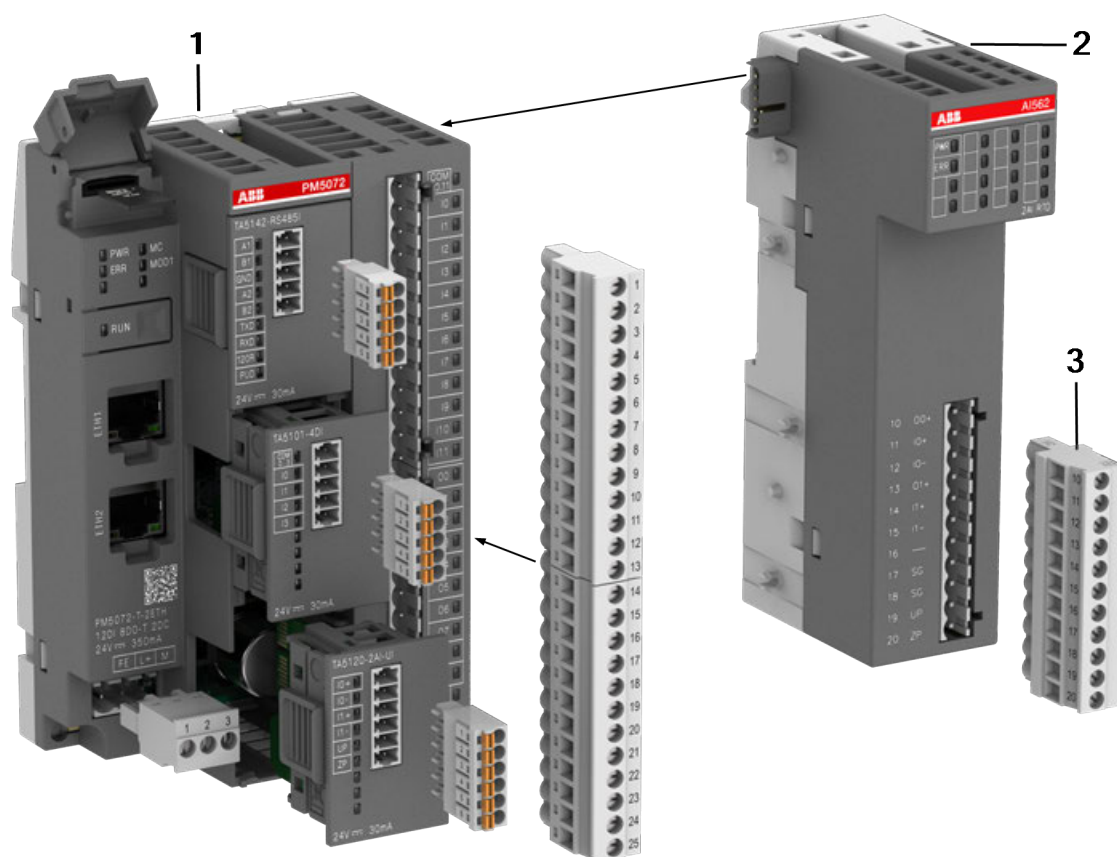
1   AC500-eCo processor module with option boards, different memory sizes, inputs and outputs available
2   S500-eCo I/O module, up to 10 I/O modules can be connected, also for decentralized extension
3   Terminal blocks in different variants available

Centralized I/O extension

Processor modules with an I/O bus interface on the right side can be expanded by up to 10 I/O modules to increase the number of the I/O channels.
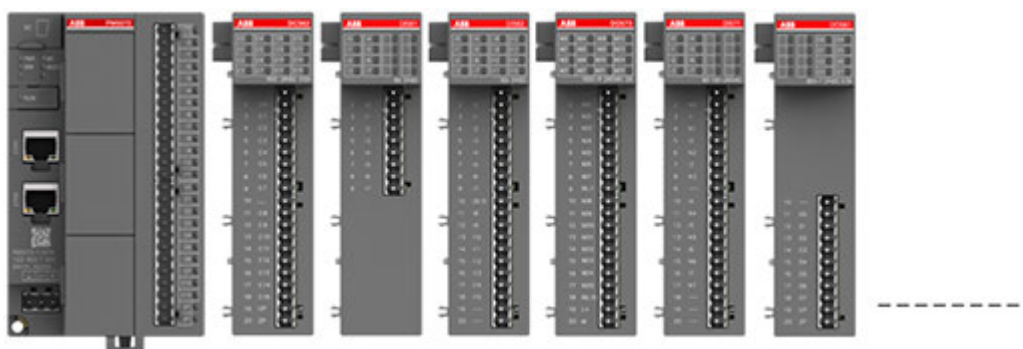
Fig. 3: I/O modules (S500-eCo) directly connected to an AC500-eCo processor module

Decentralized I/O extension

Up to 10 I/O modules can be connected remotely with the onboard Ethernet interface. Usually, a Modbus/TCP communication interface module or a processor module is used for the decentralized I/O extension.

Fig. 4: I/O modules (S500-eCo) connected to an AC500-eCo processor module via Modbus/TCP network, using a Modbus/TCP communication interface module or a processor module as client.

3.4 AC500/S500: Short description hardware
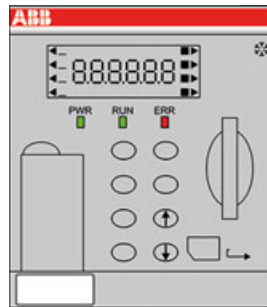
Processor modules

AC500 processor modules contain the CPU with the core component of the PLC. The CPU is connected with the user memory, input and output module, communication port and other units via the system bus and performs tasks by means of system programs preset in the system memory. The CPU adopts the function preset by the application program to command the PLC for operation.

The CPU has the following functions:

● To receive user programs and data entered
● To diagnose work faults of the power supply and PLC circuit as well as syntax errors in programming
● To receive the state or data of the site via the input interface and save it into the shadow register or data register
● To read the user programs in the memory one by one and execute them after interpretation
● To updating the state of the associated flag bits and the contents of the shadow register according to the execution results and providing output control using the output unit.

Processor modules are available in different performance classes. Only one processor module is required for a valid system architecture.

There are different types of processor module available that differ in the features and functions they provide, e.g. performance, LED display etc.

If required, processor modules are also available with an integrated Ethernet communication module (TCP/IP).

Communication modules
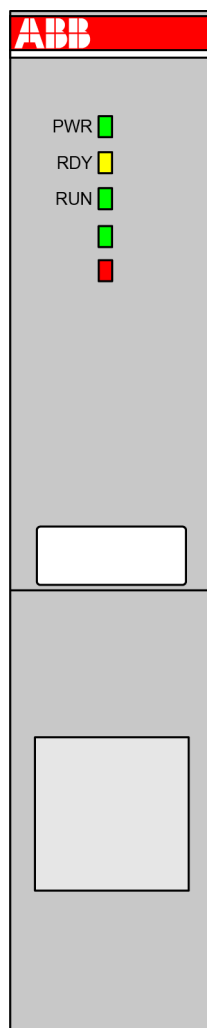
AC500 communication modules are required for the following:

● The connection to standard fieldbus systems.
● The integration into existing networks.

● The communication modules enable communication on different fieldbuses.
● The communication modules are mounted on the left side of the processor module on the same terminal base.
● The communication modules are directly powered via the internal communication module bus of the terminal base.
  A separate voltage source is not required.

Terminal bases
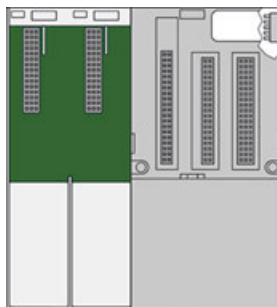
The terminal base is needed for mounting and connecting the processor module and the communication modules. The modules are plugged on the terminal base.

> *On AC500-eCo processor modules and special AC500 (Standard) processor modules the terminal base cannot be removed.*

I/O modules
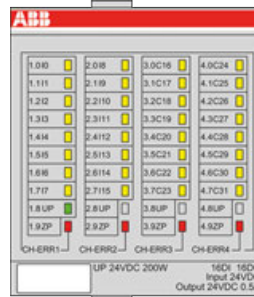
The I/O modules are the input/output unit which connects the PLC with the process. The PLC can detect controlled object data via the input interface and the data is taken as the basis for PLC control on the controlled object. In addition, the PLC sends processing results via the output interface to the controlled object to execute the control.

External input equipment and output equipment needs various signal levels whereas the information processed by the processor module in the PLC can only be the standard level. In order to perform this conversion, the I/O interface generally uses optical isolation and filtering to improve the interference immunity of the PLC. In addition, the I/O interface can generally indicate the working state to facilitate maintenance.

The PLC provides multiple I/O interfaces for operation level and drive capability to users for selection such as digital input, digital output, analog input, analog output, etc. I/O interfaces of the PLC interpret the number of input/output signals as the number of PLC I/O points. The number of I/O points is an important basis for PLC selection. If the system has insufficient I/O points, it can be expanded via the I/O extension interface of the PLC.

The I/O modules for digital and/or analog inputs and outputs are available in different versions and allow flexible use thanks to configurable channels.

The modules can be simply plugged onto a terminal unit for a centralized or decentralized I/O extension via communication interface modules.

Terminal units
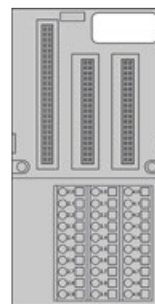
I/O modules and function modules are plugged on a terminal unit.

Terminal units enable simple prewiring without electronics and are available for 24 V DC and 120/230 V AC, optionally for spring or screw-type terminals.

**Communication
interface
modules**
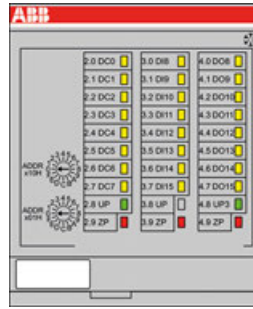
Communication interface modules are used to build decentralized I/O stations in decentralized systems. They contain the fieldbus interface and a set of onboard I/O channels. Additional I/O modules can be attached to build larger decentralized I/O stations. A communication interface module is mounted on a terminal unit.

**Function
modules**

Function modules extend the PLC system to perform special task control. These modules often provide independent components such as a CPU, system programs, memory and interfaces connected with the PLC system bus.

Function modules are connected with the PLC via the I/O bus to exchange data and independently work under cooperative management of the PLC.

Memory

In the PLC, the memory is mainly used for saving system programs, user programs and work data. There are two types of memory: Volatile memory and nonvolatile memory.

- Volatile memory:
  All saved data will be lost after power failure of the memory but the memory can provide a high access rate and unlimited programming cycles. Common volatile memories mainly include SRAM and DRAM (including common memories such as SDRAM).
- Nonvolatile memory:
  All saved data will not be lost after power failure of the memory, but the memory is subject to a low read-write rate and limited rewrite cycles. Common nonvolatile memories mainly include NORflash, NANDflash, EEPROM, memory card, etc.

AC500 PLCs store all user programs in the nonvolatile memory to protect them from power failure. The programs are exported to the volatile memory during operation of the PLC to ensure high-speed and efficient operation. If user program debugging is finished, the programs can be fixed in the nonvolatile memory when they need no change. The work data is subject to frequent change and access during the PLC operation. It is saved in the volatile memory to meet the requirements for random access.

The work data memory of the PLC has the memory area for input and output relay, auxiliary relay, timer, counter and other logic devices. The state of these devices depends on initial setting and operation of the user programs. Some data maintains its existing state by using built-in supercapacitors or backup batteries in the event of a power failure. The memory area for data saving in the event of a power failure is called the data retention area.

Power supply

The PLC is equipped with a switching power supply for the internal supply. In comparison with an ordinary power supply, the switching power supply has a higher stability and a higher noise immunity.

Some modules include a stabilized power supply for the supply of external sensors.

3.5 AC500-eCo/S500-eCo: Short description hardware

Processor modules

AC500-eCo processor modules contains the CPU with the core microprocessor of the PLC. It is integrated with power supply, onboard I/Os and communication interface.

Functions of the processor modules:

- Download the user programs.
- Run the CPU.
- Execute user programs in loops.
- Monitor the program input devices and the program output devices.

Processor modules are available in different performance classes and provide different numbers of onboard I/Os.

Only one processor module is required for a valid system architecture.

Option boards
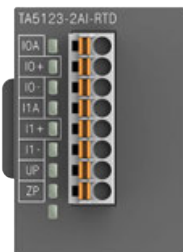
AC500-eCo processor modules can be extended with option boards. Option boards provide specific functionality. According to the processor module type, up to three option board slots are available for extension. Each option board slot supports most existing types of option board.

The option boards provide the following functionality for processor module extension:

- Serial interface RS232 (isolated) or RS485 (isolated or not isolated)
- Digital I/O channels extension (digital inputs, digital outputs, or mixed type)
- Analog I/O channels extension (analog inputs, analog outputs) for standard signal voltage or current, but also temperature measurement with RTD/NTC or thermocouple sensors
- RTC real-time clock board for processor module PM5012 (other processor modules include RTC functionality)
- Configuration address switch board for KNX protocol, only for processor modules PM5072, PM5082 and PM5092

I/O modules
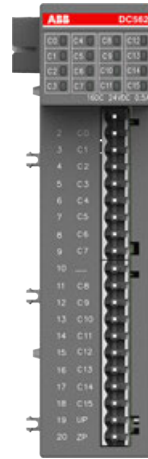
If the number of onboard I/Os provided on the processor module is insufficient for a certain use case, the PLC can be expanded with I/O modules to meet the control requirements.

Memory

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● Volatile memory:
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Power supply

The PLC is equipped with a switching power supply for the internal supply. In comparison with an ordinary power supply, the switching power supply has a higher stability and a higher noise immunity.

Some modules include a stabilized power supply for the supply of external sensors.

3.6 AC500-S

Functional safety

The AC500-S safety user manual must be read and understood before using the safety configuration and programming tools of Automation Builder/PS501 Control Builder Plus. Only qualified personnel are permitted to work with AC500-S safety PLCs.

AC500-S safety user manual

The AC500-S safety PLC includes the following safety-relevant hardware components.

- SM560-S/SM560-S-FD-1/SM560-S-FD-4
- DI581-S
- DX581-S
- AI581-S
- TU582-S

3.7 CP600 control panels

CP600 control panels platform

The CP600-eCo, CP600 and CP600-Pro control panels offer a wide range of features and functionalities for tailor-made visualization. Our CP600 platform offers different performance levels including control panels for economic applications, robust standard operator panels, high end multi-touch human machine interfaces (HMIs).

The easy to use engineering tool PB610 Panel Builder 600, part of Automation Builder, ensures easy scalability on the CP600 platform.

- CP600-eCo: The economical CP600-eCo control panel, with screen sizes from 4.3" to 10.1" widescreen, is aimed for standard functions and high usability for clear interaction with the operation process.
- CP600: The robust CP600 HMI, with screen sizes from 7" to 15" provides up-to-date visualization performance, versatile communication and representative design for machines and systems.
- CP600-Pro: The CP600-Pro HMI, with screen sizes from 5" to 21.5" widescreen, comes with high end visualization performance, multi-touch operation and versatile communication options

Further information on page 5

3.8 Automation Builder: Short description engineering software

Details about the Automation Builder license model, the features of the editions and the latest license information

Configuration and programming

Configuration and programming of all AC500 control systems (processor modules) is done by using Automation Builder software.

Features:

- Standardized programming according to IEC 61131-3, five programming languages (Structured Text (ST), Function Block Diagram (FBD), Instruction List (IL), Ladder Diagram (LD), Sequential Function Chart (SFC)), Continuous Function Chart (CFC), debugging functions for program test
- Online diagnosis
- Debugging functions for the program test: Single step, single cycle, breakpoint
- Offline simulation - simulate commands without PLC being connected
- Sampling trace - timing diagrams for process variables
- Recipe management and watch lists
- Visualization

- Configuration of the communication interface modules (for PROFINET, PROFIBUS, EtherCAT, CANopen, Ethernet, Modbus)
- Programming - serial or via Ethernet networks
- Comprehensive libraries
- Export and import interfaces for devices, signals, applications, visualization, etc.
- Multi-user support and project compare
- Project scripting

Offline simulation	IEC 61131-3 commands can be simulated without a PLC being connected, including the relevant malfunctions. After the program test, the application can be downloaded to the control system.
Sampling trace	Timing diagrams for process variables and storage of data in a circular buffer with event trigger.
Recipe management and watch lists	Values of selected variables are displayed. Pre-defined values can be assigned to variables which can then be downloaded to the control system all at once ("Write recipe"). Actual values from the control system can also be pre-assigned for reading into the Watch and Recipe Manager, and stored in memory there ("Read recipe"). These functions are also helpful, for example, for setting and entering control parameters.
Visualization	Includes color change, moving elements, bitmaps, text display, allows input of setpoint values and display of process variables read from the PLC, dynamic bar diagrams, alarm and event management, function keys and ActiveX elements.
Programming	The Ethernet interface of the processor modules is used to connect to the engineering software for programming, debugging and diagnosis.
Engineering interface	Provides access from the programming system to an external project database in which the program source code of one or several automation projects is managed. Optionally, a version control system can be used in order to ensure data consistency of the program code for several different users and projects.

4 Application planning

4.1 Safety instructions

> **!** **NOTICE!**
> Wiring diagrams and user programs must be designed to prevent hazardous situations from occurring during normal operation or in the event of a malfunction.

4.2 Processor module and I/O selection

How to select modules for your automation task: In our main catalog we offer a *CPU selector* and several comparative tables to find the modules for your application.

Reference documentation for hardware

4.3 I/O bus - Communication within the PLC

The synchronized I/O bus is the I/O data bus for the I/O modules connected with the processor modules or communication interface modules. Through this bus, I/O and diagnosis data are transferred.

With its fast data transmission, the I/O bus obtains very low reaction times.

Up to 10 I/O terminal units (for one I/O module each) can be added to one terminal base or to one AC500-eCo processor module. The I/O terminal units and the AC500-eCo I/O modules, have a bus input at the left side and a bus output at the right side. Thus the length of the I/O bus increases with the number of attached I/O modules.
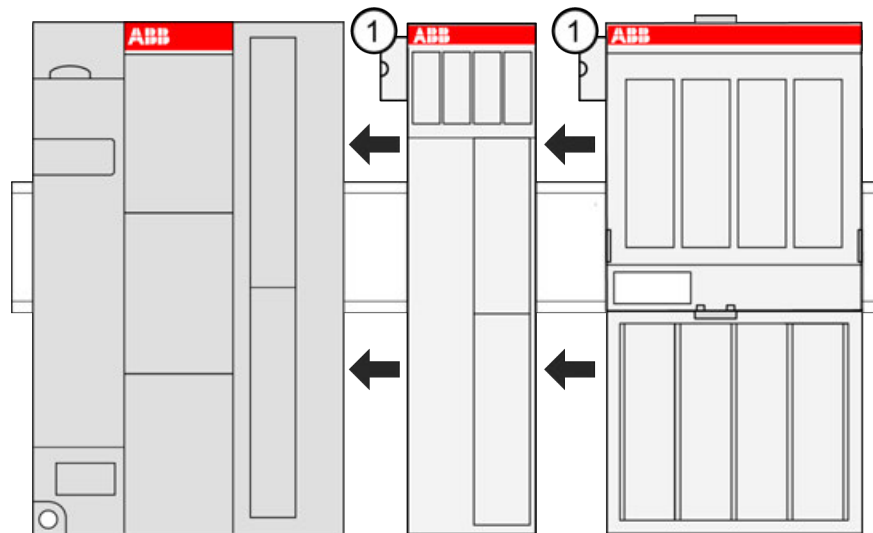
1 I/O bus connection

The connection of the I/O bus is performed automatically by telescoping the modules on the DIN rail.

The I/O bus provides the following signals:

- Supply voltage of 3.3 V DC for feeding the electronic interface components.
- 3 data lines for the synchronized serial data exchange.
- Several control signals.

> **NOTICE!**
>
> Except when using hot swap terminal units, the I/O bus is not designed for pulling and plugging modules during operation.
>
> If a module is pulled or plugged on a terminal unit that is **not** hot swap capable while the bus is running, the following consequences are possible.
>
> – Reset of the station or of the processor module.
> – System lockup.
> – Damage of the module.

> **WARNING!**
>
> **Removal/Insertion under power**
>
> Removal or insertion under power is permissible only if all conditions for hot swapping are fullfilled.
>
> ♦ *Chapter 11.3 "Replace an I/O module with hot swap" on page 99*
>
> The devices are not designed for removal or insertion under power when the conditions for hot swap do not apply. Because of unforeseeable consequences, it is not allowed to plug in or unplug devices with the power being ON.
>
> Make sure that all voltage sources (supply and process voltage) are switched off before doing any of the following actions:
>
> – Connect or disconnect any signal or terminal block.
> – Remove, mount or replace a module.
>
> Disconnecting any powered devices while they are energized in a hazardous location could result in an electric arc, which could create an ignition source resulting in fire or explosion.
>
> Prior to proceeding, make sure that power is been disconnected and that the area has been thoroughly checked to ensure that flammable materials are not present.
>
> The devices must not be opened when in operation. The same applies to the network interfaces.

Profibus (master and slave) and CM589-PNIO are available since version 2.5.0 of the Automation Builder.

4.4 Fieldbus connectivity options

The PLC and control panel portfolio offers a wide range of scalable products, communication protocols and connectivity options, from the field level to the management and visualization levels.

An overview of the different connectivity options can be found below.
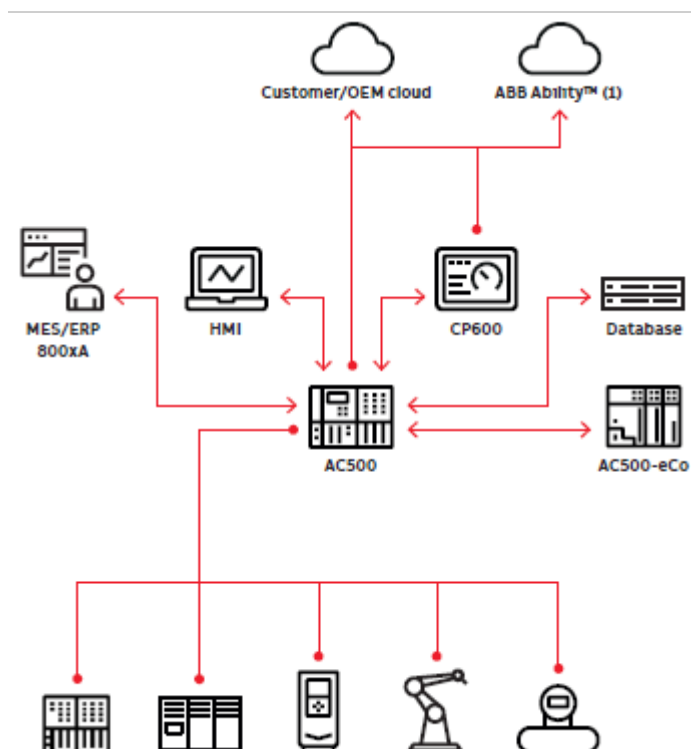
Fig. 5: Exemplary networking

IT network/internet
- FTP(S)
- HTTP(S)
- MQTT
- NTP/SNTP
- OPC UA
- SMTP(S)

Factory/side network
- BACnet
- FTP(S)
- HTTP(S)
- IEC 60870-5-104
- IEC 61850
- DNP3
- KNX
- MySQL/MSSQL
- OPC DA/AE
- OPC UA
- SNMP
- SNTP
- TCP/IP
- UDP

Control network

- CANopen
- CAN 2A/2B
- EtherCAT
- Ethernet/IP
- IEC 60870-5-104
- IEC 61850
- Modbus RTU
- Modbus TCP
- PROFIBUS DP
- PROFINET
- PROFIsafe *AC500-S*
- SAE J1939

4.5   Power supply dimensioning

4.5.1   General

The power consumption of a complete station consists of the sum of all individual consumptions.

The two supply voltages with 24 V DC are distinguished in the AC500 platform:

- Supply of the internal logic via terminals L+ and M on the CPU module, or an the AC500 terminal base for: CPU, communication mudule(s) and I/O bus.
- Supply of the process-side input/output circuits for analog signals and 24 V DC digital signals via the ZP and UP terminals of the S500 terminal units.

The two supply voltages can be provided by the same power supply unit. The CPU and the I/O modules should, however, be fused separately. Of course also separate power supplies are possible.

4.5.2   Calculation of the total current consumption

Example   In the example, the PLC consists of the following devices:

- AC500 processor module with Ethernet interface.
- 4 communication modules.
- 7 I/O modules (digital and analog).
- The compatible terminal bases and terminal units.
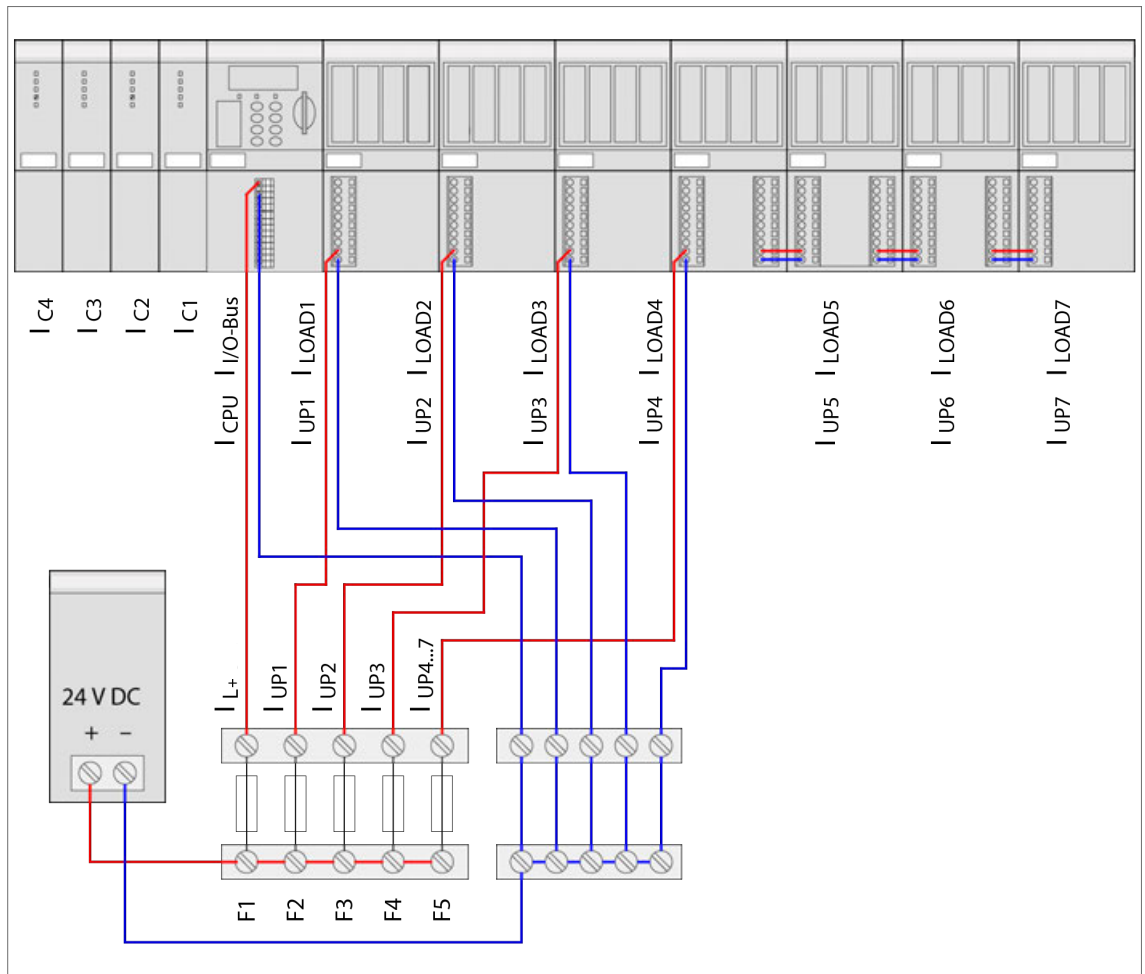
> ℹ️ *Because of the high total current consumption of the digital I/O modules (from UP = 24 V DC), the supply is divided up into several electric circuits fused separately.*
>
> *The maximum permitted total current over the supply terminals of the I/O terminal units is 8 A.*

The total current can be calculated as follows:

$I_{Total} = I_{L+} + I_{UP}$

with the assumptions

$I_{L+} = I_{CPU} + I_{I/O\ bus} + I_{C1} + I_{C2} + I_{C3} + I_{C4}$ (CPU + communication modules + I/O bus)

$I_{I/O\ bus}$ = Number of expansion modules × Current consumption through the I/O bus per module

and

$I_{UP} = I_{UP1} + I_{LOAD1} + I_{UP2} + I_{LOAD2} + I_{UP3} + I_{LOAD3} + I_{UP4} + I_{LOAD4} + I_{UP5} + I_{LOAD5} + I_{UP6} + I_{LOAD6} + I_{UP7} + I_{LOAD7}$

If one assumes that all outputs are switched on and are operated with their maximum permitted load currents (under compliance with the maximum permitted currents at the supply terminals), then the following values are the result for an example shown above:

	I_{CPU} *)	I_{Cx} *)	$I_{I/O\ bus}$ *)	I_{UPx} *)	I_{LOADx} *)
CPU/communication module part					
CPU	0.110 A	-	-	-	-
C1	-	0.050 A	-	-	-
C2	-	0.085 A	-	-	-
C3	-	0.050 A	-	-	-
C4	-	0.050 A	-	-	-
I/O module part					
Analog1	-	-	0.002 A	0.150 A	-
Analog2	-	-	0.002 A	0.150 A	0.160 A
Analog3	-	-	0.002 A	0.100 A	0.080 A
Analog4	-	-	0.002 A	0.100 A	0.080 A
Digital1	-	-	0.002 A	0.050 A	8.000 A
Digital2	-	-	0.002 A	0.050 A	8.000 A
Digital3	-	-	0.002 A	0.050 A	8.000 A
Σ columns	0.110 A	0.235 A	0.014 A	0.650 A	24.320 A
	$\Sigma\ I_{L+} \approx 0.4$ A			$\Sigma\ I_{UP} \approx 25$ A	
	$I_{Total} \approx 25.4$ A				
*) All values in this column are exemplary values					

4.5.3 Dimensioning of the fuses

To be able to select the fuses for the station correctly, both the current consumption and the inrush currents (melting integral for the series-connected fuse) must be taken into consideration.

Fuse	for	Σ of the melting integrals in A²s	I_{L+} A	I_{UPx} A	Recommended fuse	
					Type	**Value**
F1	CPU logic	1.000	≈ 0.4	-	Quick	10 A
F2	Module Digital1	0.005	-	8.050	Quick	10 A
F3	Module Digital2	0.008	-	8.050	Quick	10 A
F4	Module Digital3	0.007	-	8.050	Quick	10 A
F5	Modules Analog1 + Analog2 + Analog3 + Analog4	0.130	-	0.820	Quick	10 A

4.6 Libraries, software packages and licensed features

Many applications are included in the Automation Builder. However, there are some that need to be purchased additionally. The applications are briefly introduced here. If applicable, links lead to further information depending on the version.

HA-Modbus TCP library

Library package adds High Availability System functionality for redundant hot standby over Ethernet field network via HA-Modbus TCP.

61850 protocol

Adds engineering tool and library for 61850 Ed.1 MMS server and GOOSE publish and subscribe functionalities.

KNX protocol

Engineering and protocol package that seamlessly integrates ETS and Automation Builder.

BACnet-BC protocol

BACnet is a standardized data communication protocol for building automation and control networks as defined in the ANSI/ASHRAE standard 135 and ISO 16484-5.

Data logger library

The data logging function block library (*"DataLogger"* and *"DataLoggerEco"*) contains 5 function blocks for the purpose of advanced time-stamped data logging for different use cases.

DNP3

DNP3 is an open and in IEEE1815 standardized industrial protocol designed to efficiently transmit data from point A to point B by using serial or IP communications.

Motion control library

Library package for decentralized, centralized and coordinated motion according to the PLCopen standard.

EtherNet/IP

EtherNet/IP is used to connect any number of different terminals in a network, using a scanner-adapter relationship.

Table 1: AC500 runtime licenses

For	Description	Type	Order code
all processor modules	HA-Modbus TCP run-time license	PS5601-HA-MTCP	1SAP195400R0101
all AC500 processor modules and the AC500-eCo processor modules PM5072, PM5082 and PM5092	IEC 61850 protocol runtime license	PS5602-61850	1SAP195600R0101
all AC500 processor modules and the AC500-eCo processor modules PM5072, PM5082 and PM5092	KNX IP protocol run-time license	PS5604-KNX	1SAP195800R0101

For	Description	Type	Order code
all AC500 processor modules and the AC500-eCo processor modules PM5032, PM5052, PM5072, PM5082 and PM5092	BACnet protocol B-BC runtime license	PS5607-BACnet-BC	1SAP195550R0101
all AC500-eCo processor modules	BACnet protocol B-BC-e eCo runtime license	PS5607-BACnet-BC-e	1SAP195551R0101
all processor modules	Data logger runtime license for AC500	PS5609-Log	1SAP195002R0101
the AC500-eCo processor modules PM5072, PM5082 and PM5092	Data logger runtime license for PM5072, PM5082 and PM5092	PS5609-Log-e	1SAP195004R0101
all AC500 processor modules and the AC500-eCo processor modules PM5032 and higher	Motion control library runtime license	PS5611-MC	1SAP192150R0101
AC500/AC500-eCo (for PM5032, PM5052, PM5072, PM5082, PM5092 and PM56xx)	EtherNet/IP scanner runtime license for AC500	PS5613-EIP-S	1SAP196101R0101
AC500-eCo (for PM5032, PM5052, PM5072, PM5082 and PM5092)	EtherNet/IP scanner runtime license for AC500-eCo	PS5613-EIP-S-e	1SAP196103R0101
AC500/AC500-eCo (for PM5032, PM5052, PM5072, PM5082, PM5092 and PM56xx)	EtherNet/IP adapter runtime license for AC500	PS5613-EIP-A	1SAP196100R0101
AC500-eCo (for PM5032, PM5052, PM5072, PM5082 and PM5092)	EtherNet/IP adapter runtime license for AC500-eCo	PS5613-EIP-A-e	1SAP196102R0101
AC500-eCo pro and standard PLCs	DNP3 Outstation license AC500 V3 runtime license for onboard ETH single activation key	PS5614-DNP3-O	1SAP195610R0101

For	Description	Type	Order code
AC500-eCo pro PLCs	DNP3 Outstation license AC500 V3-eco runtime license for onboard ETH single activation key	PS5614-DNP3-O-e	1SAP195611R0101
For using runtime licensed features one license per CPU is required. The license has to be installed on the AC500 CPU either by connecting it to Automation Builder or via memory card that has been prepared by Automation Builder for license activation. The licenses can be transferred between AC500 CPUs unlimited times.			

Activating a runtime license

The linked application note provides step-by-step instructions on how to activate the runtime license for the PLC.

Activating a runtime license

Additional libraries and software packages for specific use cases are available to reduce the programming effort and implement quickly your application. In our main catalog we offer an overview of the *available libraries and software packages*.

Reference documentation for the function blocks included in the libraries

5 Mechanical planning and installation

5.1 Control cabinet assembly (indoor use)

PLC enclosure

> **!**
>
> **NOTICE!**
> **PLC damage due to incorrect housing**
> Due to their construction (degree of protection IP 20 according to EN 60529) and their connection technology, the devices are only suitable for operation in closed control cabinets.

The control cabinet must be suitable to protect the equipment from the following:

- Unauthorized access.
- Dusting and contamination.
- Humidity and moisture.
- Mechanical damage.

The equipment must be operated within the specified mechanical and enviromental conditions.

Maintain spacing from the following:

- Enclosure walls.
- Wireways.
- Adjacent equipment.

Allow a minimum of 20 mm clearance on all sides. This provides ventilation and galvanic isolation.

It is recommended to mount the modules on an grounded mounting plate, or an grounded DIN rail, independent of the mounting location.
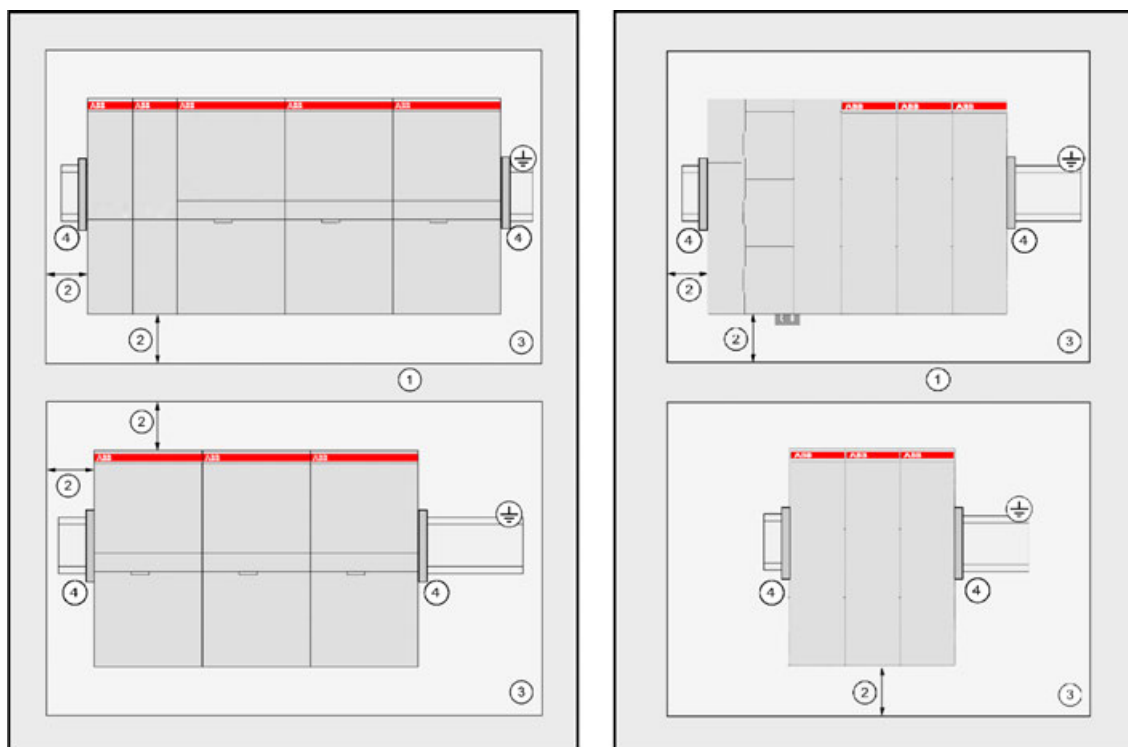
Fig. 6: Exemplary figure: left side AC500, right side AC500-eCO

1   Cable duct
2   Distance from cable duct ≥20 mm
3   Mounting plate, grounded
4   Screw end-stop clamps recommended to avoid movement of the modules on the DIN rail

---

! **NOTICE!**

Horizontal mounting is highly recommended.

Vertical mounting is possible, then derating must be considered to avoid over-heating due to poor air circulation..

When horizontal mounted, end-stop clamps are recommended to secure the modules in case of shock or vibration.

When vertically mounted, always place an end-stop clamps on the bottom and on the top of the modules to properly secure the modules.

5.2 Mounting and demounting - general information

The control system is designed to be mounted to a well-grounded mounting surface such as a metal panel. Additional grounding connections from the mounting tabs or DIN rail (if used), are not required unless the mounting surface cannot be grounded.

During panel or DIN rail mounting of all devices, be sure that all debris (metal chips, wire strands, etc.) is kept from falling into the controller. Debris that falls into the controller could cause damage while the controller is energized.

> ⓘ *All devices are grounded through the DIN rail to chassis ground. Use zinc plated yellow-chromate steel DIN rail to assure proper grounding. The use of other DIN rail materials (e.g. aluminium, plastic, etc.) that can corrode, oxidize, or are poor conductors, can result in improper or intermittent grounding.*

> ⓘ ***Consider the safety instructions***
>
> *In the description, special attention must be paid to designs using galvanic isolation, grounding and EMC measures for the reasons stated. Consider the safety instructions for AC500 product family.*

5.3 Mounting and demounting the terminal base

Mounting and demounting on DIN rail

1. Mount DIN rail 7.5 mm or 15 mm.

2. Mount the terminal base/function module terminal base:
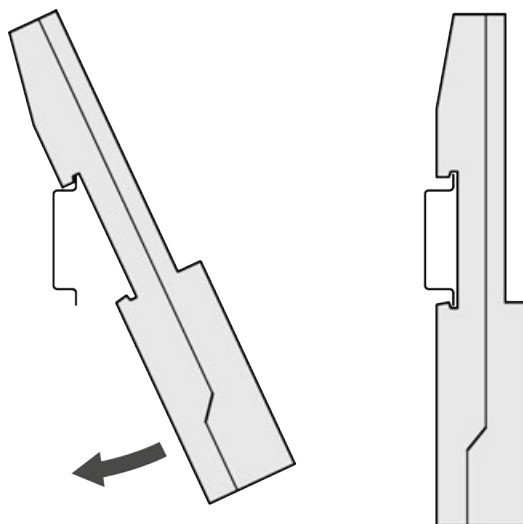
⇨ The terminal base is put on the DIN rail above and then snapped-in below.

3. The demounting is carried out in a reversed order.
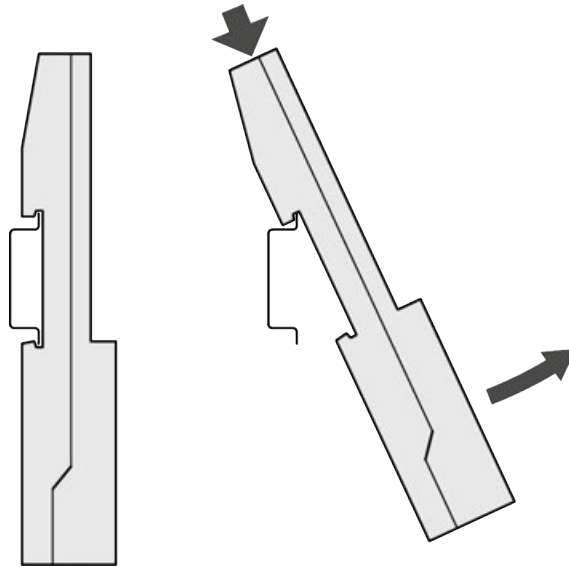
Mounting with screws

If the terminal base should be mounted with screws, wall mounting accessories TA526 must be inserted at the rear side first. These plastic parts prevent bending of the terminal base while screwing on. TB560x and TB561x need one TA526, TB562x, TB564x and TB566x need two TA526.
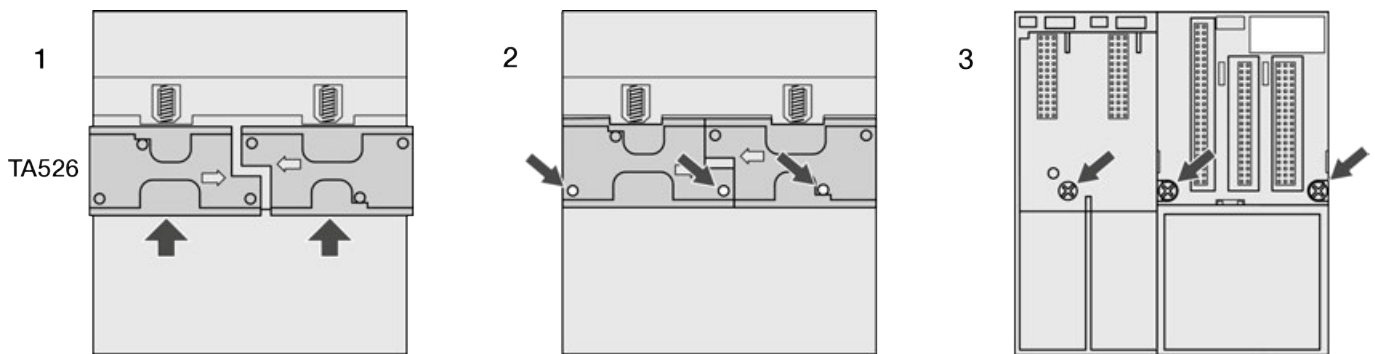
Fig. 7: Terminal bases, fastening with screws
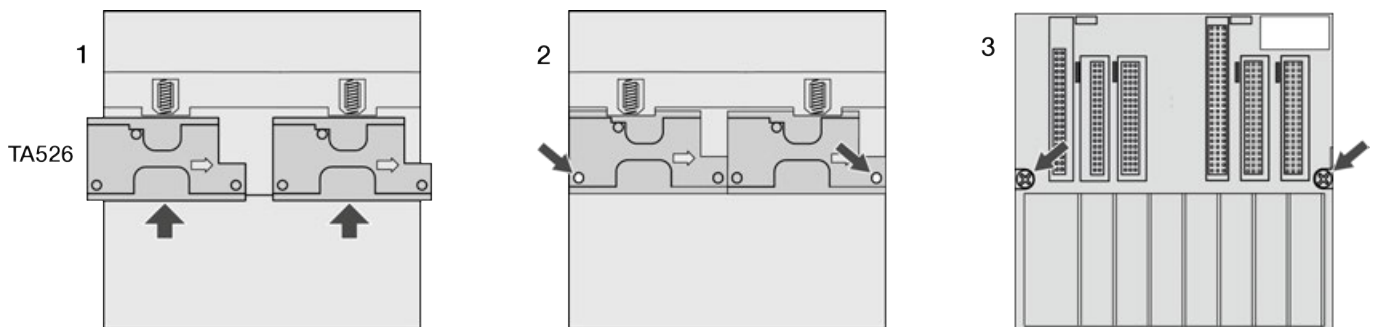
Fig. 8: Function module terminal bases, fastening with screws

> *By wall mounting, the terminal base is grounded through the screws.*
>
> – *The screws must have a conductive surface (e.g. steel zinc-plated or brass nickel-plated).*
> – *The mounting plate must be grounded.*
> – *The screws must have a good electrical contact to the mounting plate.*

Practical tip   The following procedure allows you to use the mounted modules as a template for drilling holes in the panel. Due to module mounting hole tolerance, it is important to follow these procedures:

1. On a clean work surface, mount no more than 3 modules (e.g. one terminal base and two terminal units).

2. Using the mounted modules as a template, carefully mark the center of all module-mounting holes on the panel.

3. Return the mounted modules to the clean work surface, including any previously mounted modules.

4. Drill and tap the mounting holes for the screws (M4 or #8 recommended).

5. Place the modules back on the panel and check for proper hole alignment.

6. Attach the modules to the panel using the mounting screws.

> *If mounting more modules, mount only the last one of this group and put the others aside. This reduces remounting time during drilling and tapping of the next group.*

7. Repeat the steps for all remaining modules.

5.4 Mounting and demounting the AC500 processor module

1. After mounting the terminal base on the DIN rail, mount the processor module.
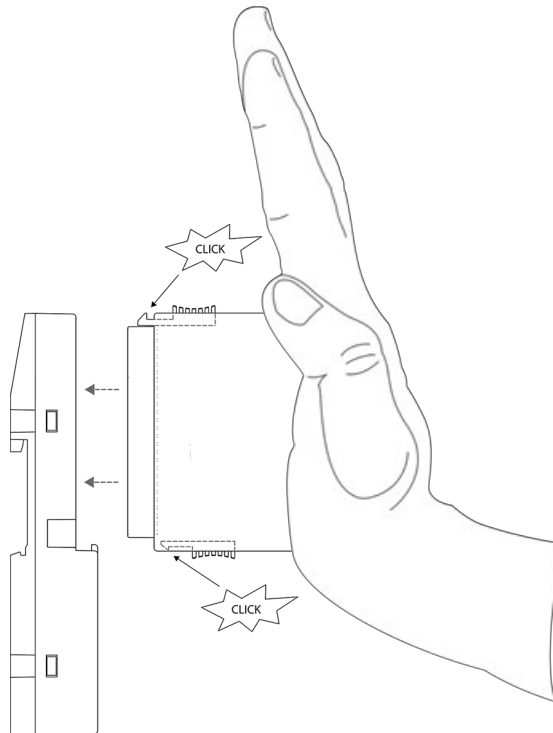
2. Press the processor module into the terminal base until it locks in place.

3.   The demounting is carried out in a reversed order. Press above and below, then remove the processor module.
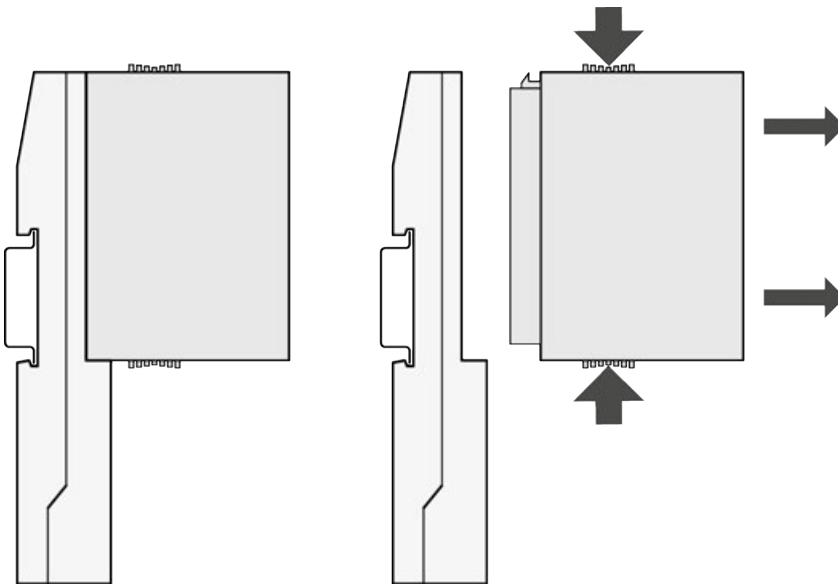
5.5 Mounting and demounting the communication module

Communication modules are mounted on the left side of the processor module on the same terminal base. The connection is established automatically when mounting the communication module.
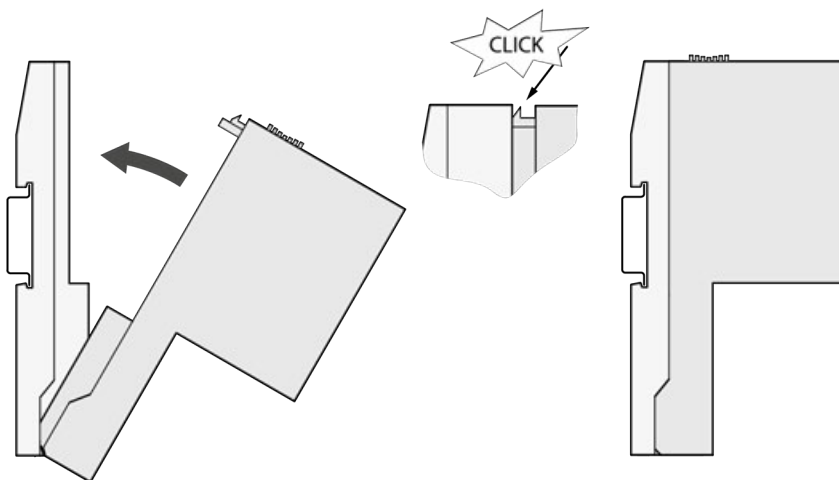
> **! NOTICE!**
> **Risk of damaging the PLC modules!**
> Overvoltages and short circuits might damage the PLC modules.
>
> –   Make sure that all voltage sources (supply voltage and process supply voltage) are switched off before you begin with operations on the system.
> –   Never connect any voltages or signals to reserved terminals (marked with ---). Reserved terminals may carry internal voltages.

After mounting the terminal base, mount the communication modules.

1. First insert the bottom nose of the communication module into the dedicated holes of the terminal base. Then, rotate the communication module on the dedicated terminal base slot until it is locked in place.

⇨

> **NOTICE!**
>
> **Risk of malfunctions!**
>
> Unused slots for communication modules are not protected against accidental physical contact.
>
> – Unused slots for communication modules must be covered with dummy communication modules to achieve IP20 rating.
> – I/O bus connectors must not be touched during operation.

2. The demounting is carried out in a reversed order.

   Press above and below, then rotate the communication module and remove it.
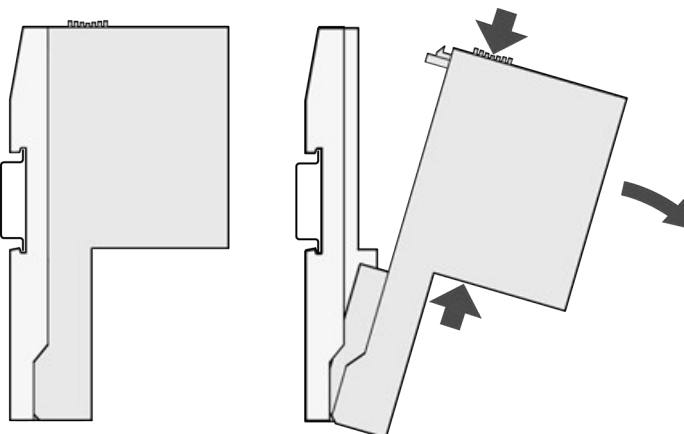
5.6 Mounting and demounting the terminal unit

**Mounting on
DIN rail**

1. Mount DIN rail 7.5 mm or 15 mm.

2. Mount the terminal unit.

    The terminal unit is snapped into the DIN rail in the same way as the terminal base. Once secured to the DIN rail, slide the terminal unit to the left until it fully locks into place creating a solid mechanical and connection.

    > ℹ️ *When attaching the devices, make sure the bus connectors are securely locked together to ensure proper connection. Max. 10 terminal units can be attached.*
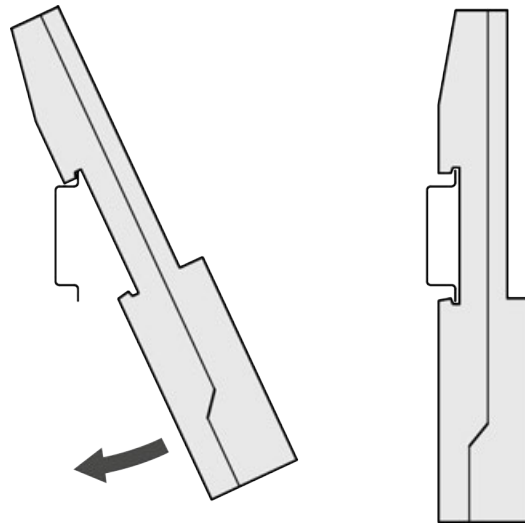
3. Demounting: A screwdriver is inserted in the indicated place to separate the terminal units.
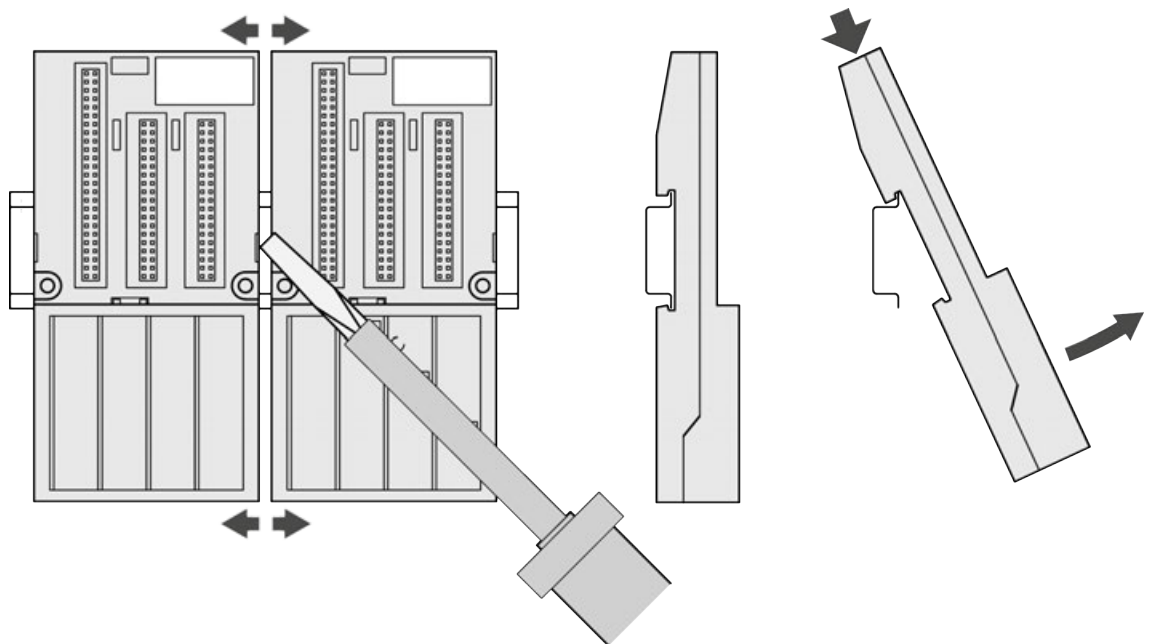
**Mounting with
screws**

If the terminal unit should be mounted with screws, wall mounting accessories TA526 must be inserted at the rear side first. These plastic parts prevent bending of the Terminal Base while screwing on.
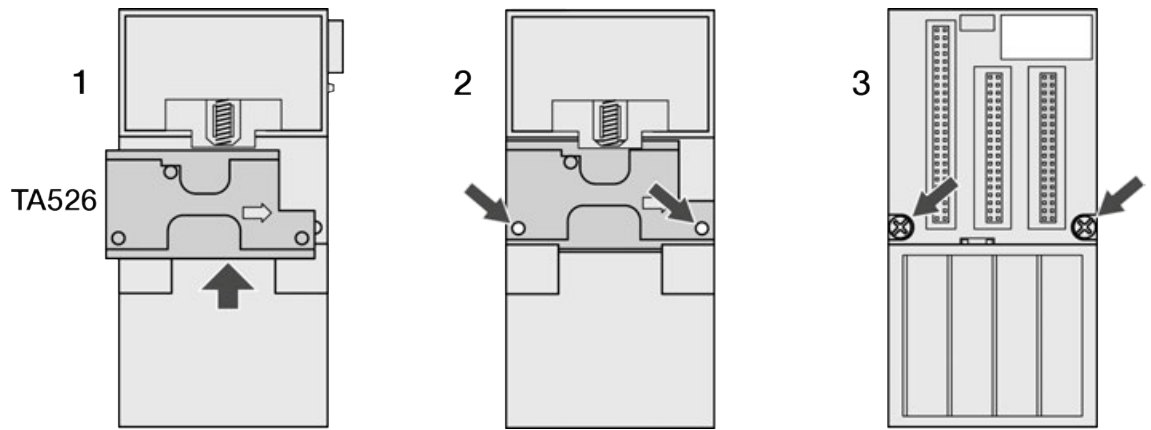
Fig. 9: Fastening with screws

> *By wall mounting, the terminal unit is grounded through the screws.*
> – *The screws must have a conductive surface (e.g. steel zinc-plated or brass nickel-plated).*
> – *The mounting plate must be grounded.*
> – *The screws must have a good electrical contact to the mounting plate.*

Practical tip   The following procedure allows you to use the mounted modules as a template for drilling holes in the panel. Due to module mounting hole tolerance, it is important to follow these procedures:

1. On a clean work surface, mount no more than 3 modules (e.g. one terminal base and two terminal units).

2. Using the mounted modules as a template, carefully mark the center of all module-mounting holes on the panel.

3. Return the mounted modules to the clean work surface, including any previously mounted modules.

4. Drill and tap the mounting holes for the screws (M4 or #8 recommended).

5. Place the modules back on the panel and check for proper hole alignment.

6. Attach the modules to the panel using the mounting screws.

> *If mounting more modules, mount only the last one of this group and put the others aside. This reduces remounting time during drilling and tapping of the next group.*

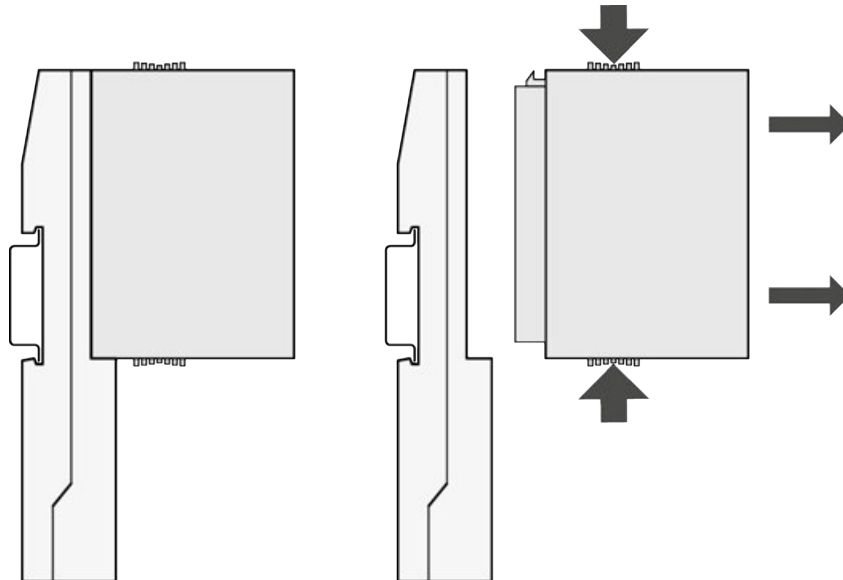7. Repeat the steps for all remaining modules.

5.7 Mounting and demounting the I/O module

After mounting the terminal unit, mount the I/O modules.

1.   Press the I/O module into the terminal unit until it locks in place.

CLICK

CLICK
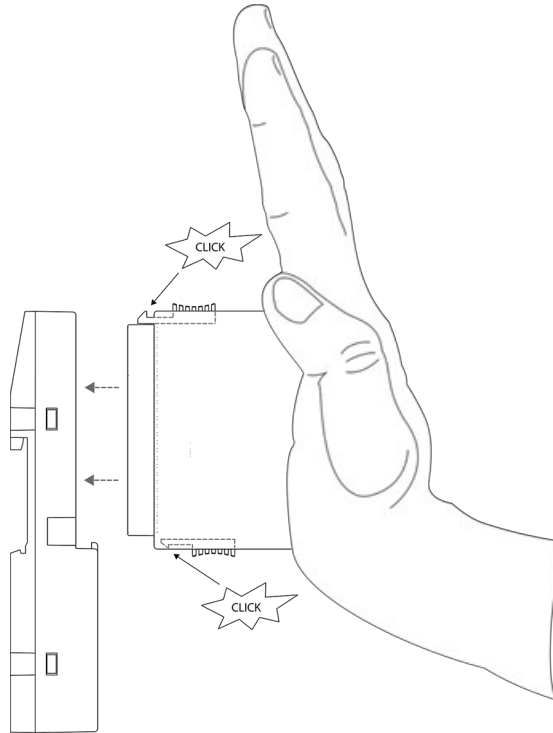
2.   The demounting is carried out in a reversed order.
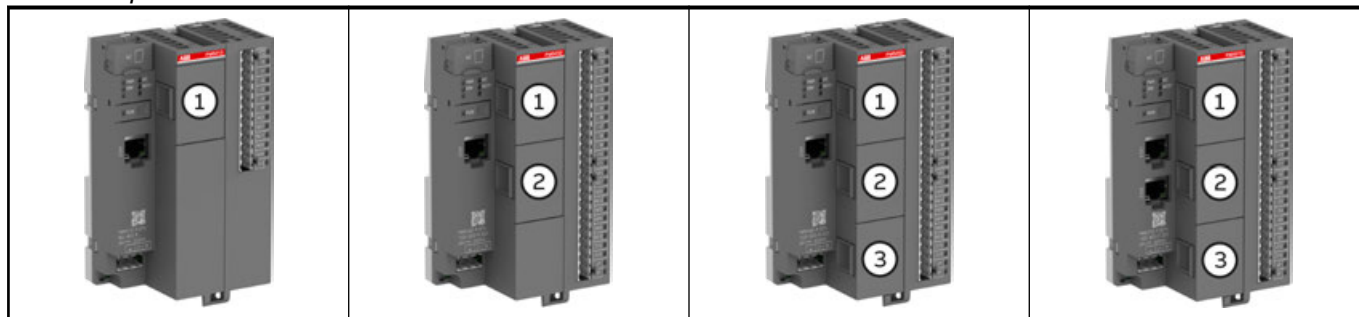
Press above and below, then remove the module.

5.8 Mounting and demounting the AC500-eCo processor module

5.8.1 Mounting and demounting the option boards

5.8.1.1   Optimized mounting of the option boards

The AC500-eCo processor modules have up to 3 slots for option boards.

Table 2: Option board slots

The best thermal circulation is given on slot 3 (bottom slot), followed by slot 2 (middle slot) and then slot 1 (top slot).

The best mounting position of the option board depends on its power dissipation.

> ○ **Rules for optimized mounting of the option boards**
> ⓘ
> – *The higher the power dissipation of the option board, the lower the mounting position should be selected.*
> – **The TA5126-2AO-UI option board has the highest power dissipation and must always be mounted at the lowest option board slot.**
>
> *The optimized mounting position can be easily determined with the help of this table.*

Table 3: Power dissipation of the option boards

Power dissipation of the option boards	Digital	Analog	Serial interface	Accessory
very small			TA5141-RS232I(W) TA5142-RS485I(W) TA5142-RS485(W)	TA5130-KNXPB(W) TA5131-RTC
small	TA5105-4DOT(W)	TA5123-2AI-RT(D/W)		
medium	TA5110-2DI2DO(T/W) TA5101-4DI(W)	TA5120-2AI-UI(W) TA5128-2AI1AO(W)	TA5146-CN(W)	
large		TA5126-2AO-UI(W)		

> ○ *If the option boards to be mounted are in the same power dissipation level, then*
> ⓘ *the slots can be freely selected.*

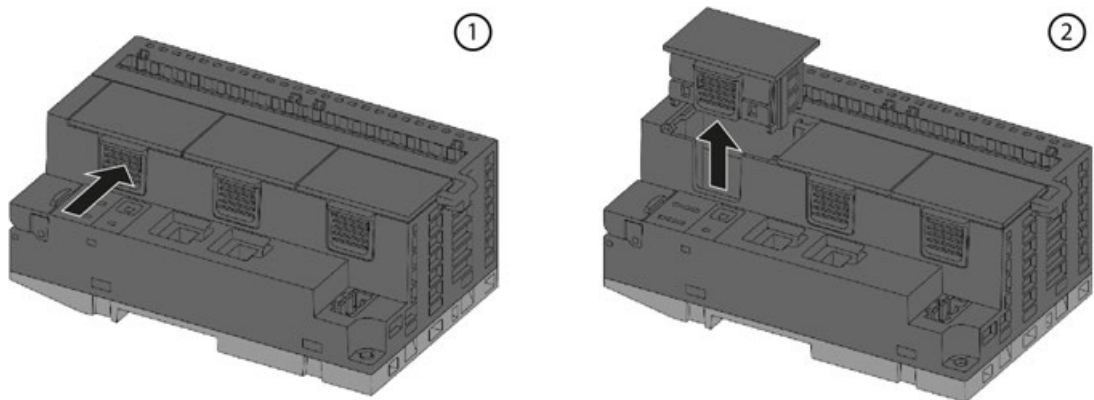#### 5.8.1.2 Inserting the option board
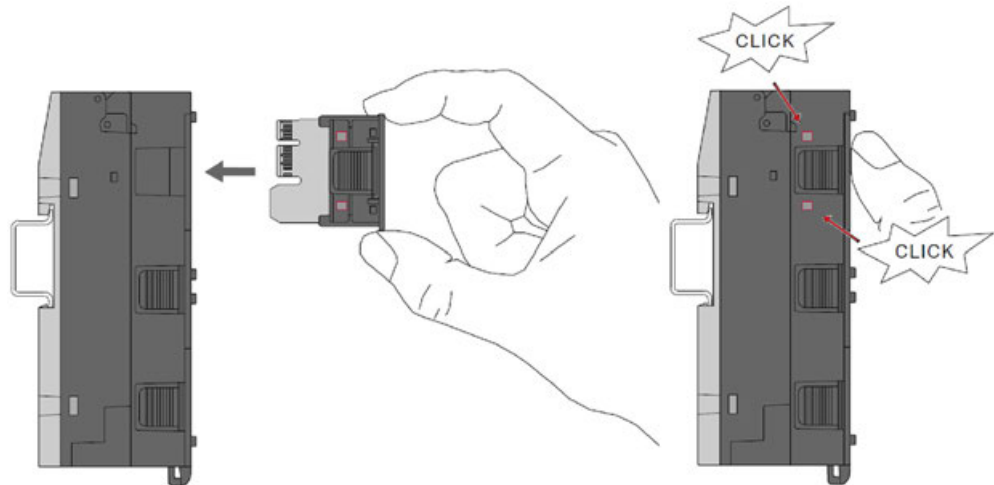
▷ Press the option board TA51xx (or TA5300-CVR) into the slot of the processor module PM50x2 until it locks in place.

> *The option board must click into the slot of the processor module.*

5.8.1.3 Removing the option board

1. Push the option board on the side to release the lock.
2. At the same time, pull the option board out of the slot.

> **CAUTION!**
> **Risk of injury and damaging the product!**
> Always plug in the option board slot cover when the option board is not inserted.
>
> If the option board slot cover is lost, please order the replacement TA5300-CVR (1SAP187500R0001).
>
> Never power up the CPU with uncovered option board slot, otherwise it may cause serious injury and/or damage the product.

5.8.2 Mounting and demounting of the terminal blocks
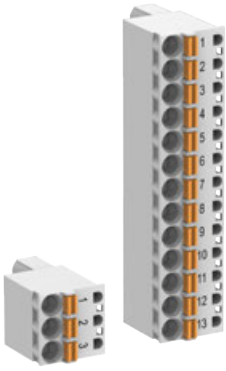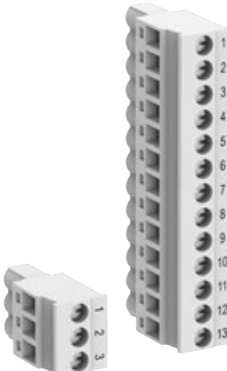
Intended purpose

Removable terminal blocks are used for power supply and for I/O connectors on AC500-eCo processor modules PM50x2.

For option boards there are different removable terminal blocks in spring version.

For the AC500-eCo **Basic CPUs** a 3-pin terminal block for power supply and a 13-pin terminal block for I/O connectors are used.
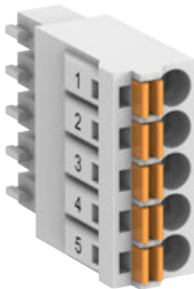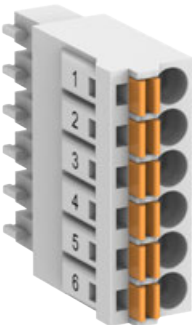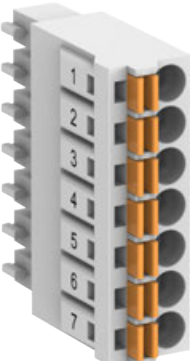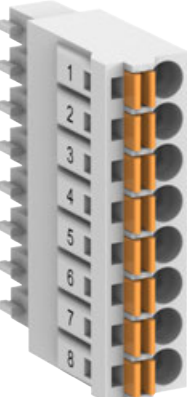
For the AC500-eCo **Standard CPUs** and **Pro CPUs** a 3-pin terminal block for power supply, a 13-pin terminal block and a 12-pin terminal block for I/O connectors are used.

For all CPUs there is a screw and a spring variant available.

Basic CPU		Standard and Pro CPUs	
Spring terminal TA5211-TSPF-B	Screw terminal TA5211-TSCL-B	Spring terminal TA5212-TSPF	Screw terminal TA5212-TSCL

Various removable spring terminal blocks are available for option boards.

The following spare parts are available (depending on the number of pins).

Spring terminals			
TA5220-SPF5	TA5220-SPF6	TA5220-SPF7	TA5220-SPF8

⚠ **CAUTION!**

Risk of injury and damaging the product!

Improper installation and maintenance may result in injury and can damage the product!

- Installation and maintenance have to be performed according to the technical rules, codes and relevant standards, e.g. EN 60204-1.
- Read product documentation carefully before wiring. Improper wiring or wrong terminal block from other devices can damage the product!
- Only by qualified personnel.

⚠ **CAUTION!**

Risk of injury and damaging the module when using unapproved terminal blocks!

Only use terminal blocks approved by ABB to avoid injury and damage to the module.

ⓘ **Terminal block set for PM50x2**

*Processor modules PM50x2 CPU are not delivered with terminal blocks.*

Screw terminal block set:

- *TA5211-TSCL-B (1SAP187400R0001) for PM5012-x-ETH*
- *TA5212-TSCL (1SAP187400R0004) for PM5032-x-ETH, PM5052-x-ETH, PM5072-T-2ETH(W), PM5082-T-2ETH, PM5092-T-2ETH*
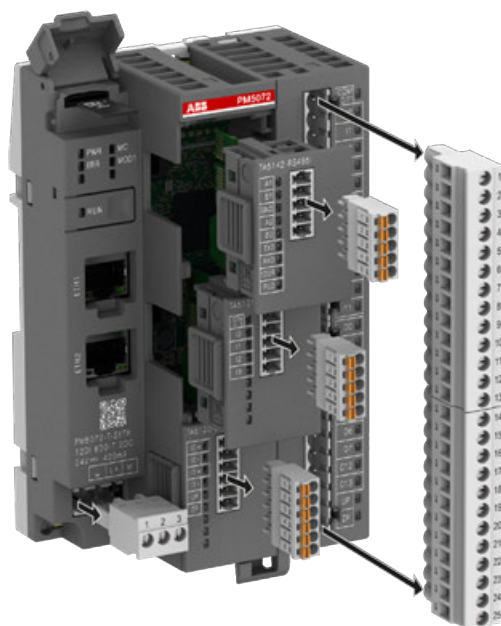
Spring terminal block set:

- *TA5211-TSPF-B (1SAP187400R0002) for PM5012-x-ETH*
- *TA5212-TSPF (1SAP187400R0005) for PM5032-x-ETH, PM5052-x-ETH, PM5072-T-2ETH(W), PM5082-T-2ETH, PM5092-T-2ETH*

Assembly
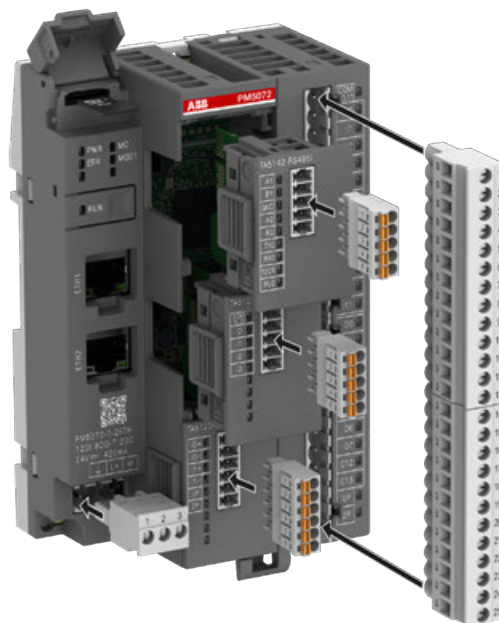
Disassembly

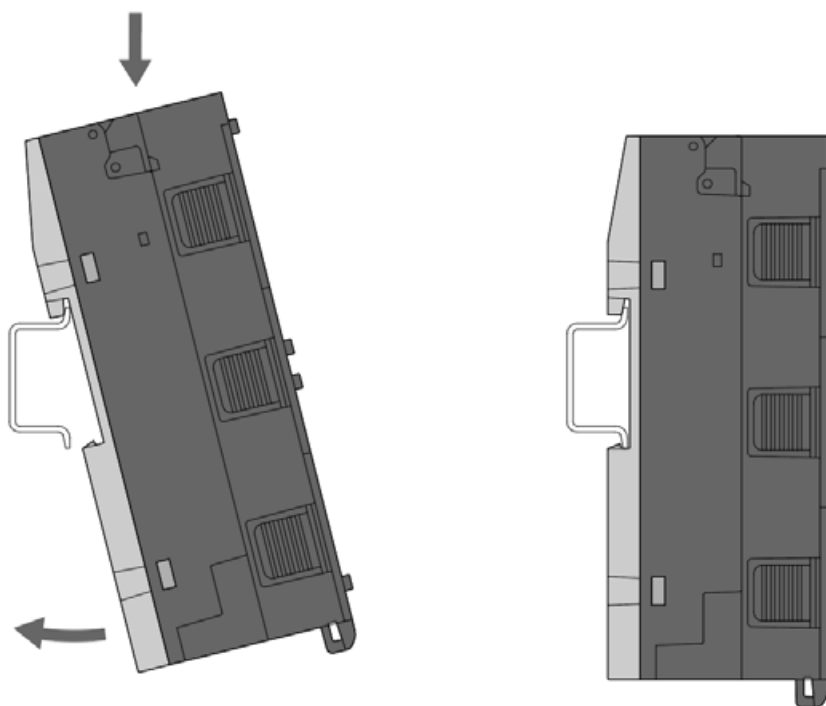## 5.8.3 Mounting a processor module on a DIN rail

> ! **NOTICE!**
> **Risk of function faults!**
> The module is grounded via DIN rail.
>
> The DIN rail must be included into the grounding conception of the plant.
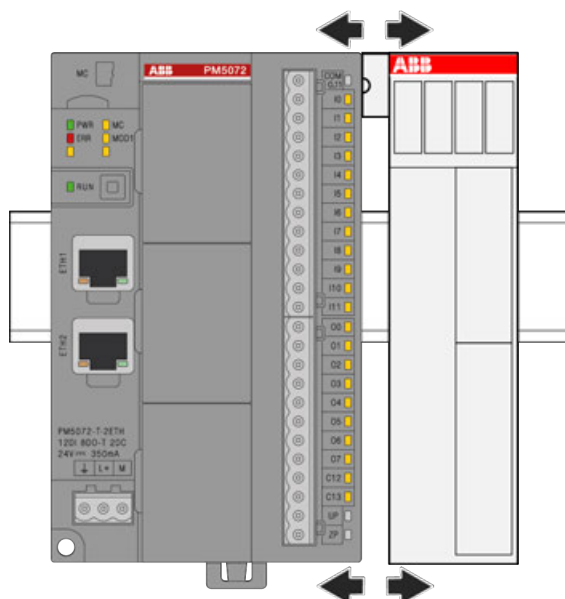>
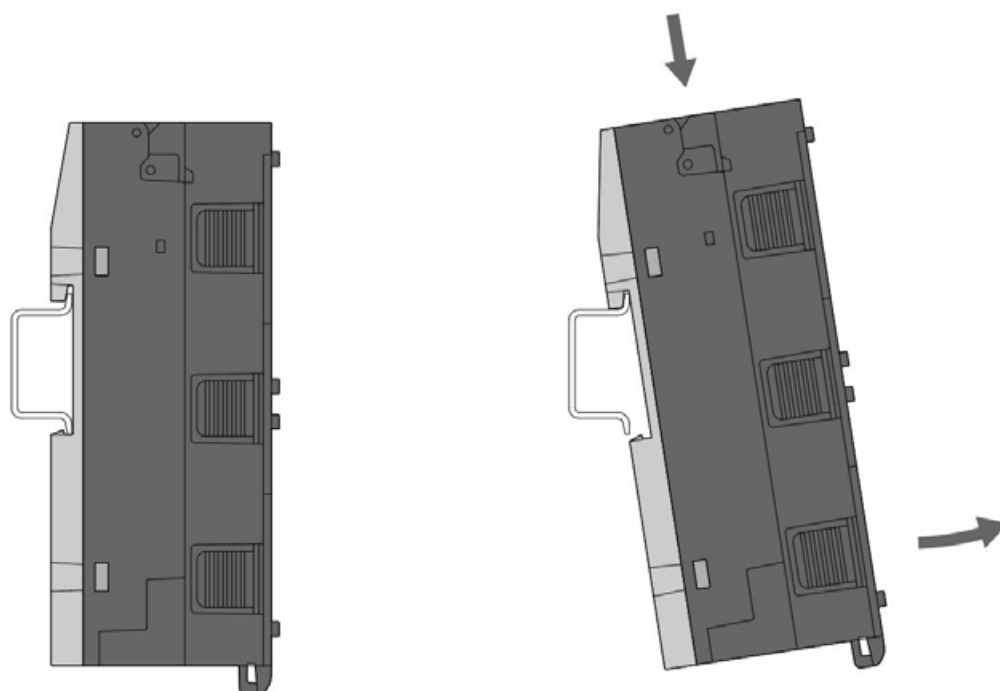> Use only metal screws for grounding.

Mount the processor module at the top of the DIN rail, then snap it in below.

5.8.4 Demounting a processor module mounted on a DIN rail

1. Remove I/O modules if connected.

2. While pressing down processor module pull it away from DIN rail.

5.8.5 Mounting a processor module on a metal plate

> **!**
> **NOTICE!**
> **Risk of function faults!**
> Missing electrical contact by isolating screws or washers!
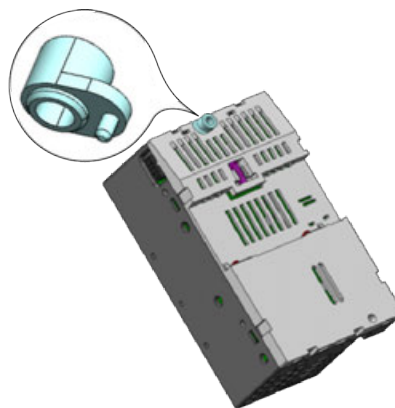> Use metal screws on the metal plate.
> The metal plate must be included into the grounding concept of the plant.
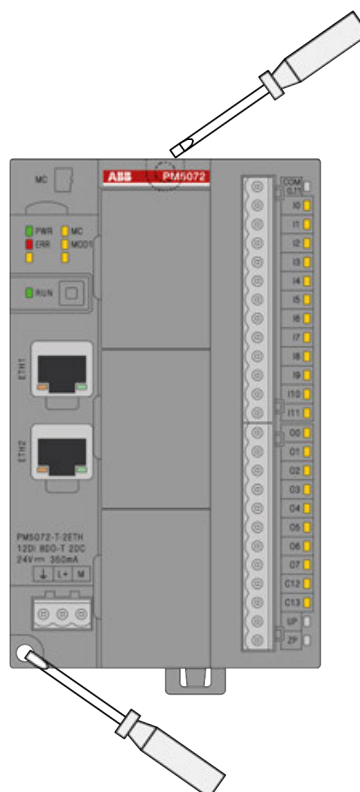> Do NOT use insulating washers!

> ⓘ *One TA543 wall mounting accessory is needed per processor module.*

1. Snap in the TA543 at the back side of the processor module.
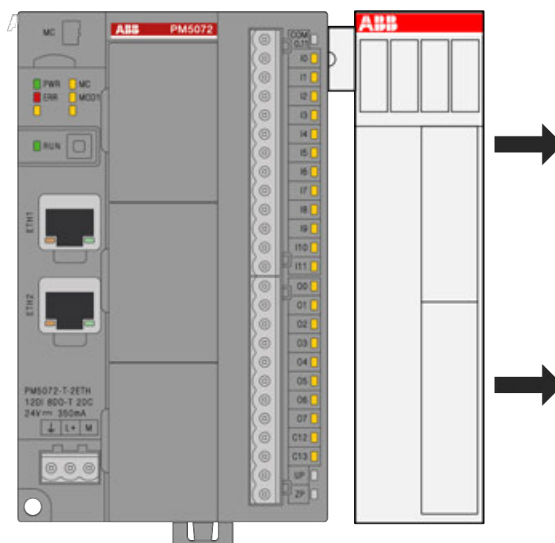

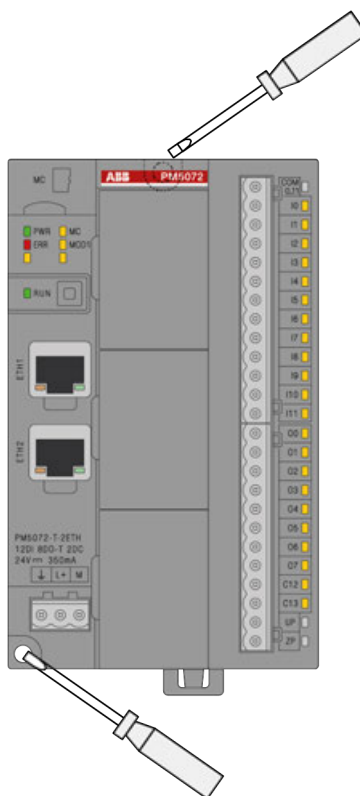2. Fasten the processor module with two screws (diameter: 4 mm) to the metal plate.

5.8.6 Demounting a processor module mounted on a metal plate

1. Remove I/O modules if connected.

2. Remove the 2 screws.

5.8.7 Mounting of the cable fixing accessory TA5301-CFA
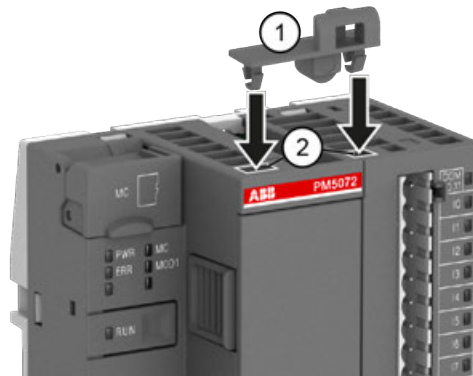
1   TA5301-CFA cable fixing accessory
2   2 openings on the PM50x2 processor module

▷   Insert the TA5301-CFA cable fixing accessory into the two openings on the PM50x2 processor module marked white in the figure.

5.9 Mounting and demounting the S500-eCo I/O module

S500-eCo I/O modules can be mounted either on a DIN rail or with screws on a metal plate.

Mounting I/O modules on a DIN rail

> **!** **NOTICE!**
> **Risk of function faults!**
> The module is grounded via DIN rail.
>
> The DIN rail must be included into the grounding conception of the plant.
>
> Use only metal screws for grounding.

1.   Mount I/O module at the top of the DIN rail, then snap it in below.
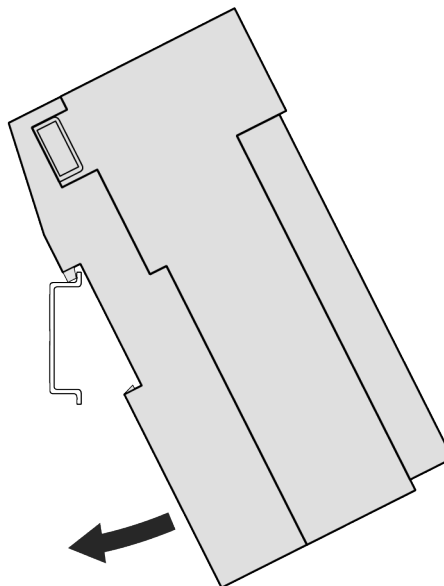
2.   Attach I/O module by hand to an other module. The I/O bus is connected automatically.
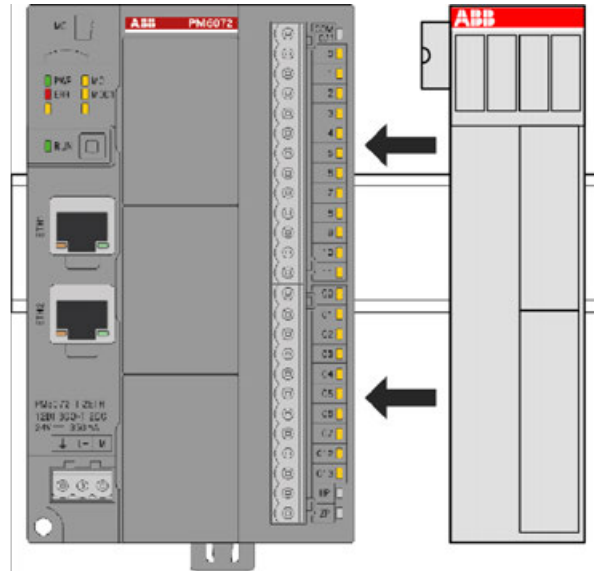
Demounting I/O modules mounted on a DIN rail

1.   Remove I/O module by hand if connected.
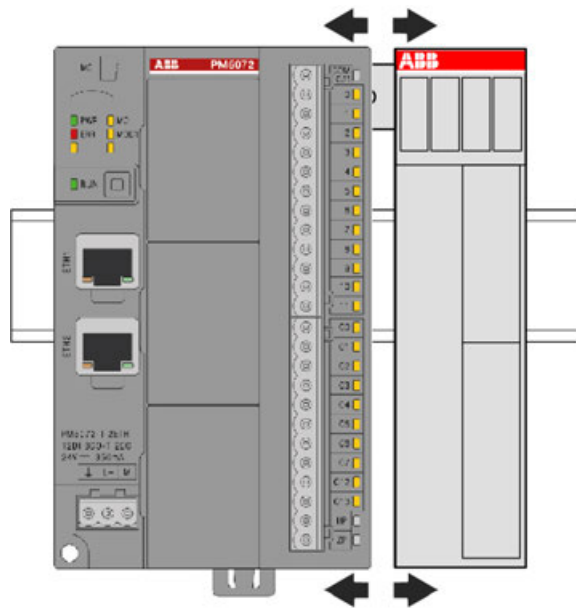
2. While pressing down I/O module pull it away from DIN rail.
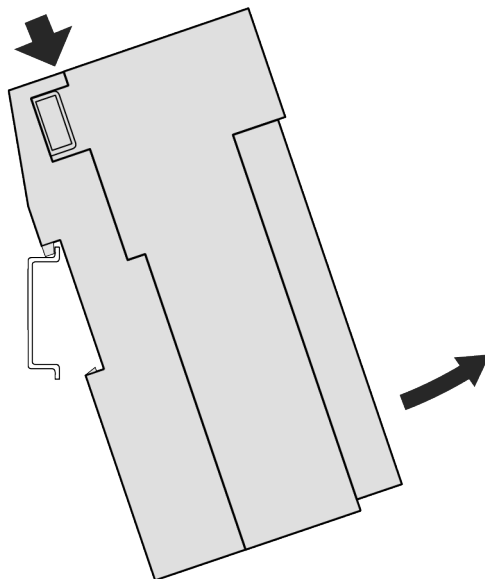
Demounting I/O modules mounted on a metal plate

1. Remove the 2 screws.
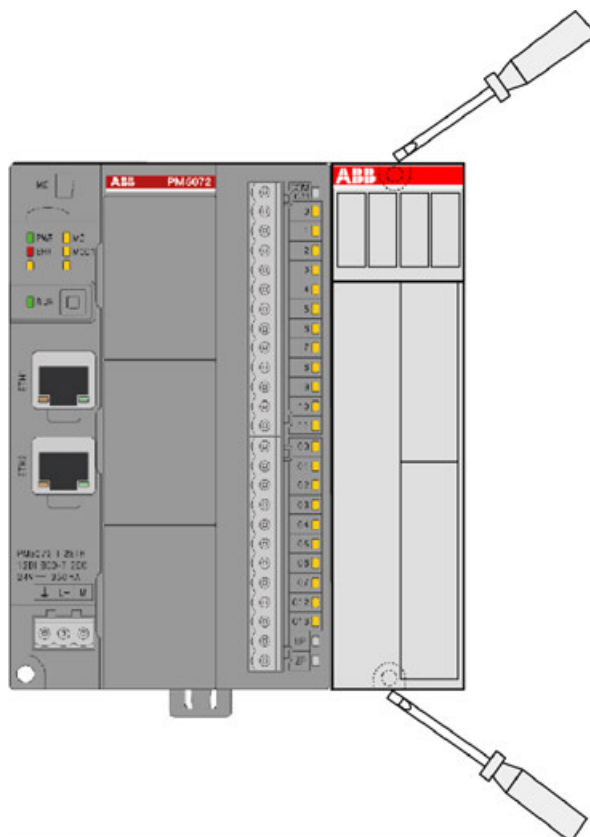
2. Remove the I/O module from the connected module by hand.
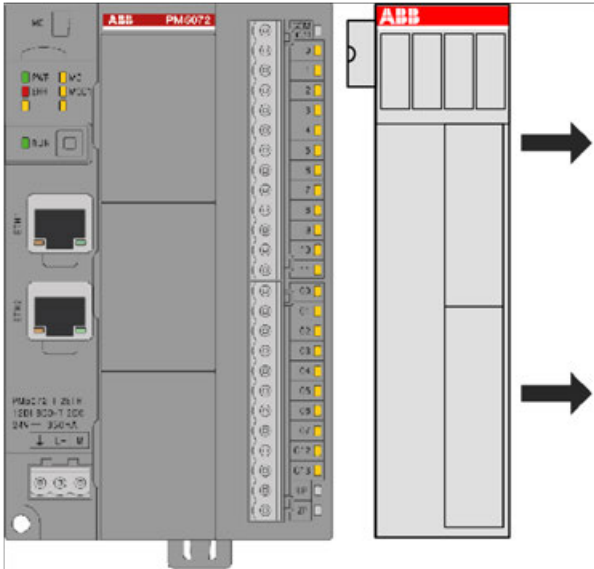
5.9.1 Terminal block selection for I/O modules

> *Terminal blocks (9 or 11 poles) are necessary for each S500-eCo I/O. The terminal blocks must be ordered separately.*

Table 4: Digital I/O modules

Terminal block required		I/O module
9 poles	**11 poles**	
1	-	DI561
1	1	DI562
1	1	DI571
1	1	DI572
-	1	DO561
1	1	DO562
-	1	DO571

Terminal block required		I/O module
9 poles	11 poles	
1	1	DO572
1	1	DO573
1	1	DX561
1	1	DX571
1	1	DC562

Table 5: Analog I/O modules

Terminal block required		I/O module
9 poles	11 poles	
1	1	AI561
-	1	AI562
1	1	AI563
-	1	AO561
1	1	AX561

Table 6: Terminal blocks for AC500-eCo I/O modules

Number of poles	Connection type	Cable entry	Type
9	Screw	Side	TA563-9
11	Screw	Side	TA563-11
9	Screw	Front	TA564-9
11	Screw	Front	TA564-11
9	Spring	Front	TA565-9
11	Spring	Front	TA555-11

> *Please refer to the PLC Automation catalog for description and ordering details of the terminal blocks.*
>
> *Terminal blocks*

5.10   Accessories for AC500 (Standard)

5.10.1   Inserting and removing a memory card
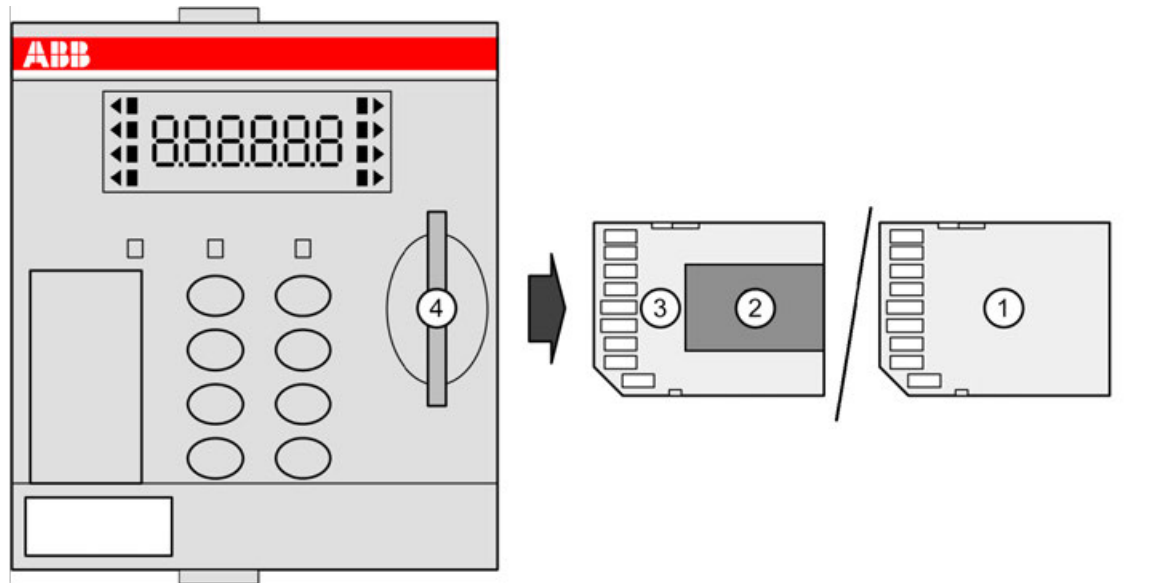

1   MC5141 memory card
2   MC5102 micro memory card
3   Micro memory card adapter
4   Memory card slot

1.   Insert the memory card into the memory card slot of the processor module until locked.

> **! NOTICE!**
>
> **Disturbed PLC operation**
>
> Do not remove the micro memory card when it is working!
>
> Otherwise the micro memory card and/or files on it might get corrupted and/or normal PLC operation might be disturbed.
>
> –   AC500: Remove the micro memory card only when no black square (■) is shown next to MC in the display.
> –   AC500-eCo: Remove the micro memory card only when the MC LED is not blinking.

2.   To remove the memory card, push on the memory card until it moves forward. By this, the memory card is unlocked and can be removed.

5.10.2   Further accessories

This section only describes accessories that are frequently used for system assembly, connection and construction.
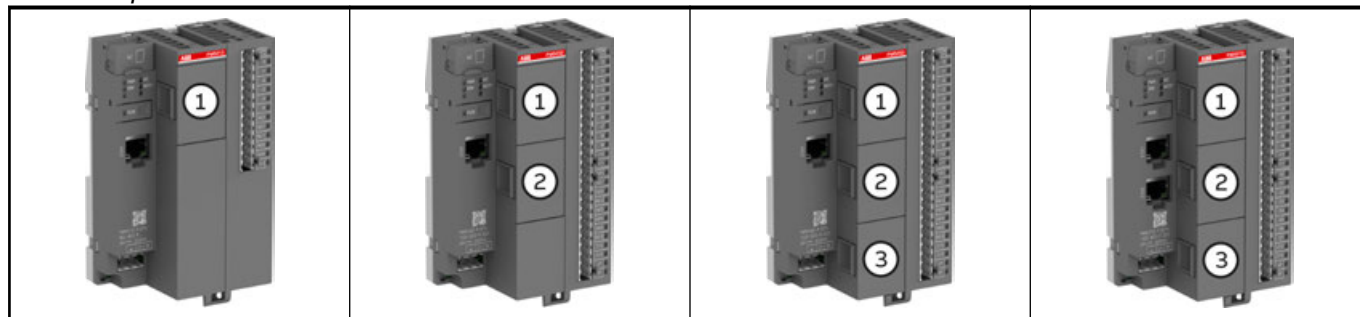
5.11   Accessories for AC500-eCo

5.11.1   Mounting and demounting the option boards

5.11.1.1   Optimized mounting of the option boards

The AC500-eCo processor modules have up to 3 slots for option boards.

Table 7: Option board slots

The best thermal circulation is given on slot 3 (bottom slot), followed by slot 2 (middle slot) and then slot 1 (top slot).

The best mounting position of the option board depends on its power dissipation.

> ***Rules for optimized mounting of the option boards***
>
> – *The higher the power dissipation of the option board, the lower the mounting position should be selected.*
> – ***The TA5126-2AO-UI option board has the highest power dissipation and must always be mounted at the lowest option board slot.***
>
> *The optimized mounting position can be easily determined with the help of this table.*

Table 8: Power dissipation of the option boards

Power dissipation of the option boards	Digital	Analog	Serial interface	Accessory
very small			TA5141-RS232I(W) TA5142-RS485I(W) TA5142-RS485(W)	TA5130-KNXPB(W) TA5131-RTC
small	TA5105-4DOT(W)	TA5123-2AI-RT(D/W)		
medium	TA5110-2DI2DO(T/W) TA5101-4DI(W)	TA5120-2AI-UI(W) TA5128-2AI1AO(W)	TA5146-CN(W)	
large		TA5126-2AO-UI(W)		

> *If the option boards to be mounted are in the same power dissipation level, then the slots can be freely selected.*

5.11.1.2   Inserting the option board
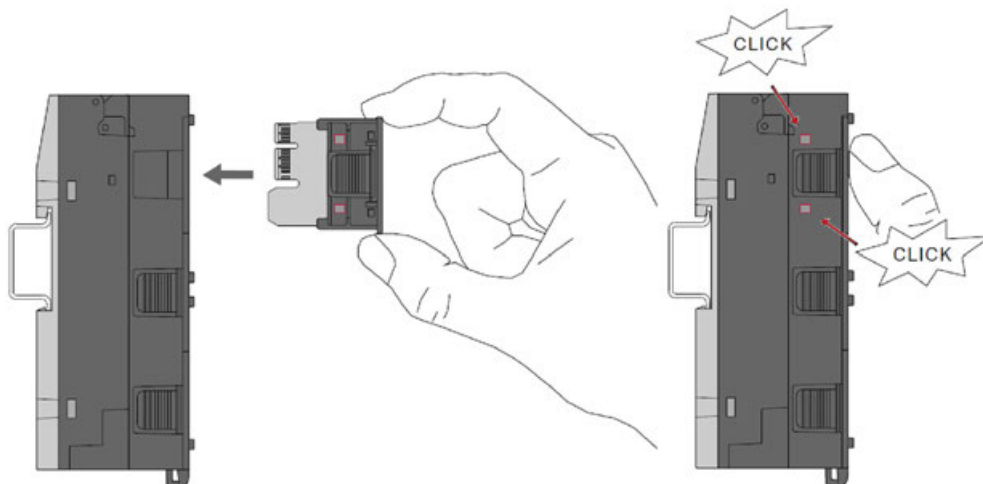
▷   Press the option board TA51xx (or TA5300-CVR) into the slot of the processor module PM50x2 until it locks in place.

> ⓘ   *The option board must click into the slot of the processor module.*

5.11.1.3   Removing the option board
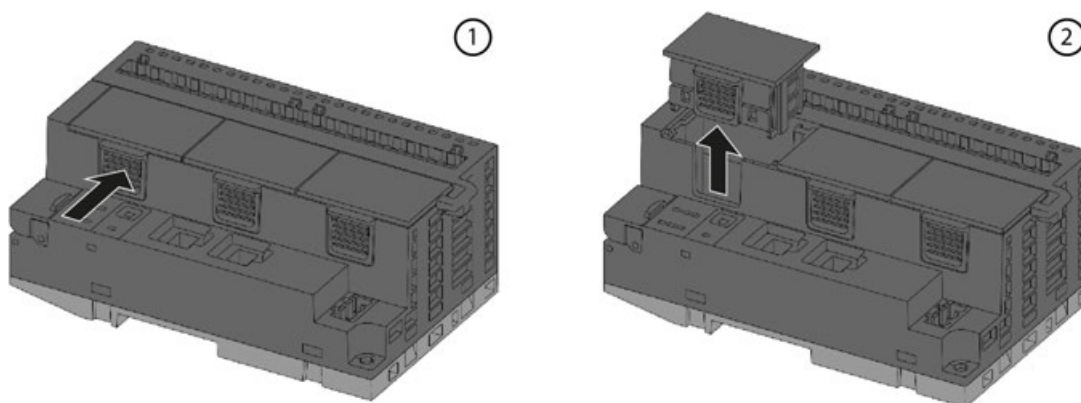
1.   Push the option board on the side to release the lock.

2.   At the same time, pull the option board out of the slot.

> ⚠️ **CAUTION!**
>
> **Risk of injury and damaging the product!**
>
> Always plug in the option board slot cover when the option board is not inserted.
>
> If the option board slot cover is lost, please order the replacement TA5300-CVR (1SAP187500R0001).
>
> Never power up the CPU with uncovered option board slot, otherwise it may cause serious injury and/or damage the product.

5.11.2   Inserting and removing a memory card

AC500-eCo

1   Micro memory card slot cover
2   Micro memory card
3   Micro memory card slot

1.   Open the micro memory card slot cover by turning it upwards.

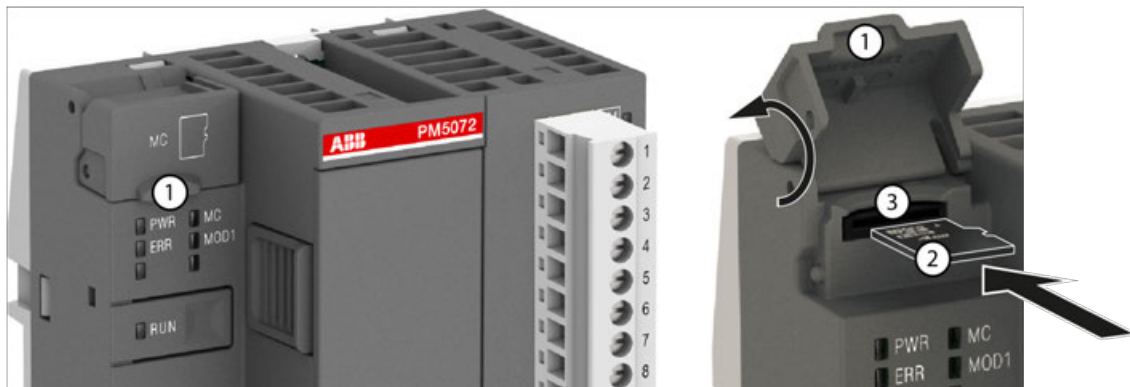2.   Carefully insert the micro memory card into the micro memory card slot as far as it will go. Observe orientation of card.

3.   Close the micro memory card slot cover by turning it downwards.

AC500-eCo

> **!**
>
> **NOTICE!**
>
> **Disturbed PLC operation**
>
> Do not remove the memory card when it is working!
>
> Otherwise the memory card and/or files on it might get corrupted and/or normal PLC operation might be disturbed.
>
> –   Remove the memory card only when no black square (■) is shown next to MC in the display.
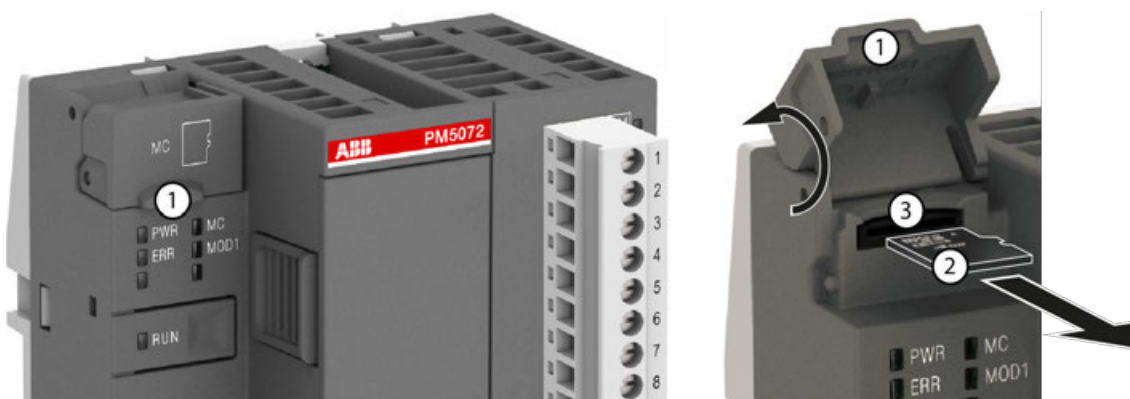
1   Micro memory card slot cover
2   Micro memory card
3   Micro memory card slot

1.   Open the micro memory card slot cover by turning it upwards.

2.   Micro memory card can be removed from the micro memory card slot by gripping and pulling with two fingers.

3.   Close the micro memory card slot cover by turning it downwards.

5.11.3   Further accessories

This section only describes accessories that are frequently used for system assembly, connection and construction.

5.12   Control panels CP600

Refer to the *installation instructions* delivered with each control panel and to the *operating instructions*.

6 Wiring

6.1 Grounding concept

> **!**
> **NOTICE!**
> **PLC damage due to missing grounding**
> – Make sure to ground the devices.
> – The grounding (switch cabinet grounding) is supplied both by the mains connection (or 24 V supply voltage) and via the DIN rail. The DIN rail must be connected to ground before power is supplied to the device. The grounding may be removed only if it is certain that no more power is being supplied to the control system.
> – In case of screw mounting, use metal screws for grounding.

Block diagram: Digital I/O modules
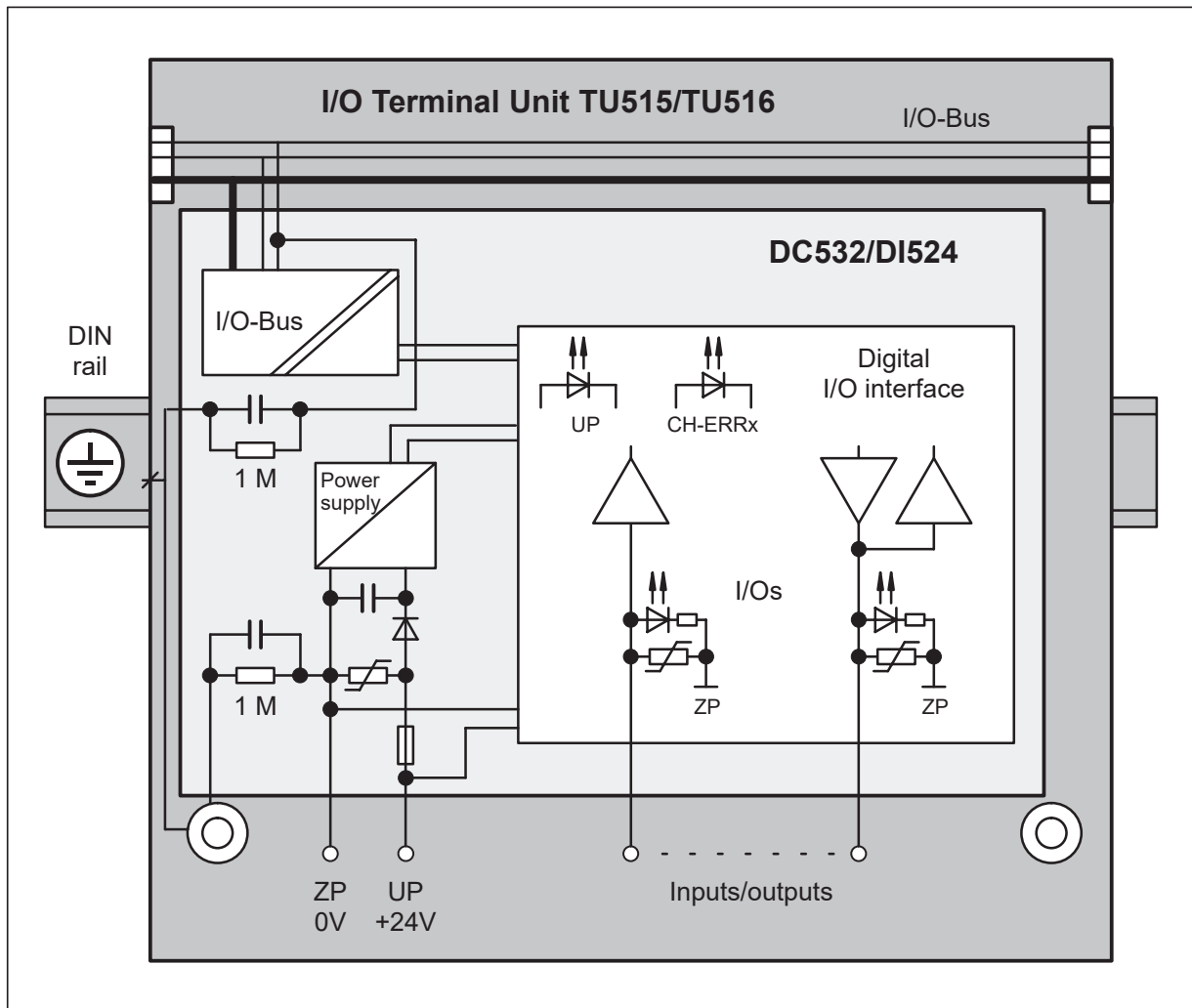
**Block diagram:
Analog I/O
modules**
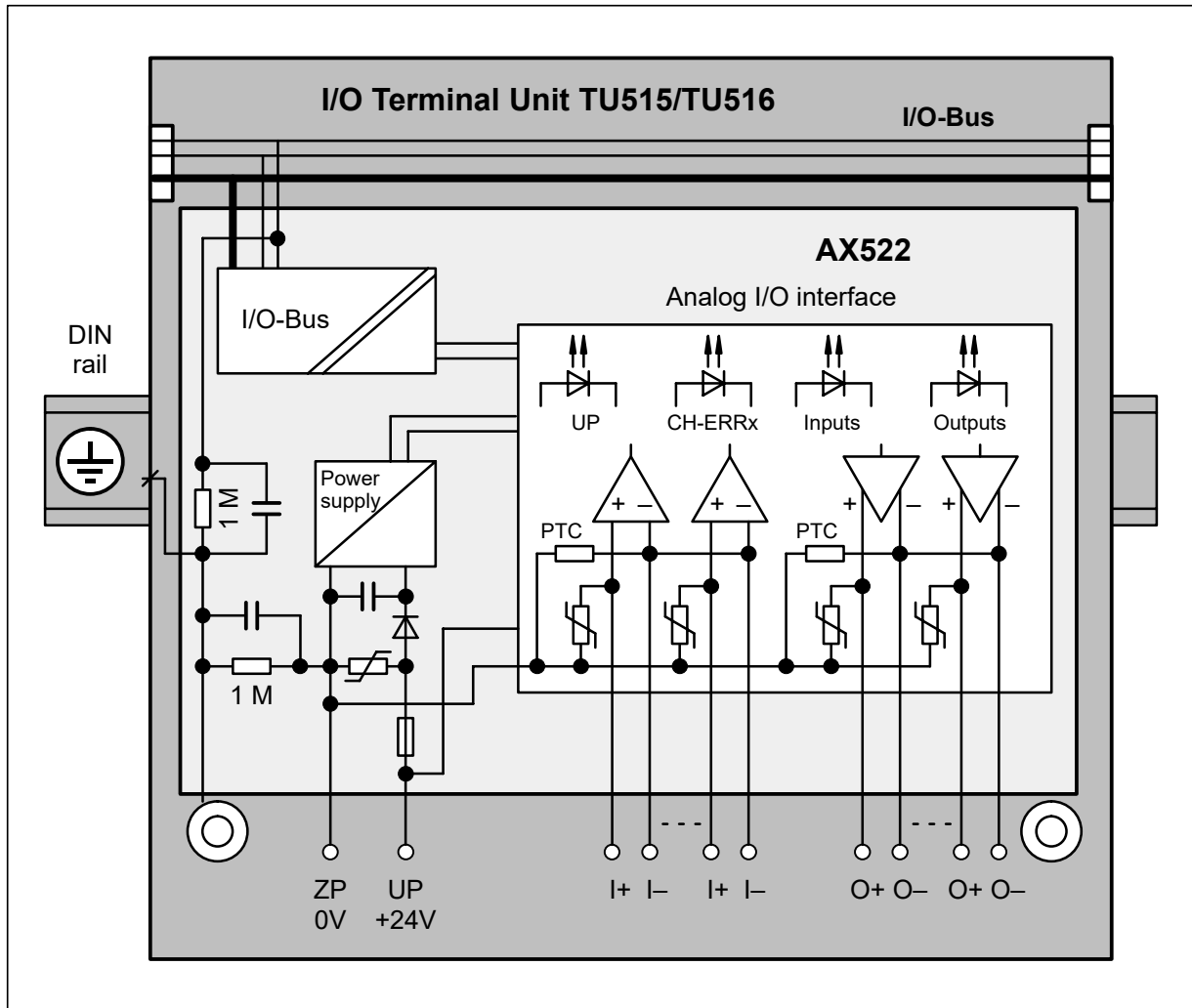
6.2 EMC-conforming assembly and construction

6.2.1 General principles

> *AC500 and AC500-eCo PLC devices are Class II/Class III devices and do not require a Protective Earth (PE) connection.*
>
> *For proper EMC performance, all metal parts, DIN rails, mounting screws, and cable shield connection terminals are connected to a common ground and provide Functional Earth (FE). This is typically connected to a common reference potential, such as equipotential bonding rails.*
>
> *Signal Grounds (SGND or GND) are used for signal reference and must not be connected to cable shields, FE or other signals unless otherwise specified in the specific device description.*

General considerations
Electric and electronical devices have to work correctly on site. This is also valid when electromagnetic influences affect them in defined and/or expected strength. The devices themselves must not emit electro-magnetic noises.

Advant controller components have a very high noise immunity.

When the wiring and grounding instructions are met, an error-free operation is given.

High electro-magnetic noises of nearby mounted applications must be taken in consideration during the planning phase.

An EMC compatible earthing concept will also guarantee an error-free operation here.

> *In order to prevent operating malfunctions, it is recommended, that the operating personnel discharge themselves prior to touching communication connectors or perform other suitable measures to reduce effects of electrostatic discharges.*

> ***There are three important principles to be especially considered.***
> – *Keep all connections as short as possible (in particular the grounding conductors).*
> – *Use large conductor cross sections (in particular for the grounding conductors).*
> – *Create low-impedance, i.e. good and large-sized contacts (in particular for the grounding conductors).*

> ***Pay attention to the following:***
> – *Use vibration-resistant connections.*
> – *Clean metallic contact areas.*
> – *Use solid plug and screw-type connections.*
> – *Use earth cable shields with clips on a well-grounded metallic surface.*
> – *Do not use aluminium parts.*
> – *Do not use sheath wires.*
> – *Do not use toothed lock washers under screw connections.*

Fig. 10: Assembly: wrong

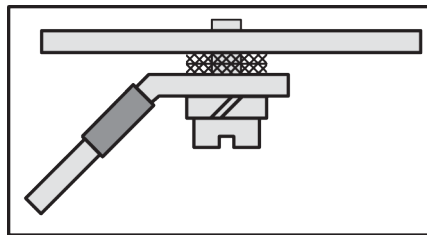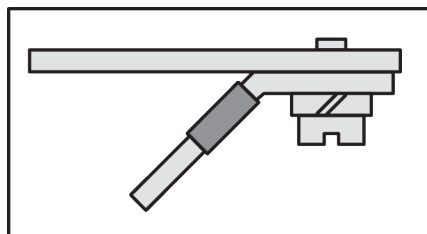*Fig. 11: Assembly: correct*

Make a connection between the DIN rails and PE (Protective Earth). For this, use an grounding wire with a minimum conductor cross section of 10 mm².

The wire is connected to the DIN rail with an M6 screw.

A large-area contact of the DIN rail with the metallic mounting plate improves the EMC behavior significantly, as the disturbances can be discharged more effective.

6.2.2 Cable routing

- Route cables meeting the standards.
- Sort the cables into cable groups:
  - Power current cables
  - Power supply cables
  - Signal cables
  - Data cables
- Route signal cables and data cables separately from the power cables.
  - Separate cable ducts or cable bundles.
  - The distance should be 20 cm or greater.
- Lay signal and data cables close to earthed surfaces.

6.2.3 Cable shields

- Use only shielded data cables. The shield should be grounded at both ends.
  A cable shield only grounded at one end can only protect from capacitively coupled interference and low-frequency disturbances (50 Hz hum).
- Avoid parasitic currents flowing through the cable shields.
  This can be done by installing current-carrying equipotential bondings.
- Use only cables with braided shields.
  Foil shields are not robust enough, cannot be contacted well and have poor HF properties.
- Use only metallic or [metal]-plated plugs for shielded data cables.
- Use only shielded cables for analog signals.
  For small signals ground the shield only at one end.
- Ground the cable shield directly with a clip when entering the control cabinet.
  Do not cut the shield until the cable reaches the module connected.

> *The connection between the PE bar and the shield bar must have a low impedance.*

6.2.4 Control cabinet

> *Installation of configurations in shielded cabinet can be required in shipping applications. Follow specific instructions in the applicable type approval certificate.*

Available certificates can be found in the internet

1. Open landing page of the product e.g. _DO526_

2. In the middle of the page, click on *[Downloads]*.

   ⇨ A two-column window opens on the page with all available documents.

3. In the left column of the downloads page click on *[Certificate]*.

   ⇨ All available certificates are listed in the right column.

In the list of certificates, the maritime certificates can be identified by the title. The title consists of the abbreviation of the maritime classification society followed by the words: Type Approval Certificate. E.g. "DNV Type Approval Certificate: ...".

Connections   The connections between the control cabinet, the mounting plates, the PE bar and the shield bar must have a low impedance.

Grounding   Ground the control cabinet doors with short and highly flexible conductors.

Control cabinet lighting   Only use lighting with interference suppression.

For supplying the PC   Use the mains socket which is located inside the control cabinet.

6.2.5 Reference potential

- Provide a uniform reference potential in the entire installation and ground all electrical appliances if possible.
- Route your grounding conductors in a star configuration so that no ground loops can occur.

6.2.6 Equipotential bonding

The Installation of equipotential bondings are necessary if there are present or expected potential differences between parts of your application.

> – *The impedance of equipotential bonding must be equal or lower than 10 % of the shield impedance of the shielded signal cables between the same points.*
> – *The conductor cross section of a equipotential bonding must be 16 mm² to withstand the maximum possible compensating current.*
> – *Equipotential bondings and shielded signal cables should be laid close to each other.*
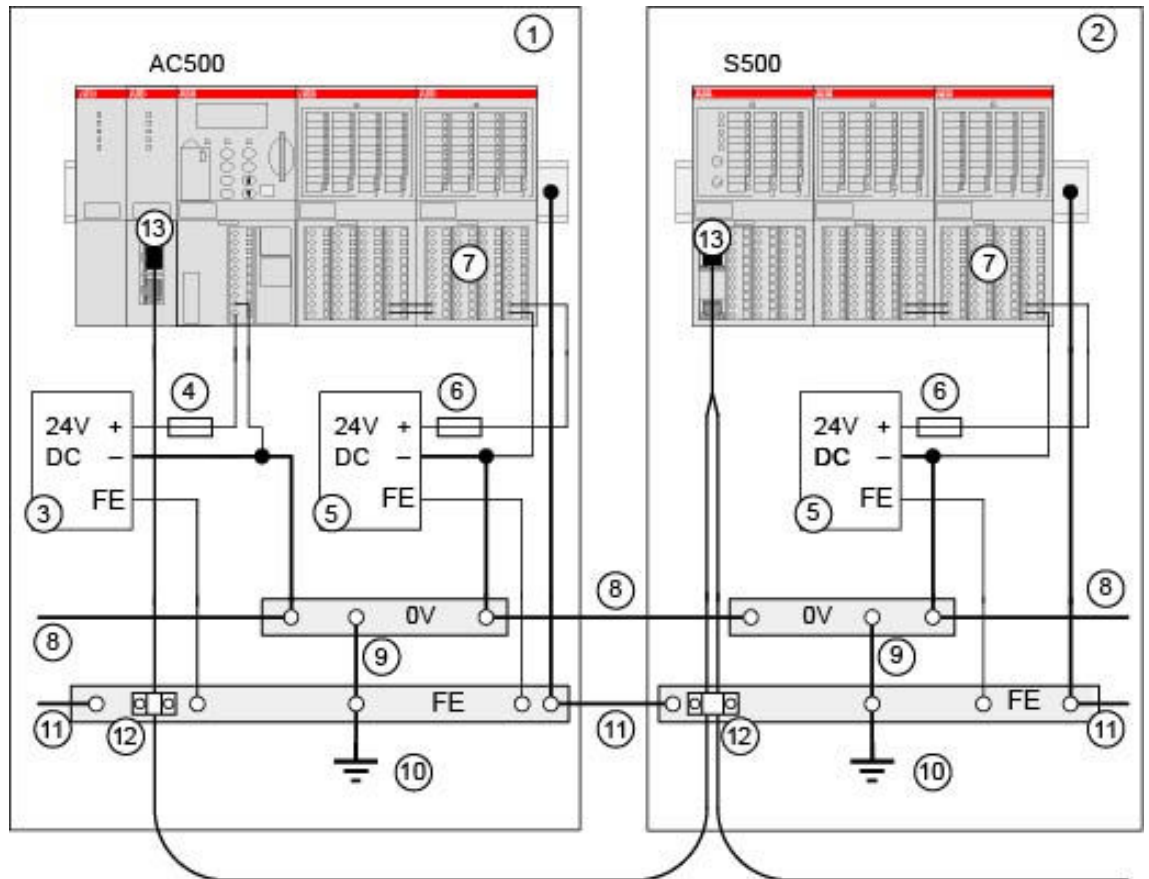> – *Equipotential bondings must be connected to PE with low impedance.*

Fig. 12: AC500, equipotential bonding

1 Cabinet 1
2 Cabinet 2
3 Power supply for the CPU
4 Fuse for the CPU power
5 Power supply for the I/Os
6 Fuse for the I/O power
7 For fuses for the contacts of the relay outputs
8 0V rail
9 Grounding of the 0V rail
10 Cabinet grounding
11 Equipotential bonding between the cabinets min. 16 mm^2
12 Cable shields grounding
13 Fieldbus connection (e.g. Ethernet)

6.3 Connection and wiring of the PLC platform

6.3.1 Safety instructions

> **!** **NOTICE!**
> **Attention:**
> The devices should be installed by experts who are trained in wiring electronic devices.
>
> In case of bad wiring, the following problems could occur:
>
> – On the terminal base, the terminals L+ and M are doubled. If the power supply is badly connected, a short circuit could happen and lead to a destruction of the power supply or its fuse. If no suitable fuse exists, the terminal base itself might be destroyed.
> – The terminal bases and all electronic modules and terminal units are protected against reverse polarity.
> – All necessary measures should be carried out to avoid damages to modules and wiring. Notice the wiring plans and connection examples.

> **!** **NOTICE!**
> All I/O channels (digital and analog) are protected against reverse polarity, reverse supply, short circuit and temporary overvoltage up to 30 V DC.

> **!** **NOTICE!**
> **Attention:**
> Due to possible loss of communcation, the communication cables should be fixed with cable duct or bracket or clamp during application.

6.3.2 AC500

6.3.2.1 Power supply for AC500 system

The system is powered by two different power circuits:

● The power supply for the processor module is provided through the terminals L+/M.
● The power supply for the I/O modules is provided through the terminals UP/ZP.

The power supply for the processor module is galvanic isolated from the power supply for the I/O modules.

As soon as the power supply for the processor module is present, the processor module starts. The power supply of the processor module and the I/O modules should be powered on the same time, otherwise the processor module will not switch to run mode after startup.

When during operation the power supply falls below the minimum process and supply voltage for more than 10 ms, the processor module switches to safe mode. A restart of the processor module only occurs by switching the power supply off and on again.
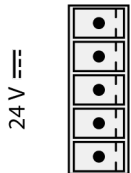
If an I/O module is disconnected during operation from the power supply while the processor module is still powered, the processor module will continue its normal operation on all other powered peripherals (other I/O modules, communication modules and communication interfaces), but freezes the input image. After recovery of the power supply of the affected I/O module it will continue normal operation and inputs and outputs will be updated.

As power supply for the AC500 system, the ABB power supplies series CP can be used.

6.3.2.2 Power supply for processor modules

The supply voltage of 24 V DC is connected to a removable 5-pin terminal block. L+/M exist twice. It is therefore possible to feed e.g. external sensors (up to 8 A max. with 1.5 mm^2 conductor) via these terminals.

Pin assignment

Pin Assignment		Label	Function	Description
		L+	+24 V DC	Positive pin of the power supply voltage
		L+	+24 V DC	Positive pin of the power supply voltage
Terminal block removed	Terminal block inserted	M	0 V	Negative pin of the power supply voltage
		M	0 V	Negative pin of the power supply voltage
		⏚	FE	Functional earth

6.3.2.3 Connection of wires at the spring terminals
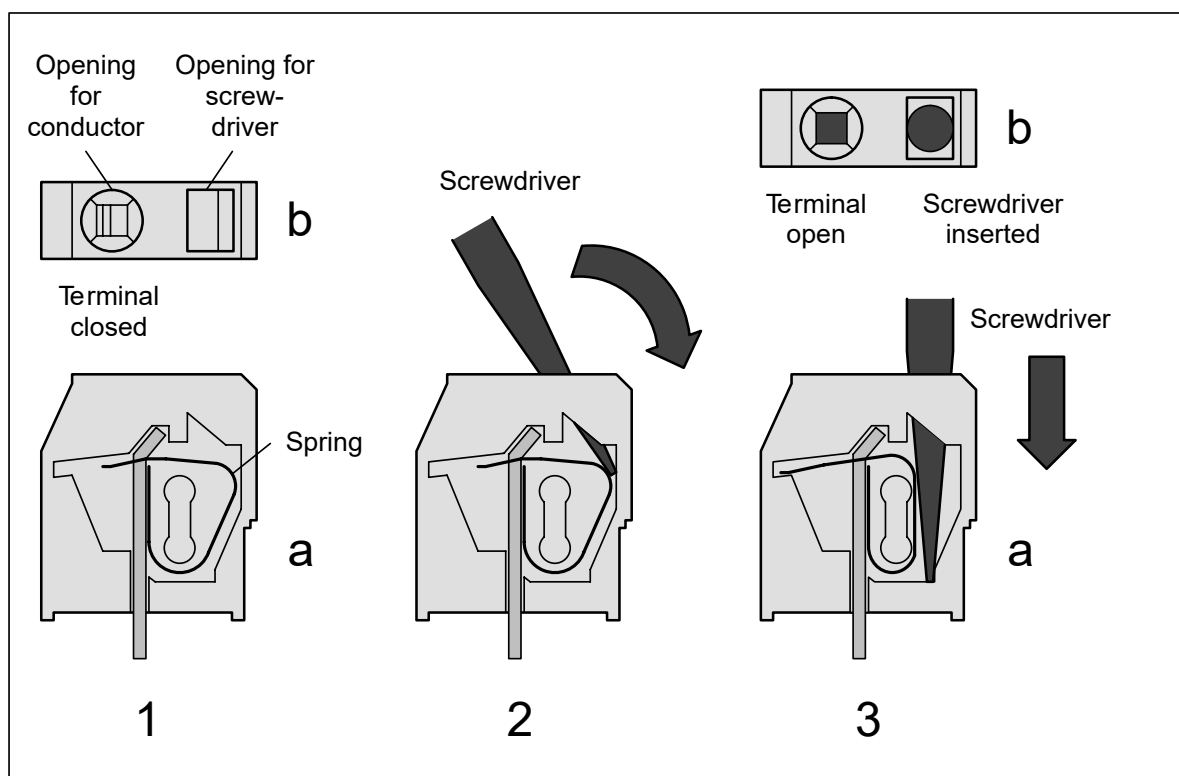
Connection

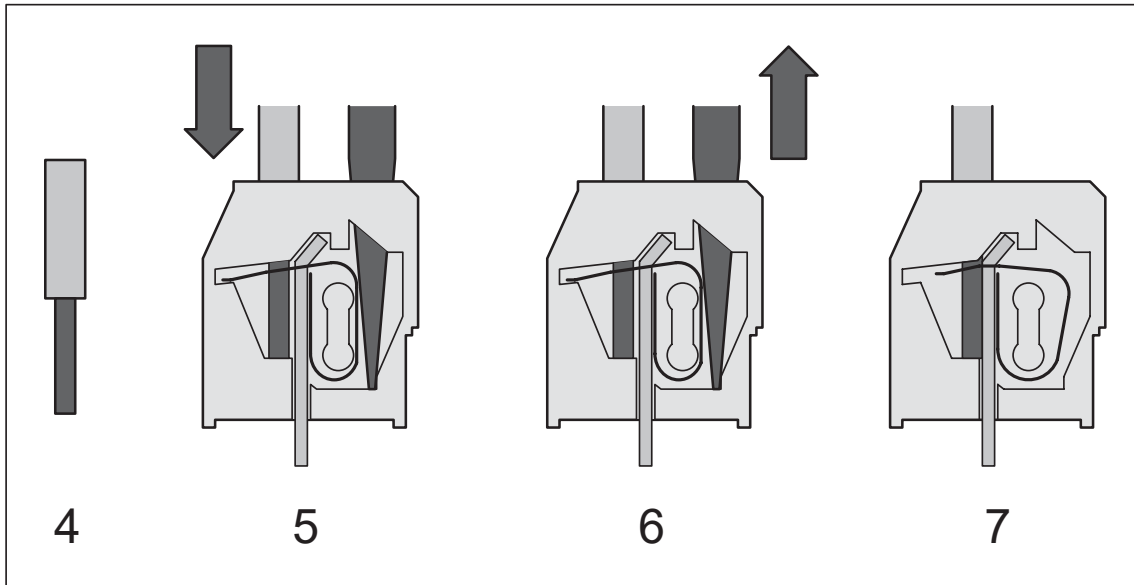*Fig. 13: Connect the wire to the spring terminal (steps 1 ... 3)*

Fig. 14: Connect the wire to the spring terminal (steps 4 ... 7)

1. Side view (open terminal drawn for illustration)
2. The top view shows the openings for wire and screwdriver
3. Insert screwdriver (2.5 x 0.4 to 3.5 x 0.5 mm) at an angle, screwdriver must be at least 15 mm free of insulation at the tip
4. While erecting the screwdriver, insert it until the stop (requires a little strength)
5. Screwdriver inserted - terminal open
6. Strip the wire for 7 mm (and put on wire-end ferrule)
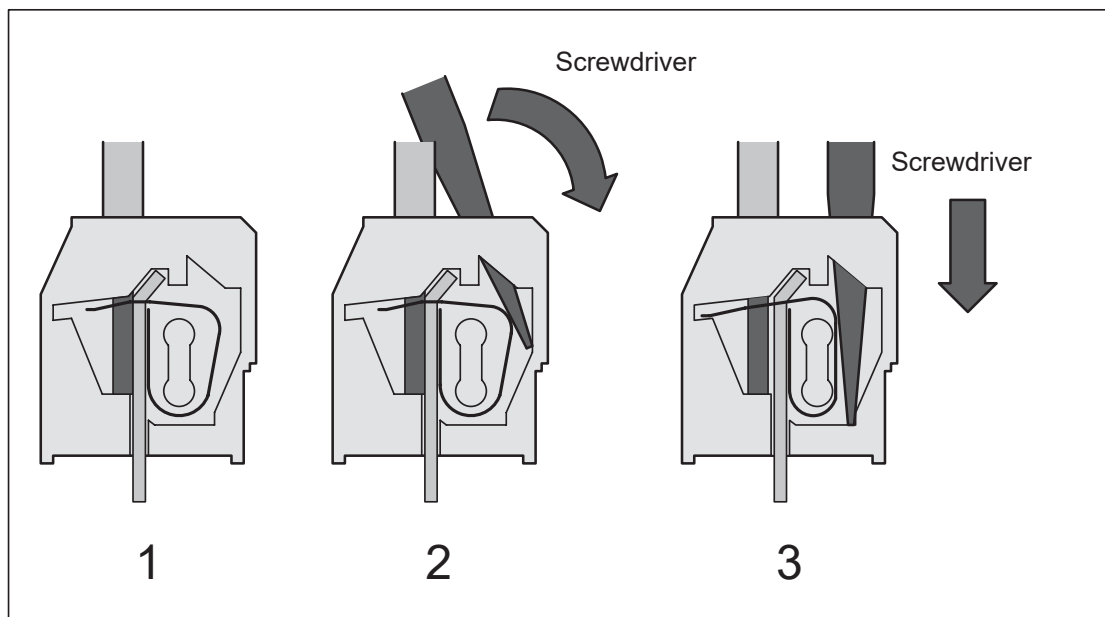7. Insert wire into the open terminal
8. Done

Disconnection

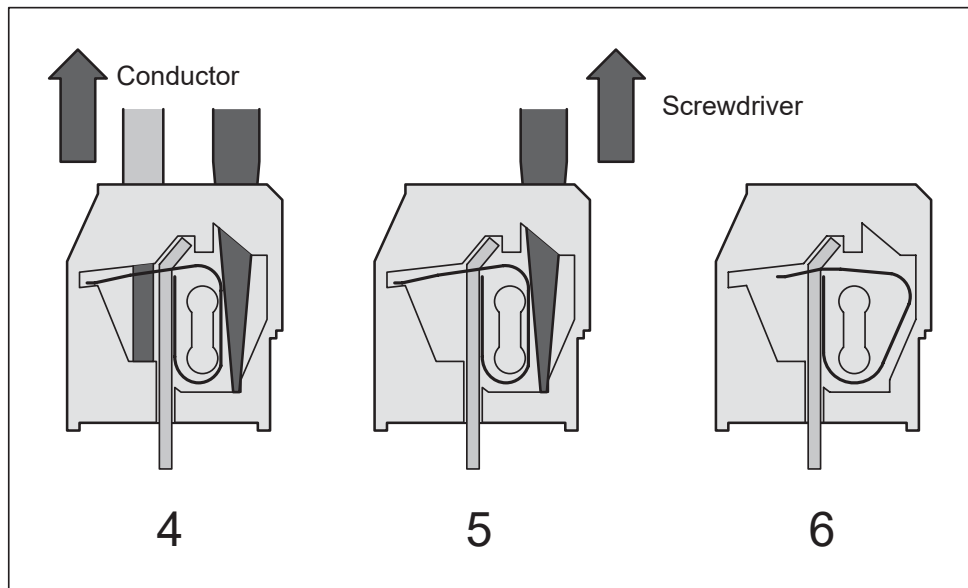*Fig. 15: Disconnect wire from the spring terminal (steps 1 ... 3)*

Fig. 16: Disconnect wire from the spring terminal (steps 4 ... 6)

1. Terminal with wire connected

2. Insert screwdriver (2.5 x 0.4 ... 3.5 x 0.5 mm) at an angle, screwdriver must be at least 15 mm free of insulation at the tip

3. While erecting the screwdriver, insert it until the stop (requires a little strength) - terminal is now open

4. Remove wire from the open terminal

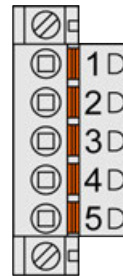5. Done

6.3.2.4 Terminals for CANopen communication modules

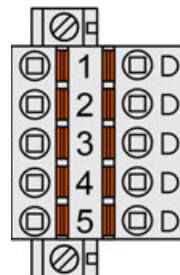*Fig. 17: Combicon, 5-pole, female, removable plug with spring terminals*

Fig. 18: Combicon, 5-pole, female, removable plug with spring terminals

Terminal type: Spring terminal

Number of cores per terminal	Conductor type	Cross section	Stripped conductor end
1	solid	0.2 mm² ... 2.5 mm²	10 mm
1	flexible	0.2 mm² ... 2.5 mm²	10 mm
1 with wire-end ferrule (without plastic sleeve)	flexible	0.25 mm² ... 2.5 mm²	10 mm
1 with wire-end ferrule (with plastic sleeve)	flexible	0.25 mm² ... 2.5 mm²	10 mm

6.3.2.5 Ethernet connection details

6.3.2.5.1 Ethernet interface

> *Ethernet is also used for PROFINET, EtherCAT and Modbus TCP connection.*

Pin assignment

Interface	Pin	Signal	Description
	1	TxD+	Transmit data +
	2	TxD-	Transmit data -
	3	RxD+	Receive data +
	4	NU	Not used
	5	NU	Not used
	6	RxD-	Receive data -
	7	NU	Not used
	8	NU	Not used
	Shield	Cable shield	Functional earth

6.3.2.5.2 Wiring

Cable length restrictions

For the maximum possible cable lengths within an Ethernet network, various factors have to be taken into account. Twisted pair cables (TP cables) are used as transmission medium for 10 Mbit/s Ethernet (10Base-T) as well as for 100 Mbit/s (Fast) Ethernet (100Base-TX). For a transmission rate of 10 Mbit/s, cables of at least category 3 (IEA/TIA 568-A-5 Cat3) or class C (according to European standards) are allowed. For fast Ethernet with a transmission rate of 100 Mbit/s, cables of category 5 (Cat5) or class D or higher have to be used. The maximum length of a segment, which is the maximum distance between two network components, is restricted to 100 m due to the electric properties of the cable.

Furthermore, the length restriction for one collision domain has to be observed. A collision domain is the area within a network which can be affected by a possibly occurring collision (i.e. the area the collision can propagate over). This, however, only applies if the components operate in half-duplex mode since the CSMA/CD access method is only used in this mode. If the components operate in full-duplex mode, no collisions can occur. Reliable operation of the collision detection method is important, which means that it has to be able to detect possible collisions even for the smallest possible frame size of 64 bytes (512 bits). But this is only

guaranteed if the first bit of the frame arrives at the most distant subscriber within the collision domain before the last bit has left the transmitting station. Furthermore, the collision must be able to propagate to both directions at the same time. Therefore, the maximum distance between two ends must not be longer than the distance corresponding to the half signal propagation time of 512 bits. Thus, the resulting maximum possible length of the collision domain is 2000 m for a transmission rate of 10 Mbit/s and 200 m for 100 Mbit/s. In addition, the bit delay times caused by the passed network components also have to be considered.

Table 9: Specified cable properties of the respective cable types per 100 m:

Parameter	10Base-T [10 MHz]	100Base-TX [100 MHz]
Attenuation [dB/100m]	10.7	23.2
NEXT [dB/100m]	23	24
ACR [dB/100m]	N/A	4
Return loss [dB/100m]	18	10
Wave impedance [Ohms]	100	100
Category	3 or higher	5
Class	C or higher	D or higher

TP cable

The TP cable has eight wires arranged in four pairs of twisted wires. Different color codes exist for the coding of the wires, the coding according to EIA/TIA 568, version 1, being the one most commonly used. In this code, the individual pairs are coded with blue, orange, green and brown color. One wire of a pair is unicolored and the corresponding second wire is striped, the respective color alternating with white. For shielded cables, a distinction is made between cables that have one single shield around all pairs of wires and cables that have an additional individual shield for each pair of wires. The following table shows the different color coding systems for TP cables:

Table 10: Color coding of TP cables:

Pairs	EIA/TIA 568 Version 1		EIA/TIA 568 Version 2		DIN 47100		IEC 189.2	
Pair 1	white/ blue	blue	green	red	white	brown	white	blue
Pair 2	white/ orange	orange	black	yellow	green	yellow	white	orange
Pair 3	white/ green	green	blue	orange	grey	pink	white	green
Pair 4	white/ brown	brown	brown	slate	blue	red	white	brown

Two general variants are distinguished for the pin assignment of the normally used RJ45 connectors: EIA/TIA 568 version A and version B. The wiring according to EIA/TIA 568 version B is the one most commonly used.
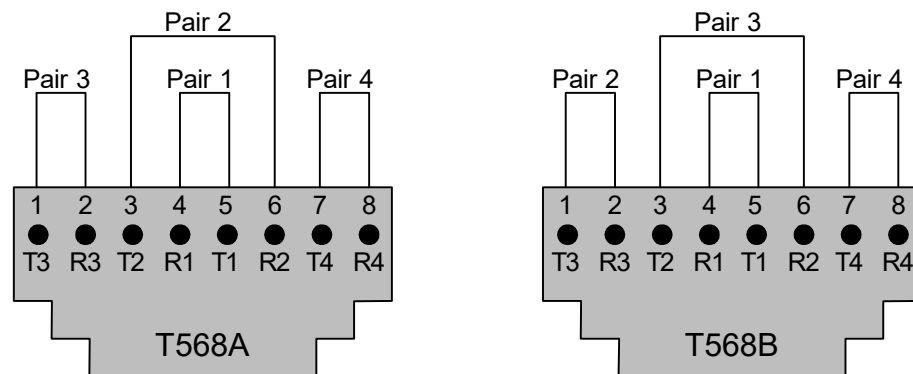
Fig. 19: Pin assignment of RJ45 sockets

6.3.2.5.3 Cable types

Crossover cable

> ⓘ **Particular use**
> *Crossover cables are needed only for a direct Ethernet connection without crossover functionality. In particular for AC500 modules in product life cycle phase "Classic".*

Crossover cables are for a direct Ethernet connection of two terminal devices as the simplest variant of a network. From transmission lines of the first station to the reception lines of the second station.
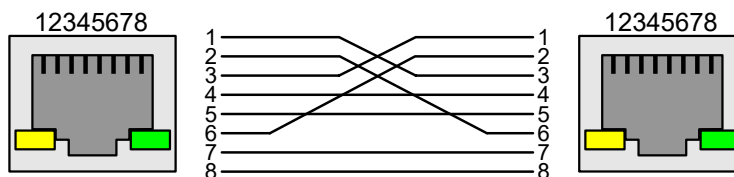

Fig. 20: Wiring of a crossover cable

Straight-through cable

For networks with more than two subscribers, hubs or switches have to be used additionally for distribution. These active devices already have the crossover functionality implemented which allows a direct connection of the terminal devices using straight-through cables.
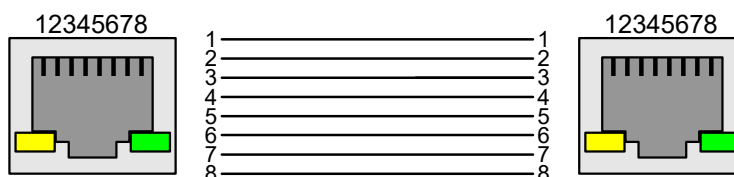

Fig. 21: Wiring of a straight-through cable

> ⚠ **CAUTION!**
> **Risk of communication faults!**
> When using inappropriate cables, malfunctions in communication may occur.
>
> Only use network cables of the categories 5 (Cat 5, Cat 5e, Cat 6 or Cat 7) or higher within PROFINET networks.

6.3.3 AC500-eCo

6.3.3.1 Power supply

The processor modules PM50x2 can be connected to the 24 V DC supply voltage via a removable 3-pin spring terminal block or a 3-pin screw terminal block.

Table 11: Removable terminal block for the supply voltage 24 V DC

3-pin spring terminal block	3-pin screw terminal block

The terminal block is available as a set for AC500-eCo processor modules.

Basic CPU (PM5012)		Standard CPUs (PM5032, PM5052) and Pro CPUs (PM5072, PM5082, PM5092)	
Spring type	**Screw type**	**Spring type**	**Screw type**
TA5211-TSPF-B	TA5211-TSCL-B	TA5212-TSPF	TA5212-TSCL

Pin assignment

Pin Assignment	Pin	Label	Function	Description
Terminal block inserted	1	$\perp$	FE	Functional earth
	2	L+	+24 V DC	Positive pin of the power supply voltage
	3	M	0 V	Negative pin of the power supply voltage

! **NOTICE!**

Risk of damaging the PLC due to improper voltage levels!

– Never exceed the maximum tolerance values for process and supply voltages.
– Never fall below the minimum tolerance values for process and supply voltages.

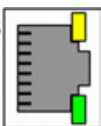Observe the **system data** and the **technical data** of the used module.

6.3.3.2 Ethernet

6.3.3.2.1 Ethernet interface

> *Ethernet is also used for Modbus TCP connection.*

The Ethernet interface is carried out via a RJ45 jack. The pin assignment of the Ethernet interface:

Interface	Pin	Description	
	1	Tx+	Transmit Data +
	2	Tx-	Transmit Data -
	3	Rx+	Receive data +
	4	NC	Not connected
	5	NC	Not connected
	6	Rx-	Receive data -
	7	NC	Not connected
	8	NC	Not connected
	Shield	Cable shield	Functional earth

6.3.4 Control panels CP600

Refer to the *installation instructions* delivered with each control panel and to the *operating instructions*.

6.4 Connection and wiring of the modules

Specific information about the connections of the modules and the wiring is available in the installation instructions.

- *Installation instructions of AC500 PLC product family*
- *Installation instructions of CP600 control panels*

7 Configuration and programming

New to AC500?
We recommend to use the step-by-step instructions in the _Getting started_ document to install the engineering suite and to configure and program your first project.

Advanced installation of engineering suite
Detailed information is available in _the installation and licensing document_.

Programming for PLC system
All information about the configuration and the programming are available in the _software manual_ (contained in PLC Automation manual).

Activating software licenses
Detailed information is available in _the installation and licensing document_.

7.1 Cyber security

7.1.1 General

Cyber security disclaimer

This product is designed to be connected to and to communicate information and data via a network interface. It is your sole responsibility to provide and continuously ensure a secure connection between the product and your network or any other network (as the case may be). You shall establish and maintain any appropriate measures (such as but not limited to the installation of firewalls, application of authentication measures, encryption of data, installation of anti-virus programs, etc.) to protect the product, the network, its system and the interface against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. ABB Ltd and its affiliates are not liable for damages and/or losses related to such security breaches, any unauthorized access, interference, intrusion, leakage and/or theft of data or information.

Although ABB provides functionality testing on the products and updates that we release, you should institute your own testing program for any product updates or other major system updates (to include but not limited to code changes, configuration file changes, third party software updates or patches, hardware exchanges, etc.) to ensure that the security measures that you have implemented have not been compromised and system functionality in your environment is as expected. This also applies to the operating system. Security measures (such as but not limited to the installation of latest patches, installation of firewalls, application of authentication measures, installation of anti-virus programs, etc.) are in your responsibility. You have to be aware that operating systems provide a considerable number of open ports that should be monitored carefully for any threats.

It has to be considered that online connections to any devices are not secured. It is your responsibility to assure that connections are established to the correct device (and e.g. not to an unknown device pretending to be a known device type). Furthermore you have to take care that confidential data exchanged with the PLC is either compiled or encrypted.

Security related deployment guidelines for industrial automation

Security details for industrial automation is provided on ABB website in a *whitepaper*.

Signed firmware updates

The firmware update files for the PLC are digitally signed releases by ABB. During the update process, these signatures are validated by a hardware security component in the PLC. This way, the PLC will only update with valid, authentic firmware, signed by ABB.

Open ports and services

As part of the ABB security concept the PLC comes with minimal services opened by default. Only the services needed for initial setup and programming are open before any user application is downloaded.

> *Only used services/ports should be enabled (e.g. to enable the functionality of an FTPS server).*

Encrypted and signed applications

An application can be encrypted and signed in order to protect a running application in a PLC and to protect a configured project. How to set-up the user management, the communication and the boot application in order to prevent unauthorized access is explained in an *application note*.

Encrypted communication between devices

An *application note* explains how an encrypted and secured communication between devices can be established by using an TLS (Transport Layer Security) handshake or by signing certificates for a trusted communication.

Secure commu-nication Whenever possible, use an encrypted communication between AC500 devices and third party devices, such as HMI devices. This is necessary to protect passwords and other data.

Secure shell access for ABB service The PLC contains a secure shell service to access core logging data in case of problems which need a deeper analysis. This service is inactive by default, which means that no one can access this privileged shell in the normal operating state.

To activate this service, local access to the PLC is necessary and activation is only valid until the next power cycle of the PLC. Once activated, the service run on TCP port 22. Each PLC also protects the secure shell access by an individual password.

Active user management Enable the user management in Automation Builder.

With the help of the integrated user management, user groups with different access rights and authorizations can be defined. Configuration and handling of the user management in Automation Builder and a PLC is decribed in an _application note_.

Frequently asked questions For more information around cyber security please see our AC500 cyber security _FAQ_.

7.1.2 Defense in depth

The defense in depth approach implements multi-layer IT security measures. Each layer provides its special security measures. All deployed security mechanisms in the system must be updated regularly. It is also important to follow the system vendor's recommendations on how to configure and use these mechanisms.

As a basis, the components must include security functions such as the following:

- Virus protection.
- Firewall protection.
- Strong and regularly changed passwords.
- User management, see _application note_.
- Using VPN tunnels for connections between networks.

Additional security components such as routers and switches with integrated firewalls should be available. A defined user and rights concept managing access to the controllers and their networks is mandatory. Finally, the manufacturer of the components should be able to quickly discover weaknesses and provide patches.

> _Only used services/ports should be enabled (e.g. to enable the functionality of an FTPS server)._

References: _CODESYS Security Whitepaper_

Security zones IT resources vary in the extent to which they can be trusted. A common security architecture is therefore based on a layered approach that uses zones of trust to provide increasing levels of security according to increasing security needs. Less-trusted zones contain more-trusted zones and connections between the zones are only possible through secure interconnections such as firewalls Fig. 22. All resources in the same zone must have the same minimum level of trust. The inner layers, where communication interaction needs to flow freely between nodes, must have the highest level of trust. This is the approach described in the IEC 62443 series of standards.

Firewalls, gateways, and proxies are used to control network traffic between zones of different security levels, and to filter out any undesirable or dangerous material. Traffic that is allowed to pass between zones should be limited to what is absolutely necessary because each type of service call or information exchange translates into a possible route that an intruder may be able to exploit. Different types of services represent different risks. Internet access, incoming e-mail and instant messaging, for example, represent very high risks.
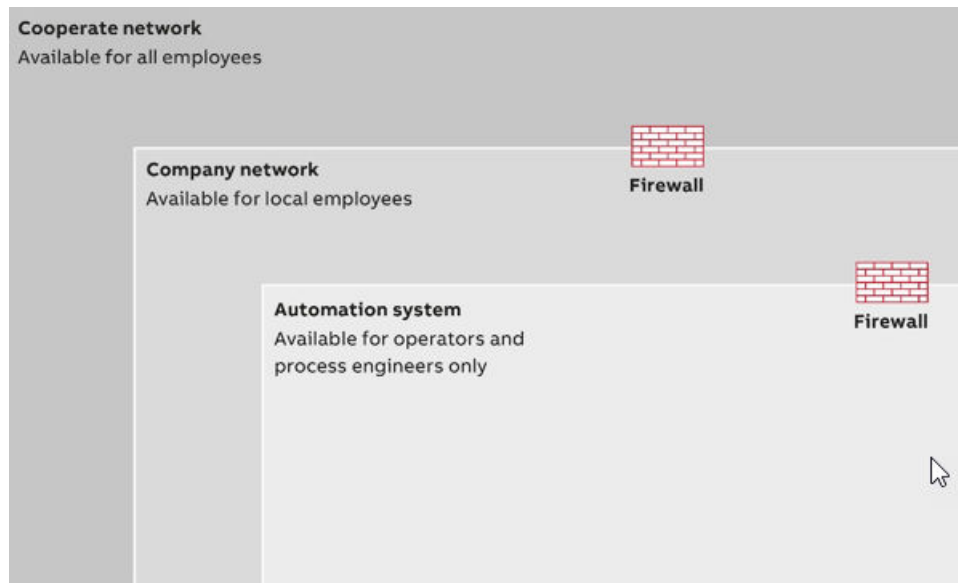
Fig. 22: Security zones

Fig. 22 shows three safety zones, but the number of zones is not necessarily decisive, there can also be more or less - depending on the safety requirement. The use of multiple zones allows access between zones of different trust levels to be controlled to protect a trusted resource from attack by a less trusted one.

High-security zones should be kept small and independent. They need to be physically protected, i.e. physical access to computers, network equipment and network cables must be limited by physical means to authorized persons only. A high-security zone should obviously not depend on resources in a less secure zone for its security. Therefore, it should form its own domain that is administered from the inside, and not depend on, e.g., a domain controller in a less secure network.

Even if a network zone is regarded as trusted, an attack is still possible: by a user or compromised resource that is inside the trusted zone, or by an outside user or resource that succeeds to penetrate the secure interconnection. Trust therefore depends also upon the types of measures taken to detect and prevent compromise of resources and violation of the security policy.

References: *Security for industrial automation and control systems*

7.1.3 Secure operation

The controller must be located in a protected environment in order to avoid accidental or intended access to the controller or the application.

A protected environment can be:

● Locked control cabinets without connection from outside.
● No direct internet connection.
● Use firewalls and VPN to separate different networks.
● Separate different production areas with different access controls.

To increase security, physical access protection measures such as fences, turnstiles, cameras or card readers can be added.

Follow these rules for the protected environment:

- Keep the trusted network as small as possible and independent from other networks.
- Protect the cross-communication of controllers and the communication between controllers and field devices via standard communication protocols (fieldbus systems) using appropriate measures.
- Protect such networks from unauthorized physical access.
- Use fieldbus systems only in protected environments. They are not protected by additional measures, such as encryption. Open physical or data access to fieldbus systems and their components is a serious security risk.
- Physically protect all equipment, i.e., ensure that physical access to computers, network equipment and cables, controllers, I/O systems, power supplies, etc., is limited to authorized persons
- When connecting a trusted network zone to outer networks, make sure that all connections are through properly configured secure interconnections only, such as a firewall or a system of firewalls, which is configured for "deny by default", i.e., blocks everything except traffic that is explicitly needed to fulfill operational requirements.
- Allow only authorized users to log on to the system, and enforce strong passwords that are changed regularly.
- Continuously maintain the definitions of authorized users, user groups, and access rights, to properly reflect the current authorities and responsibilities of all individuals at all times. Users should not have more privileges than they need to do their job.
- Do not use the system for e-mail, instant messaging, or internet browsing. Use separate computers and networks for these functions if they are needed.
- Do not allow installation of any unauthorized software in the system.
- Restrict temporary connection of portable computers, USB memory sticks and other removable data carriers. Computers that can be physically accessed by regular users should have ports for removable data carriers disabled.
- If portable computers need to be connected, e.g., for service or maintenance purposes, they should be carefully scanned for viruses immediately before connection.
- All CDs, DVDs, USB memory sticks and other removable data carriers, and files with software or software updates, should also be checked for viruses before being introduced into the trusted zone.
- Continuously monitor the system for intrusion attempts.
- Define and maintain plans for incident response, including how to recover from potential disasters.
- Regularly review the organization as well as technical systems and installations with respect to compliance with security policies, procedures and practices.

A protected local control cabinet could look like in figure 23, page 81. This network is not connected to any external network. Security is primarily a matter of physically protecting the automation system and preventing unauthorized users from accessing the system and from connecting or installing unauthorized hardware and software.
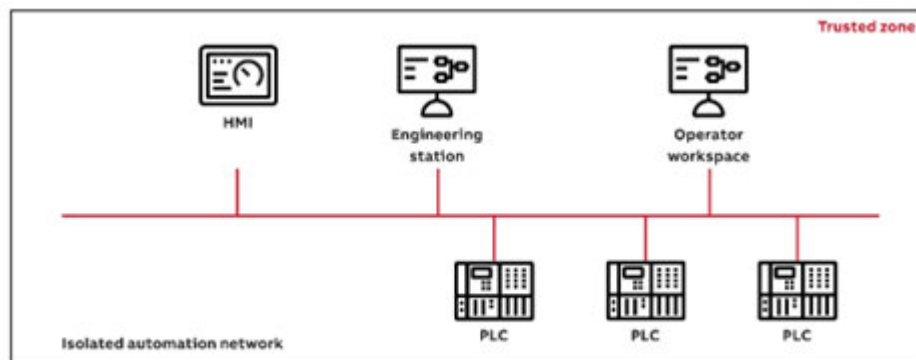

Fig. 23: Isolated automation system

A protected local control cabinet could look like in the picture below. This network is not connected to any external network. Security is primarily a matter of physically protecting the automation system and preventing unauthorized users from accessing the system and from connecting or installing un-authorized hardware and software.

Servers and workplaces that are not directly involved in the control and monitoring of the process should preferably be connected to a subnet that is separated from the automation system network by means of a router/firewall. This makes it possible to better control the network load and to limit access to certain servers on the automation system network. Note that servers and workplaces on this subnet are part of the trusted zone and thus need to be subject to the same security precautions as the nodes on the automation system network.
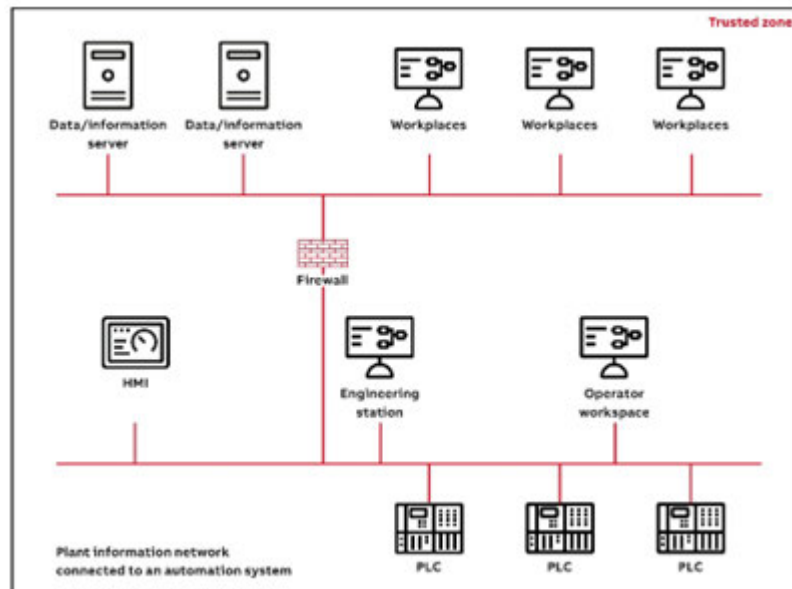
Fig. 24: Plant information network connected to an automation system

For the purposes of process control security, a general-purpose information system (IS) network should not be considered a trusted network, not the least since such networks are normally further connected to the Internet or other external networks. The IS network is therefore a different lower-security zone, and it should be separated from the automation system by means of a firewall. The IS and automation system networks should form separate domains.
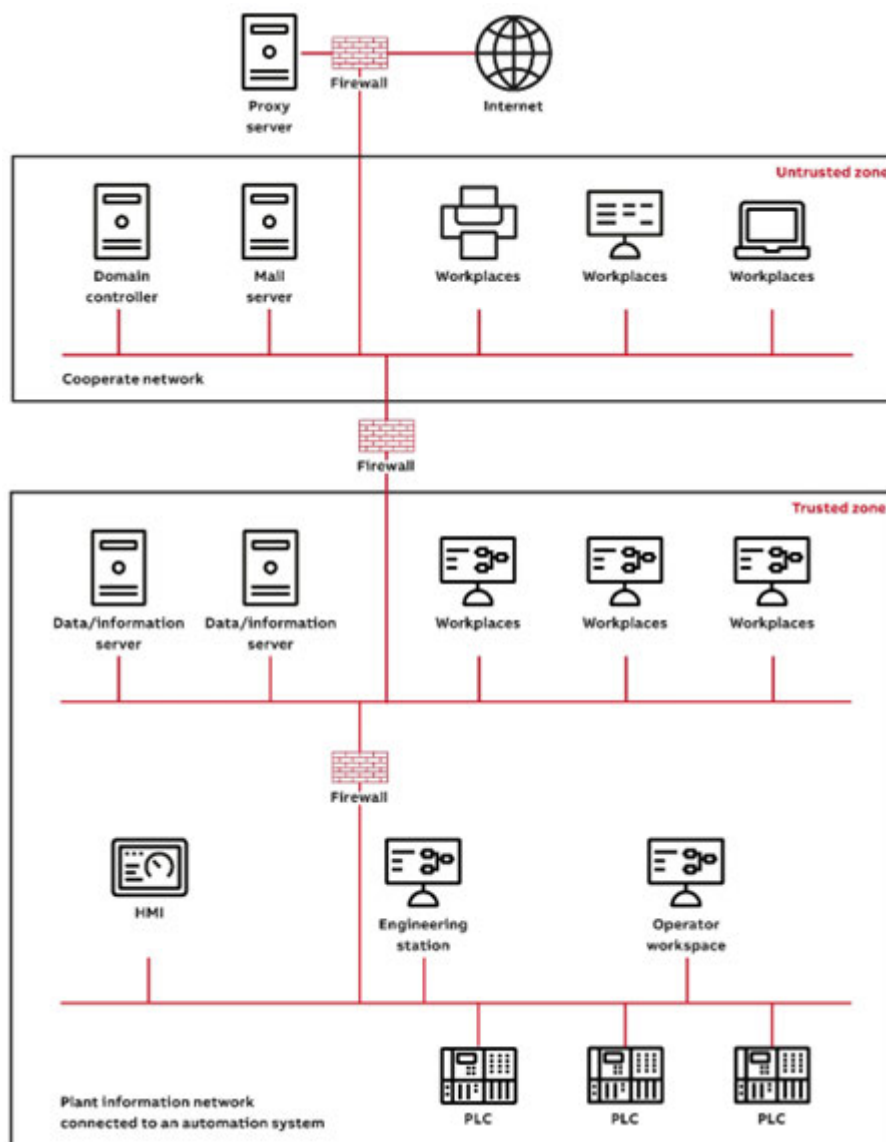
Fig. 25: Automation system and IS network

7.1.4 Hardening

System hardening means to eliminate as many security risks as possible. Hardening your system is an important step to protect your personal data and information. This process intends to eliminate attacks by patching vulnerabilities and turning off inessential services. Hardening a system involves several steps to form layers of protection.

Commissioning phase

● Protect the hardware from unauthorized access.
● Be sure the hardware is based on a secure environment.
● Disable unused software and services (network ports).
● Install firewalls.
● Disallow file sharing among programs.
● Install virus and spyware protection.
● Use containers or virtual machines.
● Create strong passwords by applying a strong password policy.
● Create and keep backups.
● Use encryption when possible.
● Disable weak encryption algorithms.

- Separate data and programs.
- Enable and use disk quotas.
- Strong logical access control.
- Adjust default settings, especially passwords.

Verification phase

- Verification of antivirus: Check antivirus is active and updated.
- Verification of the identification: Check that test and unauthorized accounts are removed.
- Verification of intrusion detection systems: Check malicious traffic is blocked.
- Verification of audit logging: Check audit log is enabled.
- You can use the checklist out of the *cyber security white paper*.

Operation phase

- Keep software up-to-date, especially by applying security patches.
- Keep antivirus up and running.
- Keep antivirus definitions up-to-date.
- Delete unused user accounts.
- Lock an active session whenever it is unattended, e.g., lock the screen of the PC or of the control panel (HMI).

Decommissioning phase

- Delete licenses
- Delete certificates
- Delete user accounts
- Delete applications and user data
- Safe disposal

Ä *Chapter 12 "Decommissioning" on page 105*

References: *Hardening in Wikipedia (2021)*

7.1.5 Certificates factory default - no encryption

As of Automation Builder Release 2.6.0, the encryption of the AC500 communication policy is set to *"No encryption"* by default. The reason for that is that the PLC clock defaults to 01/01/1970 when shipped from the factory, any pre-installed certificate would already be expired when the user attempts to connect.

Preliminary work

☑ Connection of the PLC to the Automation Builder and internet access.

☑ The PLC must be equipped with a battery to keep the date in case of power off.

☑ The PLC must be set to the current date and time.

1. If necessary reboot the PLC.

2. Connect the PLC to the Automation Builder again.

Create an CA-signed certificate

The basis for an official trusted signed certificate is the creation of a **Certificate Signing Request**.

As an example, the creation of a certificate for a FTP server is described.

1. Double-click to the PLC main node and select the *"PLC Shell"* tab. Command line input is on the bottom. Find the index number for the FTP server and type *[cert-getapplist]* in the below command line.
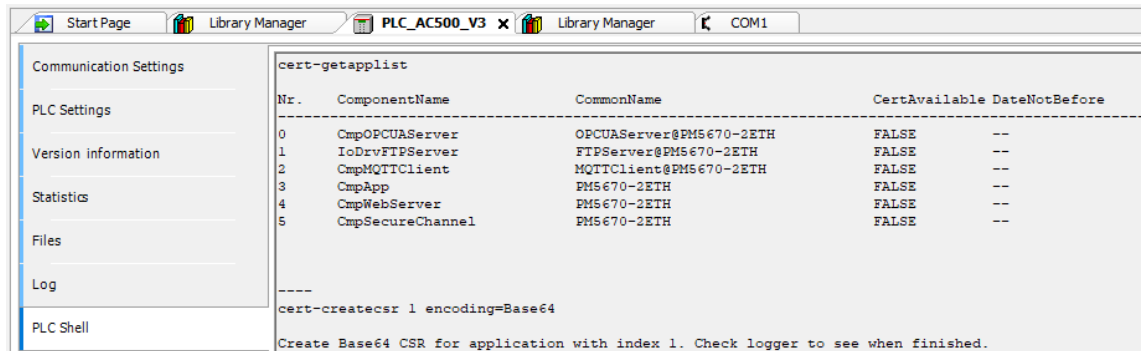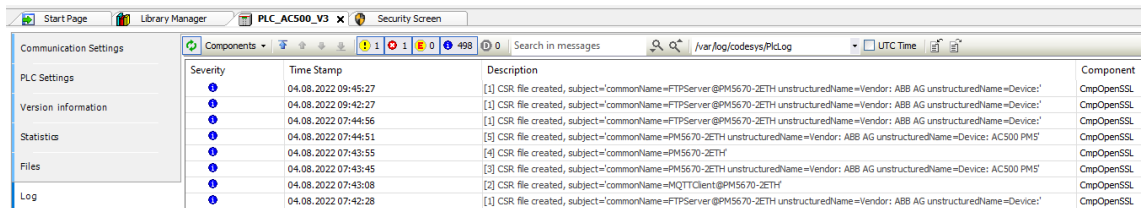

2. Type *[cert-createcsr <index number> encoding=Base64]* in the command line e.g. here: *[cert-createcsr 1 encoding=Base64]* and press *[ENTER]*.

> *For some users it may be necessary to swap "Base64" for "ASN1" if the user's PKI needs this format.*

3. Change to the *"Log"* tab.

4. Click the ⟳ refresh button.
   ⇨ Wait until the log entry of CSR file created pops up.

5. Change to the *"Files"* tab.

6. Click the ⟳ refresh button.

7. Open the *"cert"* folder in the PLC.

8. Open the *"export"* folder.

9. Copy the certificate request file *[1_IoDrvFTPServer.csr]* to any folder on your PC.
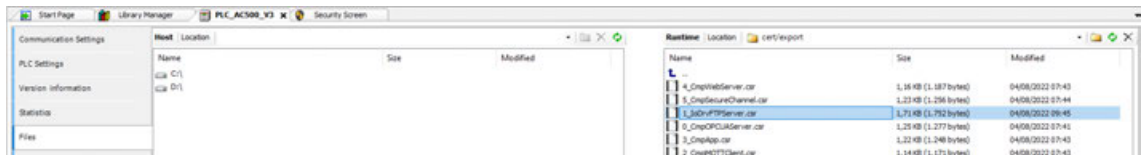
10. This file, here *[1_IoDrvFTPServer.csr]* must then be signed by your Public Key Infrastructure (PKI).

The signing process itself is outside the scope of this documentation. There are sufficient sources on the internet for building your own PKI (e.g. *PKI tutorial*) - or get in touch with your IT department.

Integrate a certificate

After the signed certificate comes back from the PKI and is stored on the PC, it has to be imported into the controller.

> ⓘ *Be sure to import into the "Own Certificates" folder.*

1. Change to the *"Security Screen"*.

2. Select tab *"Devices"*, the folder *"Own Certificates"* and press the 🔳 import button.
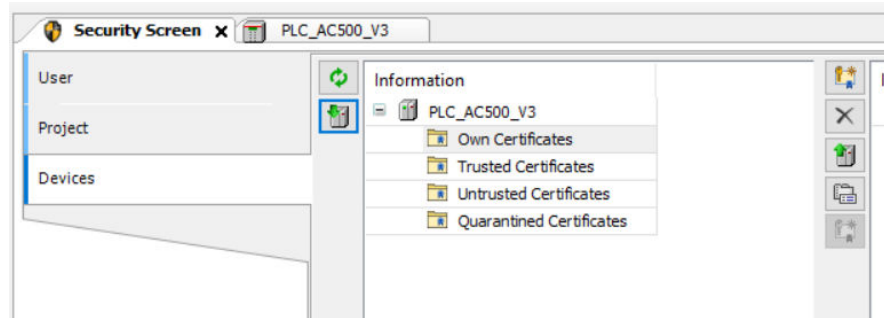
3. Select the certificate (*[1_IoDrvFTPServer.cer]*) to be imported in the opening file manager.

4. Press the *"Open"* button.

   ⇨ The new certificate will be shown as *"IoDrvFTPServer"* in the information column. The previous self-signed certificate will lose its name and is therefore not valid anymore.

> ⓘ *DON'T delete any of the installed certificates.*

5. Check the validation and *"Issued by"* of the new certificate by activating the top PLC branch.

6. Download and reboot the PLC (repower or use *"PLC Shell"* and command *[reboot]*.)

> ⓘ *We recommend changing the communication policy accordingly so that only encrypted connections are allowed.*

Encrypted and signed applications
An application can be encrypted and signed in order to protect a running application in a PLC and to protect a configured project. How to set-up the user management, the communication and the boot application in order to prevent unauthorized access is explained in an *application note*.

Enforced signing
As of Automation Builder 2.6.0 there is also the possibility to activate the *"Enforced signing"* mode in the *"Change Runtime Security Policy"*. Then the controller accepts ONLY signed downloads.

"Tab Communication Settings ➜ *Device* ➜ *Change Runtime Security Policy...* ➜ *Code Signing* ➜ *New policy* ➜ *Enforced signing"*
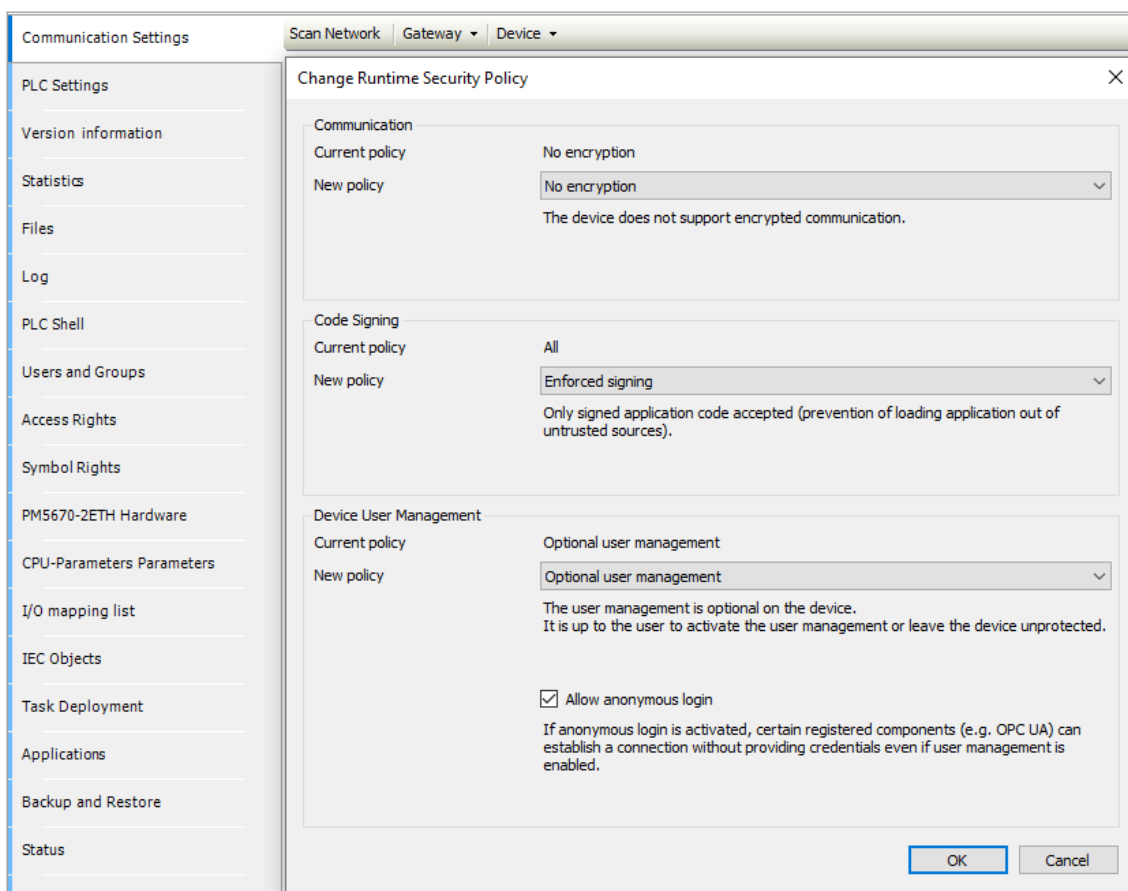
White Paper - AC500 cyber security   More information about certificates and cyber security can be found in the white paper *AC500 cyber security*.

7.1.6 Open Ports and Services

7.1.6.1   Default open Ethernet ports of AC500 and AC500-eCo CPUs

As part of the ABB security concept the AC500 V3 PLC comes with minimal services opened by default. Only the services needed for initial setup and programming are open before any user application is downloaded.

Default open Ethernet ports of AC500 V3 and AC500-eCo V3 CPUs:

Protocol	Port
ABB NetConfig [1]	UDP 24576
Communication between engineering software and PLC [2]	TCP 11740

Protocol	Port
OPC UA server [3])	TCP 4840
Remarks:	

[1]): UDP port 24576 is used for initial setup of the network configuration (e.g. to set the initial IP address). This port does not provide any further functionality.

Port 24576 for ABB NetConfig protocol can be disabled via PLC configuration by deleting the protocol node from the configuration tree of Ethernet interfaces ETH1 and ETH2.

[2]): The TCP port 11740 is used for communication between the AC500 controller and the Automation Builder engineering software. This port does not provide any further functionality.

[3]): Port 4840 for OPC UA server is closed by default as of SystemFW V3.1.0.

> Besides UDP port 24576 and TCP port 11740 no other proprietary protocols are used.

7.1.6.2 Open ports and services of the Automation Builder (Engineering PC)

Port	Protocol	Description
1217	TCP	CODESYS Gateway V3
1210	TCP	CODESYS Gateway V2
1211	TCP	CODESYS Gateway V2
22350	TCP/UDP	CodeMeter License Server (runtime) – license
22352	HTTP	CodeMeter License Server (runtime) – WebAdmin
22353	HTTPS	CodeMeter License Server (runtime) – WebAdmin
11040	HTTP	Python editor server

7.1.6.3 Supported secure protocols

Server protocols		
FTPS	TCP	21
HTTPS	TCP	443
OPC UA	TCP	4840
Encrypted communication between engi-neering soft-ware and PLC	TCP	11740
Custom TCP protocols secured by TLS	TCP	User defined
DNP3 outstation with SAv5	TCP	20000

Client protocols		
MQTT	TCP - Src port: random	Dst port: user defined
OPC UA	TCP - Src port: random	Dst port: user defined
Custom TCP protocols secured by TLS	TCP - Src port: random	Dst port: user defined

All the certificates for the different protocols can be handled in the security screen marked with 🟡 in the status bar or via *"View"* menu. The default ports can be changed in the settings.

FTP and FTPS

File Transfer Protocol (FTP) and File Transfer Protocol Secure (FTPS) are used for transferring files between devices. The AC500 can act as FTP server in this case.

An FTP client can open an FTP session and can store and retrieve files to and from the FTP server (AC500). Focus applications are large monitoring and diagnosis networks, where e.g. thousands of plants have to independently send their data to servers and may fetch files containing updates, commands, etc. In case of FTPS, a certificate must be installed on the PLC.

FTP Vulnerabilities

FTP uses unencrypted data transfer and, hence, user credentials and file contents can be eaves-dropped on. FTPS requires a certificate inside the PLC and should be preferred.

HTTP and HTTPS

Hypertext Transfer Protocol (HTTP) and Hypertext Transfer Protocol Secure (HTTPS) are used to request information from a server or send information to the client.

By default, HTTP uses TCP port 80 and HTTPS uses TCP port 443.

HTTPS transmits HTTP telegrams with encryption, commonly using TLS or SSL. The AC500 uses a webserver for the web visualization. Both protocols HTTP and HTTPS are supported. In case of HTTPS, a certificate must be installed on the PLC.

OPC UA

OPC UA (Open Platform Communications Unified Architecture) is a collection of standards for communication and data exchange in the field of industrial automation. OPC UA describes both the transport of machine-to-machine data and interfaces and the semantics of data. The complete architecture is service-oriented.

AC500 supports TLS for OPC UA secure communication. Also needs a certificate on the PLC as well as a client certificate that also needs to be stored on the PLC.

Security screen

Use the security screen in Automation Builder to activate the use of certificates and encrypted communication.

More information about protocol vulnerabilities and recommendations about how to reduce risks can be found in the white paper *AC500 cyber security*.

7.1.7 Cyber security report in Automation Builder

The cyber security report documents cyber security related settings based on the offline configuration of an AC500 V3 PLC in an Automation Builder project as well as from an online connection to this PLC.

1. Login to the PLC of your Automation Builder project.

2. In the project tree, select the appropriate PLC and click *"Online* ➔ *Cyber Security Report"* in the menu.

> *In case this entry is grayed-out, check whether you are logged in to the PLC.*

3. Automation Builder displays the created cyber security report in a web browser.

Report details:

- All TCP/IP interfaces
- PLC versions and device firmware versions
- PLC user management settings (as separate files)
- Automation Builder user management settings (as separate files)

The latest version of a cyber security report is stored as HTML under C:\Users\UserXY\App-Data\Local\Temp*.*

8 Commissioning

Commissioning the PLC

Preconditions:

- All PLC modules are installed and wired according to the configuration in Automation Builder.
- The PLC is connected to the power supply.
- The application and the necessary licenses are available.

> ⚠️ **WARNING!**
>
> **Risk of injury or damage to equipment**
>
> To avoid endangering persons or equipment, check the following before commissioning:
>
> – Mechanical and electrical installation.
> – Electrical safety of the installation.
> – Safety functions.

1. Switch on the power supply.

   ⇨ The green PWR LED goes on.

   ⇨ Processor modules with display: Wait until the processor module displays *"Update"*.

2. Install the firmware and the application on the processor module.

   Installing the firmware and the application on a very new processor module is the same process than updating a firmware and an application on a CPU.

   ♨ *Chapter 9.4 "PLC firmware/application update" on page 94*

   ⇨ The PLC starts with the new firmware and the new application.

> ⚠️ **WARNING!**
>
> **Risk of injury or damage to equipment**
>
> To avoid endangering persons or equipment, a functional test **of the application** must be performed before the final commissioning of the system.

Commissioning the control panel

Preconditions:

- The control panel is installed and wired.
- The control panel is connected to the power supply.
- The project file and the necessary licenses are available.

1. Start the control panel.
2. Set the IP address of the control panel.
3. Download the project file to the control panel.
4. Connect the PLC and the control panel with an Ethernet cable.

Commis-sioning example	_Step-by-step instructions using the example of the AC500-eCo starter kit with a control panel included_

> ⓘ *Protect your data, provide your projects with passwords and access restrictions.*

The PLC has an integrated diagnosis system to output diagnosis messages, e.g., parameter setting is wrong or battery low. A diagnosis message is indicated by ERR LED = on.

⅋ *Chapter 10 "Troubleshooting" on page 95*

9 Operation

9.1 Operating modes

The common operating mode is called run mode.

Table 12: Run mode

LED	Display	Description
PWR LED = on RUN LED = on ERR LED = off	MC SYS BATT I/O-Bus ▪ **run** ETH1 ETH2 COM1 CAN	Power supply is present. PLC is in run mode.

If the PLC is connected to the power supply, but does not operate, it is in stop mode. In stop mode, the processor module does not control the system.

Table 13: Stop mode

LED	Display	Description
PWR LED = on RUN LED = off ERR LED = off/on	MC SYS BATT I/O-Bus ▪ **StoP** ETH1 ETH2 COM1 CAN	E.g., after the download of an application, after a firmware update, an error occured or the PLC was stopped by the user, etc.

9.2 Diagnosis system

The PLC has an integrated diagnosis system to output diagnosis messages, e.g., parameter setting is wrong or battery low. A diagnosis message is indicated by ERR LED = on.

Ⅵ *Chapter 10 "Troubleshooting" on page 95*

9.3 Status LEDs, display and control elements

Depending on the device type, various operating elements provided on the front panel can be used to control the devices of the PLC system and/or to change the operating mode.

Operating elements:

- Status LEDs:
  The status LEDs indicate the availability of devices and components such as communication modules, communication interface modules or function modules. Functionality and diagnosis of the status LEDs depends on the specific module and is described in the device description of the appropriate module. Possible status: on/off/blinking.
- I/O LEDs:
  The I/O LEDs display the status of the inputs and outputs.
- Display:
  The display is available for some processor modules. The display can be used for simple configurations and for reading out diagnosis information.

  Ⅵ *Chapter 10 "Troubleshooting" on page 95*
- Function keys and switches:
  With the function keys and switches, you can change the current operating modes/status manually.

9.4 PLC firmware/application update

During runtime it might be necessary to update the firmware of the modules, e.g., for security reasons.

Updating the firmware and the application on a processor module is the same process than installing a firmware and an application on a very new processor module.

The installation can be performed either via a PC (recommended) or via a memory card. For details refer to the _software manual_.

Communication Settings	Update Firmware	ⓘ 'Check Firmware Version on Login' is enabled						* more firmware files available	
PLC Settings	PLC								
Version information		Name	Firmware Type	State	Firmware Version	Required Version	Date	Build	Info
Statistics	▶	PM5630-2ETH	CPUFW	✅	3.5.0.430_HF-2	3.5.0.430_HF-2 *			
		PM5630-2ETH	UpdateFW	✅	3.5.0.79	3.5.0.79			
Files		PM5630-2ETH	BootFW	✅	3.5.0.37	3.5.0.37			
Log		PM5630-2ETH	DisplayFW	✅	4.1.0.0	4.1.0.0			
PLC Shell									
	Communication modules								
Users and Groups		Interface	Coupler Name	Device Number	Date	Firmware Type	State	Firmware Version	Required Versions	Info
Access Rights	▶	1	CM579-ETHCAT			CM579-ETHCAT	✅	4.5.10.21	4.5.10.21	
Symbol Rights		2	CM579-PNIO			CM579-PNIO	✅	2.8.10.21	2.8.10.21 *	
PM5630-2ETH Hardware									
CPU-Parameters Parameters									

Fig. 26: The "Version information" tab of a device in the Automation Builder

9.5 Control panel firmware/application update

The system components can be updated via Panel Builder software or via USB flash drive. Refer to the _Panel Builder manual_ for a detailed description.

9.6 Reset Warm

PLC

☑ PLC is in STOP mode.

1. Press and hold (> 5 sec) _[RUN]_.

   ⇨ RUN LED = ON.

   "Reset" is displayed.

2. Press _[OK]_ to reset[+] the PLC.

Control panel   The factory restore of a control panel is described in the _Panel Builder manual_.

10 Troubleshooting

Diagnosis messages are shown in the engineering suite Automation Builder. The diagnosis information can be accessed in the IEC application and can be forwarded to, e.g., a web server or a control panel.

Diagnosis messages can also be read out from the display of the PLC.

Some diagnosis messages need to be acknowledged by the user (alarms[+]), others do not require acknowledgment (events[+]). The diagnosis system stores alarms and events in a diagnosis history.

Diagnosis messages include the severity of an error. Error severity can be used for defining system behavior, e.g., activating the error LED or stop the PLC.

10.1 Possible malfunctions

Possible malfunctions

Fault description	Cause	Remedy
A processor module, a communication interface module or an I/O module can not be plugged on the corresponding terminal base or terminal unit.	Terminal bases and terminal units have a mechanical encoding. The encoding makes it impossible to insert a module to the wrong place to prevent dangerous voltages or destroyed modules.	Check the given design scheme of your control cabinet. Get in touch with the planner of the design scheme. Check the _terminal base compatibility_ and the _terminal unit compatibility_.
An AC500-eCo processor module does not start.	Configuration error due to wrong firmware of the option boards.	Update the option boards TA5141-RS232I, TA5142-RS485I and TA5142-RS485 at least to system firmware 3.5.0_HF-7 and boot firmware 3.5.1 or higher. Use Automation Builder 2.5.2 or higher.
The module does not respond and is not available for online connection.	Module is not connected to the power supply. Or module is not functional any more.	Check power supply. Replace the module or HMI. ⓑ Chapter 11.2 "Replace an AC500 module" on page 98
I/O module on a hot swap terminal unit does not respond and is not available for online connection.	I/O module is not plugged or damaged.	As soon as the correct and operational I/O module is plugged on the terminal unit, the module is configured and ready to start.
After hot swap of a (remote) I/O module, the system and/or I/O module does not start.	Wrong I/O module type plugged. The type must be the same as of the replaced module.	Plug the correct I/O module type.
The display of the control panel is black.	Control panel is not connected to the power supply. Or control panel is not functional any more.	Check power supply. Replace the control panel.
ERR LED of the processor module flashes fast. The display shows "AC500".	A fatal system error occured.	Contact ABB technical support
ERR LED of the processor module flashes. RUN LED is off. The display shows "FAIL".	Installation or update of firmware, boot project or application failed.	Restart the device. Perform the installation or update again.

Fault description	Cause	Remedy
ERR LED of the processor module flashes. RUN LED is off. The display shows *"FAIL"*.	Installation or update of firmware, boot project or application failed.	⮂ *Chapter 9.4 "PLC firmware/application update" on page 94*
ERR LED is on.	PLC with event[+] or unacknowledged alarm[+].	- Use Automation Builder, IEC application or other external access available in your project, e.g., a control panel, to read out and acknowledge the diagnosis messages. In Automation Builder, double-click on a device and select the *"Diagnosis"* tab to access the diagnosis messages. Or: - Read out the diagnosis data on the display of the processor module.
The display of the processor module shows *"Demo"* for 5 min at every license check. (For processor modules without display only visible when logged in with Automation Builder.)	PLC runs in demo mode because at least one feature license is missing. The demo license is valid for 10 days PLC in run. After this time, PLC will go to stop mode.	You can buy the missing license or extend the demo license via Automation Builder. The PLC will not switch back to run mode until a new license is activated or the licensed features are removed from the PLC application.
Every 10 min, the display of the processor module shows *"Grace"* for 5 min.	PLC runs in grace mode because at least one feature license which has been available disappeared. If the grace time expires, PLC will go to stop mode.	You need to buy or activate the missing. We recommend to use the Automation Builder for activation. After the PLC is in stop mode, it will not switch back to run mode until a new license is activated or the licensed features are removed from the PLC application.
The CPU displays *"noConn"* (no connection).	No communication between CPU and display is possible due do very high CPU load (e.g., endless loop in user program and not activated task watchdog).	Check the application for loops and operations they need time. For example file handling. Wait for response from other device who will block the execution from other code.

If a problem persists, contact ABB technical support. In order to be able to solve your problem as soon as possible, please provide the affected Automation Builder project or Panel Builder project, the log files and the firmware versions. How to read out log files is described in an *application note*.

10.2   Execution of a hotfix

Updates (also hotfixes) are displayed at every system start, if available.

Hotfixes can be in different files - *.exe, *.package or Linux (for communication interface modules).

Hotfix file via memory card   A hotfix PLC firmware file (*.exe) can be installed via a memory card.

Communication interface (CI) module firmware   The firmware of AC500 communication interface modules can be updated with the IP configuration tool.

Advanced: Manual installation in Automation Builder

1. Download the current firmware hotfix from the *PLC website*.

2. Save and unpack the .zip file at any location of your hard disc.

3. Save and close open projects in Automation Builder.

4. In the menu bar of the Automation Builder open the *"Package Manager"*. *"Tools*
   ➜ Package Manager"

   ⇨ The *"Package Manager"* opens.

5. Follow the instructions.

11 Maintenance

11.1 Maintenance intervals

Interval	Maintenance work
After 3 years of utilisation or as soon as possible after the PLC diagnosis message "low battery warning"	Replace battery of the CPU. Refer to the _hardware manual_.
Regularly or when the faceplate of the control panel is dusty.	Keep the faceplate of the control panel clean. Refer to the panel's _operating instruction_.

11.2 Replace an AC500 module

> ⚠ **CAUTION!**
> **Risk of injury and damaging the product!**
> Improper installation and maintenance may result in injury and can damage the product!
>
> – Installation and maintenance have to be performed according to the technical rules, codes and relevant standards, e.g. EN 60204-1.
> – Only by qualified personnel.

> ⚠ **WARNING!**
> **Removal/Insertion under power**
> The devices are not designed for removal or insertion under power. Because of unforeseeable consequences, it is not allowed to plug or unplug devices with the power being ON.
>
> Make sure that all voltage sources (supply and process voltage) are switched off before doing the following:
>
> – Connect or disconnect any signal or terminal block.
> – Remove, mount or replace a module.
>
> Disconnecting any powered devices while energized in a hazardous location could result in an electric arc, which could create a flammable ignition resulting in fire or explosion.
>
> Make sure that power is removed and that the area has been thoroughly checked to ensure that flammable materials are not present prior to proceeding.
>
> The devices must not be opened when in operation. The same applies to the network interfaces.

All modules of the AC500 range are maintenance free. Spare parts are not available and repair is not allowed. If a module is not functional any more, you have to replace the whole module.

If an I/O module is installed on a hot swap terminal unit, it is possible to replace it with the same type during runtime.

If an I/O module is installed on a terminal unit that does **not** support hot swap and for all other AC500 modules, proceed as follows.

1. Disconnect the power supply.

2. For processor modules, insert the memory card into the new module.

3. For communciation modules, adjust the position of the rotary switches on the new module.

4. For terminal units and terminal bases, disconnect the connectors from the old module.

5. Demount the module to be replaced as described in the *installation instructions*.

6. Mount the new module as described in the installation instructions.

7. For terminal units and terminal bases, connect the connectors.

8. Reconnect the power supply.

    ⇨ System boots up again.

9. If necessary, update module firmware ⮎ *Chapter 9.4 "PLC firmware/application update" on page 94*.

    If a processor module is replaced, you must install the firmware, the application, the licenses, passwords and the certificates on the new processor module.

    ⮎ *Chapter 9.4 "PLC firmware/application update" on page 94*

If a problem persists, contact ABB technical support.

11.3   Replace an I/O module with hot swap

11.3.1   Preconditions for using hot swap

> *Conditions for hot swapping*
> – *Digital outputs are not under load.*
> – *Input/output voltages above safety extra low voltage/ protective extra low voltages (SELV/PELV) are switched off.*
> – *Modules are completely plugged on the terminal unit with both snap fit engaged before switching on loads or input/output voltage.*

Hot swap

> ⚠ **WARNING!**
> **Risk of explosion or fire in hazardous environments during hot swapping!**
> Hot swap must not be performed in flammable environments to avoid life-threatening injury and property damage resulting from fire or explosion.

⚠ **WARNING!**
Electric shock due to negligent behavior during hot swapping!
To avoid electric shock, do the following.

- Make sure the following conditions apply:
  - Digital outputs are not under load.
  - Input/output voltages above safety extra low voltage/ protective extra low voltage (SELV/PELV) are switched off.
  - Modules are fully interlocked with the terminal unit with both snap-fits engaged before switching on loads or input/output voltage.
- Never touch exposed contacts (dangerous voltages).
- Stay away from electrical contacts to avoid arc discharge.
- Do not operate a mechanical installation improperly.

NOTICE!
Risk of damage to I/O modules!
Hot swapping is only allowed for I/O modules.

Processor modules and communication interface modules must not be removed or inserted during operation.

Hot swap

System requirements for hot swapping of I/O modules:

- *Types of terminal units that support hot swapping of I/O modules have the appendix TU5xx-**H**.*
- *I/O modules as of index F0.*

The following I/O bus masters support hot swapping of attached I/O modules:

- *Communication interface modules CI5xx as of index F0.*
- *Processor modules PM56xx-2ETH with firmware version as of V3.2.0.*

Hot swap is not supported by AC500-eCo CPU!

Table 14: Allowed device indexes for I/O modules for hot swapping

I/O module	Minimum device index for hot swapping on a hot swap terminal unit	Minimum device index for use in a mixed configuration with hot-swappable devices
AC522(-XC)	F0	F0
AI523 (-XC)	F0	D2
AI531	F0	D4
AI531-XC	F0	D2
AI561	hot swap is not supported	B2
AI562	hot swap is not supported	B2
AI563	hot swap is not supported	B3
AI568	hot swap is not supported	A1

I/O module	Minimum device index for hot swapping on a hot swap terminal unit	Minimum device index for use in a mixed configuration with hot-swappable devices
AI581-S (-XC)	hot swap is not supported	must not be used in a configuration that includes a hot swap terminal unit
AO522 (-XC)	F0	F0
AO523 (-XC)	F0	D2
AO561	hot swap is not supported	B2
AO562	hot swap is not supported	A1
AO568	hot swap is not supported	A1
AX521 (-XC)	F0	D2
AX522 (-XC)	F0	D2
AX561	hot swap is not supported	B2
CD522 (-XC)	F0	D1
DA501 (-XC)	F0	D2
DA502 (-XC)	F0	F0
DC522 (-XC)	F0	D2
DC523 (-XC)	F0	D2
DC532 (-XC)	F0	D2
DC562	hot swap is not supported	A2
DI524 (-XC)	F0	D2
DI561	hot swap is not supported	B2
DI562	hot swap is not supported	B2
DI571	hot swap is not supported	B2
DI572	hot swap is not supported	A1
DI581-S (-XC)	hot swap is not supported	must not be used in a configuration that includes a hot swap terminal unit
DO524 (-XC)	F0	A3
DO526	F0	A2
DO526-XC	F0	A0
DO561	hot swap is not supported	B2
DO562	hot swap is not supported	A2
DO571	hot swap is not supported	B3
DO572	hot swap is not supported	B2
DO573	hot swap is not supported	A1
DX522 (-XC)	F0	D2
DX531	F0	D2
DX561	hot swap is not supported	B2
DX571	hot swap is not supported	B3

I/O module	Minimum device index for hot swapping on a hot swap terminal unit	Minimum device index for use in a mixed configuration with hot-swappable devices
DX581-S (-XC)	hot swap is not supported	must not be used in a configuration that includes a hot swap terminal unit
FM562	F0	A1
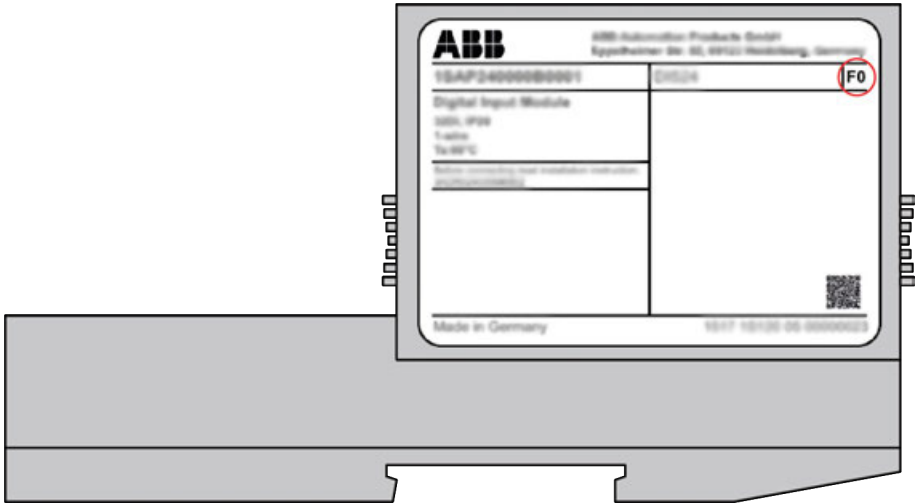
Fig. 27: The index of the module is in the right corner of the label.

> **NOTICE!**
> **Risk of damage to I/O modules!**
> Modules with index below F0 can be damaged when inserted or removed from the terminal unit in a powered system.

> **NOTICE!**
> **Risk of damage to I/O modules!**
> Do not perform hot swapping if any I/O module with a not allowed device index is part of the I/O configuration. The I/O modules can be damaged.
>
> *⮂ Table 14 "Allowed device indexes for I/O modules for hot swapping" on page 100*

11.3.2 Compatibility of hot swap

> ⓘ *Hot swap is not supported by AC500-eCo CPU!*

	Central I/O on processor module
I/O module on TU5xx-H connected to I/O bus master	AC500 processor modules PM56xx-2ETH
Required version of I/O bus master	Firmware as of V3.2.0
Fieldbus master when used as remote I/O	-
When used as remote I/O on third party controller (PLC or DCS)	-

11.3.3 Hot swap behavior

Hot swap behavior	Central I/O
Start-up behavior with unplugged or damaged I/O module on hot swap terminal unit TU5xx-H	System and I/O modules attached to the processor module are starting (except unplugged or damaged module when plugged on hot swap terminal unit). As soon as the correct and operational I/O module is plugged on the terminal unit, the module is configured and ready to start. No specific setting needed.
Start-up behavior with wrong I/O module type on any terminal unit	System and I/O modules are not starting
Diagnosis of presence of hot swap terminal unit	Diagnosis using PLC browser command "io-bus desc" in Automation Builder. The PLC browser then provides an overview of the modules on the I/O bus including the position of hot swap terminal units in the I/O bus. In the application program this can be detected with a function block "IoModuleHotSwapInfo" (Library: AC500_Io/Function Blocks/I/O-Bus). One instance of function block is needed per terminal unit on the I/O bus. The function block provides five outputs delivering information about slut number, hot swap capability and plugged/unplugged state of the I/O module
Diagnosis while hot swap module is pulled or module (mounted on hot swap terminal unit) has stopped working	If module is pulled then diagnosis Err 9480 "Module removed from Hot Swap Terminal Unit" is generated
Diagnosis after plugging the I/O module on the hot swap terminal unit	Diagnosis Err 9480 is automatically acknowledged

11.4   Replace a CP600 control panel

Control panels are maintenance free. Spare parts are not available and repair is not permitted. If a control panel becomes inoperable, it must be replaced. An operation manual is included with the new unit.

For instructions on how to transfer the runtime to a new control panel and how to load projects to a new control panel, refer to the *Panel Builder manual*.

The procedure for changing from a CP600 device to a CP600 device of the 2nd generation is described in the application example *Converting a CP600 project*. A description of the differences between both device variants can also be found in this application example.

12 Decommissioning

1. Delete the runtime licenses from the device by returning the licenses.

2. Delete certificates available on the CPU.

3. Delete applications.

4. Delete applications from memory card, if available.

5. If available, remove memory card and battery from CPU.

6. Delete all user accounts and user data.

7. Demount and dispose the hardware modules.

    ⬙ *Demount AC500, AC500-XC and AC500-S*

    ⬙ *Chapter 13 "Recycling" on page 106*

> ⓘ *If you can not access the data stored in the CPU, e.g., because the CPU is not functional any more, then physically destroy the device.*
>
> *This ensures that the credentials that are stored in the device, can not be misused.*

13 Recycling

> **Disposal and recycling information**
>
> *This symbol on the product (and on its packaging) is in accordance with the European Union's Waste Electrical and Electronic Equipment (WEEE) Directive.*
>
> *The symbol indicates that this product must be recycled/disposed of separately from other household waste.*
>
> *It is the end user's responsibility to dispose of this product by taking it to a designated WEEE collection facility for the proper collection and recycling of the waste equipment.*
>
> *The separate collection and recycling of waste equipment will help to conserve natural resources and protect human health and the environment.*
>
> *For more information about recycling, please contact your local environmental office, an electrical/electronic waste disposal company or the store where you purchased the product.*

14 Appendix

14.1 Diagnosis messages via display of the processor module

If the processor module has a display, you can access the diagnosis system via the display and the buttons.

Diagnosis messages can also be accessed within the engineering suite Automation Builder or with the IEC application.
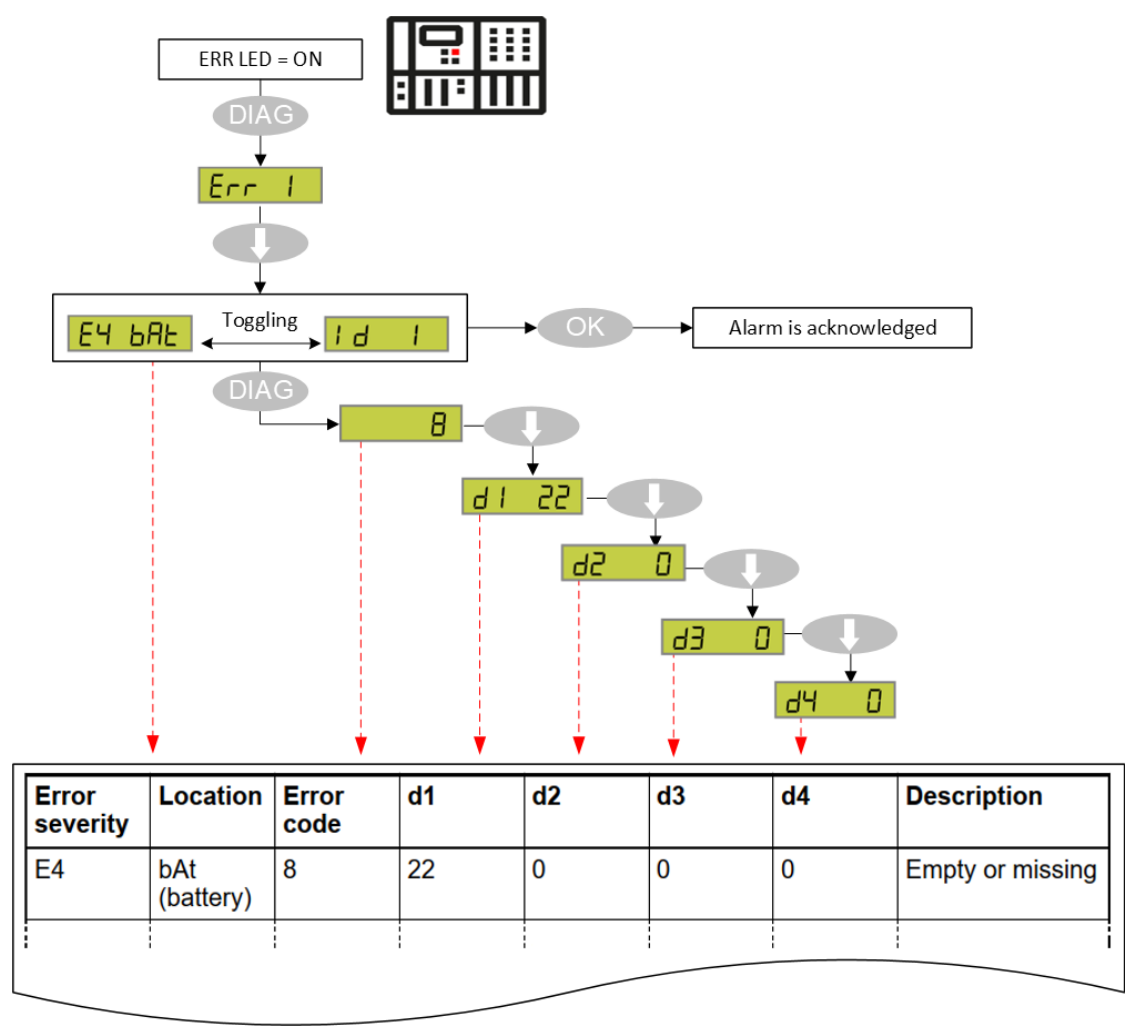
Fig. 28: Example "battery is empty or missing"

Err 1	Total number of active diagnosis messages, here: 1
E4 bat	Error severity, here: 4, and location of error, here: battery
Id 1	In the list of all errors, the position of the error, here: first error message
8, d1, d2, d3, d4	Error code, here: 8, and system information to identify the error with the help of the diagnosis lists

↻ *E2 diagnosis messages*

↻ *E3 diagnosis messages*

↻ *E4 diagnosis messages*

↻ *E11 diagnosis messages*

> ⓘ *The display of the processor module does not show any communication modules or fieldbus diagnosis. To view these diagnosis messages use Automation Builder or IEC application.*
>
> *This is valid for the following:*
> – *all external communication modules including safety processor module*
> – *CANopen on onboard CAN interface*
> – *fieldbuses on Ethernet interfaces ETH1/ETH2 like PROFINET IO controller, EtherCAT master, etc.*

14.1.1 Error severity E2: Severe errors

Table 15: Error severity E2: Severe errors
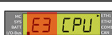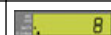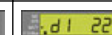
Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E2	iob (I/O bus)	2	14	0	0	0	Resource failure	
E2	iob (I/O bus)	3	14	0	0	0	Timeout	
E2	CPU	11	0	0	0	0	Type scaling on PLC startup failed	
E2	FLd (flash disk)	12	19	0	0..n	0..n	Flash memory is temporary protected (read only, panic mode)	
E2	iob (I/O bus)	17	14	0	0	0	Error setting I/O bus master parameter	
E2	diS (display)	23	21	0	0	0	Wrong version of display firmware	
E2	CPU	27	0	2	0	0	Failed to set parameter "Reboot at powerfail"	
E2	CPU	29	0	0	0	0	Combination of plugged option boards is invalid	
E2	CPU	49	0	0	0	0	Restore failed	
E2	iob (I/O bus)	8482	Module number	0	-	0	Timeout, while initializing	
E2	iob (I/O bus)	9249	Module number	0	-	0	Timeout while waiting for Reset	
E2	iob (I/O bus)	9258	Module number	0	-	0	Breakdown, communication lost	
E2	iob (I/O bus)	16129	0	0	0	0	Severe error, see log	

Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 CPU	E3 CPU	8	.d1 22	.d2 0	.d3 0	.d4 0		
E2	iob (I/O bus)	16130	0	0	0	0	Fatal error, see log	
E2	iob (I/O bus)	16194	0	0	0	0	Fatal error, not running any more	
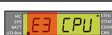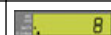
14.1.2 Error severity E3: Minor errors

Table 16: Error severity E3: Minor errors

Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 CPU	E3 CPU	8	.d1 22	.d2 0	.d3 0	.d4 0		
E3	iob (I/O bus)	3	Module number	1	Channel number	0	Discrepancy time expired	Check discrepancy time value, channel wiring and sensor.
E3	FLd (flash disk)	10	19	5	0...n	0	Medium has almost used its complete spare capacity or is already dead, action required	
E3	iob (I/O bus)	12	Module number	1	Channel number	0	Test pulse error	Check wiring and sensor
E3	iob (I/O bus)	13	Module number	1	Channel number	0	Test pulse cross-talk error	Check wiring and sensor. If this error persists, replace I/O module. Contact ABB technical support.
E3	iob (I/O bus)	18	Module number	1	Channel number	0	Test error	
E3	diS (display)	22	21	0	0	0	Error at initialization of display	
E3	iob (I/O bus)	25	Module number	1	Channel number	0	Stuck-at error	Check I/O module wiring. Restart I/O module, if needed. If this error persists, replace I/O module.

Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 `[E3 CPU]`	`[E3 CPU]`	`8`	`.d1 22`	`.d2 0`	`.d3 0`	`.d4 0`		
E3	iob (I/O bus)	28	Module number	1	Channel number	0	Cross-talk error	Check I/O module wiring. Restart I/O module, if needed. If this error persists, replace I/O module.
E3	CPU	44	0	7	0	0	Loading boot project failed due to failing load of retain data	
E3	CPU	45	0	7	0	0	Loading boot project failed due to mis-match of retain data	
E3	CPU	46	0	7	0	0	Loading boot project failed due to insuf-ficient license for application	
E3	CPU	47	0	7	0	0	Loading boot project failed due to unspe-cified reason	
E3	CPU	48	0	0	0	0	Backup failed	
E3	FLd (flash disk)	54	19	5	0	0	Root partition has 1% or less free space left	
E3	iob (I/O bus)	273	Module number	1	Channel number	0	Test error	
E3	iob (I/O bus)	311	Module number	1	Channel number	0	Value difference too high	Adjust toler-ance window for channels. Check channel wiring and sensor con-figuration.
E3	iob (I/O bus)	524	Module number	1	Channel number	0	Stuck-at error	
E3	iob (I/O bus)	525	Module number	1	Channel number	0	Readback error	Check I/O module wiring. Restart I/O module, if needed. If this error persists, replace I/O module.
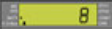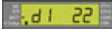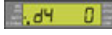
Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 CPU	E3 CPU	8	d1 22	d2 0	d3 0	d4 0		
E3	iob (I/O bus)	530	Module number	1	Channel number	0	Cross-talk error	Check I/O module wiring. Restart I/O module, if needed. If this error persists, replace I/O module.
E3	iob (I/O bus)	540	Module number	1	Channel number	0	Test error	
E3	iob (I/O bus)	555	Module number	1	Channel number	0	Internal error	
E3	iob (I/O bus)	1037	Module number	1	Channel number	0	Test error	
E3	iob (I/O bus)	8480	Module number	0	-	0	Not supported protocol variant	
E3	iob (I/O bus)	8707	Module number	0	-	0	PROFIsafe watchdog timed out	
E3	iob (I/O bus)	8708	Module number	0	-	0	Overvoltage	
E3	iob (I/O bus)	8711	Module number	0	-	0	Undervoltage	
E3	iob (I/O bus)	8722	Module number	0	-	0	Internal error	
E3	iob (I/O bus)	8723	Module number	0	-	0	Checksum error has occured in iParameters	
E3	iob (I/O bus)	8724	Module number	0	-	0	PROFIsafe communication error	
E3	iob (I/O bus)	8732	Module number	0	-	0	Internal error	
E3	iob (I/O bus)	8747	Module number	0	-	0	Internal runtime error	
E3	iob (I/O bus)	8961	Module number	0	-	0	Wrong parameter value, check configuration	
E3	iob (I/O bus)	8979	Module number	0	-	0	Checksum error has occured in iParameter or F-Parameters	
E3	iob (I/O bus)	8986	Module number	0	-	0	Invalid configuration	Check modules and parameterization
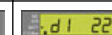
Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 CPU	E3 CPU	8	.d1 22	.d2 0	.d3 0	.d4 0		
E3	iob (I/O bus)	8988	Module number	0	-	0	F-Parameter configuration and address switch value do not match.	Check I/O module F-Parameter configuration and module address switch value.
E3	iob (I/O bus)	16131	Module number	0	-	0	Timeout	Replace I/O module
E3	iob (I/O bus)	16137	Module number	0	-	0	Overflow diagnosis buffer	Restart
E3	iob (I/O bus)	16138	Module number	0	-	0	Non-safety I/O: Voltage overflow on outputs (above UP3 level), Safety I/O: Process voltage too high	Check terminals/ process voltage
E3	iob (I/O bus)	16139	Module number	0	-	0	Process voltage UP or UP3 too low	Check process voltage
E3	iob (I/O bus)	16146	Module number	0	-	0	Plausibility check failed (iParameter)	Check configuration
E3	iob (I/O bus)	16147	Module number	0	-	0	Checksum error	Non-safety I/O: Replace I/O module Safety I/O: Check safety configuration and CRCs for I- and F-Parameters.
E3	iob (I/O bus)	16148	Module number	0	-	0	PROFIsafe communication error	Restart I/O module. If this error persists, contact ABB technical support.
E3	iob (I/O bus)	16153	Module number	0	-	0	PROFIsafe watchdog timed out	Restart I/O module. If this error persists, increase PROFIsafe watchdog time.
E3	iob (I/O bus)	16154	Module number	0	-	0	Parameter error	Check configuration.

Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 CPU	E3 CPU	8	.d1 22	.d2 0	.d3 0	.d4 0		
E3	iob (I/O bus)	16156	Module number	0	-	0	F-Parameter config-uration and address switch value do not match.	Check I/O module F-Parameter configura-tion and module address switch value.
E3	iob (I/O bus)	16164	Module number	0	-	0	Internal data inter-change failure	Replace I/O module
E3	iob (I/O bus)	16168	Module number	0	-	0	Different hard-/firm-ware versions in the module	Replace I/O module
E3	iob (I/O bus)	16171	Module number	0	-	0	Internal error	Replace I/O module
E3	iob (I/O bus)	16175	Module number	0	-	0	Sensor voltage too low	
E3	iob (I/O bus)	16128	0	0	0	0	Failed Max Wait Run	

14.1.3 Error severity E4: Warnings

Table 17: Error severity E4: Warnings

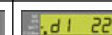| Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 CPU	E3 CPU	8	.d1 22	.d2 0	.d3 0	.d4 0		
E4	bAt (battery)	8	22	0	0	0	Empty or missing	
E4	FLd (flash disk)	9	19	5	0...n	0	Medium has used 80 % of its spare capacity	
E4	FLd (flash disk)	53	19	5	0	0	Root partition has 15% or less free space left	
E4	iob (I/O bus)	257	Module number	1	Channel number	0	Wrong measure-ment, false tempera-ture at the compen-sation channel	
E4	iob (I/O bus)	258	Module number	1	Channel number	0	AI531: wrong meas-urement, potential difference is too high; CD522: PWM duty cycle out of duty area	
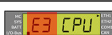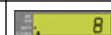
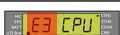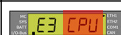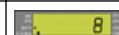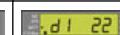| Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 CPU	E3 CPU	8	.d1 22	.d2 0	.d3 0	.d4 0		
E4	iob (I/O bus)	260	Module number	1	Channel number	0	Measurement over-flow	Check channel wiring and sensor power supply.
E4	iob (I/O bus)	263	Module number	1	Channel number	0	Measurement under-flow at analog input	Check channel wiring and sensor power supply.
E4	iob (I/O bus)	266	Module number	1	Channel number	0	Short circuit and cut wire or "out of range"	
E4	iob (I/O bus)	267	Module number	1	Channel number	0	Output/process voltage to small/low.	
E4	iob (I/O bus)	302	Module number	1	Channel number	0	External voltage feeded at the output clamps.	
E4	iob (I/O bus)	303	Module number	1	Channel number	0	Short circuit at the analog input	Check channel wiring
E4	iob (I/O bus)	304	Module number	1	Channel number	0	Analog value over-flow or broken wire at an analog input.	
E4	iob (I/O bus)	530	Module number	1	Channel number	0	Internal fuse at 0 V is defect. 0 V not connected with GND.	
E4	iob (I/O bus)	559	Module number	1	Channel number	0	Short circuit at the digital output	Check channel wiring
E4	iob (I/O bus)	772	Module number	1	Channel number	0	Measurement over-flow at an analog output	Check channel wiring
E4	iob (I/O bus)	775	Module number	1	Channel number	0	Measurement under-flow at analog output	Check channel wiring
E4	iob (I/O bus)	796	Module number	1	0	0	Different configura-tion	
E4	iob (I/O bus)	8482	Module number	0	-	0	Timeout while waiting for ready status	
E4	iob (I/O bus)	8483	Module number	0	-	0	Timeout during parameterization	
E4	iob (I/O bus)	9480	Module number	0	-	0	I/O module removed from hot swap ter-minal unit or defec-tive module on hot swap terminal unit.	Plug I/O module, replace I/O module
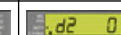
Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 CPU	E3 CPU	8	d1 22	d2 0	d3 0	d4 0		
E4	iob (I/O bus)	9480	Module number	0	0	0	Module removed from hot swap terminal unit	
E4	iob (I/O bus)	9500	Module number	0	-	0	Wrong I/O module replugged on hot swap terminal unit	Remove wrong I/O module and plug projected I/O module
E4	iob (I/O bus)	9514	Module number	0	-	0	No communication with I/O module on hot swap terminal unit	Replace I/O module
E4	iob (I/O bus)	9526	Module number	0	-	0	I/O module does not support hot swap	Power off system and replace I/O module
E4	iob (I/O bus)	9526	Module number	0	0	0	Module on hot swap terminal unit does not support hot swap functionality	
E4	iob (I/O bus)	9736	Module number	0	-	0	Hot swap terminal unit required, but not found	
E4	iob (I/O bus)	9764	Module number	0	0	0	Defective hot swap terminal unit	
E4	iob (I/O bus)	9770	Module number	0	-	0	No communication with hot swap terminal unit	Restart, if error persists replace terminal unit
E4	iob (I/O bus)	16172	Module number	0	-	0	Has not passed factory test	
E4	iob (I/O bus)	16173	Module number	0	-	0	No process voltage UP or UP3	Check process voltage

14.1.4 Error severity E11: Parameter errors

Table 18: Error severity E11: Parameter errors

Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 CPU	E3 CPU	8	d1 22	d2 0	d3 0	d4 0		
E11	CPU	18	0	2	0	0	At least one parameter not found	
E11	CPU	19	0	2	0	0	Unable to read at least one parameter value	

Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E11 CPU	E3 CPU	8	.d1 22	.d2 0	.d3 0	.d4 0		
E11	CPU	20	0	2	0	1 (too big) or 2 (too small)	Invalid value of parameter "LED"	
E11	CPU	21	0	2	0	1 (too big) or 2 (too small)	Invalid value of parameter "Battery"	
E11	CPU	24	0	2	0	1 (too big) or 2 (too small)	Invalid value of parameter "Diagnosis, stop on error class"	
E11	CPU	25	0	2	0	1 (too big) or 2 (too small)	Invalid value of parameter "Diagnosis, add Plc name to node name"	
E11	CPU	26	0	2	0	1 (too big) or 2 (too small)	Invalid value of parameter "Reboot at powerfail"	
E11	CPU	28	0	2	0	1 (too big) or 2 (too small)	Value of parameter "Missed Cycle Task behaviour" is not in range	
E11	CPU	30	0	2	0	1 (too big) or 2 (too small)	Value of parameter "Priority Scheme" is not in range	
E11	CPU	40	0	2	0	1 (too big) or 2 (too small)	Value of parameter "Reboot on E2" is not in range	
E11	CPU	50	0	2	0	1 (too big) or 2 (too small)	Invalid value of parameter "Enable diagnosis history"	
E11	CPU	51	0	2	0	1 (too big) or 2 (too small)	Invalid value of parameter "Maximum number of entries in diagnosis history"	
E11	CPU	52	0	2	0	1 (too big) or 2 (too small)	Invalid value of parameter "Maximum size of extended diagnosis data in diagnosis history"	
E11	iob (I/O bus)	16133	Module number	0	0	0	Output data size mismatch	

Error severity	Location	Error code	d1	d2	d3	d4	Description	Remedy
E3 CPU	*E3 CPU*	8	.d1 22	.d2 0	.d3 0	.d4 0		
E11	iob (I/O bus)	16134	Module number	0	0	0	Input data size mismatch	
E11	iob (I/O bus)	16145	0	0	0	0	Error setting I/O bus master parameter	
E11	iob (I/O bus)	16146	0	0	0	0	Failed to start the parameterization of modules	
E11	iob (I/O bus)	16147	Module number	0	0	0	Failed setting parameters	
E11	iob (I/O bus)	16149	Module number	0	0	0	No module data	
E11	iob (I/O bus)	16246	0	0	0	0	Failed to start the parameterization of modules	
E11	iob (I/O bus)	16247	1..20	0	0	0	Failed setting parameters	
E11	iob (I/O bus)	16248	Module number	0	0	0	Failed setting expected module	
E11	iob (I/O bus)	16254	Module number	0	0	0	Size of parameters expected by module differs from size provided by configuration	
E11	iob (I/O bus)	16158	Module number	0	0	0	Type of present module does not match configuration	
E11	-	16159	0	0	-	0	Configured number of modules differs from found ones	
E11	-	16160	0	0	-	0	At least one module failed during configuration	

14.1.5 Diagnosis messages of communication modules or fieldbuses

Table 19: Diagnosis messages of communication modules or fieldbuses

Error severity	Location	Description
E3 CPU	*E3 CPU*	
E−	CMx (communication module) x = slot number	To view these diagnosis messages use Automation Builder or IEC application.
Ex	CAn (CAN interface)	
Ex	Et1 or Et2 (Ethernet ETH1 or ETH2)	

15 Glossary

AC500	Standard PLCs
AC500-eCo	Compact PLCs
AC500-eCo V2	Range of AC500-eCo processor modules
AC500-eCo V3	Range of AC500-eCo processor modules
AC500-S	Safety PLCs
AC500-S Programming Tool	IEC 61131-3 editor, integrated in engineering suite Automation Builder
AC500-S-XC	Safety PLCs suitable for extreme environmental conditions
AC500 V2	Range of AC500 and AC500-XC processor modules
AC500 V3	Range of AC500 and AC500-XC processor modules
AC500-XC	Standard PLCs suitable for extreme environmental conditions
Alarm	Diagnosis message which must be acknowledged by the user. The alarm will continue to be displayed even if the issue has been resolved in the meantime until it is acknowledged.
Automation Builder	Engineering suite for configuration and programming of all PLCs
Cold start	Note: The AC500-eCo V3 does not use a battery for buffering the operand areas specified below, hence the "cold start" mode does not exist in this product. ● A cold start is performed by switching power OFF/ON if no battery is connected. ● All RAM memory modules are checked and erased. ● If no user program is stored in the flash EPROM, the default values (as set on delivery) are applied to the interfaces. ● If there is a user program stored in the flash EPROM, it is loaded into RAM. ● The default operating modes set by the PLC configuration are applied.
CP600	Control panels for application visualizations

Data buffering	● Data buffering, i.e., maintaining data after power ON/OFF, is only possible, if a battery is connected for AC500 CPU and the buffering will take place in flash memory with AC500-eCo V3 CPU. The following data can be buffered completely or in parts:
	  – Data in the addressable flag area (%M area)
	  – RETAIN variable
	  – PERSISTENT variable (number is limited, no structured variables)
	  – PERSISTENT area (%R area)
	● In order to buffer particular data, the data must be excluded from the initialization process.

Download	● Download means loading the complete user program into the PLC's RAM. This process is started by selecting the menu item "Online/Download" in the programming system or after confirming a corresponding system message when switching to online mode (menu item "Online/Login"). ● Execution of the user program is stopped. ● In order to store the user program to the user flash memory, the menu item "Online/Create boot project" must be called after downloading the program. ● Variables are set to their initialization values according to the initialization table.

- RETAIN variables can have wrong values as they can be allocated to other memory addresses in the new project!
- A download is forced by the following:
  - changed PLC configuration
  - changed task configuration
  - changed library management
  - changed compile-specific settings (segment sizes)
  - execution of the commands "Project/Clean all" and "Project/Rebuild All".

Event	Diagnosis message which does not require acknowledgement. The event describes the current status of the device. The event disappears once the issue has been resolved.
HMI	Human machine interface
Online change	- After a project has changed, only these changes are compiled when pressing the key \<F11\> or calling the menu item "Project/Build". The changed program parts are marked with a blue arrow in the block list. - The term Online Change means loading the changes made in the user program into the PLC's RAM using the programming system (after confirming a corresponding system message when switching to online mode, menu item "Online/Login"). - Execution of the user program is not stopped. After downloading the program changes, the program is re-organized. During re-organization, no further online change command is allowed. The storage of the user program to the user flash memory using the command "Online/Create boot project" cannot be initiated until re-organization is completed. - Online Change is not possible after: - changes in the PLC configuration - changes in the task configuration - changes in the library management - changed compile-specific settings (segment sizes) - performing the commands "Project/Clean all" and "Project/Rebuild All".
Panel Builder PB610	Engineering tool for control panels, integrated in engineering suite Automation Builder
Reset	- Performs a START -> STOP process. - Preparation for program restart, i.e., the variables (VAR) (exception: RETAIN variables) are set to their initialization values. - Reset is performed using the menu item "Online/Reset" in the programming system or pressing the function key RUN for $\geq$ 5 s in STOP mode.
Reset (cold)	- Performs a START -> STOP process. - Preparation for program restart, i.e., the variables (VAR) (also RETAIN variables) are set to their initialization values. - Reset (cold) is performed using the menu item "Online/Reset (cold)" in the programming system.
Reset (original)	- Resets the controller to its original state (deletion of flash, SRAM (%M, area, %R area, RETAIN, RETAIN PERSISTENT), Communication Module configurations and user program!). - Reset (original) is performed using the menu item "Online/Reset (original)" in the programming system.
RUN -> STOP	- RUN -> STOP means pressing the RUN function key on the PLC while the PLC is in run mode (AC500 PLC display "run", AC500-eCo PLC "RUN LED" is ON). - If a user program is loaded into RAM, execution is stopped. - All outputs are set to FALSE or 0. - Variables keep their current values, i.e., they are not initialized. - The AC500 PLC display changes from "run" to "StoP", AC500-eCo "RUN LED" changes from ON to OFF.

START -> STOP	● START -> STOP means stopping the execution of the user program in the PLC's RAM using the menu item "Online/Stop" in the programming system.
	● All outputs are set to FALSE or 0.
	● Variables keep their current values, i.e., they are not initialized.
	● The AC500 PLC display changes from "run" to "StoP".
STOP -> RUN	● STOP -> RUN means short pressing the RUN function key on the PLC while the PLC is in STOP mode (AC500 PLC display "StoP", AC500-eCo "RUN LED" is ON). "RUN LED" is OFF of the toggle switch of an AC500-eCo CPU.
	● If a user program is loaded into RAM, execution is continued, i.e., variables will not be set to their initialization values.
	● The AC500 PLC display changes from "StoP" to "run", AC500-eCo "RUN LED" changes from OFF to ON.
STOP -> START	● STOP -> START means continuing the execution of the user program in the PLC's RAM using the menu item "Online/Start" in the programming system.
	● If a user program is loaded into RAM, execution is continued, i.e., variables will not be set to their initialization values.
	● The AC500 PLC display changes from "StoP" to "run", AC500-eCo PLC "RUN LED" changes from OFF to ON.
Warm start	● A warm start is performed by switching power OFF/ON with a battery connected.
	● All RAM memory modules are checked and erased except of the buffered operand areas and the RETAIN variables.
	● If there is a user program stored in the flash EPROM, it is loaded into RAM.
	● The default operating modes set by the PLC configuration are applied.

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