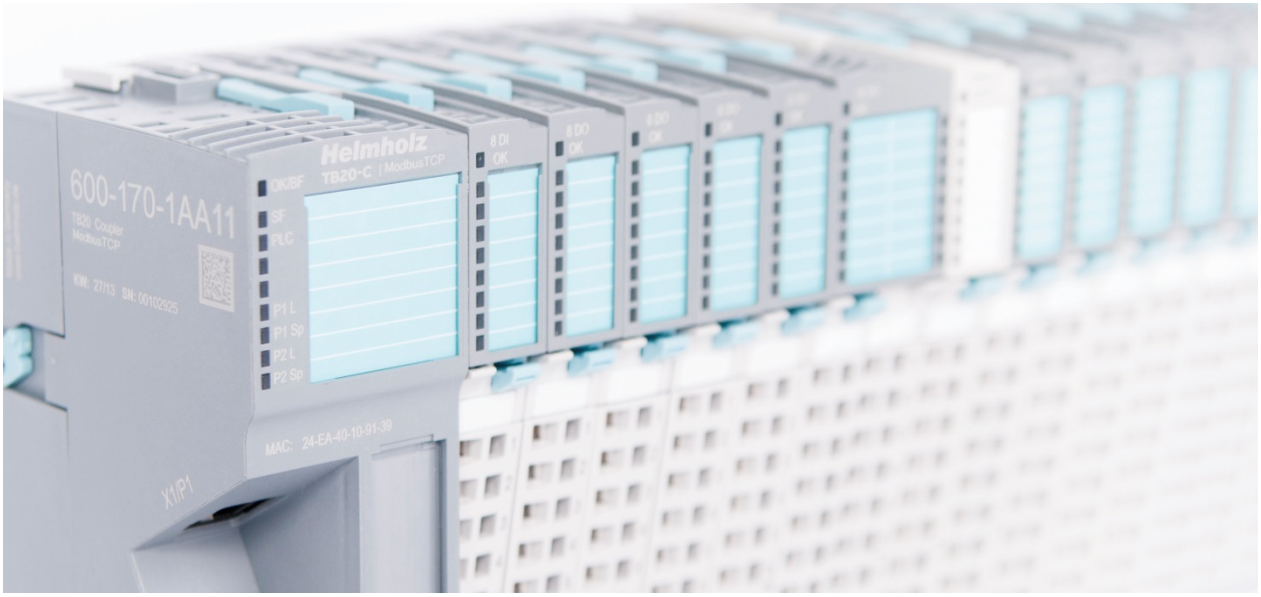
Helmholz
COMPATIBLE WITH YOU



TB20 – ModbusTCP Coupler

Manual

Version 3 / 18.02.2020

for HW 1-1 & FW 1.20 and higher

Helmholz GmbH & Co. KG | Hannberger Weg 2 | D-91091 Großenseebach
Phone +49 9135 7380-0 | Fax +49 9135 7380-110 | info@helmholz.de | www.helmholz.com

Notes

Helmholz GmbH & Co. KG
Hannberger Weg 2, 91091 Großenseebach, Germany

To download the latest version of this manual, please visit our website at www.helmholz.de.

We welcome all ideas and suggestions.

Trademarks

Windows is a registered trademark of Microsoft Corporation.

Revision Record

Version	Date	Change
1	15.05.14	First version
2	-	Not released
3	13.02.20	Corrections technical data and pictures Introductory chapter updated LED description improved Layout update ToolBox V2 update

Table of Contents

1. General

This operating manual applies only to devices, assemblies, software, and services of Helmholz GmbH & Co. KG.

1.1. Target audience for this manual

This description is only intended for trained personnel qualified in control and automation engineering who are familiar with the applicable national standards. For installation, commissioning, and operation of the components, compliance with the instructions and explanations in this operating manual is essential.

WARNING

Configuration, execution, and operating errors can interfere with the proper operation of the TB20 devices and result in personal injury as well as material or environmental damage. Only suitably qualified personnel may operate the TB20 devices!

Qualified personnel must ensure that the application and use of the products described meet all the safety requirements, including all relevant laws, regulations, provisions, and standards.

1.2. Safety instructions

The safety instructions must be observed in order to prevent harm to persons and living creatures, material goods, and the environment. The safety instructions indicate possible hazards and provide information on how hazardous situations can be prevented.

1.3. Note symbols and signal words in the manual

HAZARD

If the hazard warning is ignored, there is an imminent danger to life and health of people from electrical voltage.

WARNING

If the hazard warning is ignored, there is a probable danger to life and health of people from electrical voltage.

CAUTION

If the hazard warning is ignored, people can be injured or harmed.

ATTENTION

Draws attention to sources of error that can damage equipment or the environment.

NOTE

Gives an indication for better understanding or preventing errors.

1.4. Intended use

The TB20 I/O system is an open, modular, and distributed peripheral system designed to be mounted on a 35 mm DIN rail.

Communication with a higher-level control system takes place via a bus system / network through a TB20 bus coupler. Up to 64 modules from the TB20 range can be set up on a bus coupler. The bus couplers support hot plug for replacing modules during ongoing operation.

All components are supplied with a factory hardware and software configuration. The user must carry out the hardware and software configuration for the conditions of use. Modifications to hardware or software configurations which are beyond the documented options are not permitted and nullify the liability of Helmholz GmbH & Co. KG.

The TB20 devices should not be used as the only means for preventing hazardous situations on machinery and equipment.

Successful and safe operation of the TB20 devices requires proper transport, storage, installation, assembly, installation, commissioning, operation, and maintenance.

The ambient conditions provided in the technical specifications must be adhered to.

The TB20 systems have a protection rating of IP20 and must have a control box/cabinet fitted to protect against environmental influences in an electrical operating room. To prevent unauthorized access, the doors of control boxes/cabinets must be closed and possibly locked during operation.

HAZARD

TB20 devices can be equipped with modules that can carry dangerously high voltages. The voltages connected to the TB20 devices can result in hazards during work on the TB20 devices.

1.5. Improper use

WARNING

The consequences of improper use may include injury of the user or third parties, as well as property damage to the control system, the product, or environment. Use TB20 devices only as intended!

1.6. Installation

1.6.1. Access restriction

The modules are open operating equipment and must only be installed in electrical equipment rooms, cabinets, or housings.

Access to the electrical equipment rooms, cabinets, or housings must only be possible using a tool or key, and access should only be granted to trained or authorized personnel.

1.6.2. Electrical installation

Observe the regional safety regulations.

HAZARD

TB20 devices can be equipped with modules that can carry dangerously high voltages. The voltages connected to the TB20 devices can result in hazards during work on the TB20 devices.

1.6.3. Protection against electrostatic discharges

To prevent damage through electrostatic discharges, the following safety measures are to be followed during assembly and service work:

- Never place components and modules directly on plastic items (such as polystyrene, PE film) or in their vicinity.
- Before starting work, touch the grounded housing to discharge static electricity.
- Only work with discharged tools.
- Do not touch components and assemblies on contacts.

1.6.4. Overcurrent protection

To protect the TB20 and the supply line, a slow-blowing 8 A line protection fuse is required.

1.6.5. EMC protection

To ensure electromagnetic compatibility (EMC) in your control cabinets in electrically harsh environments, the known rules of EMC-compliant configuration are to be observed in the design and construction.

1.6.6. Operation

Operate the TB20 only in flawless condition. The permissible operating conditions and performance limits must be adhered to.

Retrofits, changes, or modifications to the device are strictly forbidden.

The TB20 is an operating means intended for use in industrial plants. During operation, the TB20 can carry dangerous voltages. During operation, all covers on the unit and the installation must be closed in order to ensure protection against contact.

1.6.7. Liability

The contents of this manual are subject to technical changes resulting from the continuous development of products of Helmholz GmbH & Co. KG. In the event that this manual contains technical or clerical errors, we reserve the right to make changes at any time without notice. No claims for modification of delivered products can be asserted based on the information, illustrations, and descriptions in this documentation. Beyond the instructions contained in the operating manual, the applicable national and international standards and regulations must also in any case be observed.

1.6.8. Disclaimer of liability

Helmholz GmbH & Co. KG is not liable for damages if these were caused by use or application of products that was improper or not as intended.

Helmholz GmbH & Co. KG assumes no responsibility for any printing errors or other inaccuracies that may appear in the operating manual, unless there are serious errors about which Helmholz GmbH & Co. KG was already demonstrably aware.

Beyond the instructions contained in the operating manual, the applicable national and international standards and regulations must also in any case be observed.

Helmholz GmbH & Co. KG is not liable for damage caused by software that is running on the user's equipment which compromises, damages, or infects additional equipment or processes through the remote maintenance connection and which triggers or permits unwanted data transfer.

1.6.9. Warranty

Report any defects to the manufacturer immediately after discovery of the defect.

The warranty is not valid in case of:

- Failure to observe these operating instructions
- Use of the device that is not as intended
- Improper work on and with the device
- Operating errors
- Unauthorized modifications to the device

The agreements met upon contract conclusion under "General Terms and Conditions of Helmholz GmbH & Co. KG" apply.

1.6.10. Recycling / WEEE

The company Helmholz GmbH & Co. KG is registered as a manufacturer with the HELMHOLZ brand and the device type "Small devices of information and telecommunications technology for exclusive use in households other than private households" as well as the following registration data:

Helmholz GmbH & Co. KG,
Location / Headquarters: 91091 Großenseebach,
Address: Hannberger Weg 2,
Name of authorized representative: Carsten Bokholt,

Registration number: DE 44315750.

The electrical devices described in this document are to be recycled. According to Directive 2012/19 / EU on waste electrical and electronic equipment (WEEE), they must not be disposed of by municipal waste disposal companies.

2. System overview

2.1. General

The TB20 I/O system is an open, modular, and distributed peripheral system designed to be mounted on a 35mm DIN rail.

It is made up of the following components:

- Bus couplers
- Peripheral modules
- Power and isolation modules
- Power modules

By using these components, you can build a custom automation system that is tailored to your specific needs and that can have up to 64 modules connected in series to a bus coupler. All components have a protection rating of IP20.

2.2. The components that make up the TB20 I/O system

2.2.1. Bus coupler

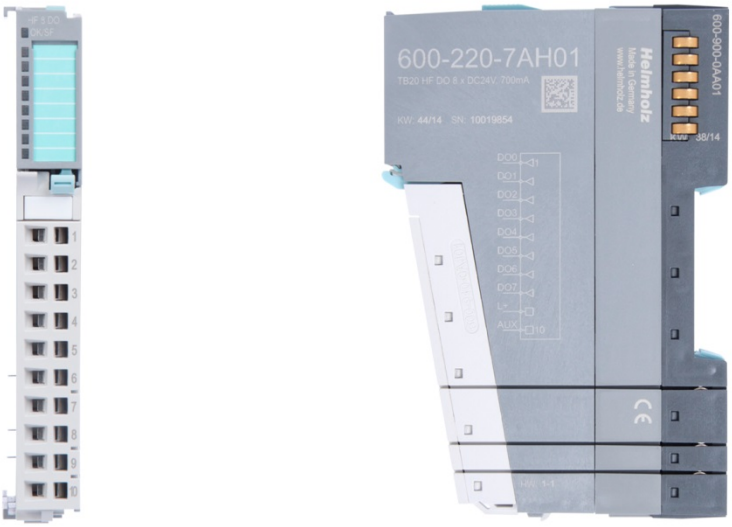
The system's bus coupler includes a bus interface and a power module. The bus interface is responsible for establishing a connection to the higher-level bus system and is used to exchange I/O signals with the automation system's CPU.

The power module is responsible for powering the coupler's electronics and all connected peripheral modules.

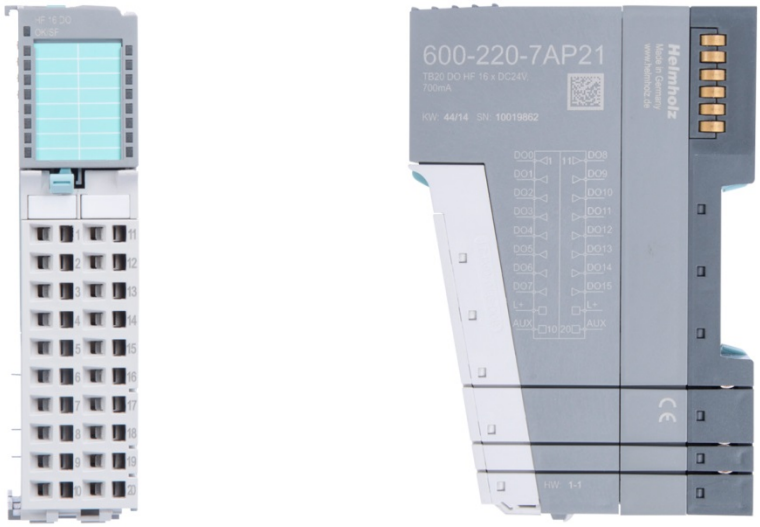
2.2.2. Peripheral modules

The system's peripheral modules are electronic components to which peripheral devices such as sensors and actuators can be connected. A variety of peripheral modules with different tasks and functions are available.

Example: Peripheral module with 10-pin front connector



Example: Peripheral module with 20-pin front connector



2.2.3. Power and isolation module

The system's bus coupler provides the supply voltage for the communications bus (5 V, top) and for external signals (24 V, bottom). These voltages are passed from module to module through the base modules.

Power and isolation modules make it possible to segment the power supply for external signals into individual power supply sections that are powered separately. On the other hand, the communications bus signals and supply voltage for the communications bus are simply passed through, in contrast to the way they are handled in the power modules (see section 2.2.4).

NOTE

Power and insulation modules have a lighter body color.

2.2.4. Power module

The system's bus coupler provides the supply voltage for the communications bus (5 V, top) and for external signals (24 V, bottom). These voltages are passed from module to module through the base modules.

Power modules make it possible to segment the power supply for both external signals and the communication bus into individual power supply sections that are powered separately.

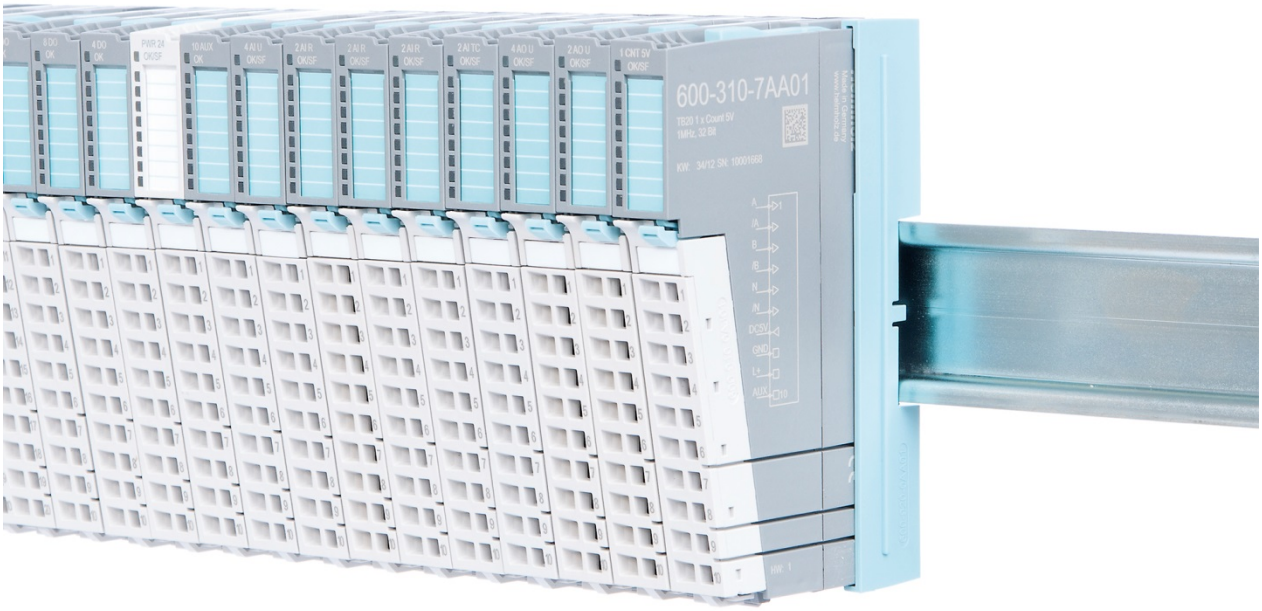
Power modules deliver all necessary power to the peripheral modules connected after them and, if applicable, all the way to the next power module or power and isolation module. A power module is required whenever the power supplied by the coupler alone is not sufficient, e.g., when there are a large number of modules with high power requirements. The "TB20 ToolBox" configuration program can be used to determine whether power modules are needed, as well as how many of them will be needed.

NOTE

Power modules have a lighter body color.

2.2.5. Final cover

The final cover protects the contacts on the last base module from accidental contact by covering its outer right-hand side.



2.2.6. Components in a module

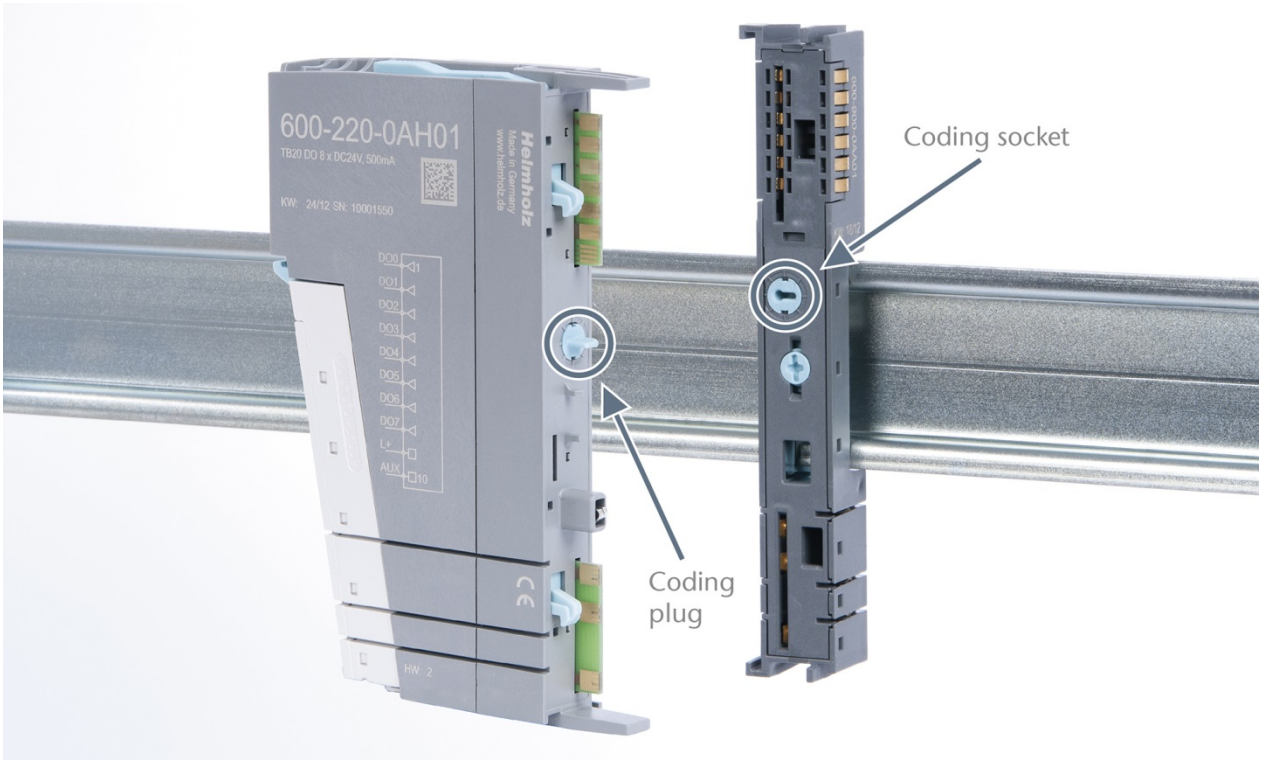
Each module consists of three parts:

- A base module
- An electronic module
- A front connector

2.2.7. Module Coding

Electronic modules and base modules feature coding elements meant to prevent the wrong spare electronic modules from being plugged in during maintenance and repairs.

These coding elements consist of a coding plug on the electronic module and a coding socket on the base module (see following figure).



The coding plug and coding socket can each be in one of eight different positions. Each of these eight positions can be used for a specific type of module (Digital In, Digital Out, Analog In, Analog Out, Power). It will only be possible to plug an electronic module into a base module if the position of the coding plug and the position of the coding socket match. If the positions differ, the electronic module is mechanically blocked.

3. Installation and removal

HAZARD

TB20 modules can carry lethal voltage.

Before starting any work on TB20 system components, make sure to de-energize all components and the cables supplying them with power! Carrying out work when the system is live poses the risk of fatal electrocution!

ATTENTION

Installation must be carried out according to VDE 0100/IEC 364 and in accordance with applicable national standards. The TB20 IO system has protection rating IP20. If a higher protection rating is required, the system must be installed in a housing or control cabinet. In order to ensure safe operation, the ambient temperature must not exceed 60 °C.

3.1. Installation position

The TB20 I/O system can be installed in any position.

Optimal ventilation and thus the maximum ambient temperature can only be achieved in the horizontal installation layout.

3.2. Minimum clearance

It is recommended to adhere to the minimum clearances specified when installing the coupler and modules. Adhering to these minimum clearances will ensure that:

- the modules can be installed and removed without having to remove any other system components
- there will be enough space to make connections to all existing terminals and contacts using commercially available accessories.
- there will be enough space for potentially necessary cable management systems.

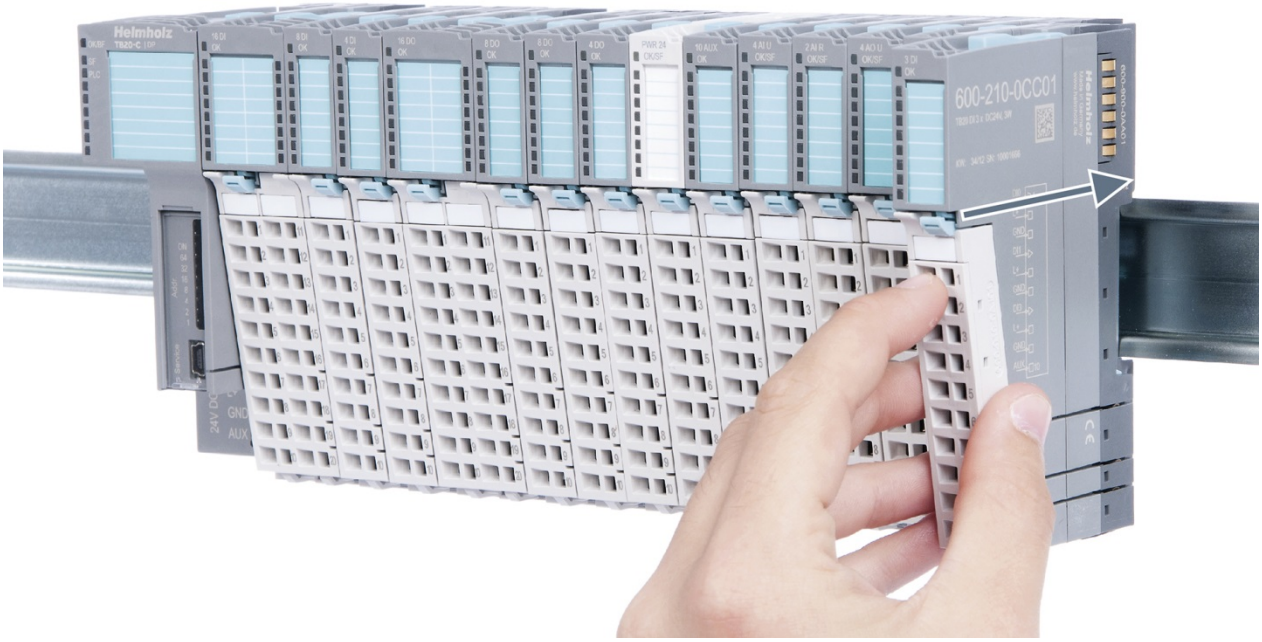
The minimum clearances for mounting TB20 components are: 30 mm on the top and on bottom and 10 mm on each side.

3.3. Installing and removing peripheral modules

3.3.1. Installation

Installing an assembled peripheral module

Place the assembled module on the DIN rail by moving it straight towards the rail. Make sure that the module engages the upper and lower guide elements of the previous module. Then push the upper part of the module towards the DIN rail until the rail fastener fastens into place on the inside snaps with a soft click.



Installing the individual parts of a peripheral module one after the other:

Place the base module on the DIN rail from below in an inclined position. Then push the upper part of the base module towards the rail until the module is parallel to the rail and the rail fastener on the inside snaps into place with a soft click.

Place an electronic module with matching coding (see “Module Coding” in section 2.2.7) on the base module in a straight line from above and then gently push it onto the base module until both modules are fully resting on top of one another and the module fastener snaps into place with a soft click.

Finally, place the front connector on the electronic module from below in an inclined position and then gently push it onto the electronic module until the front connector fastener snaps into place with a soft click.

3.3.2. Removal

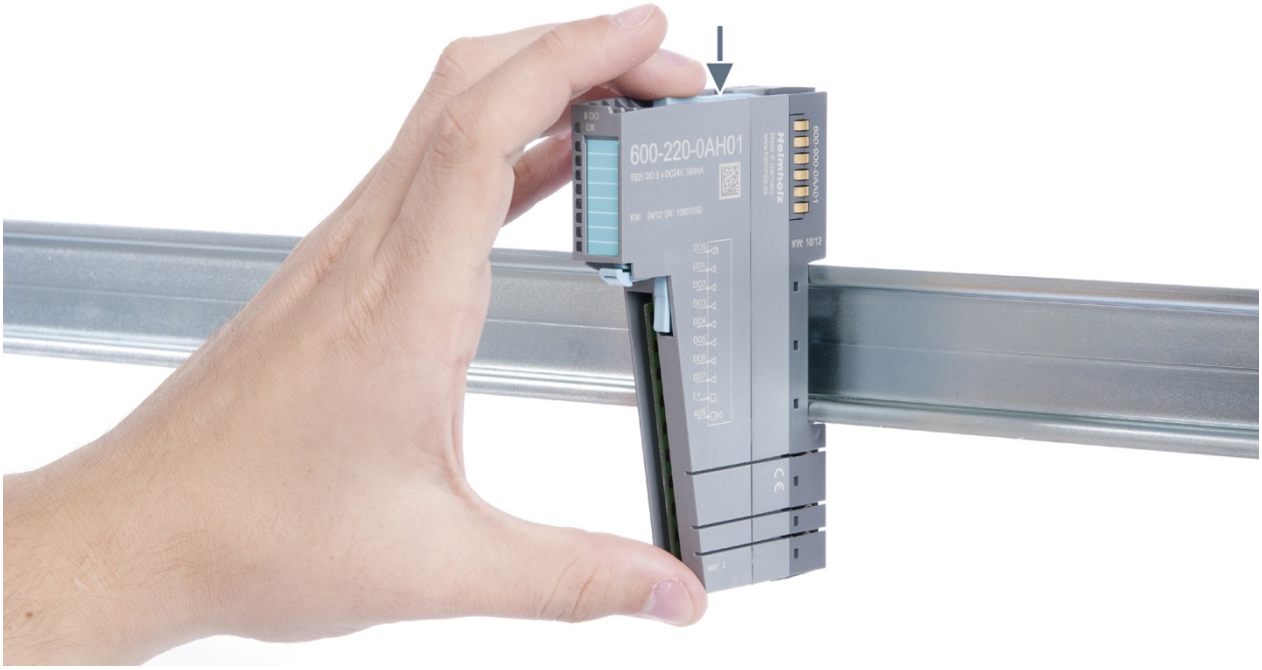
To remove a peripheral module, follow the four steps below:

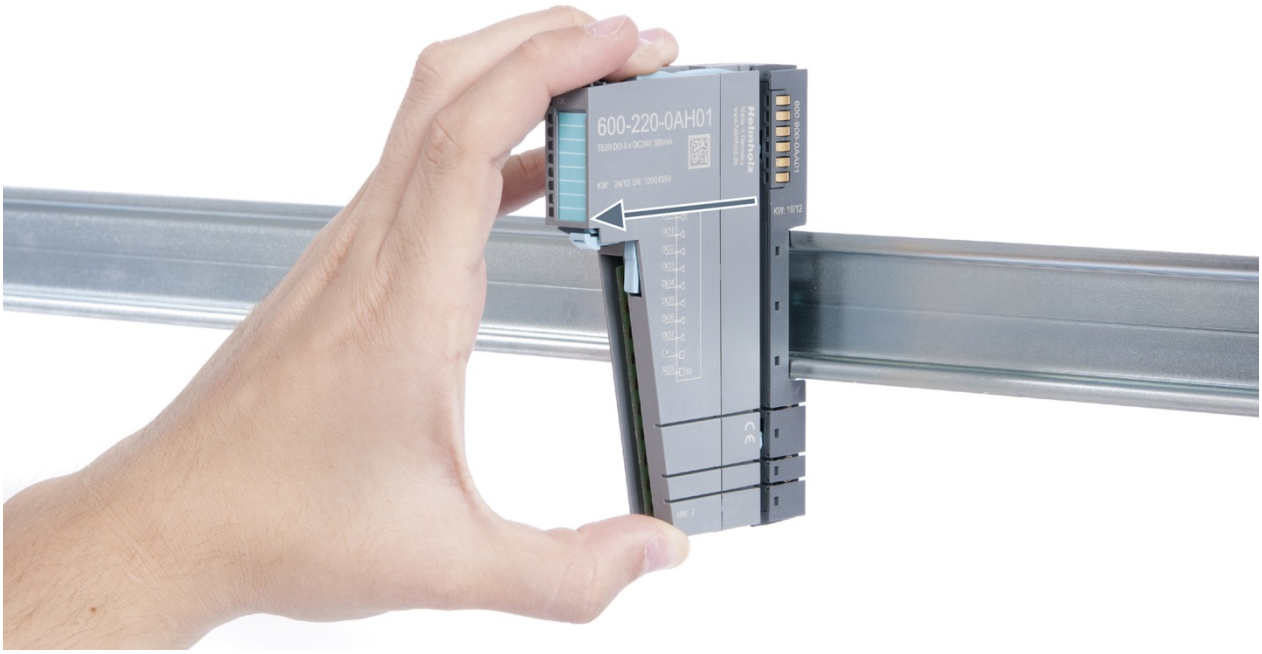
Step 1: Remove the front connector

To remove the front connector, push the tab above the front connector upwards (see the picture below). This will push out the front connector, after which you can pull it out.

Step 2: Remove the electronic module

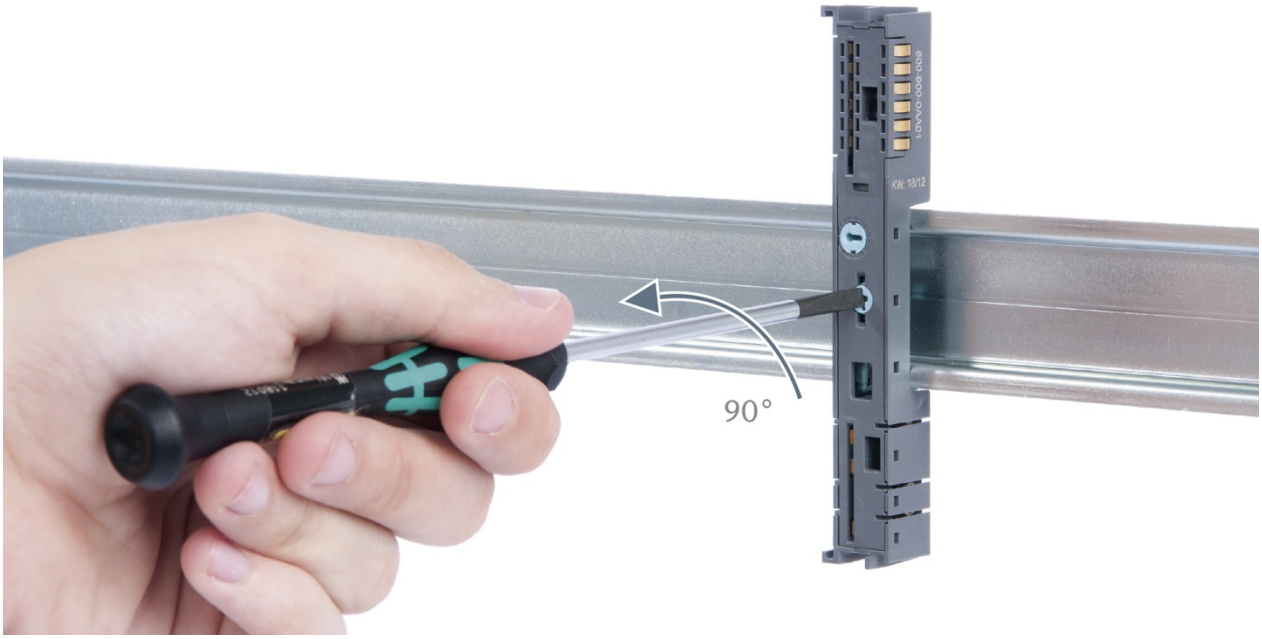
To do so, use your middle finger to push on the lever from above and then use your thumb and index finger to pull out the electronic module while holding the lever down (see the picture below).





Step 3: Release the base module

Use a screwdriver to release the base module. Turn the screwdriver 90° counterclockwise to release.



Step 4: Remove the base module

Remove the base module by pulling it towards you.

3.4. Replacing an electronic module

The procedure for replacing the electronic module on a peripheral module consists of four steps.

If you need to replace the electronic module while the system is running, make sure to take into account the general technical specifications for the bus coupler being used.

HAZARD

TB20 modules can carry lethal voltage.

Before starting any work on TB20 system components, make sure to de-energize all components and the cables supplying them with power! Carrying out work when the system is live poses the risk of fatal electrocution!

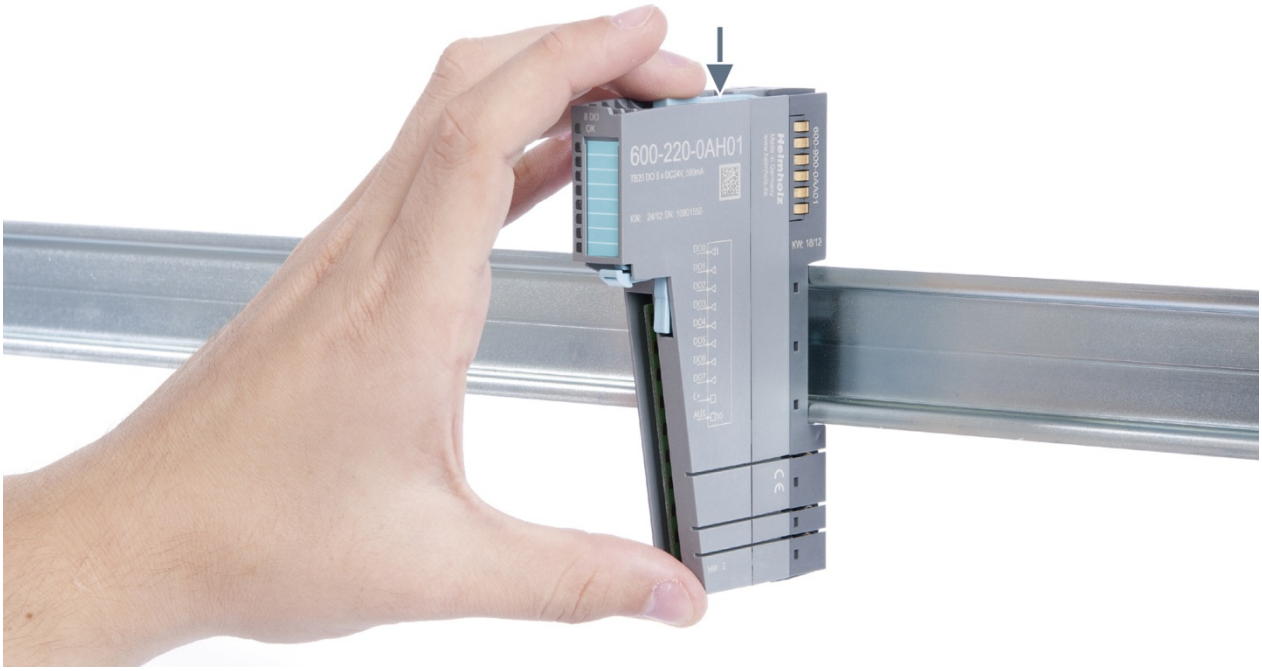
Note the wiring diagram of the system and switch off dangerous voltages before starting work!

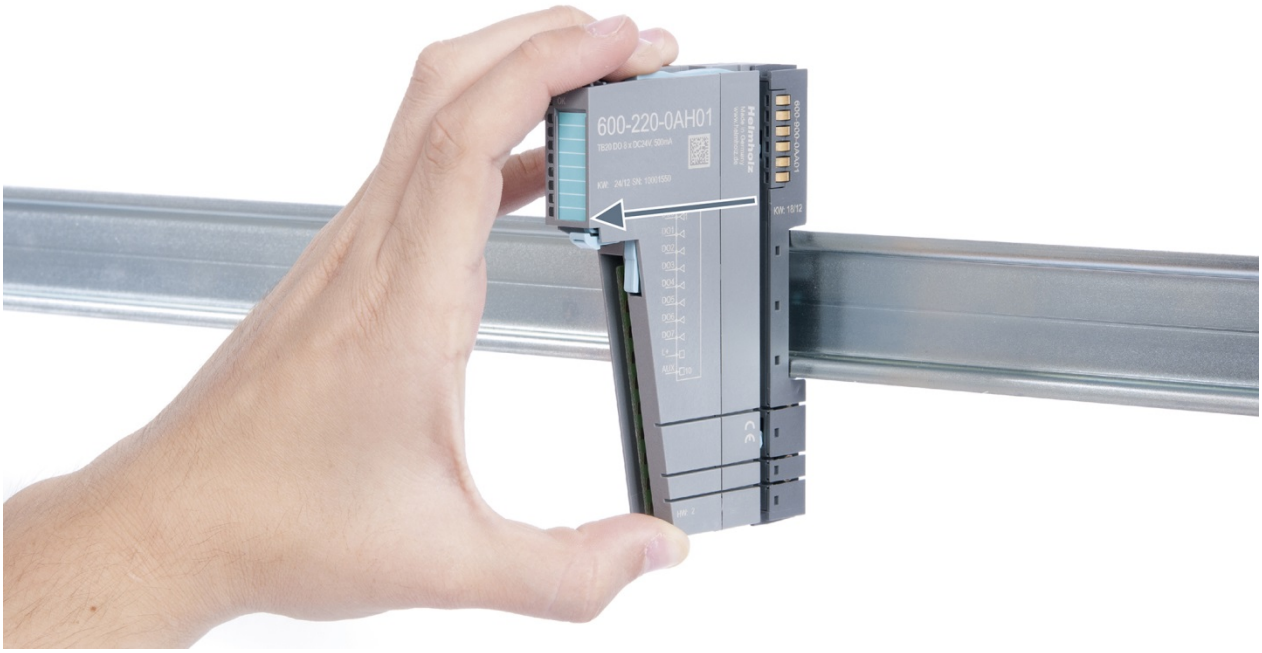
Step 1: Remove the front connector

To remove the front connector, push the tab above the front connector upwards (see the picture below). This will push out the front connector, after which you can pull it out.

Step 2: Remove the electronic module

To remove the electronic module, use your middle finger to push on the lever from above and then use your thumb and index finger to pull out the electronic module while holding the lever down (see the picture below).





Step 3: Plug in a new electronic module

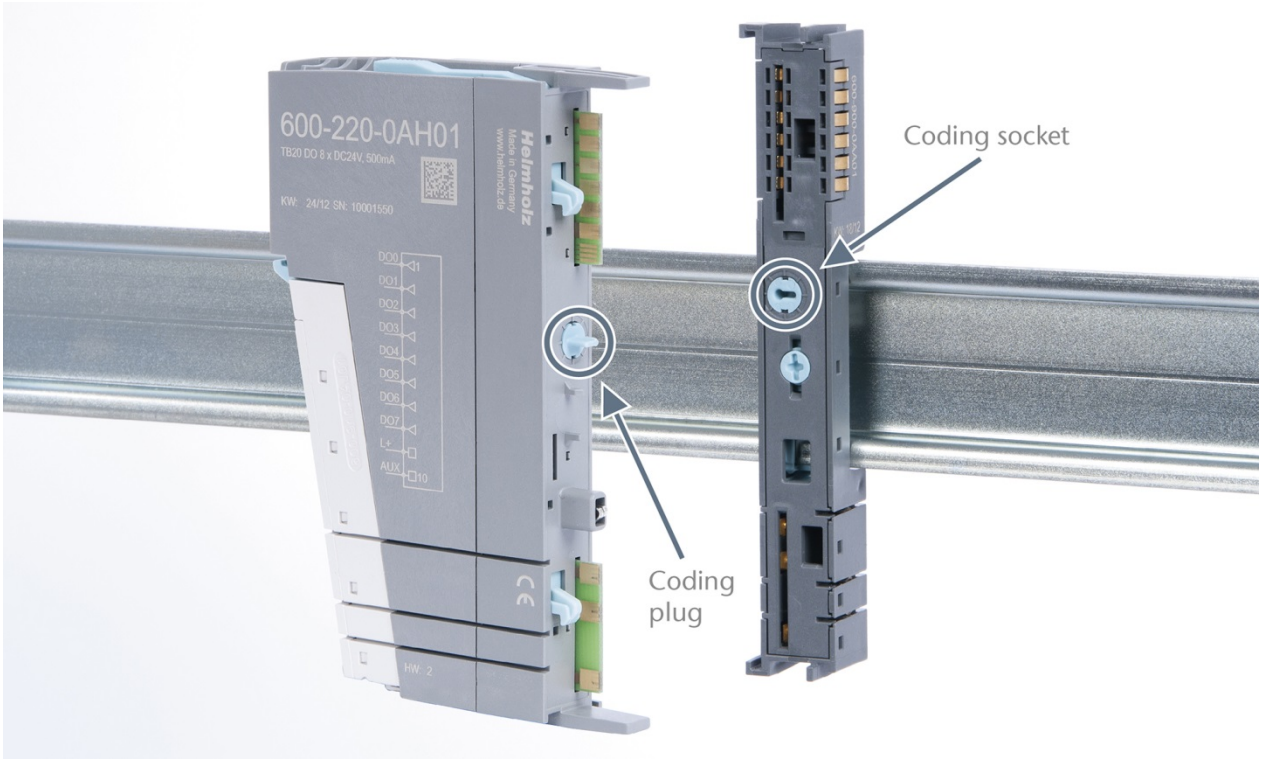
ATTENTION

The electronic module must be snapped into place on the base module with a single continuous movement. If the electronic module is not snapped into place firmly and straight on the base module, bus malfunctions may occur.

ATTENTION

If the electronic module cannot be plugged into the base module, check whether the coding elements on the electronic module and base module (see figure below) match. If the coding elements on the electronic module do not match those on the base module, you may be attempting to plug in the wrong electronic module.

For more information on coding elements, please consult section 2.2.7.

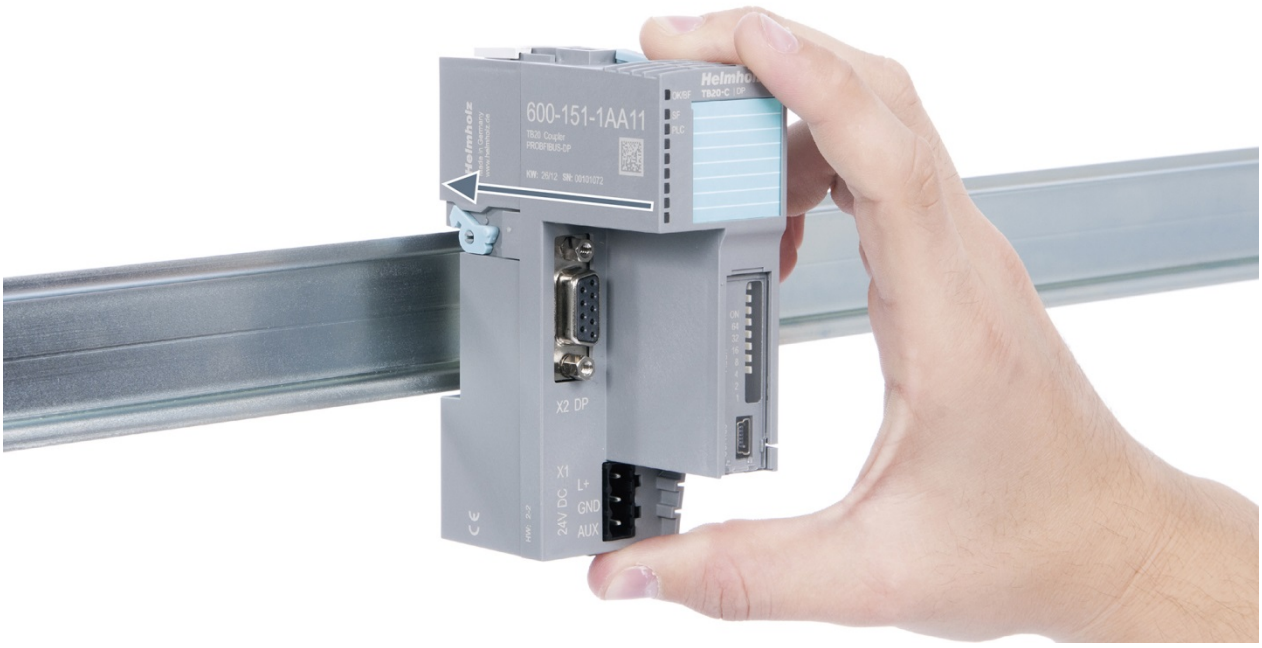


Step 4: Plug in the front connector

3.5. Installing and removing the coupler

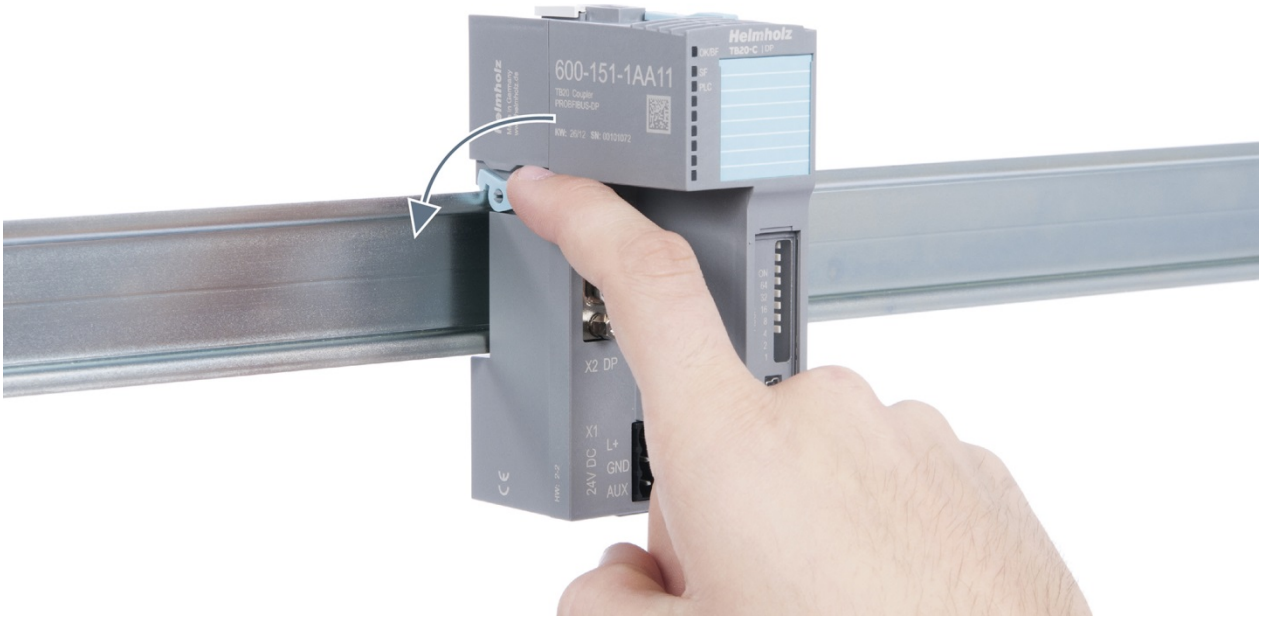
3.5.1. Installation

Place the coupler, together with the attached base module, on the DIN rail by moving it straight towards the rail. Then push the coupler towards the rail until the base module's rail fastener snaps into place with a soft click.



Step 2: Secure the coupler on the DIN rail

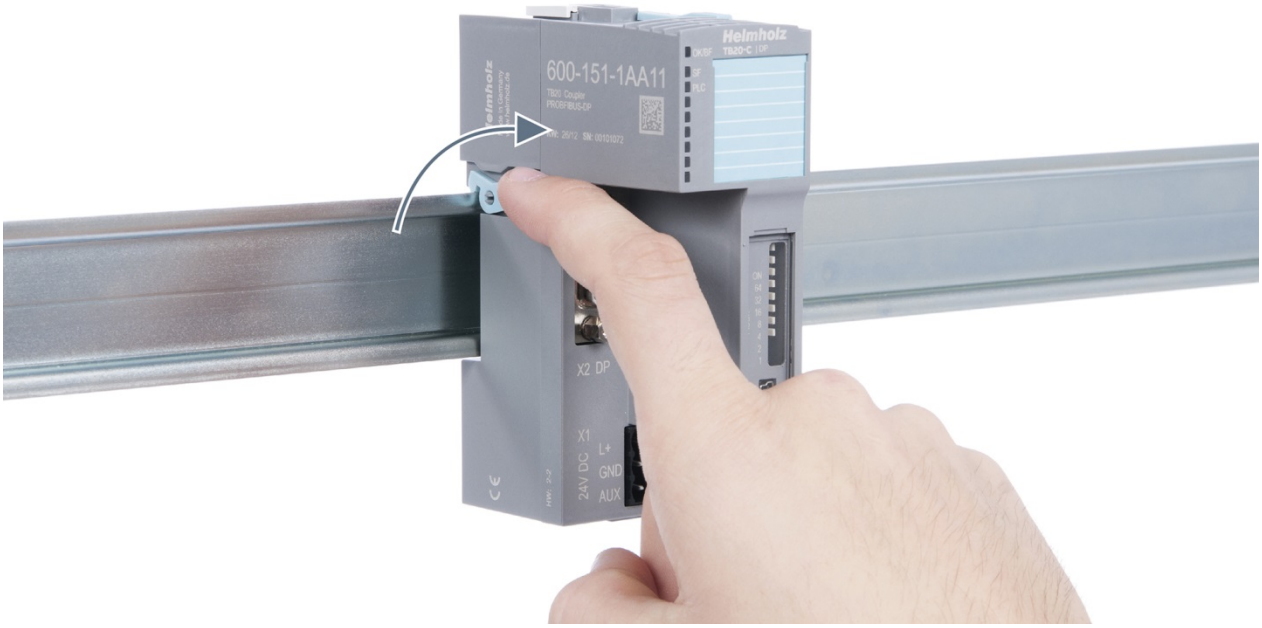
Use the locking lever on the left side of the coupler to lock the coupler into position on the DIN rail.



3.5.2. Removal

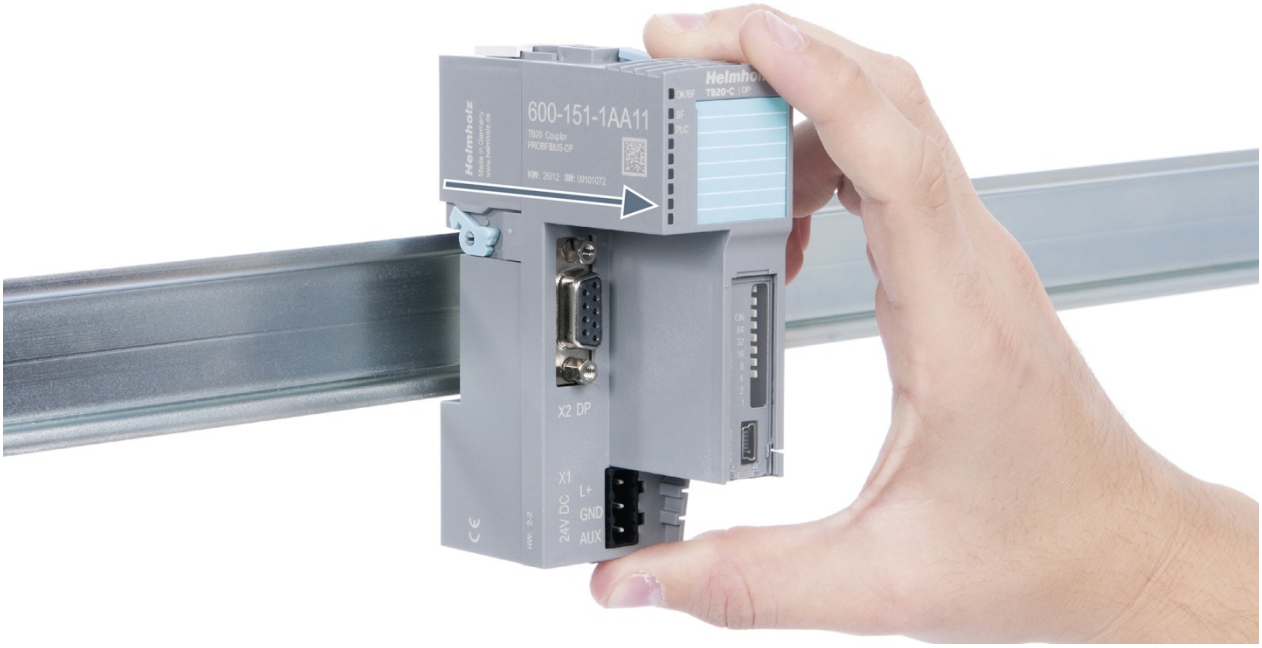
Step 1: Release the locking mechanism

Release the locking lever on the left side of the coupler in order to disengage it from the DIN rail.



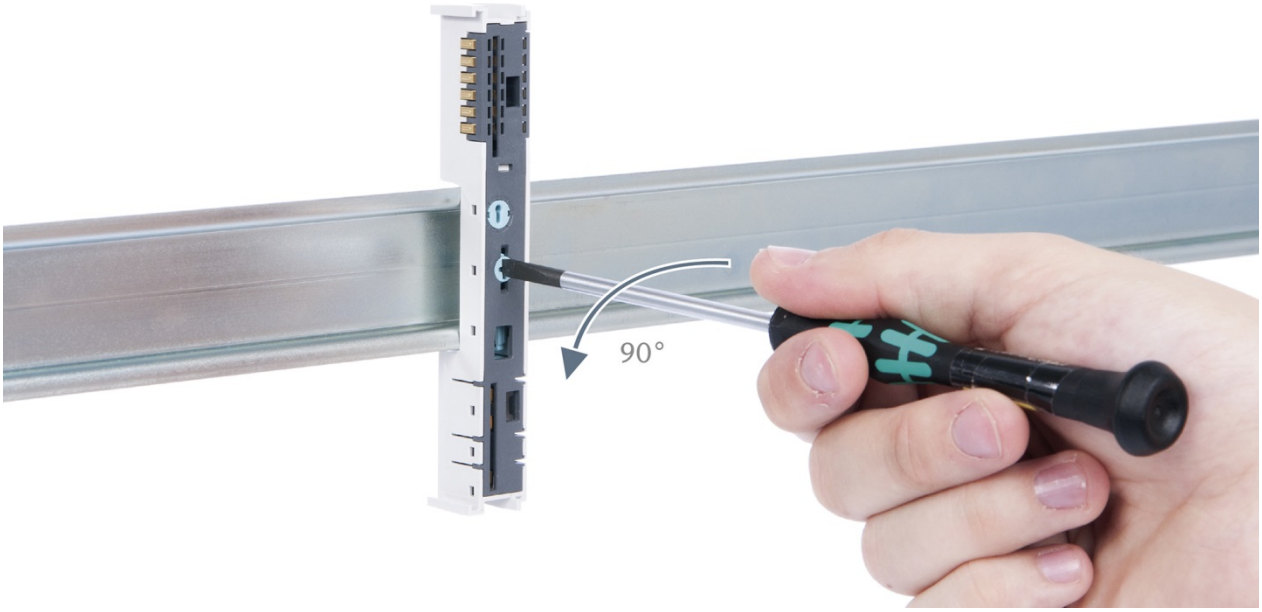
Step 2: Remove the coupler

Use your middle finger to push on the lever from above and use your thumb and index finger to pull out the coupler while holding the lever down.



Step 3: Release the base module

Use a screwdriver to release the base module.



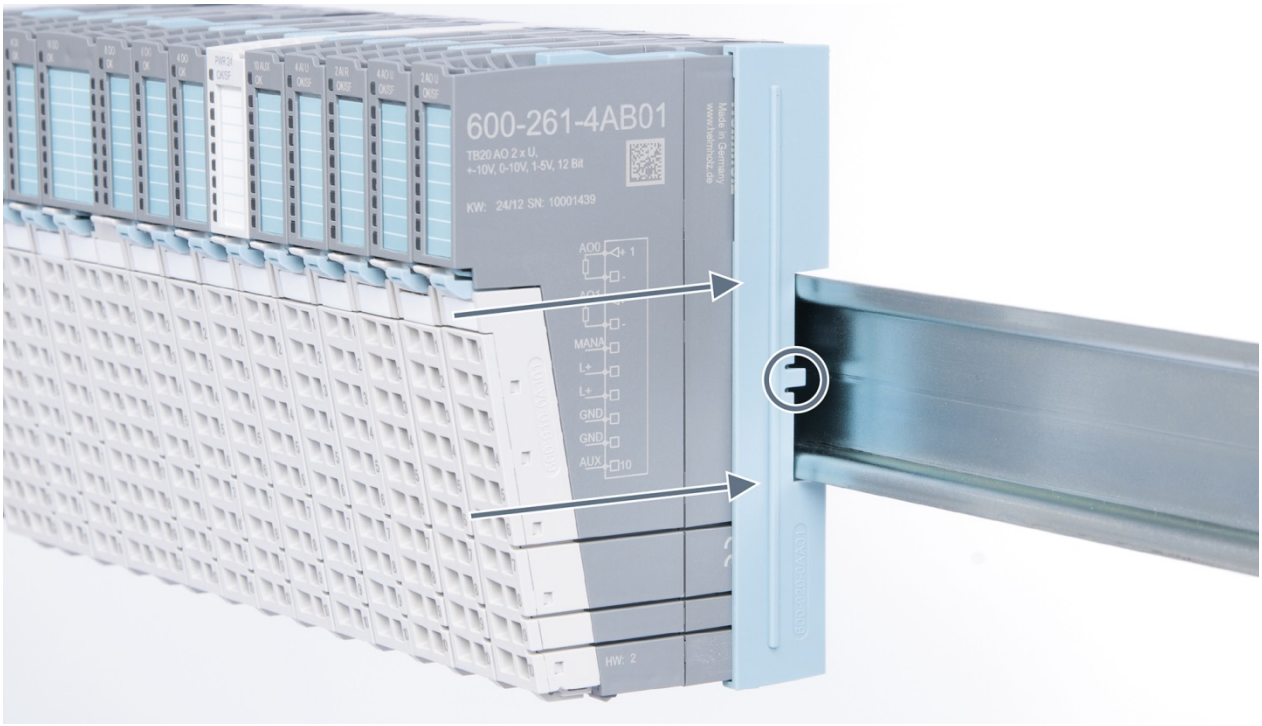
Step 4: Remove the base module

Remove the base module by pulling it towards you.

3.6. Installing and removing the final cover

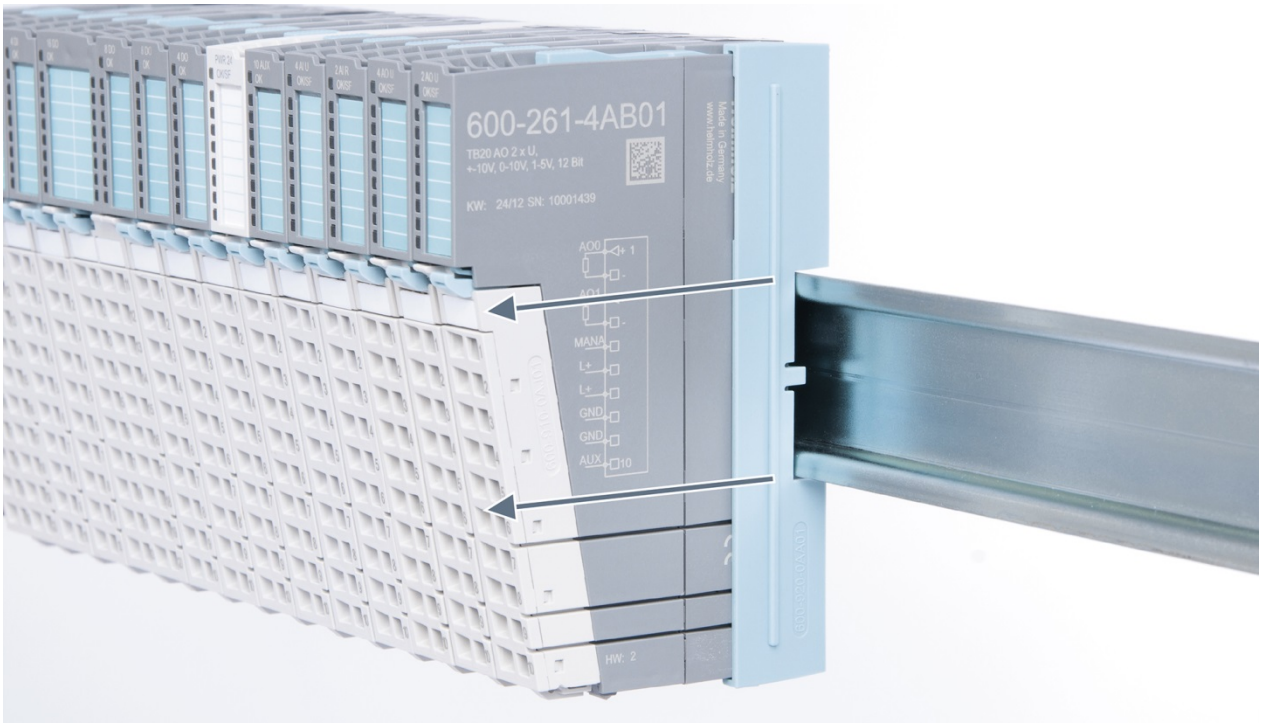
3.6.1. Installation

Slide the final cover onto the last module along the case, starting from the end with the front connector and moving towards the DIN rail, until the cover covers the base module's contacts and the tab snaps into place.



3.6.2. Removal

Pull the final bus cover upward along and off of the module.



4. Setup and wiring

4.1. EMC/safety/shielding

The TB20 IO system complies with EU Directive 2004/108/EC (“Electromagnetic Compatibility”).

One effective way to protect against disturbances caused by electromagnetic interference is to shield electric cables, wires, and components.

ATTENTION

When setting up the system and laying the necessary cables, make sure to fully comply with all standards, regulations, and rules regarding shielding (please also consult the relevant guidelines and documents published by the PROFIBUS User Organization). All work must be done professionally!

Shielding faults can result in serious malfunctions, including the system’s failure.

To ensure electromagnetic compatibility (EMC) in your control cabinets in electrically harsh environments, the following EMC rules are to be observed in the design and the setup:

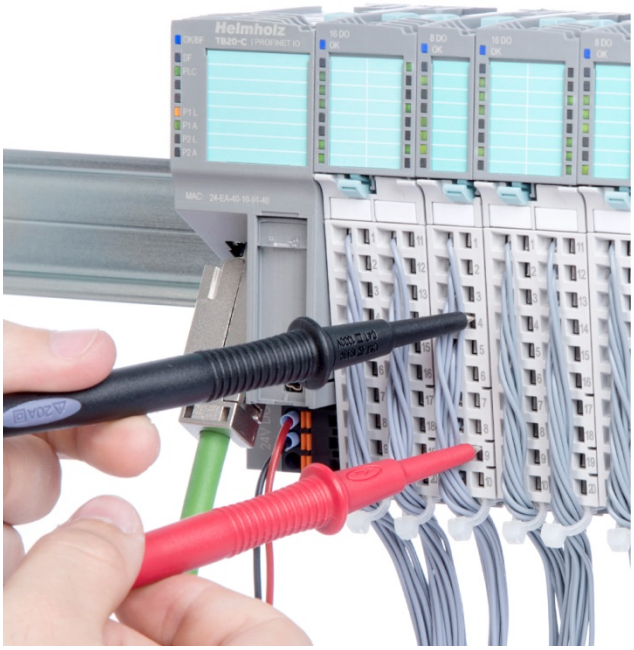
- All metal parts of the cabinet are to be connected with each other over a large area with good conductivity (no paint on paint). Where necessary, use contact washers or serrated washers.
- The cabinet door must be connected to the ground straps (top, middle, bottom) over as short a distance as possible.
- Signal cables and power cables are to be laid separated spatially by a minimum distance of 20 cm from each in order to avoid coupling paths.
- Run signal lines only from one level into the cabinet if possible.
- Unshielded cables in the same circuit (outgoing and incoming conductors) must be twisted if possible.
- Contactors, relays, and solenoid valves in the closet, or in adjacent cabinets if applicable, must be provided with quenching combinations; e.g., with RC elements, varistors, diodes.
- Do not lay wires freely in the closet; instead, run them as closely as possible to the cabinet housing or mounting panels. This also applies to reserve cables. These must be grounded on at least one end, and it is better if they are grounded at both ends (additional shielding effect).
- Unnecessary line lengths should be avoided. Coupling capacitances and inductances are kept low in this way.
- Analog signal lines and data lines must be shielded.

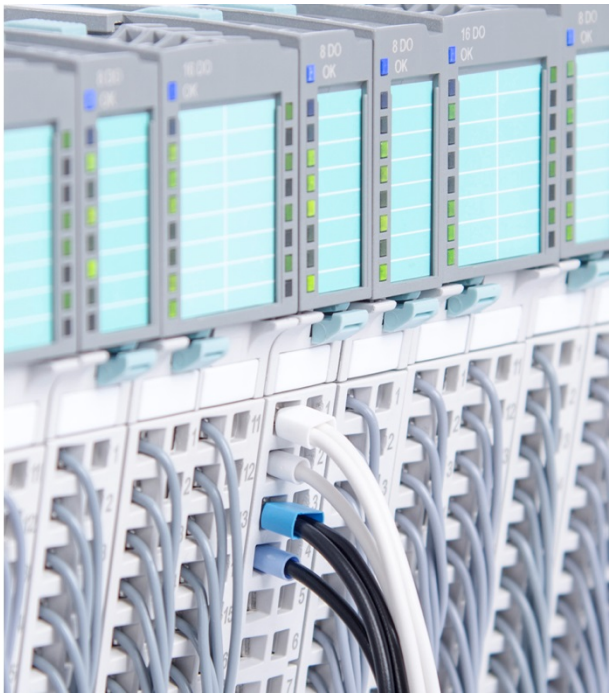
4.2. Front connectors

The front connector's spring-clamp terminals are designed for a cross-sectional cable area of up to 1.5 mm² (16–22 AWG) with or without ferrules.

It is also possible, for example, to connect two 0.75 mm² wires to a single spring-type terminal, provided the maximum cross-sectional cable area of 1.5 mm² per terminal is not exceeded.

The cables can be attached to the underside of the front connector with a cable tie.





4.3. Wiring the coupler

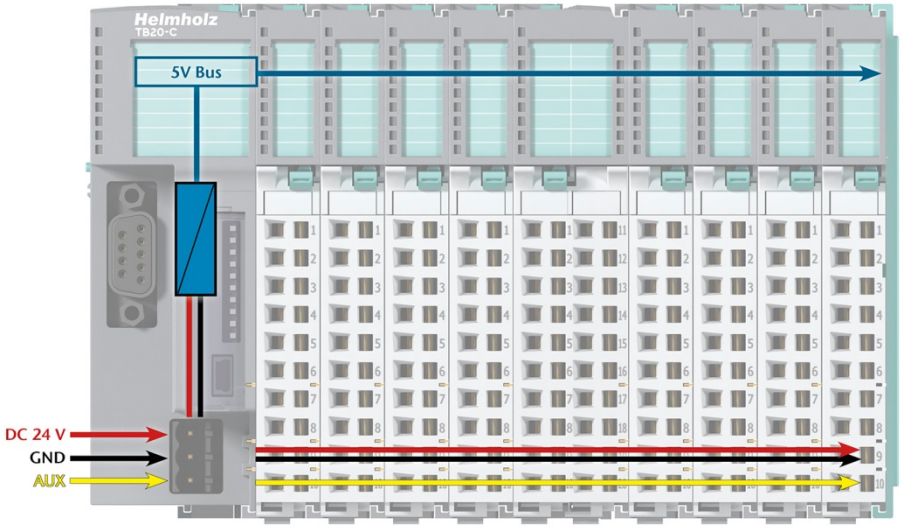
A power supply unit is integrated into the bus coupler. The power supply unit is responsible for powering the peripheral modules connected to the coupler.

In turn, it draws its own power from the three-pin connector on the front (24 VDC, GND, AUX).

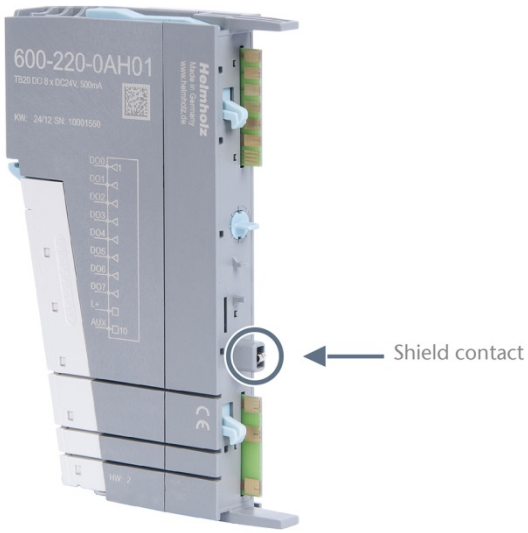
The 24 V connector is used to power two buses:

- The power bus used to power the I/O components (24 VDC, GND, AUX)
- The communications bus used to power the electronics in the peripheral modules

The AUX pin can be used to connect and use an additional voltage potential. Every peripheral module has an AUX terminal on its front connector (the bottommost terminal, i.e., terminals 10 and 20).

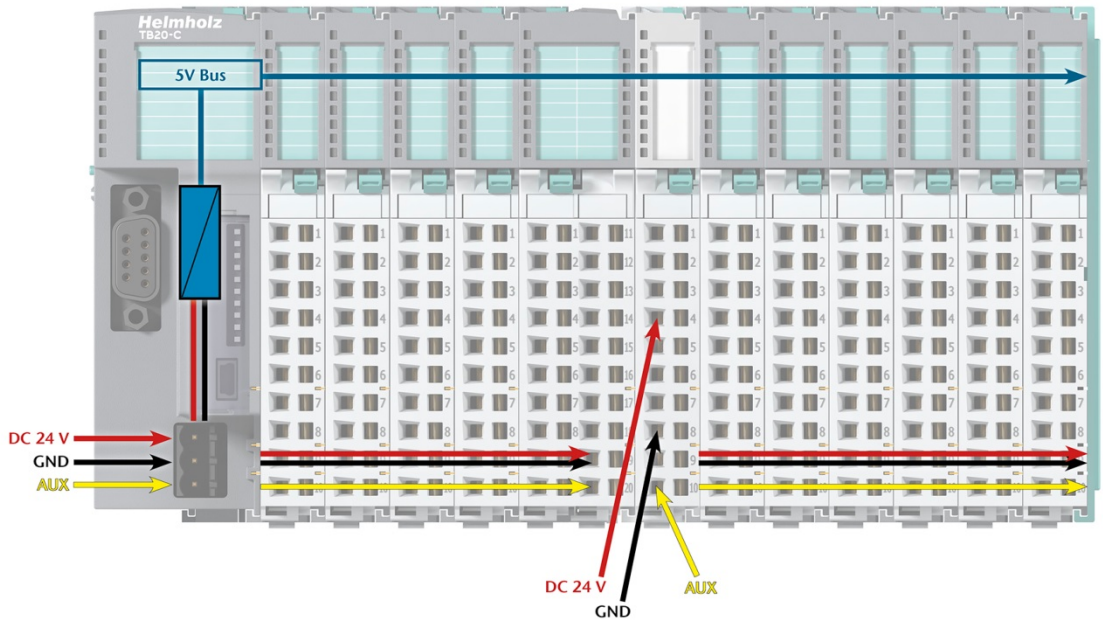


The coupler and the modules are grounded via the shield contact to the DIN rail. The DIN rail must be grounded. The surface of the DIN rail must be clean and conduct electricity well.



4.4. Using power and isolation modules

Power and isolation modules make it possible to segment the power supply for external signals (24 V, GND, AUX) into individual power supply sections that are powered separately.

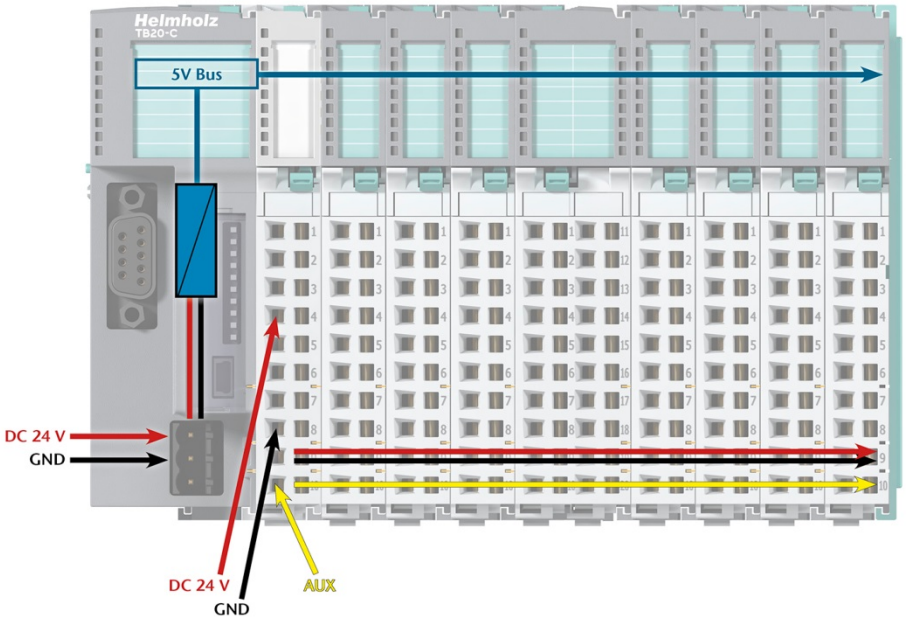


The order no. for the power and isolation module for 24 V signals is 600-710-0AA01.

Its electronic module and base module have the same light gray color as the front connector, ensuring that all power and isolation modules will stand out visually in the system and make it easy to clearly distinguish each individual power supply segment.

4.5. Separate power supply segments for the coupler and the I/O components

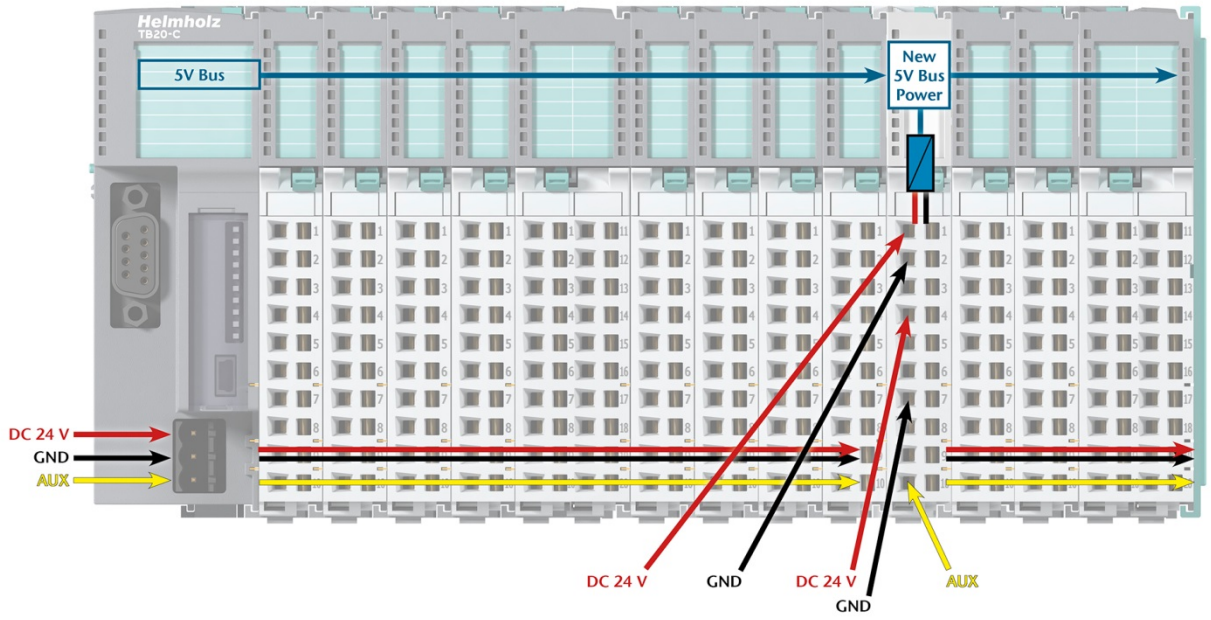
If the power supply for the coupler needs to be separate from the power supply for the I/O modules, a power and isolation module can be used right after the coupler.



4.6. Using power modules

Power modules deliver all necessary power to the connected peripheral modules and, if applicable, all the way to the next power module or power and isolation module. Power modules must be used whenever the power supplied by the coupler alone is not sufficient, that is, when there are a large number of modules on the bus. The “TB20 ToolBox” parameter configuration and diagnosis program can be used to calculate a system’s total current draw.

24 VDC, GND, and AUX are fed into the terminals on the front, while the connected modules are powered through the base modules’ bus system.



The order no. for the power module is 600-700-0AA01. The electronic module of the power module is light gray like the front connector. The base module of the power module is light gray with a dark top part.

4.7. Electronic nameplate

All of a TB20 module's important information can be found on its electronic nameplate. This information includes, for example, the corresponding module ID, module type, order number, unique serial number, hardware version, firmware version, and internal range of functionalities.

This information can be read in a number of ways, one of which is using the "TB20 ToolBox" configuration and diagnosis program. The modules' electronic nameplates not only make it possible to prevent configuration errors (setup), but also make maintenance (servicing) easier.

4.8. Fusing

The TB20 coupler's and power modules' power supply must be externally fused with a slow-blowing fuse, maximum 8 A, appropriate for the required maximum current.

5. ModbusTCP Coupler Characteristics

The TB20 ModbusTCP coupler has the following characteristics:

- ModbusTCP protocol
- Modbus watchdog for monitoring the connection
- Integrated two-port switch
- Access from up to 10 stations simultaneously (TCP connections)
- A maximum of 64 modules
- Two RJ45 connectors
- 2,084 bytes of input data / 2,084 bytes of output data
- 126 bytes of parameter data per module
- With the help of "TB20 ToolBox", modules can be freely configured
- The coupler's behavior can be configured using control registers
- The coupler's state can be read from status registers
- Supports module diagnostics
- Supports hot-swap
- 24 VDC power supply
- Integrated power supply unit for powering peripheral modules (2.5 A)
- Supplies the system’s I/O voltage (24 VDC)
- Seven LEDs, one of them bi-color
- USB device port for online diagnostics, configuring parameters, setup, and firmware updates with "TB20-ToolBox"
- Concealed switch for "factory reset" function

6. Setup and Use

6.1. Configuration with the TB20 ToolBox

The TB20-ToolBox V2 is free software for configuration, testing and diagnosis of the TB20 system. The TB20 ToolBox is not absolutely necessary to configure and operate the TB20 ModbusTCP coupler, but it can be used for commissioning and for function testing.

A USB cable is required for communication with the TB20 ModbusTCP coupler.

6.2. Installation of TB20-ToolBox

The software can be downloaded free of charge from the TB20 system's download area at www.helmholz.de. The software currently runs on Windows 7 and 10.

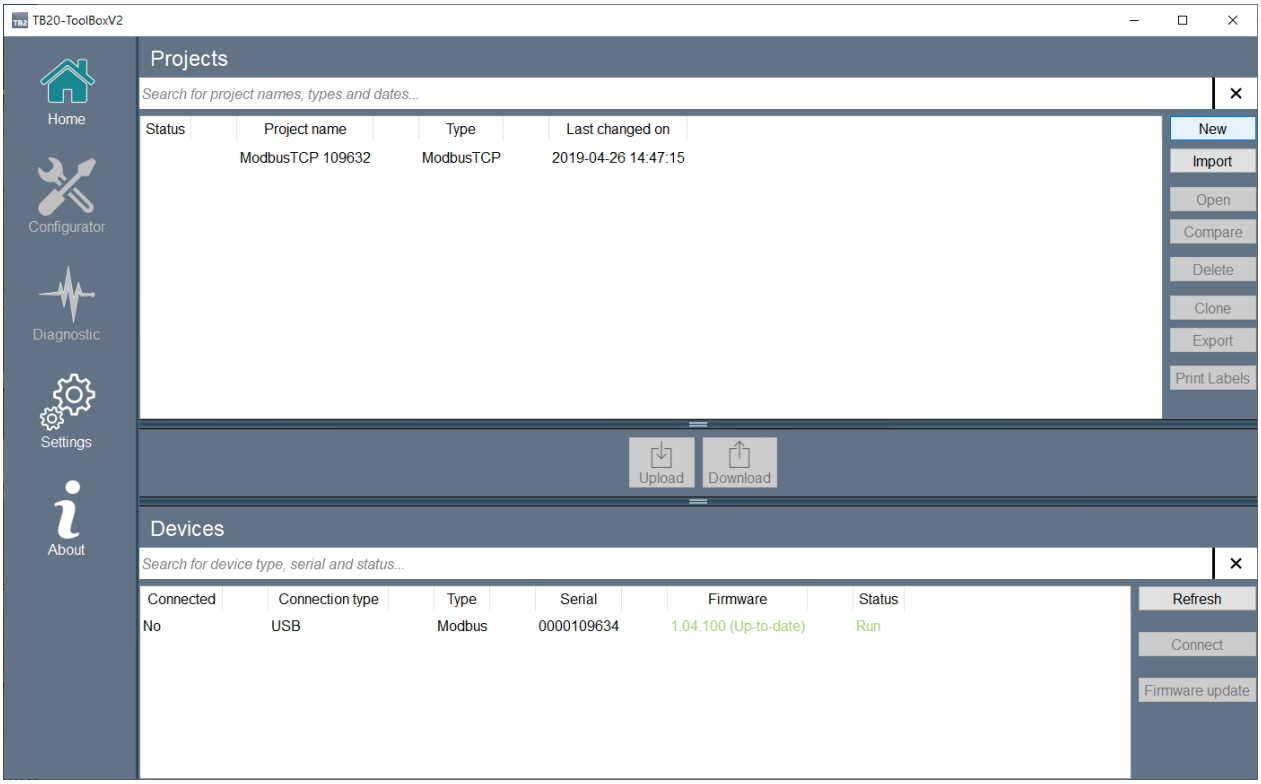
Run the setup and follow the instructions of the program.

The USB driver is copied to the hard disk with the TB20 ToolBox and is ready for installation. You can find the USB driver in the TB20 ToolBox under "Settings".

6.3. Start and create a new project ("Home")

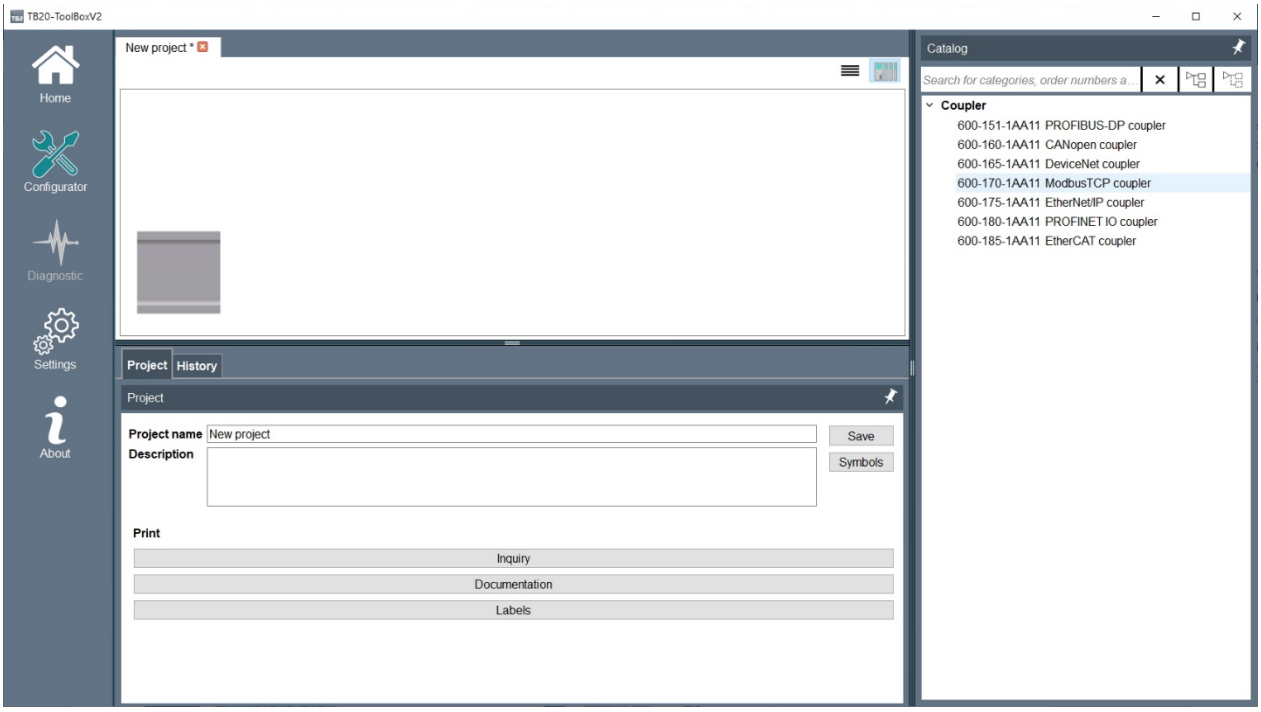
In the TB20 ToolBox view "Home" you can create a new project, import a project, open an existing project or read a project from a connected coupler. You can also see the couplers connected via USB in the lower area under "Devices".

To create a new project, select the "New" button in the menu on the right.

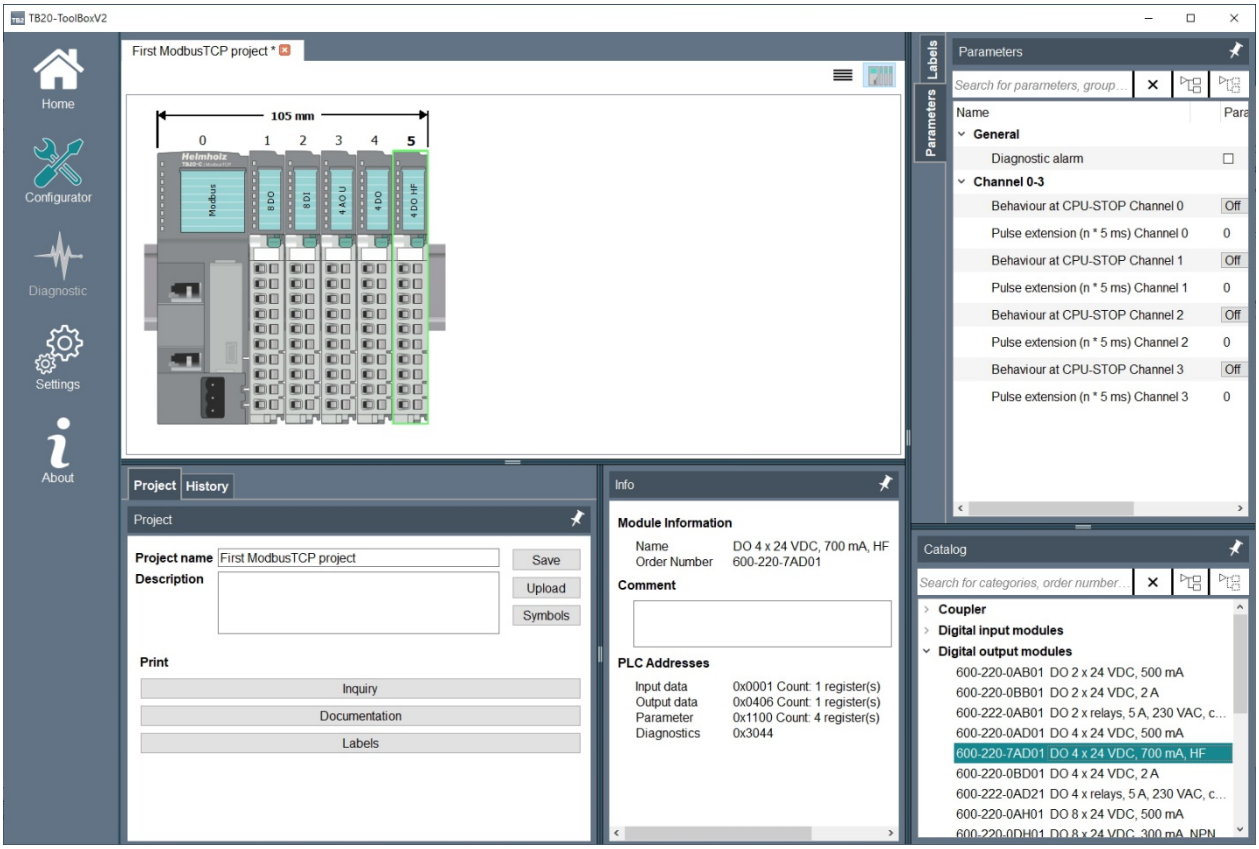


6.4. Configurator

After entering a project name and selecting the desired coupler, the "Configurator" view opens.



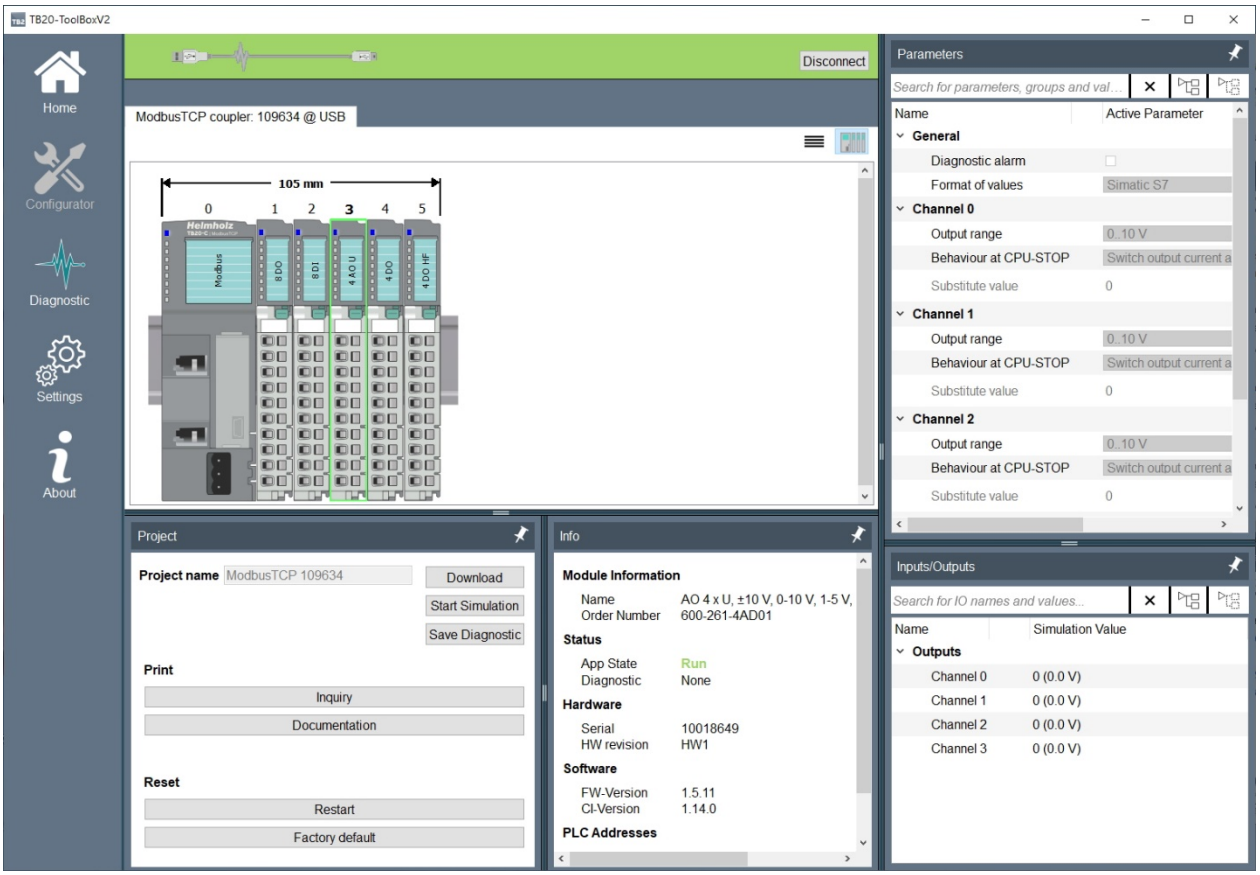
In this view, you can add new modules to the TB20 system, define the symbols, edit the labeling texts ("Labels") and print the labeling strips.



6.5. Diagnostic

You can monitor the current status of the TB20 ModbusTCP coupler and all modules in the TB20 ToolBox view "Diagnostic".

To activate the diagnosis of a connected coupler, click on the desired coupler and "Connect" in the "Home" window.



In addition to the functions "Restart" and reset to "Factory default", the diagnosis status can also be saved in a text file on your computer ("Save Diagnostic"). The diagnostic status contains important information for support.

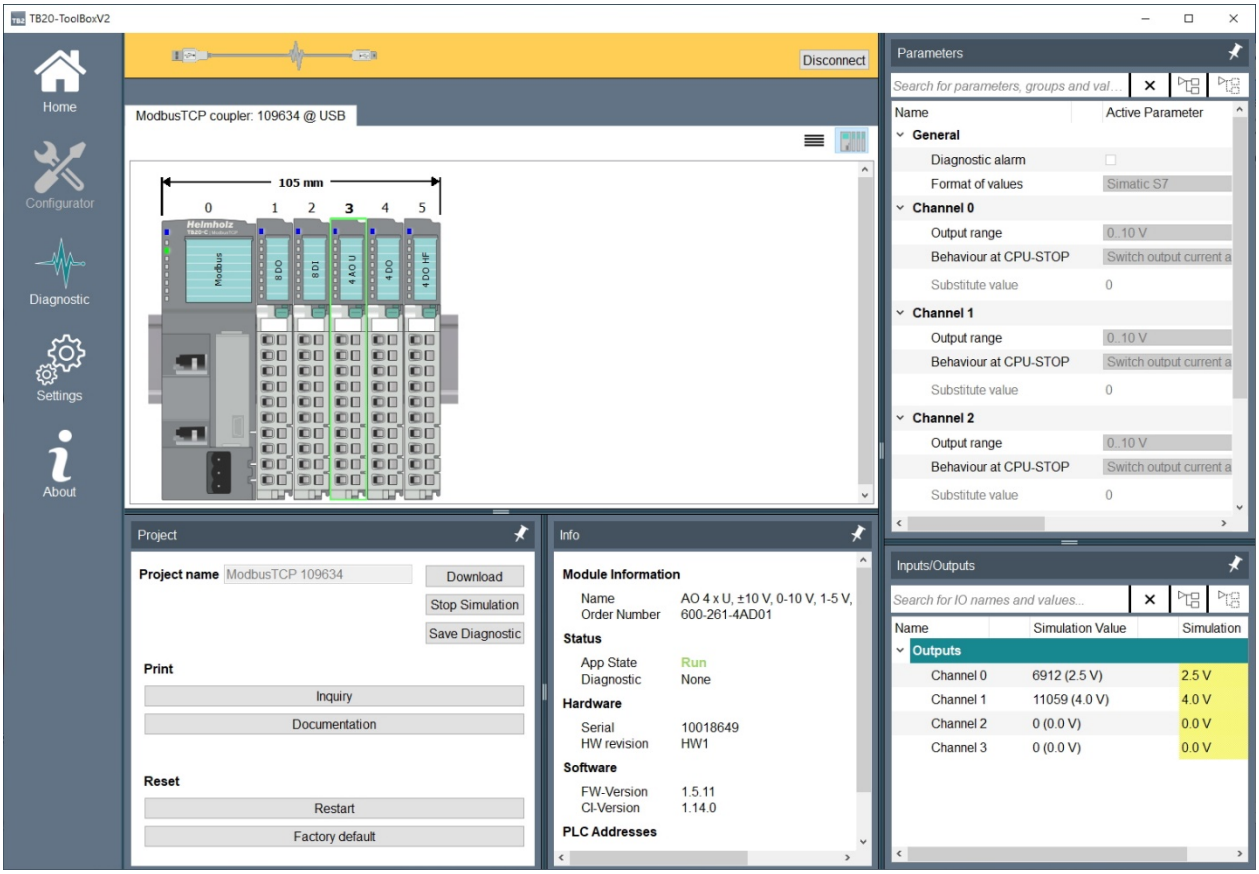
6.5.1. Load project from the coupler ("Download")

If you have not created a project from an existing TB20 system or the project file has been lost, you can load the current status of the coupler with all modules and module parameters into the TB20 ToolBox.

In the "Diagnostics" view, use the "Download " function if you are connected to a coupler via USB. The function loads all relevant information from the coupler and creates a new project file.

6.5.2. Simulation

In the "Diagnostic" view you can switch the TB20 ModbusTCP coupler in a simulation mode ("Start Simulation"). You take over the control of the coupler in its current state and can display the current input data, switch outputs and change the parameters of the modules.



The coupler indicates the simulation mode by a fast flashing green "PLC" LED.

ATTENTION

In simulation mode, the TB20 ModbusTCP coupler is completely separated from the ModbusTCP client. Hot swap is activated by default in simulation mode.

If the simulation mode is ended, all changes made in simulation mode are discarded.

6.6. Startup Flow

The three following events will all trigger a ModbusTCP coupler (re)start.

1. Power on
2. "Reset" command from the ModbusTCP bus (see coupler control bits) or TB20-ToolBox
3. A change to the module configuration

The TB20-IO system can be in three different states:

IDLE: TB20 is not yet operational

STOP: TB20 is ready for operation, but outputs are inactive or hold substitute values

RUN: TB20 in cyclic operation, outputs are switched, inputs are read

The status of the coupler or module can be read from the operating LEDs (see also chapters. 6.5.1 and 6.5.2).

There are two different possible startup flows for the ModbusTCP coupler:

Startup flow 1: A project is already stored in the coupler's non-volatile memory.

1. The coupler carries out a basic initialization routine and assigns all required addresses
2. The coupler scans the modules
3. The coupler compares the results from the bus scan with the modules stored in its configuration.

The coupler will first wait to make sure that the entire module configuration is present, i.e., starting with a gap in the module configuration (even with hot plugging enabled) is not permitted.

As soon as the coupler determines that there are no gaps in the module configuration and the modules match the ones in the stored list, mapping will be activated, after which point all mapping assignments can be read and written to.

The remaining startup flow will depend on how the "Autostart" and "Connection timeout" parameters are configured. These parameters are described in section 8.1.6.

Startup flow 2: The coupler will be obtaining the module list from the backplane bus and will use this information to go online.

1. The coupler carries out a basic initialization routine and assigns all required addresses
2. The coupler scans the modules

3. If the coupler detects a gap in the configuration, all modules remain **IDLE**.

If there are no gaps, the modules will be switched to STOP and then start running (RUN) with their standard configuration.

Once this is done, the coupler will carry out its mapping routine based on the modules that are plugged in. The remaining startup flow will depend on how the "Autostart" and "Connection timeout" parameters are configured. These parameters are described in section 8.1.6.

6.7. Hot Swap

Modules can be hot swapped while the ModbusTCP coupler is running. There are a number of scenarios in which hot swapping can prove to be very useful, one of them being when a module starts malfunctioning due to a defect (e.g., a defective input caused by overvoltage). In a case such as this, the defective modules can be swapped during ongoing operation and the remaining modules will continue to work normally.

If a module is removed, the coupler's "SF" LED will start flashing.

If a replacement module of the same model is plugged in, it will be configured automatically and added to the system's cyclic operation.

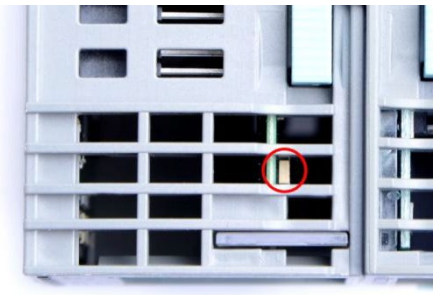
Hot swapping will only be enabled if the configured configuration (module layout) matches the existing module layout and the ModbusTCP coupler has switched to cyclic operation.

Do not remove more than one module at any one time. Removing a second module will cause the system to stop!

6.8. Factory Reset (Restoring the Coupler to Its Factory Settings)

The ModbusTCP coupler's factory settings can be restored by pressing a purposefully hard-to-find button. If you press this button, all coupler parameters, as well as the project, will be deleted and the coupler will be restored to its original system state.

The button can be accessed from above through the case's ventilation opening (see the picture on the right) To restore the unit to its factory settings, press the button and hold it down while the power is on. As soon as the first three LEDs light up, you can let go of the button.



At this point, the coupler will restart with its factory settings.

6.9. LED-Based Diagnosis

6.9.1. ModbusTCP Coupler LEDs

The blue "**OK**" LED is used to indicate the coupler's general status:

Solid light: correct configuration, system running

Flashing light: The coupler is starting up or is unable to switch to cyclic operation due to its module configuration (gaps, wrong modules)

The red "**BF**" LED (bus error) is used for diagnostic module messages:

Solid light: There is a diagnostic module message.

Flashing light: The coupler has received incorrect or no parametrization

The yellow "**SF**" LED is used to indicate the module bus' status:

Flashing light: Modules missing (startup) / Module removed (hot swap)

Solid light: The wrong module is plugged in

The green "**PLC**" LED is used to indicate the Modbus connection's state:

Off: A Modbus client has not been connected

Solid light: There is at least one Modbus connection and the system is running (RUN)

Flashing light: There is at least one Modbus connection and the system is stopped (STOP)

Quickly flashing light: The coupler has been switched to simulation mode with the TB20-ToolBox program. All Modbus connections have been terminated.

The yellow "**P1 L**" and "**P2 L**" LEDs are used to indicate the link status for the ports.

Off: No link

Solid light: Link established

Flashing light: Link established and ongoing activity

The green "**P1 Sp**" and "**P2 Sp**" LEDs are used to indicate the ports' speed.

Solid light: 100 Mbps

Off: 10 Mbps

6.9.2. Module LEDs

The topmost LED ("**OK/SF**") on every module indicates the module's current system status.

Solid blue light:	The module is running (**RUN**)
Slow flashing blue light:	The module is stopped (**STOP**); substitute values (if any) are active
Quick flashing blue light:	The module is idle (**IDLE**); it has not been configured yet
Solid red light:	The module is indicating a diagnostic error
Flashing red light:	The module is indicating a parameter assignment error

The red "**SF**" LED light will only be shown on modules with configurable parameters or diagnostic capabilities.

NOTE

IDLE mode (quick flashing blue LED) indicates modules that have not been added to ongoing system operation by the coupler. One of the reasons that can cause this is an incorrect configuration (wrong module model on the slot).

7. ModbusTCP

7.1. Introduction

The Modbus protocol is a client-server protocol in which only the server can initiate communications.

The Modbus protocol can be used both for bit-based and register-based data transfers (with each register containing 16 bits). These data transfers are controlled using function codes.

7.2. General Frame Format

ModbusTCP ADU (Application Data Unit) frames are made up of the following blocks:

MBAP header	Function code	Data
7 bytes	1 byte	n bytes

- MBAP header (Modbus Application Protocol Header):

  Bytes 0,1: Transaction identifier - ID No. when there are multiple requests active at the same time.

  Bytes 2,3: Protocol identifier - always 0 (Modbus protocol)

  Byte 4: Number of data bytes that follow (high byte) - always 0 (since all messages are shorter than 256 bytes)

  Byte 5: Number of data bytes that follow (low byte)

  Byte 6: Unit identifier (previously "device address"). Since the devices are addressed directly via their IP addresses, this parameter serves no purpose and should be set to 0xFF.

- Function code:

  The standard Modbus protocol's function code (please consult the ModbusTCP specification).

- Data:

  Bytes 8..n: The range is the same as the one for the standard Modbus protocol (please refer to Section 1) However, the CRC checksum is omitted, since it is implemented at the TCP/IP protocol level.

7.3. Communications Management

Modbus communications require for a TCP connection to be established between a client (e.g., computer) and the server.

TCP port 502, which is reserved for Modbus, is normally used for communications, but you can configure a different port if necessary.

If there is a firewall between the server and client, you will need to make sure that the configured TCP port is open.

Up to 10 clients can be connected at the same time.

7.4. ModbusTCP function codes

Function codes are used to define the meaning of each frame, as well as the frame's remaining syntax.

Function code	Function as per Modbus	Function in the PLC (for client)
01 / 02	Read discrete outputs/inputs	Read coils
03 / 04	Read multiple registers / input registers	Read
05	Write single output	Write ON/OFF
06	Write single registers	Write to register
15	Write multiple output	Write ON/OFF to multiple coils
16	Write multiple registers	Write block to registers (1 – 123 registers)
22	Mask write register	Write to register using a combination of an AND mask and OR mask
23	Read/write multiple registers	Write to/read multiple registers

7.5. Sample Frames

Function 01H : Read discrete outputs/inputs

Example: The following example reads (digital) output states 2 to 11, i.e., 10 states that can be represented using two data bytes.

Request
Master → Slave

Address	**Function**	**Data**			
		Starting address		**Number of states**	
Addr	01H	High byte	Low byte	High byte	Low byte

Response
Slave → Master

Address	**Function**	**Data**		
		Number of data bytes	**States 9–2**	**States 11–10**
Addr	01H	8 bits	8 bits	8 bits

Example (Hex): >>> FF 01 00 01 00 0A
<<< FF 01 02 **11 01**

11H = 00010001b: outputs 6,2 ON; outputs 9,8,7,5,4,3 OFF
01H = 00000001b: output 10 ON; output 11 OFF

Note:

As per Modbus specification, starting address 1 is addressed as register 0.

8. Registers

Modbus register address	Modbus bit address	Section	Permitted Modbus function codes
0x0000 - 0x03FF	0x0000 - 0x3FFF	Inputs 64 * 32 bytes	1, 2, 3, 4, 23*
0x0400 - 0x07FF	0x4000 - 0x7FFF	Outputs 64 * 32 bytes	1, 2, 3, 4, 5, 6, 15, 16, 22, 23
0x0800 - 0x0803	0x8000 - 0x803F	Diagnostic status bits 8 bytes	1, 2, 3, 4, 23*
0x0804 - 0x0807	0x8040 - 0x807F	Process alarm status bits 8 bytes	1, 2, 3, 4, 23*
0x0808 - 0x080B	0x8080 - 0x80BF	Module status bits 8 bytes	1, 2, 3, 4, 23*
0x080C	0x80C0 - 0x80CF	Coupler control bits 2 byte	1, 2, 3, 4, 5, 6, 15, 16, 22, 23
...			
0x1000 - 0x1FFF	-	Module parameters 64 * 128 bytes	3, 4, 6, 16, 22, 23
...			
0x3000 - 0x33FF	-	Diagnostic status 64 * 32 bytes	3, 4, 23*
...			
0x4000 - 0x40FF	-	Coupler parameters 1 * 256 bytes	3, 4, 6, 16, 22, 23
0x4100 – 0x41FF	-	Coupler status 1 * 256 bytes	3, 4, 23*
...			
0x5000 – 0x57FF	-	Module list 64 * 64 bytes	3, 4, 23*
0x6000 – 0x60BF	-	Input/Output/Parameter mapping information 3 * 64 registers	3, 4, 23*

23* = Read access only

8.1. Inputs / Outputs

The ModbusTCP coupler has an address space of 2,084 bytes for inputs and 2,084 bytes for outputs. These inputs and outputs are automatically assigned to the address space (what is referred to as "mapping") when the coupler starts, and the corresponding assignments cannot be manually changed or otherwise configured.

The space required by the modules is stored, in the order in which the modules are plugged in, in the mapping input and output space.

Modules can only be mapped to even addresses (since each register contains 16 bits)

Rules:

All the modules will be mapped in ascending order starting from the first register or first bit address from left to right.

The input space and output space are separate from each other (e.g., if a module has both input and output data, each will be stored in different addresses).

The system will not distinguish between digital and analog data, i.e., the ModbusTCP coupler will generate a continuous array for input data and a continuous array for output data based on all the modules.

You can read the mapping assignments by using

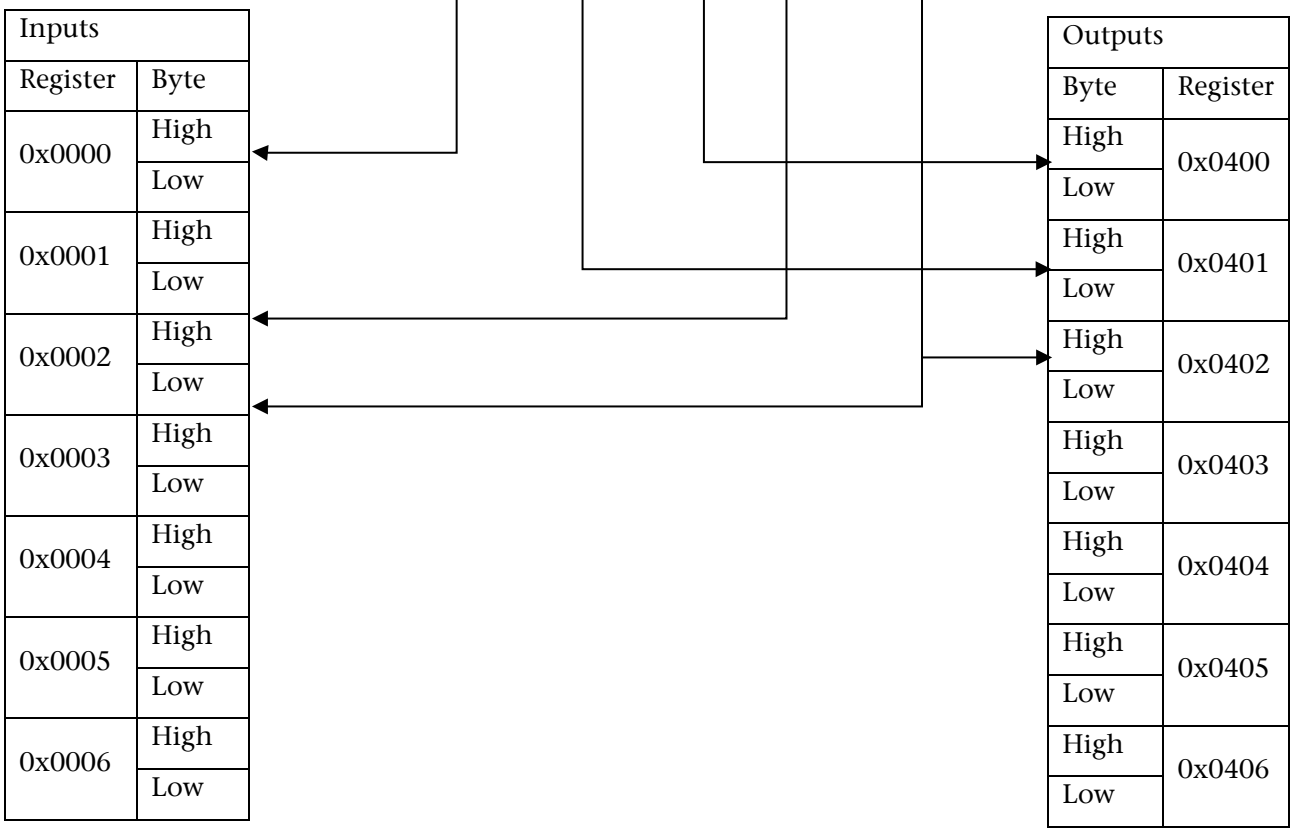
the TB20-ToolBox program. You can find the mapping information for each module under the “Extended” tab either in the “Configurator” or in “Online Diagnostic Mode”.

the "Input/Output/Parameter mapping information" section (please refer to section 8.1.9).

For a description of the input and output space that a module will take up, please consult the manual for that module.

Note: Outputs can only be written to, when the coupler is running (**RUN**).

-	**Slot 1**	**Slot 2**	**Slot 3**	**Slot 4**	**Slot 6**
Modbus TCP Coupler	2 DO x 24 VDC	2 AO x 24 VDC	2 AI/TC x 24 VDC	2 DI x 24 VDC	1 CNT x 24 VDC
	I data: 0 byte	I data: 0 byte	I data: 4 byte	I data: 1 byte	I data: 8 byte
	O data: 1 byte	O data: 4 byte	O data: 0 byte	O data: 0 byte	O data: 8 byte
600-170-1AA11	600-220-0AB01	600-260-4AB01	600-254-4AB01	600-210-0AB01	600-300-7AA01



Inputs	
Register	Byte
0x0000	High
	Low
0x0001	High
	Low
0x0002	High
	Low
0x0003	High
	Low
0x0004	High
	Low
0x0005	High
	Low
0x0006	High
	Low

Outputs	
Byte	Register
High	0x0400
Low	
High	0x0401
Low	
High	0x0402
Low	
High	0x0403
Low	
High	0x0404
Low	
High	0x0405
Low	
High	0x0406
Low	

8.1.1. Section: Diagnostic Status Bits

Shows the diagnostic status for the individual modules bit by bit following the order in which the modules are plugged in. This space makes it easier to evaluate diagnoses.

Register	Bits															
0x0800	7	6	5	4	3	2	1	0	15	14	13	12	11	10	9	8
...	...															
0x0803	55	54	53	52	51	50	49	48	63	62	61	60	59	58	57	56

8.1.2. Section: Module Status Bits

Shows whether a module is plugged in bit by bit following the order in which the modules are plugged in.

Register	Bits															
0x0808	7	6	5	4	3	2	1	0	15	14	13	12	11	10	9	8
...	...															
0x080B	55	54	53	52	51	50	49	48	63	62	61	60	59	58	57	56

8.1.3. Section: Coupler Control Bits

The bits must be set to 1 by the user, and will be reset by the coupler once the requested action is successfully completed.

Since the actions triggered by some of the control bits may be the exact opposite of the actions triggered by others, only one single bit should be set at a time.

Register	Bits							
0x080C	*Reserved*	*Reserved*	*Reserved*	Start modules	Stop modules	Save parameters	Delete module parameters	Restart

Restart: Restarts the coupler and applies any changes made to the coupler parameters.

Important: Restarting the coupler will terminate all existing Modbus connections!

Delete module parameters: Deletes stored module parameters from the coupler's non-volatile memory. After the coupler is de-energized, all modules will be restored to their default parameter values.

Save parameters: Writes the current module and coupler parameters to the coupler's non-volatile memory.

Start modules: Switches all modules to the **RUN** operating state. Will be ignored in **IDLE.**

Stop modules: Switches all modules to the **STOP** operating state. Will be ignored in **IDLE.**

8.1.4. Section: Module Parameters

Module parameters are mapped one after the other following the order in which the modules are plugged in. Regardless of the actual length of a module's parameter data, each module will always take up 128 bytes (64 register) when mapped. The starting address of each module can be calculated using the following formula:

$0x1000 + 0x40 * (\text{slot number}_{HEX} - 1)$

If the number for the parameter byte you want is odd, use the next higher even number.

The first byte of a module's first register contains the length of the module's parameter data.

Writing to this space will cause the new parameters to be applied immediately.

Register	Module	Parameters	
0x1000	1	-	Parameter length (bytes)
0x1001		Parameter byte 0	Parameter byte 1
...		...	
0x103F		Parameter byte 124	Parameter byte 125
0x1040	2	...	Parameter length (bytes)
0x1041		Parameter byte 0	Parameter byte 1
...		...	
0x107F		Parameter byte 124	Parameter byte 125
...			
0x10C0	64	...	Parameter length (bytes)
0x10C1		Parameter byte 0	Parameter byte 1
...		...	
0x1FFF		Parameter byte 124	Parameter byte 125

8.1.5. Section: Diagnostic Status

Diagnostic data is mapped in succession following the order in which the modules are plugged in. Regardless of the actual length of a module's diagnostic data, each module will always take up 16 bytes (8 register) when mapped. The starting address of each module can be calculated using the following formula:

$0x3000 + 0x10 * (\text{slot number}_{HEX} - 1)$

Register	Module	Diagnoses	
0x3000	1	Diagnostic byte 0	Diagnostic byte 1
...		...	
0x300F		Diagnostic byte 30	Diagnostic byte 31
0x3010	2	Diagnostic byte 0	Diagnostic byte 1
...		...	
0x301F		Diagnostic byte 30	Diagnostic byte 31
...			
0x33F0	64	Diagnostic byte 0	Diagnostic byte 1
...		...	
0x33FF		Diagnostic byte 30	Diagnostic byte 31

8.1.6. Section: Coupler Parameters

This space is used to map all of the coupler's configurable properties.

To apply newly written parameters, you have to restart the coupler via the “Restart” bit in the “Coupler Control Bits”. However, to save in non-volatile memory use the “Save Parameter” bit.

Register	Parameters	Bytes	
0x4000	IP address	Octet 0	Octet 1
0x4001		Octet 2	Octet 3
0x4002	Subnet mask	Octet 0	Octet 1
0x4003		Octet 2	Octet 3
0x4004	Default gateway	Octet 0	Octet 1
0x4005		Octet 2	Octet 3
0x4006	Settings	Configuration bits	Reserved
0x4007		Modbus port	
0x4008		Connection timeout	

Configuration bits

7	6	5	4	3	2	1	0
Reserved	*Reserved*	*Reserved*	*Reserved*	Keepalive	Autostart	Hot swap	DHCP

DHCP:
The coupler will get its network configuration via DHCP (IP/SNMP/gateway settings will be ignored).

Hot swap:
A module can be replaced during ongoing operation without the coupler stopping (**STOP**). “Hot swap active” is the default setting.

Autostart:
If ‘1’: The coupler will start running (**RUN**) after a successful module configuration check.
If Connection timeout monitoring is enabled, the modules will not start running (**RUN**) until after the first correct Modbus packet is received. “Autostart on” is the default setting.

If ‘0’: The modules will remain stopped (**STOP**) until they are commanded to start running (**RUN**) using coupler control bits.

Keepalive:
If '1': The Modbus master's TCP stack regularly sends "keepalive" packets to the slave. If the coupler can no longer be reached, the connection is closed.

If '0': Keepalive is not activated. This is the default setting.

Modbus port:
Used to define which port should be used to establish Modbus connections to the coupler (from 0 to 65535, Default is 502).

Connection timeout:
Used to specify the time, in seconds, after which TCP connections will be terminated if they are inactive. If a valid Modbus packet is not received during the specified time, all the modules will be stopped (**STOP**). The connection timeout is deactivated by default.

8.1.7. Section: Coupler Status

This space is used to map all of the coupler's properties that cannot be modified.

Register	Parameters	Bytes	
0x4100	Order number	Char 0	Char 1
...		...	...
0x4109		Char 18	Char 19
0x410A	Serial number	Byte 0	Byte 1
0x410B		Byte 2	Byte 3
0x410C	Firmware version	Major	Minor
0x410D		Beta	0
0x410E	Hardware version	Char 0	Char 1
...		...	...
0x4117		Char 18	Char 19
0x4118	The coupler's MAC address	Octet 0	Octet 1
0x4119		Octet 2	Octet 3
0x411A		Octet 4	Octet 5
0x411B	Reserved		
0x411C	Active IP address	Octet 0	Octet 1
0x411D		Octet 2	Octet 3
0x411E	Active subnet mask	Octet 0	Octet 1
0x411F		Octet 2	Octet 3
0x4120	Active gateway	Octet 0	Octet 1
0x4121		Octet 2	Octet 3

8.1.8. Section: Module List

This space is used to map all the module properties (of the 64 modules) that cannot be modified.

Register	Parameters	Bytes		
0x5000	Module ID	Byte 0		Byte 1
0x5001	Order number	Char 0		Char 1
...				
0x500B		Char 18		Char 19
0x500C	Serial number	Byte 0		Byte 1
0x500D		Byte 2		Byte 3
0x500E	Firmware version	Major		Minor
0x500F		Beta		0
0x5010	Hardware version	Char 0		Char 1
...				
0x5019		Char 18		Char 19
0x501A	I/O length in bytes	Output data length		Input data length
0x501B	Data length in bytes	Diagnosis length	Process alarm length	Parameter length
0x501C - 0x501F	Reserved	0		0

This structure will be repeated a maximum of 64 times.

8.1.9. Section: Mapping Information

This is where the input/output/parameter register addresses for all the modules are stored.

If a module does not have any input, output, or parameter data, 0xFFFF will be shown instead.

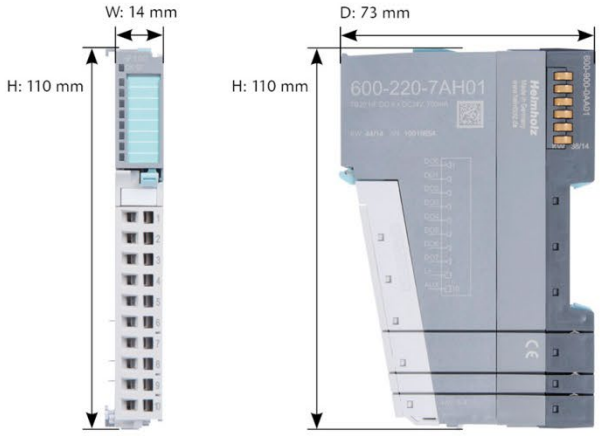
Register	Parameters	Bytes	
0x6000	Input address for module 1	Byte 0	Byte 1
...	...	..	
0x603F	Input address for module 64	Byte 0	Byte 1
0x6040	Output address for module 1	Byte 0	Byte 1
...	...	...	
0x607F	Output address for module 64	Byte 0	Byte 1
0x6080	Parameter address for module 1	Byte 0	Byte 1
...	...	...	
0x60BF	Parameter address for module 64	Byte 0	Byte 1

9. Technical Specifications

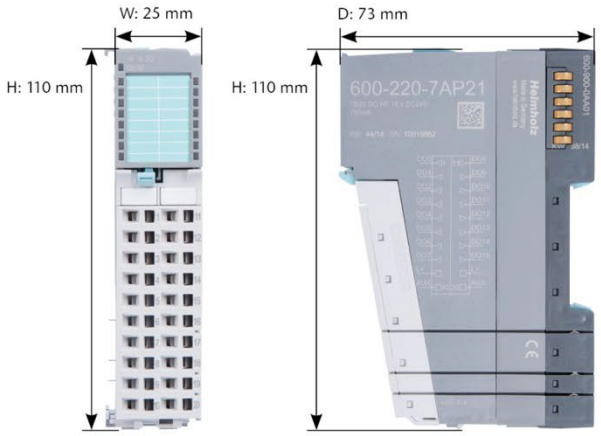
Order No.	**600-170-1AA11**
Module designation	ModbusTCP coupler
Ethernet port	
Protocol	ModbusTCP
Transmission rate	10/100 Mbps, automatic detection (auto-negotiation, auto-crossover)
I/O image size	2,048 / 2,048 bytes
Parameters per module	126 bytes
Connector	2x RJ45, integrated switch
Supports Modbus function codes	1, 2, 3, 4, 5, 6, 15, 16, 22, 23
TCP connections	10 stations
USB port	
Protocol	Full-speed USB 2.0 Device
Connector	mini-USB
Isolation voltage	1.5 kV
Electrical isolation	Yes
Number of modules that can be connected in series	64, all products
Voltage supply	24 VDC, 18–28 VDC
Current draw without modules (internal)	75 mA
Power dissipation	Max. 8 W
Power supply for modules	5 VDC, max. 2.5 A
Dimensions (H x W x D)	110 mm x 35 mm x 73 mm
Weight	115 g
Certifications	CE, UL
Noise immunity	DIN EN 61000-6-2 “EMC Immunity”
Interference emission	DIN EN 61000-6-4 “EMC Emission”
Vibration and shock resistance	DIN EN 60068-2-6:2008 “Vibration” DIN EN 60068-2-27:2010 “Shock”
Protection rating	IP 20
Relative humidity	95% without condensation
Installation position	Any
Permissible ambient temperature	0 °C to 60 °C For UL applications: 0 °C to 50 °C
Transport and storage temperature	-20 °C to 80 °C
Pollution degree	2

10. Dimensions

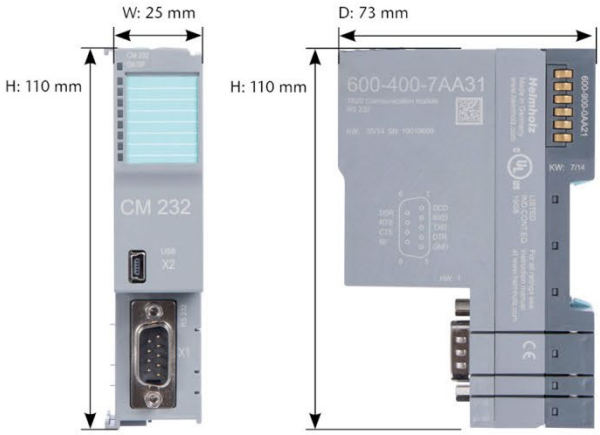
Module with standard width



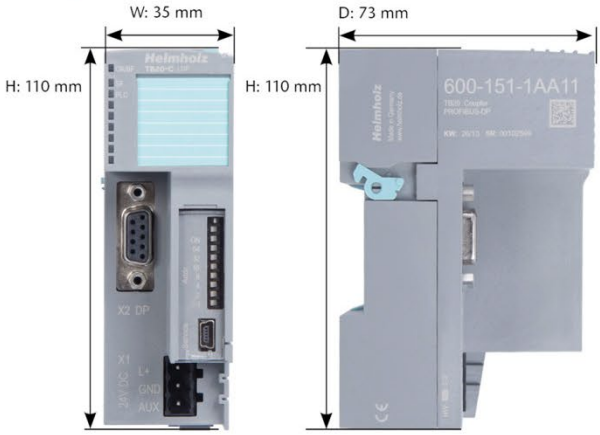
Module with double width

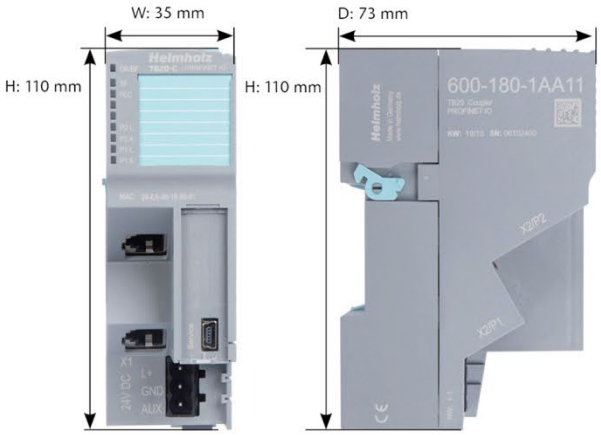


Communication Module



Bus Coupler





11. Spare Parts

11.1. Base Modules

11.1.1. 14 mm-Width Standard Base Module

The 14-mm standard base module is available in sets of five with order No. 600-900-9AA01.

11.1.2. 25 mm-Width Base Module

The 25-mm standard base module is available in sets of five with order No. 600-900-9AA21.

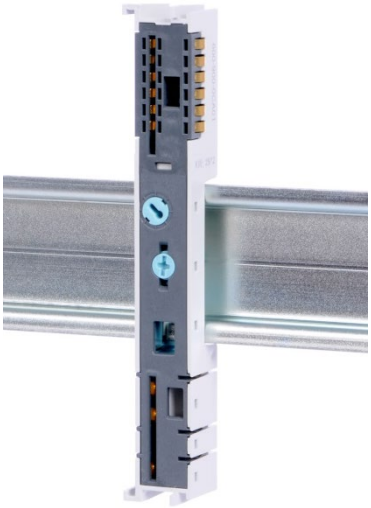
11.1.3. Power and Isolation Base Module

The power and isolation base module is available in sets of five with order No. 600-900-9BA01.

11.1.4. Power Base Module

The power base module is available in sets of five with order No. 600-900-9CA01.

It can be used with the power module (600-700-0AA01) and with all bus couplers.



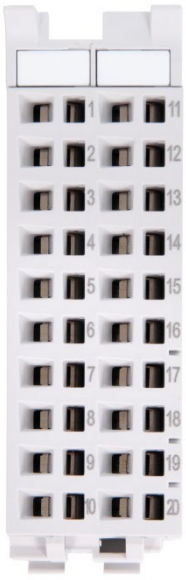
11.2. Front Connectors

11.2.1. 10-Terminal Front Connector

The 10-terminal front connector is available in sets of five with order No. 600-910-9AJ01.

11.2.2. 20-Terminal Front Connector

The 20-terminal front connector is available in sets of five with order No. 600-910-9AT21.



11.3. Electronic Modules

To order spare electronic modules, simply use the order No. for the original product. Electronic modules are always sent as a complete assembly, including the corresponding base module and front connector.

11.4. Final Cover

The final cover is available in sets of five with order No. 600-920-9AA01.