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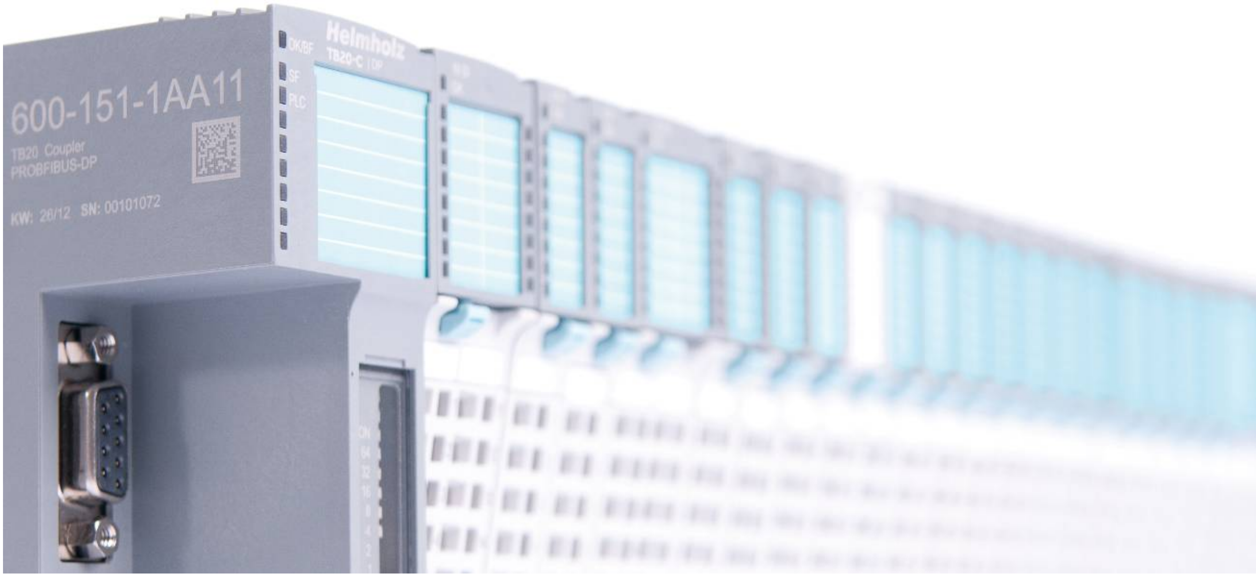

TB20 – 1x Counter 24 V, 500 kHz, 32-Bit

Manual

Version 3 | 2/2/2015 for HW 1 & FW 1.04 and higher

Manual Order No.: 960-300-0AA01/en

Systeme Helmholz GmbH | Hannberger Weg 2 | D-91091 Großenseebach | Germany

Phone +49 9135 7380-0 | Fax +49 9135 7380-110 | info@helmholz.de | www.helmholz.com

Notes

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Revision Record

Version	Date	Change
1	04/09/13	First version
2	7/2/2013	Minor corrections
3	11/28/2014	Minor corrections, corrections picture 20
4	1/20/2015	Corrections for counting and direction evaluation

Table of Contents

1. General Information

This manual explains how to use the TB20 I/O system's 24-V counter modules and goes over their components. In addition, it provides technicians with all the information required to install these modules.

1.1. Target Group for This Manual

This manual is intended for all project engineers, design engineers, technicians (skilled workers with electrical training), and users who work with the TB20 I/O system.

1.2. Symbols Used Throughout This Manual

The following symbols are used throughout this manual:

Used for tips and general information, e.g., to point out potential sources of error.

CAUTION!

Risk of property damage or malfunction.

WARNING!

Risk of bodily injury, e.g., due to electric shock.

1.3. Safety Instructions

For your own safety, and for the safety of others in the vicinity of the equipment, please follow the safety instructions below.

⚠ *WARNING!*

All applicable accident prevention and safety regulations must be complied with when planning the use of, installing, and operating this equipment! The company operating the equipment is responsible for ensuring compliance with these regulations!

⚠ *WARNING!*

Any processes in the equipment that have the potential of resulting in property damage or bodily injury must be safeguarded with the use of additional external devices. These devices must ensure that the equipment will remain in a safe operating state even in the event of a fault or malfunction. These devices include, but are not limited to, electromechanical safety switches, mechanical interlocks, etc. (please refer to EN 954-1, Risk Assessment!).

⚠ *WARNING!*

TB20 modules should only be used for the functions characteristic of a communications and signaling system. Safety-relevant functions should not be controlled solely with the coupler or with an operating terminal.
Emergency stop devices as per EN 60204/IEC 204 must remain fully functional and effective in all of the equipment's operating modes.
The equipment must not be able to restart in an uncontrolled or undefined manner!
Uncontrolled restarts must be rendered impossible by means of appropriate programming!

2. System Overview

2.1. General Information

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

It is made up of the following components:

1. A bus coupler

2. One or more peripheral modules

3. Optionally, one or more power and isolation modules

4 Optionally, one or more 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 IP 20.

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.

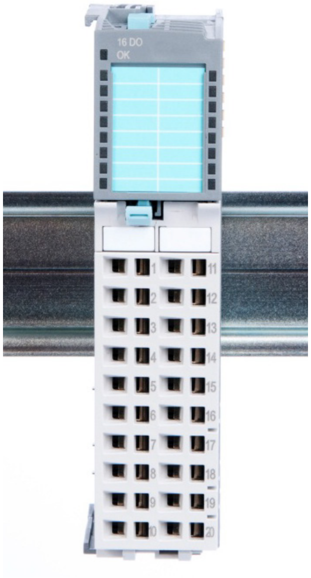
Meanwhile, the power module is responsible for powering the coupler's electronics and all connected peripheral modules.

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. This is why a variety of peripheral modules with different tasks and functions are available.

Example: peripheral module with 10-terminal front connector

Example: peripheral module with 20-terminal front connector



2.2.3. Power and Isolation Modules

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. Meanwhile, the communications bus' signals and supply voltage simply continue to be passed through, in contrast to the way they are handled by power modules (see below).

> ℹ
>
> *Power and isolation modules can be recognized by the bright color of their case.*

2.2.4. Power Modules

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

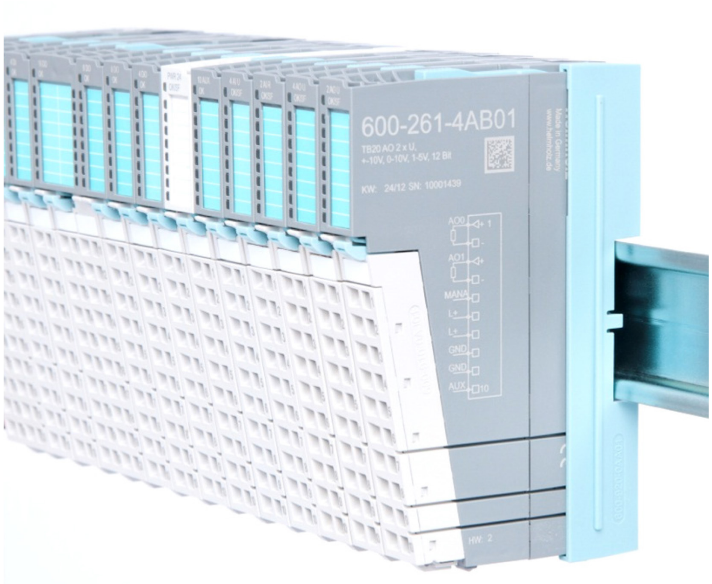
Power modules make it possible to segment the power supply for both external signals and the communication bus into individual power supply sections that are powered separately.

In other words, power modules deliver all the 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. This is required whenever the power supplied by the coupler alone is not sufficient, e.g., when there are a large number of modules on the bus. 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.

> *Power modules can be recognized by the bright color of their case.*

2.2.5. Final Bus Cover

The final bus 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

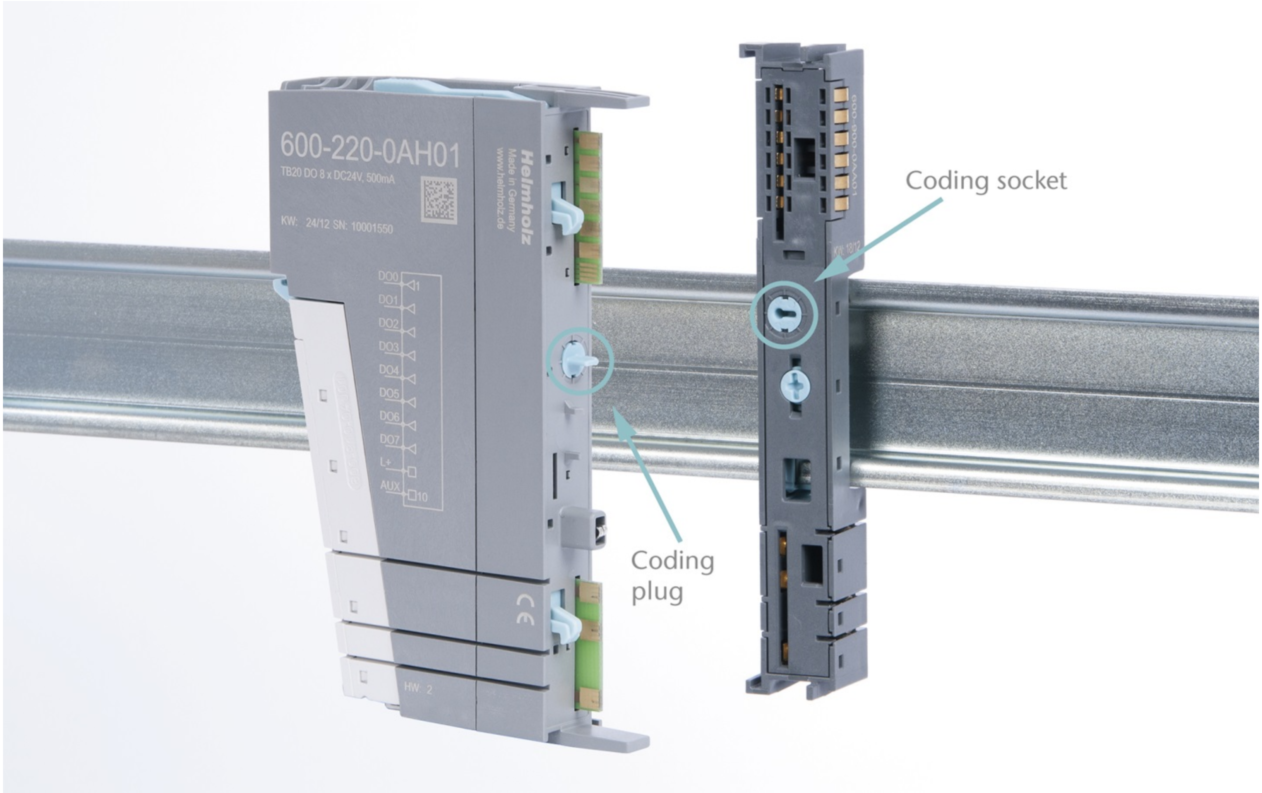
Each module consists of three parts:

- 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 figure below).



The coding plug and coding socket can each be in one of eight different positions. Each of these eight positions is factory-assigned to a specific type of module (digital in, digital out, analog in, analog out, power, etc.) from the TB20 system. 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. Otherwise, the electronic module will be mechanically prevented from being plugged in.

3. Installation and Removal

⚠ *WARNING!*

Before starting any work on TB20 system components, make sure to de-energize all components, as well as the cables supplying them with power! Failure to do so will pose a life-threatening electric shock hazard!

⚠ *CAUTION!*

Installation must be carried out as per VDE 0100/IEC 364. Since the coupler and segments are modules with a protection rating of IP 20, they must be installed inside an enclosure. In order to ensure safe operation, make sure the ambient temperature does not exceed 60 °C!

3.1. Installation position

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

In order to achieve optimum ventilation and be able to use the system at the specified maximum ambient temperature, it will, however, be necessary to use a horizontal installation layout.

3.2. Minimum Clearance

It is recommended to adhere to the minimum clearances specified below 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 standard accessories
- There will be enough space for cable management systems (if needed)

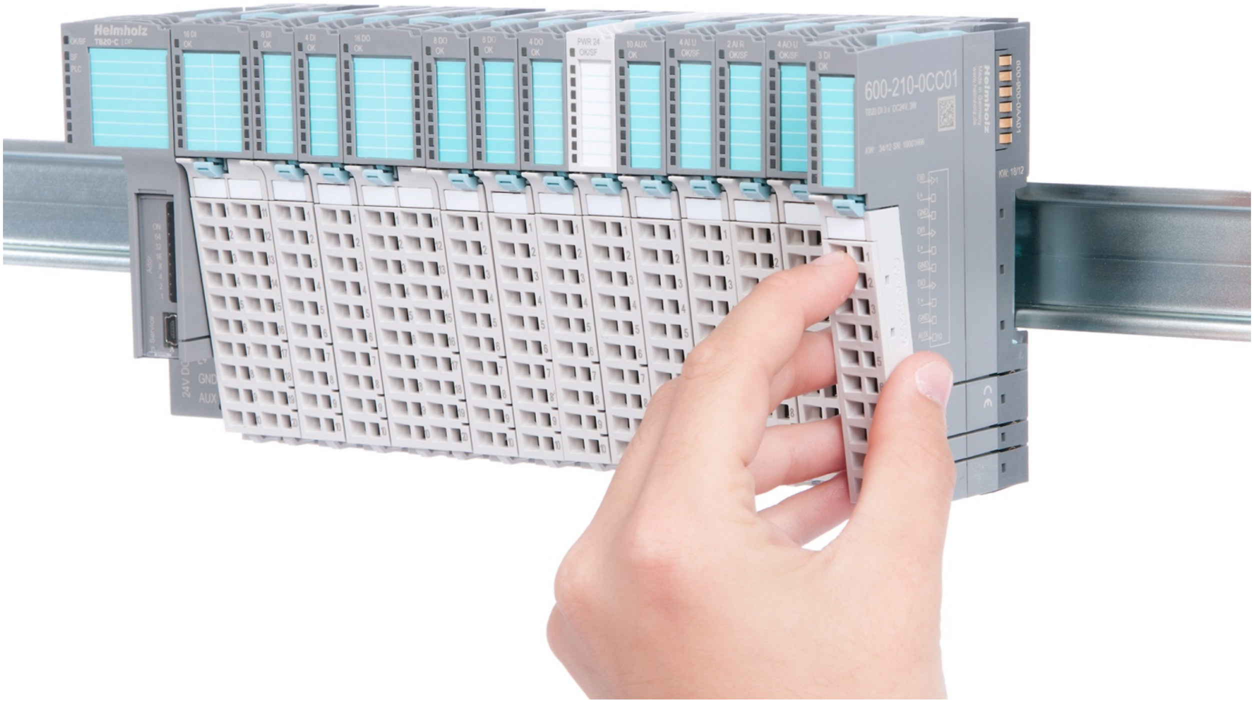
The minimum clearances for TB20 components are: 30 mm on top and on the bottom and 10 mm on each side.

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 on the inside snaps into place 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 the "Module Coding" Section on page 7) on the base module in a straight line from the front and then gently push it into the base module until both modules are fully resting against each other and the module fastener snaps into place with a soft click.

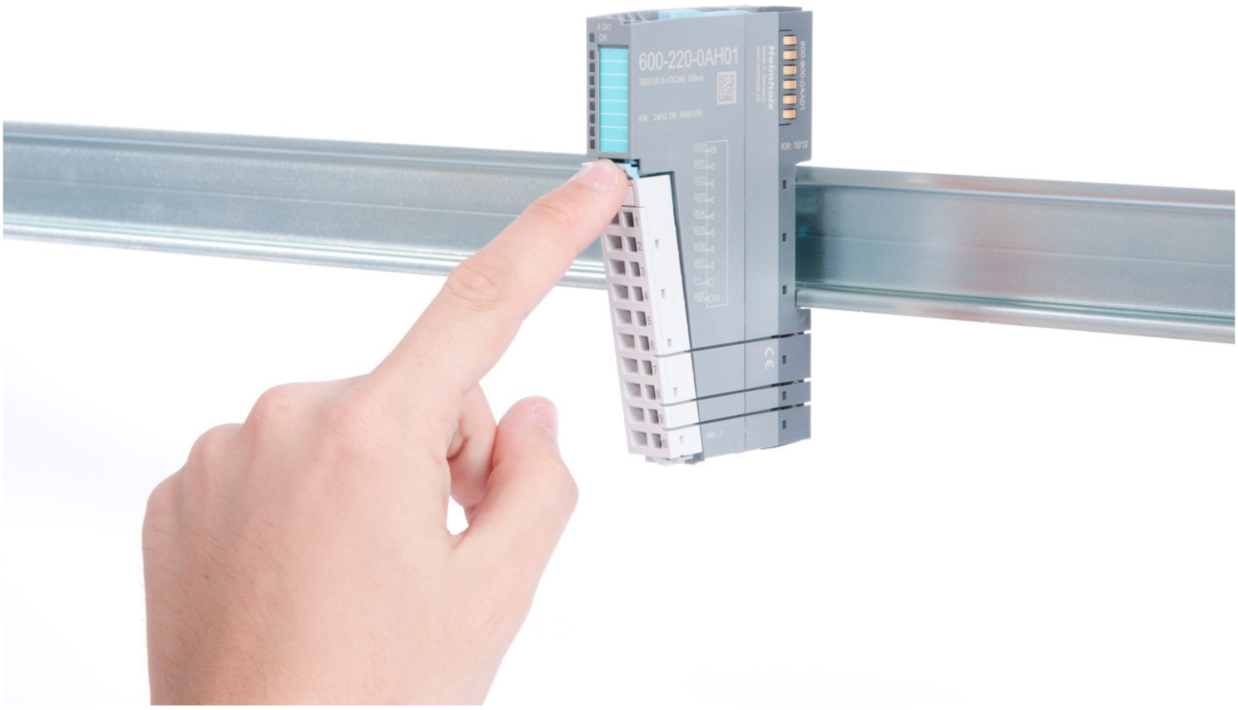
Finally, place the front connector on the electronic module from below in an inclined position and then gently push it onto the electronic module until the front connector fastener snaps into place with a soft click.

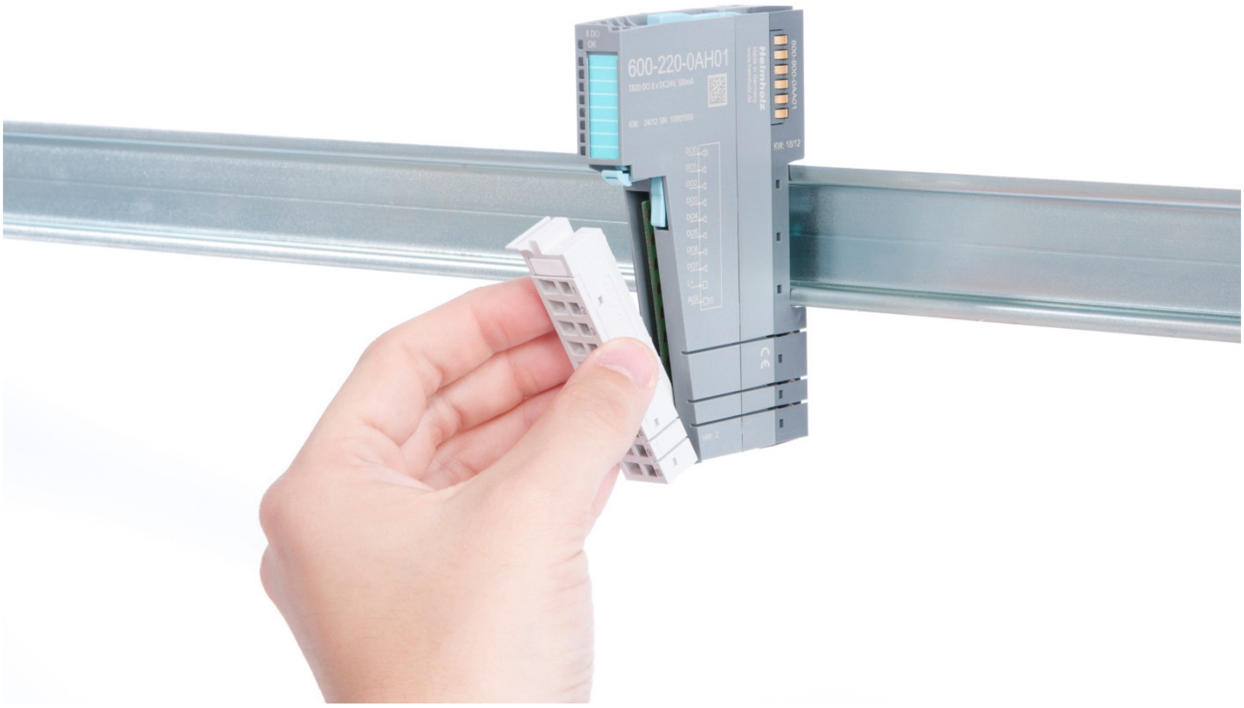
3.3.2. Removal

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

Step 1: Remove the front connector

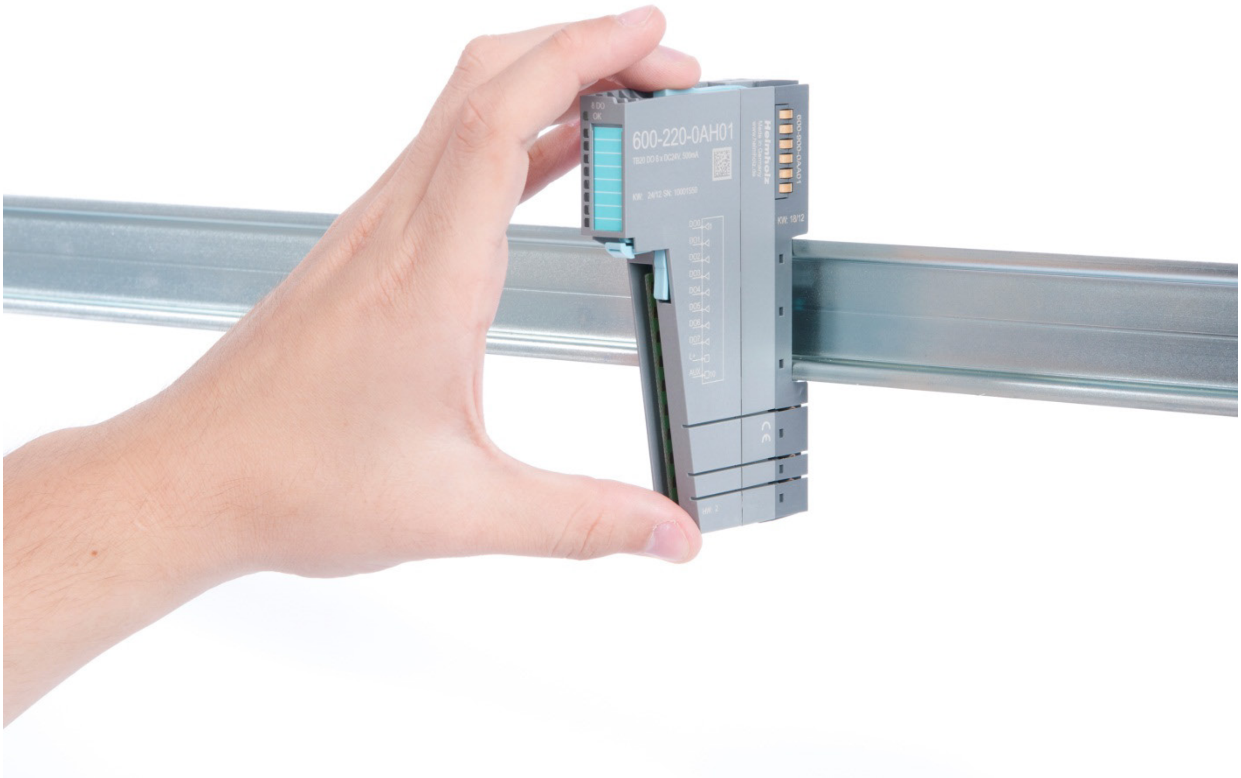
To do so, push the tab above the front connector upwards (see the figure below). This will push out the front connector, after which you can pull it out.

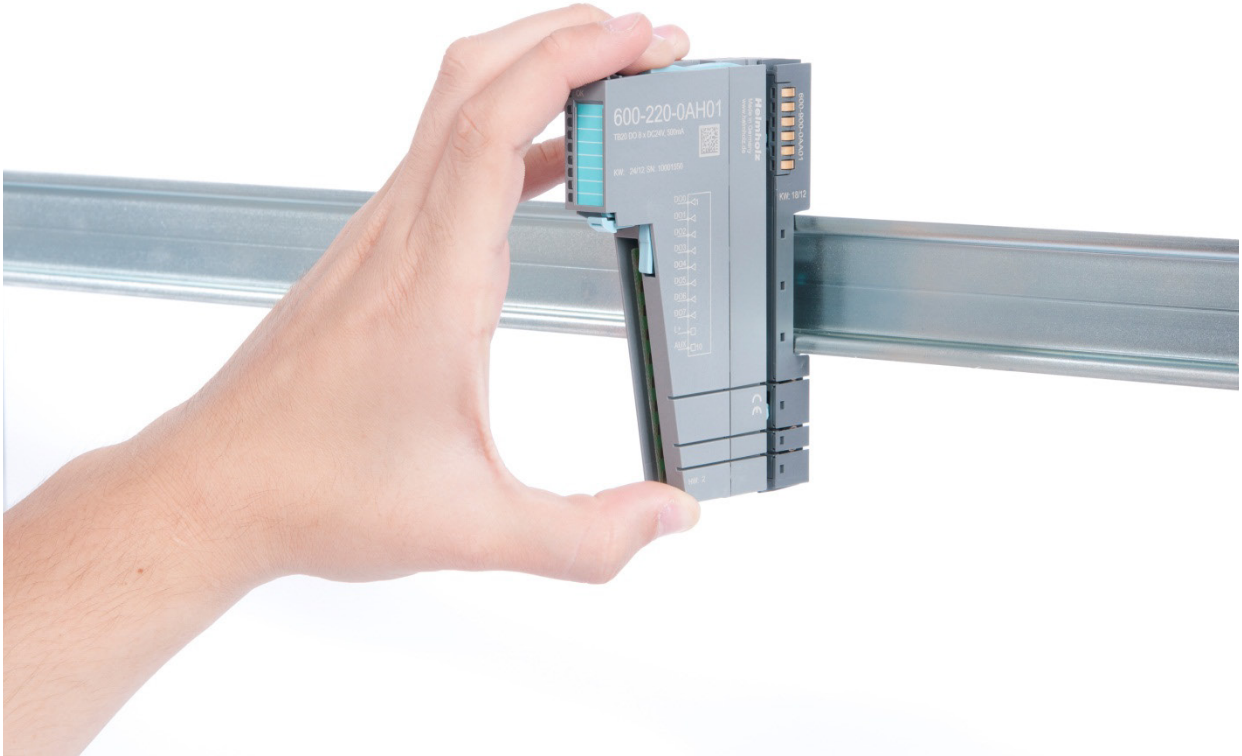




Step 2: Remove the electronic module

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 by turning the locking mechanism 90° clockwise.

Step 4: Remove the base module

Remove the base module by pulling it towards you.

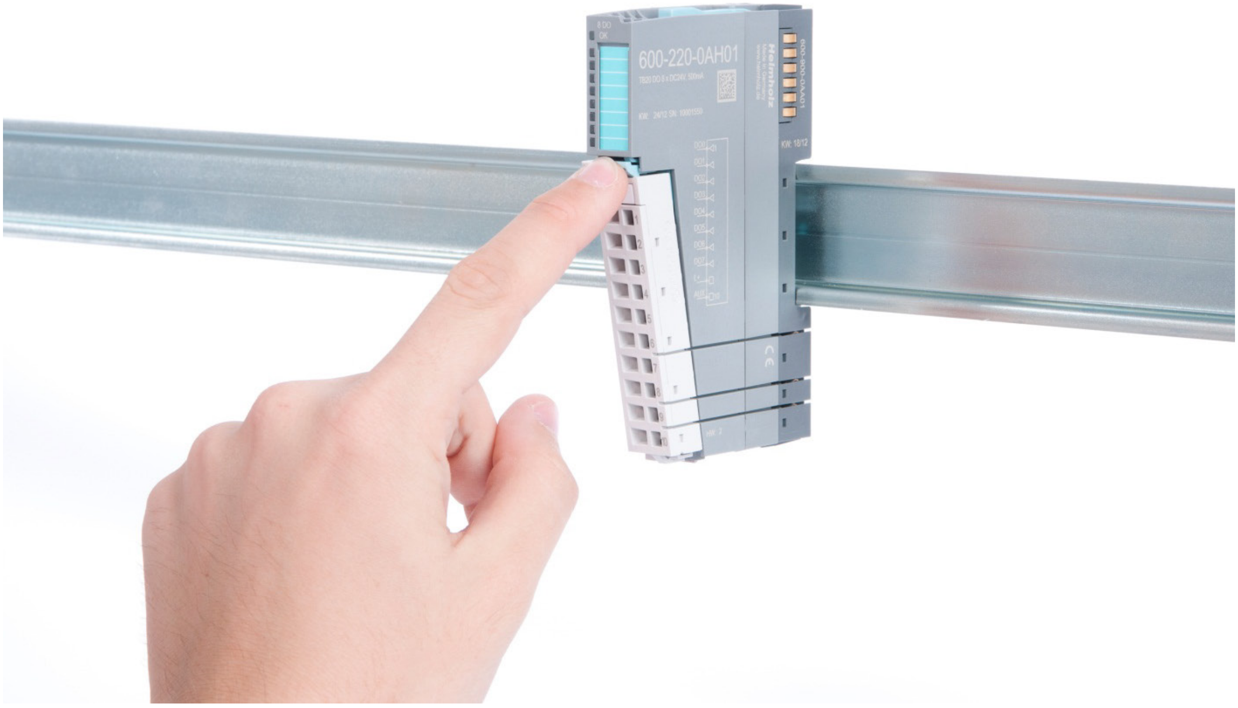
3.4. Replacing an Electronic Module

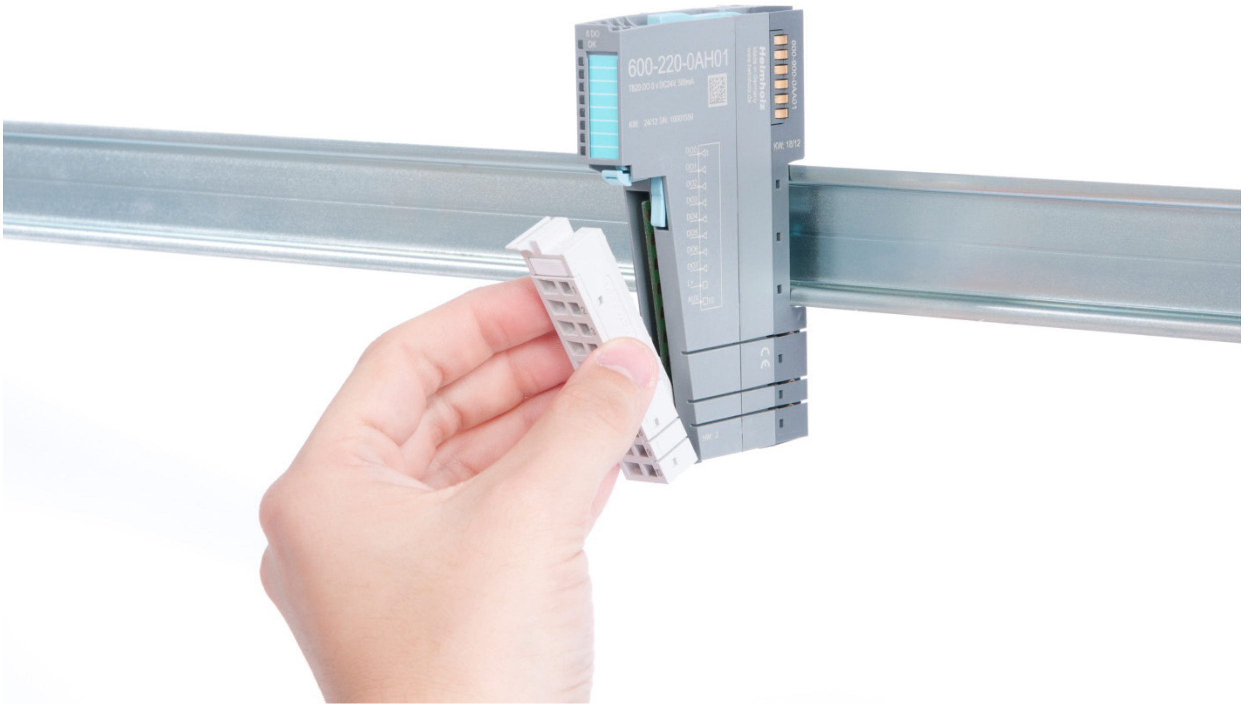
The procedure for replacing the electronic module on a peripheral module consists of four steps.

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.

Step 1: Remove the front connector

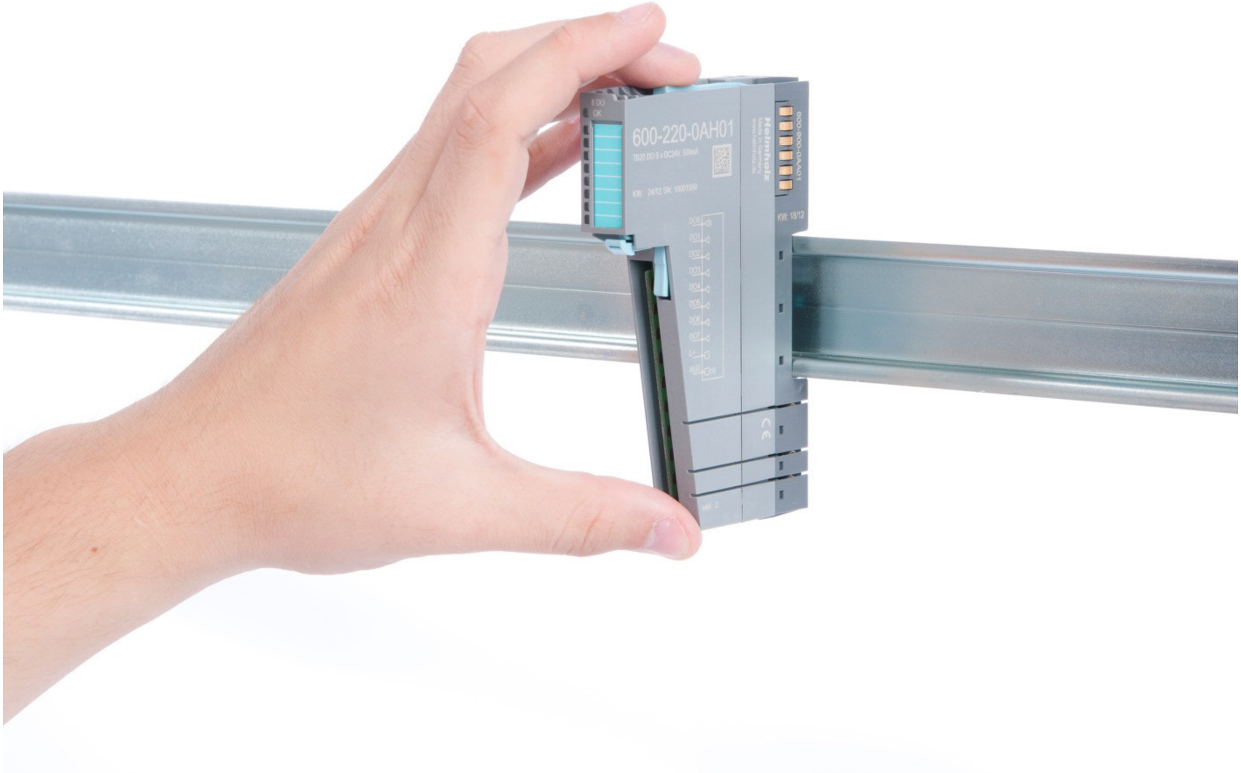
To do so, push the tab above the front connector upwards (see the arrow in the picture below on the left). The front connector will come loose, after which you can pull it out.

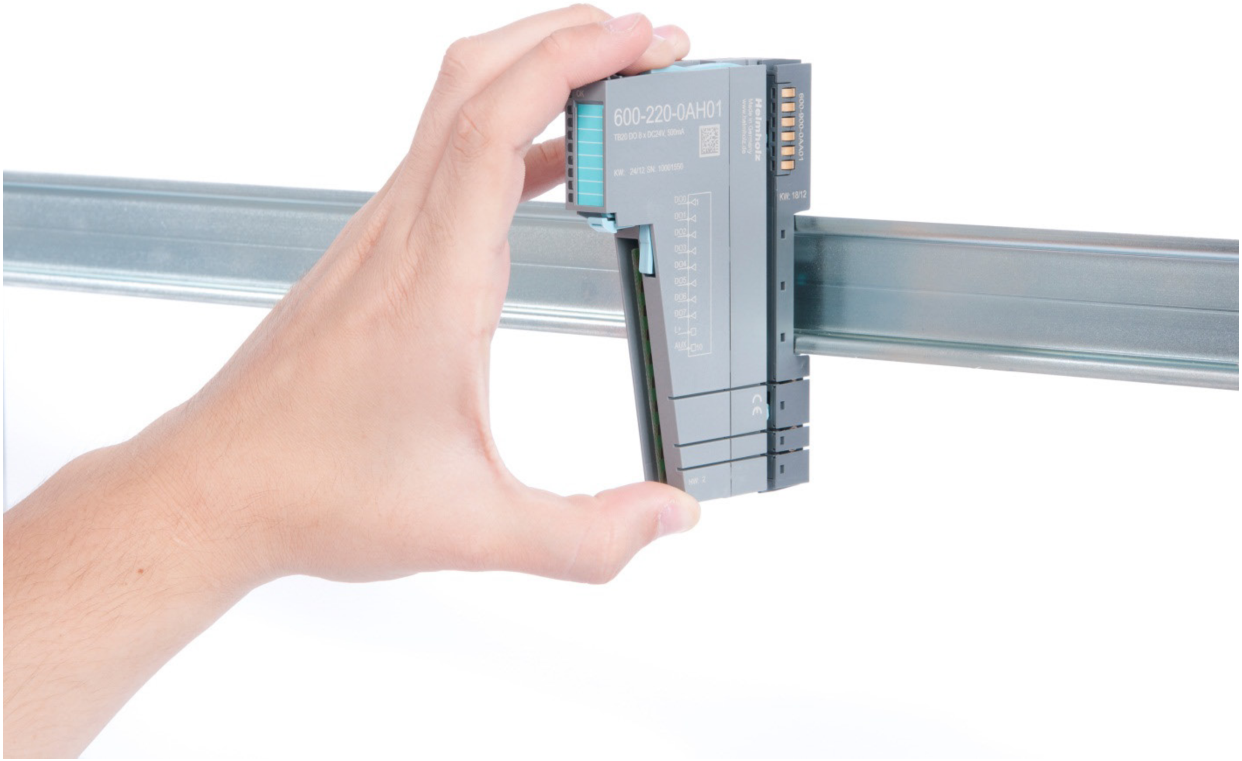




Step 2: Remove the electronic module

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





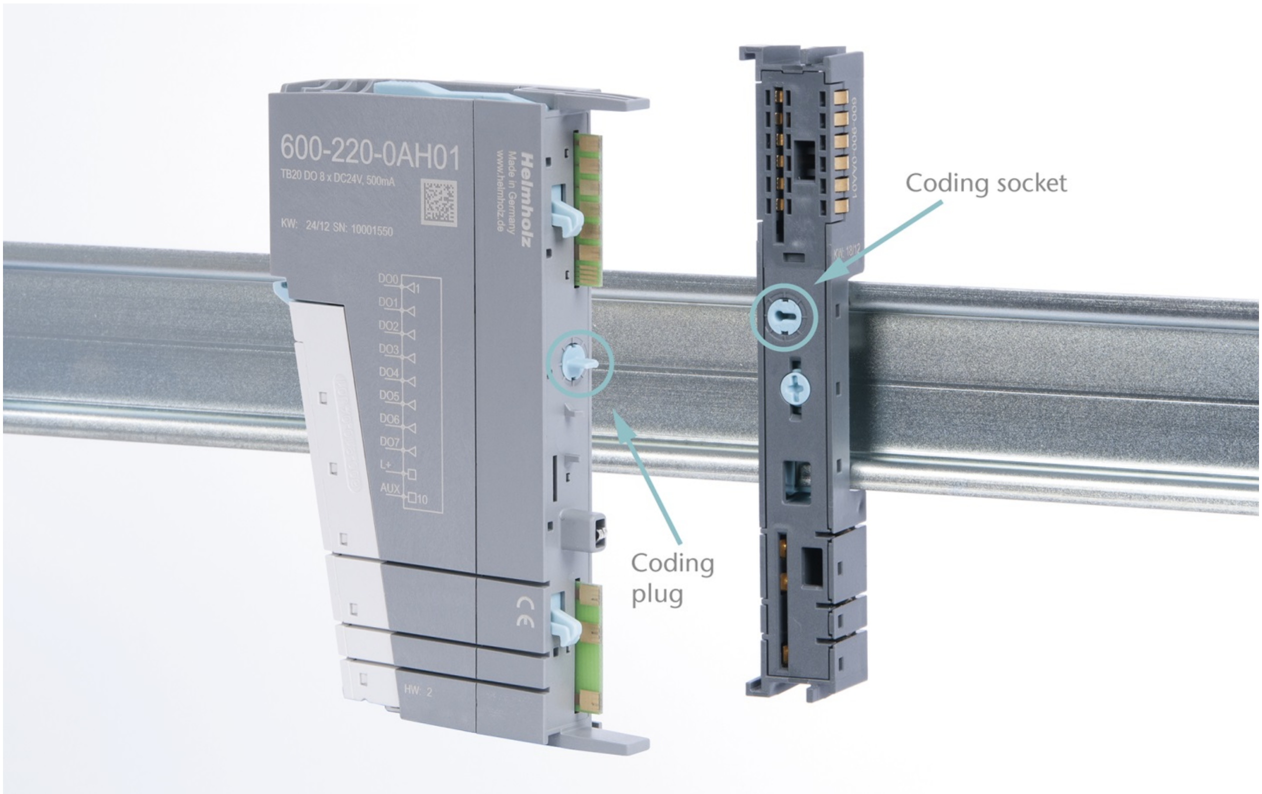
Step 3: Plug in a new electronic module

CAUTION!

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.

CAUTION!

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.



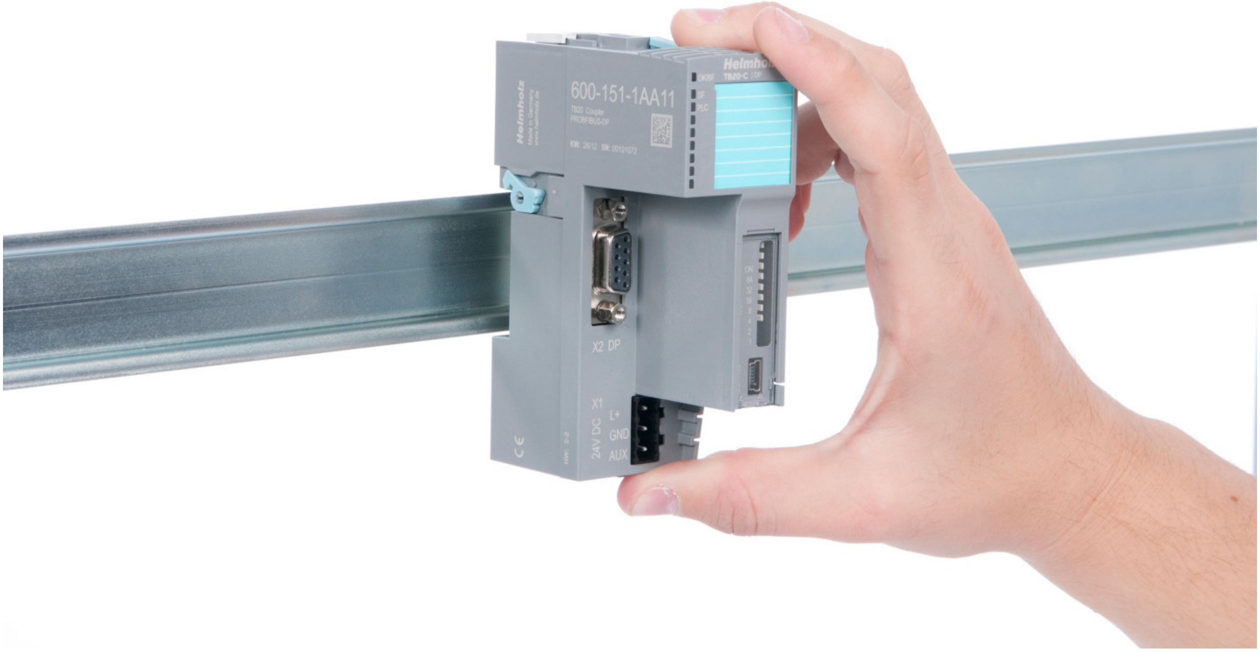
Step 4: Plug in the front connector

3.5. Installing and Removing the Coupler

3.5.1. Installation

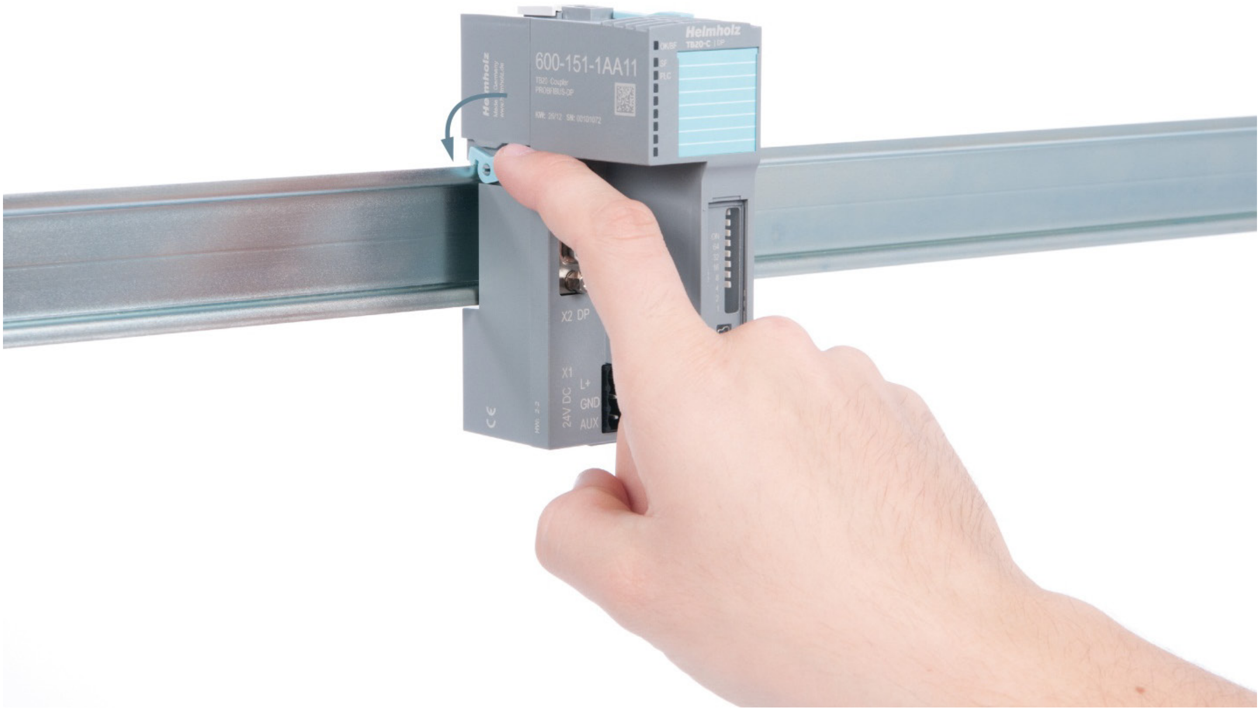
Step 1: Place the coupler on the DIN rail

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

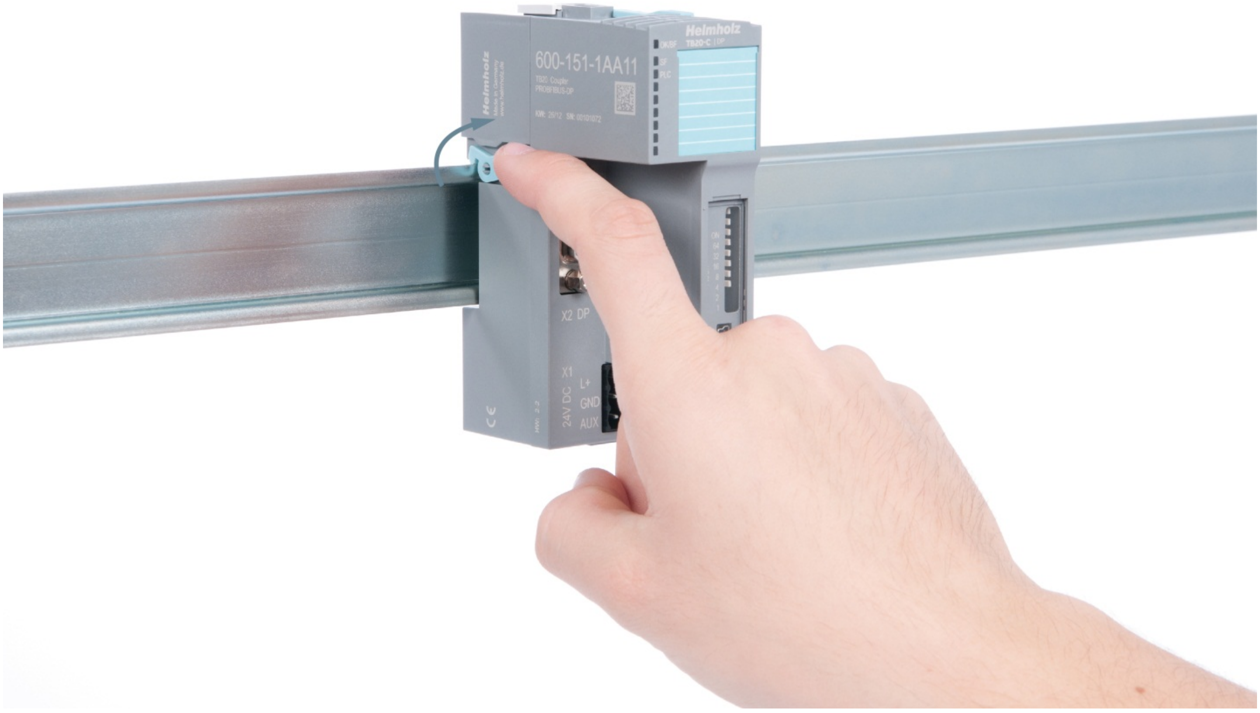
Use the locking lever on the left side to lock the coupler into position on the DIN rail.



3.5.2. Removal

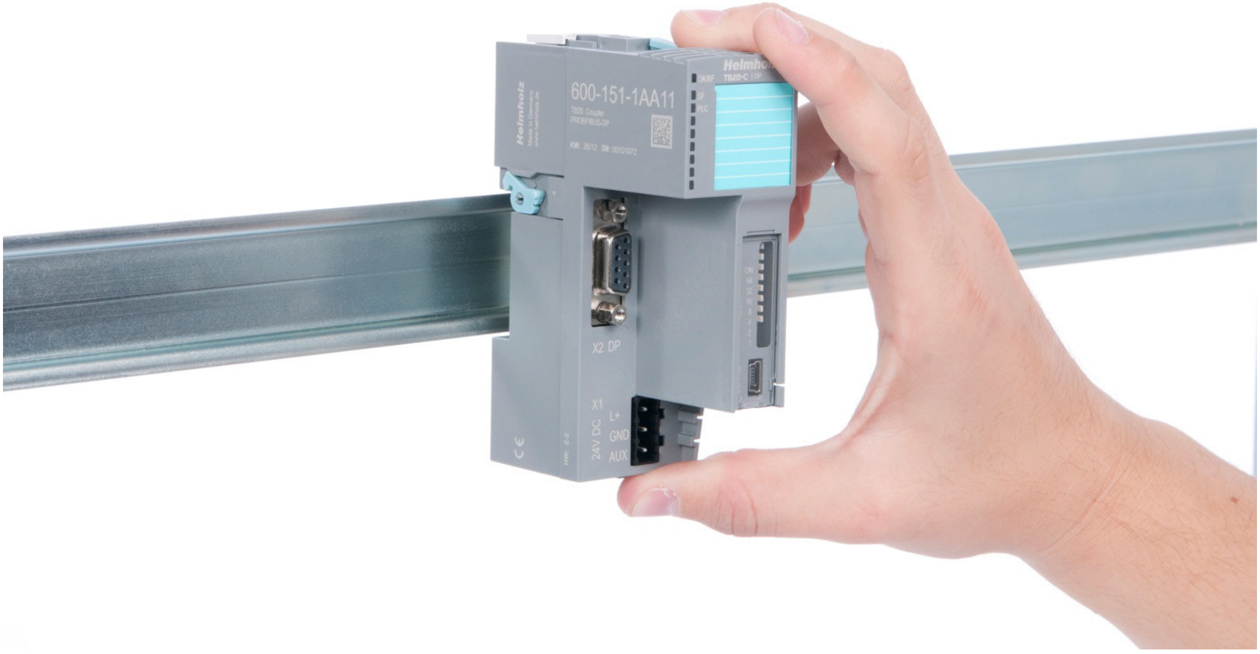
Step 1: Release the locking mechanism

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



Step 2: Remove the coupler

Use your middle finger to push on the release lever from above and then 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.

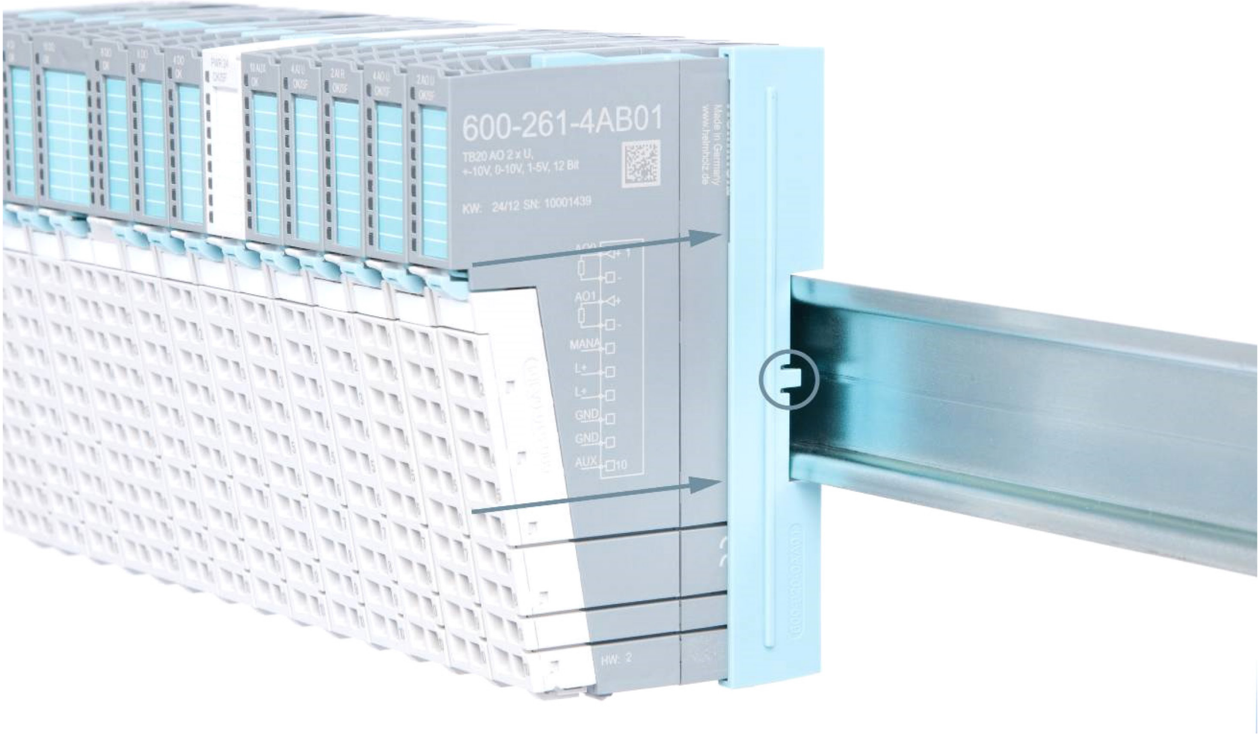
Step 4: Remove the base module

Remove the base module by pulling it towards you.

3.6. Installing and Removing the Final Cover

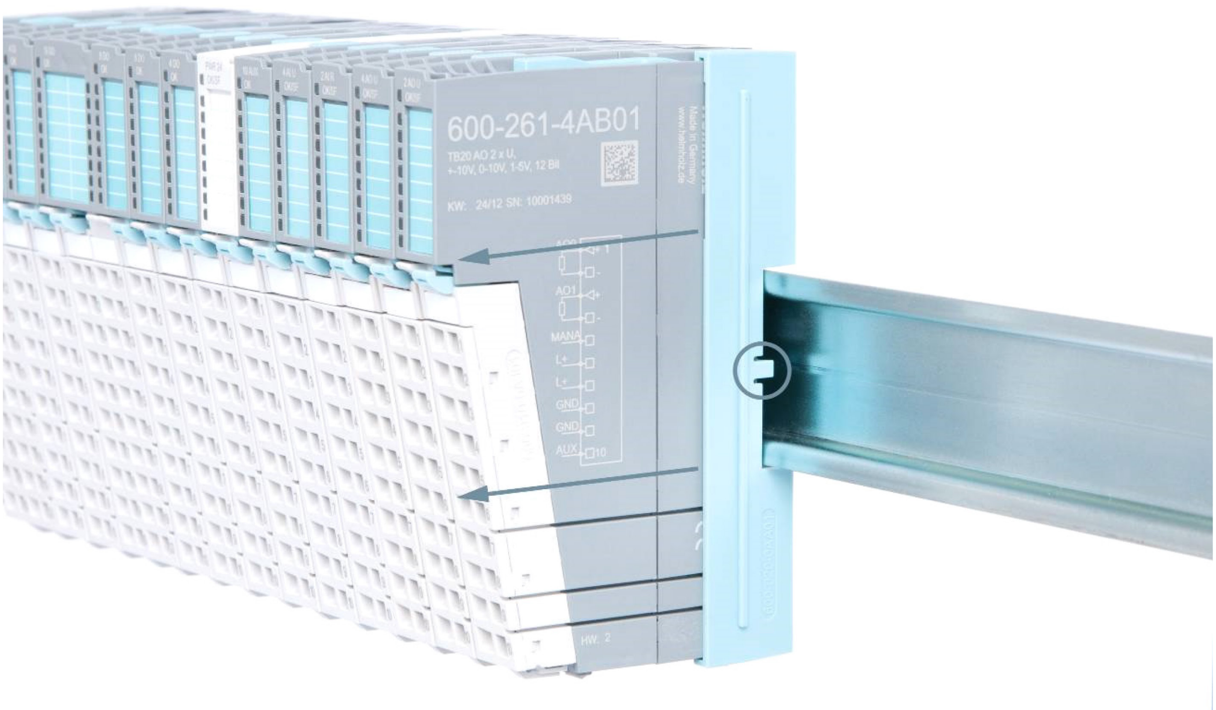
3.6.1. Installation

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 cover along the module's case and away from the DIN rail in order to remove it from the module.



4. Configuration / Wiring

4.1. EMC / Safety / Shielding

EU Directive 2004/108/EC (“Electromagnetic Compatibility”) defines which electrical devices and equipment must be designed in such a way as to not inevitably affect other neighboring devices and/or equipment with electromagnetic radiation. Within this context, the term “electromagnetic compatibility” refers to all electromagnetic factors that are relevant to the simultaneous operation of various electrical devices and/or equipment in close proximity to each other.

The directive requires, on one hand, for electrical devices and equipment to function flawlessly in an existing environment that exerts an electromagnetic influence within its area, and, on the other, for said devices and equipment not to produce impermissible levels of electromagnetic interference within said environment.

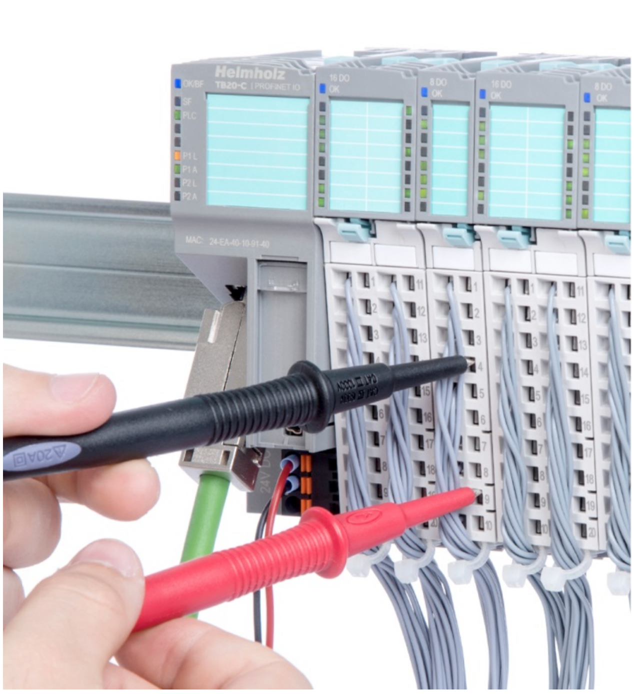
One effective way to protect against disturbances caused by electromagnetic interference is to shield electric cables, wires, and components.

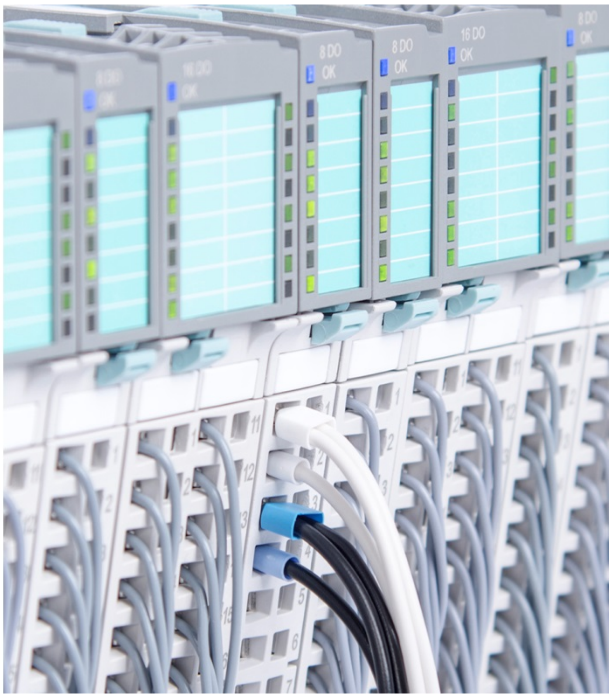
CAUTION!

When putting together the system and routing the required cables, make sure to fully comply with all standards, regulations, and rules regarding shielding (please consult the relevant guidelines and documents published by the PROFIBUS User Organization as well). All work must be done professionally!
Shielding faults can result in serious malfunctions, including the system’s failure.

4.2. Front Connectors

The front connector’s spring-type 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.





4.3. Wiring the Coupler

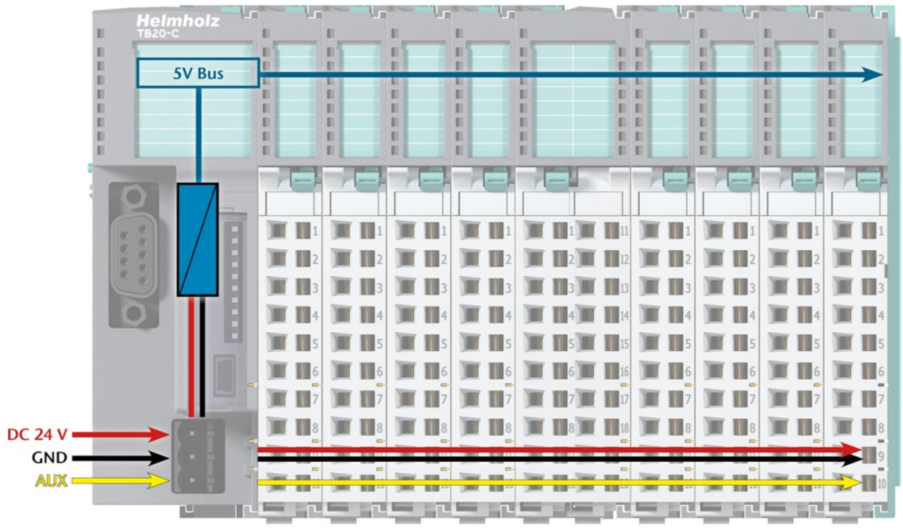
A power supply unit is integrated into the bus coupler. This unit is responsible for powering the peripheral modules connected to the coupler.

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

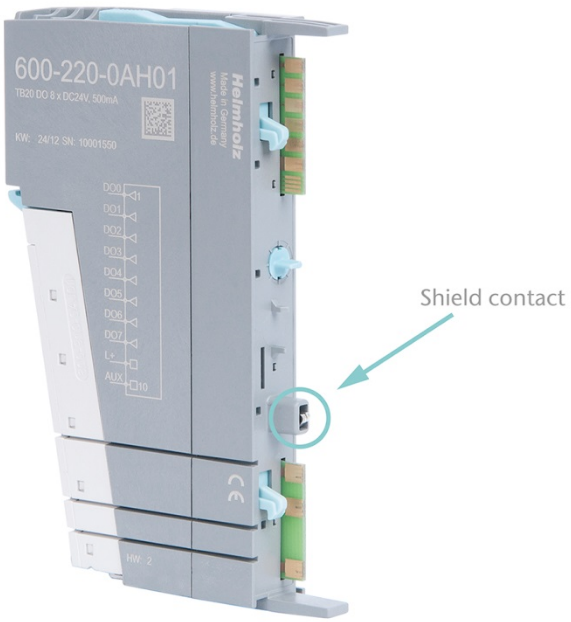
The 24-V connector is used to power two buses:

- 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 set up and use an additional wiring channel. Every peripheral module has an AUX terminal on its front connector (the bottommost terminal, i.e., terminals 10 and 20).

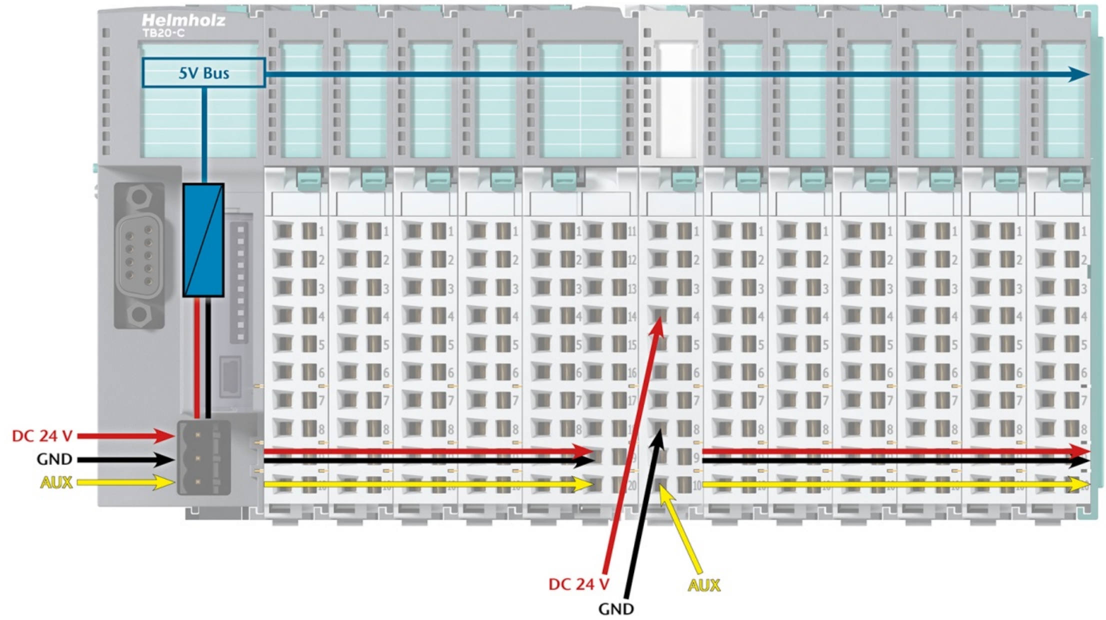


Shielding/grounding is achieved with a corresponding shield contact on the DIN rail:



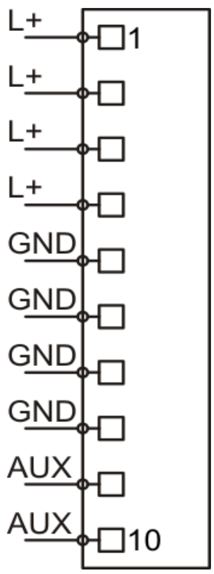
4.4. Using Power and Isolation Modules

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.



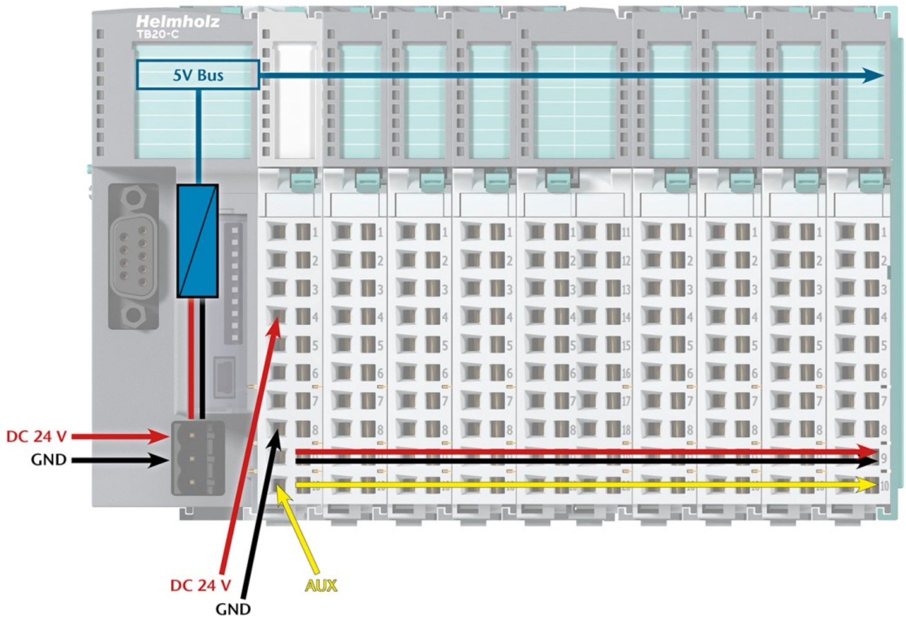
The order No. for the power and isolation module for 24-V signals is 600-710-0AA01.

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

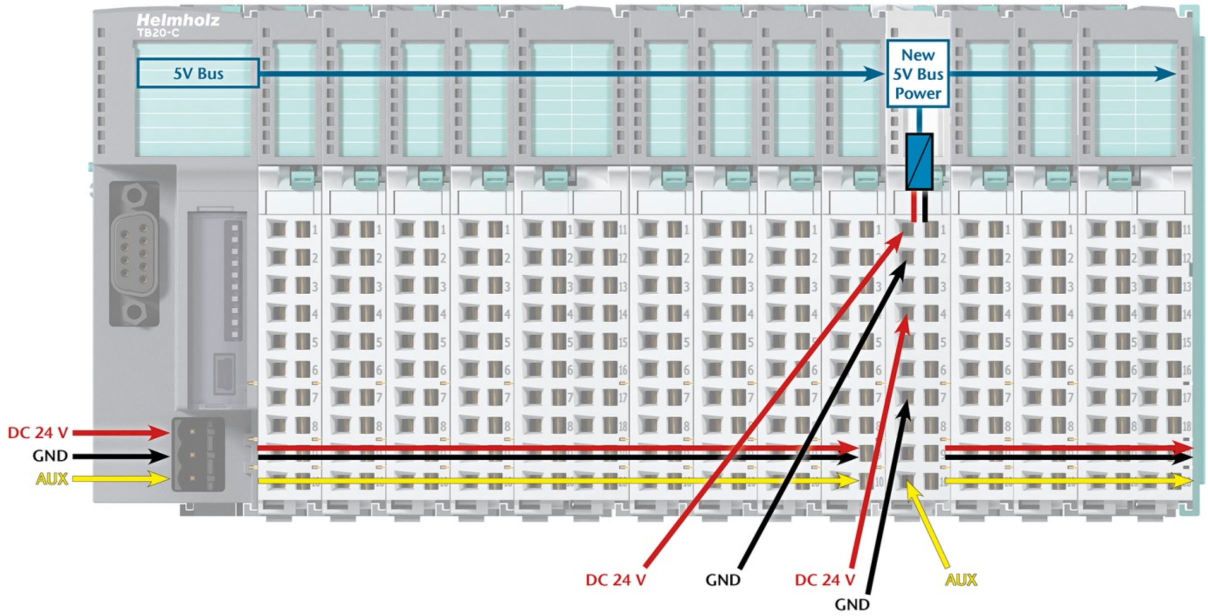
If the power supply for the coupler needs to be separate from the power supply for the I/O modules, a power and isolation module can be used right after the coupler.



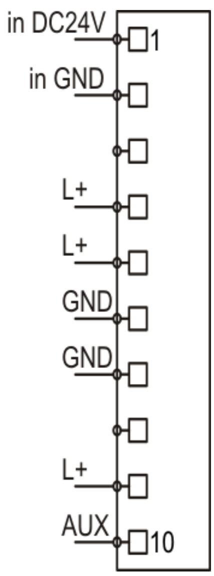
4.6. Using Power Modules

Power modules deliver all necessary power to the peripheral modules connected after them 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, e.g., 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. Its electronic module has the same light gray color as the front connector, while its base module is light gray with a dark core.



4.7. Fusing

The coupler's and power modules' power supply must be externally fused with a fast-blow fuse appropriate for the required maximum current.

4.8. Electronic Nameplate

Every TB20 peripheral module features an electronic nameplate containing all of the module's important information. This information includes, for example, the corresponding module ID, module model, 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.

5. 24-V Counter Module Characteristics

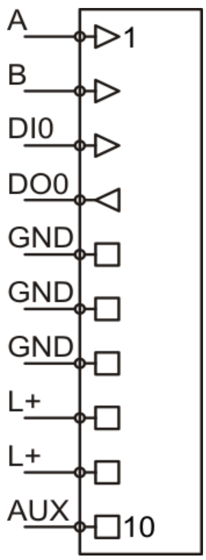
Counters are used to detect pulses that are faster than a controller's cycles, i.e., signals that the controller will be unable to detect properly and that therefore need to be pre-processed. This counter module detects the edges of 24-V signals as pulses. Pulses can be counted or converted into a frequency, rotational speed, or period. This counter module features an additional 24-V input and a 24-V output for a direct response to start pulses and to quick system state changes.

General characteristics:

- 32-bit counter
- Up to 500 kHz (4-fold evaluation)
- Accommodates 24-V incremental encoders and proximity sensors
- Capturing modes: Pulse & direction / Rotary encoder with single evaluation / Rotary encoder with double evaluation / Rotary encoder with 4-fold evaluation
- Counter mode: Endless Counting / Once-only counting / Periodic counting
- Measuring mode: Frequency measurement / Rotational speed measurement / Period measurement
- Programmable input: PLC input / Enable (HW gate) / Synchronization / Periodic synchronization / Latch / Latch & retrigger / Can be inverted
- Programmable output: PLC output / Count >= Comparison value / Count <= Comparison value / Count = Comparison value
- Can apply a substitute value at STOP
- Filters: 10 / 50 / 100 / 125 KHz
- All inputs can be inverted
- Limits for counter and measured readings
- Hysteresis for input
- Pulse duration for output
- Refresh rate / integration time for measuring mode
- 8 bytes of input data (count and status)
- 8 bytes of output data (load value and commands)

5.1. Connector pinout

Connector	I/O	Function
1	A	"Up" counting input
2	B	"Down" counting input
3	Input 0	Digital input
4	Output 0	Digital output
5	GND	GND from coupler, power module, or power and isolation module
6	GND	GND from coupler, power module, or power and isolation module
7	GND	GND from coupler, power module, or power and isolation module
8	L+, 24 VDC	L+ power supply from coupler, power module, or power and isolation module
9	L+, 24 VDC	L+ power supply from coupler, power module, or power and isolation module
10	AUX	AUX potential from coupler, power module, or power and isolation module



5.2. LEDs

The topmost LED “**OK/SF**” (1) on every module indicates the module’s current system status.

Solid blue light: The module is running (RUN)

Slowly flashing blue light: The module is stopped (STOP); substitute values (if any) are being applied

Quickly flashing blue light: The module is idle (IDLE); its parameters have 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

Green LED (2): Flashes when the internal count is incremented

Green LED (3): Flashes when the internal count is decremented

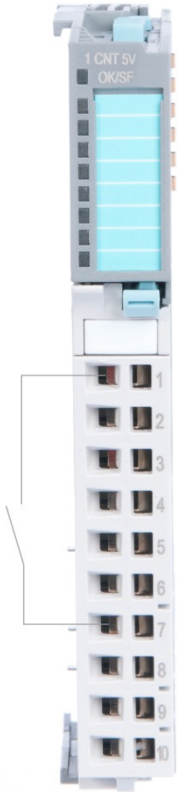
Green LED (4): Digital input status
Used to indicate the presence of voltage at the input, regardless of the module's evaluation. Shows a solid light when there is voltage, even if DI is disabled in the configuration.

Green LED (5): Digital output status
Used to indicate the presence of voltage at the output, regardless of whether the voltage is being applied by an external source. Shows a solid light when there is voltage, even if DO is disabled in the configuration.

IDLE mode (quickly 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).*

IDLE mode (quickly 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).

5.3. Quick Start Setup Guide for Counter Module



- Please refer to Section 3.3 for installation instructions
- Please refer to Section 4 for instructions on how to wire the TB20 system
- Connect debounced switches to terminals 1 and 8 or wire a sensor as indicated in the corresponding operating manual
- Please refer to Section 6.8 for more information on how the counter will work when using its default parameters
- To open the SW gate, use the "SW gate control bit;" please refer to Section 6.7.2 for more information
- Provide the counting pulses

→ Please refer to Section 5.2 for information on the module's LED indicators

If the counter module is used with a PROFIBUS-DP coupler, GSD file version 1.06 or higher must be used.

6. Counter Mode

6.1. Counting Methods

The counter mode can be used to record input pulses using one of the following three counting methods:

- Endless Counting
- Once-only counting
- Periodic counting

Counter range

- Upper limit (max.): $+2^{31\ -1}$ = +2147483647
- Lower limit (min.): -2^{31} = -2147483648

Load value

The counter can be given a specific value that will be loaded as its new count either directly (load counter value directly) or once it is triggered by a specific event (prepare load value).

When using the "once-only counting" and "periodic counting" modes, the load value will be adopted as the counter value when:

- The upper or lower counter limit is reached

The load value will be loaded in all operating modes when the following occur:

- The counting process is started by the SW gate or HW gate (only in gate function “cancelling”)
- Synchronization
- Latch and retrigger

The default setting for the load value is 0.

Gate-based control

The gate functions need to be used in order to be able to control the counter module. The counter's hardware and software gates are connected to each other by means of a logic AND.

6.2. Overview of the Parameters for the Counter Mode

Behavior DO at CPU-STOP: Used to specify whether a substitute value will be applied at DO if the PLC stops

- Retain last value
- Switch substitute value

Substitute value DO at CPU STOP: This bit is used to define the substitute value for the DO on CPU-STOP:

- 0 = DO will be deactivated when the PLC stops
- 1 = DO will be activated when the PLC stops

Behavior on CPU STOP: Used to define whether the counter will continue counting when the PLC is stopped

- Stop = The counter will stop when the PLC is stopped
- Continue = The counter will continue counting when the PLC is stopped

Counting mode (Section 6.3):

- Endless counting: No stop
- Once-only counting: Stop when a counter limit is reached
- Periodic counting: Counting starts from the load value when a counter limit is reached

Capturing mode (Section 8):

- Pulse and direction
- Rotary transducer (single)
- Rotary transducer (double)
- Rotary transducer (4-fold)

Gate function (Section 6.4):

- Interrupting: When the gate is opened, counting will resume with the current count
- Cancelling: When the gate is opened, counting will restart with the current load value

Invert A, B, DI: This parameter is set individually for each input

- OFF = The input will not be inverted
- ON = The input will be inverted

Function DI (Section 6.5): Used to select a function for the DI digital input

- Switch off
- Input
- HW gate

- Synchronization (Section 6.5.2)
- Periodic synchronization (Section 6.5.2)
- Latch (Section 6.5.1)
- Latch and retrigger (Section 6.5.1)

Filter A, B, DI: Used to choose from various input filters

- 125 kHz
- 100 kHz
- 50 kHz
- 10 kHz

Function DO (Section 6.6): Used to select a function for the DO digital output

- Switch off
- Output
- Count = Comparison value 1 or 2
- Count ≥ Comparison value 1
- Count ≤ Comparison value 1

Upper limit: Used to define the upper counter limit in the form of a 32-bit decimal number. The counter's behavior when this limit is reached will depend on the counting method that is set.

Lower limit: Used to define the lower counter limit in the form of a 32-bit decimal number. The counter's behavior when this limit is reached will depend on the counting method that is set.

Special restriction that must be taken into account when configuring the upper and lower limit parameters with a GSD file in PROFIBUS-DP:

If the counter is being used on a PROFIBUS-DP master, it is important to bear in mind that it is not possible to set 32-bit numbers due to the limitations inherent to the GSD file format. In this case, you will have to use two parameters (high word, low word) to configure the upper limit and lower limit each:

	Upper limit		**Lower limit**	
Numeric limit	1,000,000		-1,000,000	
Hex (neg. as two's complement)	000F 4240		FFF0 BDC0	
	High word	Low word	High word	Low word
Input [dec]	15	16,960	65,520	48,576

Pulse duration [2 ms]: If this parameter contains any value other than 0, pulses will be output when a comparison value is reached. The pulses' duration will be equal to the parameter's value multiplied by 2 ms. If the value is greater than 0, DO will be set when the comparison condition is met and reset after the configured time elapses. DO will be reset regardless of the comparison condition.

- Input value: decimal value of 0–255

Hysteresis: Used to define the hysteresis range. The current value will be considered to have "moved away" from the comparison value if the difference between them is equal to or greater than the hysteresis value that has been set. If the hysteresis is set to a value of 0, the hysteresis function will be disabled.

- Input value: decimal value of 0–255

6.3. Counting Methods

6.3.1. Endless Counting

When the "Endless Counting" method is set, the counter will start counting continuously from the current count when there is a gate start signal.

If the counter module reaches the upper counter limit when counting upwards, the count will jump to the lower counter limit the next time there is a counting pulse and continue to keep counting upwards without missing any pulses.

If the counter module reaches the lower counter limit when counting downward, the count will jump to the upper counter limit the next time there is a counting pulse and continue to keep counting downward without missing any pulses.

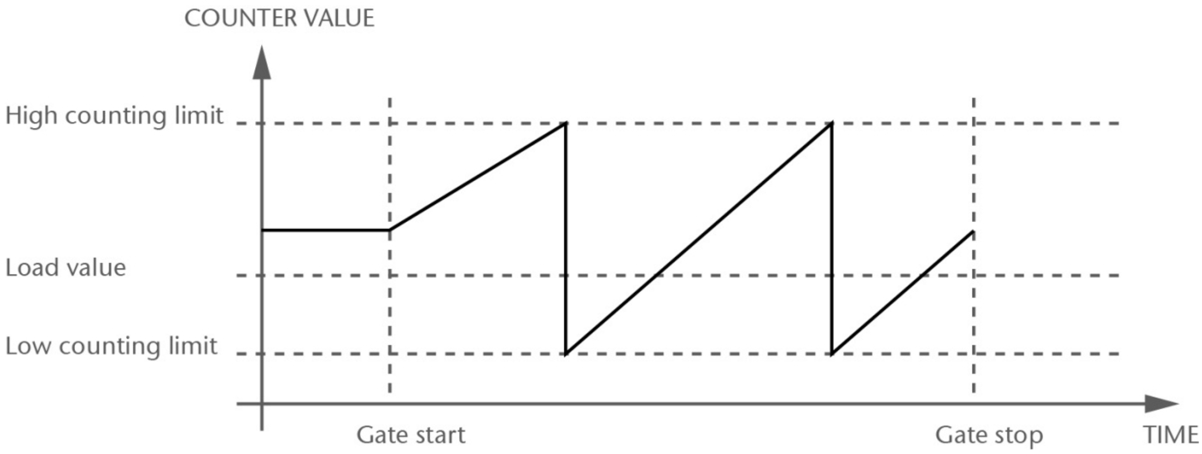


Figure 1: Endless Counting with gate function

Digital output behavior

The behavior of digital output DO can be manipulated by using:

- Hysteresis with a configurable value

or

- Pulse duration with a configurable duration

Changing values during ongoing operation

The following values can be changed during ongoing operation:

- Load value ("Prepare load value")
- Count ("Load counter value")
- "Load comparison value 1"
- "Load comparison value 2"

6.3.2. Once-Only Counting

When the "once-only counting" method is set, the counter will resume counting from the current count when there is a gate start signal. The counter will count either upwards or downwards. If a counter limit is reached, the counter will stop counting with an overflow. The counter can then be restarted so that it starts counting from the load value. To do so, the gate needs to be closed and then opened again. Please note that the gate will not be closed automatically when the counter limit is reached. If the gate is closed, the count will remain on the lower counter limit.

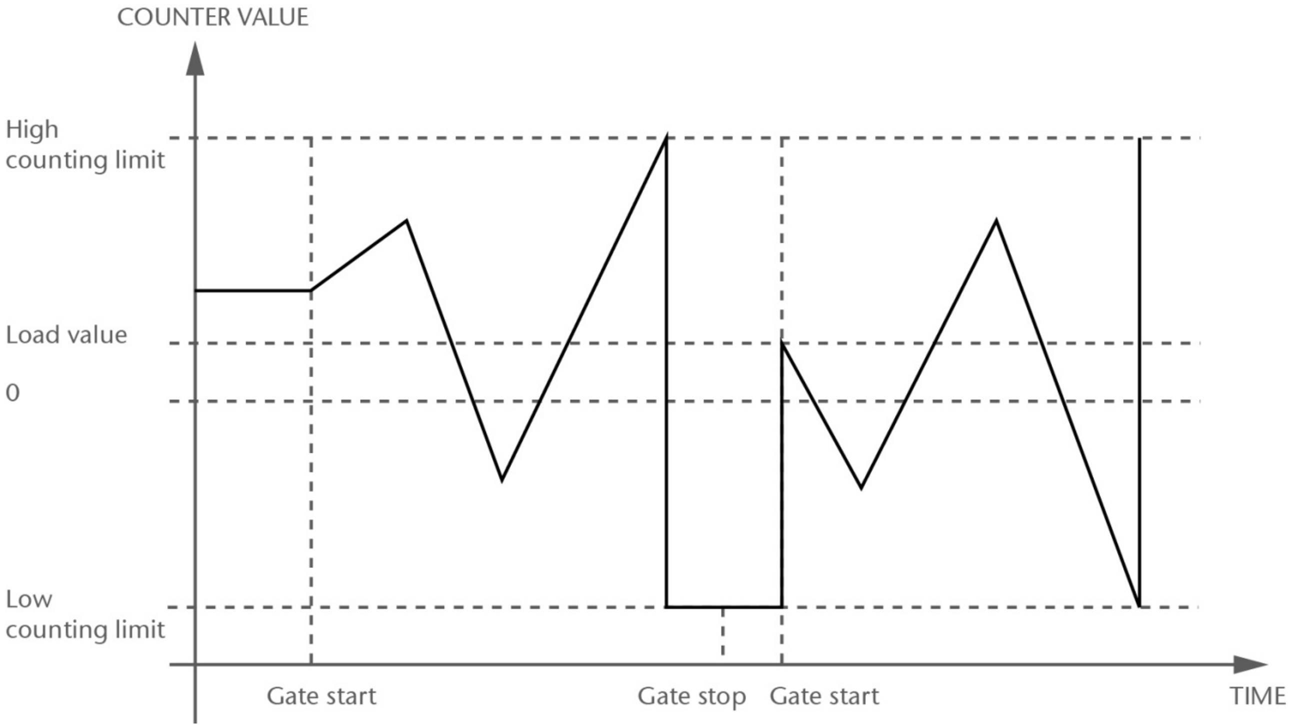


Figure 2: Once-only counting with gate function

Digital output behavior

The behavior of digital output DO can be manipulated by using:

- Hysteresis with a configurable value

or

- Pulse duration with a configurable duration

Changing values during ongoing operation

The following values can be changed during ongoing operation:

- Load value ("Prepare load value")
- Count ("Load count value")
- "Load comparison value 1"
- "Load comparison value 2"

6.3.3. Periodic counting

When the "periodic counting" method is set, the counter will resume counting from the current count when there is a gate start signal. If a counter limit is reached, the counter will start counting again from the load value.

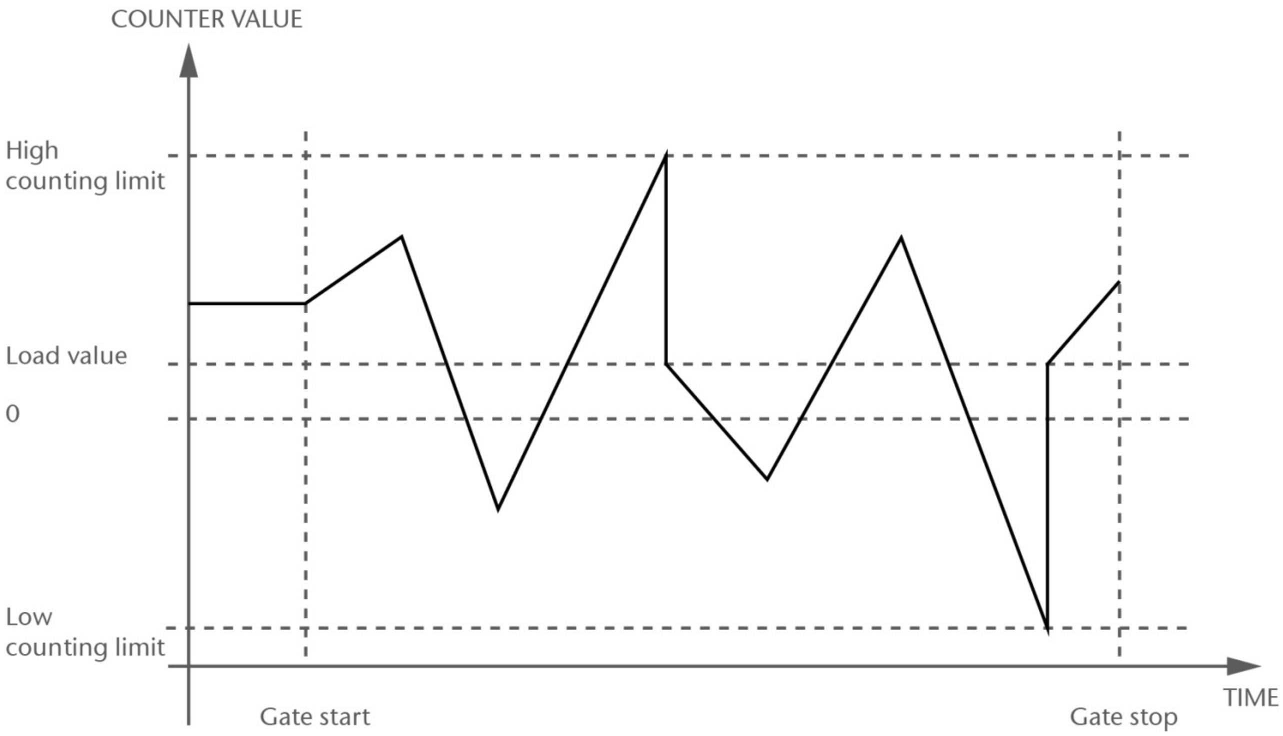


Figure 3: Periodic counting

Digital output behavior

The behavior of digital output DO can be manipulated by using:

- Hysteresis with a configurable value
- Pulse duration with a configurable duration

Changing values during ongoing operation

The following values can be changed during ongoing operation:

- Load value ("Prepare load value")
- Count ("Load count value")
- "Load comparison value 1"
- "Load comparison value 2"

6.4. Gate Functions and Counting Methods

Software gate

The software gate (SW GATE) is controlled with the "SW gate control bit." The software gate will be opened when there is a rising edge on the "SW gate control bit" signal. On the other hand, it will be closed when the "SW gate control bit" is reset. Please make sure to take the control program's transmission times and run times into account.

Hardware gate

The hardware gate (HW gate) is controlled with the counter module's DI digital input (see 6.5). The digital input must be configured as a hardware gate. If a rising edge is detected on the digital input, the gate will be opened. If a falling edge is detected, the gate will be closed.

Internal gate

The internal gate is used to start, interrupt/resume, and cancel counting. The internal gate is a logic AND gate with the following two logical inputs: the hardware gate and the software gate. In other words, counting will only be active if both gates are open. The "SW gate state" feedback bit indicates the internal gate's state. If a hardware gate has not been configured, only the SW gate will determine the internal gate's value.

Cancelling / interrupting gate function

The "gate function" parameter is used to specify whether the internal gate will interrupt or cancel counting. If the gate function is set to "cancelling," counting will start over from the load value after the internal gate is closed and then reopened. Meanwhile, if the gate function is set to "interrupting," counting will stop when the internal gate is closed and will resume from the last count when the internal gate is reopened.

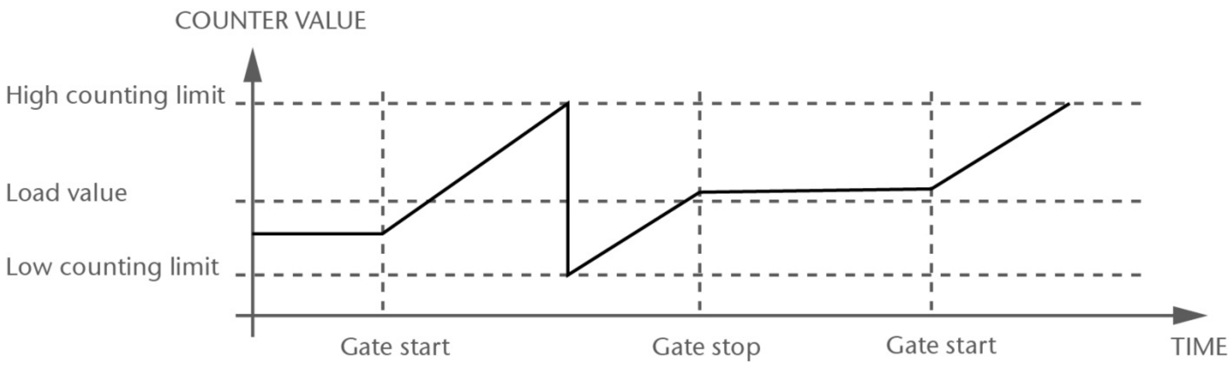


Figure 4: Upward Endless Counting with interrupting gate function

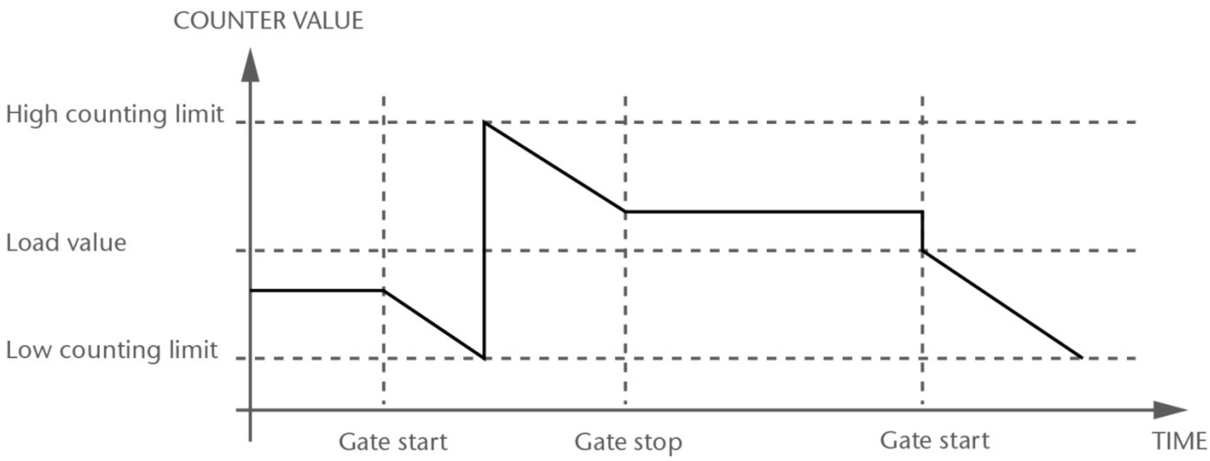


Figure 5: Downward Endless Counting with cancelling gate function

Behavior when the counter is controlled with the software gate only

When the SW gate is opened:

- Interrupting gate function: Counting will resume from the current count
- Cancelling gate function: Counting will restart from the load value

Behavior when the counter is controlled with the hardware and software gate

When the SW gate is opened while the HW gate is open / When the HW gate is opened while the SW gate is open:

- Interrupting gate function: Counting will resume from the current count
- Cancelling gate function: Counting will restart from the load value

6.5. Behavior of the DI, A, and B Inputs in Counter Mode

Connecting sensors

- Current-sourcing switch
- Push-pull

Inverting the input signal

Inputs A, B, and DI can be inverted by using the appropriate parameters.

- Invert B: 0 = OFF / 1 = ON
- Invert A: 0 = OFF / 1 = ON
- Invert DI: 0 = OFF / 1 = ON

The input signals can also be filtered

- Filters A, B, DI: 0 = 125 kHz / 1 = 100 kHz / 2 = 50 kHz / 3 = 10 kHz

Digital input functions

The Function DI parameter can be used to set the following digital input functions:

- Switch off—the digital input will be disabled
- Input—can be used as a digital input that can be read with the "DI state" status bit (this bit is not used by the counter module)
- Hardware gate—please refer to Section 6.4
- Synchronization—please refer to Section 6.5.2
- Periodic synchronization—please refer to Section 6.5.2
- Latch—please refer to Section 6.5.1
- Latch and retrigger—please refer to Section 6.5.1

The "DI state" bit indicates the level at the digital input.

6.5.1. DI Function: Latch and Retrigger

The latch function can be used to store the current count and is controlled with the digital input. There are two different latch functions available:

- Latch and retrigger
- Latch

Latch and retrigger

If a rising edge is detected at the digital input, the counter module's current internal count will be stored as a latch value and the counter will be retriggered. The count will be stored (latch value) when the rising edge occurs. In addition, the load value will be loaded and the counter will resume counting starting from the load value.

Counting must be enabled with the SW gate. The actual counting will start with the first rising edge at the DI digital input. The feedback interface will indicate the latch value instead of the count. Meanwhile, the "DI state" bit will indicate the state of the latch and retrigger signal.

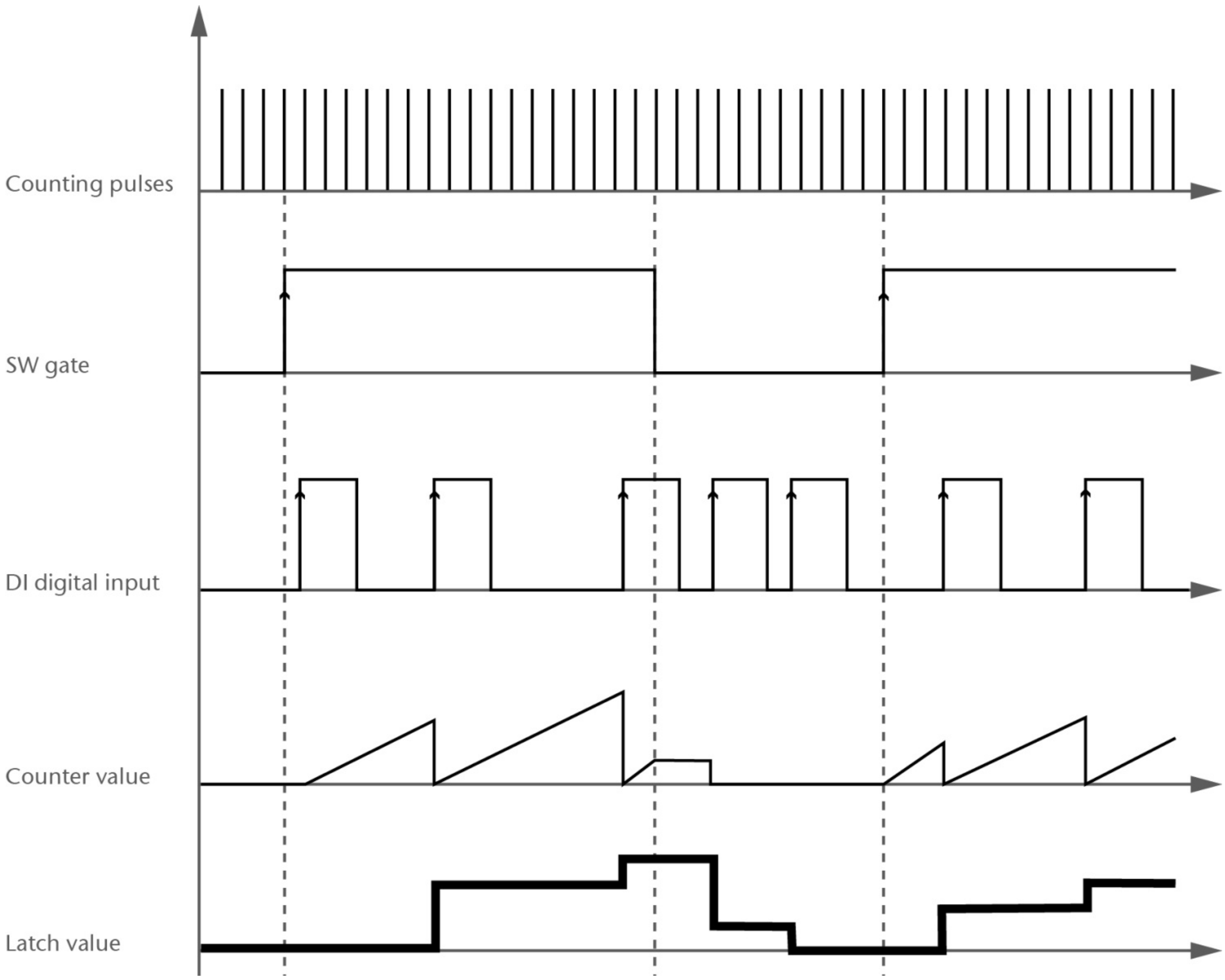


Figure 6: Latch and retrigger with load value = 0

The latch value will not change when the SW gate is opened.

Directly loading a new counter value will not change the stored count being indicated.

Closing the SW gate will have an interrupting effect, i.e., counting will be resumed when the SW gate is opened again. The digital input will remain active even if the SW gate is closed.

The count will be stored (latch value) when there is a rising edge.

Latch

Counting will start when a rising edge is detected at the SW gate. Closing the SW gate will have an interrupting or cancelling effect, depending on the way it has been configured. The count will be stored (latch value) when there is a rising edge. The digital input will remain active even if the SW gate is closed.

The feedback interface will indicate the latch value instead of the count. Meanwhile, the DI status bit will indicate the state of the latch signal.

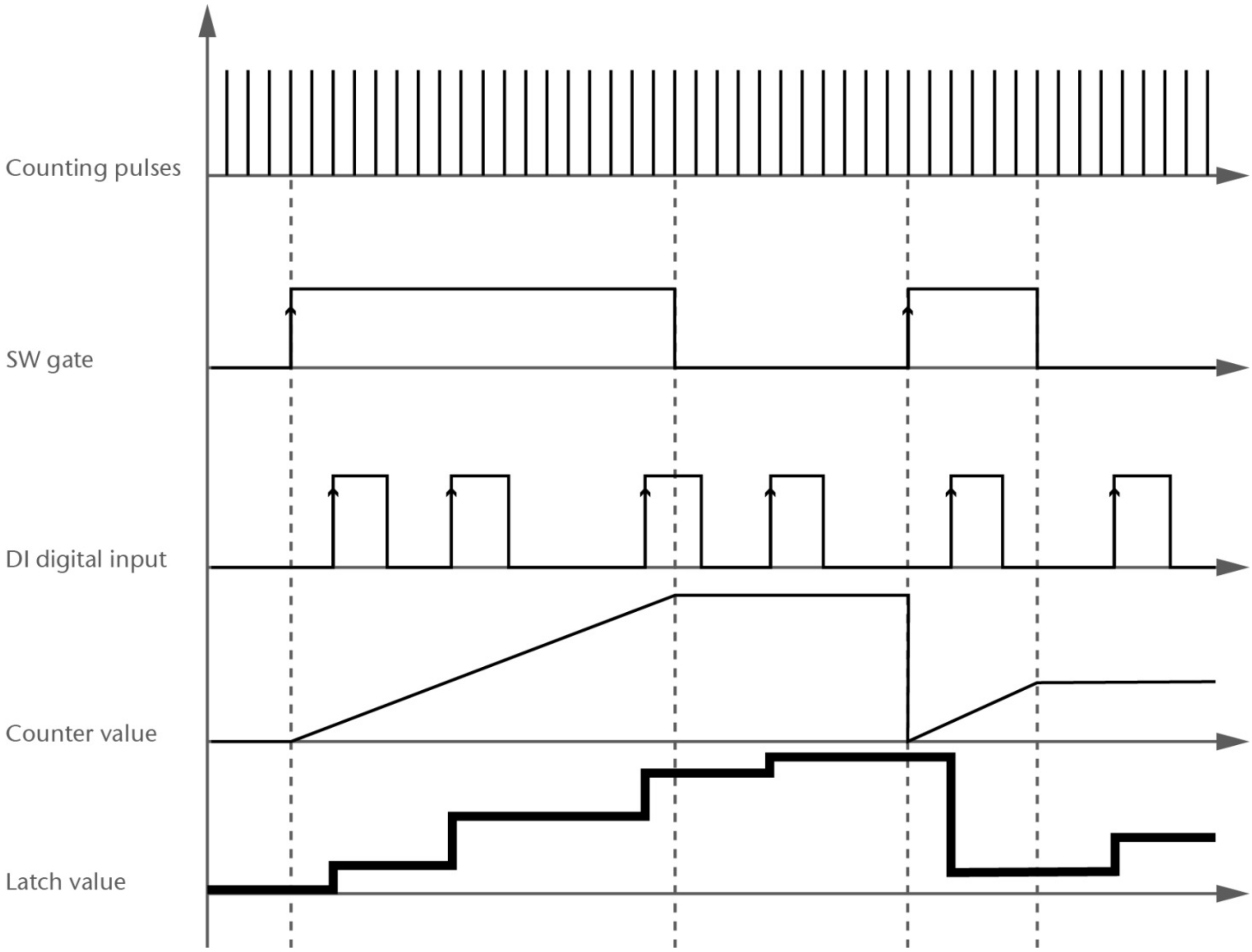


Figure 7: Latch

The count and the latch value are initialized with their default reset values.

The latch value will not change when the SW gate is opened.

Directly loading a new counter value will not change the stored count being indicated.

6.5.2. DI Function: Synchronization

The synchronization function can be used to adopt a load value with the rising edge of a reference signal at the counter module's digital input. There are two different functions available:

- Synchronization
- Periodic synchronization

How it works:

The SW gate starts the counting process.

The "Enable synchronization" control bit is set to 1.

When synchronization is successful, the "synchronization status" feedback bit is set to 1. The feedback bit must be reset with the "Reset status bits" control bit.

Either a bounce-free switch or the zero reference mark of a rotary encoder can be used as a reference signal.

The "DI state" feedback bit will indicate the reference signal's level.

One-time synchronization:

If the enable bit is set, the first edge the counter module will adopt the load value.

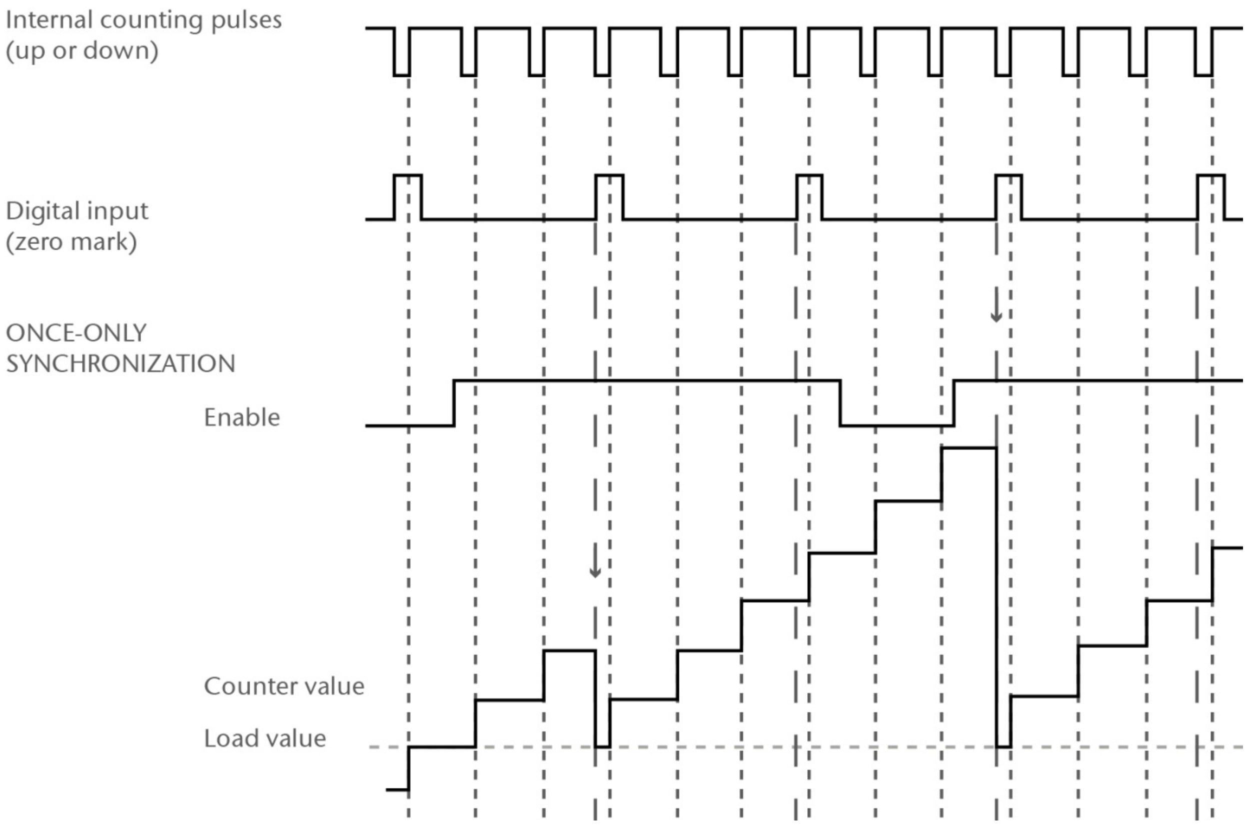


Figure 8: One-time synchronization

Periodic synchronization

If the enable bit is set, the first edge, as well as any subsequent edge, will adopt the load value in the counter module.

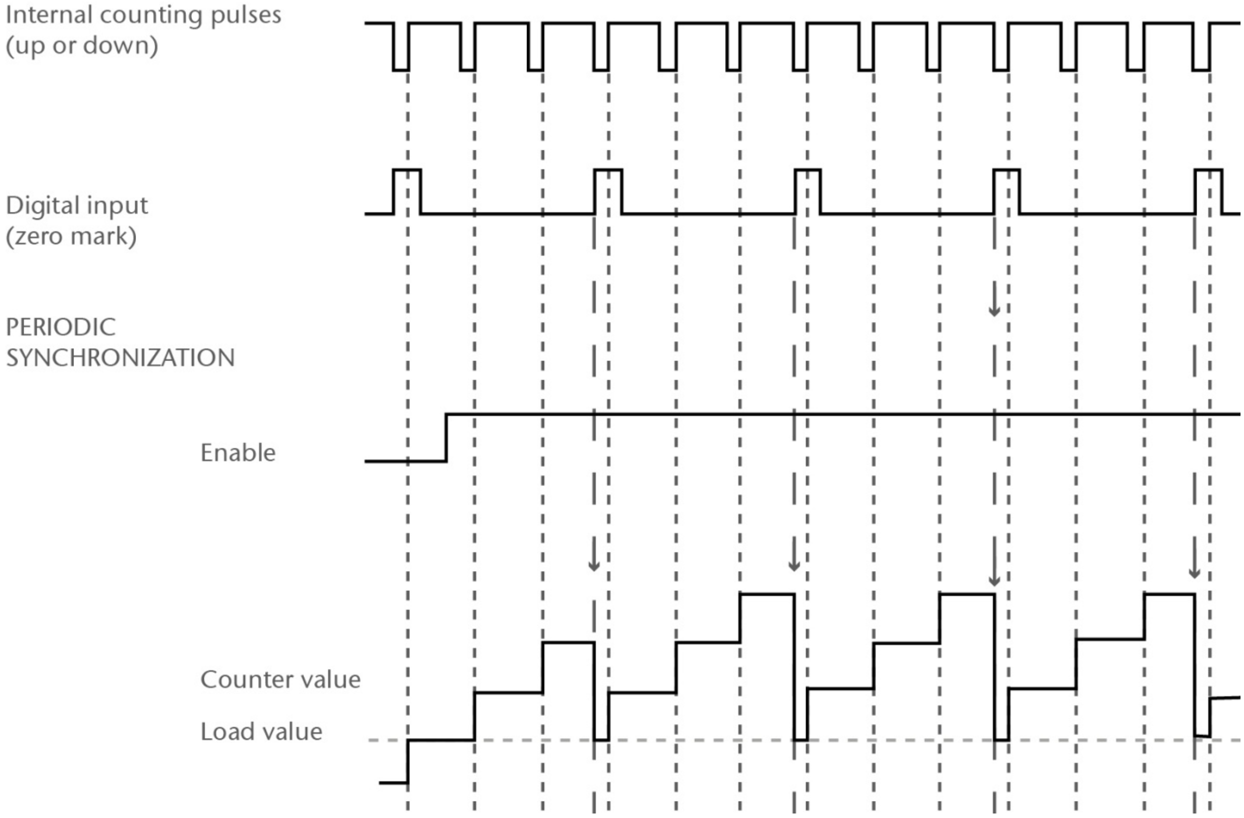


Figure 9: Periodic synchronization

6.6. Behavior of DO Digital Output in Counter Mode

Comparison values can be stored in counter module. The digital output can then be switched in various ways by comparing the counter's count to these comparison values. Accordingly, the digital output's behavior can be configured as necessary.

Digital output functions

The "Function DO" parameter can be used to set the following digital output functions:

- Switch off - the digital output will be disabled
- Output - can be used as a digital output (not used by the counter module)
- Count ≥ Comparison value 1; please refer to 6.6.2
- Count ≤ Comparison value 1; please refer to 6.6.3
- Count = Comparison value 1 or 2; please refer to 6.6.4

Switch off

If the DO digital output is disabled, the comparator's state will not be output and it will not be possible to use DO as a digital output.

DO output

Digital output DO is switched on and off with the "DO control bit." In order to enable switching, the "Enable DO" control bit must be set to 1.

The "DO state" status bit can be used to check the DO digital output's state at the feedback interface. The "DO state" status bit will be set to 0 immediately if the DO digital output is switched off.

Hysteresis

In order to prevent the DO digital output from switching when there are small fluctuations at the counting input, a hysteresis can be configured for the counter.

The current value will be considered to have "moved away" from the comparison value if the difference between them is equal to or greater than the hysteresis value that has been set. If the hysteresis is set to a value of 0, the hysteresis function will be disabled. This hysteresis will also work in the event of an overflow or underflow.

The hysteresis' function will depend on the comparators' operating mode (please refer to Section 6.6.1).

Pulse duration

If the configured pulse duration is greater than 0, pulses will be output when comparison values are reached. The pulses' duration will be equal to the parameter's value multiplied by 2 ms. If the value = 0, DO will remain active until the reset condition is met. The reset condition will depend on the configuration for DO and the hysteresis. If the value is greater than 0, DO will be set when the comparison condition is met and reset after the configured time elapses. DO will be reset regardless of the comparison condition.

The pulse duration's function will depend on the comparators' operating mode (please refer to Section 6.6.1).

6.6.1. Overview of DO Switching Behavior When Comparison Values Are Used

The DO digital output will be switched on when the comparison condition is met.

The "DO state" status bit can be used to check the DO digital output's state at the feedback interface. The "DO state" status bit will be set to 0 immediately if the digital output is switched off.

How it works:

Comparison values can be loaded by using the "Comparison value 1" and "Comparison value 2" loading function.

The default configuration for the comparators is as follows:

- Comparison value 1: 0
- Comparison value 2: 10000

Digital output DO only needs to be enabled if DO is configured as an output. The hysteresis function can be used.

If comparison value 1 or 2 is reached, the "Comparator 1 state" or "Comparator 2 state" (as the case may be) bit will be set to 1 regardless of how DO is configured. These bits can be reset with the "Reset status" bit.

The DO digital output cannot be controlled with the "DO control bit" when the output is switched based on comparison values.

6.6.2. DO Switching Behavior When "Count ≥ Comparison value 1"

When this configuration is used, only comparison value 1 will be evaluated.

Hysteresis = 0 / Pulse duration = 0

If the "Count ≥ Comparison value 1" condition is met, DO will be switched to ON. If the condition ceases to be met, DO will be switched to OFF.

See Figure 10.

Hysteresis > 0 / Pulse duration = 0

If comparison value 1 is reached in the "up" counting direction, DO will be switched to ON and the hysteresis will be activated. As long as this hysteresis remains active, DO will not be able to change state. The hysteresis will be deactivated if the count reaches "Comparison value 1 ± hysteresis value." If the hysteresis is deactivated, the "Count ≥ Comparison value 1" condition will be evaluated again and DO will be switched accordingly.

If the condition ceases to be met when the hysteresis is deactivated, DO will be switched to OFF and the hysteresis will be activated again. Just like in the case above, DO's state will not be able to change as long as the hysteresis remains active.

See Figure 10.

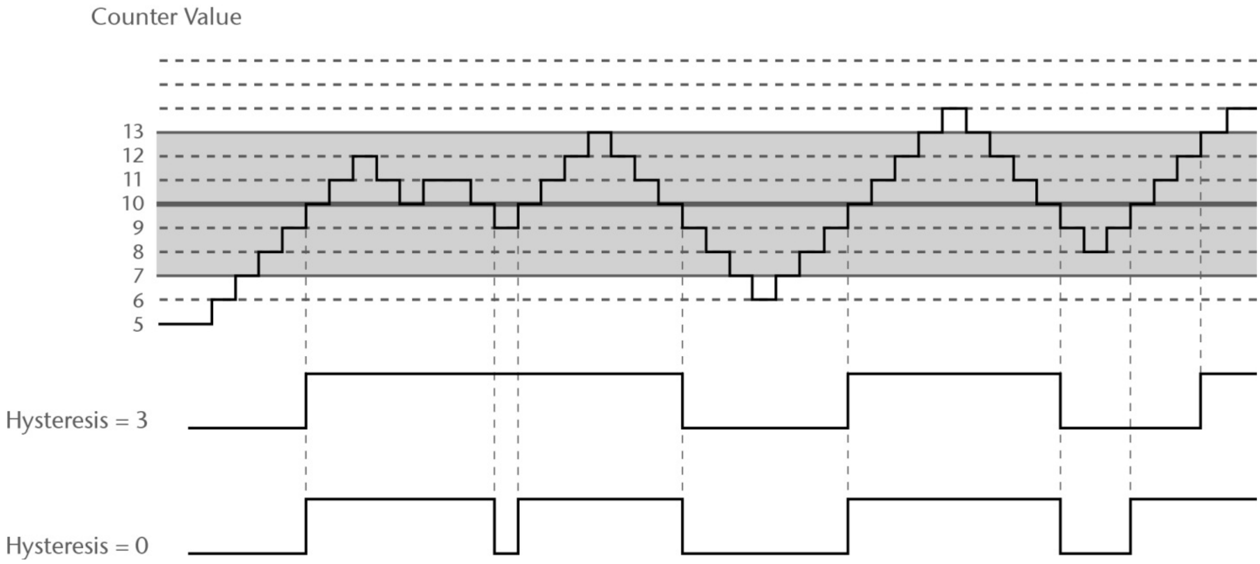


Figure 10: Hysteresis with count ≥ comparison value and pulse duration = 0

Hysteresis = 0 / Pulse duration > 0

If comparison value 1 is reached in the "up" counting direction, a pulse with the configured length will be output.

See Figure 11.

Hysteresis > 0 / Pulse duration > 0

If comparison value 1 is reached in the "up" counting direction, a pulse with the configured length will be output and the hysteresis will be activated. As long as the hysteresis remains active, it will not be possible to trigger another pulse. The hysteresis will be deactivated if the count reaches "Comparison value 1 ± hysteresis value."

If comparison value 1 is reached in the "down" counting direction, a pulse will not be output, but the hysteresis will be activated. Just as above, it will not be possible to trigger another pulse as long as the hysteresis remains active.

See Figure 11.

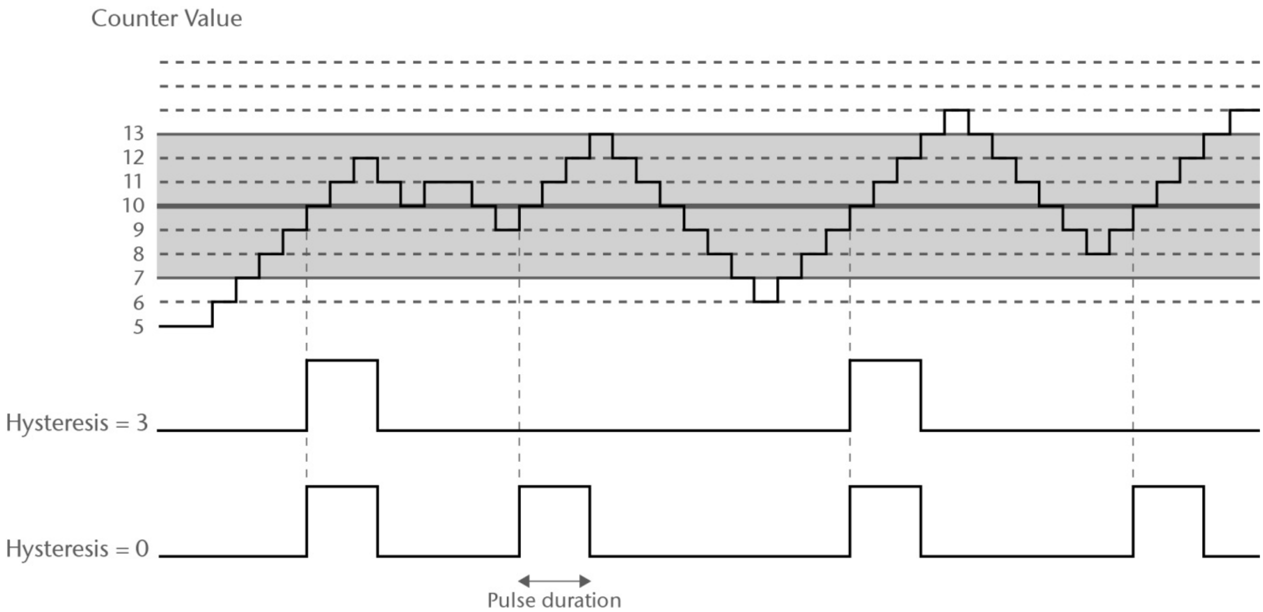


Figure 11: Hysteresis with count ≥ comparison value and pulse duration > 0

6.6.3. DO Switching Behavior When "Count ≤ Comparison value 1"

When this configuration is used, only comparison value 1 will be evaluated.

Hysteresis = 0 / Pulse duration = 0

If the "Count ≤ Comparison value 1" condition is met, DO will be switched to ON. If the condition ceases to be met, DO will be switched to OFF.

See Figure 12.

Hysteresis > 0 / Pulse duration = 0

If comparison value 1 is reached in the "down" counting direction, DO will be switched to ON and the hysteresis will be activated. As long as this hysteresis remains active, DO will not be able to change state. The hysteresis will be deactivated if the count reaches "Comparison value 1 ± hysteresis value." If the hysteresis is deactivated, the "Count ≤ Comparison value" condition will be evaluated again and DO will be switched accordingly.

If the condition ceases to be met when the hysteresis is deactivated, DO will be switched to OFF and the hysteresis will be activated again. Just like in the case above, DO's state will not be able to change as long as the hysteresis remains active.

See Figure 12.

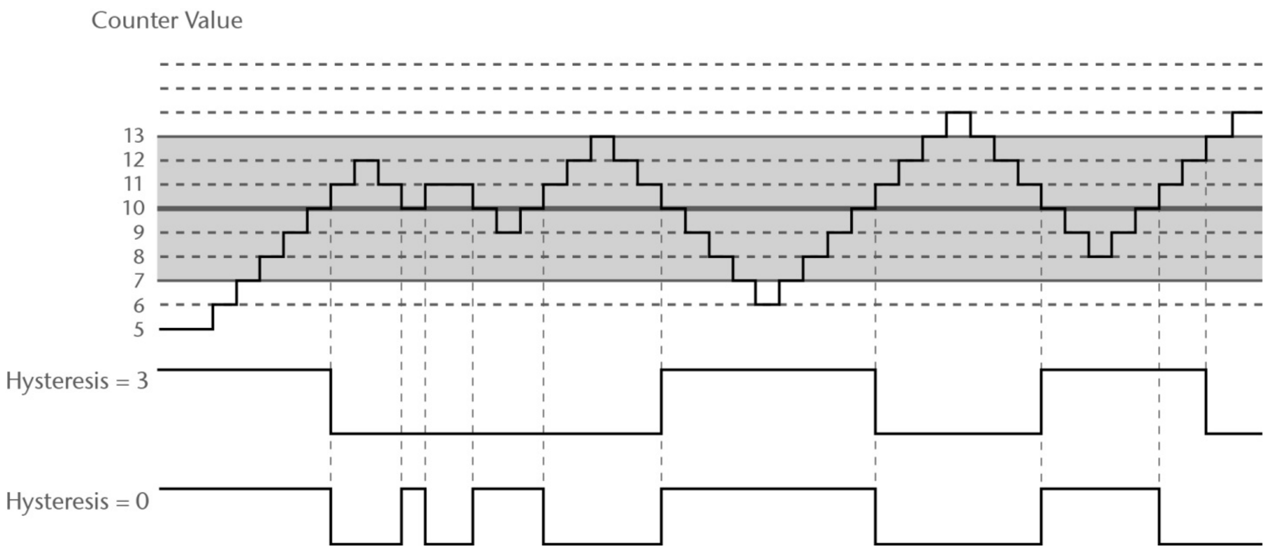


Figure 12: Hysteresis with count ≤ comparison value and pulse duration = 0

Hysteresis = 0 / Pulse duration > 0

If comparison value 1 is reached in the "down" counting direction, a pulse with the configured length will be output.

See Figure 13.

Hysteresis > 0 / Pulse duration > 0

If comparison value 1 is reached in the "down" counting direction, a pulse with the configured length will be output and the hysteresis will be activated. As long as the hysteresis remains active, it will not be possible to trigger another pulse. The hysteresis will be deactivated if the count reaches "Comparison value 1 ± hysteresis value."

If comparison value 1 is reached in the "up" counting direction, a pulse will not be output, but the hysteresis will be activated. Just as above, it will not be possible to trigger another pulse as long as the hysteresis remains active.

See Figure 13.

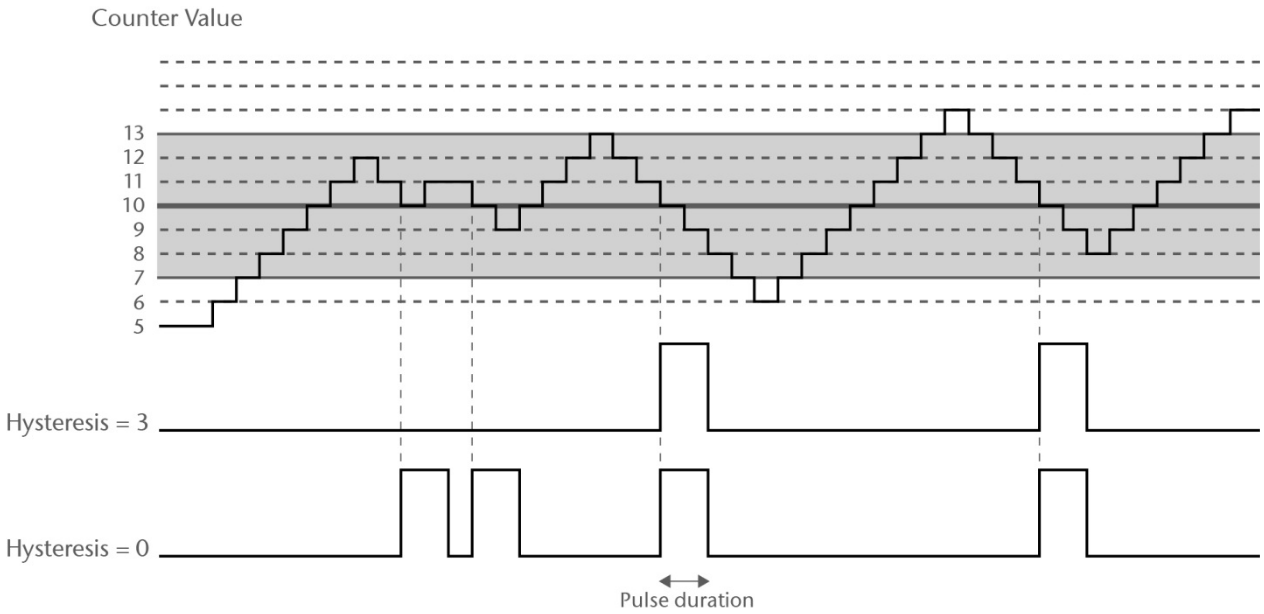


Figure 13: Hysteresis with count ≤ comparison value and pulse duration > 0

6.6.4. DO Switching Behavior When "Count = Comparison value 1 or 2"

With this configuration, both comparison values 1 and 2 will be evaluated.

Hysteresis = 0 / Pulse duration = 0

If the "Count = Comparison value 1 or 2" condition is met, DO will be switched to ON. If the condition ceases to be met, DO will be switched to OFF.

See Figure 14.

Hysteresis > 0 / Pulse duration = 0

If a comparison value is reached, DO will be switched to ON and the hysteresis will be activated. As long as this hysteresis remains active, DO will not be able to change state. The hysteresis will be deactivated if the count reaches "Comparison value ± hysteresis value." If the hysteresis is deactivated, DO will be switched to OFF.

See Figure 14.

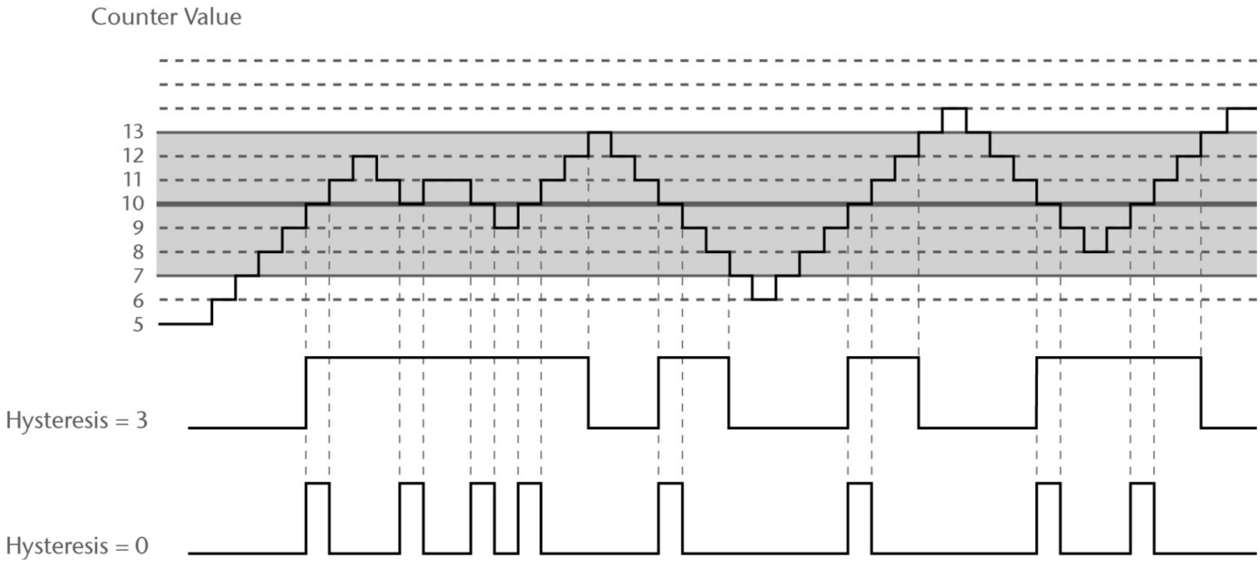


Figure 14: Hysteresis with count = comparison value and pulse duration = 0

Hysteresis = 0 / Pulse duration > 0

If a comparison value is reached, a pulse with the configured length will be output.

See Figure 15.

Hysteresis > 0 / Pulse duration > 0

If a comparison value is reached, a pulse with the configured length will be output, the hysteresis will be activated, and the counting direction will be stored. As long as the hysteresis remains active, it will not be possible to trigger another pulse. The hysteresis will be deactivated if the count reaches "Comparison value 1 ± hysteresis value."

If the count leaves the hysteresis range in the direction opposite to the stored counting direction, another pulse will be output.

See Figure 15.

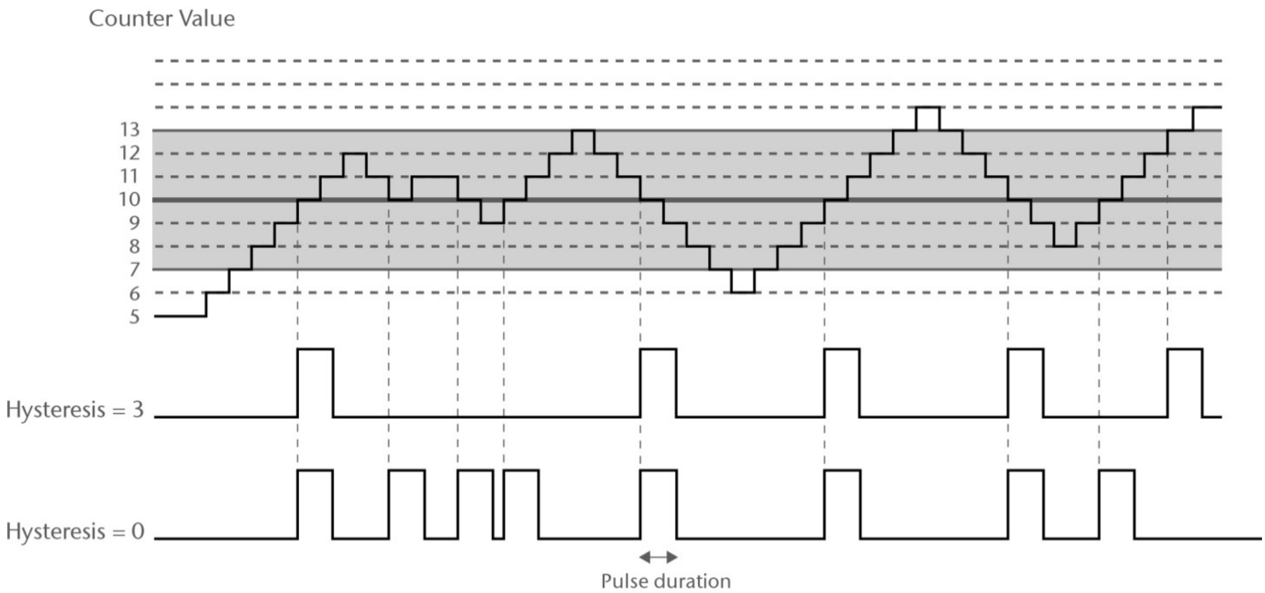


Figure 15: Hysteresis with count = comparison value and pulse duration > 0

6.7. Input and Output Variables in Counter Mode

6.7.1. Feedback (Inputs)

Input data length: 8 bytes

	7	6	5	4	3	2	1	0
Byte 0–3	Count							
Byte 4	-	-	Parameter assignment error	-	-	Status bits being reset	-	Value being loaded
Byte 5	"Down" counting direction	"Up" counting direction	-	-	DO state	-	DI state	SW gate state
Byte 6	Zero crossing	Lower limit	Upper limit	Comparator2 state	Comparator1 state	-	-	Synchroniza-tion status
Byte 7	-	-	-	-	-	-	-	-

Count The current count / latch value

Parameter assignment error This bit will be set to 1 if there is an incorrect parameter configuration. This bit will be set to 1 if there is an incorrect parameter configuration. In case of a parameter assignment error the module will assume a save operating mode. This means the counter will neither return feedback, nor will it execute control commands. Additionally the DI and DO will be deactivated. Normal operation continues as soon as the counter receives valid parameters.

Status bits being reset This bit will be set to 1 if the status bits have been reset

Value being loaded This bit will be set to 1 if the loading function has been triggered. The control bit for loading a value can be reset

"Down" counting direction The counter is counting downwards

"Up" counting direction The counter is counting upwards

DO state Indicates the digital output's current state

DI state Indicates the digital input's current state

SW gate state Indicates the software gate's current state

Zero crossing Set to 1 when the count passes through zero

Lower limit Set to 1 if the lower counter limit is reached

Upper limit Set to 1 if the upper counter limit is reached

Comparator2 state Set to 1 if comparison value 2 is reached. This bit is independent of the DO output's configuration

Comparator1 state Set to 1 if comparison value 1 is reached. This bit is independent of the DO output's configuration

Synchronization status Set to 1 if synchronized counting has been started

6.7.2. Control Interface (Outputs)

Output data length: 8 bytes

	7	6	5	4	3	2	1	0
Byte 0–3	Count value, load value, comparison value 1 or 2							
Byte 4	-	-	-	Enable DO	DO control bit	Reset status bits	Enable synchroniza-tion	SW gate control bit
Byte 5	-	-	-	-	Load comparison value 2	Load comparison value 1	Prepare load value	Load count value
Byte 6	-	-	-	-	-	--	-	-
Byte 7	-	-	-	-	-	-	-	-

Count value, load value, comparison value 1 or 2
Used to transfer a new count value, load value or comparison value

Enable DO Must be set to 1 in order for the PLC application to be able to control DO

DO control bit Used by the PLC application to control DO if DO has been configured as an output. In order for the PLC application to be able to control DO, the enable bit for DO must first be activated

Reset status bits Resets all status bits, e.g., the Parameter assignment error and Comparator1 state bits

Enable synchronization Must be set to 1 in order for synchronization pulses to be accepted

SW gate control bit Used to open (1) and close (0) the software gate. The software gate must be open in order for counting pulses to be accepted

Load comparison value 2
Used to load comparison value 2. Before this, the desired value must be loaded into the storage space used to transfer values that should be loaded. After this, the "Load comparison value 2" bit should be set to 1. As soon as the "Value being loaded" input bit switches to HIGH, the "Load comparison value 2" bit can be reset

Load comparison value 1
Used to load comparison value 1. Before this, the desired value must be loaded into the storage space used to transfer values that should be loaded. After this, the "Load comparison value 1" bit should be set to 1. As soon as the "Value being loaded" input bit switches to HIGH, the "Load comparison value 1" bit can be reset

Prepare load value Used to prepare a new count for loading. The new count will be set when counting restarts. A counting restart is considered to have happened, for example, when counting is resumed after a cancelling gate function. Another instance is when periodic counting is being used and a counter limit is reached (the load value will be loaded in this case as well). The default load value is 0. Before this, the desired value must be loaded into the storage space used to transfer values that should be loaded. After this, the "Prepare load value" bit should be set to 1.
As soon as the "Value being loaded" input bit switches to HIGH, the "Prepare load value" bit can be reset

Load count value

Use to immediately load a new count. Before this, the desired value must be loaded into the storage space used to transfer values that should be loaded. After this, the "Load count value" bit should be set to 1.
As soon as the "Value being loaded" input bit switches to HIGH, the "Load count value" bit can be reset

6.8. Parameters for Counter Mode

All configurable modules come with a default parameter configuration. Depending on the bus system being used, the bus coupler will automatically load the desired operating parameter configuration into the modules when starting up or the user will have to transfer the configuration from the PLC by using the relevant methods. When using bus couplers with project storage capabilities (e.g., CANopen couplers), the parameters can be configured in advance with the "TB20 ToolBox" program. Modules can also be reconfigured at any time - even during operation. The methods that have to be used for this purpose will vary depending on the bus system and PLC being used.

Parameter set structure (length of 14 bytes)

Parameters	Byte	7	6	5	4	3	2	1	0
1	0	Mode = 3							
2	1	0	Operating mode on CPU-STOP	Gate function	Capturing mode		Invert DI	Invert A	Invert B
3	2	Filter A / B / DI		0	0	0	0	Behavior DO at CPU-STOP	Substitute value DO at CPU-STOP
4	3	Function DO			Function DI			Counting method	
5	4	Upper limit (Int32)							
	5								
	6								
	7								
6	8	Lower limit (Int32)							
	9								
	10								
	11								
7	12	Pulse duration [2 ms]							
8	13	Hysteresis							

Operating mode on CPU-STOP
0 = Stop / 1 = Continue counting

Gate function 0 = Interrupting / 1 = Cancelling

Capturing mode 0 = Pulse and direction / 1 = Rotary transducer (single) / 2 = Rotary transducer (double) / 3 = Rotary transducer (4-fold)

A, B, DI filters 0 = 125 kHz / 1 = 100 kHz / 2 = 50 kHz / 3 = 10 kHz

DO behavior at CPU-STOP 0 = Retain last value / 1 = Apply substitute vale

Function DO 0 = Switch off / 1 = Output / 2 = Count ≥ Comparison value 1 / c 3 = Count ≤ Comparison value 1 / 4 = At comparison value 1 or 2

Function DI 0 = Switch off / 1 = Input / 2 = HW gate / 3 = Synchronization / 4 = Periodic synchronization / 5 = Latch / 6 = Latch and retrigger

Counting method 0 = Endless Counting / 1 = Once-only counting / 2 = Periodic counting

Upper limit Used to define the upper counter limit in the form of a 32-bit integer. Range: -2,147,483,648 to +2,147,483,647

Lower limit Used to define the lower counter limit in the form of a 32-bit integer. Range: -2,147,483,648 to +2,147,483,647

Pulse duration	Pulse duration for DO when using comparison value monitoring [value * 2 ms]
Hysteresis	Hysteresis centered on the comparison values [0–255]

Note: The corresponding default settings are underlined.

7. Measuring Mode

7.1. Measuring Methods

When using the measuring mode, readings are measured continuously. The following measuring methods are available:

- Frequency measurement
- Rotational speed measurement
- Period measurement

Measurements will be taken during the configured integration time. Once the integration time elapses, the measured reading will be updated. The "Measuring ended" status bit is used to signal the end of a measurement. This status bit is reset with the "Reset status bits" control bit.

A reading of 0 will be output until the first measurement integration time ends.

In order for there to be a measurement, at least one input pulse is required during the integration time. If there are fewer than one pulse, a reading of 0 will be output.

An integration time < 1 will be set to an integration time of 1 instead.

Change in the direction of rotation

If the direction of rotation is reversed during the integration time, the reading for the corresponding period will be undefined. Measuring errors can be caught by evaluating the "'Up' counting direction" and "'Down' counting direction" status bits.

7.2. Overview of the Parameters for the Measuring Mode

Behavior DO at CPU-STOP: Used to specify whether a substitute value will be applied at DO if the PLC stops

- Retain last value
- Switch substitute value

Substitute value DO at CPU-STOP: This bit is used to define the substitute value.

- On = DO will be deactivated when the PLC stops
- Off = DO will be activated when the PLC stops

Behavior on CPU-STOP: Used to define whether the counter will continue counting when the PLC is stopped

- Stop = The counter will stop when the PLC is stopped
- Continue = The counter will continue when the PLC is stopped

Measuring method:

- Frequency measurement
- Rotational speed measurement
- Period measurement

Capturing mode (please refer to Section 8 as well):

- Pulse and direction
- Rotary transducer (single)
- Rotary transducer (double)
- Rotary transducer (4-fold)

Resolution of period:

- Microseconds
- 1/16 of a microsecond

Invert A, B, DI: This parameter is set individually for each input

- OFF The input will not be inverted
- ON The input will be inverted

Function DI: Used to select a function for DI

- Switch off
- Input
- HW gate

Filters A, B, DI: Used to choose from various input filters

- 125 kHz
- 100 kHz
- 50 kHz
- 10 kHz

Function DO: Used to select a function for DO

- Switch off
- Output
- Above upper limit
- Below lower limit
- Outside limits

Upper limit: Used to define the upper measuring limit in the form of a 32-bit decimal number.

Lower limit: Used to define the lower measuring limit in the form of a 32-bit decimal number.

Special restriction that must be taken into account when configuring the upper and lower limit parameters with a GSD file in PROFIBUS-DP:

If the counter is being used on a PROFIBUS-DP master, it is important to bear in mind that it will not be possible to set 32-bit numbers due to the limitations inherent to the GSD file format. In this case, you will have to use two parameters (high word, low word) to configure the upper limit and lower limit each:

	Upper limit		**Lower limit**	
Numeric limit	1,000,000		0	
Hex (neg. as two's complement)	000F 4240		0000 0000	
	High word	Low word	High word	Low word
Input [dec]	15	16960	0	0

Sensor pulses per rotation: Number of sensor pulses for a single revolution.

- Input value: decimal value of 1–32767

Integration time [n * 10 ms]:

- Input value: decimal value of 1–32767
-

7.3. Measuring Methods

7.3.1. Frequency Measurement

The input signal's frequency will be continuously measured. The integration time can be configured. Once a measurement ends, the "Measurement ended" bit will be set to 1.

In order to obtain accurate measurements, the integration time should be longer than 10 counting pulses.

- Integration time n x 10 ms, value range: $n_{min} = 1$–$n_{max} = 32767$
- Reading [10^{-3} Hz]

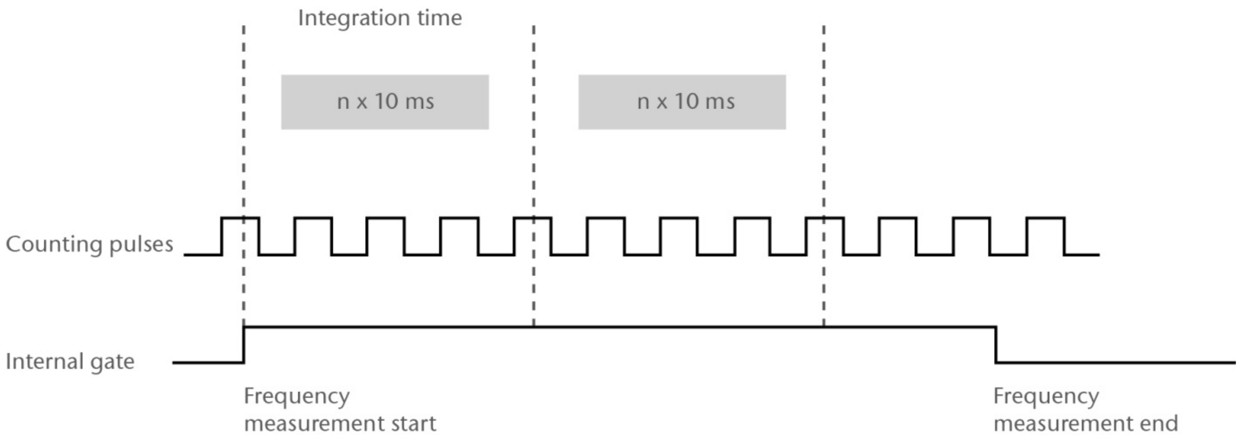


Figure 16: Frequency measurement with gate function

Limit monitoring

Encoder	Lower limit f_L	Upper limit f_U
Single evaluation	0–99,999,999 x 10^{-3} Hz	f_L +1–100,000,000 x 10^{-3} Hz
Other	0–124,999,999 x 10^{-3} Hz	f_L +1–125,000,000 x 10^{-3} Hz

Measuring ranges and measuring errors

Integration time	f_{max} ± absolute error	f_{max} (single evaluation) ± absolute error
10 s	125,000 Hz ± 3.3 Hz	100,000 Hz ± 2.4 Hz
1 s	125,000 Hz ± 5.4 Hz	100,000 Hz ± 4.5 Hz
0.1 s	125,000 Hz ± 32.3 Hz	100,000 Hz ± 4.5 Hz
0.01 s	125,000 Hz ± 321.7 Hz	100,000 Hz ± 254.9 Hz

7.3.2. Rotational Speed Measurement

A rotational speed will be calculated continuously based on the input signal's frequency. The integration time can be configured. In addition, the number of pulses per revolution must be configured. Once a measurement ends, the "Measurement ended" status bit will be set to 1.

In order to obtain accurate measurements, the integration time should be longer than 10 counting pulses.

- Integration time n x 10 ms, value range: n_{min} = 1–n_{max} = 32767
- Reading in [rpm]

For the rotational speed measurement, the sensor must additionally be configured in "Sensor pulses per rotation."

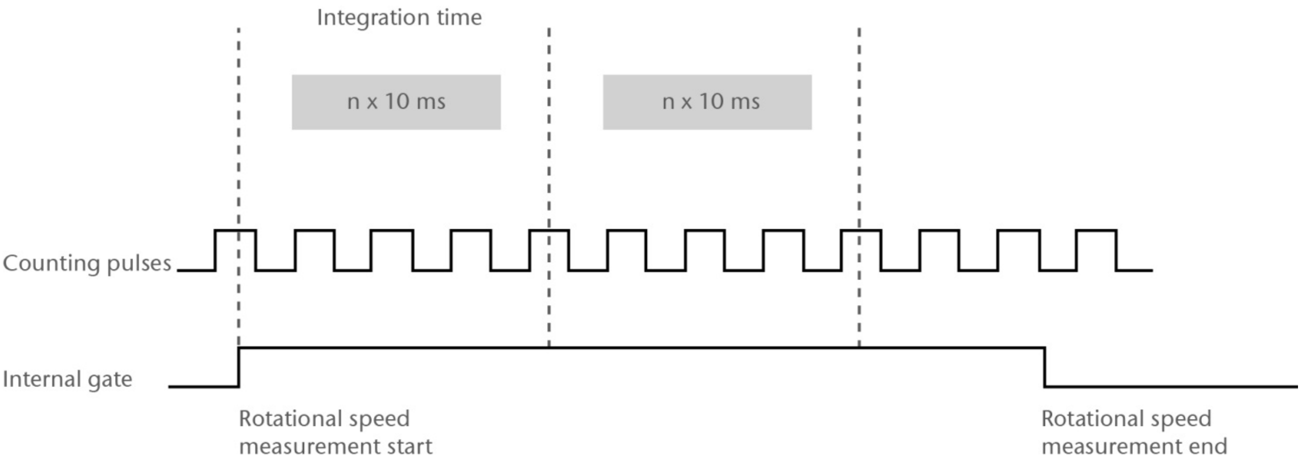


Figure 17: Rotational speed measurement with gate function

Limit monitoring

Lower limit n_L	Upper limit n_U
0–24,999,999 x 10^{-3} rpm	n_L +1–25,000,000 x 10^{-3} rpm

Measuring ranges and measuring errors

Integration time	n_{max} ± absolute error	n_{max} (single evaluation) ± error
10 s	150,000 ± 3.9 rpm	120,000 ± 2.9 rpm
1 s	150,000 ± 6.48 rpm	120,000 ± 5.4 rpm
0.1 s	150,000 ± 38.8 rpm	120,000 ± 33.1 rpm
0.01 s	150,000 ± 386.0 rpm	120,000 ± 305.9 rpm

- With 50 pulses/revolution

7.3.3. Period Measurement

The input signal's period will be continuously measured. The value will be a mean value calculated during the integration time. The integration time can be configured. The time measured will be the time that elapses between two rising counting pulse edges. Once a measurement ends, the "Measurement ended" status bit will be set to 1.

In order to obtain accurate measurements, the integration time should be longer than 10 counting pulses.

- Integration time n x 10 ms, value range: n_{min} = 1–n_{max} = 32767
- The reading resolution can be set to [µs] or [1/16 µs]

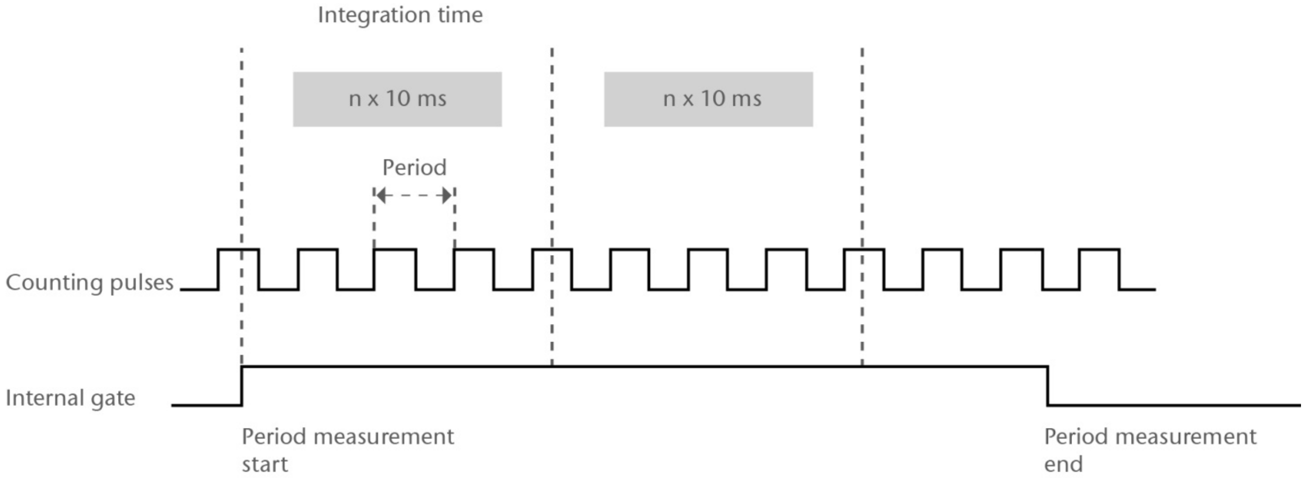


Figure 18: Period measurement with gate function

Limit monitoring

Resolution	Lower limit T_L	Upper limit T_U
1 µs	0–99,999,999 µs	T_L +1–100,000,000 µs
1/16 µs	0–149,999,999 x 1/16 µs	T_L +1–1,600,000,000 x 1/16 µs

Measuring ranges and measuring errors

Resolution 1 µs	n_{min} ± absolute error	n_{min}(single evaluation) ± absolute error
10 s	8 ± 0 µs	10 ± 0 µs
1 s	8 ± 0 µs	10 ± 0 µs
0.1 s	8 ± 0 µs	10 ± 0 µs
0.01 s	8 ± 0 µs	10 ± 0 µs

Resolution 1/16 µs	n_{min} ± absolute error	n_{max} ± absolute error
10 s	128 ± 0 µs	160 ± 0 µs
1 s	128 ± 0 µs	160 ± 0 µs
0.1 s	128 ± 0 µs	160 ± 0 µs
0.01 s	128 ± 0 µs	160 ± 0 µs

7.4. Behavior of the DI, A, and B Inputs in Measuring Mode

Connecting sensors

- Current-sourcing switch
- Push-pull

Inverting the input signal

Inputs A, B, and DI can be inverted by using the appropriate parameters.

- Invert B: 0 = OFF / 1 = ON
- Invert A: 0 = OFF / 1 = ON
- Invert DI: 0 = OFF / 1 = ON

The input signals can also be filtered

- A, B, DI filters: 0 = 125 kHz / 1 = 100 kHz / 2 = 50 kHz / 3 = 10 kHz

Digital input functions

The Function DI parameter can be used to set the following digital input functions:

- Switch off—the digital input will be disabled
- Input—Can be used as a digital input; read with the "DI state" status bit (the measurement will not be affected by the digital input)
- Hardware gate—please refer to Section 7.5

The "DI state" bit indicates the level at the digital input.

7.5. Gate Functions

Gate functions are used to interrupt or cancel a measurement as necessary. The counter features two different gates: a software gate and a hardware gate.

Software gate

The software gate is controlled with the I/O image table. Pulses at inputs A and B will only affect the measurement if the software gate is open.

Hardware gate

The hardware gate is controlled via the digital input. In order for this to be possible, the digital input must be configured as a hardware gate. The hardware gate is internally linked with the software gate by means of a logic AND gate.

Interrupting gate function

The measurement will be interrupted if the gate is closed. If the gate is opened again, the measurement will resume.

7.6. Behavior of DO Digital Output in Measuring Mode

An upper limit and a lower limit can be stored in the counter module. The digital output can then be switched in various ways by comparing the counter's reading to these limits.

The default configuration for the limits is as follows:

- Lower limit: 0
- Upper limit: 10000

Digital output functions

The Function DO parameter can be used to set the following digital output functions:

- Switch off—the digital output will be disabled
- Output—can be used as a digital output; read with the "DO state" status bit
- Above upper limit
- Below lower limit
- Outside limits

Switch off

If the DO digital output is disabled, the comparator's state will not be output and it will not be possible to use DO as a digital output.

DO output

Digital output DO is switched on and off with the "DO control bit." In order to enable switching, the "Enable DO" control bit must be set to 1.

The "DO state" status bit can be used to check the DO digital output's state at the feedback interface. The "DO state" status bit will be set to 0 immediately if the DO digital output is switched off.

Above upper limit

Digital output DO will be switched to ON if the measured reading is higher than the configured upper limit.

Below lower limit

Digital output DO will be switched to ON if the measured reading is lower than the configured lower limit.

Outside limits

Digital output DO will be switched to ON if the measured reading is higher than the configured upper limit or lower than the configured lower limit.

7.7. Input and Output Variables

7.7.1. Feedback (Inputs)

Input data length: 8 bytes

	7	6	5	4	3	2	1	0
Byte 0–3	Reading							
Byte 4	-	-	Parameter assignment error	-	-	Status bits being reset	-	Value being loaded
Byte 5	"Down" counting direction	"Up" counting direction	-	-	DO state	-	DI state	SW gate state
Byte 6	-	Lower measuring range	Upper measuring range		Measurement ended	-	-	-
Byte 7	-	-	-	-	-	-	-	-

Reading The current measured reading

Parameter assignment error This bit will be set to 1 if there is an incorrect parameter configuration. In case of a parameter assignment error the module will assume a save operating mode. This means the counter will neither return feedback, nor will it execute control commands. Additionally the DI and DO will be deactivated. Normal operation continues as soon as the counter receives valid parameters.

Status bits being reset This bit will be set to 1 if the status bits have been reset

Value being loaded This bit will be set to 1 if the loading function has been triggered. The control bit for loading a value can be reset

"Down" counting direction The measured value decreases.

"Up" counting direction The measured value increases.

DO state Indicates the digital output's current state

DI state Indicates the digital input's current state

SW gate state Indicates the software gate's current state

Lower measuring range If the measured reading falls below the configured lower limit, this bit will be set to 1. It can be reset by using "Reset status bits"

Upper measuring range If the measured reading rises above the configured upper limit, this bit will be set to 1. It can be reset by using "Reset status bits"

Measurement ended This bit will be set to 1 after an integration time period elapses. It can be reset by using "Reset status bits"

7.7.2. Control Interface (Outputs)

Output space length: 8 bytes

	7	6	5	4	3	2	1	0
Byte 0–3	Lower limit or upper limit							
Byte 4	-	-	-	Enable DO	DO control bit	Reset status bits	-	SW gate control bit
Byte 5	-	-	-	-	Load upper limit	Load lower limit	-	-
Byte 6	-	-	-	-	-	--	-	-
Byte 7	-	-	-	-	-	-	-	-

Lower limit/upper limit Storage space for transferring the lower and upper limits to the counter module.

Enable DO Must be set to 1 in order for the PLC application to be able to control DO

DO control bit Used by the PLC application to control DO if DO has been configured as an output. In order for the PLC application to be able to control DO, the enable bit for DO must first be activated

Reset status bits Resets all status bits, e.g., the Parameter assignment error and Comparator1 state bits

SW gate control bit Used to open (1) and close (0) the software gate. The software gate must be open in order for counting pulses to be accepted

Load upper limit Used to load the upper limit. Before this, the desired value must be loaded into the storage space used to transfer values that should be loaded. After this, the "Load upper limit" bit should be set to 1. As soon as the "Value being loaded" input bit switches to HIGH, the "Load upper limit" bit can be reset. If no errors are indicated (see "Loading function error"), this means that the value has been loaded successfully

Load lower limit Used to load the lower limit. Before this, the desired value must be loaded into the storage space used to transfer values that should be loaded. After this, the "Load lower limit" bit should be set to 1. As soon as the "Value being loaded" input bit switches to HIGH, the "Load lower limit" bit can be reset. If no errors are indicated (see "Loading function error"), this means that the value has been loaded successfully

SW gate control bit Used to open (1) and close (0) the software gate. The software gate must be open in order for counting pulses to be accepted

7.8. Parameters for Measuring Mode

All configurable modules come with a default parameter configuration. Depending on the bus system being used, the bus coupler will automatically load the desired operating parameter configuration into the modules when starting up or the user will have to transfer the configuration from the PLC by using the relevant methods. When using bus couplers with project storage capabilities (e.g., CANopen couplers), the parameters can be configured in advance with the "TB20 ToolBox" program.

Modules can also be reconfigured at any time—even during operation. The methods that have to be used for this purpose will vary depending on the bus system and PLC being used.

Parameter set structure (length of 16 bytes)

<table>
<tr><th>Parameter</th><th>Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>1</td><td>0</td><td colspan="8">Mode = 1</td></tr>
<tr><td>2</td><td>1</td><td>0</td><td>Behavior at CPU-STOP</td><td>0</td><td colspan="2">Capturing modes</td><td>Invert DI</td><td>Invert A</td><td>Invert B</td></tr>
<tr><td>3</td><td>2</td><td colspan="2">A / B / DI filters</td><td>0</td><td>0</td><td>0</td><td>0</td><td>DO behavior at CPU-STOP</td><td>Substitute value DO at CPU-STOP</td></tr>
<tr><td>4</td><td>3</td><td colspan="3">Function DO</td><td colspan="2">Function DI</td><td colspan="2">Measuring method</td><td>Resolution of period</td></tr>
<tr><td rowspan="4">5</td><td>4</td><td colspan="8" rowspan="4">Upper limit (Int32)</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td rowspan="4">6</td><td>8</td><td colspan="8" rowspan="4">Lower limit (Int32)</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td rowspan="2">7</td><td>12</td><td colspan="8" rowspan="2">Sensor pulses per rotation (UInt16)</td></tr>
<tr><td>13</td></tr>
<tr><td rowspan="2">8</td><td>14</td><td colspan="8" rowspan="2">Integration time [n * 10 ms] (UInt16)</td></tr>
<tr><td>15</td></tr>
</table>

Operating mode on CPU-STOP
0 = Stop / 1 = Continue counting

Capturing mode 0 = Pulse and direction / 1 = Rotary transducer (single) / 2 = Rotary transducer (double) / 3 = Rotary transducer (4-fold)

A, B, DI filters 0 = 500 kHz / 1 = 100 kHz / 2 = 50 kHz / 3 = 10 kHz

Function DO 0 = Switch off / 1 = Output / 2 = Above upper limit / 3 = Below lower limit / 4 = Outside limits

DO behavior at CPU-STOP 0 = Retain last value / 1 = Switch substitute value

Function DI 0 = Switch off / 1 = Input / 2 = HW gate

Measuring method 0 = Frequency measurement / 1 = Rotational speed measurement / 2 = Period measurement

Upper limit Used to define the upper measurement limit in the form of a positive 32-bit decimal number. The real value range will depend on the selected measuring method

Lower limit Used to define the lower measurement limit in the form of a positive 32-bit decimal number. The real value range will depend on the selected measuring method

Period measurement resolution

0 = Microseconds / 1 = 1/16 of a microsecond

Sensor pulses per rotation Number of sensor pulses for a single revolution
Range: 1 - 32767. Default value = 1000

Integration time Integration time in ms. Range: 1–32767. Default value = 100

Note: The corresponding default settings are underlined.

8. Counting and Direction Evaluation (Capturing Mode)

There are four capturing modes available for directional counting:

- Pulse and direction
- Rotary encoder with single evaluation
- Rotary encoder with double evaluation
- Rotary encoder with 4-fold evaluation

When using a rotary encoder configuration, pulses on inputs A and B will be counted. If single or double evaluation is used, only edges at input A will be counted. If 4-fold evaluation is used, all edges at inputs A and B will be counted.

8.1. Pulse and direction

Pulses on input A will be counted. Meanwhile, signal B's level will determine the counting direction:

- LOW: Up
- HIGH: Down

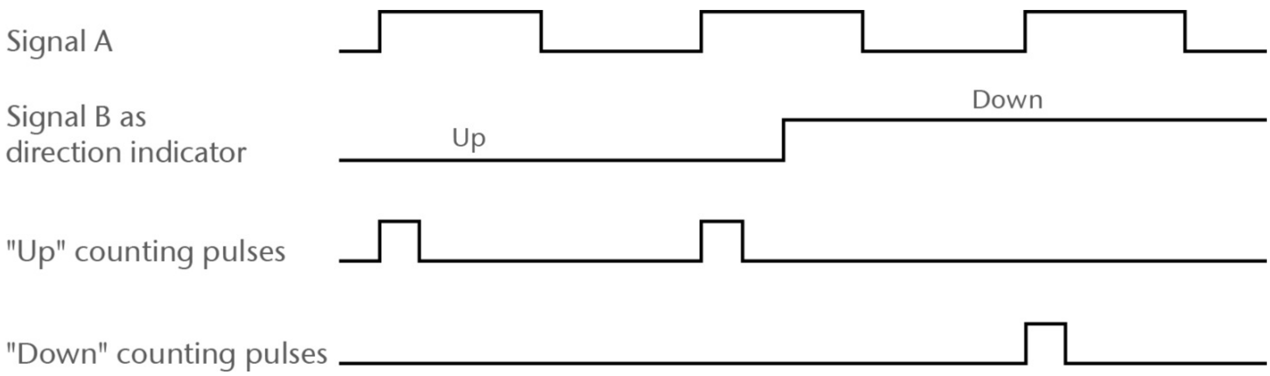


Figure 19: Signals from a pulse generator with a directional level

Limits:

- Input frequency in_{max} = 125 kHz on signal A
- Counting frequency out_{max} = 125 kHz

8.2. Rotary Encoder with Single Evaluation

Single evaluation can only be used with encoders that deliver two signals that are staggered, i.e., out of phase relative to each other. All positive edges on signals B will be evaluated. If two edges are detected on an input before the other input has an edge, the counting direction will change.

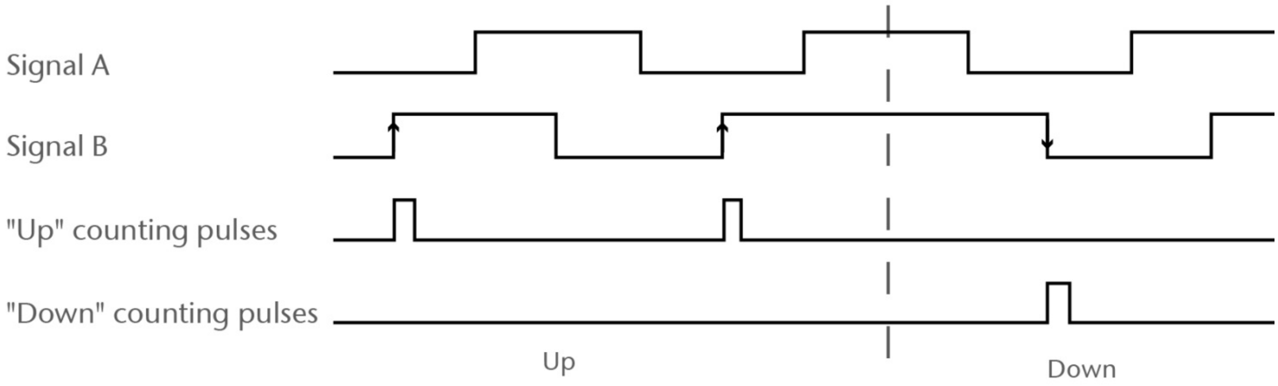


Figure 20: Single evaluation

Limits:

- Input frequency in_{max} = 100 kHz per signal
- Counting frequency out_{max} = 100 kHz

8.3. Rotary Encoder with Double Evaluation

Double evaluation can only be used with encoders that deliver two signals that are staggered, i.e., out of phase relative to each other. All edges on signals A will be evaluated. If two edges are detected on an input before the other input has an edge, the counting direction will change.

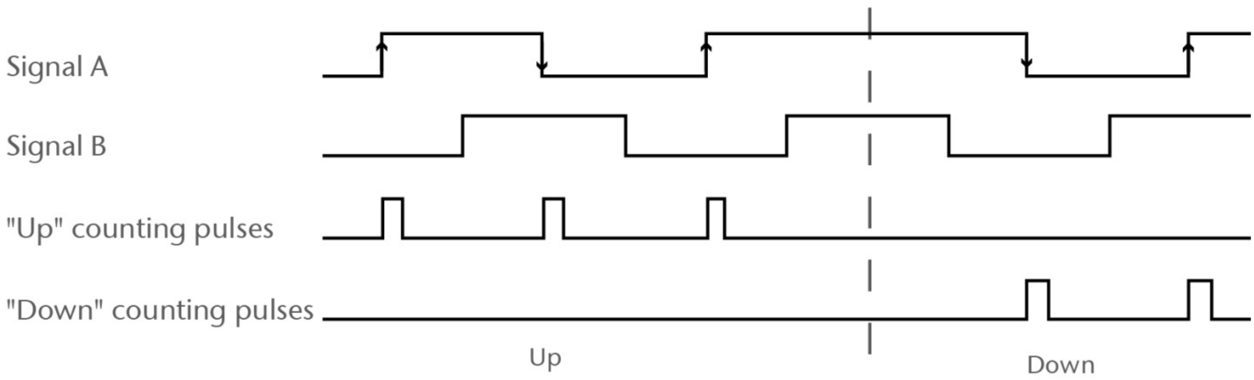


Figure 21: Double evaluation

Limits:

- Input frequency in_{max} = 125 kHz per signal
- Counting frequency out_{max} = 250 kHz

8.4. Rotary Encoder with 4-fold Evaluation

4-fold evaluation can only be used with encoders that deliver two signals that are staggered, i.e., out of phase relative to each other. All edges on signals A and B will be evaluated. If two edges are detected on an input before the other input has an edge, the counting direction will change.

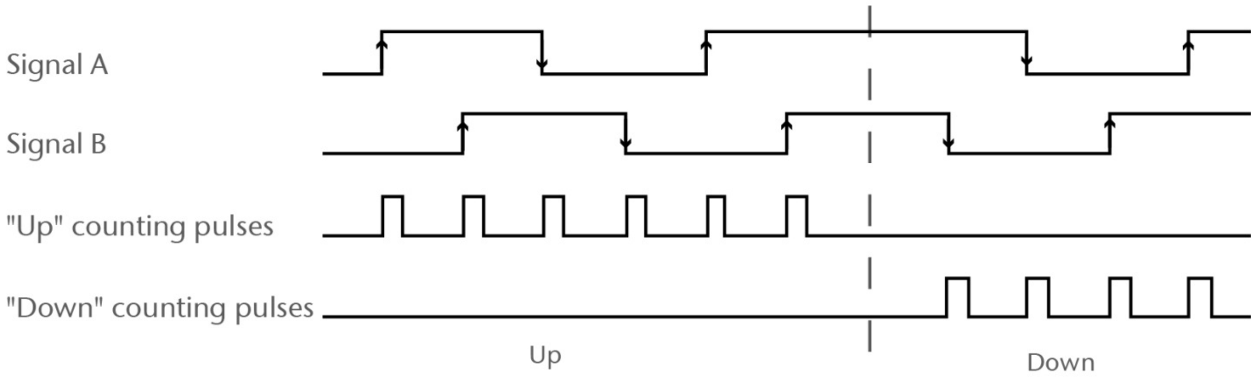


Figure 22: 4-fold evaluation

Limits:

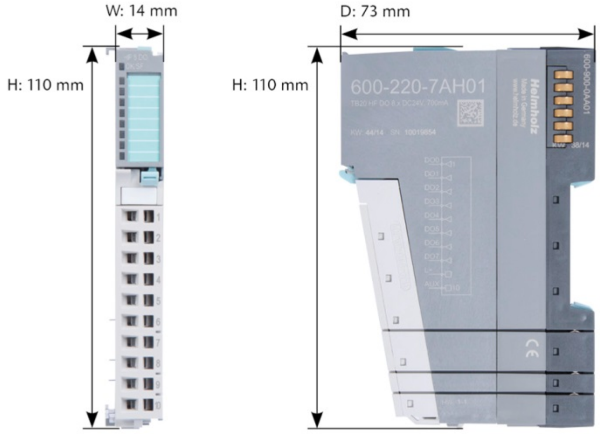
- Input frequency in_{max} = 125 kHz per signal
- Counting frequency out_{max} = 500 kHz

9. Technical Specifications

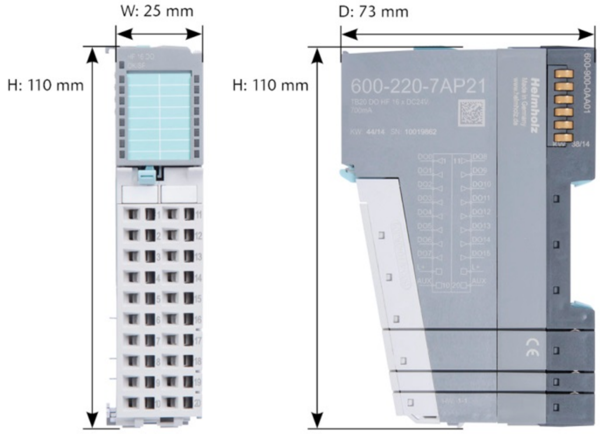
Order No.	**600-300-7AA01**
Modulename	1x counter 24 V, 500 KHz, 32-bit
Module ID / Module model	10100 / 0301
Number of counters	1
Counter bit depth	32 bits
Input frequency	Max. 125 KHz
Counting frequency	Max. 500 KHz (for 4-fold evaluation)
Input voltage	24 VDC
Electrically isolated from backplane bus	Yes
Inputs/outputs electrically isolated from each other	No
Current draw	
External	Max. 10 mA + load
Internal	Max. 86 mA
Power dissipation	Max. 0.8 W
Input characteristic curve	Type 2, EN 61131-2
Output current	
Rated	500 mA
Leakage current	Max. 0.5 mA
Short-circuit protection	Electronic
Hot-pluggable	Yes
Parameter configuration length	16 bytes
Dimensions (H x W x D)	110 mm x 14 mm x 73 mm
Weight	70 g
Certifications	CE, UL 508
Noise immunity	DIN EN 61000-6-2 “EMC Immunity”
Interference emission	DIN EN 61000-6-4 “EMC Emission”
Vibration and shock resistance	DIN EN 60068-2-8:2008 “Vibration” DIN 60068-27:2010 “Shock”
Protection rating	IP 20
Relative humidity	95% without condensation
Installation position	Any
Permissible ambient temperature	0 °C to 60 °C
Transport and storage temperature	-20 °C to 80 °C

10. Dimensions

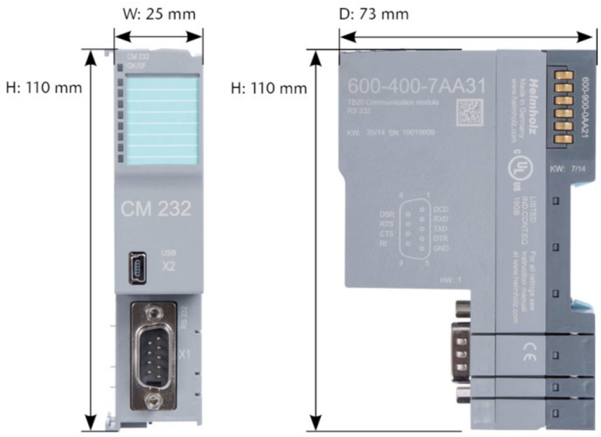
Module with standart width



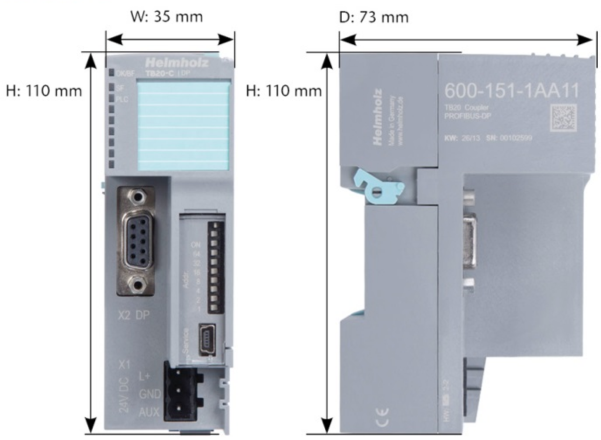
Module with double width

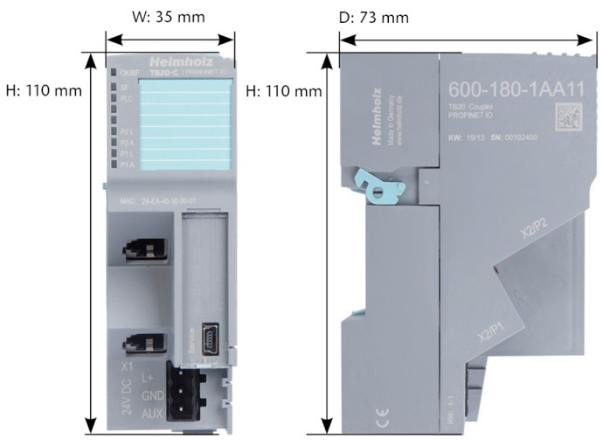


Communication Module



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.

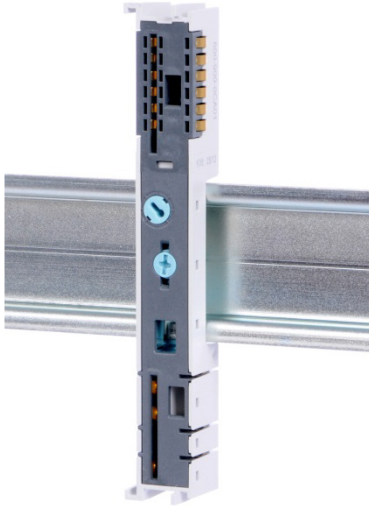
11.1.3. Power and Isolation Base Module

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.

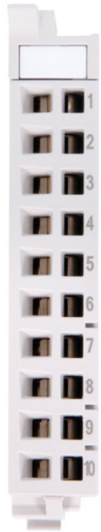
It can be used with the power module (600-700-0AA01) and with all bus couplers.



11.2. Front Connectors

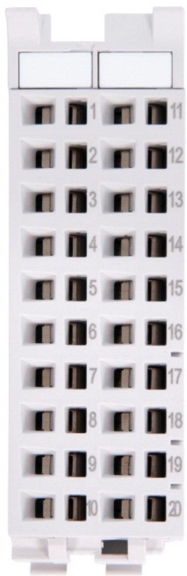
11.2.1. 10-Terminal Front Connector

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.